AGRICULTURAL AND FORESTRY SCIENCES ACADEMY

"GHEORGHE IONESCU - SISESTI"

ACTA AGRICOLA ROMANICA

FIELD CROPS

Tom 7, Year 7, No.7.1.

August 2025

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CONTENT

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RESEARCH ON THE EFFICIENCY OF PHYTOSANITARY TREATMENTS AT DIFFERENT PHENOLOGICAL STAGES FOR CONTROLING PATHOGENS IN WHEAT CROPS

CERCETĂRI PRIVIND EFICIENȚA TRATAMENTELOR FITOSANITARE ÎN DIFERITE FENOFAZE PENTRU CONTROLUL PATOGENILOR ÎN CULTURA DE GRÂU

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Abstract

In recent years, mild winters have contributed to an increased pressure of pathogens on wheat crops. Determining the optimal timing for applying plant protection treatments is essential to achieve a healthy crop and ensure high production, both in terms of quantity and quality. Since pathogens are active throughout the entire growing season, applying phytosanitary treatments becomes a necessity. However, it is crucial to consider economic efficiency, as applying numerous treatments, if they are costly and ineffective, does not bring real benefits.

The objective of this research is to identify the optimal phenological stages for applying treatments against the pathogen complex in wheat crops, using two complex fungicides. Treatments were applied in three main phenological stages (tillering, booting, and heading) as well as in combinations of these stages.

The results obtained indicate that applying three treatments in the tillering+booting+heading stages represents the most effective strategy for significantly reducing the degree of pathogen attack.

From a production perspective, the most effective treatment timing was found to be the tillering + booting combination, resulting in a 19% yield increase compared to the untreated control.

Rezumat

În ultimii ani, iernile blânde au favorizat intensificarea presiunii patogenilor asupra culturii de grâu. Determinarea momentului optim pentru aplicarea tratamentelor fitosanitare este esențială pentru obținerea unei culturi sănătoase și a unei producții satisfăcătoare, atât din punct de vedere cantitativ, cât și calitativ.

Deoarece patogenii se manifestă pe tot parcursul perioadei de vegetație, aplicarea tratamentelor fitosanitare devine o necesitate. Totuși, este important să luăm în considerare eficiența economică, aplicarea unui număr mare de tratamente, dacă acestea sunt costisitoare și ineficiente, nu aduce beneficii .

Obiectivul acestei cercetări este de a identifica fenofazele optime pentru aplicarea tratamentelor împotriva complexului de patogeni la cultura de grâu, utilizând două fungicide complexe. Tratamentele au fost aplicate în trei fenofaze principale (înfrățit, burduf și înspicar) și în combinațiile acestora.

Rezultatele obținute au evidențiat că aplicarea a trei tratamente în fenofazele de înfrățit+burduf+spic este cea mai eficientă strategie pentru reducerea semnificativă a gradului de atac al agenților patogeni.

Din perspectiva producției, cele mai eficiente momente de aplicare s-au dovedit a fi înfrățit+burduf, înregistrându-se un spor de producție de 19% comparativ cu martorul netratat.

Keywords: winter wheat, foliar pathogens, fungicide treatment, phenophase
Cuvinte cheie: grâu de toamnă, patogeni foliari, tratament fungicid, fenofază

INTRODUCTION

Wheat (*Triticum aestivum* L.) is a cornerstone of global agriculture, serving as a primary food source for a significant portion of the world's population. However, its cultivation is continually challenged by a myriad of fungal pathogens that can severely compromise both yield and grain quality. Effective disease management is thus pivotal to ensure food security and the economic viability of wheat production.

Among the prevalent fungal diseases affecting wheat are Septoria tritici blotch (*Septoria tritici*), (https://cropprotectionnetwork.org/) leaf rust (*Puccinia sp.*), powdery mildew (*Blumeria graminis* f. sp. *tritici*), and Fusarium head blight (*Fusarium spp.*). (Edward, 2020; Fernandez et al. 2020). These pathogens exhibit varying infection patterns and optimal conditions for proliferation, necessitating tailored management strategies. (https://cropprotectionnetwork.org/) For instance, Septoria tritici blotch thrives in humid conditions and can lead to significant yield losses if not promptly addressed (Brown et al., 2002). Similarly, Fusarium head blight not only reduces yield but also contaminates grain with mycotoxins, posing health risks to consumers (Bai et al, 2004).

Fungicide application remains a cornerstone in the integrated management of these diseases. However, the efficacy of such treatments is profoundly influenced by the timing of application relative to the wheat's phenological stages. Research indicates that applications synchronized with specific growth stages, such as the flag leaf emergence or heading, can maximize disease control and yield benefits (Madden et al., 2007). Conversely, misaligned applications may result in suboptimal disease suppression and unnecessary economic expenditure. (https://cropwatch.unl.edu/)

In this context, our study aims to evaluate the efficiency of fungicide applications at distinct phenological stages—specifically tillering (BBCH 21–29), booting (BBCH 41–49), and heading (BBCH 51–59)—as well as their combinations, in controlling prevalent wheat pathogens. The research was conducted at the Agricultural Research and Development Station (ARDS) in Livada, Satu Mare County, Romania. The experimental site is characterized by an acidic, low-fertility albic luvisol, representative of the region's soil profile.

The experimental design encompassed eight treatment variants: individual applications at each of the three phenological stages, three combinations of two-stage applications, a comprehensive three-stage application, and an untreated control. The primary objectives were to, determine the most effective phenological stage or combination thereof for fungicide application in terms of disease suppression, assess the impact of these treatments on wheat yield and grain quality and evaluate the economic efficiency of each treatment strategy, considering both input costs and yield returns.

By elucidating the optimal timing for fungicide applications, this study seeks to provide actionable insights for wheat producers aiming to enhance disease management, optimize yields, and improve profitability.

MATERIAL AND METHOD

The objective of the research is to determine the most effective and efficient treatment timings (phenophases) against the pathogen complex in wheat cultivation.

The influence of the timing (phenophase) of fungicide application on the wheat crop, cultivar Glosa, was assessed by setting up an experiment based on the randomized block design, using the fungicide Ortiva Top at a dose of 0.5 L/ha.

The experiment was conducted during the 2023–2024 agricultural year at ARDS Livada on an albic Luvisol and included the variants presented in Table 1.

This experiment involved the application of a complex fungicide to the wheat crop at different phenological stages. The objective was to cover the three critical phenophases of wheat—tillering, booting, and heading—as well as their combinations: tillering + booting; tillering + booting + heading; tillering + heading; booting + heading, in order to determine the most optimal technology for achieving both high-quality and high-quantity yields.

Table 1. Experimental variants//Variantele experienței

Nr. Crt.	Application phenophase	Fungicide	Doze L/ha	Application date
1	tillering (BBCH 29-30)	Ortiva Top (200 g/l azoxistrobin 125 g/l difenoconazol)	0,5	08.04.2024
2	tillering+booting	Ortiva	0,5	
3	tillering+heading	Ortiva	0,5	
4	tillering+booting+heading	Ortiva	0,5	
5	booting (BBCH 39-40)	Ortiva	0,5	23.04.2024
6	booting+heading	Ortiva	0,5	
7	heading	Ortiva	0,5	13.05.2025

Nr. Crt.	Application phenophase	Fungicide	Doze L/ha	Application date
	(BBCH 49-50)			
8	control	Netratat	-	-

This experiment involved the application of a complex fungicide to the wheat crop at different phenological stages. The objective was to cover the three critical phenophases of wheat—tillering, booting, and heading—as well as their combinations: tillering + booting; tillering + booting + heading; tillering + heading; booting + heading, in order to determine the most optimal technology for achieving both high-quality and high-quantity yields.

The experiment was laid out according to the randomized block design, with four replications. (Figure 1).

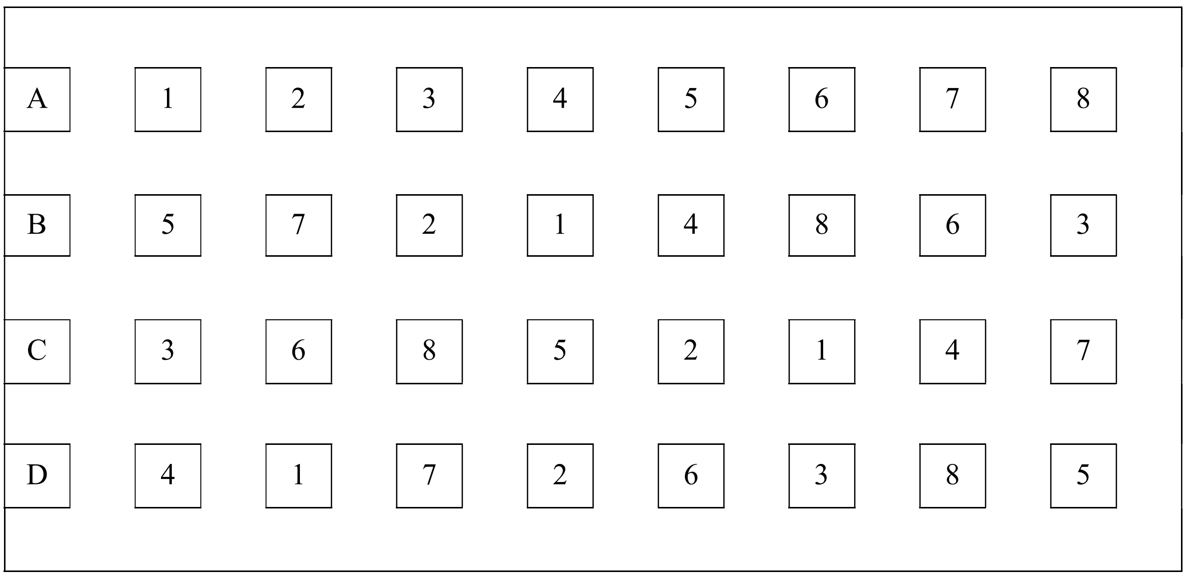

Figure 1. Schița experineței//Experimental layout

The temperatures during the experimental period were characterized by higher values compared to the multiannual average, with the most significant deviations recorded in February (+7.4°C) and March (+4.6°C). These variations indicate a trend of climatic warming, particularly during the winter months and mid-summer. (Figure 2).

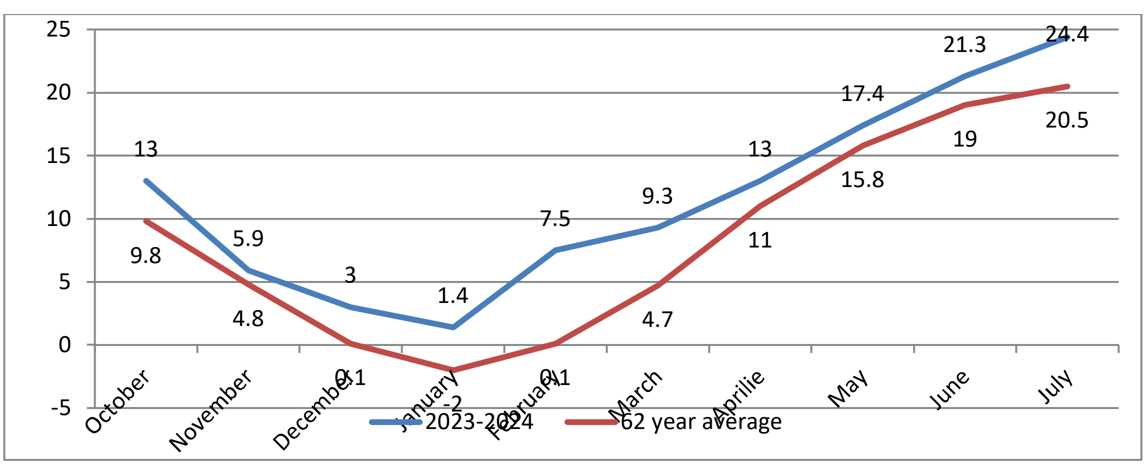

Figure 2. Temperatures in the vegetation period of wheat//Temperaturile lunare din perioada de vegetație a grâului

The distribution of precipitation during the wheat growing season was highly uneven, with amounts significantly exceeding the multiannual average in November and December, and an exceptionally high quantity (147 mm) recorded in June. In contrast, all other months within this period registered significantly lower amounts of precipitation compared to the multiannual average. (Figure 3).

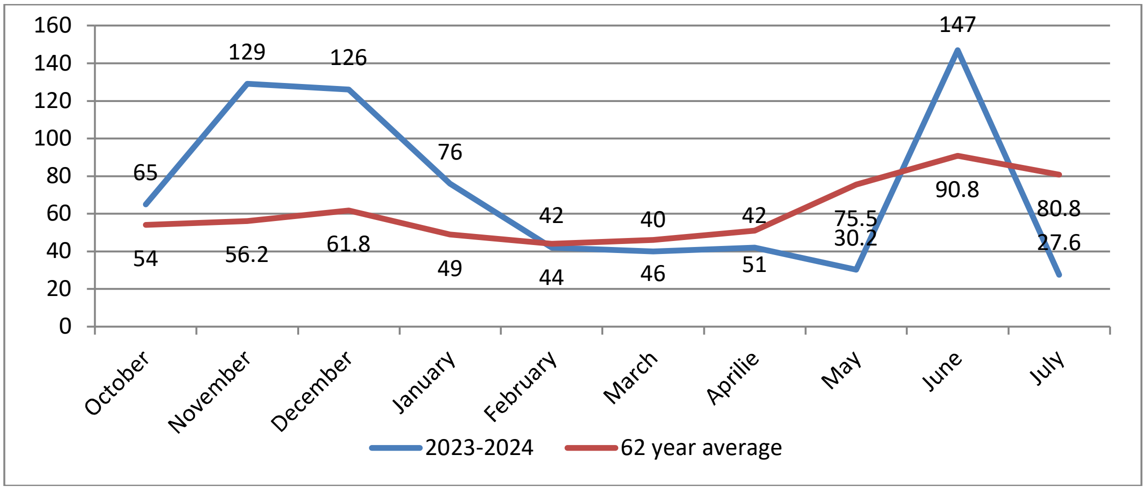

Figure 3. Precipitations //Precipitații

RESULTS AND DISCUSSIONS

Prior to the fungicide treatments, the phytosanitary status of the wheat crop was assessed. It was observed that, before the treatments, the disease commonly known as powdery mildew, caused by the fungus *Erysiphe graminis*, was not present in the wheat crop.

Septoria, caused by the pathogen *Septoria graminis*, was present on the basal leaves, with a frequency of 83.3% on the fourth leaf and 54.1% below the fourth leaf, exhibiting an attack severity of 5% and 51.5%, respectively, and a desiccation percentage of 100%. (Table 2).

Table 2. Pathogen complex manifestation in BBCH 29-30//Manifestarea complexului patogen foliar în fenofaza BBCH 29-30

Leaf order from top to bottom	Disease (Pathogen)				Dryness (%)
	Powdery mildew (Erysiphae graminis)		Leaf blotch (Septoria graminis)		
	Frequency (%)	Degree of attack (%)	Frequency (%)	Degree of attack (%)	
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	20,0	2,0	0
4	0	0	83,3	5,0	100
Sub 4	0	0	54,1	51,5	100

After only 15 days, the severity of attack by the pathogens *Erysiphe graminis* (commonly known as powdery mildew) and *Septoria tritici* (also known as septoria leaf blotch) was significantly reduced in the variants treated during the tillering phenophase, compared to the other variants that were scheduled for treatment at a later time. The statistical analysis of pathogen occurrence and attack severity on leaves 1–3 and the leaf below the third is presented in the table below. (Table 3).

Table 3. The foliar pathogen complex în BBCH 39-40 phenophase, 15 days after the first treatment // Manifestarea complexului patogen foliar în fenofaza BBCH 39-40 după 15 zile de la primul tratament

Nr. crt.	Experimental variants			Pathogens											
	Fungicide	Dose (l/ha)	Application phenophas	Powdery mildew D.A.%						Leaf blotch D.A.%					
				Leaf1-3			Sub 3			Leaf 1-3			Sub 3		
				m	d	s	m	d	s	m	d	s	M	d	s
1	Ortiva	0,5	tillering (BBCH 29-30)	0,0	-0,9	OOO	0,8	-3,4	OOO	0,0	-3,0	OOO	13,7	-8,8	-
2	Ortiva	0,5	tillering+booting	0,0	-0,9	OOO	0,5	-3,7	OOO	0,0	-3,0	OOO	12,0	-10,5	O

Nr. crt.	Experimental variants			Pathogens											
	Fungicide	Dose (l/ha)	Application phenophas	Powdery mildew D.A.%						Leaf blotch D.A.%					
				Leaf1-3			Sub 3			Leaf 1-3			Sub 3		
				m	d	s	m	d	s	m	d	s	M	d	s
3	Ortiva	0,5	tillering+heading	0,0	-0,9	OOO	1,5	-2,7	OOO	0,0	-3,0	OOO	10,0	-12,5	O
4	Ortiva	0,5	tillering+booting+heading	0,0	-0,9	OOO	0,6	-3,6	OOO	0,0	-3,0	OOO	10,8	-11,7	O
5	Ortiva	0,5	booting (BBCH 39-40)	0,6	-0,3	-	3,2	-1,0	O	1,9	-1,1	O	17,5	-5,0	-
6	Ortiva	0,5	burduf+heading	0,8	-0,1	-	3,3	-0,9	-	2,4	-0,6	-	22,5	0	-
7	Ortiva	0,5	heading (BBCH 49-50)	0,6	-0,3	-	3,6	-0,6	-	2,1	-0,9	O	18,8	-3,7	-
8	Control	-	-	0,9		-	4,2	-	-	-3,0	-	-	22,5	-	-
			LSD 5%			0,4%			0,9%			0,8%			9,3%
			LSD 1%			0,5%			1,3%			1,1%			12,7%
			LSD 0,1%			0,7%			1,7%			1,4%			17,2%

Similarly, the pathogen *Puccinia* (rust) and the level of leaf desiccation showed comparable results in the same phenophase as the others. (Table 4).

The chart shows that the lowest *Septoria* attack levels were recorded in treatments applied at the tillering stage and its combinations (especially tillering and tillering+booting+heading), with values under 7% on leaves 1+2 and around 40–46% on leaf 3. In contrast, late treatments (heading) and the untreated control showed significantly higher infection levels, with up to 29.2% and 70.8% respectively. (Figure 4).

Table 4. The foliar pathogen complex în BBCH 39-40 phenophase, 15 days after the first treatment // Manifestarea complexului patogen foliar în fenofaza BBCH 39-40 după 15 zile de la primul tratament

Nr. crt.	Experimental variants			Pathogens				Dryness %		
				D.A.%						
	Fungicide	Dose (l/ha)	Application phenophas	Leaf 1-3			Sub 3	Sub 3		
				m	d	s	m	m	d	s
1	Ortiva	0,5	tillering (BBCH 29-30)	0	-1,9	OOO	0,0	28,1	-6,9	O
2	Ortiva	0,5	tillering+booting	0	-1,9	OOO	0,0	25,6	-9,4	OO
3	Ortiva	0,5	tillering+heading	0	-1,9	OOO	0,0	25,0	-10,0	OO
4	Ortiva	0,5	tillering+booting+heading	0	-1,9	OOO	0,0	25,5	-9,5	OO
5	Ortiva	0,5	booting (BBCH 39-40)	1,7	-0,2	-	0,0	29,1	-5,9	-
6	Ortiva	0,5	booting+heading	1,8	-0,1	-	0,0	35,4	0,4	-
7	Ortiva	0,5	heading (BBCH 49-50)	1,8	-0,1	-	0,0	33,3	-1,7	-
8	Control (fără tratament)	-	-	1,9	-	-	0,0	35,0	-	-
			LSD 5%			0,8%				6,5%
			LSD 1%			1,1%				8,9%
			LSD 0,1%			1,4%				12,0%

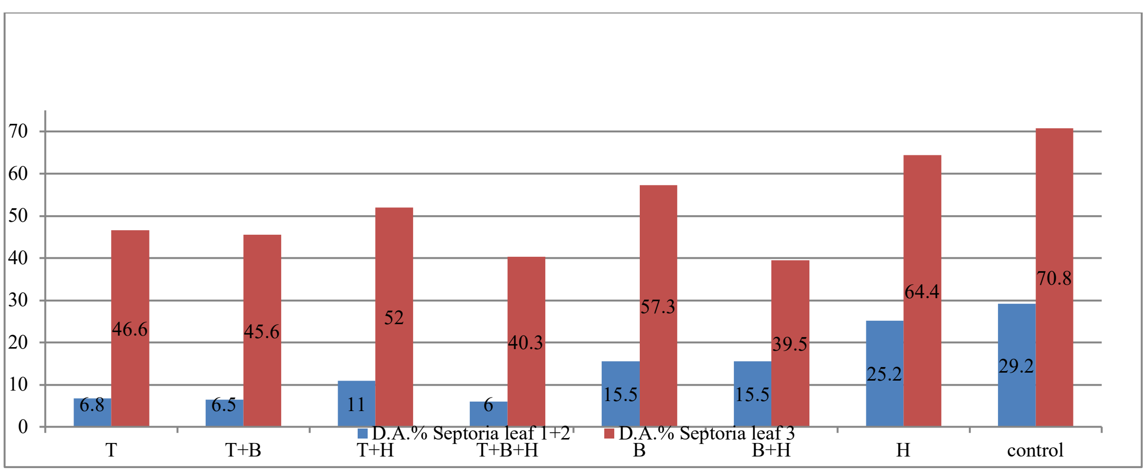

Figure 4. The foliar pathogen complex în BBCH 60 phenophase, 20 days after the second treatment // Manifestarea complexului patogen foliar în fenofaza BBCH 60 după 20 zile de la al doilea tratament

The lowest leaf desiccation was observed in early treatments, especially tillering and tillering+booting, with minimal damage on leaves 1–2 and moderate one on leaf 3. Late treatments (heading) and the untreated control showed the highest desiccation levels, with up to 34.6% on leaves 1–2 and 95.5% on leaf 3. (Figure 5).

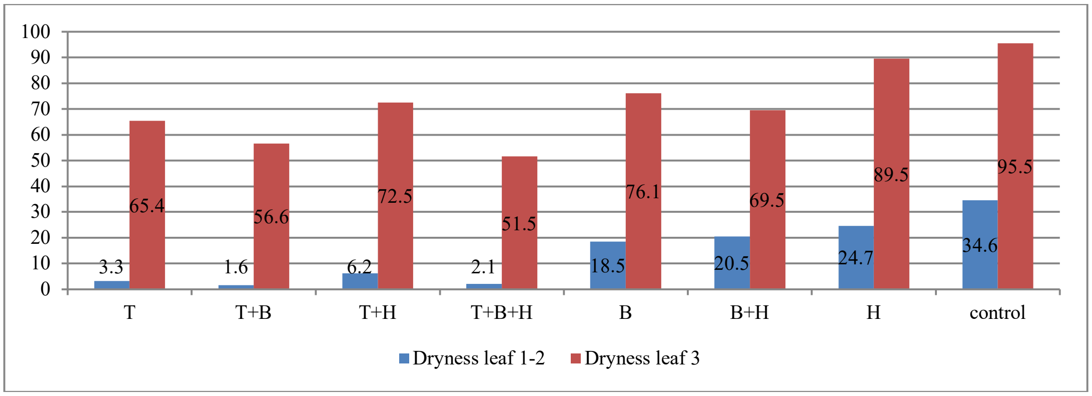

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Figure 5. The foliar pathogen complex în BBCH 60 phenophase, 20 days after the second treatment //Manifestarea complexului patogen foliar în fenofaza BBCH 60 după 20 zile de la al doilea tratament

Very low levels of powdery mildew and rust were recorded in all treated variants, especially those applied early. Only the heading treatment and untreated control showed high rust severity (14.3–14.5%) and slight powdery mildew presence. (Figure 6).

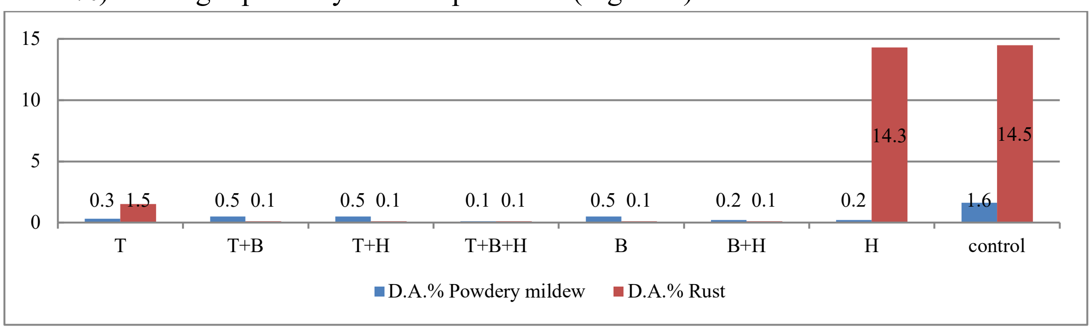

Figure 6. The foliar pathogen complex în BBCH 70 phenophase, 15 days after the third treatment // Manifestarea complexului patogen foliar în fenofaza BBCH 70 după 15 zile de la al treilea tratament

The lowest values for both *Septoria* attack and leaf desiccation were observed in tillering, tillering.+B+S, and booting, confirming the effectiveness of early and combined treatments. The highest severity was recorded in heading and untreated variants, with *Septoria* attack over 37% and desiccation reaching 71.1% and 58.3%, respectively. (Figure 7).

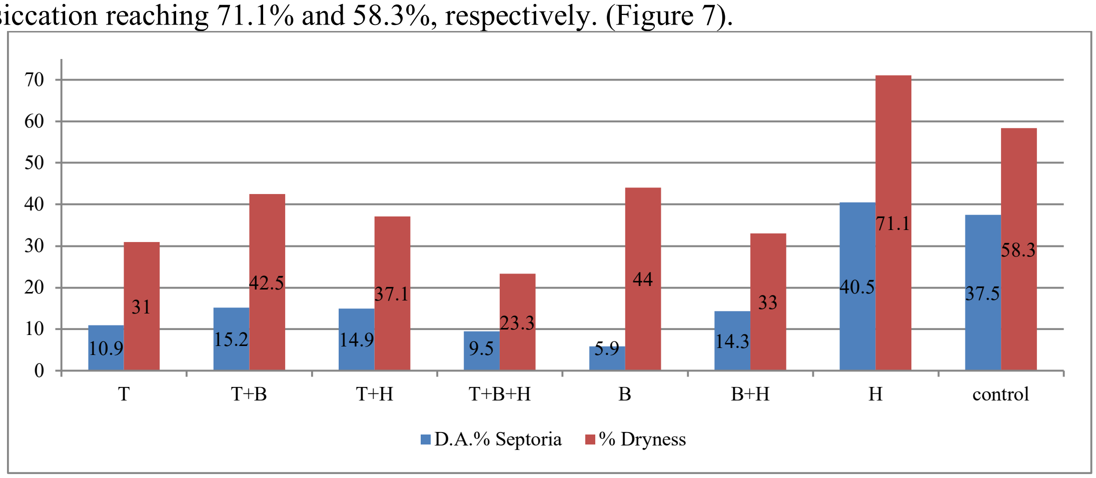

Figure 7. The foliar pathogen complex în BBCH 70 phenophase, 15 days after the third treatment // Manifestarea complexului patogen foliar în fenofaza BBCH 70 după 15 zile de la al treilea tratament

The analysis of variance (Table 5) revealed significant differences ($F = 3.0$, $p < 0.05$) between the treatment variants applied at different phenophases. This result indicates that the timing of fungicide application has a significant influence on wheat yield. The low mean square value for replications suggests that the use of experimental blocks was effective in standardizing conditions.

These findings demonstrate that the phenophase at which the treatment is applied plays a crucial role in both disease control efficacy and yield improvement.

Table 5. ANOVA calculation over the wheat yield//Calculul ANOVA asupra producției de grâu

Source of variance	Sum square	Degree of freedom	Means square	F
Variant	4334392	7	619198,8	3,0*
Replication	306531,3	3	102177,1	
Variant error	4334642	21	206411,5	
T o t a l	8975564	31		

The influence of fungicide treatment timing on yield, as determined by the analysis of variance of differences, shows that the booting + tillering and booting + tillering + heading phenophases are the most important, resulting in statistically significant yield differences. Under conditions where climatic factors had a limited impact on spike diseases (such as fusarium head blight), treatments applied only at heading or in the tillering + heading variant did not lead to significant yield differences. (Table 6).

Table 6. The influence of treatments on the wheat yield//Influența tratamentelor asupre producției de grâu

Variant	Yield (kg/ha)	%	Difference	Signification
Control	5500,25	100,0	0,00	Ct.
tillering	6250,25	113,6	750,00	*
tillering+booting	6547,25	119,0	1047,00	**
tillering+heading	6125,25	111,4	625,00	-
Tillering+booting+heading	6469,25	117,6	969,00	**
booting	6359,75	115,6	859,50	*
booting+heading	6344,00	115,3	843,75	*
heading	5593,75	101,7	93,50	-

LSD (p 5%) 668,21 // LSD (p 1%) 909,16// LSD (p 0.1%)1227,20

Multiple comparisons (Duncan's test) grouped the treatment variants into three classes. The control variant was placed in Class A, with the lowest yield of 5,500 kg/ha. The highest yields, ranging between 6,344 and 6,547 kg/ha, were assigned to Class C, corresponding to treatments applied at booting and all combinations that included the booting phenophase. (Table 7).

Table 7. Duncan test on the wheat yield//Testul Duncan asupra producției

Nr. Crt.	Varinat	Yield (kg/ha)	Classification
1	**Control**	5500,25	A
2	**heading**	5593,75	AB
3	**tillering+heading**	6125,25	ABC
4	**tillering**	6250,25	BC
5	**booting+heading**	6344,00	C
6	**booting**	6359,75	C
7	**tillering+booting+heading**	6469,25	C
8	**tillering+booting**	6547,25	C

In addition to the yield increases obtained through treatment application, the influence is also reflected in the quality traits of the grain.

Significantly positive differences in protein content were recorded in the tillering and tillering + booting variants, and statistically significant differences were observed in the tillering + heading variant.

Table 8. The influence of treatments on the protein content//Influența tratamentelor asupre conținutului de proteine

Variant	Proteine (%)	%	Difference	Signification
Control	13,00	100,0	0,00	Ct.
tillering	14,55	111,9	1,55	**

Variant	Proteine (%)	%	Difference	Signification
tillering+booting	14,63	112,5	1,63	**
tillering+heading	14,45	111,2	1,45	*
Tillering+booting+heading	13,53	104,0	0,52	-
booting	14,00	107,7	1,00	-
booting+heading	13,38	102,9	0,38	-
heading	13,48	103,7	0,47	-

LSD (p 5%) 1,13// LSD (p 1%)1,54 // LSD (p 0.1%)2,08

Table 9. The influence of treatments on the gluten content//Influența tratamentelor asupre conținutului de gluten

Variant	Gluten (%)	%	Difference	Signification
Control	22,45	100,0	0,00	Ct.
tillering	26,43	117,7	3,97	**
tillering+booting	26,68	118,8	4,23	***
tillering+heading	26,58	118,4	4,12	**
Tillering+booting+heading	23,90	106,5	1,45	-
booting	26,28	117,0	3,82	**
booting+heading	23,43	104,3	0,98	-
heading	23,58	105,0	1,13	-

LSD (p 5%) 2,28 // LSD (p 1%) 3,10 // LSD (p 0.1%) 4,18

The gluten content was positively and highly significantly influenced in the tillering + booting variant, and significantly influenced in the tillering, tillering + heading, and booting variants. In the untreated control, the recorded gluten percentage was 22.45%.

According to the multiple comparison analysis, this indicator was divided into two classes, with Class A including the lowest gluten content, ranging from 22.45% to 23.9% and with class B from 26,27 to 26,68%.

Table 10. Duncans test on the gluten content//Testul Duncan asupra conținutului de gluten

Nr. crt.	Variant	Gluten (%)	Classification
1	Control	22,45	A
2	booting+heading	23,43	A
3	heading	23,58	A
4	tillering+burd+heading	23,90	A
5	booting	26,27	B
6	tillering	26,42	B
7	tillering+heading	26,57	B
8	tillering+booting	26,68	B

The sedimentation index reached its highest value of 49.78 in the tillering + booting variant, with significant values also recorded in the tillering and tillering + heading variants.

Table 11. The influence of treatments on the sedimentation index//Influența tratamentelor asupra indicelui de sedimentare

Variant	Sedimentation index	%	Difference	Signification
Control	37,65	100,0	0,00	Ct.
tillering	47,05	125,0	9,40	*
tillering+booting	49,78	132,2	12,13	**
tillering+heading	46,65	123,9	9,00	*
Tillering+booting+heading	38,78	103,0	1,13	-
booting	44,35	117,8	6,70	-
booting+heading	37,78	100,3	0,13	-
heading	40,20	106,8	2,55	-

LSD (p 5%) 8,33// LSD (p 1%) 11,34 // LSD (p 0.1%) 15,30

The hectoliter weight ranged from 72.63 kg in the untreated control to 76.23 kg in the variant with three treatments.

Highly significant differences were recorded in the variants with three treatments, and distinctly significant differences in the booting + heading variant.

According to the multiple comparison test, treatment timing differentiated the variants into three classes based on hectoliter weight:

- Class A: 72.63–73.70 kg
- Class AB: 74.2 kg (*tillering* variant)
- Class BC: 75.2 kg (*booting* + *heading* variant)
- Class C: 76.23 kg (*three treatments* variant)

Table 12. The influence of treatments on the hectoliter weight//Influența tratamentelor asupra masei hectolitrice

Variant	Hectoliter weight	%	Difference	Signification
Control	72,63	100,0	0,00	Ct.
tillering	74,20	102,2	1,57	-
tillering+booting	73,10	100,7	0,47	-
tillering+heading	73,70	101,5	1,07	-

Variant	Hectoliter weight	%	Difference	Signification
Tillering+booting+heading	76,23	105,0	3,60	***
booting	73,33	101,0	0,70	-
booting+heading	75,50	104,0	2,88	**
heading	73,05	100,6	0,43	-

LSD (p 5%) 1,69 // LSD (p 1%) 2,30 // LSD (p 0.1%) 3,11

Table 13. Duncans test on the hectoliter weight//Testul Duncan asupra masei hectolitrice

Nr. crt.	Varianta	HL weight	Classification
1	**Control**	72,63	A
2	**heading**	73,05	A
3	**Tillering+booting**	73,10	A
4	**booting**	73,32	A
5	**tillering+heading**	73,70	A
6	**tillering**	74,20	AB
7	**booting+heading**	75,50	BC
8	**tillering+burd+heading**	76,22	C

From the perspective of economic efficiency, the calculation of income differences based on the costs incurred by fungicide application and the yield increases achieved per treatment variant shows that, in the experimental year, all treatment variants except the one applied only at heading (heading) recorded a positive profit.

The highest profit, amounting to 719.4 RON/ha, was obtained with a single treatment at booting, followed by the tillering + booting variant with a profit of 632.4 RON/ha.

In contrast, the variant with a single treatment applied only at heading (heading) did not result in a profit; instead, it led to a reduction in income of -199.8 RON/ha.
It is important to note that this outcome occurred under climatic conditions less favorable for spike diseases.

However, in years when precipitation is abundant during heading, fusarium head blight can cause significant qualitative and quantitative yield losses, especially in seed production systems. (Table 14).

Table 14. Economic efficiency//Eficiența economică

Nr.	Variant	Yield increase over the control (kg/ha)	Value (lei)	Expenses/ha (lei)	Profit/ha (lei)
1	tillering	750	900	312	588
2	tillering+booting	1047	1256,4	624	632,4
3	tillering+heading	625	750	624	126
4	Tillering+booting+heading	969	1162,8	936	226,8
5	booting	860	1031,4	312	719,4
6	booting+heading	844	1012,5	624	388,5
7	heading	94	112,2	312	-199,8
	Whweat cost - Prețul grâului din 2024 (lei/kg)			1,2	RON
	Treatement expences - Cheltuieli cu aplicarea tratamentelor (lei/ha)			120	RON
	Fungicide - Fungicid Ortiva Top 0,6l/ha (lei/ha)			192	RON

CONCLUSION

Timing of fungicide application has a decisive impact on both disease control and yield performance in wheat. The application of treatments in multiple phenological stages, particularly tillering + booting + heading, significantly reduced the severity of foliar pathogens such as *Septoria tritici*, *Puccinia spp.*, and *Erysiphe graminis*.

The tillering + booting treatment combination proved to be the most economically efficient, offering both high disease suppression and a 19% yield increase over the untreated control. It generated a profit of 632.4 RON/ha, second only to the booting-only treatment (719.4 RON/ha).

Treatments applied only at heading were the least effective in disease control and did not result in a profitable yield under the climatic conditions of the 2023–2024 growing season, showing a negative economic return.

Regarding grain quality, early and combined applications positively influenced key traits:

- Protein content was significantly increased in the tillering and tillering + booting variants.
- Gluten content reached its highest levels in the tillering + booting combination (26.68%), with other early treatments also showing strong improvements.
- The sedimentation index peaked in the tillering + booting variant (49.78), confirming improved baking quality.

- Hectoliter weight was highest (76.23 kg/hl) in the variant with three treatments, indicating improved grain density.

Statistical analyses (ANOVA and Duncan's test) confirmed the significance of treatment timing, with booting-inclusive variants forming a distinct group with the highest yields and quality parameters.

In years with low fusarium pressure, treatments at heading alone are not justified economically. However, in wetter years, especially during heading, Fusarium head blight risks may shift the optimal timing, necessitating site- and season-specific strategies.

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COMPARATIVE ANALYSIS OF SOME CORN HYBRIDS BASED ON PROTEIN AND OIL CONTENT

ANALIZA COMPARATIVĂ A UNOR HIBRIZI DE PORUMB PE BAZA CONȚINUTULUI DE PROTEINĂ ȘI ULEI

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Abstract
Fifteen corn hybrids, created within NARDI Fundulea, were tested in comparative crops, under specific climate and soil conditions within ARDS Lovrin, agricultural year 2023 - 2024. Based on a common technology, fertilization was differentiated into a fertilized and an unfertilized version. The quality indices represented by protein (Pro, %) and oil (Oil, %) were analyzed comparatively. In the unfertilized version, the protein content varied between 7.93% (hybrid 8029) and 10.63% (hybrid 8034), and the oil content varied between 5.10% (hybrid 8021) and 6.10% (hybrid 8031). On the fertilized variant, protein values between 7.63% (hybrid 8032) and 10.13% (hybrid 8034) were recorded, and oil content values between 4.93% (hybrid 8026) and 6.37% (hybrid 8023). Hybrids were identified that showed statistically significant differences in protein and oil content within each fertilization variant. The average values of protein content ($\overline{\mathrm{Pro}}$) between the two variants (fertilized / unfertilized) showed statistically significant differences (p = 0.0126). The average oil content ($\overline{\mathrm{Oil}}$) between the two fertilization options did not shown statistical significance (p = 0.651). Cluster analysis facilitated the grouping of hybrids based on similarity in protein and oil content, for each fertilized variant.

Abstract
Cincisprezece hibrizi de porumb, creați în cadrul INCDA Fundulea, au fost testați in culturi comparative, în condițiile specifice de climă și sol in cadrul SCDA Lovrin, anul agricol 2023 – 2024. Pe fondul unei tehnologii comune, a fost diferentiata fertilizarea, în variantă fertilizată și variantă nefertilizată. Indicii de calitate reprezentați de proteină (Pro, %) și ulei (Oil, %) au fost analizati comparativ. Pe varianta nefertilizată, conținutul de proteină a variat intre 7.93% (hibridul 8029) și 10.63% (hibridul 8034), iar conținutul de ulei a variat între 5.10% (hibridul 8021) și 6.10% (hibridul 8031). Pe varianta fertilizată, s-au inregistrat valori ale proteinei între 7.63% (hibridul 8032) și 10.13% (hibridul 8034), și valori ale conținutul de ulei între 4.93% (hibridul 8026) și 6.37% (hibridul 8023). Au fost identificați hibrizi care au prezentat diferențe ăn conditii de siguranța statistică pentru conținutul de proteină și ulei, in cadrul fiecărei variante de fertilizare. Valorile medii ale conținutului de proteina ($\overline{\mathrm{Pro}}$) dintre cele două variante (fertilizat / nefertilizat) au prezentat diferențe cu siguranță statistică (p = 0.0126). Media conținutului de ulei ($\overline{\mathrm{Oil}}$) dintre cele două variante de fertilizare, nu a prezentat siguranță statistică (p = 0.651). Analiza clusterială a facilitat gruparea hibrizilor pe bază de similaritate pentru conținutul de proteină și ulei, pe fiecare variantă de fertilizare.

Keywords: *corn hybrids, protein, oil, comparative analysis, fertilization*
Cuvinte cheie: *hibrizi porumb, proteină, ulei, analiză comparativă, fertilizare*

INTRODUCTION

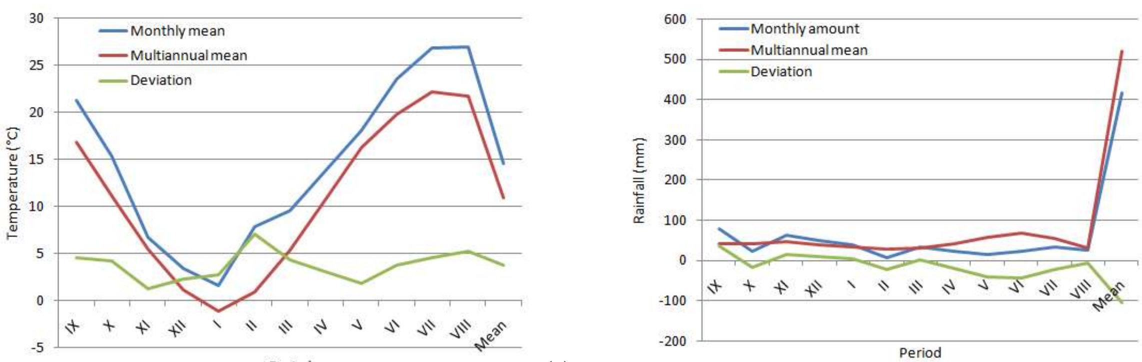
Agricultural crops provide various resources for human food, animal feed, and raw materials for various industries (Fuglie et al., 2021; Feng et al., 2023; Knorr and Augustin, 2025). Among agricultural crops, corn is a plant with a high share globally, of agronomic, ecological, economic and social importance (Tiammee and Likasiri, 2020; Wang and Hu, 2021; Afshar and Dekamin, 2022). Corn grains have a series of physical, chemical, biochemical indices, with food and feed value, or for industrialization (Paulsen et al., 2019; Song et al., 2023; Sun et al., 2023).

Yield and quality indices in corn varied in relation to genotype, environmental factors (e.g. soil, climate), and crop technology (Jahangirlou et al., 2021; Liu et al., 2023; Liu et al., 2025). Protein content is a relevant indicator for the quality of corn production, in order to support the increasing

demand for protein for human consumption and animal feed (Rouf Shah et al., 2016; Maqbool et al., 2021). Protein is also an important indicator for genetic selection in breeding programs (Maqbool et al., 2021; Amegbor et al., 2022; Lu et al., 2022). Oil content is also an important index for the quality and value of corn production and also in breeding programs (Fang et al., 2021; Zhang et al., 2023). Variation in protein and oil content in corn kernels has been studied in relation to different types of fertilizers and fertilization rates (Wang et al., 2023; Lu et al., 2024; Yin et al., 2025).
This research evaluated the protein and oil content of fifteen corn hybrids grown in fertilized and unfertilized systems, and comparatively analyzed the performance of the hybrids based on the two quality indices.

MATERIAL AND METHODS

The study and field research were carried out within ARDS Lovrin. Fifteen corn hybrids were cultivated, originating from NARDI Fundulea. The field experiments were carried out during 2023 – 2024 agricultural year. The values of the climatic parameters are presented in figure 1.



(a) (b)

Figure 1. Climatic parameter values during the study period; (a) – temperature, (b) – rainfall
Figura 1. Valorile parametrilor climatici pe perioada de studiu; (a) – temperatura, (b) – precipitatii

The comparative crop of corn hybrids was carried out under non-irrigated conditions, on a cambic chernozem soil. The land was prepared in a conventional system. The corn hybrids were cultivated in a fertilized (F) and unfertilized (UF) system. Complex fertilizers (N/P/K - 15/15/15; 300 kg ha^{-1}) and ammonium nitrate (200 kg ha^{-1}) were applied. Sowing was done in early April, at a distance of 70 cm between rows. Pre-emergence herbicide was applied and mechanical and manual weeding (as necessary) was done in the vegetation. According to the source of the biological material, the corn hybrids were assigned numerical codes (8021 to 8035). Each corn hybrid was cultivated in replicates. Grain samples were harvested at physiological maturity (Meier, 2001), and protein (Pro, %) and oil (Oil, %) were analyzed. Statistical analysis of the data was performed in the EXCEL mathematical module and PAST software (Hammer et al., 2001).

RESULTS AND DISCUSSION

The protein (Pro, %) and oil (Oil, %) content were determined in the 15 corn hybrids, in fertilized and unfertilized systems. The recorded values for each corn hybrid in the two fertilization systems, the mean calculated value for each quality index, and the standard error are presented in table 1. The experimental data presented statistical reliability, according to the Anova Test, table 2. The series of mean values presented normal distribution, with r = 0.903 for $Pro_{(F)}$, r = 0.981 for $Oil_{(F)}$, r = 0.933 for $Pro_{(UF)}$, r = 0.981 for $Oil_{(UF)}$, figure 2.

Table 1. Values of protein and oil content in grains of corn hybrids in fertilized and unfertilized systems // *alori ale continutului de proteina si ulei in boabe la hibrizi de porumb in system fertilizat si nefertilizat*

Corn Hybrid	Fertilized		Unfertilized	
	Pro	Oil	Pro	Oil
	(%)			
8021	8.07	5.17	8.40	5.10
8022	8.63	5.10	8.37	5.43
8023	8.77	6.37	8.93	6.10
8024	8.47	5.50	9.40	5.63
8025	8.07	5.13	8.40	5.23
8026	8.67	4.93	9.07	5.13
8027	8.70	5.20	9.33	5.37
8028	8.10	5.33	8.37	5.40
8029	7.83	5.77	7.93	5.80
8030	8.13	5.87	8.33	5.70
8031	8.60	5.60	9.07	5.80
8032	7.63	5.60	8.23	5.67
8033	8.33	5.93	9.17	5.63
8034	10.13	5.80	10.63	6.10
8035	8.37	5.70	9.20	5.63
Mean	8.43	5.53	8.86	5.58
SE	±0.15	±0.10	±0.17	±0.08

Table 2. ANOVA Test results // *Rezultatle Testului ANOVA*

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	432.8029	3	144.2676	402.2870	1.64E-78	5.6639
Within Groups	63.1169	176	0.3586			
Total	495.9198	179				

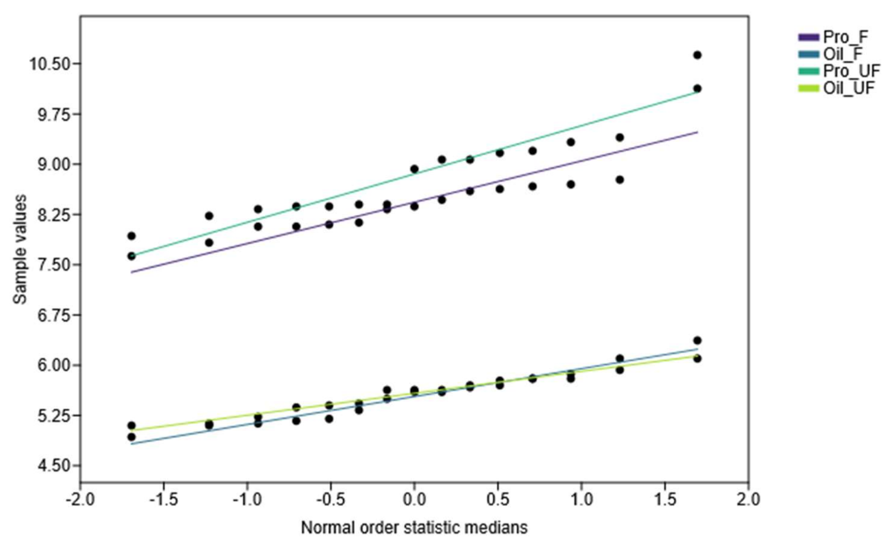


Figure 2. Probability plot for data series // *Probabilitatea de distributie a seriilor de date*

The mean values of the quality indices, in the fertilized / unfertilized system, were analyzed comparatively. The mean protein content in the fertilized system was $\overline{\text{Pro}}_{(F)}$ = 8.43±0.15%, and in the unfertilized system was $\overline{\text{Pro}}_{(UF)}$ = 8.86±0.17%, with a statistically significant difference at the p = 0.0126 level. The mean oil content in the fertilized system was $\overline{\mathrm{Oil}}_{(F)}$ = 5.53±0.10%, and in the unfertilized system was $\overline{\mathrm{Oil}}_{(UF)}$ = 5.58±0.08%, with a difference without statistical significance, p = 0.651. Within each fertilization system, each hybrid was analyzed in comparison to the mean of the hybrid group. The results for protein are presented in table 3, and the results for oil content are presented in table 4.

Table 3. Differences in protein content in corn hybrids compared to the mean value of the fertilization system // *Diferentele continutului de proteina la hibrizii de porumb fata de valoarea medie a sistemului de fertilizare*

Corn hybrid	Protein (%)		Statistical Parameters				
	Given mean	Sample mean:	95% conf. interval:	Difference:	95% conf. interval:	t:	p (same mean):
	Fertilized System						
8021	8.07			-0.36^{O}	(0.043215 0.68345)	2.4343	0.029
8022	8.63			0.20^{ns}	(-0.12345 0.51678)	-1.3177	0.209
8023	8.77			0.34*	(0.016548 0.65678)	-2.2557	0.041
8024	8.47			0.04^{ns}	(-0.28345 0.35678)	-0.2457	0.810
8025	8.07			-0.36^{O}	(0.043215 0.68345)	2.4343	0.029
8026	8.67			0.24^{ns}	(-0.083452 0.55678)	-1.5857	0.135
8027	8.70			0.27^{ns}	(-0.053452 0.58678)	-1.7867	0.096
8028	8.10	8.43	(8.1132 8.7535)	-0.33^{O}	(0.013215 0.65345)	2.2333	0.042
8029	7.83			-0.60^{OO}	(0.28322 0.92345)	4.0423	0.001
8030	8.13			-0.30^{O}	(-0.016785 0.62345)	2.0323	0.062
8031	8.60			0.17^{ns}	(-0.15345 0.48678)	-1.1167	0.283
8032	7.63			-0.80^{OOO}	(0.48322 1.1235)	5.3823	<0.001
8033	8.33			-0.10^{ns}	(-0.21678 0.42345)	0.6923	0.500
8034	10.13			1.70***	(1.3765 2.0168)	-11.3680	<0.001
8035	8.37			-0.06^{ns}	(-0.25678 0.38345)	0.4243	0.678
	Unfertilized System						
8021	8.40			-0.46^{O}	(0.081027 0.82964)	2.6091	0.021
8022	8.37			-0.49^{O}	(0.11103 0.85964)	2.7810	0.015
8023	8.93			0.07^{ns}	(-0.29964 0.44897)	-0.4278	0.675
8024	9.40			0.54**	(0.17036 0.91897)	-3.1210	0.008
8025	8.40			-0.46^{O}	(0.081027 0.82964)	2.6091	0.021
8026	9.07			0.21^{ns}	(-0.15964 0.58897)	-1.2300	0.239
8027	9.33			0.47*	(0.10036 0.84897)	-2.7199	0.017
8028	8.37	8.86	(8.481 9.2296)	-0.49^{O}	(0.11103 0.85964)	2.7810	0.015
8029	7.93			-0.93^{OOO}	(0.55103 1.2996)	5.3022	<0.001
8030	8.33			-0.53^{OO}	(0.15103 0.89964)	3.0102	0.009
8031	9.07			0.21^{ns}	(-0.15964 0.58897)	-1.2300	0.239
8032	8.23			-0.63^{OO}	(0.25103 0.99964)	3.5832	0.003
8033	9.17			0.31^{ns}	(-0.05964 0.68897)	-1.8030	0.093
8034	10.63			1.77***	(1.4004 2.149)	-10.1690	<0.001
8035	9.20			0.34^{ns}	(-0.02964 0.71897)	-1.9749	0.068

Table 4. Differences in oil content in corn hybrids compared to the average value of the fertilization system // *Diferentele continutului de ulei la hibrizii de porumb fata de valoarea medie a sistemului de fertilizare*

Corn hybrid	Oil (%)		Statistical Parameters				
	Given mean:	Sample mean:	95% conf. interval:	Difference:	95% conf. interval:	t:	p (same mean):
	Fertilized System						
8021	5.17			-0.36^{OO}	(0.1471 0.57957)	3.6038	0.003
8022	5.10	5.53	(5.3171 5.7496)	-0.43^{OO}	(0.2171 0.64957)	4.2981	0.001
8023	6.37			0.84***	(0.62043 1.0529)	-8.2987	<0.001

Corn hybrid	Oil (%)		Statistical Parameters				
	Given mean:	Sample mean:	95% conf. interval:	Difference:	95% conf. interval:	t:	p (same mean):
8024	5.50			-0.03ns	(-0.1829 0.24957)	0.3306	0.746
8025	5.13			-0.40^{OO}	(0.1871 0.61957)	4.0006	0.001
8026	4.93			-0.60^{OOO}	(0.3871 0.81957)	5.9843	<0.001
8027	5.20			-0.33^{OO}	(0.1171 0.54957)	3.3063	0.005
8028	5.33			-0.20^{ns}	(-0.012901 0.41957)	2.0168	0.063
8029	5.77			0.24*	(0.020432 0.4529)	-2.3474	0.034
8030	5.87			0.34**	(0.12043 0.5529)	-3.3393	0.005
8031	5.60			0.07^{ns}	(-0.14957 0.2829)	-0.6613	0.519
8032	5.60			0.07^{ns}	(-0.14957 0.2829)	-0.6613	0.519
8033	5.93			0.40**	(0.18043 0.6129)	-3.9344	0.001
8034	5.80			0.27*	(0.050432 0.4829)	-2.6450	0.019
8035	5.70			0.17^{ns}	(-0.049568 0.3829)	-1.6531	0.121
	Unfertilized System						
8021	5.10			-0.48^{OOO}	(0.31116 0.6515)	6.0666	<0.001
8022	5.43			-0.15^{ns}	(-0.018838 0.3215)	1.9074	0.077
8023	6.10			0.52***	(0.3485 0.68884)	-6.5371	<0.001
8024	5.63			0.05^{ns}	(-0.1215 0.21884)	-0.6134	0.549
8025	5.23			-0.35^{OO}	(0.18116 0.5215)	4.4281	0.001
8026	5.13			-0.45^{OOO}	(0.28116 0.6215)	5.6885	<0.001
8027	5.37			-0.21^{O}	(0.041162 0.3815)	2.6636	0.019
8028	5.40	5.58	(5.4112 5.7515)	-0.18^{O}	(0.011162 0.3515)	2.2855	0.038
8029	5.80			0.22*	(0.048496 0.38884)	-2.7560	0.015
8030	5.70			0.12^{ns}	(-0.051504 0.28884)	-1.4956	0.157
8031	5.80			0.22*	(0.048496 0.38884)	-2.7560	0.015
8032	5.67			0.09^{ns}	(-0.081504 0.25884)	-1.1175	0.283
8033	5.63			0.05^{ns}	(-0.1215 0.21884)	-0.6134	0.549
8034	6.10			0.52***	(0.3485 0.68884)	-6.5371	<0.001
8035	5.63			0.05^{ns}	(-0.1215 0.21884)	-0.6134	0.549

For protein content (Pro, %), in the case of the fertilized system, two corn hybrids presented valuesabove the mean, in conditions of statistical safety, respectively hybrid 8023 ($p<0.05$, *) and hybrid 8034 $p<0.001$, ***). Six hybrids presented negative differences from the mean value, in conditions of statistical safety, respectively hybrids 8021, 8025, 8028 and 8030 ($p<0.05$, ^{O}), hybrid 8029 ($p<0.01$, ^{OO}), and hybrid 8032 ($p<0.001$, ^{OOO}). The other hybrids presented differences (positive or negative) from the mean, without statistical safety. Within the unfertilized system, three hybrids presented positive differences from the mean value, in conditions of statistical safety, respectively hybrid 8027 ($p<0.05$, *), hybrid 8024 ($p<0.01$, **) and hybrid 8034 ($p<0.001$, ***). Seven hybrids presented negative differences from the mean value, in conditions of statistical safety, namely hybrids 8021, 8022, 8025, 8028 ($p<0.05$, ^{O}), hybrids 8030 and 8032 ($p<0.01$, ^{OO}), and hybrid 8029 ($p<0.001$, ^{OOO}). The other hybrids showed differences from the mean value, without statistical safety. The graphic presentation of the protein content values in relation to the mean values on fertilization systems is given in figure 3.

Figure 3. Graphical representation of protein content compared to the mean value, by fertilization systems // *Reprezentarea grafică a conținutului de proteină față de valoarea medie, pe sisteme de fertilizare*

For oil content (Oil, %), in the case of the fertilized system, five hybrids showed positive differences from the mean value with statistical safety, respectively hybrids 8029 and 8034 ($p<0.05$, *), hybrids 8030 and 8033 ($p<0.01$, **), respectively hybrid 8023 ($p<0.001$, ***). Five hybrids showed negative differences, respectively hybrids 8021, 8022, 8025 and 8027 ($p<0.01$, ^{OO}) and hybrid 8026 ($p<0.001$, ^{OOO}). The other hybrids showed differences without statistical safety.

In the case of the unfertilized system, five hybrids showed positive differences, with statistical safety, respectively hybrids 8029 and 8031 ($p<0.05$, *), and hybrids 8023 and 8034 ($p<0.001$, ***). Five hybrids showed negative differences with statistical safety, respectively hybrids 8027 and 8028 ($p<0.05$, ^{O}), hybrid 8025 ($p<0.01$, ^{OO}), and the hybrids 8021 and 8026 ($p<0.001$, ^{OOO}). The other hybrids showed differences without statistical safety. The graphic presentation of the oil content values in relation to the mean values on fertilization systems is given in figure 4.

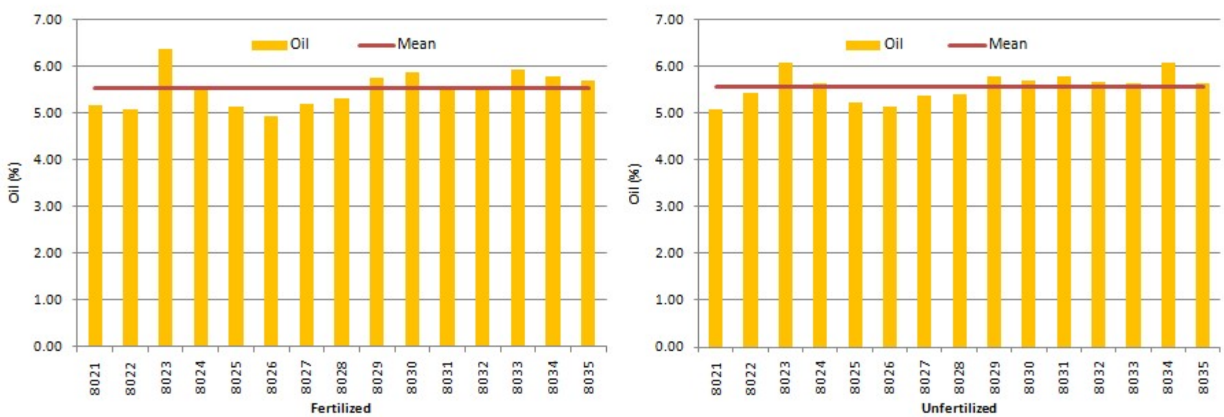


Figure 4. Graphical representation of oil content compared to the mean value, on fertilization systems // *Reprezentarea grafică a conținutului de ulei față de valoarea medie, pe sisteme de fertilizare*

The multivariate analysis led to the PCA diagram, figure 5, in which the corn hybrids were distributed differently in relation to quality parameters. There were corn hybrids positioned correlated with protein, or with oil, and hybrids with independent positioning. The cluster analysis led to the dendrogram in figure 6 (Coph.corr. = 0.865). Two distinct clusters were found that include the corn hybrids.

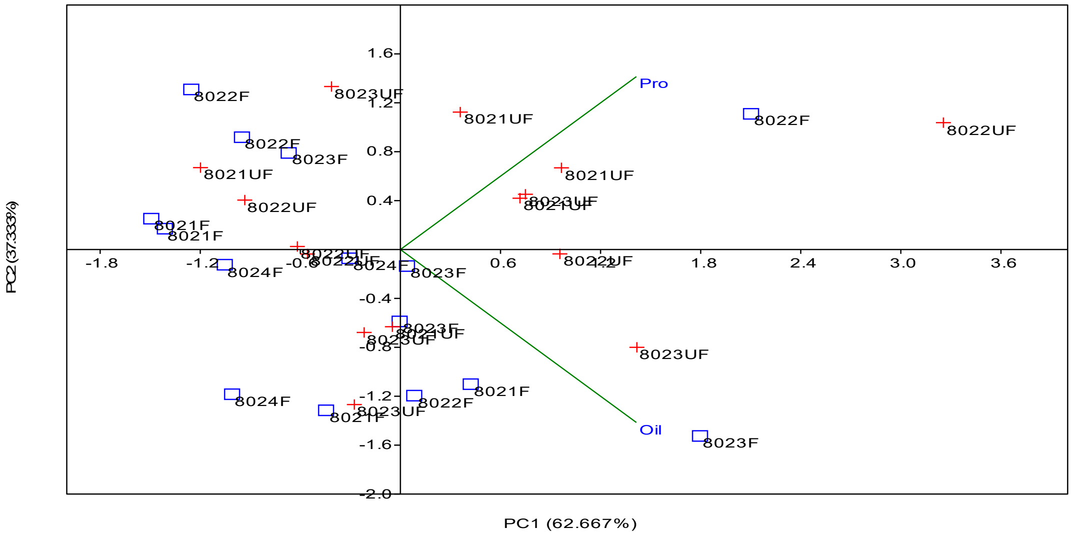


Figure 5. PCA diagram with the distribution of corn hybrids in relation to quality parameters (blue color – fertilized system; red color – unfertilized system) // *Figura 5. Diagrama PCA cu distributia hibrizilor de porumb în raport cu parametri de calitate (culoare albastra – sistem fertilizat; culoare roșie – sistem nefertilizat)*

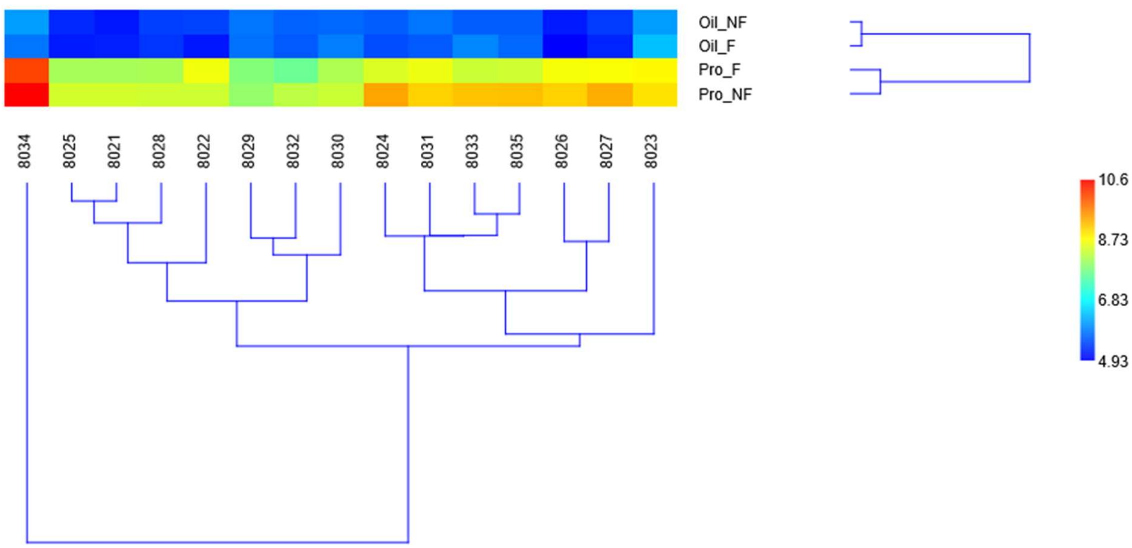


Figure 6. Cluster diagram based on Euclidean distances // *Diagrama cluster pe baza distantelor Euclidiene*

Cluster C1 included hybrid 8034 which showed advantage for protein content in both crop systems (fertilized/unfertilized). The other hybrids were positioned in cluster C2, with several subclusters, in which hybrids were associated based on similarity.

The highest level of similarity was recorded between hybrids 8021 and 8025 (SDI = 0.136). The SDI values for all maize hybrids tested in the two cropping systems (fertilized / unfertilized) in relation to determined quality parameters are presented in Table 5.

Table 5. SDI values for corn hybrids // *Valorile SDI pentru hibrizii de porumb*

	8021	8022	8023	8024	8025	8026	8027	8028	8029	8030	8031	8032	8033	8034	8035
8021		0.654	1.792	1.245	0.136	0.931	1.156	0.343	1.062	0.927	1.185	0.856	1.232	3.258	1.137
8022	0.654		1.548	1.134	0.596	0.781	0.970	0.579	1.191	0.958	0.937	1.152	1.208	2.880	1.075
8023	1.792	1.548		1.135	1.751	1.745	1.438	1.528	1.528	1.086	0.855	1.602	0.816	2.250	0.950
8024	1.245	1.134	1.135		1.207	0.851	0.464	1.131	1.635	1.184	0.406	1.444	0.507	2.140	0.300
8025	0.136	0.596	1.751	1.207		0.927	1.134	0.266	1.006	0.881	1.129	0.798	1.209	3.228	1.102
8026	0.931	0.781	1.745	0.851	0.927		0.446	1.024	1.778	1.431	0.950	1.590	1.173	2.503	0.975

	8021	8022	8023	8024	8025	8026	8027	8028	8029	8030	8031	8032	8033	8034	8035
8027	1.156	0.970	1.438	0.464	1.134	0.446		1.140	1.796	1.372	0.650	1.614	0.873	2.151	0.666
8028	0.343	0.579	1.528	1.131	0.266	1.024	1.140		0.787	0.620	0.986	0.622	1.052	3.153	0.975
8029	1.062	1.191	1.528	1.635	1.006	1.778	1.796	0.787		0.520	1.386	0.419	1.357	3.560	1.392
8030	0.927	0.958	1.086	1.184	0.881	1.431	1.372	0.620	0.520		0.923	0.578	0.868	3.075	0.921
8031	1.185	0.937	0.855	0.406	1.129	0.950	0.650	0.986	1.386	0.923		1.290	0.470	2.215	0.330
8032	0.856	1.152	1.602	1.444	0.798	1.590	1.614	0.622	0.419	0.578	1.290		1.218	3.498	1.225
8033	1.232	1.208	0.816	0.507	1.209	1.173	0.873	1.052	1.357	0.868	0.470	1.218		2.368	0.235
8034	3.258	2.880	2.250	2.140	3.228	2.503	2.151	3.153	3.560	3.075	2.215	3.498	2.368		2.318
8035	1.137	1.075	0.950	0.300	1.102	0.975	0.666	0.975	1.392	0.921	0.330	1.225	0.235	2.318	

A ranking of corn hybrids was generated based on protein and oil content values, in a fertilized system, figure 7 (a) and in an unfertilized system, figure 7 (b).

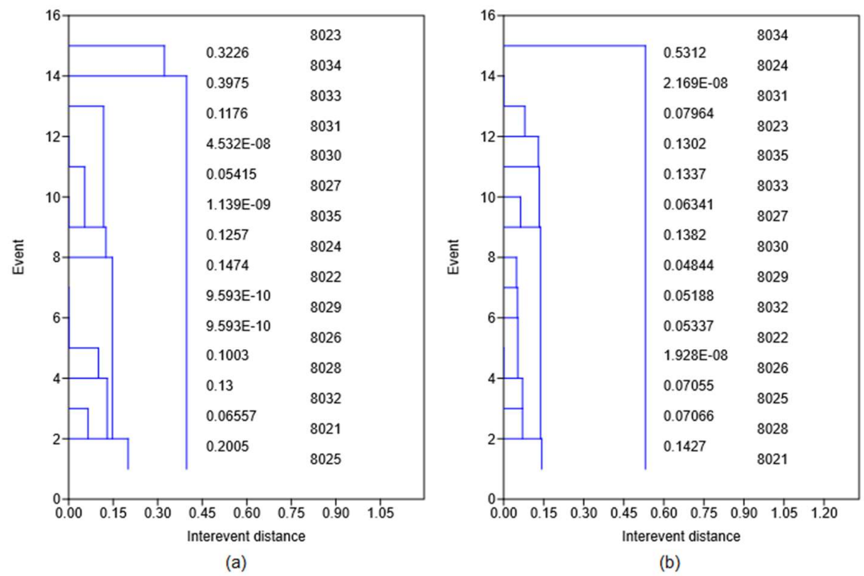


Figura 7. Ranking of corn hybrids// *Ierarhizarea hibrizilor de porumb*

The variation of yield and quality indices in corn were analyzed in relation to different fertilizers, to improve crop technologies and optimize yields (Boldea and Sala, 2011; Abdo et al., 2022; Lu et al., 2024; Ojeniyi et al., 2024).

The genetic potential of corn hybrids for protein and oil was analyzed under different technology and environmental factors to select and promote high-performing genotypes for breeding programs and specific crop conditions (Amegbor et al., 2022; Liu et al., 2023; Zhang et al., 2023).

Under the specific conditions of the present study, valuable data were recorded regarding protein and oil production in corn hybrids in comparative crops.

CONCLUSIONS

1. Corn hybrids grown in a fertilized system (N-15/P-15/K-15 complex fertilizer, ammonium nitrate) and in an unfertilized system responded differently in the accumulation of protein and oil in corn kernels, in relation to the genetic potential and the complex response to the "genotype x environment x technology" interaction.
2. Under the study conditions, the mean protein content in the fertilized system was $\overline{Pro}_{(F)}$ = 8.43±0.15%, and in the unfertilized system was $\overline{Pro}_{(UF)}$ = 8.86±0.17%, with a statistically significant difference, at the p = 0.0126 level. The mean oil content in the fertilized system was $\overline{Oil}_{(F)}$ = 5.53±0.10%, and in the unfertilized system was $\overline{Oil}_{(UF)}$ = 5.58±0.08%, without

statistically significance, p = 0.651.

3. For protein content (Pro, %), in the fertilized system, two corn hybrids presented values above the mean, in statistical safety conditions, respectively hybrid 8023 (p<0.05, *) and hybrid 8034 p<0.001, ***). In the unfertilized system, three hybrids presented positive differences from the mean value, in statistical safety conditions, respectively hybrid 8027 (p<0.05, *), hybrid 8024 (p<0.01, **) and hybrid 8034 (p<0.001, ***).
4. For oil content (Oil, %), in the fertilized system, five hybrids showed positive differences from the mean value, with statistical safety, respectively hybrids 8029 and 8034 (p<0.05, *), hybrids 8030 and 8033 (p<0.01, **), respectively hybrid 8023 (p<0.001, ***). In the unfertilized system, five hybrids showed positive differences, with statistical safety, respectively hybrids 8029 and 8031 (p<0.05, *), and hybrids 8023 and 8034 (p<0.001, ***).
5. The 8034 corn hybrid was noted for its high protein content and statistically significant differences in both, fertilized and unfertilized systems. The 8023 corn hybrid was noted for its high oil content and statistically significant differences in both, fertilized and unfertilized systems. These hybrids showed high genetic stability for the two quality indices in the study conditions.

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THE IMPACT OF YELLOW RUST ATTACK (*PUCCINIA STRIIFORMIS* F. SP.*TRITICI*) ON THE QUALITY INDICES OF TRITICALE GRAINS (*TRITICOSECALE* WITTMACK)

IMPACTUL ATACULUI DE RUGINĂ GALBENĂ (PUCCINIA STRIIFORMIS F. SP.TRITICI) ASUPRA INDICILOR DE CALITATE A BOABELOR DE TRITICALE (*TRITICOSECALE* WITTMACK)

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Abstract

Triticale is a nearlyy creted genus as the result of human crossbreeding between the species Triticum aestivum and Secale cereale. It has inherited the high production capacity and high protein content from wheat, and from rye it has a high lysine content and high resistance to biotic and abiotic stress factors. Due to these properties, it is used in a variety of fields such as: the baking and biscuit industries, beer production, fish nutrition, the pulp industry, human medicine, animal feed in different forms (concentrated feed, straw, silage, grazing), bioethanol production, and in the manufacture of food packaging. Through the improvement of this species, the dominant genes are those of wheat, and thus it has started to show a reduced resistance to pathogen attacks, including the attack of yellow rust.

At A.R.D.S. Livada, during complex ecological testing on triticale, 15 triticale varieties were evaluated in comparative crops during the 2023-2024 period, with an emphasis on the degree of attack on the quality indices of the grains.

In 2021 and 2022, the attack of yellow rust was nonexistent or almost nonexistent, but as the temperatures during the winter period increased, with positive monthly temperature averages, yellow rust showed a strong attack early in the spring, almost completely compromising the crop. The degree of attack by yellow rust ranged between 10% and 75%. The most resistant triticale variety was Zaraza, which, even under climatic conditions that favored the intense manifestation of yellow rust, demonstrated good genetic resistance (GA 10%), leading to a hectoliter weight of 70 kg/hl and a thousand grain weight of 46.8 g. The hectoliter weight for the other 14 varieties ranged between 43 and 61 kg/hl, and the thousand grain weight varied between 24 and 34 g.

Rezumat

Triticalele sunt rezultatul încrucișării de către om dintre genurile Triticum aestivum și Secale cereale. Acestea au preluat de la grâu capacitatea ridicată de producție și conținutul ridicat în proteină, iar de la secară conținut ridicat în lizină și o rezistență ridicată la factorii de stres biotici și abiotici. Datorită acestor proprietăți se utilizează într-o multitudine de domenii precum: industria de panificație și a biscuiților, a berii, in nutriția peștilor, industria celulozei, în medicină umană, hrana animalelor sub diferite forme (furaj concentrat, paie, siloz, pășunat), industria bioetanolului și în fabricarea ambalajelor alimentare. Prin ameliorarea acestei specii genele dominante sunt cele ale grâului și astfel au început să manifeste o rezistență mai mică la atacul agenților patogeni, inclusiv la atacul de rugină galbenă.

La S.C.D.A. Livada, în cadrul testărilor ecologice complexe la triticale, s-au luat în evidență 15 soiuri de triticale testate în culturi comparative în perioada 2023-2024 și evidențierea gradului de atac asupra indicilor de calitate a boabelor.

In 2021 și 2022, atacul de rugină galbenă a fost inexistent sau aproape inexistent, dar odată cu creșterea temperaturilor din perioada iernii, când media temperaturilor lunare a fost pozitivă, rugina galbenă a manifestat un atac puternic primăvara devreme, ajungând să compromită aproape în totalitate această cultură. Gradul de atac la rugina galbenă a fost între 10 și 76%. Cel mai rezistent soi de triticale a fost soiul Zaraza, care și în conditiile climatice care au favorizat manifestarea intensă a atacului de rugină galbenă, a confirmat o bună rezistență genetică (GA 10%) rezistență care a dus la înregistrare unei mase hectolitrice de 70 kg/hl și masa a o mie de boabe de 46,8 g. Masa hectolitrica la cele 14 soiuri a fost cuprinsă între 41 si 61 kg/hl iar masa a o mie de boabe între 24 și 34 g.

Key words: *attack, yellow rust, hectoliter weight, resistence, triticale.*
Cuvinte cheie: *atac, rugină galben, masă hectolitrică, rezistență, triticale.*

INTRODUCTION

Triticale was first developed in 1875 through artificial hybridization between wheat (*Triticum aestivum*) and rye (*Secale cereale*), with the objective of combining the most advantageous agronomic traits of both parental species (McGoverin et al., 2011), namely high productivity and enhanced resistance to extreme environmental conditions (Zhu, 2018). Due to its favorable agronomic characteristics, triticale can be successfully cultivated on marginal lands characterized by low fertility and high acidity (Çiftci et al., 2003).

From a chemical composition standpoint, triticale grains present intermediate values between those of wheat and rye. A limiting factor for its use in the baking industry is the relatively low content of the essential amino acid lysine. Reported protein contents in triticale grains vary considerably among studies, ranging from 12% to 22% (Lorenz and Pomeranz, 1974). Other sources report an average protein content of 11.7%, with 66.5% starch and 4.6% crude sugars (Petterson and Aman, 1987), while additional studies indicate protein contents between 11.4% and 14.0%, and lysine levels between 0.33% and 0.71% (Fras et al., 2016). According to Sehgal (1983), who conducted comparative analyses on several triticale and wheat cultivars, the mean protein content was found to be 13.1%.

Given these compositional attributes, triticale flour is suitable for certain applications in the baking industry, particularly in the production of biscuits (Perez et al., 2003; Leon et al., 1996). Although its primary historical use has been as feed for livestock—especially poultry and swine—this application remains predominant today, with triticale being recognized as a valuable feed grain (Gaviley et al., 2024). Furthermore, triticale has been integrated into various industrial sectors, including brewing (Glatthar et al., 2003; Ambriez-Vidal et al., 2019), pulp and paper production (Tarres et al., 2017), and bioethanol manufacturing (Pejin et al., 2011; García-Aparicio et al., 2010).

Recent investigations have also demonstrated the potential of triticale in human health applications, highlighting its anti-inflammatory properties and cholesterol-lowering effects, attributed to its high content of lunasin (Nakurte et al., 2012), as well as its immunostimulatory activity (Jańczak-Pieniążek et al., 2023). Additionally, when it is cultivated in mixtures with other forage species, triticale can serve as a valuable pasture component (Baron et al., 2015). Due to its compositional similarity to wheat, it is also utilized in aquaculture nutrition (Dawood et al., 2020; Hughes, 1990).

Given its broad spectrum of uses, the global cultivated area of triticale in 2023 exceeded 3.5 million hectares, according to data from the Food and Agriculture Organization (FAO). Poland was the leading producer with 1.2 million hectares, followed by Belarus (442 thousand ha), France (326 thousand ha), and Germany (311 thousand ha). In Romania, the cultivated area reached 59,460 hectares in the same year (FAO, 2023).

Triticale has historically been recognized for its resistance to a wide range of phytopathogens, a trait conferred by resistance genes inherited from rye. Initially, the species was intended to act as a genetic bridge for the transfer of rye resistance traits into wheat. Although its reputed resistance has been reevaluated in recent years, triticale generally exhibit a healthier status when compared to their wheat and rye counterparts.

The fungal pathogen *Puccinia striiformis* f. sp. *tritici* was first reported in Australia and became the initial disease to reach epidemic levels in triticale crops (Arseniuk, 1996), particularly affecting regions with colder climates (Zhao et al., 2022). In recent years, several triticale cultivars have also exhibited susceptibility to Blumeria graminis, another pathogen reaching epidemic proportions (Arseniuk and Goral, 2015). Among foliar diseases, yellow rust remains the most significant for triticale, with resistance being largely associated with the rye-derived genomic component (Skowrońska et al., 2020).

MATERAL AND METHOD

The present study was conducted at the Livada Agricultural Research-Development Station and it is part of the complex ecological testing carried at the national level. Fifteen triticale varieties were tested using the randomized block method, in experimental plots of 10 m², with three replications. The varieties used in the experiment were developed by the National Agricultural Research and Development Institute, Fundulea.

The soil type where the experiment was located is a typical preluvosol, characterized by an acidic reaction, with a pH ranging from 5.82 in the arable layer to 6.65 deeper in the soil profile. This type of soil has a low humus content in the arable layer, of 2.82% (Table 1).

Table 1. Soil characteristics from the experimental field in Livada//Caracteristicile de sol din câmpul experimental de la Livada

Specification	UM cm	Ap 0-18	Ao 18–40		AB 40–55	Bt_1w 55–70	Bt_2w 70–110
			20-30	30-40		55–70	80–95
Humus (C x 1.72)	%	2.82	1.44	0.90	0.90	0.84	3.24
N total	%	0.168	0.102	0.072	0.068	0.064	-
C:N	-	8.21	9.15	10.14	10.34	10.57	-
pH in water	-	5.19	6.24	6.65	6.53	5.62	5.28
Clay (<0.002 mm)	%g/g	20.9	21.1	23.1	27.0	32.4	33.1
Apparent density	g/cm^3	1.35	1.54	1.49	1.48	-	1.48
Hydraulic Conductivity	mm/h	31.27	5.87	3.11	0.35	-	1.04

In the experiment, no phytosanitary treatments were applied in order to highlight the most resistant and adapted triticale varieties in the north-western part of Romania.

The preceding crop was fodder pea (variety MagistraLiv). After harvesting it in July, a pass was made with a disc harrow to interrupt capillarity and water evaporation from the soil. In September, plowing was performed at a depth of 22-25 cm, followed by another pass with the disc harrow in October. The base fertilization of the soil was carried out using a complex fertilizer of the DAP 18:46:0 type at a dose of 150 kg/ha. Sowing took place on October 9th using the experimental seeder from Wintersteiger (Figure 1).

Figure 1. Sowing with Wintersteiger seeder//Semănatul cu semănătoare Wintersteiger

In the spring, in March, after the elongation of the stem, additional fertilization was carried out with a nitrogen-based fertilizer, Calcium Ammonium Nitrate 27% nitrogen active substance, at a dose of 300 kg/ha. Weed control was performed with the herbicide Sekator Progress OD at a dose of

0.15 l/ha. During the vegetation period, the phytosanitary status of the experimental plots was recorded using the FAO scale from 1 to 9. Harvesting took place in July using the experimental combine from Wintersteiger (Figure 3).

Figure 2. Harvesting with Wintersteiger combine//Recoltarea cu combina Wintersteiger

RESULTS AND DISCUSSIONS

The greatest influence on the attack of yellow rust is the climatic conditions. The increase in average temperatures and the rise in precipitation levels are the predominant factors that favor the establishment of the phytopathogenic agent.

The average temperature during the vegetation period of triticale in the 2023-2024 season was 11.6°C, which is 3.2°C higher than the multi-year average temperature for the same period. The largest difference between the average temperature and the multi-year average was recorded in February, with a 7.4°C difference, where the average temperature in the winter month was 7.5°C. A significant temperature difference was mainly recorded during the winter months, where temperatures were positive: January showed a 3.4°C difference compared to the multi-year average, December had a 2.9°C difference, March had a 4.6°C difference, and July had a 3.9°C difference (Figure 3).

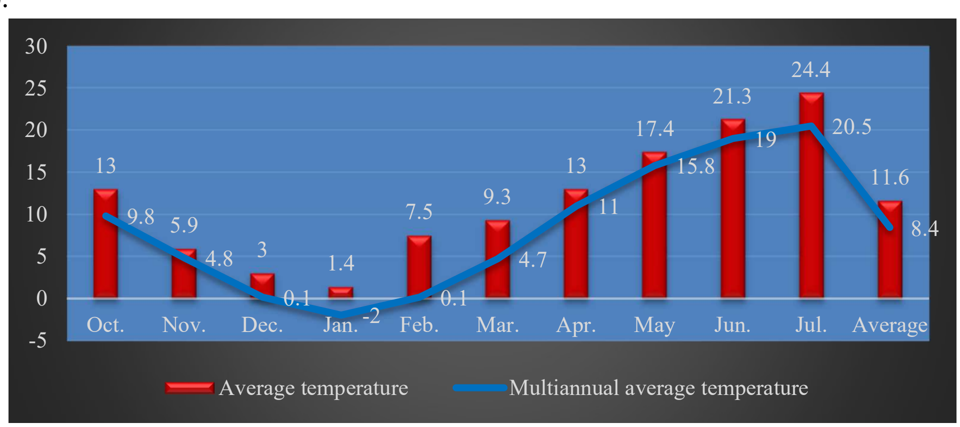

Figure 3. Average temperatures during the vegetation period, 2023-2024//Temperaturi medii în perioada de vegetație, 2023-2024

The total precipitation during the vegetation period of the triticale recorded an excess of 115.7 mm/m² compared to the multi-year average (Figure 4).

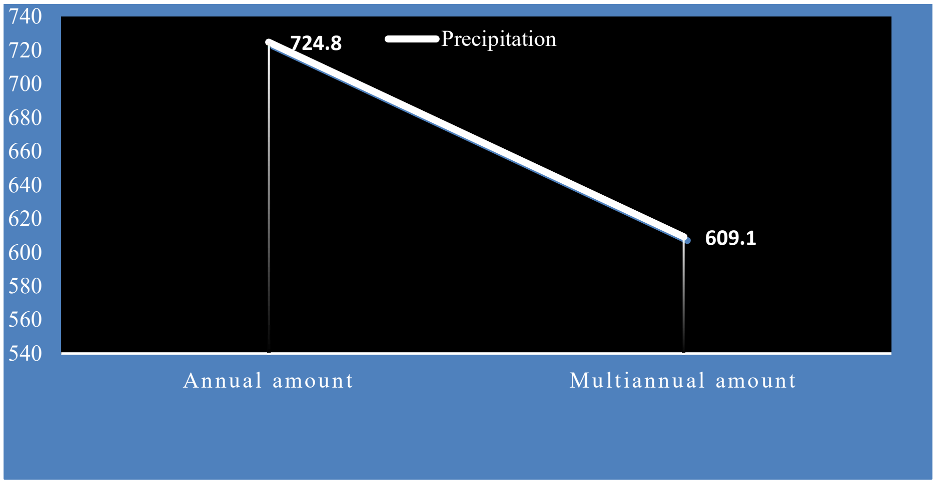

Figure 4. Annual and multi-annual precipitation sum for 2023-2024//Suma anuală și multianuală a precipitațiilor din 2023-2024

The highest precipitation levels were recorded in July (147 mm/m²), November (129 mm/m²), and December (126 mm/m²). In the spring, the values were close to the multi-year averages. The largest deficit occurred in July, with 53.2 mm/m², and in May, with 45.3 mm/m² (Figure5).

The high temperatures during winter, which did not lead to the destruction of pathogens, along with the precipitation and high temperatures in the spring, contributed to the favoring of yellow rust attacks, even on the most resistant plant species.

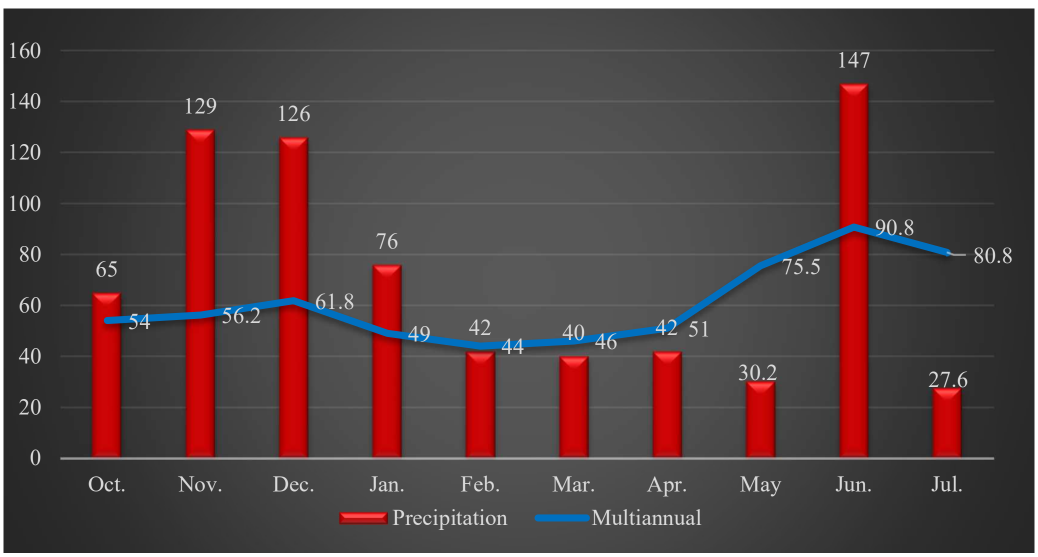

Figure 5. The amount of precipitation during the vegetation period, 2023-2024// Suma de precipitații în perioada de vegetație, 2023-

The results obtained are primarily due to the high level of yellow rust attack on triticale plants (Figure 6). Climatic conditions are the main factor that favored the appearance and massive attack of yellow rust.

In this study, 15 triticale varieties from I.N.C.D.A. Fundulea were tested, and they were cultivated according to the growing technology used in the north-western part of the country. The experiment was set up without phytosanitary treatments to highlight the most resistant and adapted varieties for the reference area. To assess the degree of attack by the main phytopathogenic agents, observations were made during the vegetation period on a scale from 1 to 9, according to FAO standards.

The degree of yellow rust attack ranged from 10% to 76%. Most of the varieties recorded a yellow rust attack level of 76%, meaning that 76% of the total plant area was affected by this pathogen. The control variety (Plai) recorded a 54% attack level, and Negoiu showed a similar level. FDL Ascendent, Pisc, and Tulnic recorded an attack level of 63%. The most resistant to this pathogen attack was the variety Zaraza, which has consistently proven to be the most resistant variety over the years, with an attack level of 10% (Figure 6, 7).

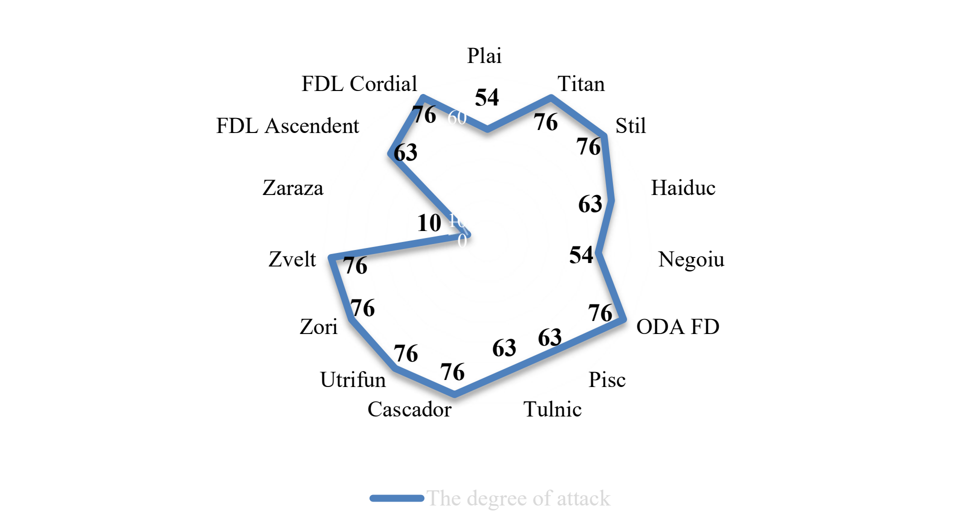

Figure 6. The degree of attack recorded on triticale plants//Gradul de atac înregistrat la nivelul plantelor de triticale

Figure 7. The experiement field//Câmpul experimental

The massive attack of yellow rust was evident in the quality index results. The control variety, which recorded an attack level of 54%, had a TGW (thousand grain weight) of 34.4 g. The varieties that recorded the highest attack levels, such as Titan, Stil, and Haiduc, had a TGW ranging between 25 and 27 g. The lowest TGW value was recorded by Zori, at 24 g. Zaraza, the most resistant variety, recorded a thousand-grain weight of 46.8 g, which is a normal value for cereals where the attack is present to a small extent or when phytosanitary treatments have been applied (Figure 7).

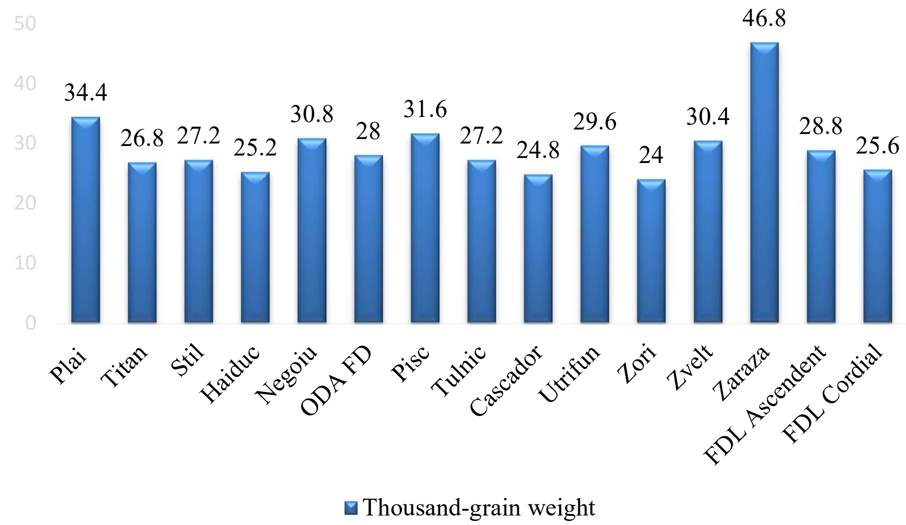

Figure 7. Thousand-grain weight recorder by the 15 varieties//Masa a o mie de boabe înregistrată de cele 15 soiuri

In the experiment, the hectolitric weight ranged between 41 and 70 kg/hl. The control variety, which had 54% of its leaf area attacked by yellow rust, recorded a hectolitric weight of 61.9 kg/hl. For the varieties with the highest attack levels (76%), the hectolitric weight did not exceed 51 kg/hl. The lowest value was recorded by the variety Cascador, with 41.4 kg/hl. Similarly to the thousand-grain weight, the Zaraza variety also recorded the highest hectolitric weight, further demonstrating its resistance (70 kg/hl).

As observed, the degree of attack recorded by the 15 triticale varieties directly influenced the quality index values. Thus, the varieties with the highest degree of attack recorded the lowest values for thousand-grain weight and hectolitric weight (Figure 8).

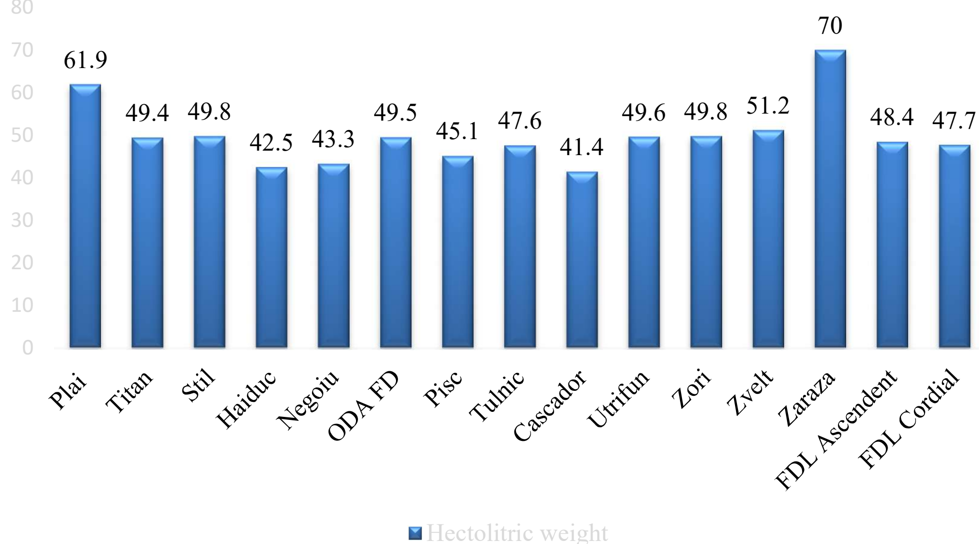

Figure 8. Hectolitric weight recorder by the 15 varieties//Masa hectolitrică înregistrată de cele 15 soiuri

CONCLUSIONS

1. The experiment was part of the national testing plant of varieties and lines aimed at adapting and identifying the most productive varieties in the reference area. No treatments were applied against foliar diseases during these tests. The experiment was conducted on a typical

preluvosol, which has a humus content of 2.82% and an acidic reaction with a pH ranging from 5.59 to 6.65.

2. Out of the 15 varieties tested, 8 recorded an attack level of 76%. The control variety (Plai) along with Negoiu recorded an attack level of 54%. The most resistant variety proved to be Zaraza, with an attack level of only 10%.
3. Of the 15 varieties, 10 recorded a thousand-grain weight (TGW) of less than 30 g. The control variety Plai recorded 34.4 g. Zaraza, the most resistant variety to this pathogen attack, recorded 46.8 g.
4. The hectoliter weight values ranged from 41 to 70 kg/hl. The lowest value was recorded by Cascador, with 41.4 kg/hl, while 13 of the 15 varieties recorded values below 50 kg/hl. The highest value was recorded by Zaraza at 70 kg/hl.
5. The results confirm that recent climate changes, the increase in average monthly temperatures, and the unevenly distributed high levels of precipitation are predominant factors in the installation of the yellow rust pathogen and its the manifestation. This study highlights that the Zaraza variety exhibits high resistance to this pathogen attack, but this could be confirmed in future studies under different climatic conditions.

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SUNFLOWER PRODUCTION IN RELATION TO MORPHOLOGICAL PARAMETERS AND PLANT DENSITY

PRODUCȚIA DE FLOARE-SOARELUI ÎN RAPORT CU PARAMETRII MORFOLOGICI ȘI DENSITATEA PLANTELOR

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Abstract

*This study analyzed the variation of several morphological parameters and yield in sunflower hybrids grown at three planting densities under non-irrigated conditions. The field experiment was conducted at ARDS Lovrin during the 2023–2024 agricultural year. The sunflower hybrids - ES Celion SU (G1), LID 1046H SU (G2), and LID 5053L SU (G3) were cultivated at planting densities of 40,000 (A), 60,000 (B), and 80,000 (C) plants/ha. Morphological parameters, including plant height (PH), stem diameter (SD), and calatidium diameter (CD), along with yield (P), were measured. Polynomial models were used to describe the variation in yield in relation to morphological traits and planting density. Among the morphological parameters, SD and PH showed the highest accuracy in yield estimation (RMSE = 193.2755). When plant density (PD) was included, the combination of PD and SD provided even greater precision (RMSE = 94.0254). Compared to the average yield ($\overline{P}$), certain hybrid × density combinations showed statistically significant yield differences, either positive (e.g., G1C**, p<0.01; G2C*, p<0.05) or negative ($G2A^{OOO}$, p<0.001; $G3A^{OO}$, p<0.01). Principal component analysis (PCA) explained the total variance and illustrated the relationship between biometric parameters, yield, and experimental variants. Cluster analysis grouped variants based on their similarity in achieved yield (Cophenetic corr. = 0.875). These results support the selection of optimal sowing strategies for tested hybrids under non-irrigated conditions to achieve maximum yield.*

Abstract

*Studiul a analizat variația unor parametri morfologici și a producției la hibrizi de floarea-soarelui cultivați la trei densități de semănat, în condiții de neirigare. Experimentul de câmp a fost realizat la SCDA Lovrin, în anul agricol 2023–2024. Hibrizii de floarea-soarelui — ES Celion SU (G1), LID 1046H SU (G2) și LID 5053L SU (G3) — au fost cultivați la densități de plantare de 40.000 (A), 60.000 (B) și 80.000 (C) plante/ha. S-au determinat parametrii morfologici, inclusiv înălțimea plantei (PH), diametrul tulpinii (SD) și diametrul calatidiului (CD), precum și producția (P). Modelele polinomiale au fost utilizate pentru a descrie variația producției în funcție de caracterele morfologice și densitatea plantelor. Dintre parametrii morfologici, SD și PH au oferit cea mai mare precizie în estimarea producției (RMSE = 193.2755). Atunci când a fost inclusă și densitatea plantelor (PD), combinația PD și SD a furnizat o precizie și mai mare (RMSE = 94.0254). Comparativ cu producția medie ($\overline{P}$), anumite combinații hibrid × densitate au prezentat diferențe semnificative statistic, fie pozitive (de exemplu, G1C**, p<0.01; G2C*, p<0.05), fie negative ($G2A^{OOO}$, p<0.001; $G3A^{OO}$, p<0.01). Analiza componentelor principale (PCA) a explicat variația totală și a ilustrat relația dintre parametrii biometrici, producție și variantele experimentale. Analiza cluster a grupat variantele în funcție de similitudinea valorilor producției obținute (Coeficientul cofenetic = 0.875). Rezultatele susțin alegerea strategiilor optime de semănat pentru hibrizii testați, în sistem neirigat, pentru a obține producții maxime.*

Keywords: *plant density, sunflower, models, morphological parameters, production*
Cuvinte cheie: *densitate plante, floarea soarelui, modele, parametri morfologici, producție*

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is a crop of major global importance due to the nutritional value of its seeds and, particularly, as a source of oil (Adeleke et al., 2020; Puttha et al., 2023). Both physiological and agronomic aspects have been studied in relation to sunflower genetics as well as crop management practices (Alberio et al., 2015; Giannini et al., 2022; Lamichhane et al., 2022).
Ecological plasticity in sunflower has been analyzed to understand the response of genotypes to climate and soil conditions, to support hybrid zoning, and to adapt agricultural technologies for achieving high yields (Sadras et al., 2009; Saucă et al., 2018; Debaeke et al., 2021; Bustos-Korts et al., 2022; Aboye and Edo, 2024).

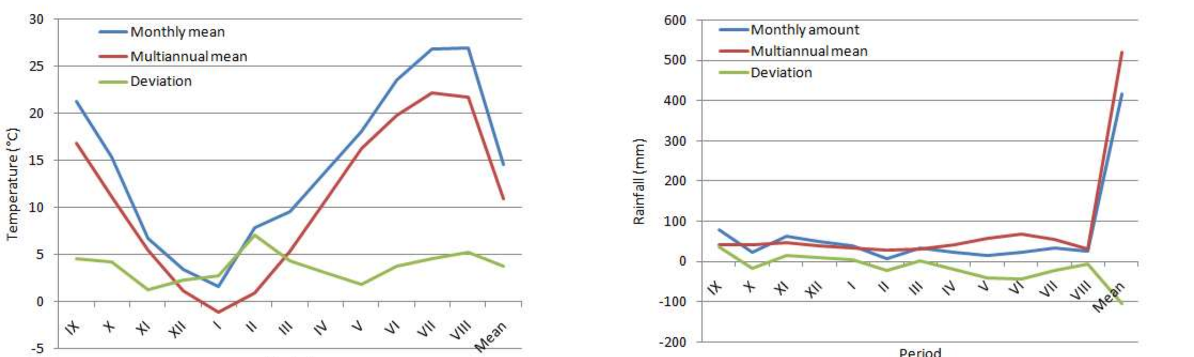
Sunflower yield has been evaluated in relation to cultivated genotypes, environmental factors, and technological inputs (Li et al., 2019; Modanlo et al., 2021; Nagy et al., 2024; Li and Liu, 2025). In the context of climate change, various aspects of sunflower cultivation have been analyzed with regard to their impact on seed yield and quality (Gurkan et al., 2021; Beteri et al., 2024).

Plant density is a key factor influencing sunflower yield and has recently been the focus of intensive study, particularly in the context of technological optimization (Li et al., 2019; Nagy et al., 2024; Olson et al., 2024; Tomasi et al., 2024).

The present study analyzed agronomic parameters and yield variation in three sunflower hybrids under different planting densities. It explored the correlations between yield and agronomic traits and identified yield variation patterns in relation to both planting density and plant morphology.

MATERIAL AND METHODS

The study was conducted in ARDS Lovrin, Timis County, Romania. Field experiments, in comparative culture, were carried out in the agricultural year 2023 - 2024. The values of the climatic conditions are presented in figure 1.



(a) (b)

Figure 1. Climatic conditions during the study period; (a) – temperatue, (b) – rainfall // *Condițiile climatice în perioada de studiu; (a) – temperatura, (b) – precipitatii*

The comparative sunflower trial was conducted under non-irrigated conditions. Appropriate crop technology for sunflower was applied throughout the experiment. The hybrids ES Celion SU (G1 – experimental code), LID 1046H SU (G2), and LID 5053L SU (G3) were cultivated. Each hybrid was grown at three planting densities: 40,000 plants ha^{-1} (A – experimental code), 60,000 plants ha^{-1} (B), and 80,000 plants ha^{-1} (C). The resulting experimental variants were: G1A, G1B, G1C; G2A, G2B, G2C; and G3A, G3B, G3C. Each variant was replicated three times. Agronomic parameters were measured for each variant, including stem diameter (SD, cm), plant height (PH, cm), and calatidium diameter (CD, cm). All experimental variants were harvested mechanically at physiological maturity (Meier, 2001). Yield (Y, kg ha^{-1}) was determined for each variant and replicate. Statistical analysis was conducted using the Excel analysis tools and the PAST software package (Hammer et al., 2001).

RESULTS AND DISCUSSIONS

The values of the agronomic parameters and yield of the sunflower hybrids cultivated at three planting densities are presented in Table 1. The stem diameter (SD) ranged from 7.02 ± 0.32 cm (G3C) to 10.38 ± 0.32 cm (G3A). Plant height (PH) ranged from 116.40 ± 2.72 cm (G3A) to 140.60 ± 2.72 cm (G1C). Calatidium diameter (CD) varied between 13.32 ± 0.77 cm (G3C) and 20.85 ± 0.77 cm (G2A, G2B). Yield (Y) ranged from 1354.29 ± 116.00 kg ha^{-1} (G2A) to 2371.43 ± 116.00 kg ha^{-1} (G1C).

The experimental data demonstrated statistical reliability, and the presence of variance in the recorded values was confirmed (Table 2). The level of correlation between agronomic parameters, yield, and plant density is illustrated in Figure 2.

Table 1. Values of agronomic parameters and yield of sunflower hybrids// V*alori ale parametrilor agronomici şi randamentului la hibrizii de floarea soarelui*

Sunflower hybrid	Trial	PD	Plant parameters			Y
			SD	PH	CD	
		(no)	(cm)	(cm)	(cm)	(kg ha^{-1})
ES Celion SU	G1A	40000	8.74	133.60	17.00	1954.29
ES Celion SU	G1B	60000	8.98	129.60	16.75	2160.00
ES Celion SU	G1C	80000	8.84	140.60	17.10	2371.43
LID 1046H SU	G2A	40000	9.72	131.20	20.85	1354.29
LID 1046H SU	G2B	60000	9.74	132.20	20.85	2051.43
LID 1046H SU	G2C	80000	8.60	130.20	18.60	2262.86
LID 5053L SU	G3A	40000	10.38	116.40	17.90	1508.57
LID 5053L SU	G3B	60000	9.30	117.20	16.65	1851.43
LID 5053L SU	G3C	80000	7.02	137.20	13.32	2240.00

Table 2. ANOVA Test results// *Rezultatele Testului ANOVA*

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	2.55E+10	4	6.37E+09	106.1534	9.65E-21	2.6060
Within Groups	2.4E+09	40	60024235			
Total	2.79E+10	44				

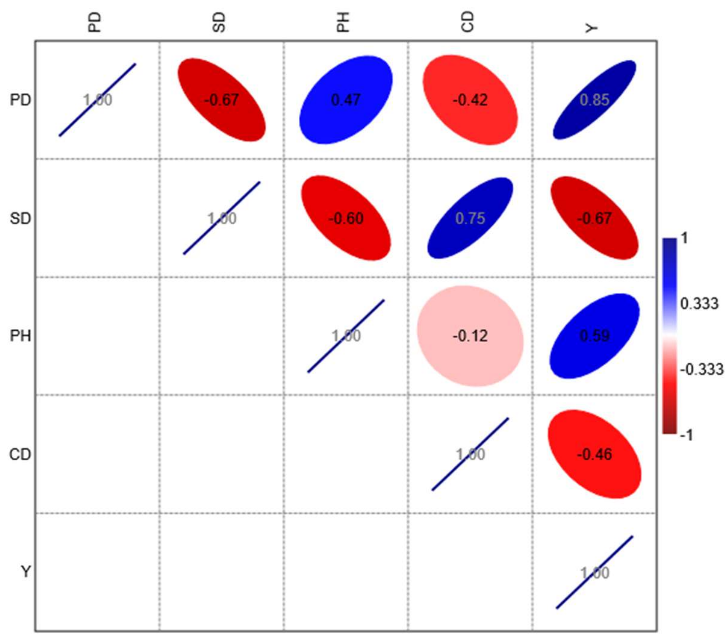


Figura 2. The level of correlation between agronomic parameters, yield and plant density in sunflower // *Nivelul de corelaţie între parametri agronomici, randament şi densitatea plantelor la floarea soarelui*

The yield for each experimental variant was analyzed compared to the average yield value at the experiment level. The differences recorded, and the values of the statistical parameters are presented in Table 3, with a graphical representation in Figure 3.

Table 3. Differences in sunflower yield compared to the average value of the experiment// *Diferentele randamentului la floarea soarelui in*

raport cu valoarea medie a experimentului

Trial code	Yield (kg ha^{-1})		Statistical parameters					
	Given mean:	Sample mean:	95% conf. interval:	Difference:	95% conf. interval:	t:	p (same mean):	Significance of differences
G1A	1954.29	1972.7	(1705.2 2240.2)	-18.41	(-249.08 285.9)	0.1587	0.878	ns
G1B	2160.00			187.30	(-80.189 454.79)	-1.6147	0.145	ns
G1C	2371.43			398.73	(131.24 666.22)	-3.4374	0.009	**
G2A	1354.29			-618.41	(350.92 885.9)	5.3312	<0.001	ooo
G2B	2051.43			78.73	(-188.76 346.22)	-0.6787	0.516	ns
G2C	2262.86			290.16	(22.671 557.65)	-2.5014	0.037	*
G3A	1508.57			-464.13	(196.64 731.62)	4.0012	0.004	oo
G3B	1851.43			-121.27	(-146.22 388.76)	1.0454	0.326	ns
G3C	2240.00			267.30	(-0.18924 534.79)	-2.3043	0.050	ns

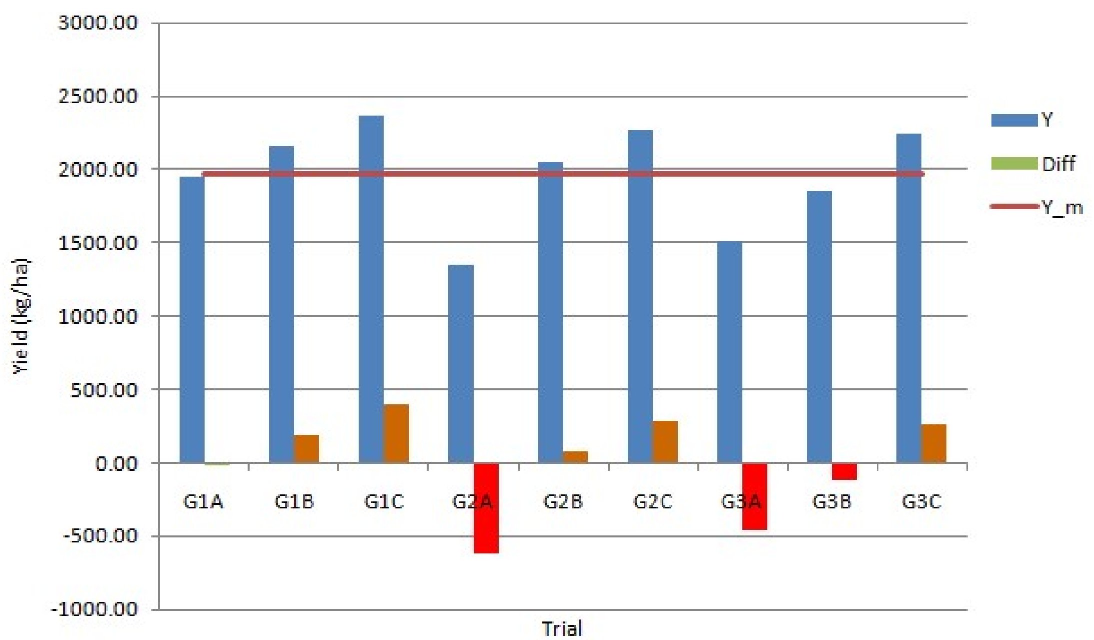


Figura 3. Graphical representation of yield and differences from the experiment average in sunflower hybrids in relation to plant density // *Reprezentarea grafică a randamentului și a diferențelor față de media experimentului la hibrizii de floarea soarelui în raport cu densitatea plantelor*

Under the planting density of 40,000 plants ha^{-1} (experimental code A), all three tested hybrids produced yields below the experimental average (Table 3, Figure 3). At a density of 60,000 plants ha^{-1} (experimental code B), an improvement in yield was recorded. At a density of 80,000 plants ha^{-1} (experimental code C), all variants recorded yields above the experimental average, with statistically significant differences observed for G1C and G2C.

Multivariate analysis explained 84.343% of the total variance based on the first two principal components (Figure 4). A correlation between yield and plant density (Y, PD) was observed, along with the associated positioning of variants G1C, G2C, and G3C in relation to these two parameters, as shown in the biplot.

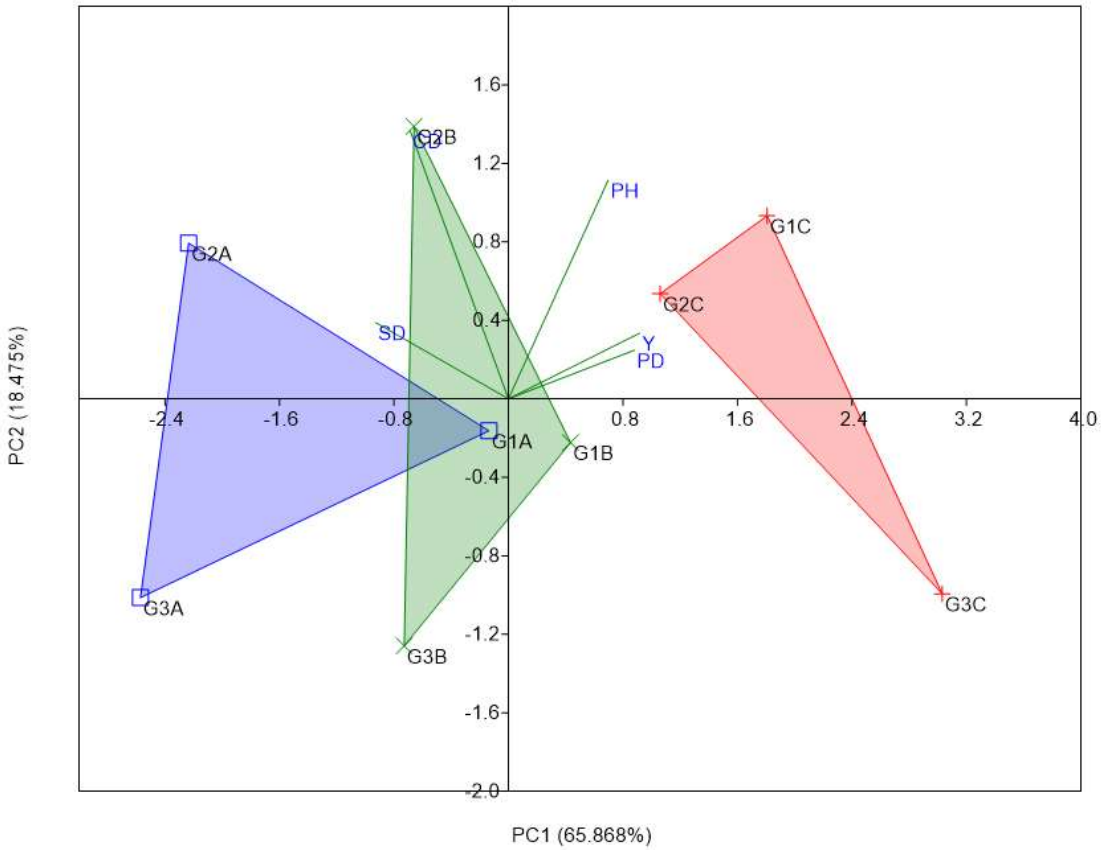


Figure 4. PCA diagram with the distribution of variants in sunflower (blue color – density 40000 plt ha^{-1}; green color – density 60000 plt ha^{-1}; red color – density 80000 plt ha^{-1}) // *Diagrama PCA cu distribuția variantelor la floarea soarelui (culoare albastra – densitate 40000 plt ha^{-1}; culoare verde – densitate 60000 plt ha^{-1}; culoare roșie – densitate 80000 plt ha^{-1})*

Cluster analysis resulted in the dendrogram shown in Figure 5, where the experimental variants were grouped based on similarity (Cophenetic correlation = 0.875). Three distinct subclusters were identified. A high degree of similarity was observed between variants G2C and G3C (SDI = 24.54). The SDI values for all experimental variants are presented in Table 4.

The variation in sunflower yield was further analyzed in relation to plant morphological parameters, using different combinations. Regression analysis produced a general equation, presented as Equation (1), with coefficient values varying depending on the parameters considered (Table 5). Table 5 also includes the statistical significance values for each combination of parameters used in yield estimation.

The graphical representation of yield (Y, kg ha^{-1}) in relation to plant morphological parameters and planting density (*x, y* variables) is shown in Figures 6 to 10: (a) 3D model; (b) isoquants model.

$$Y = a\,x^2 + b\,y^2 + c\,x + d\,y + e\,xy + f \quad (1)$$

where: a, b, c, d, e, f – parameters of equation (1), with values in table 5

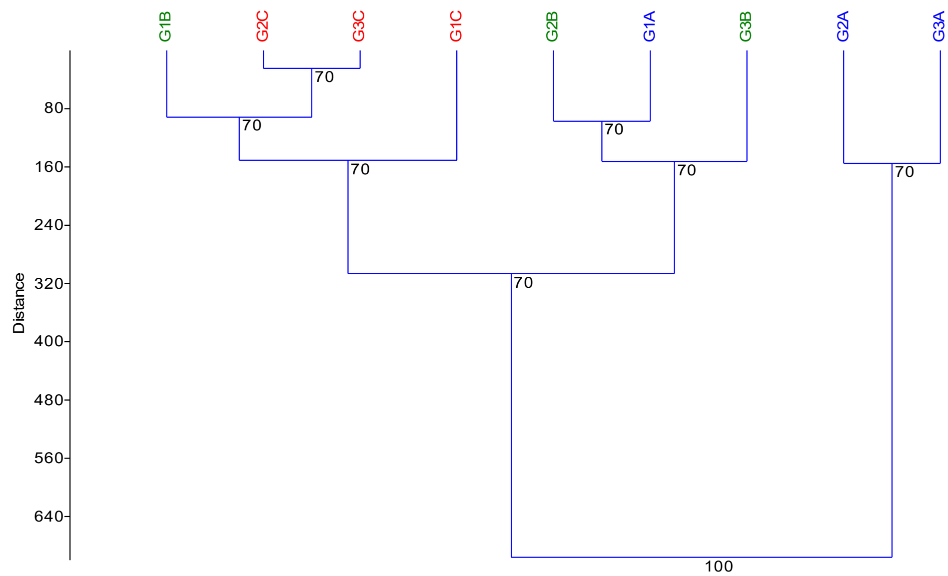


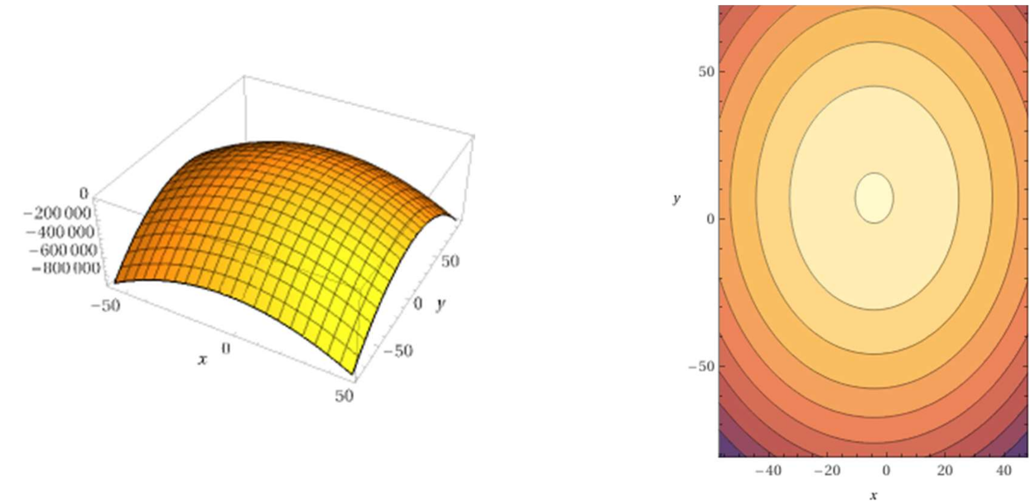
Figure 5. Cluster diagram of experimental variants in sunflower, based on Euclidean distances// *Diagrama cluster a variantelor experimentale la floarea soarelui, pe baza distantelor Euclidiene*

Table 4. SDI values for experimental variants in sunflower// *Valorile SDI pentru variantele experimentale la floarea soarelui*

	G1A	G2A	G3A	G1B	G2B	G3B	G1C	G2C	G3C
G1A		600.02	446.06	205.75	97.23	104.16	417.20	308.59	285.76
G2A	600.02		155.02	805.72	697.14	497.35	1017.20	908.57	885.77
G3A	446.06	155.02		651.57	543.10	342.86	863.20	754.42	731.75
G1B	205.75	805.72	651.57		108.68	308.82	211.72	102.88	80.46
G2B	97.23	697.14	543.10	108.68		200.61	320.13	211.45	188.81
G3B	104.16	497.35	342.86	308.82	200.61		520.53	411.64	389.11
G1C	417.20	1017.20	863.20	211.72	320.13	520.53		109.08	131.54
G2C	308.59	908.57	754.42	102.88	211.45	411.64	109.08		24.54
G3C	285.76	885.77	731.75	80.46	188.81	389.11	131.54	24.54	

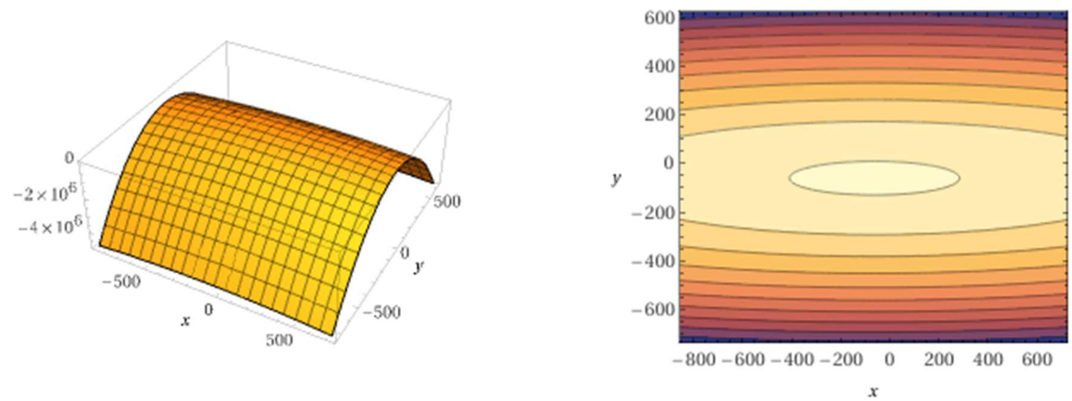
Table 5. The values of the coefficients and statistical parameters of equation (1) // *Valorile coeficienților si a parametrilor statistici ai ecuației (1)*

Model number	Variables of equation (1)	Coefficients of equation (1) values						Statistical parameters		
		a	b	c	d	e	f	R^2	F	p
M1	x = SD, y = PH	-171.7249549	0.7257931	4437.3845253	-60.7351286	-12.5793965	-13649.9799882	0.653	4.5159	0.0151
M2	x = SD, y = CD	-127.6688472	-72.7780473	-1115.1080848	1071.8852059	173.2190554	-1206.9146649	0.633	4.1409	0.0203
M3	x = PH, y = CD	-0.4071720	-10.1069213	-53.6670659	-1147.9488432	10.7657830	14640.6698529	0.629	4.0675	0.0215
M4	x = PD, y = SD	3.11728E-07	230.2261192	-0.2718578	-5832.9303904	0.0279159	35939.4467831	0.918	26.8222	0.000001
M5	x = PD, y = PH	-3.3865E-07	0.4222055	0.0834655	-80.9544904	-0.0002208	3376.3355903	0.811	10.2958	0.00051
M6	x = PD, y = CD	5.90441E-08	18.6883058	-0.1057039	-1087.8853163	0.0064065	14689.4310102	0.872	16.3886	0.000001



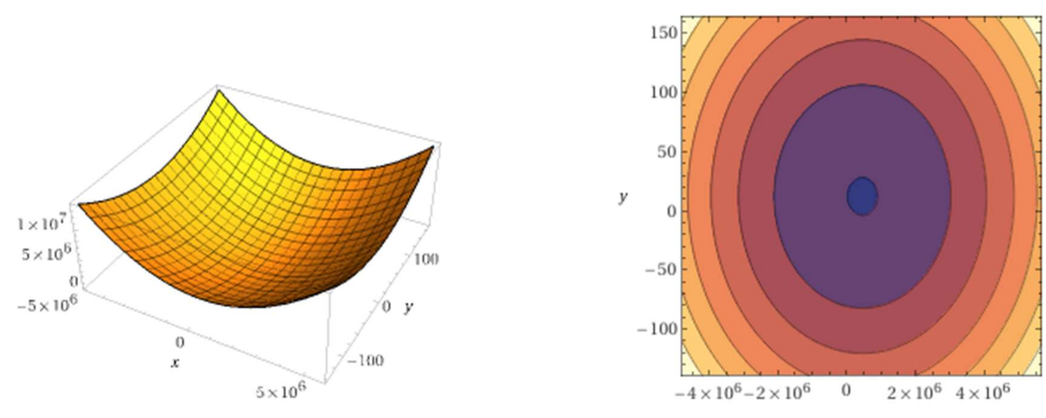
(a) (b)

Figure 6. Yield variation in relation to SD (*x*-axis), and CD (*y*-axis) parameters // *Variatia randamentului in relatie cu parametri SD (axa x), si CD (axa y)*



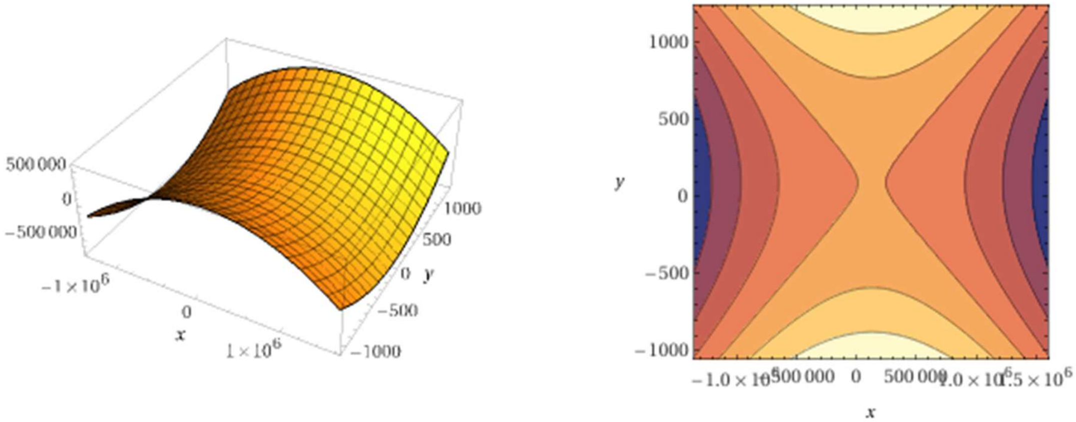
(a) (b)

Figure 7. Yield variation in relation to PH (*x*-axis), and CD (*y*-axis) parameters // *Variatia randamentului în relație cu parametri PH (axa x), si CD (axa y)*



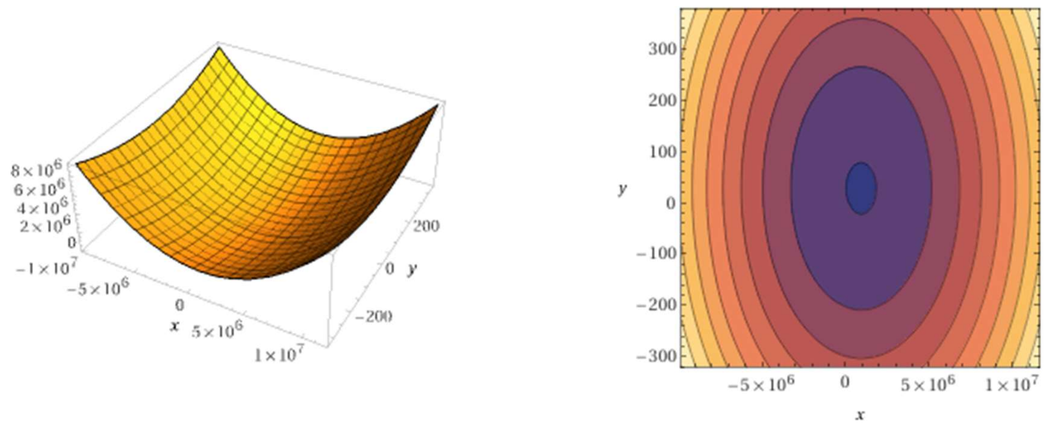
(a) (b)

Figure 8. Yield variation in relation to PD (*x*-axis), and SD (*y*-axis) parameters// *Variația randamentului in relatie cu parametri PD (axa x), si SD (axa y)*



(a) (b)

Figure 9. Yield variation in relation to PD (*x*-axis), and PH (*y*-axis) parameters// *Variația randamentului în relatie cu parametri PD (axa x), si PH (axa y)*



(a) (b)

Figure 10. Yield variation in relation to PD (*x*-axis), and CD (*y*-axis) parameters // *Figura 10. Variația randamentului în relatie cu parametri PD (axa x), si CD (axa y)*

The RMSEP parameter was calculated for each yield prediction model. The RMSEP parameter values are graphically presented in Figure 11.

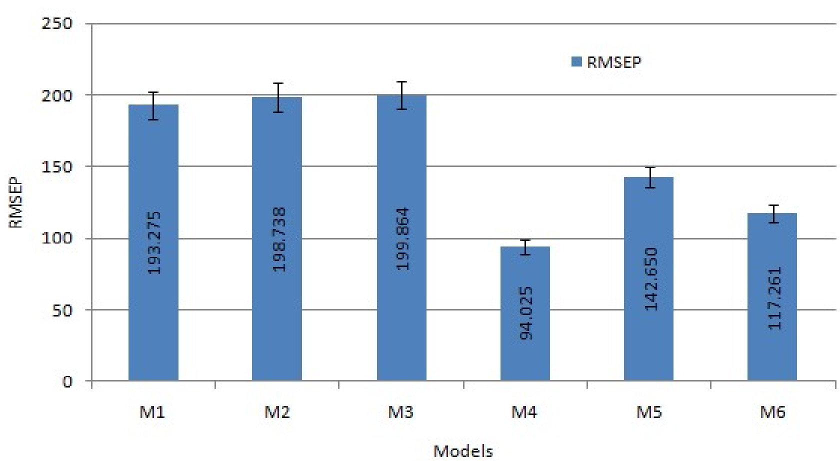


Figure 11. Graphical representation of RMSEP values, associated with yield estimation models// *Reprezentarea grafica a valorilor RMSEP, associate modelelor de estimare a randamentului*

Sunflower cultivation has been analyzed in relation to various soil and plant interventions, incorporating different inputs and cropping systems, to improve agricultural technologies in line with the requirements of cultivated genotypes (Pîrvulescu et al., 2015; Hamzei and Seyyedi, 2016;

Khalifani et al., 2023; Centorame et al., 2024).

Interest in modeling agricultural crops has been reflected in numerous studies aimed at describing responses to vegetation and technological factors, nutritional status, biomass production, and more (Constantinescu et al., 2018; Herbei et al., 2023; Centorame et al., 2024).

In relation to plant density, this study recorded varying values for agronomic parameters and yield in the sunflower hybrids analyzed.

Yield estimation models based on different combinations of agronomic parameters and plant density revealed the distinct contributions of these variables within the models. A convergent contribution was observed in most models, though with varying levels of precision. However, when plant density (PD) and plant height (PH) were used as variables, a divergent behavior between the two was recorded (Table 5, Figure 9).

The results indicate that some elements used as variables in the yield optimization process can be approached uniformly, while others require a differentiated approach.

CONCLUSIONS

6. Differential response of sunflower hybrids under experimental conditions was recorded, based on agronomic parameters and yield.
7. Plant density influenced the yield of the tested sunflower hybrids. The density of 40,000 plants ha^{-1} led to yields below the average of the experiment, except for the G1A variant which presented close values. The density of 60,000 plants ha^{-1} led to yields above the average for the G1B and G2B variants (without statistical certainty). The density of 80,000 plants ha^{-1} led to yields above the average for all three tested hybrids, with statistical certainty for the G1C ($p<0.01$, **) and G2C variants ($p<0.05$, *).
8. PCA analysis showed the correlation of yield with plant density, and the G1C and G2C hybrids were positioned in association.
9. Mathematical and graphical models described the variation of yield in relation to agronomic parameters and plant density. Plant density (PD) and stem diameter (SD) facilitated the estimation of yield with the highest level of certainty (RMSEP = 94.025 kg ha^{-1}).
10. The analysis method and the obtained models can be extended to other sunflower hybrids, and can also be adapted for other agronomic, physiological parameters, or technology elements, as variables that influence sunflower crop yield.

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THE INFLUENCE OF CLIMATE CHANGES ON MAIZE GRAIN YIELD IN CENTRAL TRANSILVANIA IN EARLY SOWING CONDITIONS

INFLUENȚA SCHIMBĂRILOR CLIMATICE ASUPRA PRODUCȚIEI DE BOABE LA PORUMB ÎN CENTRUL TRANSILVANIEI ÎN CONDIȚIILE SEMĂNATULUI TIMPURIU

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ABSTRACT

The main climatic factors that have changed in recent years have had a negative influence primarily on maize production.

Scientists in the field are making efforts to obtain maize biotypes capable of overcoming these changes, but until these results are obtained, intervention in crop technology remains a possibility.

In solving this problem for the time being, we have developed earlier sowing without waiting for the minimum germination threshold to be achieved in the soil. Finding hybrids with resistance to temperatures lower than 10 °C at germination has been a constant concern.

In this study, we present the evolution of the average daily temperature and the amount of precipitation compared to the multiannual average and the maize production achieved at R.D.S.C.B. Târgu Mureș.

REZUMAT

Principali factori climatici care au cunoscut modificări în ultimii ani, au avut o influență negativă privind în primul rând producția la cultura porumbului.

Oamenii de știință din domeniu depun eforturi în obținerea de biotipuri de porumb capabile să treacă peste aceste schimbări, dar până la obținerea acestor rezultate intervenția în tehnologia de cultură rămâne o posibilitate.

În rezolvarea pe moment a acestui deziderat am elaborat semănatul mai timpuriu fără a aștepta realizarea în sol a pragului minim de germinare. Găsirea unor hibrizi cu rezistență la temperaturi mai mici de 10 °C la încolțire a fost o preocupare constantă.

În acest studiu prezentăm evoluția temperaturii medii zilnice și cantitatea de precipitații în comparație cu media mutianuală și producția de porumb boabe realizată la SCDCB Târgu Mureș.

Keywords: *maize, climate conditions, grain production, early sowing*
Cuvinte cheie: *porumb, condiții climatice, producția de boabe, semănat timpuriu*

INTRODUCTION

Maize (*Zea mays L.*) is an important food for world population and as such emphasis is placed on achieving the higest yield, but this also depends on the agricultural tehnologies which are applied (Yusuf D.D., 2006). In Romania maize is the most extensive crop, with a use in human and animal nutrition, that is why it is necessary to consider the achievement of a balance between the production capacity in the choice of corn hybrids and grain quality indicators (Scott et all., 2006).

Climat changes has become the bigest global challenge, causing problems in crop development and yield, leadind to threats the food security for the growing population (Bennetzen et al., 2016).

Global warming is recognized as an extremely worrying environmental problem by both the scientific community and the world population in general. A total increase in temperature of 3.2 °C is expected by the end of the current century. Also, the increase in CO2 concentration in the atmosphere is in itself a worrying factor if we think that sustainable agricultural production and food security are one of the major challenges both at present and in the future. Assessing the effects of climate change on agriculture is a major concern especially in countries where extreme climatic conditions (tempera-ture, precipitation) are registered (Harison P. A., at all, 1996; Tatar Ö. 2016).

Drought is a particularly significant phenomenon which limits plant production in all countries of the world. The negative effects of the drought depend, in particular, on its severity and the period of its occurrence, which causes a state of stress that influences production. The state of stress to which plants are subjected may vary from year to year depending on the amount of rainfall and the temperature of the air (Soltani A. At all, 2001).

According to predictions, global cereal demand for water will increase. And this is because climate change is expected to increase global temperature by 4-6 °C (Casaretto J.A, at all, 2016). There is currently extensive research sugesting alternatives to secure water supplies for soil and plants such as corn, a plant that plays a crucial role in human and animal nutrition (İştipliler D. et all 2016). Total world corn production was, according to FAO data, in 2014, for example, of about 1 billion tons and for this reason, the addition of irrigated water supply and the cultivation of drought-tolerant corn hybrids are among the most appropriate solutions (İştipliler D., et all 2016).

Temperature influences growth processes through cardinal points, minimum, optimum, maximum, which are differentiated according to the species and the stage of development of the plant (Şumălan, 2000). Regarding growth, it generally follows the curve of biochemical processes (Gâdea, 2013).

The period that a plant needs to complete a certain stage of growth is directly related to the temperatures and especially to the sums of the daily temperatures in that stage, but also those before. Research conducted on temperatures and stages of development of corn has shown that corn can survive between 0ºC and 43ºC, with slow growth below 10ºC and above 30ºC (Lehenbauer, 1914).

Domokos et al. (2022) observed that early sowing did not reduce the percentage of plants that emerged compared to the optimal sowing date, but influenced the emergence dynamics, as the number of days with suboptimal temperatures increased.

Corn growth takes place under good conditions when average temperatures do not fall below 13°C in May and below 18°C in July and August (Vâtcă et al., 2021). The highest growth rate is recorded at temperatures between 24 and 30°C. In the flowering phase, in June-August, the optimal temperature is between 18 and 23°C (Rogojanu and Chisel, 1952).

Maize has good drought resistance, especially in the first part of the vegetation period, due to the low transpiration coefficient (between 246 and 589), the strongly developed root system and the possibility of reducing the transpiration surface by twisting the leaves in case of drought, it is considered a drought-resistant plant, but it responds differently to water deficit depending on the stages of development (Cakir, 2004).

The critical period for water is between 10-20 June and 10-20 August, respectively before the appearance of panicles and until milk maturity. During this period, the soil should have 60-80% water of the field capacity. In a study by Udomprasert et al., (2005), the anthesis-silk interval increased by 2-3 days when moisture stress occurred in the early stages of silking, and the anthesis-silk interval increased by 0.75-1.25 days when water was deficient during the anthesis period. In the grain filling phase, the lack of moisture causes the grain to shrink.

For our country, the optimal distribution of precipitation during the vegetation period is as follows: 60-80 mm in May, 100-120 mm in June, 100-120 mm in July and 20-60 mm in August (Bâlteanu, 1998). Corn finds the best vegetation conditions when annual precipitation is over 500 mm, precipitation between January 1 and August 31 is over 350 mm or precipitation between May 1 and August 31 is over 250 mm (Bâlteanu, 1998).

MATERIALS AND METHODS

A ten-year experiment (2015-2024) was conducted at the Research and Development Station for Cattle Breeding Tg. Mures (R.D.S.C.B. Tg. Mures) at Sangeorgiu de Mures, Romania (46°33˒ N, 24°33˒ E).

The soil on which the experiment was located, was a brown forest soil, weakly podzolic, clay loam texture (representative of most of the Mures county area), with a humus content of 1.9, pH of

5.8, P_2O_2 supply is 17.4 mg/100g soil, K_2O 21.7 mg/100 g soil and an N index of 1.4. The predecessor plant was soybean.

The sowing rate was 65,000 plants/ha, with a distance of 70 cm between rows, and the plot size of each experimental plot was of 2,8m x 7m. Sowing date was an early sowing (ES), conducted when the soil temperature reached 6°C Fieldwork was done by harrowing in August, deep plowing in the autumn, leveling discs in the spring, and a work with the cultivator to prepare the germinative bed. The application of the whole dose of fertilizers was done after the disk, and their incorporation into the soil was done with the combinator. The amount and type of fertilizer used were $N_{16}P_{16}K_{16}$ 500 kg/ha, and every three years 4 t amendments per ha were applied.

The results of the studies were analyzed according to the climatic conditions of the area, recorded at the weather station in Sângeorgiu de Mureș and presented in Table 1.

Table 1. Mean monthly (T_m) air temperatures and total monthly rainfall at Sangeorgiu de Mures, during the experiment (from 2015 to 2024). Long-term (60 years) mean annual temperature and rainfall values at Sangeorgiu de Mures// Temperaturile medii lunare (Tm) ale aerului și precipitațiile totale lunare la Sângeorgiu de Mureș, în timpul experimentului (2015 - 2024). Temperatura medie anuală și valorile precipitațiilor pe termen lung (60 de ani) la Sângeorgiu de Mureș

	10 Years	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX	Avg. sum
mm	2014-2015	23,0	36,0	30,0	24,0	20,0	20,0	23,0	0,0	132,0	27,0	90,0	73,0	**498,0**
	2015-2016	46,0	47,8	19,8	25,6	35,6	46,7	75,6	89,9	127,9	59,0	59,6	15,3	**648,8**
	2016-2017	77,3	90,8	19,3	9,1	32,1	26,0	51,0	111,5	51,8	50,0	26,5	53,0	**598,4**
	2017-2018	60,7	52,6	43,2	32,5	41,2	64,9	12,7	53,8	187,2	58,5	8,7	58,8	**674,8**
	2018-2019	32,2	30,5	60,1	36,2	27,7	16,6	30,3	134,5	49,8	59,9	78,6	50,1	**606,5**
	2019-2020	31,6	28,2	41,7	7,9	57,8	36,3	20,1	61,4	120,9	99,0	40,9	62,2	**608,0**
	2020-2021	74,2	34,9	50,6	9,0	37,2	66,4	93,9	95,0	70,4	98,2	77,5	59,7	**767,0**
	2021-2022	12,5	34,0	87,7	27,4	11,2	3,6	118,9	49,0	9,2	56,3	100,5	176,4	**686,7**
	2022-2023	45,7	71,5	47,5	28,2	55,8	31,6	74,0	39,0	151,5	84,8	67,0	19,0	**715,6**
	2023-2024	28,0	112,0	29,5	22,0	40,0	50,0	66,0	61,0	91,0	59,0	35,0	77,0	**670,5**
	Avg. rain fall	**43,1**	**53,8**	**42,9**	**22,2**	**35,9**	**36,2**	**56,6**	**69,5**	**99,2**	**65,2**	**58,4**	**64,5**	**647**
	10 Years	**X**	**XI**	**XII**	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**Avg.**
t °C	2014-2015	10,8	4,8	2,4	2,4	2,1	5,0	9,2	15,8	18,9	21,7	21,5	17,3	**10,98**
	2015-2016	9,9	5,7	1,9	-2,0	5,3	6,4	13,1	14,5	20,8	21,4	20,4	17,2	**11,21**
	2016-2017	8,8	3,3	-3,1	-6,6	1,9	8,3	10,2	16,7	20,5	21,1	24,0	16,2	**10,12**
	2017-2018	10,1	5,4	1,7	0,9	0,2	4,3	15,6	18,7	20,1	20,7	22,8	16,2	**11,40**
	2018-2019	12,1	5,7	-0,1	-1,5	1,7	6,9	12,3	15,3	22,1	20,7	21,8	17,0	**11,17**
	2019-2020	11,6	10,0	1,2	-2,5	2,9	6,6	10,3	14,3	19,7	21,0	22,0	18,3	**11,28**
	2020-2021	12,5	4,4	4,3	2,6	2,2	2,7	8,6	14,9	20,0	23,8	20,6	17,0	**11,13**
	2021-2022	8,7	4,9	2,0	-4,2	2,6	3,7	9,3	16,6	21,7	23,0	22,5	14,8	**10,47**
	2022-2023	12,1	6,2	2,5	3,9	1,4	6,4	9,6	16,1	19,1	19,1	22,5	19,5	**11,53**
	2023-2024	13,3	5,8	2,4	0,7	7,3	9,0	13,4	16,1	22,1	24,0	22,6	18,2	**12,90**
	Avg. temp.	**11,0**	**5,6**	**1,5**	**-0,6**	**2,8**	**5,9**	**11,2**	**15,9**	**20,5**	**21,7**	**22,1**	**17,2**	**11,2**

The analysis of the two climatic factors over the entire agricultural year revealed a yearly variation in precipitation distribution, with an increasing trend observed in recent years within the station's area of influence.

However, in terms of thermal input, there has been a clear rise in the annual average temperature from 2014–2015 to 2023–2024, with an increase of 1.92 °C over ten years (from 10.9 °C to 12.90 °C).

Factor 1 is represented by years and factor 2 by the 6 tested maize hybrids. Six hybrids from the company KWS Semences, KWS 2370 (FAO 290), Karpatis (FAO 340), Kashmir (FAO 370), Durango (FAO 450), Smaragd (FAO 350), Kapitolis (FAO 410).

Fig. 1 Aspects from the experimental field // Aspecte din câmpul experimental

RESULTS AND DISCUSSIONS

Climate change, increasingly pronounced in recent years, has substantially affected the production capacity of cultivated plants. The crop that has suffered the most was corn. In this paper, we attempted to identify the degree of influence of the main climatic factors, temperature and precipitation on grain production, in our region, Central Transylvania.

From the statistical analysis, it results that the greatest share of influence on production over 80% was determined by the effect of the year. The hybrid accounted for 3.1%, and the interaction between year and hybrid accounted for 5.68%.

Table 2. Weigh of factors// Ponderea factorilor

Variation source	*SPA*	*DF*	*S^2*		*F*	*Weight of factors*
A	97071330,00	9	107857000,00		47,904	85,4
H	34892650,00	5	6978531,00		33,951	3,1
AH	64603970,00	45	1435644,00		6,985	5,68
R	5433570,00	2	2716785,00			0,47
AR	40527360,00	18	2251520,00			3,56
HR	1506894,00	10	150689,40			0,13
AHR	19047640,00	90	211640,50			1,67
Eroarea A	40527360,00	18	2251520,00			
Eroarea H	20554540,00	100	205545,40			
Total	1136726000,00					100

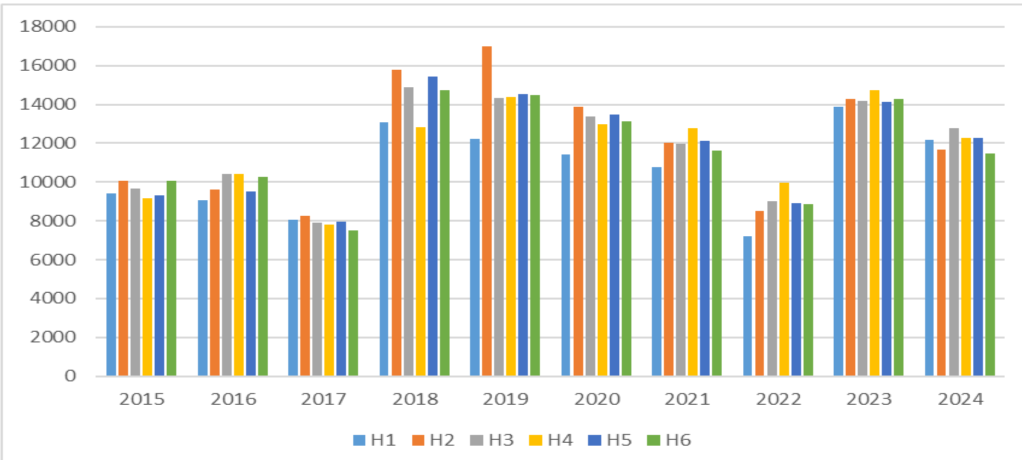
An analysis of the study years highlights that in 2015-2024 time period, 2017, and 2022 had a very significant negative impact on production, while 2016 had a significant negative impact. The years 2018, 2019, and 2023 had a very significant positive influence, and the year 2020 had a significant positive influence. From the analysis of production achieved by hybrids compared to the control, a genetic progress of 10.2% is observed. The results for the hybrids are very significantly positive compared to the control.

Table 3. The influence of the year and maize hybrids on grain yield//Influența anului și hibridului asupra producției de boabe

Factors	*Grain yield kg/ha*	*% Control*	*Difference (%)*	*Significance*
		Year		
Years average	11651,12	100	0,00	Control
2015	9602,22	82,4	-2048,90	000
2016	9894,33	84,9	-1756,78	00
2017	8012,89	68,8	-3638,23	000
2018	14464,39	124,1	2813,27	***
2019	14488,00	124,3	2836,88	***
2020	13032,67	111,9	1381,55	*
2021	11886,39	102,0	235,27	-
2022	8733,78	75	-2917,34	000

Factors	*Grain yield kg/ha*	*% Control*	*Difference (%)*	*Significance*
2023	14243,00	122,2	2591,88	***
2024	12153,50	104,3	502,38	-
DL /LSD p 5% = 1050,36; DL/ LSD p1%=1440,49; DL/LSD p 0,1% = 1960,66				
Hybrids				
KWS 2370	10726,23	100,0	0,00	Control
KWS KARPATIS	12129,33	113,1	1403,10	***
KWS KASHMIR	11851,00	110,5	1124,77	***
KWS DURANGO	11733,23	109,4	1007,00	***
KWS SMARAGD	11830,23	110,3	1104,00	***
KWS KAPITOLIS	11636,37	108,5	910,43	***
DL /LSD p 5% = 231,78; DL /LSD p 1% = 307,87; DL LSD p 0,1% = 396,83				

Fig. 2 Grain yield at 6 maize hybid during the experiment (from 2015 to 2024)// Producția de boabe la 6 hibrizi ecperimentați (între 2015-2024)



An analysis of the number of thermally unfavorable days during the crop vegetation period highlighted both the number of days with temperatures below the optimum and those above it.

The highest number of unfavorable days was recorded in the years 2015, 2017, and 2022 years in which yields also reached their lowest levels.

The greatest number of unfavorable days were those with temperatures above 30°C, starting in June and peaking in July and August.

The number of days with temperatures exceeding 30°C ranged between 32 and 55 days in 2022.

It is worth noting that during the April–August interval, the total number of unfavorable days for the growth and development of maize plants ranged between 58 and 67 days in the years analyzed.

Table 4. Number of thermally unfavorable days from the growing season of maize// Număr zile nefavorabile din punct de vedere termic din perioada de vegetație a porumbului

Year		**IV** **<10⁰C**	**V** **<13⁰C**	**VI** **<18⁰C**	**VII** **<18⁰C**	**VIII** **<18⁰C**	**Total**
2015	Number of days below the optimal germination threshold	6	0	0	0	0	**6**
	Number of days below the optimal development threshold	0	2	9	3	3	**17**
	Number of days with temperatures above 30 °C	0	0	5	14	19	**38**
Total		**6**	**5**	**14**	**17**	**22**	**61**
2016	Number of days below the optimal germination threshold	4	0	0	0	0	**4**
	Number of days below the optimal development threshold	0	9	10	0	3	**22**
	Number of days with temperatures above 30 °C	0	0	9	15	8	**32**
Total		**4**	**9**	**19**	**15**	**11**	**58**

Year		IV <10^0C	V <13^0C	VI <18^0C	VII <18^0C	VIII <18^0C	Total
2017	Number of days below the optimal germination threshold	10	0	0	0	0	**10**
	Number of days below the optimal development threshold	0	3	4	4	4	**15**
	Number of days with temperatures above 30 °C	0	0	6	10	19	**35**
Total		**10**	**3**	**10**	**14**	**23**	**60**
2022	Number of days below the optimal germination threshold	10	0	0	0	0	**10**
	Number of days below the optimal development threshold	**0**	**0**	1	1	0	**2**
	Number of days with temperatures above 30 °C	0	0	**12**	**19**	**24**	**55**
Total		**10**	**0**	**13**	**20**	**24**	**67**

Another element studied that helped us identify the disturbing factors affecting maize plants was the hydrothermal index for the June–August period (the ratio between the sum of temperatures and precipitation).

Table 5. Hydrothermal index // Indici hidrotermici

Year/Month	VI	VII	VIII	Avg.	Defination
2015	2,30	0,40	1,35	1,30	Moderate deficit
2016	2,05	0,88	0,94	1,29	Dry
2017	0,84	0,76	0,38	0,66	Dry
2018	3,10	0,90	0,12	1,38	Optimal
2019	0,74	0,91	1,10	0,92	Dry
2020	2,05	1,52	0,60	1,39	Optimal
2021	1,17	1,37	1,20	1,25	Moderate deficit
2022	0,14	0,79	1,44	0,79	Dry
2023	2,64	1,25	1,27	1,72	Slight surplus
2024	1,15	0,90	0,49	0,85	Dry

<1 = dry; 1,01-1,30 = moderate deficit; 1,31-1,70 = optimal; 1,71-2,00 = slight surplus; >2,01 = Surplus

Based on the compiled data, we concluded that in the years with the lowest yields, the lowest hydrothermal index was also recorded—0.66 in 2017 and 0.79 in 2022—indicating that these periods were characterized by drought.

For the two climatic factors (temperature and precipitation), the correlation coefficient with yield was also calculated.

In the case of precipitation, a negative correlation between grain yield and rain fall was observed in the months of April and August for all analyzed hybrids, and a positive correlation in May, June, and July. The value of the correlation coefficient varied from one hybrid to another and from one month to the next.

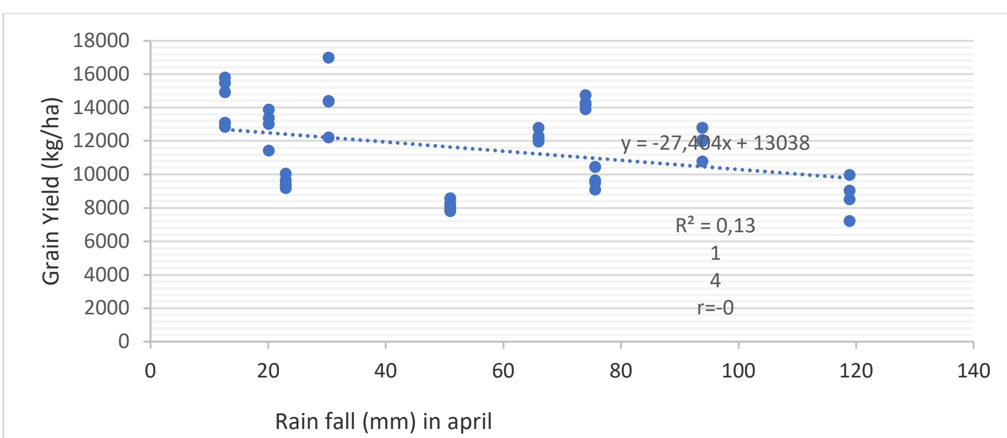


Fig. 3 Coralation between grain yield and rain fall in April // Analiza de corelație între producția de boabe și precipitațiile în luna aprilie

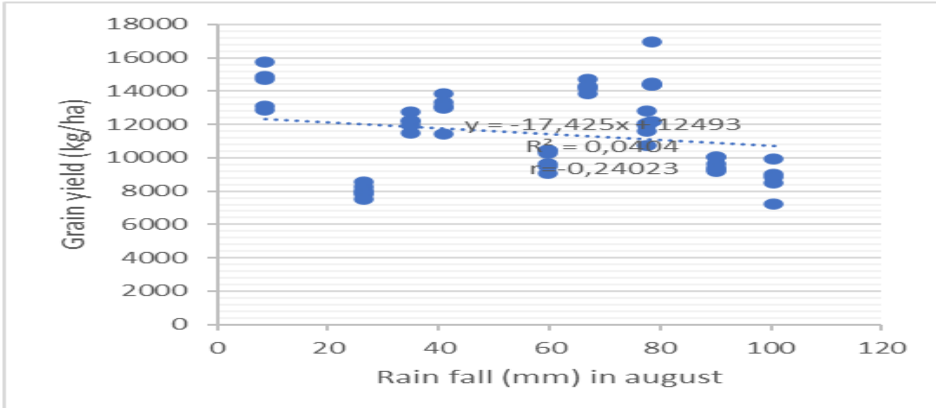


Fig. 4 Coralation between grain yield and rain fall in August// Analiza de colerație între producția de boabe și precipitațiile în luna august

The analysis of the correlation coefficient between production and average monthly temperature revealed that in the months of April and May, a positive correlation was recorded. However, starting from July and August, the correlations were negative.

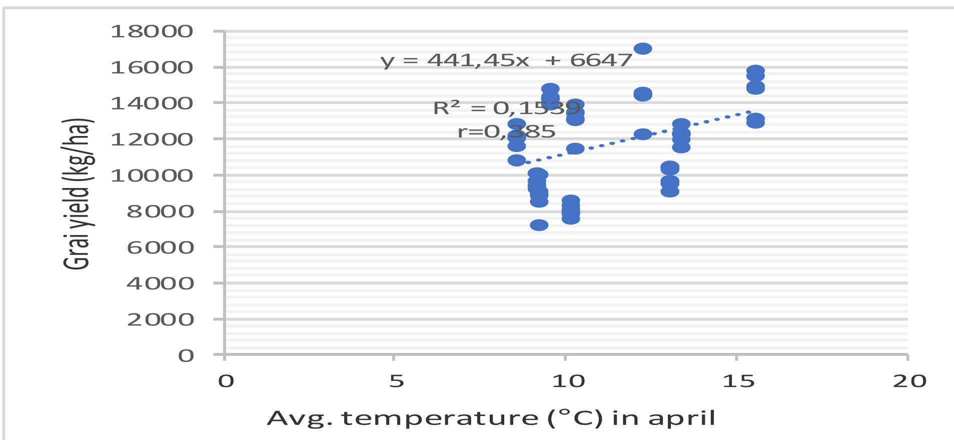


Fig. 5 Coralation between grain yield and average temperature// Analiza de colerație între producția de boabe și temperature medie în luna august

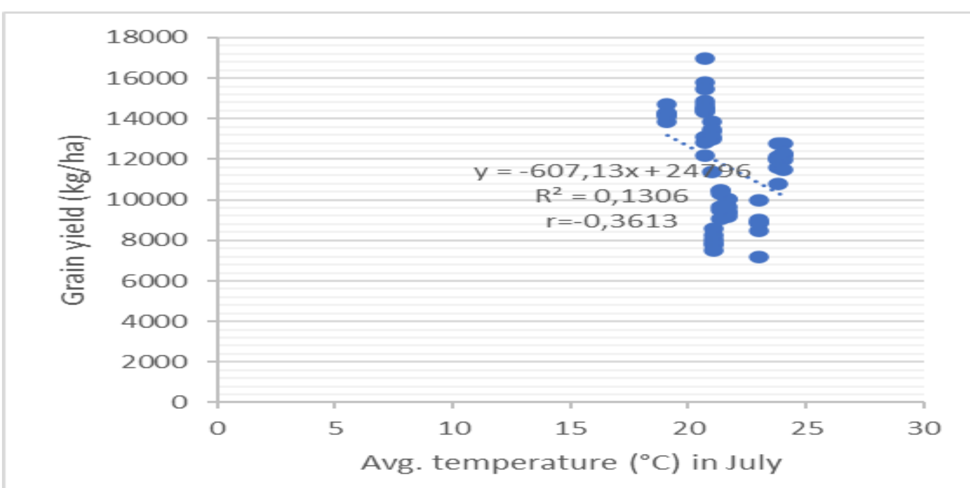


Fig. 6 Coralation between grain yield and average temperature in July // Analiza de colerație între producția de boabe și temperature medie în luna iulie

In August, however, the hybrids reacted differently to the amount of precipitation. The hybrids KWS 2370, Karpatis, Kashmir, and Kapitolis recorded lower values, while the hybrids Durango and Kapitolis showed a more pronounced negative response.

We believe that this reaction is due to the different vegetation periods of the hybrids. In general, it can be concluded that each hybrid reacted differently to the two factors, but there was a tendency for yield to decrease in the years when the two factors were not harmonized, either there were periods with high temperatures and no rain, or there were periods with more precipitation but lower temperatures.

CONCLUSIONS

1. Under the conditions in the area where the experiments were conducted, the evolution of the two analyzed factors varied during the studied years, which also led to differences in yields.
2. The least favorable years for corn were 2017 and 2022, years in which the production potential was significantly reduced.
3. The best years climatically for maize cultivation in the Transylvania region were 2018, 2019, and 2023, years in which the production potential recorded the highest values.
4. For zoning new maize hybrids, testing over at least 3 years is necessary in order to verify their response to climate changes.

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STUDY ON CONSUMER OPINIONS ON THE USE OF BIOTECHNOLOGIES IN AGRICULTURE

STUDIU PRIVIND OPINIILE CONSUMATORILOR PRIVIND UTILIZAREA BIOTEHNOLOGIILOR IN AGRICULTURA

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Abstract: *Biotechnologies are playing an increasingly important role in food production, offering solutions to increase agricultural yields, reduce pesticide use and improve product quality. This study explores consumers' attitudes towards foods derived from biotechnology, their level of information and the factors influencing their purchasing decisions. Understanding consumer perceptions is essential for developing transparent policies and effective communication strategies in the field of food safety.*

Rezumat*: Biotehnologiile joacă un rol din ce în ce mai important în producția de alimente, oferind soluții pentru creşterea randamentelor agricole, reducerea utilizării pesticidelor și îmbunătățirea calității produselor. Acest studiu explorează atitudinile consumatorilor față de alimentele obținute prin biotehnologie, gradul lor de informare și factorii care influențează decizia de cumpărare. Înțelegerea percepțiilor consumatorilor este esențială pentru dezvoltarea unor politici transparente și a unor strategii eficiente de comunicare în domeniul securității alimentare.*

Cuvinte cheie: *biotehnologii agricole, organisme modificate genetic (OMG), percepția consumatorilor, etichetare alimentară, securitate alimentară*
Keywords: *agricultural biotechnologies, genetically modified organisms (GMOs), consumer perception, food labeling, food safety*

INTRODUCTION

Biotechnology is a research- and capital-intensive sector, one of the most rapidly developing fields globally. Its progress therefore depends crucially on a strong intellectual property protection framework and an effective competition regulatory system (Sharma et al., 2010).

Since the beginning of the 21st century, the potential of new biotechnologies to contribute to strengthening sustainable food security and increasing incomes in the agricultural sector has been the subject of extensive debate.

According to Chatterjee and Ghose (2010), agricultural biotechnology is expected to have a significant impact on ensuring long-term food security by increasing agricultural yields, reducing dependence on chemical inputs such as pesticides, reducing soil degradation, increasing the nutritional value of crops and, at the same time, promoting sustainable agricultural practices that contribute to protecting the environment for future generations.

Sehgal (2000) believes that biotechnology has considerable potential in increasing food production and promoting sustainable agricultural development, both on high-fertility and marginal lands. Given that seeds are the main vector for the transfer of biotechnological innovations in agriculture, the benefits of this technology can be exploited by farmers only to the extent that they have access to high-quality seeds.

Agricultural biotechnology offers promising prospects for improving food security in developing countries by increasing farmers' incomes and providing more affordable and nutritionally superior food products to consumers. However, the realization of this potential is significantly limited by the restrictive regulatory framework imposed by the European Union, which has established rigorous policies on the authorization, production and marketing of genetically modified organisms

(GMOs), including strict rules on imports of agri-food products that do not meet these standards (Anderson, 2010).

The objectives of the study were:

- identifying the level of consumer awareness about GMOs and agricultural biotechnologies;
- analysis of attitudes and level of trust towards these products;
- observing behaviors related to reading labels and making purchasing decisions;
- exploring perceptions of the role of authorities and information channels;
- assessing consumers' openness to accepting biotech products.

MATERIAL AND METHOD

The research was based on the application of a structured questionnaire, composed of 25 closed and semi-open questions. It was applied to a sample of 103 respondents, randomly selected from various regions of the country, both urban and rural. The questionnaire was divided into four thematic sections:

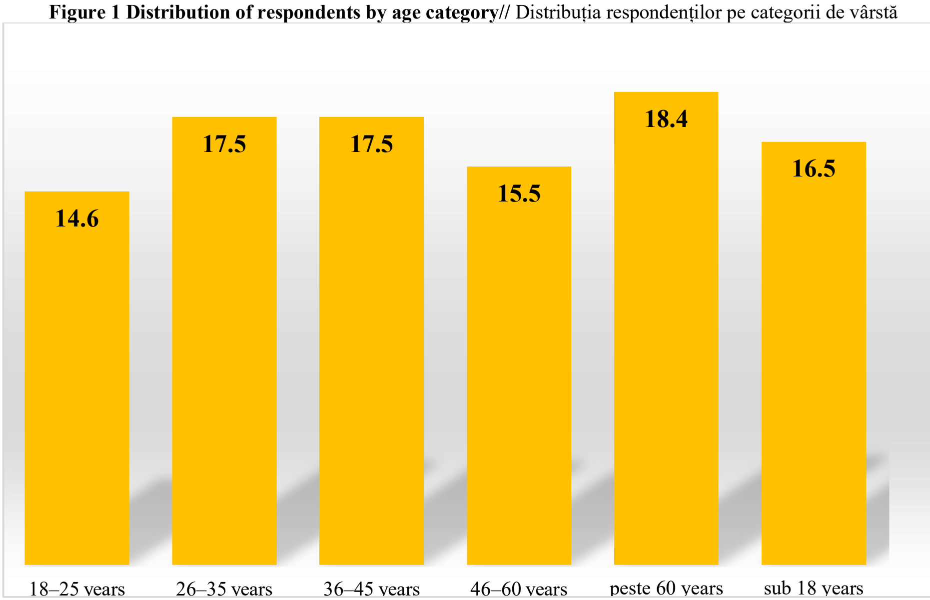
1. Socio-demographic data;
2. Knowledge about biotechnologies and GMOs
3. Behaviors regarding product labeling;
4. Opinions regarding the consumption of genetically modified products.

The data were centralized and analyzed using Microsoft Excel software, aiming to identify frequencies, simple correlations and major trends among respondents

RESULTS AND DISCUSSION

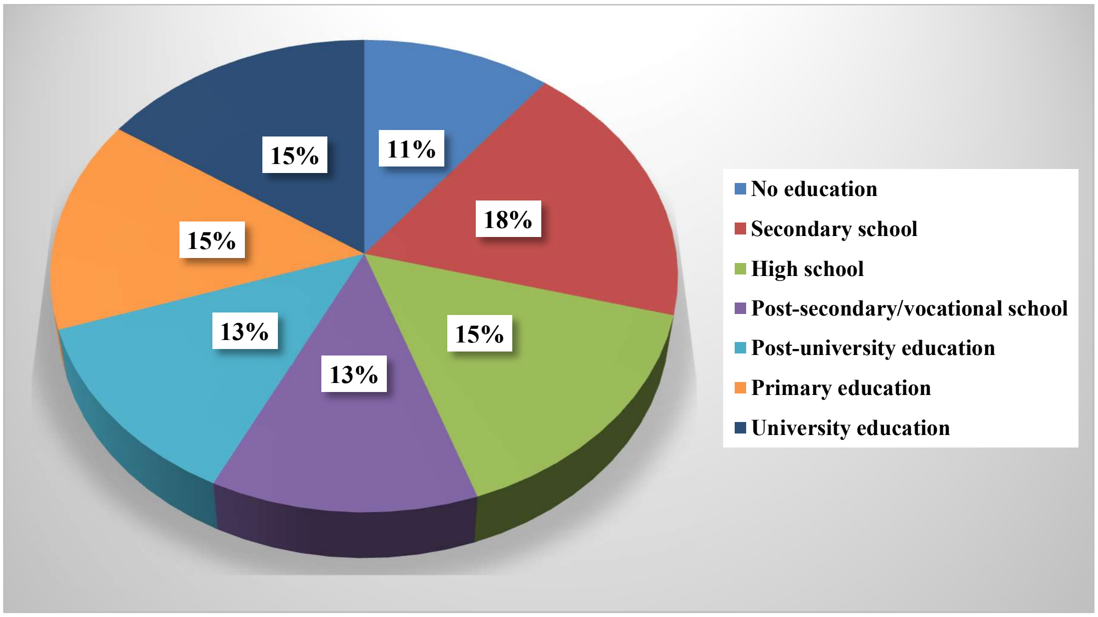
Regarding the profile of the respondents, the socio-demographic analysis showed that the majority of respondents are between 18 and 35 years old (over 60%), which suggests a relatively young and active population. The gender distribution was balanced, with a slight female predominance. The level of education is high, over 70% of the participants have university or postgraduate studies, which may positively influence the level of information and the ability to understand scientific concepts. Also, 60% of the respondents come from urban areas, where access to information is generally easier (Figure 1, 2).

Figure 1 Distribution of respondents by age category// Distribuția respondenților pe categorii de vârstă



Source: processing based on questionnaire data

Figure 2 Distribution of respondents by level of education// Distribuția respondenților pe nivelul de studii

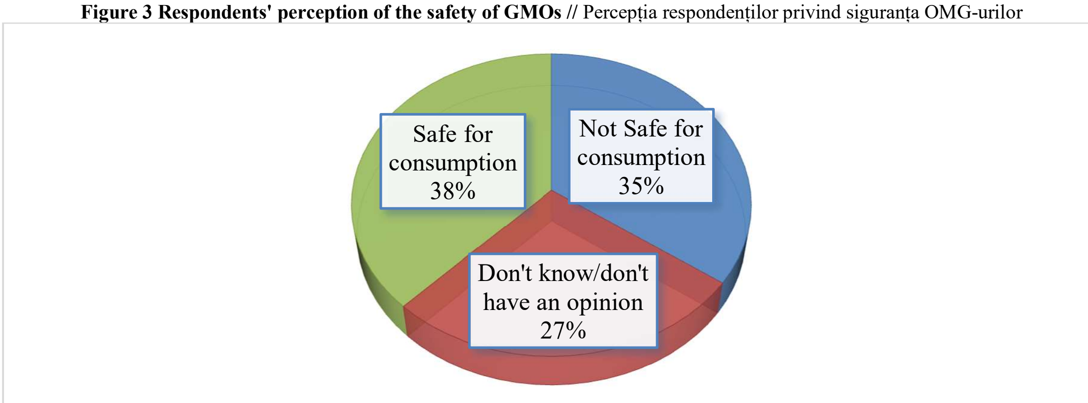


Source: processing based on questionnaire data

Questions regarding knowledge about GMOs revealed that over 80% of respondents had heard of their existence. The main sources of information were the internet (70%), television (50%) and formal education (25%). However, only 60% were able to provide a correct or partially correct definition of GMOs. The rest admitted that they did not fully understand the term or confused it with other concepts such as food additives.

Perceptions regarding the safety of genetically modified foods are divided: 40% consider these products safe, 35% perceive them as unsafe, and 25% have no clear opinion. The perceived advantages of GMOs include: increased production, increased resistance to diseases and pests, but also lower product prices. Among the disadvantages frequently mentioned are possible health effects, ecological impact, and the lack of conclusive long-term studies (Figure 4).

Figure 3 Respondents' perception of the safety of GMOs // Percepția respondenților privind siguranța OMG-urilor



Source: processing based on questionnaire data

Labeling-related behaviors. Regarding food labeling, over 55% of participants say they constantly check the information on the packaging. The most searched elements are ingredients, nutritional values, and the origin of the product. Only 35% specifically look for mentions of GMOs.

A significant number (45%) say they have not noticed any labels regarding GMOs, and 78% believe that these mentions should be mandatory and clearly formulated. At the same time, 60% of respondents believe that current labeling does not provide sufficient information about the presence of GMOs in food products.

By age group, the situation is as follows (Table 1):

- **18–25 years old** (15 respondents) are distinguished by a strong presence in the categories with ***university*** (6) and ***post-secondary education*** (3). *These young people seem interested in the label, in line with the younger generation's concerns for healthy eating.*
- **26–45 years old** (36 respondents) is distinguished by a large number of people with high school education (6), a sign that it is a ***mature category*****,** possibly involved in the decision to purchase food for the entire family.
- **over 60 years old** (19 respondents) has a heterogeneous behavior: they are present both among those ***without education*** (2) and among those with ***higher education*** (3). *Label checking among seniors is not negligible, but it is likely to be limited to basic elements (expiration, ingredients).*

-

Table 1 Distribution by age category regarding label checking // Distribuția pe categorii de vârstă în ceea ce privește verificarea etichetei

Age Category	Number of Responses (%)
under 18 years 16.5	16.5
18–25 years	14.6
26–35 years	17.5
36–45 years	17.5
46–60 years	15.5
over 60 years	18.4
Total	100.0

Source: processing based on questionnaire data

One of the key questions in the study was about the acceptance of genetically modified (GMO) products. The results showed a relatively low level of acceptance, with only 25% of respondents willing to accept their consumption. This figure suggests a significant reluctance of the population towards genetically modified products, which reflects the fears and uncertainties that exist among consumers.

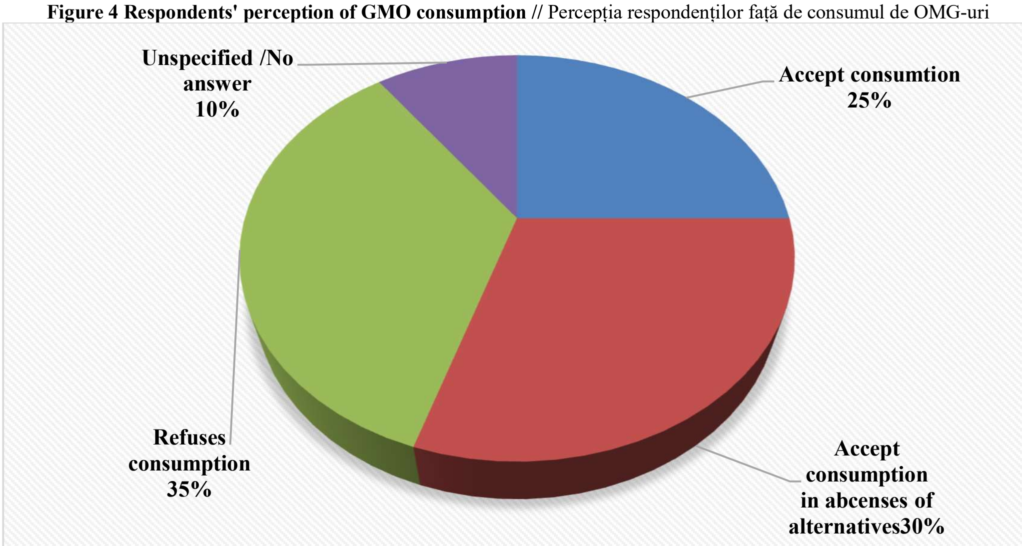
On the other hand, 35% of respondents actively reject the consumption of GMO products. They are firmly against these products, raising concerns about food safety, the long-term impact on health and the environment, as well as the ethics involved in the use of biotechnologies in food. These people seem to be very reluctant to accept any argument in favor of the use of GMOs, considering them a risky choice, even in the face of more attractive economic possibilities.

In contrast, 30% of respondents would accept genetically modified products, but only in the absence of safer and more affordable alternatives. They are therefore more flexible, being willing to accept these products only for economic reasons or in conditions where there are no other viable options on the market. They could be positively influenced by the lower prices of GMO products, which could offer them a more affordable solution compared to the higher costs associated with natural or conventional products.

The reasons given by those willing to accept the consumption of genetically modified products are diverse. These include reduced costs for consumers, the possibility of more affordable food, recommendations and studies carried out by specialists in the field of biotechnology, as well as the belief that GMO products do not pose major risks to health or the environment. These people rely on information from experts, considering that current technology is sufficiently advanced to guarantee the safety of these products.

Those who reject GMO products cite a number of reasons related to their safety. The main concern is the uncertainty about the long-term impact on human health and the environment. The lack of long-term studies and concrete evidence of their absolute safety contributes to consumer fears. Many of those who reject these products also highlight the lack of clear and transparent information about the process of genetic modification and the potential associated risks. In addition, there is a significant preference for natural, unprocessed products, perceived as healthier and safer. This reflects a broader trend of consumers seeking authentic, traditional foods and foods perceived as closer to nature.

Figure 4 Respondents' perception of GMO consumption // Percepția respondenților față de consumul de OMG-uri



Source: processing based on questionnaire data

An important aspect highlighted by the study results is the low level of trust that citizens have towards the authorities that regulate the field of biotechnology. Thus, only 15% of respondents declared that they have full trust in the state institutions responsible for this field. This figure indicates a significant deficit of credibility, which can influence the public perception of the decisions taken at the governmental level and the regulations in force.

Amidst this lack of trust, most respondents choose to get their information from alternative sources. The most frequently used channels are traditional media (television, radio, newspapers) and, to an increasing extent, the internet, especially social networks and news websites. This trend highlights the need for more efficient and transparent communication from authorities, as well as the importance of verifying the quality and veracity of information available in the public space.

Regarding the responsibility for informing the public about biotechnology, the majority opinion is that this task should not fall exclusively on a single entity. Respondents stressed the need for a collective and coordinated effort, involving the state (through competent and transparent institutions), independent specialists (who can provide objective and scientifically substantiated opinions), non-governmental organizations (who can represent the interests of civil society) and even manufacturers in the biotechnology industry (who must assume an active role in ensuring correct and responsible information for consumers). This collaborative model is seen as essential for building a lasting relationship of trust between citizens and the actors involved in the development and regulation of biotechnology.

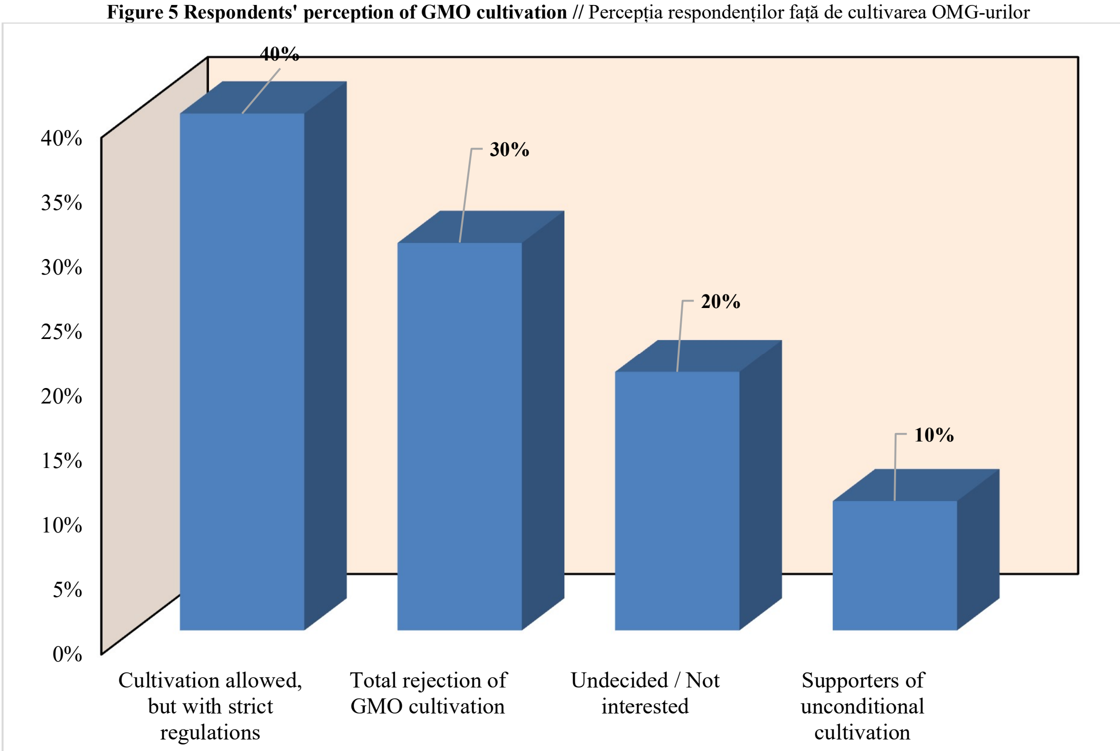
Regarding the cultivation of genetically modified organisms (GMOs) in Romania, the study revealed a diversity of opinions, reflecting a cautious and sometimes skeptical attitude of the public towards this practice. Approximately 40% of respondents believe that GMOs could be cultivated in the country, but only under strictly regulated and monitored conditions. These participants emphasize the need for a rigorous legal framework, which would ensure the safety of both the environment and the health of the population. They also believe that regulations should include rigorous control measures to prevent any potential risks related to the use of these technologies in agriculture. This group is open to the possibility of integrating GMOs, but only under the close supervision of the competent authorities.

Another significant group, 30%, is completely opposed to the cultivation of genetically modified organisms in Romania. These people are strongly against the use of GMOs, for various reasons, including concerns about food safety, the impact on biodiversity, and the long-term risks to the environment and health. Many of them believe that, even with strict regulations, genetic modification technology represents too risky an artificial intervention in natural ecosystems, and the potential economic benefits do not justify the possible irreversible damage. Some of them are also influenced by environmental movements and the global trend to promote a sustainable and natural agricultural model.

A percentage of 20% of respondents do not have a clear opinion on this topic, being undecided or simply uninterested in the topic of GMOs. They may either be uninformed about the long-term implications of the use of GMOs in agriculture, or simply do not consider this topic to be a major priority in the context of the economic, political or social problems facing the country.

Only 10% of respondents support the unconditional cultivation of genetically modified organisms. They are generally more confident in the potential of biotechnology technologies and believe that the economic and production benefits could outweigh any perceived risks. Many of them are influenced by scientific arguments that GMOs can contribute to more efficient agricultural production, more resilient to extreme climate conditions and better able to meet the demands of a growing world population. They believe that safety fears are unfounded, given that existing scientific studies have not identified major risks to human health (Figure 5).

Figure 5 Respondents' perception of GMO cultivation // Percepția respondenților față de cultivarea OMG-urilor



Source: processing based on questionnaire data

Regarding the future of biotechnology in agriculture, the majority of respondents (over half) believe that biotechnology holds significant potential for the development of agriculture in the future. They are convinced that biotechnologies can play a key role in increasing agricultural production, especially in the face of global challenges such as climate change, frequent droughts and increased food requirements. However, these opinions are accompanied by a constant call for accurate and continuous information for the population. Respondents emphasize that, in order to gain public trust and successfully integrate biotechnologies into agriculture, it is essential that authorities, research institutions and companies in the field provide transparent and accessible information about the benefits and risks associated with their use. In addition, many participants suggest the need for educational campaigns to help citizens better understand biotechnological technologies, differentiate between myths and reality and make informed decisions regarding their use.

Thus, while biotechnology has considerable potential to revolutionize agriculture, there is still a significant need for dialogue and education to overcome public reluctance and create a regulatory framework that addresses safety and sustainability concerns.

CONCLUSIONS

1. Regarding the level of information and knowledge about GMOs, a significant percentage of respondents (80%) are aware of the existence of GMOs, but only 60% manage to provide a correct or partially correct definition of them. This suggests a lack of detailed understanding of biotechnology concepts, even among those who are informed. In addition, the main sources of information are the internet (70%) and television (50%), which indicates a significant dependence on media channels and a potential lack of objective scientific information.
2. The perception of the safety of GMOs is divided. Thus, 40% consider GMOs safe, 35% consider them unsafe, and 25% have no clear opinion. This highlights a general uncertainty among the population about the impact of GMOs on health and the environment, which can be a significant factor in influencing consumer decisions.
3. Regarding product labelling, the majority of respondents (55%) check food labels, but only 35% pay attention to GMO claims. There is a significant desire (78%) for these claims to be mandatory and clear. These findings suggest a clear need for stricter and clearer regulations on the labelling of genetically modified products, to facilitate informed consumer choices.
4. The study highlights a general reluctance to consume genetically modified products, with only 25% of respondents willing to accept them. This low percentage reflects concerns about food safety and long-term health and environmental effects. A significant group (35%) also categorically refuses to consume GMOs for safety and ethical reasons.
5. Regarding the cultivation of GMOs in Romania, 40% of respondents claim that they could be cultivated, but only under strictly regulated conditions. However, 30% are completely opposed, while 10% are open to unconditional cultivation. This factindicates a cautious attitude, but also an interest in the possibility of strict regulation of the use of GMOs, which reflects a desire for a balance between innovation and safety.
6. Trust in the authorities regulating biotechnology is very low (only 15% of respondents have complete trust in them). This highlights a problem of communication and transparency, suggesting that a sustained effort is needed from the authorities to gain public trust and clarify regulations and processes related to GMOs.
7. Over half of respondents believe that biotechnology has significant potential for the future of agriculture, being seen as a solution to increase production and respond to global challenges such as climate change and food needs. However, these views are accompanied by a clear call for accurate and continuous information to ensure public confidence in the use of biotechnology.
8. The study suggests that while biotechnologies and GMOs are perceived as having the potential for more efficient agriculture, there is considerable reluctance to use them, largely due to uncertainty about long-term safety and a lack of transparency in regulations. It is essential that authorities, researchers and industry work together to provide clear, objective and accessible information about biotechnologies so that greater trust in these technologies can be built and their informed and responsible adoption in agriculture can be supported.

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UTILIZATION OF THE OLD MAIZE POPULATIONS IN THE BREEDING PROGRAM FOR EXTRA-EARLY HYBRIDS

ACCESAREA POPULAȚIILOR VECHI ÎN PROGRAMUL DE AMELIORARE A HIBRIZILOR EXTRATIMPURII DE PORUMB

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Abstract

This study explores the potential of old maize populations from Suceava County in northern Romania for inclusion in breeding programs aimed at developing extra-early hybrids. Sixteen local maize populations were evaluated in both field and laboratory conditions to assess their morphological and physiological traits related to earliness, cold tolerance, and productivity. The results revealed significant genetic variability among the populations, with several ones showing promising characteristics for early development and stress resistance. Particular attention was given to traits such as early spring emergence, seedling vigor, flowering time, and grain yield. Populations Rodna 16, Vama 31 and Ciocănești stood out due to their early vegetation onset, uniform development, and resilience to unfavorable environmental conditions. These populations also demonstrated stable productivity and phenotypic traits that make them suitable candidates for hybridization in breeding programs targeting short vegetation cycles. Overall, the study confirms that certain old maize populations in Bucovina possess valuable genetic traits that can contribute to the creation of extra-early maize hybrids. These findings highlight the importance of conserving and utilizing traditional germplasm in modern crop improvement strategies, especially in regions with short growing seasons and climatic constraints.

Rezumat

Acest studiu explorează o parte din potențialul populațiilor de porumb vechi din județul Suceava, din nordul României, pentru includerea acestora în programe de ameliorare care vizează dezvoltarea de hibrizi extra-timpurii si timpurii. Saișprezece populații locale de porumb au fost evaluate atât în condiții de câmp, cât și in laborator pentru a evalua trăsăturile lor morfologice și fiziologice legate de timpurietate, toleranță la frig și productivitate. Rezultatele au relevat o variabilitate genetică semnificativă în rândul populațiilor, câteva prezentând caracteristici promițătoare pentru dezvoltarea timpurie și rezistența la stress termic. O atenție deosebită a fost acordată unor trăsături precum răsărirea, vigoarea, perioada de înflorire și producția de boabe. Populațiile Rodna 16, Vama 31 și Ciocănești s-au remarcat datorită debutului vegetativ timpuriu, dezvoltării uniforme și rezistenței la condiții de mediu nefavorabile. Aceste populații au demonstrat, de asemenea, o productivitate stabilă și trăsături fenotipice care le fac candidate potrivite pentru hibridizare în programele de ameliorare care vizează cicluri de vegetație scurte. Per total, studiul confirmă faptul că anumite populații de porumb vechi din Bucovina posedă trăsături genetice valoroase care pot contribui la crearea de hibrizi de porumb extra-timpurii si timpurii. Aceste constatări subliniază importanța conservării și utilizării germoplasmei tradiționale în strategiile moderne de ameliorare a culturilor, în special în regiunile cu sezoane de creștere scurte și constrângeri climatice.

Keywords: old maize population; extra-early hybrids; breeding program
Cuvinte cheie: populații vechi de porumb; hibrizi extra-timpurii și timpurii; program de ameliorare

INTRODUCTION

Accessing ancient maize populations is essential for genetic diversification and improvement of specific traits of modern crops. Traditional populations present higher genetic variability compared to modern hybrids, which allows the identification of useful genes for traits such as drought tolerance, disease resistance, nutrient use efficiency, production size and quality, etc. By combining traditional selection methods with advanced genetic technologies, these resources can significantly contribute to the creation of new, resistant, more productive and more sustainable varieties. Bucovina is a region with a special agricultural tradition and presents significant diversity in terms of maize crop zoning.

Ancient maize populations in this area represent an essential component of the country's agricultural heritage and an example of important genetic diversity for crop adaptation to local conditions and climate change. Their characterization involves studying various aspects related to genesis, morphology, behavior in the face of environmental factors and their use in agriculture.

The morphological characterization descriptors of plant architecture, cobs, grains and those of physiological characterization regarding plant resistance to breakage and falling, to diseases and sterility, highlight local populations from those studied, as sources of real interest for improvement. Also, earlier populations up to the silking phase were identified, which may constitute a valuable initial material for improving corn earliness.

MATERIAL AND METHOD

Characterization of local maize populations based on physical descriptors involves the evaluation and description of plant morphological traits, which can be used for identification, selection and conservation of genetic diversity. These descriptors provide information about the appearance and structure of plants, being essential for the management and improvement of local maize populations. A number of 16 local maize populations from Bucovina were analyzed.

The morphology of old maize populations is an essential aspect in understanding their characteristics and their adaptability to different environmental conditions. Compared to modern hybrids, old maize populations are distinguished by a greater diversity in morphological traits, due to natural selection and traditional cultivation practices. These traits are directly influenced by the ecological and climatic characteristics of the region in which they are cultivated. We present some key aspects of the morphology of these populations: plant height, main ear insertion height, stem diameter (min./max.), total number of leaves, panicle length, ear length, ear diameter (max./min.), number of rows of grains per ear, number of grains/row, grain weight per ear and 1000-grain weight. These descriptors are used to differentiate local populations, to select material for breeding and conservation programs, as well as to understand their adaptation to local environmental conditions. In addition, the use of a standard set of physical descriptors allows for the objective comparison and assessment of genetic diversity between maize populations.

Among the physiological descriptors studied were: plant resistance to low temperatures, plant vigor, sum of useful temperatures until stigma appearance, plant resistance to breakage and fall, and resistance to fusarium. The observations were carried out directly in the field and in the laboratory before measurements.

In the laboratory, the resistance of corn plants to low temperatures was determined, the assessment being carried out by the Debbert method. The Debbert method is a technique used to evaluate the resistance of plants to low temperatures, especially in corn. This method is used to determine the ability of plants to withstand stress caused by low temperatures or frost, which can negatively affect their development and yield. The purpose of this method is to identify corn genotypes that are more resistant to low temperatures, thus allowing to establish populations that have a greater chance of surviving in cold or frost conditions. There are also more advanced laboratory techniques that can be used to complement the Debbert method, such as genotype analysis or physiological tests that measure plant responses to low temperatures.

In the Debbert method, several parameters are monitored, such as:

- visual assessment of cold stress symptoms: after exposing plants to low temperatures, their general appearance is observed. Symptoms usually include spots or abnormal coloration on the leaves, yellowing, necrosis or stunting.

- measurement of freezing temperature: the temperature at which tissue damage due to freezing begins to occur is determined. This can be done by measuring the temperature at which corn plants begin to show signs of visible damage or by evaluating the electrical conductivity of a leaf extract, which can indicate cellular damage.

- plant vigor testing: plants exposed to low temperature conditions are then monitored as they recover. Measuring the speed of plant recovery is another indicator of their resistance to cold.

According to this method, each variant was made up of two samples: the low temperature test sample and the control sample. For this, each type of genetic resource was sown in two pots (30 seeds each). After germination, 25 plants were left to grow under optimal artificial laboratory conditions: temperature= 25 °C, light 10-15 thousand lux, day (14 hours) and night (10 hours), for 14-15 days until the third leaf developed. At this stage, one pot of each genetic resource was transferred to the LabTech growth chamber available at the unit. (Murariu M. et all., 2010)

Here, the genetic resources matched to those in the laboratory were subjected to 7 days under the same conditions, but with two temperature regimes: night 4-5 °C, day 8-9 °C. The growth chamber performs successive day-night cycles in an automated system, with the achievement of programmed parameters of light, temperature and humidity. After the 7 days of low temperature treatment, the growth chamber casseroles were transferred back to the laboratory, for another 6-7 days next to the paired pots.

Finally, 20 seedlings from the experiment (seedlings subjected to low temperatures in the growth chamber) and 20 seedlings from the control variant (grown under optimal laboratory conditions) were cut. All samples were dried in ovens until constant weight. The coldtest index was assessed after the accumulation of dry mass calculated with Ki index = the ratio of the dry mass of the experimental sample to the control sample, according to the following scale:

- resistant genotypes > 80%
- semi-resistant genotypes 60 - 79%
- weakly resistant genotypes 40 - 59%
- sensitive genotypes < 40%.

The cold-test index with high values coincides in most cases with the higher grades (7,8,9) awarded in the field for plant resistance to low temperatures.

The following estimators were calculated for a number of 13 morphological descriptors and 7 physiological descriptors: arithmetic mean (x), amplitude of variation, variance (s2) and coefficient of variation (s%). The dispersion of the results regarding the morphophysiological characterization descriptors of the analyzed local maize populations provides a conclusive picture of the genetic diversity existing within this category of germplasm, insufficiently exploited.

RESULTS AND DISCUSSIONS

Under natural conditions, corn finds in the Suceava Plateau the necessary rainfall (over 500mm) but also average temperatures of over 8.0 ºC. Below this limit, it is necessary to cultivate early and extra-early hybrids, in order to have enough time to reach maturity before the first frosts and early autumn frosts are recorded.

However, the temperatures required for different phenological phases are also important. Thus, the minimum thermal threshold for triggering germination varies depending on the hybrid, between 6 and 12 ºC. The optimal sowing period is May 1-10, a period in which seed germination and sprouting take place under normal conditions, with average daily temperatures being favorable.

The average temperatures of June and July, exceeding 15 – 16 ºC and approaching 20 ºC (sometimes even exceeding this value), are corresponding to the following phenological phases, which require daily averages of 10-20 ºC after sunrise, until the appearance of the leaf 10-14 and 20-22 ºC during the period of panicle appearance, flowering and silking.

The high daily temperatures and durations of sunshine in this interval, favor first abundant flowering and then normal pollination, under normal conditions of atmospheric and pedological humidity. Both abundant precipitation and their lack during the flowering and pollination period of plants are harmful to these processes.

It has been found so far that optimal development conditions are met for corn cultivation in the Suceava Plateau, especially in its southern part, where thermal advantages prevail, while in the northern half, water conditions prevail. In Suceava too, corn cultivation benefited in the 144 days of phenological evolution from a thermal potential of over 3000ºC and a pluviometric one of 374 mm precipitation (table 1).

Table 1 Phenological evolution and main bioclimatic indicators of corn cultivation in Suceava (5 year average 2020-2024)/ *Evoluţia fenologică şi principalii indicatori bioclimatici ai culturii porumbului la Suceava (medie pe 5 ani 2020-2024)*

No. crt .	Phase phenological	inter-phases (days)	ΣT >0 (°C)		ΣP	
			in inter-phase	cumulative from sowing	mm	mm
1	Sowing					
2	Risen	7	132.7	132.7	17.2	17.2
3	appearance the 3rd leaf	4	126.4	259.1	2.2	19.4
4	appearance panicle	52	1379.1	1638.2	123.9	143.3
5	Flourishing panicle	4	104.3	1742.5	0.0	143.3
6	Flourishing cob	3	67.0	1809.5	0.2	143.5
7	Maturity in milk	25	492.2	2301.7	116.4	259.9
8	Maturity in wax	28	454.4	2756.1	98.4	358.3
9	Maturity wholly	21	271.5	3027.6	16.2	374.5
Total		144	3027.6		374.5	

Type of genetic material	Insertion height (cm)
Local populations	60 – 100 cm
Commercial hybrids (semi-early)	80 – 120 cm
Late hybrids, tall	100 – 140 cm
Inbred lines	50 – 90 cm

The second table shows the values of morphological descriptors in maize populations selected based on the coldtest index>78%. Old maize populations have a variable height, usually lower than modern hybrids. Although plant height can vary significantly depending on the region and cultivation conditions, old maize tends to be more resistant to winds and extreme weather conditions due to its shorter stature.

The total plant height records an average value of 195.4 cm, which denotes that the maize populations analyzed generally have a medium to tall height. However, populations with very tall height over 220 cm (Rodna 26, Ciocănești) and populations with low and very low height, below 160 cm (Slatina22, Valea Stânei 203).

The height of the main ear insertion in corn, represents the distance from the base of the plant (soil) to the attachment point (insertion) of the first ear on the stem. It is an important morphological descriptor used in breeding, agronomy and the evaluation of harvesting mechanization. The average values of the cob insertion height differ depending on the type of genetic material (see tab.1).

The insertion height of the main cob is, on average, approximately 60 cm, with very large variations between populations, from 105 cm, in the very tall population, Ciocănești, to 28 cm, in the very short population, Valea Stânei 203.

The maximum and minimum diameter of the stem, as well as the total number of leaves, are naturally higher in tall populations and lower in short-stemmed populations.

Compared to modern hybrids, the stems of old-growth corn are usually thicker and more resistant, having a better ability to withstand difficult environmental conditions, such as strong winds or the weight of the ear.

The corn leaves of old-growth corn populations are generally wider and longer than those of modern hybrids. They help photosynthesis more efficiently and protect the plant from excessive water evaporation, providing additional protection against drought. The leaves are arranged on the stem in a way that maximizes light capture and minimizes water loss, providing better protection under variable environmental conditions.

The panicle length has an average value of about 63 cm, with a small variation within the populations analyzed, ranging from 70 to 53 cm, regardless of the size of the plants

Morphological descriptors for corn cobs — such as length, maximum diameter and minimum diameter — are essential parameters used in research, breeding and selection, as they directly influence the production potential of a variety or population (Murariu D., et all., 1999).

The descriptors, cob length, maximum diameter and minimum diameter, highlight many populations with large cobs: Rodna 16, Pîrteștii de Sus 1, Rodna 26, Ciocănești. The values of the descriptors regarding cob sizes provide an image of the productivity of the local corn populations analyzed.

Table 2 Values of morphological descriptors in selected maize populations based on coldtest index>78%// *Valorile descriptorilor morfologici în populații selectate de porumb pe baza unui indice de test la rece > 78%*

Population name	Plant height cm	Cob insertion height cm	Maximum diameter, mm	Minimum diameter mm	Total number of leaves	Panicle length cm	Cob length, cm	Maximum cob diameter mm	Minimum cob diameter mm	No. of rows of grains	No. of grains per row	Grain/cob weight g	MMB g
Lunca Ilvei 3	179	51	17	7	9	57	14,9	41,0	31,8	16	31	99	240
Rodna 16	211	68	21	10	10	66	17,5	44,7	33,9	14	37	146	332
Pîrteștii de Sus 1	182	50	19	9	9	65	17,1	45,1	29,0	16	36	137	276
Frumosu 32	196	54	19	8	10	66	12,9	42,7	33,0	14	28	87	244
Solca 3	203	68	20	9	10	65	16,9	43,8	36,3	12	34	133	328
Slatina 2	154	50	17	7	9	53	14,8	43,6	35,1	14	32	121	288
Vama 7	208	51	19	9	9	68	13,7	44,1	32,5	14	30	96	216
Rodna 26	226	79	20	9	10	66	17,2	44,5	35,2	14	36	143	356
Vama 31	192	59	18	7	8	62	15,9	41,5	30,4	16	34	104	212
Straja 14	195	54	19	8	10	65	13,5	41,5	24,7	16	30	85	188
Frumosu 12	189	54	18	8	9	63	16,0	44,6	33,7	16	32	111	220
Frumosu 166	174	44	16	6	8	59	13,1	39,0	22,6	14	29	64	184
Ciocănești	246	105	22	8	14	59	21,0	51,4	39,3	16	42	212	360
Brodina 1	189	59	19	8	8	65	13,8	43,5	26,6	16	32	91	200
Valea stânei 203	155	28	14	5	7	60	14,0	38,0	28,7	16	28	76	176
Pojorâta	172	40	15	6	8	58	11,8	43,7	30,9	16	28	82	200

The weight of grains per cob records an average value of 113.5g, with a very large amplitude of variation (212+63g). A series of populations with high values for this descriptor, over 140 g, are noted: Rodna 16, Vama 31, Ciocănești. The highest value of the weight of grains per cob is the local population of Ciocănești, 212 g. The weight of 1000 grains also highlights local corn populations with values over 300g: Rodna 16, Solca 3, Rodna 26, Ciocănești (table 3).

Table 3 Values of morphological descriptor estimators for old local maize populations characterized in Suceava// *Valorile estimatorilor descriptorilor morfologici pentru populații locale vechi de porumb caracterizate în Suceava*

Estimated	Plant height cm	Cob insertion height cm	Maximum diameter, mm	Minimum diameter mm	Total number of leaves	Panicle length cm	Cob length, cm	Maximum cob diameter mm	Minimum cob diameter mm	No. of rows of grains	No. of grains per row	Grain/cob weight g	MMB g
16 local maize populations tested													
X	194.8	60.6	18.5	8.1	9.4	62.9	16.4	42.5	32.1		32.6	114.8	271.4
Maximal	246.0	105.0	25.0	12.0	14.0	71.0	23.7	52.6	39.9	22	43.0	212.0	484.0
Minimum	132.0	27.0	11.0	5.0	6.0	39.0	10.5	32.2	22.2	10	23.0	48.0	108.0
X2	509.9	209.2	5.7	1.5	1.7	22.2	7.5	12.0	10.6		21.1	1116.2	4490.9
S%	11.6	23.9	12.9	15.2	13.8	7.5	16.7	8.1	10.2		14.1	29.1	24.7
7 local maize populations with higher coldtest index values													
X	195.4	61.2	18.7	8.3	9.4	63.2	16.2	42.8	31.9		33.3	113.5	259.2
Maximal	246.0	105.0	23.0	10.0	14.0	70.0	22.4	51.4	39.3	20	42.0	212.0	456.0
Minimum	154.0	28.0	14.0	5.0	7.0	53.0	11.8	35.3	22.6	10	27.0	63.0	108.0
X2	414.5	198.5	3.6	1.3	1.5	12.3	6.1	9.5	11.7		14.9	988.8	4361.1
S%	10.4	23.0	10.2	13.8	13.0	5.5	15.2	7.2	10.7		11.6	27.7	25.5

From the analysis of the coldtest indices determined for the local populations in the entire experimental system, it results that most of the maize populations are semi-resistant to low temperatures, with the values of this index ranging between 60-79%. However, resistant and even very resistant populations (coldtest index > 80%) were detected in this biological material (Murariu D., 2001).

These populations, to which are added only a few with a coldtest index of 78-79%, were the subject of this study (table 4). Among the local maize populations with very high values of the coldtest index, the following can be highlighted: Slatina 22, Vama 7, Vama 31, Straja 14, Frumosu 12.

Many of these populations show good and very good growth vigor and have proven to be resistant, both at the seedling stage and in the field. These populations represent valuable sources of genes for improving maize resistance to low temperatures.

The sum of useful temperatures (0C) from the sowing period to the appearance of stigmas (silk) represents an indirect indicator of the earliness of maize populations. The calculation of the average of this indicator of development processes and earliness, determined in Suceava, highlights a series of earlier populations up to this phase, needing less than 550 0C t.u. up to the silking phase: Frumosu 32, Vama 31, Straja 14, Frumosu 12, Pojorâta. These populations can constitute a valuable initial material for improving the earliness of maize.

The resistance of plants to breakage and falling represents an important technological indicator for maize. From the analysis of the average results obtained in Suceava it results that the vast majority of the studied populations are less resistant with regard to this characteristic, which can be explained by the fact that old local maize populations represent unimproved genetic material. Only a few populations with a proportion of broken and fallen plants of 25 and below 25% are noted: Pîrteştii de Sus 1, Frumosu 32, Solca 3, Vama 31, Ciocăneşti, Valea Stânei 203.

Table 4 Value of the coldtest index and descriptors of local maize populations// *Valoarea indicelui de temperatură scăzută şi descriptorii populaţiilor locale de porumb*

Population name	Index coldtest	Growth vigor	Resistance to low temperatures in the field	Sum of useful temperatures up to silkiness	Broken + fallen plants at harvest	Sterile plants	*Fusarium* resistance
	%	notes	notes	$0\,^0C$	%	%	notes
Lunca Ilvei 3	81	8,5	8,5	488,2	29,4	23,5	4
Rodna 16	85	9	7,5	531,5	41,6	5,5	7
Pîrteştii de Sus 1	79	7	7,5	531,5	24,0	16,0	7
Frumosu 32	82	7	7,5	518,7	22,5	25,0	6
Solca 3	84	7,5	7,5	557,1	19,3	3,8	5
Slatina 2	90	6,5	8	570,4	37,0	8,7	4
Vama 7	94	6,5	7	570,4	33,3	27,8	7
Rodna 26	83	7,5	8	570,4	34,1	4,5	4
Vama 31	97	6	5,5	544,5	18,2	36,4	4
Straja 14	85	7,5	6,5	518,7	34,8	13,0	6
Frumosu 12	85	7	6,5	531,5	33,3	23,8	5
Frumosu 166	81	7	6	570,4	27,8	16,7	5
Ciocăneşti	84	6.5	6	645.5	18.0	8.0	5
Brodina 1	86	7	5	557.1	28.3	7.7	6
Valea stanei 203	80	6	4.5	557.1	17.5	15.0	6
Pojorata	92	4	6	518.7	27.3	18.2	7

CONCLUSIONS

1. Old maize populations in Romania are highly diverse from a genetic standpoint. These populations have traditionally evolved under various climatic, soil, and cultivation conditions, becoming well-adapted to the different regions of the country. Over the decades, Romanian farmers have preserved these varieties through both natural and local selection practices, leading to the development of populations with genetics specific to their respective regions.

2. The morphology of traditional maize populations in Romania reflects a continuous adaptation process to local environmental conditions, resulting in plants with highly variable traits. These morphological characteristics are crucial for the resilience and adaptability of traditional maize to extreme weather events and for ensuring sustainable yields across a wide range of ecological conditions. Moreover, the morphological diversity of these populations makes them extremely valuable for conserving agricultural biodiversity and contributing to future crop improvement programs.

3. In the Suceava region, where maize cultivation approaches the northern limit of its viable growing area in Romania, specific temperature and humidity conditions highlight the ecological need to improve extra-early and very early maize types. The breeding strategy for such areas should focus on developing high-yielding hybrids with strong ecological plasticity, resistance to low spring temperatures, a short growing season, and genetic resistance to diseases and pests.

4. Breeding efforts will continue with the specific goal of genetically mitigating certain antagonistic correlations between biological processes, so that the resulting maize genotypes align as closely as possible with the proposed ideotype.

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IMPACT OF WATER STRESS ON THE GROWTH AND DEVELOPMENT OF *PHASEOLUS VULGARIS* L.: COMPARATIVE STUDIES AND PERSPECTIVES

IMPACTUL STRESULUI HIDRIC ASUPRA CREȘTERII ȘI DEZVOLTĂRII SPECIEI *PHASEOLUS VULGARIS* L.: STUDII COMPARATIVE ȘI PERSPECTIVE

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Abstract
FAO places Phaseolus vulgaris L. as the most important legume worldwide. Scarcity of water has a significant negative effect on the growth, development and hence crop production of Phaseolus vulgaris L. To assess the drought tolerance of Phaseolus vulgaris L., comparative morphological and physiological studies were carried out by subjecting three variants (two landraces with different geographical origin and one with increased drought resistance) to 8 and 12 days of water stress. The results revealed that the response to water lack is dependent on the intensity of the stimulus, the type of variant analyzed.

Rezumat
FAO plasează specia Phaseolus vulgaris L. pe primul loc, ca fiind cea mai importantă leguminoasă la nivel mondial. Lipsa apei are un efect negativ semnificativ asupra creșterii, dezvoltării și implicit a producției agricole, în cazul speciei Phaseolus vulgaris L. Pentru testarea toleranței la secetă a speciei Phaseolus vulgaris L. au fost efectuate studii comparative la nivel morfologic și, fiziologic, prin expunerea a trei variante (2 populații locale cu origini geografice diferite și o varintă cu rezistență mărită la secetă), la 8 și 12 zile de stres hidric. Rezultatele au arătat că, răspunsul față de lipsa apei este dependent de intensitatea stimulului, de tipul variantei analizate.

Keywords: drought, Phaseolus vulgaris L., physiological studies, morphological studies
Cuvinte cheie: *Phaseolus vulgaris L., secetă, fiziologie, morfologie*

INTRODUCTION

Plant species are considered, in a special kind of way, the lungs of the Earth. Plants are a major source of energy for the existence and evolution of species. FAO states that *Phaseolus vulgaris* L. is the most important legume in the world. This importance derives from the nutritional intake provided to the consumer, e.g. the protein concentration varies between 23-33%, depending on the variety, and the energy intake is provided by the high carbohydrate content (over 50%) (Hayat et al., 2014). Bean seeds are considered a key food in disadvantaged regions of the world, contributing greatly to the food security of the area concerned. Studies based on genome research are essential for understanding plant physiological processes and the changes that occur at the morphological, cellular or biochemical level when plant organisms are exposed to environmental factors less favorable for their growth and development. The information obtained can be essential, in particular, for breeding and can respond to current needs in direct proportion to climate change and, of course, to global population expansion.

Climate change causes severe changes in temperature or long periods of drought, which extremely affects crops regardless of its type by sharply decreasing production yield. If we talk about the production of *Phaseolus vulgaris* L., it can be affected up to 70% by lack of water (Polania et al., 2016).

For this reason, research studies based on the identification of individuals with increased resistance to various abiotic stress factors, mainly water stress, are of great importance at the present time, and the findings may be of major importance, in the creation of resistant varieties to the current pedo-climatic conditions.

Phaseolus vulgaris L. is an important crop worldwide, and biotic and abiotic stresses can decrease bean yields by up to <600 kg/ha^{-1} in poor countries (Porch et al., 2013). Accelerated population growth is in direct proportion to the increasing demand for food, and global warming is resulting in lower crop yields due to reduced rainfall and higher temperatures, which ultimately leads to food insecurity, especially in underdeveloped countries.

Drought is considered to be the greatest abiotic stressor that limits plant growth and development by altering metabolic and biological activities. Currently, about 45% of the world's agricultural lands, where about 38% of the human population is counted, are subject to frequent or continuous drought. Every stage of plant growth is dependent on water, from the germination process to the maturity stage of plants, the lack of water results in crop failure and the socio-economic consequences can be far-reaching (Hussain et al., 2012).

Research studies based on the identification of individuals with increased resistance to various abiotic stress factors, mainly water stress, are of great importance at present, and the findings may be of major significance in the development of varieties resistant to current soil and climatic conditions.

MATERIAL AND METHOD

The biological material used is represented by two landraces (SVGB-1988 - Andean origin, SVGB-2087 - Mesoamerican origin) of the species *Phaseolus vulgaris* L., currently kept in the collection of the Plant Genetic Resources Bank "Mihai Cristea" Suceava, as well as a variety with increased resistance to water stress (Lechința, representing the positive control, the variety is in the collection of the Research and Development Institute for Legumiculture Bacău). A total of 3 variants of *Phaseolus vulg*aris L. were assessed.

To assess whether plants exposed to drought are morphologically affected, a phenotypic characterization of *Phaseolus vulgaris* L. plants from control and water-stressed groups was performed. The studies aimed to determine total plant height, root system length, above-ground height, root system biomass weight, shoot biomass weight and total weight, respectively. The determinations were performed for 5 individuals from each experimental lots.

In this study, the amount of chlorophyll *a*, chlorophyll *b*, total chlorophyll and carotenoids were determined for both control and water-stressed samples. The amount of chlorophyll a and carotenoids, may indicate *Phaseolus vulgaris* L. variants with increased drought resistance. The higher the amount of chlorophyll, the higher the resistance of the plants during drought periods. The chlorophyll pigment IS content was determined by spectrophotometric readings in the UV-VIS range at a certain wavelength, dictated by the type of solvent used (Nayek et al., 2014).

The relative growth rate (RGR) can give an indication of the degree of plant growth under different conditions (normal growth conditions and water stress conditions respectively). This parameter indicates the growth rate of the plant per unittime. The RGR value can be determined by using a mathematical formula, where fresh plant weight values are entered for different growing days: : $RGR=(FW_{t22}-FW_{t30/34})/FW_{t30/34} \times 17$;; where: FW_{t22}, FW_{t30} and FW_{t34}, represent the weight of the fresh plant at 22, 30 and 34 days of growth, respectively (Lizana et al., 2006). From each experimental batch, 5 individuals were evaluated.

The relative water content (RWC) was determined using the method developed by Weatherley (Weatherley, 1950). The method consists of using trifoliate leaves from the plant and weighing them immediately. They are placed in a container of distilled water and kept under these conditions for 4 hours at room temperature and light. The leaves are then weighed and the turgor weight is determined. The leaf tissue is further dried by forced air recirculation at 60°C for 72 hours. The dried samples are weighed and then the weighed values are converted into the formula below, which indicates the relative water content (%): $RWC=(FW-DW)/(TW-DW)X100$ (Qayyum et al., 2021).

RESULTS AND DISCUSSION

Different phenotypic changes and adaptation mechanisms were reported in *Phaseolus vulgaris* L., depending on the intensity of the applied water stress and the variety analyzed. Thus, morphological analysis of SVGB-1988 plants (from the Andean geographical basin) showed the presence of flowers in both irrigated and non-irrigated plants for 8 and 12 days (Figure 1). This is a classic phenomenon of adaptation to lack of water, referred to as drought escape, the plant channels all its energy and nutrients to complete the cell cycle, allowing flower and later fruit development.

Figure 1. Phenotypic study of the variety SVGB-1988 (Andean): a) control lot, irrigated for 30 days; b) water-stressed lot, 8 days; c) control lot, irrigated for 34 days; d) water-stressed lot, 12 days// Studiu fenotipic al soiului SVGB-1988 (Andean): a) lot de control, irigat timp de 30 de zile; b) lot sub stres hidric, 8 zile; c) lot de control, irigat timp de 34 de zile; d) lot sub stres hidric, 12 zile

For the genotype SVGB-2087, a less accentuated development of the individuals in the water-stressed lot was recorded for 8 and 12 days, respectively, compared to the plants irrigated throughout the experiment. Plants in the control plots showed much faster development, which can also be observed by the appearance and development of a much higher number of trifoliate leaves compared to the water-stressed plants with one or at most two poorly developed trifoliate leaf tiers. Figure 2 also shows the appearance of senescence in the leaf tissue for individuals irrigated for 8 days.

Figure 2. Phenotypic study of the variety SVGB-2087 (Mezoamerica): a) control lot, irrigated for 30 days; b) water-stressed lot, 8 days; c) control lot, irrigated for 34 days; d) water-stressed lot, 12 days// Studiu fenotipic al soiului SVGB-2087 (Mezoamerica): a) lot de control, irigat timp de 30 de zile; b) lot sub stres hidric, 8 zile; c) lot de control, irigat timp de 34 de zile; d) lot sub stres hidric, 12 zile

Although the Lechința variety is known to have a higher drought resistance, a simple morphological analysis of the plants shows a poor development of the non-irrigated individuals compared to the control plots (Figure 3), where the flower is also developed and the number of trifoliate leaves is much higher.

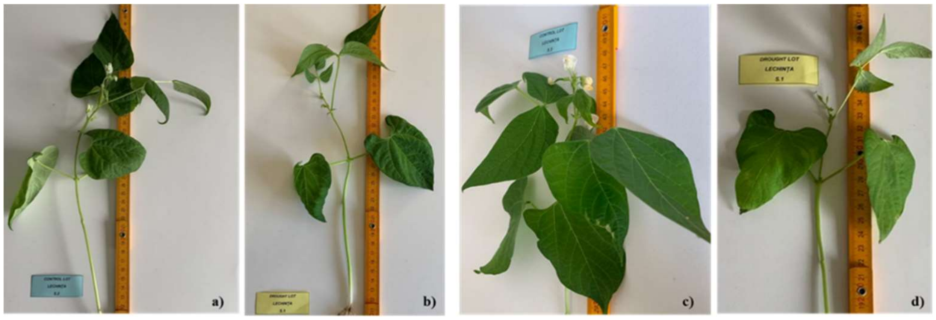

Figure 3. Phenotypic study of the variety Lechința: a) control lot, irrigated for 30 days; b) water-stressed lot, 8 days; c) control lot, irrigated for 34 days; d) water-stressed lot, 12 days// Studiu fenotipic al soiului Lechintima: a) lot de control, irigat timp de 30 de zile; b) lot sub stres hidric, 8 zile; c) lot de control, irigat timp de 34 de zile; d) lot sub stres hidric, 12 zile

After exposure of the *Phaseolus vulgaris* L. variants to 8 days (Figure 4) of water stress, the measurements showed significant and non-significant differences between the individuals belonging to the two experimental groups for all three varieties analyzed, according to the all morphological parameters evaluated.

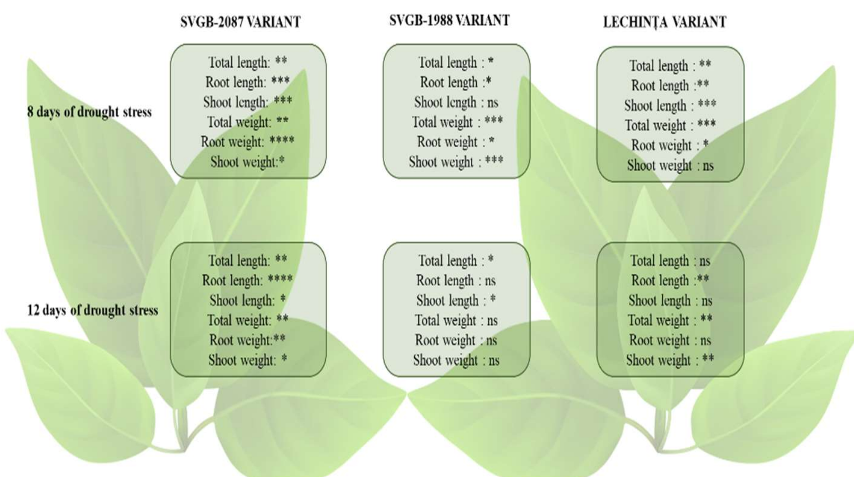

Figure 4. Summary of the differences achieved between irrigated and non-irrigated plots of the 3 varieties of *Phaseolus vulgaris* L., following the determination of morphological parameters and highlighting the statistical significance; with asterisks and "ns" indicating statistically significant differences: (*) $p \leq 0.05$, (**) $p \leq 0.01$, (***) $p \leq 0.001$ and (****) $p \leq 0.0001$// *Rezumatul diferențelor obținute între parcelele irigate și neirigate din cele 3 soiuri de Phaseolus vulgaris L., în urma determinării parametrilor morfologici și evidențierea semnificației statistice; cu asteriscuri și "ns" indicând diferențe semnificative statistic: (*) p ≤ 0.05, (**) p ≤ 0.01, (***) p ≤ 0.001 and (****) p ≤ 0.0001*

When plants do not have a sufficient water supply, they will undergo a variety of changes, not only morphologically, but also physiologically and biochemically. This category includes changes that occur during photosynthesis. Chlorophyll *a* is considered to be the pigment with the main role in photosynthesis, whereas chlorophyll *b* is the pigment that collects energy and passes it on for further processing, chlorophyll *a*. The 8 days of water stress led to a decrease in the concentration of chlorophyll *a* and *b*, but also for carotenoids, for water-stressed plants, compared to the control, for all the genotypes analyzed. However, the 12 days of drought led to a greater decrease in the concentration of assimilatory pigments in non-irrigated compared to irrigated samples. Analyzing from a biochemical point of view, the Lechința variety showed better drought resistance, while the Mesoamerica variety was the least resistant (Figure 5).

During periods of drought, plant organisms respond to these stressors by altering physiological and biochemical processes. By understanding the multiple mechanisms involved in plant resistance to water stress, it is possible to respond to the current challenge posed by global warming to identify specific plant species that can grow, develop and maintain increased yields under less favorable environmental conditions. By determining parameters such as relative water content (RWC) (Figure 6) and relative plant growth rate, it is possible to identify varieties of *Phaseolus vulgaris* L. with increased resistance to water stress factors. In theory, the value of these indicators is lower for drought-exposed individuals, which tolerate these environmental conditions more easily.

Relative leaf water content is an indicator of water content and reflects the balance between leaf tissue water supply and transpiration rate (Soltys-Kalina et al., 2016).

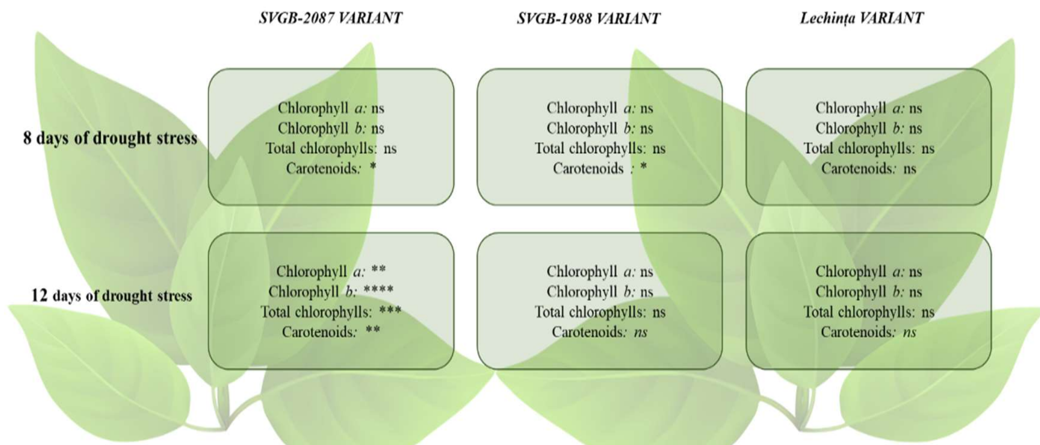

Figure 5. Summary of the differences achieved between irrigated and non-irrigated plots of the 3 varieties of *Phaseolus vulgaris* L., following the determination of some biochemical parameters and highlighting the statistical significance; with asterisks and "ns" indicating statistically significant differences: (*) $p \leq 0.05$, (**) $p \leq 0.01$, (***) $p \leq 0.001$ and (****) $p \leq 0.0001$// Rezumatul diferențelor obținute între parcelele irigate și neirigate din cele 3 soiuri de Phaseolus vulgaris L., în urma determinării unor parametri biochimici și evidențierea semnificației statistice; cu asteriscuri și "ns" indicând diferențe semnificative statistic: (*) p ≤ 0.05, (***) $p \leq 0.001$ and (****) $p \leq 0.0001$

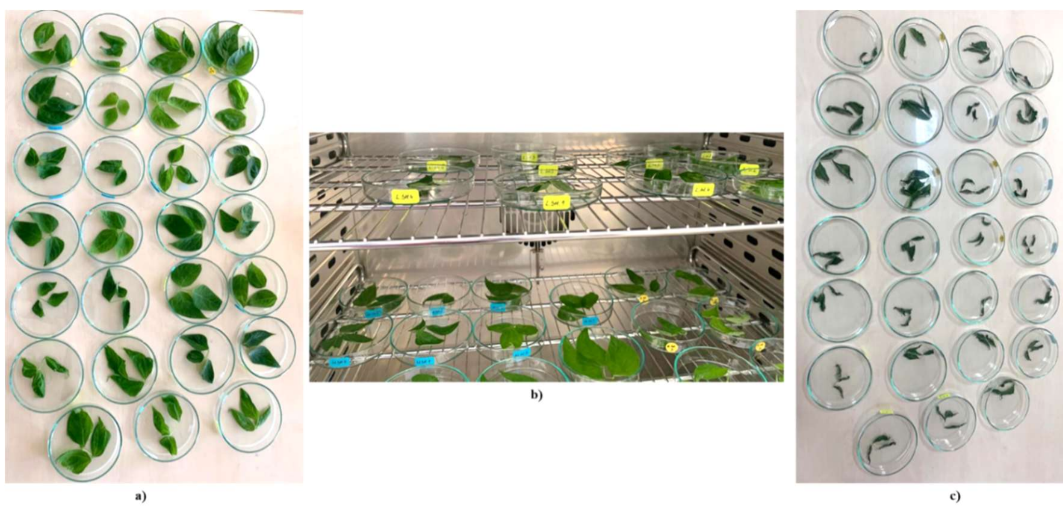

Figure 6. Emphasize the steps involved in the determination of the physiological index - relative water content: a) weighing trifoliate leaves immediately after sampling; b) placing the biological material in an oven at 60°C for 72 hours; c) preparing the dried plant material for final weighing// Evidențierea etapele implicate în determinarea indicelui fiziologic - conținutul relativ de apă: a) cântărirea frunzelor trifoliate imediat după prelevare; b) plasarea materialului biologic într-un cuptor la 60°C timp de 72 de ore; c) pregătirea materialului vegetal uscat pentru cântărirea finală

After 8 days of water stress, the RWC parameter for SVGB-1988 showed large differences between control and water-stressed individuals. For the SVGB-1988 variety, the same significant differences were observed between the individuals of the two groups after 12 days of water stress. The Lechința variety shows the smallest differences between individuals of the two plots (irrigated/non-irrigated), both at 8 days of water stress and at 12 days of water stress. Insignificant differences were observed between individuals of the two experimental plots (irrigated/non-irrigated) of SVGB-2087 after 8 days of water stress. In the case of the same genotype, SVGB-2087, after 12 days of water stress, the differences between the individuals of the two experimental groups were significant.

After 8 days of water stress, the relative plant growth rate varied according to the genotype analyzed. SVGB-1988 showed the greatest difference between individuals of the two experimental groups, both at 8 days of drought and at 12 days. In contrast, insignificant differences were reported between individuals of the experimental plots (irrigated/non-irrigated) and for SVGB-2087 and Lechința varieties at 8 and 12 days of water stress.

CONCLUSIONS

1. Water stress is one of the most important factors limiting productivity in the agricultural sector and its effects are devastating. According to the Food and Agriculture Organization (FAO), by 2021, more than 828 million people were affected by hunger due to drought, with economic losses in the tens of billions of dollars worldwide.
2. Plants need water at all stages of growth and development. Lack of water causes changes and thus responses are generated at morphological, cellular, physiological, biochemical and molecular levels. However, the most important issue is the duration and intensity of water stress.
3. The phenotypic measurements indicated that Lechința and SVGB-1988 (originating from the Andean geographical basin) are the most drought resistant varieties, while SVGB-2087 shows a much lower adaptability to low water environment.
4. Quantification of assimilatory pigments, such as chlorophyll *a*, chlorophyll *b*, total chlorophyll and carotenoids again revealed that Lechința and SVGB-1988 are the most drought resistant varieties compared to SVGB-2087, a genotype with Mesoamerican origins.
5. The determination of physiological parameters such as RGR and RWC revealed the same aspects, the SVGB-2087 variety is the most poorly resistant to water shortage.

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COMPARATIVE MORPHOLOGICAL ANALYSIS OF TRIVALE AND BEZOSTAIA WHEAT VARIETIES WITHIN CONVENTIONAL AND ECOLOGICAL CROP SYSTEMS

ANALIZA MORFOLOGICĂ COMPARATIVĂ A SOIURILOR DE GRÂU TRIVALE ȘI BEZOSTAIA ÎN CADRUL SISTEMELOR DE CULTURĂ CONVENTIONALĂ ȘI ECOLOGICĂ

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Abstract

At the current stage in wheat, the aim is to improve the genetic endowment with as many supports as possible expressed through quantitative and qualitative valences. On the one hand, the aim is to increase the level of grain biomass, and on the other hand, it is also required to obtain sustainability performances for the cultivation environment. Recently, however, this sustainability is also oriented towards promoting the conventional system along with the ecological (green) one. From this point of view an analysis, even morphological aspects, some useful sustainability characters could be identified, with the promotion in fact for both cultivation systems. For the analysis of this material, two wheat varieties with a somewhat longer history in cultivation were used. These are: the Trivale variety, which has been cultivated for over 20 years, and the Bezostaia variety with a much longer history (the 1960s). Both here and elsewhere, it is considered that cereals of the type presented here could increasingly gain ground, given their variable genetic heritage, with greater resilience, high tolerance to biotic and abiotic stress and growth capacity.

Comparing the two varieties cultivated in the two systems: Conventional-Conv. and Ecological-Eco. it was found that the straw length was reduced by about 9 cm in the Trivale variety and by only 2 cm in Bezostaia. The thickness of the straw at the base was thickened in both varieties by the Eco type culture. The ears of the two varieties were shortened in ecological system by 1 cm. The weight of the ears was reduced in both varieties, by 0.8 g in Trivale and 0.4 g in Bezostaia, both by the ecological (Eco) culture. The number of spikelets in the ear was lower by 2 in both varieties in eco system. The membranes of the spikelets - the glumes and the blades were in the same order, shorter by 1 mm. The number of grains in the ear was 12 higher in the Trivale variety compared to Bezostaia, cultivated Conv., and by the Eco system. this number was reduced by 8 grains in Trivale and by 10 grains in Bezostaia in eco system. The weight of the grains in the two varieties was at the level of 0.6 g/Trivale Eco and 0.4 g/Bezostaia-Eco.

Grain length decreased slightly in both Conv. varieties, and grain thickness was greater in Bezostaia Eco. Crude protein remained above 12% in Trivale Conv., as in Bezostaia Conv. The Bezostaia-Eco. variety had a CP of about 11%. Good wet gluten for baking (minimum 22%) was obtained only in Trivale Conv. The Zeleny sedimentation index oscillated in both varieties between the percentages qualified as good-not so good only in the Trivale variety: 9.7 mm to 22.0 mm, while in the Bezostaia variety the percentages were not so good-good in the Conv. and Eco. systems: 21.0 mm to 37.6 mm. The correlations obtained between the main characters emphasized their support at significant positive levels in the Eco. crop system in both varieties. These results could prove to be supportive for the promotion of both current cropping systems and in the case of white luvic soils in the south of the territory.

Rezumat

În etapa actuală la grâu se dorește îmbunătățirea zestrei genetice cu cât mai multe susțineri exprimate prin valențe cantitative și calitative. Pe de o parte este vizată sporirea nivelului biomasei boabelor, iar pe de altă parte se cere și obținerea de performanțe de sustenabilitate pentru mediul de cultură. De curând însă această sustenabilitate este orientată și spre a promova sistemul convențional cu cel ecologic (green). Dintr-o astfel de analiză, chiar și prin aspectele morfologice, s-ar putea identifica unele caractere utile de sustenabilitate, cu promovarea de fapt pentru ambele sisteme de cultură. Pentru analiza din acest material s-au folosit două soiuri de grâu cu vechime ceva mai mare în cultură. Acestea sunt: soiul Trivale care se cultivă de peste 20 de ani și Bezostaia cu vechime mult mai mare (anii '60). Atât la noi, cât și în alte părți se consideră că cerealele de tipul celor de față ar putea să-și facă tot mai mult loc, având în vedere "variable genetic heritage, with greater resilience", cu toleranță ridicată la stresul biotic și abiotic și la creștere.

Comparând cele două soiuri cultivate în cele două sisteme: Convențional-Conv. și Ecologic-Eco. s-a constatat că lungimea paiului s-a redus cu circa 9 cm la soiul Trivale și cu numai 2 cm la Bezostaia. Grosimea paiului la bază a cunoscut îngroșări la ambele soiuri prin cultura de tip Eco. Spicele celor două soiuri s-au scurtat la ambele sisteme Eco. cu 1 cm. Greutatea spicelor s-a redus le ambele soiuri, cu 0.8 g la Trivale și 0.4 g la Bezostaia, ambele prin cultura Eco. Numărul de spiculețe din spic a fost mai mic cu 2 la ambele soiuri Eco. Membranele spiculețelor- glumele și paleile au fost în aceeași ordine, mai scurte cu 1 mm. Numărul de boabe în spic a fost cu 12 mai mare la soiul Trivale față de Bezostaia, cultivate Conv., iar prin sistemul Eco. acest număr s-au redus echivalent cu 8 boabe la Trivale și cu 10 boabe la Bezostaia. Greutatea boabelor la cele două soiuri s-a situat la nivelul 0,6 g/Trivale Eco. și 0.4 g/Bezostaia-Eco.

Lungimea boabelor a scăzut ușor la ambele soiuri Conv., iar grosimea boabelor de grâu a fost mai mare la Bezostaia Eco. Proteina brută s-a menținut la peste 12% la Trivale Conv., la fel ca și la Bezostaia Conv. Soiul Bezostaia-Eco. a avut PB de circa 11%. Glutenul umed bun de panificație (minim 22%) s-a obținut numai la Trivale Conv. Indicele de sedimentare Zeleny a oscilat la ambele soiuri între procentele calificate sub formă de bun-nu așa bun numai la soiul Trivale: 9.7 mm la 22.0 mm, în timp ce la soiul Bezostaia precentele au fost nu așa bun-bun îm sistemele Conv. și Eco. :21.0 mm la 37,6 mm. Corelațiile obținute între principalele caractere au accentuat susținerea acestora la nivele semnificative pozitive în sistemul de cultură Eco. la ambele soiuri. Aceste rezultate s-ar putea dovedi de susținere pentru promovarea ambelor sisteme actuale de cultură și în cazul luvosolurilor albce sin sudul teritoriului

***Keywords**: Conv, cropping systems, Eco, morphology, wheat*
***Cuvinte- cheie**: Conv, Eco, grâu, morfologie, sisteme de cultură*

INTRODUCTION

Being characterized as an ancestral species (Caligari & Bradham, 2001), wheat [Triticum aestivum (L.) Thell ssp. vulgare (Will.) M.K.], (pro syn. Triticum hybernum L., T. macha Dekap. & Menab., T. sativum Lam., T. sphaerococcum Percival, T. vulgare Will., common wheat, bread wheat) has been and still is one of the most important crop plants.

Triticum was adopted from the word threshing (bruising) which means to thresh, and aestivum characterizes the maturation of the plant in summer conditions. Threshing wheat is also called spelt. This characteristic together with genes from the species Aegilops tauschii, give this bread wheat the cold resistance, so necessary in temperate climates. In terms of surface area in the world, wheat actually ranks first, being cultivated in a multitude of ecological conditions.

The purpose of wheat cultivation is the production of grains, usually used in bread making (L-Baeckstrom et al., 2004). Qualitatively, the content of wheat grains in nutrients is considered both diverse (Mason et al., 2007) and balanced (Tester & Langridge, 2010) having a particularly high importance in human nutrition (Austin, 1999; Olesen et al., 2011). Over time, the plant has experienced particularly valuable developments (Bray & West, 2005) and namely through various specific characters.

Wheat represents one of the most diverse cereals/plants from a genetic point of view (Brenchley et al., 2012). Wheat has both autumn types and spring forms, some of which are rambling (Bonjean & William, 2001). There are also varieties with coated grains, while others are naked, with the membranes separated.

The present varieties, Trivale and Bezostaia have the hexaploid genome 2n = 6x (6x7) = 42, with six sets of chromosomes of the form AuAuBBDD (Li et al., 2014). The variety of these two varieties is erythrospermum Körn., with white spike, glabrous glumes and red grain.

The inflorescence of the plant is a terminal, distichous spike, 4-18 cm long, with sessile spikelets, attached solitary on the zigzag rachis. The spikelet is 10-15 mm long, being compressed laterally with two glumes and several flowers. The glumes have a short, blunt tooth-like tip, but also a short awn, 3-5 cm long. Each flower has a palea and lemma (lower membrane/pale). Depending on the variety, the lemma extends in the form of an awn, or as an extension in the form of a hood. When the palea and lemma adhere to the grain, it becomes covered. The grain (caryopses) is ellipsoidal in shape, with a central channel on one side. The grain is generally 4-12 mm long and 1.5-4.0 mm thick. The thousand grain weight (MMB) is between the wide limits of 15-60 g. The plant generally forms stems with heights ranging between 50 (60) and 140 (150) cm (Black & Halmer, 2006).

The research carried out to observe the variation of some morphological characters (Annicchiarico et al., 2010) of the two wheat varieties: Trivale and Bezostaia in the two crop systems - Conv. and Eco. included: i) the stem by the total length of the straw and the thickness of the basal internode, ii) the length and weight of the spike, iii) the number of spikelets/ spike, iv) the length of the external glume, the length of the lower blade (lemma), v) the number of grains/spike, their weight, vi) the dimensions of the grains (length and thickness) and the mass of one thousand grains (MMB). The results were obtained under the soil conditions of the location (Hillocks, 2012).

MATERIAL AND METHOD

The variants were cultivated in the more special climatic conditions of the 2024 harvest with the Trivale and Bezostaia varieties (Marrige, 1985), in two already known cropping systems: the conventional system - Conv. and the ecological system - Eco (Murphy et al., 2007; Przystalski et al., 2008). The experiments were set up at the same time in the two systems, according to the block method, with the variants in an area of 25 m^2 each, in 4 repetitions/ replications.

The technology used was the one recommended by the location for both systems (Tilman et al., 2002; Tomos, 2010). Their characteristic consisted in the fact that the culture soil was constituted by the stagnant albic luvic soil with its characteristics (Mader et al., 2002; Toncea, 2007). At full maturity, 25 plants/stems were randomly chosen from each repetition (100 in total), cut and brought to the laboratory. The 100 stems were measured and determined: total length of the straw, thickness of the basal internode, length and weight of the spike, number of spikelets in the spike, length of the glume and the panicle, number of grains in an ear and their weight, thousand grain mass (MMB), as well as grain dimensions: length and thickness.

The morphological characters (Hole et al., 2005) obtained were statistically analyzed by the histogram method (or frequency polygons-PF%). In their expression, class intervals established according to the specific series of values obtained were used. The study carried out highlighted several aspects, namely: i) the mode values (with the highest frequencies), ii) the limits of the variability intervals of the studied characters and iii) the specificity of each character of the wheat ecotypes in the analyzed area. Correlations were established between the analyzed characters, with the help of which their trends could also be observed within the studied crop systems. The Excel program was used to express the values. The significance of the correlation coefficients was obtained by comparing them with the r_{max} values (Erna Weber, 1961) for the 5%, 1% and 0.1% levels of transgression probabilities.

In the statistical calculation of all obtained values, the analysis of variance (Anova test) was used on the variation series. Statistical parameters were calculated using the formulas: $\bar{a} = \Sigma x/n$, where $\bar{a}$ = the average of the determinations, and x = the determined values, S^2 (variance) $= 1/(n-1)\,[\Sigma x^2 - (\Sigma x)^2/n]$, S (standard error) = $\sqrt{S^2}$), S % (variation coefficient) = $S/\bar{a}.100$.

RESULTS AND DISCUSSIONS

Observations on climatic elements in a year with drought accents (Olsen et al., 2011). Regarding the monthly temperature regime, it was generally found that they exceeded the multiannual average by 2-4^0 C (table 1). In a single month - May, the average value was slightly below normal. For the entire wheat vegetation, the average temperature achieved was +3.2^0 C. Under these conditions of excess heat (Mason et al., 2007) wheat plants showed either an acceleration of vegetation evolution in some plant morphological phases, or a relative stagnation of the deposition of reserve substances in grains (Eira & Caldas, 2000).

The precipitation regime that fell on the wheat vegetation experienced either slightly higher amounts close to normal, or at levels that induced the drought phenomenon. For the initial period, the month of September experienced a reduced level of rain, namely 120 mm. Under these conditions, both the soil water reserve and the establishment of wheat crops were favored. Against this background (Jones et al., 2010), the following periods of drought for wheat were in the months of

October, December and February. The months of November, January, March and April had ensured amounts of water that generally created somewhat more favorable conditions for the growth and development of wheat plants. In order to characterize the wheat crop year in more detail, the hydro-climatic index was used. From the data presented, it is found that for multiannual values, wheat has ensured water factor from sowing to February. For the period of intensive growth and maturity, the values are at sub-optimal levels. In the analyzed crop year, favorable situations were observed only in the months of November, January and March. Drought clearly set in during May and June. However, it is considered that for this year wheat benefited from a relatively good supply through the water reserve accumulated before the sowing period and through the periodic rains in January, March and April.

Table 1. Climatic factors evolution from winter wheat vegetation// *Evoluția factorilor climatici în perioada de vegetație a grâului de toamnă*

	Temperatures t^0C		Precipitations. mm		Hidro-climatic indices, %	
	Multi	2023-2024	Multi	2023-2024	Multi	2023- 2024
Oct.	11.1	15.1	45	7	**125**	19
Nov.	5.5	7.2	51	**67**	**283**	**112**
Dec.	0.7	3.7	44	18	**157**	97
Jan.	-1.1	0.8	40	**70**	**134**	**277**
Feb.	0.7	7.3	38	13	**136**	46
Mar.	4.8	8.1	37	**42**	92	**104**
Apr.	11.0	14.6	54	**45**	75	63
May	16.3	15.8	80	15	83	16
Jun.	19.5	24.7	91	16	80	14
Mean Sum	7.61	10.81	480	293	129.4	83,1
±		**+3.20**	±	**-190**	±	**-46.3**

HI* % = P mm/ETP.100 (ETP, evapotranspiration potential)

Variability of wheat straw dimensions. The wheat stalk or straw has a configuration with several internodes (usually 5-7) with their lengths increasing towards the ear. The actual straw has lengths between 50(60) cm and 150 cm.

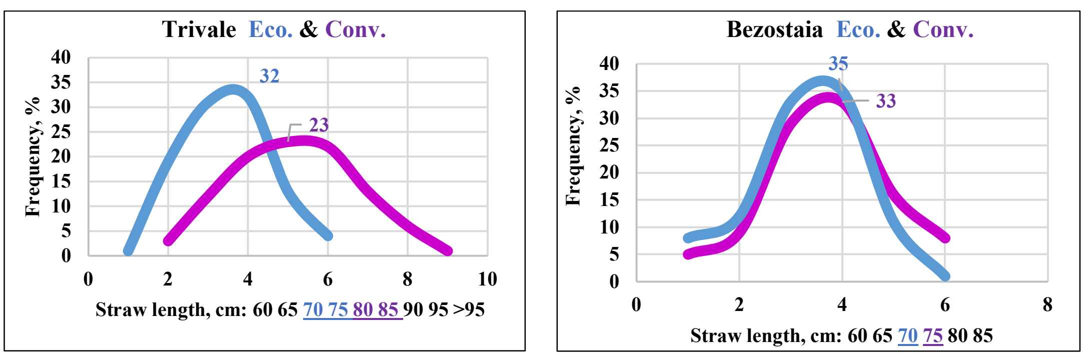

Fig. 1a- 1b. Frequencies of wheat straw length. // *Frecvențele lungimii paiului de grâu*

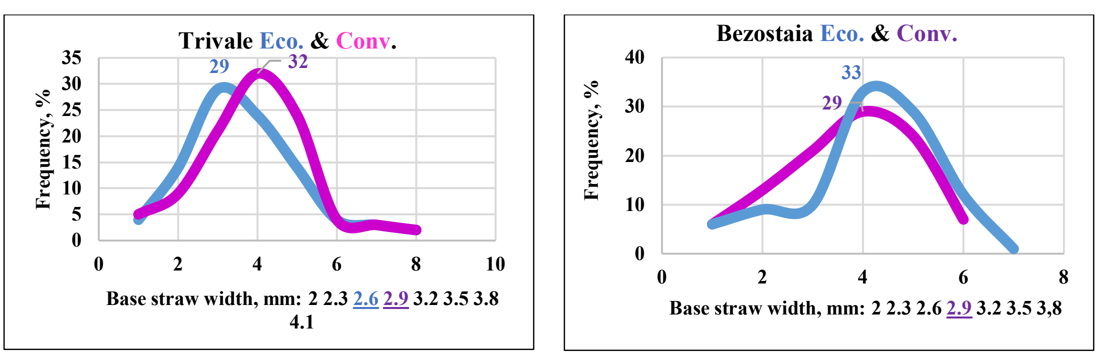

Fig. 2a- 2b. Frequencies of wheat straw diameter// *Frecvențele diametrului paiului de grâu*

At harvest maturity, the stems have a vertical position, with a relatively high task in both varieties. The measurements showed that the straw in the Trivale-Conv. variety was between 65 cm and over

95 cm. The straw of 80-85 cm (23%) had the highest frequency (figure 1a). In the case of Trivale-Eco. the straw had dimensions between 60 cm and 80 cm, with a maximum between 70-75 cm (32%). In the Bezostaia variety, the straws demonstrated a similarity between the systems, regarding length. These ranged from 60 to 85 cm, with the highest frequencies at 70-75 cm (33% and 35%, respectively) (figure 1b).

Regarding the thickness of the straw at the basal internode, specific situations were found depending on the crop system. Thus, in the Trivale variety, the straws had a diameter at the base between 2 mm and 4.1 mm (figure 2a). This size in the Eco. system was dominant at 2.6 mm, compared to Conv. in which 2.9 mm diameter met the highest percentages. The Bezostaia variety demonstrated somewhat smaller straw diameters, between 2 mm and 3.8 mm. The dominants were at the same thickness, namely 2.9 mm with 29% in Conv. and 33% in Eco. From the data in figure 2b, the straw thickness values were somewhat higher in the Eco system. In the images of the two varieties cultivated in the Conv. system, the specific appearance of the plants and ears in the post-flowering period is observed (figure 3a and 3b).

Fig. 3a- 3b. The two varieties of winter wheat, Trivale and Bezostaia, Conv. System // *Aspectul în cultură al celor două soiuri de grâu, Trivale și Bezistaia în sistemul Conv.*

Variability of wheat ears. The appearance and dimensions of the ear of these wheat varieties are characteristic, namely depending on the cropping system practiced. Thus, the length of the ear of the Trivale Conv. variety was between 7 and 11 cm. The length of 9 cm dominated (36%) (figure 4a). In the Eco system, the ears were shorter, between 5 and 10 cm, and the dominant ones were the ears with lengths of 7 cm (38%).

The variability of the length of the ears of the Bezostaia variety demonstrated the same limits: between 5 and 11 cm. In the Conv system, the ears with 8 cm length dominated (45%), while in the Eco system, the ear lengths with 7 cm length (57%) were highlighted (figure 4b).

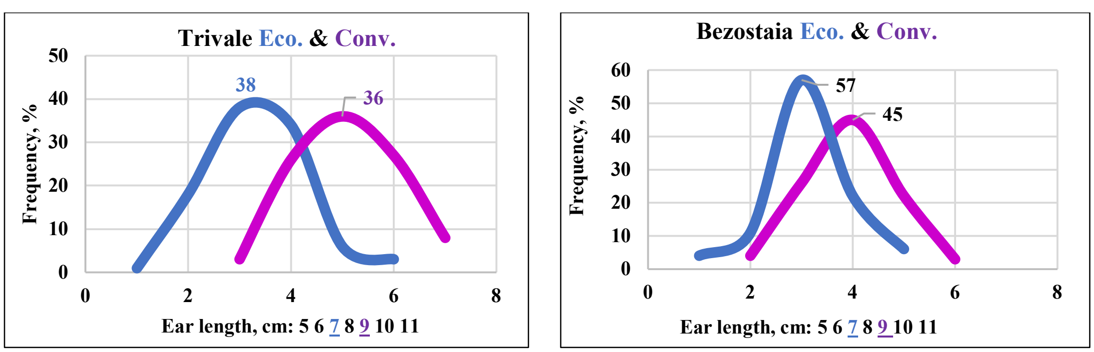

Fig. 4a-4b. Frequencies of wheat ear length. // *Frecvențele lungimii spicului de grâu*

Wheat ear weight showed a more obvious differentiation between the two winter wheat varieties. The Trivale variety formed ears with weights between 1.5 g and over 4 g. (Figure 5a). Spikes with 2.5 g biomass (30%) were dominant. In the Eco system, the Trivale variety formed spikes weighing between 1g and 3g, of which those with 1.5 g dominated. There is a separation of the heavier spikes of the Trivale variety in the Conv. system towards weights of 3g and even 4g. The Bezostaia variety formed similar weights as a range of spike biomass (figure 5b). In the Conv. system, spikes with 2g weight (34%) dominated, while in the Eco system, the most obvious spikes (41%) were at 1.5 g. The graph also shows that the spikes in the Conv. system had an intention to move towards 2.5 g and even 3g.

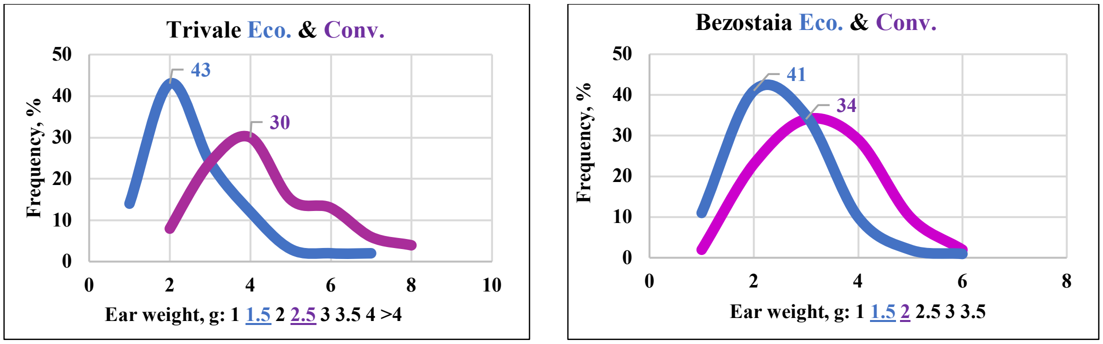

Fig. 5a-5b. Frequencies of wheat ear weight. // *Frecvențele greutății spicului de grâu*

Variability of the absolute weight of wheat grains. The mass of a thousand grains (MMB) showed slight differences in terms of variability (Trivale figure 6a and Bezostaia figure 6b). An analysis of the evolution of the absolute weight of the grains of the two wheat varieties shows the differentiation of the values towards higher thresholds through the Eco system. In the Trivale variety, the grains ranged between 25 g and over 50g (figure 7a). In the Conv. system, MMB was between 25g and 50g, with a maximum frequency at 35g (27-32%). In the Eco. system, the values were wider (as seen above), with a maximum at 40g (53%), as dominance.

Fig. 6a- 6b. The aspect of two wheat varieties from Eco. Systems // *Aspectul spicelor și al boabelor celor două soiuri de grâu cultivate în sistemul Eco.*

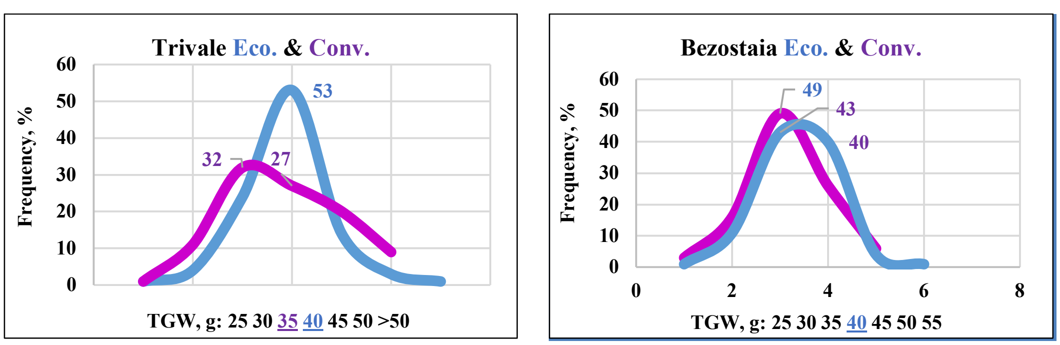

Fig. 7a-7b. Frequencies of TGW wheat grains // *Frecvențele masei a o mie de boabe*.

In the Bezostaia variety, the MMB limits were between 25g and 55g (figure 7b). And in this variety, the same thing was observed in a similar way: the grains obtained in the Eco system. tended to outpace those in the Conv system. The highest frequencies were obtained in both systems at 40g, with frequencies higher than 49% in the Conv system. and also 40 g with higher frequencies at 40-43%.

Correlations between the main characters. The correlations obtained demonstrated positive aspects in their vast majority and with very obvious significance. This is the case of the two winter wheat varieties cultivated in the Eco system.

Thus, correlation values between 0.203 and 0.995 highlight the favorability of cultivating the Trivale variety in this new Eco system (table 2). By comparison with this, in the Conv. system a series of 6 negative correlations were obtained, in particular between straw length with: ear length (-0.065), grain weight (-0.062) and with the mass of a thousand grains (-0.153).

Table 2. Correlations between morphological characters of Trivale wheat from conventional and ecological systems// *Corelații între caracterele morfologice ale soiului de grâu Trivale cultivat în sistemele Conv. și Eco.*

Indices	Ear length, cm	Ear weight, g	No.grains/ ear	Grains weight, g	TGW*, g	Straw length, cm
	Trivale Conv.					
Ear weight, g	.709	1				
No. grains	.773	.933	1			
Grains weight, g	.703	.976	.934	1		
TGW, g	.394	.754	.555	.803	1	
Straw length, cm	-.065	-.048	.014	-.062	-.153	1
Straw diameter, mm	.322	.369	.387	-.079	.254	-.079
	Trivale Eco.					
Ear weight, g	.827	1				
No. grains	.843	.954	1			
Grains weight, g	.813	.995	.955	1		
TGW, g	.306	.525	.287	.541	1	
Straw length, cm	.551	.526	.547	.523	.203	1
Straw diameter, mm	.437	.490	.438	.483	.365	.256
LSD	(5%)- (0.195) (1%)- (0.254) (0.1%)- (0,32)					

TGW*, thousand grains weight

Table 3. Correlations between morphological characters of Bezostaia variety from Conv. and Eco. Sysstems // *Corelații între caracterele morfologice ale soiului Bezostaia cultivat în sistemele Conv. și Eco.*

Indicii	Length ear, cm	Ear weight, g	No.grains/ ear	Grains weight, g	TGW, g	Straw length, cm
	Bezostaia Conv.					
Ear weight, g	.719	1				
Nr. grains	.738	.953	1			
Grains weight, g	.693	.996	.950	1		
TGW, g	.407	.702	.488	.718	1	
Straw length, cm	**-.091**	.094	.063	.099	.194	1
Straw width, mm	.038	.383	.363	.384	.343	.079
	Bezostaia Eco.					
Ear weight, g	.823	1				
Nr. grains	.790	.961	1			
Grains weight, g	.804	.992	.950	1		
TGW, g	.020	.091	.488	.094	1	
Straw length, cm	.249	.298	.063	.312	.240	1
Straw width, mm	.412	.525	.363	.500	.220	.196
LSD	(.05)- (.195) (.01)- (.254) (.001)- (.320)					

Regarding the correlation values between 0.196 and 0.992, they also highlight the favorability of cultivating the Bezostaia variety in this new Eco system (table 3). By comparison, in the Bezostaia Conv. system, a single negative correlation was obtained, especially between straw length and spike length (-0.091).

From a comparative point of view, it is found that in the case of both wheat varieties, the stochastic links between the main morphological characters presented both positive and negative values through the Conv. system, while in the Eco. system these correlations were entirely favorable, positive and very well assured statistically (Wolfe et al., 2008).

Statistical analysis of the morphological characters variability. The results obtained in the morphological analysis of morphological characters in winter wheat showed specific aspects, in both varieties and in both crop systems. Thus, in the Trivale variety the average straw length in the Conv. system was 9 cm higher than in the Eco. system, both with small variabilities (below 10%) (table 4).

Table 4.Statistical indices of some Trivale wheat plants morphology: straw, ear, base glume // Indicii statistici ai unor caractere morfologice la soiul de grâu Trivale: paiul, spicul, gluma inferioară

Indices	Straw length, cm	Ø straw, mm	Ear length, cm	Ear weight, g	No. spikelets	Glume length, mm
	Trivale Conv.					
Mean ā	**78.93**	**2.80**	**8.61**	**2.446**	**17.7**	**9.23**
Variance S^2	55.86	0.15	1.06	0.693	4.34	0.34
Standard deviation, S	7.474	0.39	1.03	0.832	2.08	0.59
Coeff.variability, CV,%	**9.47**	**13.9**	**12.0**	**34.03**	**11.8**	**6.36**
	Trivale Eco.					
Mean ā	**70.28**	**2.62**	**6.86**	**1.584**	**15.0**	**8.29**
Variance S^2	30.04	0.14	1.18	0.375	6.36	0.38
Standard deviation, S	5.481	0.37	1.09	0.613	2.52	0.62
Coeff.variability, CV,%	**7.80**	**14.3**	**15.8**	**38.71**	**16.9**	**7.43**

Table 5.Statistical indices of some Trivale wheat plants morphology: external palea, grains and TGW// *Indicii statistici ai unor caractere morfologice la soiul de grâu Trivale: palea externă, boabele și MMB*

Indices	Palea length, mm	Grain no./ ear	Grain weight, g	Grain length, mm	Grain thick, mm	TGW, g
	Trivale Conv.					
Mean ā	**10.3**	**49.35**	**1.832**	**6.38**	**2.82**	**36.63**
Variance S^2	0.51	152.3	0.475	0.27	0.11	11.60
Standard deviation, S	0.71	12.34	0.689	0.52	0.33	3.405
Coeff.variability, CV,%	**6.91**	**25.01**	**37.61**	**8.12**	**11.9**	**9.296**
	Trivale Eco.					
Mean ā	**9.24**	**31.69**	**1.195**	**5.96**	**2.77**	**37.27**
Variance S^2	0.53	116.3	0.229	0.18	0.02	20.27
Standard deviation, S	0.73	10.79	0.478	0.42	0.13	4.502
Coeff.variability, CV,%	**7.89**	**34.04**	**40.05**	**7.07**	**4.83**	**12.08**

Table 6.Statistical indices of some Bezostaia wheat plants morphology: straw, ear, base glume / *Indicii statistici ai unor caractere morfologice la soiul de grâu Bezostaia: paiul, spicul, gluma inferioară*

Indices	Straw		Ears			
	Length, cm	Width, mm	Length, cm	Weight, g	No. spikelets	Glume, mm
	Bezostaia Conv.					
Mean ā	**71,6**	**2,75**	**7,50**	**1,95**	**18,1**	**8,51**
Variance S^2	22,5	0,05	0,66	0,18	3,83	0,24
Standard deviation, S	4,74	0,23	0,81	0,43	1,96	0,49
Coeff.variability, CV,%	**6,63**	**8,25**	**10,84**	**21,75**	**10,89**	**5,75**
	Bezostaia Eco					
Mean ā	**69,4**	**2,84**	**6,69**	**1,52**	**16,2**	**8,07**
Variance S^2	37,6	0,16	0,64	0,14	7,47	0,31
Standard deviation, S	6,13	0,40	0,80	0,39	2,73	0,56
Coeff.variability, CV,%	**8,83**	**14,07**	**11,92**	**24,21**	**16,84**	**6,90**

The straw thickness decreased in the Eco system by 0.2 mm, with average variability of the character (13.9-14.3%). In the same sense, the spike decreased in length by 1.7 cm, and both had average variability. The weight of the spike was lower by 0.8g in conditions of very high variability (34-38%). The number of spikelets was reduced by 2.7 at an average variability. The dimensions of the grain membranes: the glumes decreased in length by 1 mm, with low variability, and the blades were reduced very little, to 1 mm (table 5). The number of grains in an ear was reduced in the Eco system by 18 against a background of very high variability. The dimensions of the grains of the Trivale variety: the length and thickness had significant decreases, and the MMB was higher in the Eco system by 0.6 g at a low to average variability.

The characters of the Bezostaia variety demonstrated significant reductions in the morphological characters studied. Thus, the straw length decreased by only 2 cm under conditions of straw thickness greater by 0.1 mm in the Conv. system compared to the Eco. system and with similar, small and medium variabilities (table 6). The length of the spikelets decreased by 0.8 cm, and the weight by 0.4 g. The number of spikelets decreased by 2, the jokes being significantly equal. The palea decreased very little, while the number of grains per spike decreased by 10. In the Conv. system, the Bezostaia variety had an average of 37 grains, while in the Eco. system this number decreased to 28 (table 7).

The variability was greater in the Eco system. The weight of the grains per spike decreased by 0.4 g. The grain dimensions showed significant decreases in length and increases of 0.1 mm in thickness. MMB was 1.2 g higher in the Eco system.

Table 7.Statistical indices of some Trivale wheat plants morphology: external palea, grains and TGW// *Indicii statistici ai unor caractere morfologice la soiul de grâu Bezostaia: palea externă, boabele și MMB*

Indices		Grains				
	Palea, mm	No. grains/ ear	Grains weight, g	Grain length, mm	Grain width, mm	TGW, g
		Bezostaia Conv.				
Mean ā	**10,18**	**37,26**	**1,48**	**6,27**	**2,62**	**38,38**
Variance S^2	0,47	23,0	0,01	0,12	0,03	5,36
Standard deviation, S	0,69	4,79	0,10	0,35	0,18	2,32
Coeff.variability, CV,%	**6,75**	**12,86**	**6,67**	**5,55**	**6,92**	**6,03**
		Bezostaia Eco				
Mean ā	**9,71**	**27,94**	**1,10**	**5,93**	**2,74**	**39,62**
Variance S^2	0,55	90,0	0,12	0,15	0,08	14,93
Standard deviation, S	0,74	9,49	0,35	0,39	0,28	3,86
Coeff.variability, CV,%	**7,61**	**33,95**	**31,94**	**6,61**	**10,04**	**9,75**

Aspects of the quality of wheat grains grown in the Conv. and Eco systems. Under the conditions of this year, the expression of quality indices (Hannell et al., 2004; Mader et al., Doltra et al., 2011) was somewhat better. Thus, the crude protein exceeded 12% in all cropping systems, which placed both the Trivale variety and the Bezostaia variety in the first quality, with one exception. The PB content of the Bezostaia variety in the Eco. system placed the grains in the second quality (below 12%). Starch was appropriate in all four situations: varieties and cropping systems. Wet gluten had better quality only in the Conv. system in both varieties, and in the Eco. system in both varieties it was unsatisfactory. The fourth character, the Zeleny sedimentation index, had good values in the Conv. system in the Trivale variety and in the Eco system. at Bezostaia (table 8).

Table 8. Quality indices of Trivale and Bezostaia varieties from the two crop systems// Indicii de calitate obținuți la soiurile Trivale și Bezostaia în cele două sisteme de cultură

System	Grain humidity, %	Crude Protein, %	Starch, %	Wet Gluten, %	Green index (Zeleny, ml)
	Trivale variety				
Conventional	12.6	**12.5**	**69.1**	**24.0**	39.7**
Ecological	15.0	**12.9**	**71.2**	18.8	22.0*
	Bezostaia variety				
Conventional	15.1	**13.6**	**71.6**	18.0	21.0*
Ecological	15.4	10.9	68.4	20.9	37.6**
Observations		Cal.I >12.0%	69.2-72.8 %, good conțent	Minim 22 %, bakery good	Not so good* Good**

It is possible that, given the specific climatic background with periods of drought, existing in the wheat crop, accumulations of nutrients in the grains have occurred, at somewhat better levels, even at higher categories.

CONCLUSIONS

1. The results of this analysis were obtained in a better climatic year: the temperatures during the wheat growing season were somewhat higher, and the rainfall received by the plants of the two wheat varieties was more inconstant. The hydro climatic index better expressed the fact that in three months the wheat benefited from normal rainfall, in two it rained with over 50% of the necessary amount, and in 4 months there were periods of drought. Due to the existing climatic inconstancy, specific morphological reactions were observed in the experiments carried out.
2. Among the morphological characters obtained, there were generally negative differences for the Eco. cultivation system conditions, in the case of both varieties used: Trivale and Bezostaia. There were also some exceptions. Thus, the thickness of the straw at the base of Bezostaia in the Eco system showed more obvious thickening tendencies compared to the Conv. system, and the

mass of a thousand grains expressed higher values in both varieties in the Eco system. From the point of view of improvement, these Eco. cultivation tendencies could also be used in the seed production system.

3. From the study of the correlations between the most important characters, very significant positive situations were found in both varieties in the Eco cultivation system. It is possible that through this cultivation system in the two varieties there was a greater harmonization between the growth and development factors of the plants.
4. The calculation of the studied statistical indices clearly highlighted the differences due to the two crop systems: Conv. and Eco. These calculations generally revealed negative differences in the case of the Eco system, for both varieties. The clearer differentiation between the two crop systems was observed in the case of the Trivale variety. In the case of the Bezostaia variety, the differences between the crop systems were relatively smaller, which leads to a practical advantage by which this very old variety is equally well suited to the Eco crop system. In addition, the thickness of the straw in the Bezostaia variety had larger dimensions, which highlights an increased resistance to plant fall.
5. The mass of a thousand grains demonstrated the achievement of higher values in the Eco system. compared to the Conv system. This actually demonstrated the favoring of this particularly important index in the possibilities of the increasingly broad promotion of the two varieties in the new system of sustainability of the culture environment.
6. The quality of the grains in the case of the two traditional wheat varieties was at relatively high levels, normal and good for baking. For quality, both the Trivale and Bezostaia varieties were also favored by the variability of the three vegetation factors: the warm thermal regime, the relatively sufficient precipitation on a background of water reserves in the soil, from the cold season, and the hydroclimatic index that better demonstrated the passage of the wheat plants this year, of periods with increased drought.
7. The present study demonstrated certain research performances of environmental sustainability by comparing morphological and quality characters of two old varieties, in two farming systems, Conv. and Eco. In addition, this study could also find some aspects of resilience and even tolerance to biotic and abiotic stress, demonstrated by both varieties.

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RESEARCHES ON THE EFFECTS OF CLIMATE CHANGE ON SUNFLOWER, MAIZE AND SORGHUM IN THE CONDITIONS OF THE SOUTH DOBROGEA PLATEAU

CERCETĂRI PRIVIND EFECTELE SCHIMBĂRILOR CLIMATICE LA FLOAREA-SOARELUI, PORUMB ȘI SORG ÎN CONDITIILE PODIȘULUI DOBROGEI DE SUD

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ABSTRACT

Climate change is a phenomenon affecting the plant growth and level, variability and quality of the obtained yields. Therefore, both researchers and farmers are interested to find the most suitable ways to adapt to the present climatic context. Starting from these ideas, the aim of this paper is to present the effects of climate change on sunflower, corn and sorghum in the conditions of the South Dobrogea Plateau, with an emphasis on the effects of hybrid and planting time. Research was performed under rainfed conditions, in the fields of S.C. SPORT AGRA S.RL. located in Amzacea Village, Constanța County, in the South Dobrogea Plateau (South-East of Romania). There were studied 3 crops (sunflower, corn and sorghum) in two years (2022 and 2024, except corn which was cultivated only in 2024), for each crop being tested several hybrids planted at different dates.

Under rainfed conditions, the actual climatic context affects significantly the spring crops (sunflower, corn, sorghum) yielding capacity in South Dobrogea Plateau (South-East of Romania). Among the studied crops, corn is by far the most affected by the climatic changes from the last years. In a context of less favourable climatic conditions, characterised by high temperatures and drought in the vegetation period of the cultivated plants, it becomes essential to choice the most suitable variety for cultivation and to adapt the crop technology. Adaptation of crop technology could be made through several ways, among which the early planting, as soon as the minimum germination temperature for each crop is reached in the soil, is essential. Generally, delaying the planting time is associated with important yield losses to all spring crops.

REZUMAT

Schimbarea climatică este un fenomen care afectează creșterea plantelor și nivelul, variabilitatea și calitatea recoltelor obținute. Prin urmare, atât cercetătorii, cât și fermierii sunt interesați să găsească cele mai potrivite modalități de adaptare la contextul climatic actual. Pornind de la aceste idei, scopul acestei lucrări este de a prezenta efectele schimbărilor climatice la floarea-soarelui, porumb şi sorg în condiţiile Podişului Dobrogei de Sud, cu accent pe efectele hibridului şi momentului semănatului. Cercetările au fost efectuate în condiții de neirigat, pe terenurile S.C. SPORT AGRA S.RL. situate în satul Amzacea, judeţul Constanţa, în Podişul Dobrogei de Sud (sud-estul României). Au fost studiate 3 culturi (floarea-soarelui, porumb şi sorg) în doi ani (2022 şi 2024, cu excepţia porumbului care a fost studiat numai în 2024), pentru fiecare cultură fiind testaţi mai mulţi hibrizi semănaţi la date diferite.

În condiții de neirigat, contextul climatic actual afectează semnificativ capacitatea de producție a culturilor de primăvară (floarea-soarelui, porumb, sorg) în Podişul Dobrogei de Sud (sud-estul României). Dintre culturile studiate, porumbul este de departe cel mai afectat de schimbările climatice din ultimii ani. Într-un context climatic mai puțin favorabil, caracterizat prin temperaturi ridicate și secetă în perioada de vegetație a plantelor cultivate, devine esențială alegerea celui mai potrivit cultivar și adaptarea tehnologiei de cultivare. Adaptarea tehnologiei de cultivare se poate face prin mai multe metode, printre care semănatul timpuriu, imediat ce se atinge temperatura minimă de germinare în sol corespunzător plantei cultivate, este esențială. În general, întârzierea perioadei de semănat este asociată cu pierderi importante de producție la toate culturile de primăvară.

Key words: *climate change, sunflower, corn, sorghum, hybrids, planting time.*
Cuvinte cheie: *schimbări climatice, floarea-soarelui, porumb, sorg, hibrizi, momentul semănatului.*

INTRODUCERE

Climate change is a global phenomenon that poses significant challenges to various sectors including agriculture, rising temperatures, altered precipitation patterns and more frequent extreme weather events transforming the agricultural landscape and posing risks to global food security (Vijai et al., 2023). Climate changes characterized by higher temperatures, extreme climatic hazards and low water for agriculture determine the extension of the areas affected by drought, the agriculture being the most affected by the climate variability and the extreme meteorological phenomenon (Prodan et al., 2021). Climatic variability is a major cause of inability of agricultural crops to achieve potential yield (Agele, 2003). Therefore, understanding crop responses to climate change is crucial for ensuring food security (Hu et al., 2024).

Climate is an important source for the variability of the length of the growth period of the crops (Bran and Ion, 2020), and finally of the variability concerning the obtained yield. The unprecedented rise in temperature has led to an increase in the incidence of heat waves, droughts, floods, and irregular patterns of precipitation; these changes have a dramatic impact on prevailing agricultural cropping systems, productivity, and food security of people regionally and globally (Alotaibi, 2023). Temperature affects the duration of all plant phenological stages (Alberio et al., 2015). Droughts occur naturally, but climate change has generally accelerated the hydrological processes to make them set in quicker and become more intense, with many consequences (Mukherjee et al., 2018).

In Romania, Dobrogea region in South-East Romania is the most drought area, the Constanta County from this region having the largest area cultivated with sunflower crop (Manole et al., 2023). Thus, in Contanța County, sunflower is cultivated on 115-120 thousand ha, while the corn decreased from 55 - 65 thousand ha in 2022 to 27 thousand ha in 2024, and sorghum increased from 155 ha in 2022 to 200 ha in 2024.

Sunflower is a temperate zone crop which can perform well under various climatic and soil conditions (Qadir et al., 2007). This is a versatile crop, which can grow on a wide range of soils in many latitudes and are tolerant of dry conditions (Myers, 2017). If drought resistant cultivars are developed, sunflower can be grown successfully in areas where water is a limiting factor (Farzad et al., 2013). Although sunflower is a moderately drought tolerant crop, severe drought causes reduction in the seed and oil production; therefore, to ensure sustainable sunflower achene and oil yields, it is very important to understand the relationship among the physiological, biochemical, genetic and agronomic basis of drought for its sustainable management (Hussain et al., 2018).

Corn's ecological flexibility makes it "the plant of choice" for grain and feed in climates raging from temperate to tropical as long as there is no frost and mean temperatures are mostly above 10^{o}C (Haraga and Ion, 2022). The great variety of genotypes and the high ecological plasticity made it possible to cultivate corn in different conditions in terms of soil, climate, and relief (Kusmec et al., 2018). Identifying corn hybrids with genetically improved characteristics and high level of adaptability in order to have low yielding losses is indeed relevant (Schitea and Motca, 2013).

Sorghum is one of the World's major cereal crops, it being valued for its grain, stalks and leaves; among different forms, grain sorghum is the most commonly cultivated agronomic type of sorghum worldwide (Dahlberg, 2011). It is particularly adapted to drought prone areas: hot, semi-arid tropical environments with 400-600 mm rainfall-areas that are too dry for other cereals (Dicko et al., 2006). Sorghum is tolerant to water stress at different stages of growth, but the water deficiency may exert its effect on yield and yield components (Abdel-Motagally, 2010).

Variety selection is one of the most important decisions a farmer makes each year for each planting area (Koonsanit et al., 2011). Planting time is important to improve the adaptation of cultivars to environmental conditions and to achieve high seed yields (Butkevičienė et al., 2021). Starting from these ideas, the aim of this paper is to present the effects of climate change on sunflower, corn and sorghum in the conditions of the South Dobrogea Plateau (in South-East Romania), with an emphasis on the effects of hybrid and planting time.

MATHERIAL AND METHOD

Research was performed under rainfed conditions, in the fields of S.C. SPORT AGRA S.RL. located in Amzacea Village, Constanța County, in the South Dobrogea Plateau (South-East of Romania).

There were studied 3 crops (sunflower, corn, and grain sorghum) in two years (2022 and 2024, except corn which was cultivated only in 2024), for each crop being tested several hybrids planted at different dates.

The soil where the research was performed is a cambic chernozem with a deeper profile than other chernozems and a blackish-brown layer of 40-50 cm thickness. The soil is characterised by the following characteristics: medium texture; nitrogen index of 3,34-4; phosphorus content of 72 mg/kg; potassium content of 140 mg/kg; humus content of 3.11%; neutral pH (7.2 value).

Constanta County has temperate continental climate, being characterised by an average annually air temperature of 10.8ºC and an average annually rainfall of 434 mm (Table 1). In the last 10-20 years, the weather were characterised by frequent droughts and high temperatures in the summer period.

Table 1. Average climatic conditions on 69 years in Dobrogea area (S.C.D.A. Valu lui Traian) / Condițiile climatice ca valori medii pe 69 de ani în zona Dobrogea (S.C.D.A. Valu lui Traian)

Month	Rainfall (mm)	Temperature (ºC)
January	58.9	-0.6
February	24.0	0.7
March	25.4	4.0
April	32.1	9.6
May	39.0	15.3
June	47.8	19.5
July	33.8	21.7
August	33.0	21.2
September	29.9	17.0
October	34.2	11.8
November	41.2	6.5
December	34.7	2.1
Annual sum/average	**434**	**10.8**

The water reserve from September to December 2021, for the year 2022, was of 296.5 mm, and the reserve in the same period, but for the year 2024, was of 168.6 mm (Tables 1 and 2). In the period March-July, the cumulated rainfall was of 158 mm in 2022 and of 267.5 mm.

The year 2022 was characterised by drought in May (with only 14 mm rainfall) and by severe drought in July and August (with only 10 mm rainfall in two months) (Table 2). In total, in the year 2022, the rainfall amount was of 336.5 mm.

The year 2024 was characterised by rainy periods in April (118 mm rainfall) and August (186 mm rainfall), but with drought in June and July (Table 3). In total, in the year 2024, the rainfall amount was of 751.5 mm.

For all the three study crops (sunflower, corn, sorghum), the preceding crop was winter wheat. After harvesting the wheat, the soil was loosened to a depth of 23-25 cm without turning the furrow. After that soil tillage, the soil was kept free of weeds by applying an herbicide based on glyphosate. Before winter, there were performed a soil work with a combinatory. In spring, the soil was worked before planting with a combinatory.

The weed control was performed by using herbicides according to crop, the diseases were control at sunflower crop, and the pest were control by using insecticides at sorghum crop (Table 4). For all the three crops, after 10-12 days from the herbicide application in the vegetation period (Table 4), there were performed the first mechanical weeding, and with the second mechanical weeding there was applied the ammonium nitrate fertilizer (34% N) in a rate of 200 kg/ha for sunflower and sorghum and 370 kg/ha for corn.

Table 2. Climatic conditions in the period September 2021 – December 2022 in Amzacea / Condițiile climatice în perioada septembrie 2021 – decembrie 2022 la Amzacea

Months in 2021					**Months in 2022**												
09	10	11	12	**Amount**	01	02	03	04	05	06	07	08	09	10	11	12	**Amount**
40	115	49	92.5	**296.5**	19	40	42	46,5	14	45,5	10	3	69,5	0	26	21	**336.5**

Table 3. Climatic conditions in the period September 2023 – December 2024 in Amzacea / Condițiile climatice în perioada septembrie 2021 – decembrie 2022 la Amzacea

Months in 2023					**Months in 2024**												
09	10	11	12	**Amount**	01	02	03	04	05	06	07	08	09	10	11	12	**Amount**
0	2.4	119.2	47	**168.6**	29	2.2	39.5	118	68	13.5	28.5	186	63	57	56	90.4	**751.1**

Table 4. Synthetically data on crop technology of the three analysed crops in 2022 and 2024 / Date sintetice cu privire la tehnologia de cultură la cele 3 culturile analizate în 2022 și 2024

Crop	**2022**	**2024**

Sunflower	- Herbicides applied in pre-emergence:
	  - Efica 960 EC (S-Metolachlor 960 g/l) in rate of 1.5 l/ha;
	  - Racer 25 EC (Fluorocloridon 250 g/l) in rate of 2 l/ha.
	- Herbicides applied in vegetation period:
	  - Trimmer 50 WG (Tribenuron-methyl 500 g/kg) in rate of 0.03 kg/ha, applied only at the resistant hybrids.
	- Fungicides applied in vegetation period:
	  - Mirage 45 EC (Prochloraz 450 g/l) in rate of 1 l/ha applied in the growth stage of 6-8 leaves;
	  - Pictor (Dimoxystrobin 200 g/l + Boscalid 200g/l) in rate of 0.5 l/ha applied in the growth stage of flower bud appears.
	- Planting density: 64,250 seeds/ha.
	- Harvesting date: 23 of August.
		- Herbicides applied in pre-emergence:
		  - Efica 960 EC (S-Metolachlor 960 g/l) in rate of 1.5 l/ha;
		  - Racer 25 EC (Fluorocloridon 250 g/l) in rate of 2 l/ha.
		- Herbicides applied in vegetation period:
		  - Pulsar Plus 25 EC (Imazamox 25 g/l) in rate of 2 l/ha, applied only at the resistant hybrids;
		  - Trimmer 50 WG (Tribenuron- methyl 500 g/kg) in rate of 0.03 kg/ha, applied only at the resistant hybrids.
		- Fungicides applied in vegetation period:
		  - Pictor (Dimoxystrobin 200 g/l + Boscalid 200g/l) in rate of 0.5 l/ha applied in the growth stage of flower bud appears.
		- Planting density: 64,500 seeds/ha.
		- Harvesting date: 14 of August.

Corn	-	- Herbicides applied in pre-emergence:
		  - Efica 960 EC (S-Metolachlor 960 g/l) in rate of 1.5 l/ha.
		- Herbicides applied in vegetation period:
		  - Pyxides (Dicamba 312.5 g/kg + Mesotrione 150 g/kg + Nicosulfuron 100 g/kg) in rate of 0.6 kg/ha applied in the growth stage of 4-6 leaves.
		- Planting density: 72,000 seeds/ha.
		- Harvesting date: 14 of August.

Sorghum	- Herbicides applied in pre-emergence:
	  - Efica 960 EC (S-Metolachlor 960 g/l) in rate of 1-1.5 l/ha.
	- Herbicides applied in vegetation period:
	  - Dicopur D (600 g/l acid 2.4 D from Dimethylamine salt) in rate of 1 l/ha applied in the growth stage of 3-4 leaves.
	- Insecticides applied in vegetation period for controlling *Schizaphis graminum*:
	  - Lamdex Extra (Lambda- cyhalothrin 25 g/kg) in rate of 0.30 kg/ha.
	- Planting density: 262,000 seeds/ha.
	- Harvesting date: 23 of August.
		- Herbicides applied in pre-emergence:
		  - Efica 960 EC (S-Metolachlor 960 g/l) in rate of 1-1.5 l/ha.
		- Herbicides applied in vegetation period:
		  - Basagran SL (Bentazona 480 g/l) in rate of 2 l/ha + Dicopur Top 464 SL (344 g/l acid 2.4 D from Dimethylamine salt + 120 g/l Dicamba) in rate of 1 l/ha applied in the growth stage of 3-4 leaves.
		- Insecticides applied in vegetation period for controlling *Schizaphis graminum*:
		  - Lamdex Extra (Lambda-cyhalothrin 25 g/kg) in rate of 0.30 kg/ha.
		- Planting density: 280,000 seeds/ha.
		- Harvesting date: 20 of August.

The seeds for all the three crops were treated with Cruiser 350 FS (Thiamethoxam 350 g/l) in a rate of 10 l/t for sunflower, 9 t/t for corn and 8 l/t for sorghum, for controlling especially the pests *Tanymecus dilaticolis* and *Agriotis* spp. At sunflower, the seed were also treated with the fungicide Apron XL 350 ES (Metalaxyl-M 350 g/l) in a rate of 3 l/t. The planting depth was of 5-6 cm for sunflower, 6-7 cm for corn and 4 cm for sorghum.

Together with planting, there were applied the complex fertilizer Granoro (N-10:P-20:K-0 + 4CaO + $20SO_3$ + 0.03Zn + 0.01B + 7.5C-Org 2N-Org) in a rate of 250 kg/ha in the year 2022, and the complex fertilizer Universal Up (N-9:P-30:K-0 + 6CaO + $11SO^3$) in a rate of 200 kg/ha in the year 2024.

There were tested several hybrids for each crop planted at different dates (Table 5), each hybrid being cultivated on a plot of 560 m^2.

Table 5. Synthetically data on planting date and tested hybrids of the three analysed crops in 2022 and 2024 / Date sintetice cu privire la data de semănat și hibrizii studiați la cele 3 culturi analizate în 2022 și 2024

Crop	2022		2024	
	Planting date	Tested hybrids	Planting date	Tested hybrids
Sunflower	March 26	- 6 hybrids with resistance at Tribenuron-Methyl: P64LE25; P64LE99; P64LE162; Suomi; Sureli; Aromatic - 13 hybrids with resistance at Imazamox: P64LP170; P64LP180; Odessa; Onestar; Michigan; Genesis; Janis; Anthemis; Acordis; Aluris; Dracaris; InSun 200; InSun 222	April 8	- 4 hybrids with resistance at Tribenuron-Methyl: Ceylon; P64LE99; P64LE162; P64LE280 - 7 hybrids with resistance at Imazamox: P64LP170; Genesis; Belfis; Coloris; InSun 222; Dragaris; Michigan
	April 8	- 2 sunflower hybrids with resistance at Imazamox: Genesis; In Sun 200		
Corn	-	-	April 8	- 7 hybrids: Maxxatac; Lipex; MyLady; LID3306; P8812; P8834; Chorintos
	-	-	April 20	- 1 hybrid: Maxxatac
Sorghum	March 26	- 3 hybrids: Anggy; Huggo; Iceberggg	April 8	- 4 hybrids: Anggy; Legend; Feohn; Willy
	April 8	- 1 hybrid: Anggy	May 7	- 4 hybrids: Anggy; Legend; Feohn; Willy

RESULTS AND DISCUTIONS

In the two years of research, the climatic factors, especially air temperature and soil temperature, influenced the planting time and the growth phases, especially in the case of sunflower and corn crops, and less so in the case of grain sorghum.

In the year 2022, with a normal spring in terms of air temperature, the planting time was March 26, both in the case of sunflower and sorghum. In the year 2024, the late spring frosts that occurred in the last decade of March and the first decade of April made the planting time to be on April 08 for all the three studied crops, respectively sunflower, corn, and sorghum.

In the year 2022, the sunflower, as well as the sorghum developed well. At sunflower, the flowering process occurred in the period June 23 – 29, according to hybrid and planting time (Table 6). The plant height was in average of 188 cm for the resistant hybrids at Tribenurom-Methyl and of 179.5 cm for the resistant hybrids at Imazamox. Seed moisture content differed according to the hybrid, respectively with the precocity of the hybrid, and planting time. Hectolitre Mass was in average good, with values over 40 kg/100 l and a variation between 36.5 and 43.5 kg/100 l.

The grain yield registered good and very good values, being in average of 4358.7 kg/ha for the resistant hybrids at Tribenurom-Methyl and of 4430.4 kg/ha for the resistant hybrids at Imazamox (Table 6). For the resistant hybrids at Tribenurom-Methyl, the highest grain yield of 4608 kg/ha was registered at the Surely hybrid, while for the resistant hybrids at Imazamox the highest grain yield of 5260 kg/ha was registered at the InSun 222 hybrid.

Delaying the planting time from March 26th to April 08th delayed the flowering time, decreased the plant height, the Hectolitre Mass and the grain yield, and increased the seed moisture content at harvesting (Table 6). Delaying of planting time at Genesis hybrid decreased the grain yield by 63 kg/ha (1.4% yield decrease), while the delaying of planting time at InSun 200 hybrid decreased the grain yield by 852 kg/ha (19% yield decrease).

Table 6. Results obtained at sunflower in the year 2022 / Rezultate obținute la floarea-soarelui în anul 2022

Nr. Crt.	Hybrid	Planting date	Emergence date	Plants / m^2	Flowering date	Plant height (cm)	Seed moisture content (%)	Hectolitre Mass (kg/100 l)	Yield at 9% moisture (kg/ha)
Tribenurom-Methyl resistent hybrids									
1	P64LE25	26.03.2022	13.04.2022	6.5	28.06.2022	210	11.5	38.5	4525
2	P64LE99	26.03.2022	15.04.2022	6.5	28.06.2022	182	15.5	39.6	4590
3	P64LE162	26.03.2022	15.04.2022	6.0	28.06.2022	215	13.6	40.8	4258

Nr. Crt.	Hybrid	Planting date	Emergence date	Plants / m²	Flowering date	Plant height (cm)	Seed moisture content (%)	Hectolitre Mass (kg/100 l)	Yield at 9% moisture (kg/ha)
4	Suomi	26.03.2022	15.04.2022	6.5	21.06.2022	165	10.2	43	4322
5	Sureli	26.03.2022	13.04.2022	6.0	28.06.2022	180	12.9	41	4608
6	Aromatic	26.03.2022	15.04.2022	5.0	28.06.2022	176	12.1	40.4	3849
Average		**-**	**-**	***6.1***	**-**	***188.0***	***12.6***	***40.5***	***4358.7***
CV (%)		**-**	**-**	***8.77***	**-**	***9.68***	***13.21***	***3.40***	***6.03***
Imazamox resistent hybrids									
7	P64LP170	26.03.2022	13.04.2022	7.0	28.06.2022	171	12.1	36.5	4757
8	P64LP180	26.03.2022	13.04.2022	6.5	23.06.2022	192	12.7	38.5	4298
9	Odessa	26.03.2022	13.04.2022	6.0	23.06.2022	170	12.8	39.8	4766
10	Onestar	26.03.2022	13.04.2022	6.5	23.06.2022	174	10.8	43.3	4252
11	Michigan	26.03.2022	13.04.2022	6.0	28.06.2022	178	12.8	41	4336
12	Genesis	26.03.2022	13.04.2022	6.0	21.06.2022	168	8.6	42.6	4616
13	**Genesis**	**08.04.2022**	**27.04.2022**	**6.0**	**28.06.2022**	**165**	**9**	**41.4**	**4553**
14	Janis	26.03.2022	13.04.2022	6.0	23.06.2022	160	8.2	43.1	4364
15	Anthemis	26.03.2022	15.04.2022	6.0	28.06.2022	182	9.4	39.5	4401
16	Acordis	26.03.2022	13.04.2022	6.5	28.06.2022	180	12.7	37.8	4255
17	Aluris	26.03.2022	13.04.2022	6.5	29.06.2022	198	11	39	4112
18	Dracaris	26.03.2022	15.04.2022	6.0	23.06.2022	195	8.1	43.5	4368
19	InSun 200	26.03.2022	13.04.2022	6.0	29.06.2022	185	9.5	39	4485
20	**InSun 200**	**08.04.2022**	**28.04.2022**	**5.0**	**02.07.2022**	**183**	**12.1**	**37.1**	**3633**
21	InSun 222	26.03.2022	15.04.2022	6.5	28.06.2022	192	12.4	39.3	5260
Average		**-**	**-**	***6.2***	**-**	***179.5***	***10.8***	***40.1***	***4430.4***
CV (%)		**-**	**-**	***7.05***	**-**	***6.21***	***16.37***	***5.50***	***7.81***

For grain sorghum in 2022, the seed moisture content was below 15% but in the case of the Anggy hybrid planted later on April 8th, the registered seed moisture content was 16.8% (Table 7). The Hectolitre Mass was in average of 78.7 kg/100 l, with a variation from 77.7 to 79.7 kg/100 l, according to hybrid and planting time. The grain yield was in average of 6922.7 kg/ha, with a variation from 6418 kg/ha for the hybrid Icebergg and 7710 kg/ha for the hybrid Anggy planted on March 26th.

As in the case of sunflower, also for the sorghum the delaying the planting time from March 26th to April 08th increased the seed moisture content and decreased the Hectolitre Mass and the grain yield where registered (Table 7). The delaying of planting time at Anggy hybrid decreased the grain yield by 647 kg/ha (8.4% yield decrease).

Among the determined parameters, the highest coefficient of variation was registered for the seed moisture content, while the most stable one, with the smallest values of the coefficient of variation, was the Hectolitre Mass, both for sunflower and sorghum. The yield coefficient of variation for the sunflower hybrids resistant at Tribenurom-Methyl was of 6.03%, for the sunflower hybrids resistant at Imazamox it was of 7.81%, and for the sorghum hybrids was of 7.48%.

Table 7. Results obtained at sorghum in the year 2022/ Rezultate obținute la sorg în anul 2022

Nr. Crt.	Hybrid	Planting date	Emergence date	Plants / m²	Plant height (cm)	Seed moisture content (%)	Hectolitre Mass (kg/100 l)	Yield at 14% moisture (kg/ha)
1	Anggy	26.03.2022	30.04.2022	21	-	13.1	79.3	7710
2	**Anggy**	**08.04.2022**	**04.05.2022**	**21**	**-**	**16.8**	**78.0**	**7063**
3	Huggo	26.03.2022	30.04.2022	21	-	13.5	79.7	6500

Nr. Crt.	Hybrid	Planting date	Emergence date	Plants / m²	Plant height (cm)	Seed moisture content (%)	Hectolitre Mass (kg/100 l)	Yield at 14% moisture (kg/ha)
4	Icebergg	26.03.2022	30.04.2022	21	-	14.8	77.7	6418
Average		-	-	*21*	-	*14.55*	*78.7*	*6922.7*
CV (%)		-	-	*0*	-	*9.92*	*1.07*	*7.48*

In the year 2024, the sunflower hybrids, as well as the corn hybrids and sorghum hybrids developed not so well. The high daily temperatures of June and July negatively influenced the pollination processes, the formation and filling of grains in sunflower and corn hybrids. The registered temperatures at the Amzacea weather station were: June 9th - 29.7ºC; June 11th - 31.3ºC; July 9th- 34ºC; July 12th - 35.3ºC; July 16th - 34.6ºC; July 18th - 34.7ºC; July 19th - 34ºC; July 28th- 33ºC.

At sunflower, the flowering process occurred in 2024 in the period of June 21-29, according to hybrid (Table 8). The plant height was in average of 170.7 cm for the hybrids resistant at Tribenurom-Methyl and of 173.5 cm for the resistant hybrids at Imazamox. Seed moisture content differed according to the hybrid, respectively with the precocity of the hybrid, this being smaller than that registered in 2022, with the smallest value reaching 6.4%. Hectolitre Mass was not as good as in 2022, with values less than 40 kg/100 l and a variation between 33.4 and 38.4 kg/100 l.

The sunflower hybrids yield registered values below 2000 kg/ha with two exceptions, respectively hybrid Ceylon with 2211 kg/ha and hybrid P64LE162 with 2148 kg/ha. The grain yield was in average of 2082.2 kg/ha for the resistant hybrids at Tribenurom-Methyl and of 1601.0 kg/ha for the resistant hybrids at Imazamox (Table 8).

At corn, the flowering process occurred in 2024 in the period of June 23 – July 5, according to hybrid and planting time (Table 9). The seed moisture content varied between 18.1% in the case of Maxxatac hybrid planted on April 8th and 35.3% in the case of the same hybrid but planted later on April 20th. The Hectolitre Mass registered the extreme values for the same hybrid Maxxatac, respectively 58.4 kg/100 l when the planting was on April 20th and 61.8 kg/ha when the planting was on April 8th. The yield varied between 966 kg/ha in the case of hybrid Chorintos and 3524 kg/ha in the case of Maxxatac hybrid planted on April 8th. Delaying the planting from April 08th to April 20th in the case of Maxxatac hybrid decreased the yield with 1565 kg/ha, representing 44.4% (Table 9).

As in 2022, in the case of sunflower and sorghum, delaying the plating time for corn in 2024 increased the seed moisture content and decreased the Hectolitre Mass and the yield.

If sunflower in 2024 registered the coefficient of variation with the smallest value for Hectolitre Mass (3.47%), a small valued for seed moisture content (6.88%) and a high value for grain yield (10.85%) (Table 8), the corn registered also the smallest value for Hectolitre Mass (2.58%), but a much higher value for seed moisture content (20.08%) and even a much higher values for yield (34.10%) (Table 9). This means a much more variation between corn hybrids for seed moisture content and grain yield than in the case of the sunflower hybrids.

Table 8. Results obtained at sunflower in the year 2024 / Rezultate obținute la floarea-soarelui în anul 2024

Nr. Crt.	Hybrid	Planting date	Emergence date	Plants / m²	Flowering date	Plant height (cm)	Seed moisture content (%)	Hectolitre Mass (kg/100 l)	Yield at 9% moisture (kg/ha)
Tribenurom metil resistent hybrids									
1	Ceylon	8.04.2024	17.04.2024	6	23.06.2024	178	12.1	38.4	2211
2	P64LE99	8.04.2024	17.04.2024	6	27.06.2024	162	13.2	34	1979
3	P64LE162	8.04.2024	17.04.2024	6	26.06.2024	174	10.6	36.2	2148
4	P64LE280	8.04.2024	17.04.2024	6	24.06.2024	169	8.6	33.4	1991
Average		-	-	*6*	-	*170.7*	*11.1*	*35.5*	*2082.2*
CV (%)		-	-	*0*	-	*3.50*	*15.51*	*5.56*	*4.80*
Imazamox resistent hybrids									

Nr. Crt.	Hybrid	Planting date	Emergence date	Plants / m²	Flowering date	Plant height (cm)	Seed moisture content (%)	Hectolitre Mass (kg/100 l)	Yield at 9% moisture (kg/ha)
5	P64LP170	8.04.2024	17.04.2024	7	29.06.2024	188	7.9	35.9	1705
6	Genesis	8.04.2024	17.04.2024	7	23.06.2024	162	6.4	37.8	1628
7	Belfis	8.04.2024	17.04.2024	7	26.06.2024	165	7.5	37.9	1712
8	Coloris	8.04.2024	17.04.2024	8	29.06.2024	173	7.1	37.1	1314
9	InSun 222	8.04.2024	17.04.2024	7	26.06.2024	172	7.0	36.6	1618
10	Dracaris	8.04.2024	17.04.2024	6	26.06.2024	185	6.9	34.4	1317
11	Michigan	8.04.2024	17.04.2024	6	26.06.2024	155	7.7	34.5	1809
12	P64LP170	8.04.2024	17.04.2024	7	29.06.2024	188	7.9	35.9	1705
Average		-	-	***6.9***	-	***173.5***	***7.3***	***36.3***	***1601.0***
CV (%)		-	-	***7.05***	-	***6.76***	***6.88***	***3.47***	***10.85***

Table 9. Results obtained at corn in the year 2024 / Rezultate obținute la porumb în anul 2024

Nr. Crt.	Hybrid	Planting date	Emergence date	Plants / m²	Flowering date	Seed moisture content (%)	Hectolitre Mass (kg/100 l)	Yield at 14% moisture (kg/ha)
1	Maxxatac	8.04.2024	17.04.2024	7.0	23.06.2024	18.1	61.8	3524
2	Maxxatac	20.04.2024	5.05.2024	7.0	5.07.2024	35.3	58.4	1959
3	Lipex	8.04.2024	17.04.2024	7.0	24.06.2024	19.4	61.2	1978
4	MyLady	8.04.2024	17.04.2024	6.8	27.06.2024	25.6	60.7	2017
5	LID3306	8.04.2024	17.04.2024	7.0	26.06.2024	22.7	60.5	1640
6	P8812	8.04.2024	17.04.2024	7.0	26.06.2024	23.1	61.7	1785
7	P8834	8.04.2024	17.04.2024	7.0	27.06.2024	25.8	58.8	1837
8	Chorintos	8.04.2024	17.04.2024	7.0	01.07.2024	25.4	63.6	966
Average		-	-	***6.97***	-	***24.4***	***60.8***	***1963.2***
CV (%)		-	-	***0.95***	-	***20.08***	***2.58***	***34.10***

At sorghum in 2024, the plant height was in average of 120 cm, with a variation from 110 cm to 140 cm, according to hybrid and planting date (Table 10). Seed moisture content varied between 11.9 and 16.1%, and Hectolitre Mass varied between 70.2 and 76.9 kg/100 l, according to hybrid and planting date.

The average yield was of 3335.2 kg/ha, with limits of variation from 2768 kg/ha (Feohn hybrid planted on May 7th) to 3998 kg/ha (Legend hybrid planted on April 8th). In average for the four studied sorghum hybrids planted on April 8th 2024, the yield was of 3576.7 kg/ha, while when they were planted on May 7th 2024, the average yield was of 3093.7 kg/ha, which mean a decrease of 483 kg/ha, representing 13.5% (Table 10).

Also for sorghum in the climatic conditions of 2024, delaying the planting time increased the seed moisture content and decreased the plant height and the yield (Table 10). The coefficient of variation registered the smallest value for Hectolitre Mass (3.05%) and the highest value for yield (10.70%) (Table 10).

Table 10. Results obtained at sorghum in the year 2024/ Rezultate obținute la sorg în anul 2024

Nr. Crt.	Hybrid	Planting date	Emergence date	Plants / m²	Plant height (cm)	Seed moisture content (%)	Hectolitre Mass (kg/100 l)	Yield at 14% moisture (kg/ha)
1	Anggy	8.04.2024	17.04.2024	27	130	11.9	73.6	3281
2	**Anggy**	**7.05.2024**	**19.05.2024**	**26**	**115**	**16.1**	**74.3**	**2972**
3	Legend	8.04.2024	17.04.2024	27	115	14.5	70.2	3998
4	**Legend**	**7.05.2024**	**19.05.2024**	**27**	**110**	**14.6**	**71.3**	**3195**
5	Feohn	8.04.2024	17.04.2024	25	140	13.9	74	3396
6	**Feohn**	**7.05.2024**	**19.05.2024**	**26**	**120**	**14**	**76.9**	**2768**

Nr. Crt.	Hybrid	Planting date	Emergence date	Plants / m^2	Plant height (cm)	Seed moisture content (%)	Hectolitre Mass (kg/100 l)	Yield at 14% moisture (kg/ha)
7	Willy	8.04.2024	17.04.2024	26	120	12.3	77.1	3632
8	**Willy**	**7.05.2024**	**19.05.2024**	**27**	**110**	**12.6**	**74.9**	**3440**
Average		**-**	**-**	***26.4***	***120***	***13.7***	***74.0***	***3335.2***
CV (%)		**-**	**-**	***2.64***	***8.07***	***9.54***	***3.05***	***10.70***

Regarding the weed control, it has to be pointed out that the autumn application of the herbicide active substance glyphosate led to a good control of some weed species from the monocotyledonous group, such as *Sorghum halepense*, *Echinocloa* spp., *Setaria* spp. etc., as well as of some broadleaf weed species. In recent years, a whole series of weeds such as *Veronica* sp., *Chenopodium album*, *Convolvulus arvensis*, and *Apera spica-venti* cannot be completely controlled due to the lack of appropriate herbicide active substances.

In 2022, the weed control at the sorghum crop by applying in the vegetation period of the herbicide Dicopur D based on one active substance, respectively 2.4 D from Dimethylamine salt, was not enough for a good control of the weeds. In exchange, in 2024, the mixture of the three active substances, respectively Bentazona from Basagran SL herbicide, and 2.4 D from Dimethylamine salt + Dicamba from Dicopur Top 464 SL herbicide controlled well the range of weeds in sorghum crop. Also, in 2024, the use of the three active substances Dicamba + Mesotrione + Nicosulfuron from the Pyxides herbicide in post-emergence (4-6 leaves) realised a good weed control in corn crop.

Planting early the sunflower, corn, and sorghum crops has reduced the attack of corn leaf weevil (*Tanymecus dilaticollis* Gyll.), which is an important pest for these crops in Romania, especially in the areas from South and South-East. Also, planting early the sunflower crop reduced the attack of broomrape (*Orobanche cumana* Wallr.), which is very problematic in South-East of Romania.

CONCLUSIONS

1. Under rainfed conditions, the actual climatic context affects significantly the yielding capacity of the spring crops (sunflower, corn, sorghum) the spring crop (sunflower, corn, sorghum) yielding capacity in South Dobrogea Plateau (South-East of Romania). Among the studied crops, corn is by far the most affected by the climatic changes from the last years.
2. In a context of less favourable climatic conditions, characterised by high temperatures and drought in the vegetation period of the cultivated plants, it becomes essential to choice the most suitable variety for cultivation and to adapt the crop technology.
3. Adaptation of crop technology could be made through several ways, among which the early planting, as soon as the minimum germination temperature is reached in the soil, that being essential. Generally, delaying the planting time is associated with important yield losses to all spring crops.
4. Another important task to be reached in the crop technology is to have a well weed control, thus eliminating the weeds which are competitors to cultivated plants for growing resources.
5. For the studied area, early planting proved to be a good way to diminish the negative aspects related to the pest *Tanymecus dilaticollis* Gyll. and to the parasitic plant *Orobanche sp*.

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RESEARCH ON THE INFLUENCE OF SOME TECHNOLOGICAL SEQUENCES ON PRODUCTIVITY IN DRACOCEPHALUM MOLDAVICA UNDER ORGANIC FARMING

CERCETĂRI PRIVIND INFLUENŢA UNOR SECVENŢE TEHNOLOGICE ASUPRA PRODUCTIVITĂŢII LA SPECIA DRACOCEPHALUM MOLDOVICA ÎN CONDIŢII DE AGRICULTURĂ ECOLOGICĂ

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Rezumat.

În lucrarea de faţă se prezintă date privind influenţa epocii de semănat şi a spaţiului de nutriţie la specia Dracocephalum moldavica asupra producţiei de herba şi sământă, cultivată în sistem de agricultură ecologică în cadrul laboratorului de Plante medicinale şi aromatice de la S.C.D.A. Secuieni în perioada 2018-2020. În urma interacţiunii factorilor, distanţa între rânduri şi distanţa între plante pe rând s-a constatat că la varianta semănată la 50 cm între rânduri şi 25 cm între plante pe rând s-a evidenţiat cea mai ridicată producţie de sământă de 648 kg/ha. În ceea ce priveşte producţia de herba uscată, aceasta a oscilat între 9103 kg/ha la varianta semănată în decada a III-a a lunii martie şi 10236 kg/ha la varianta semănată în decada a II-a a lunii aprilie.

Abstract.

This paper presents data on the influence of sowing time and nutrition space at the Dracocephalum moldavica species on herb and seed production, cultivated in an organic farming system within the Medicinal and Aromatic Plants Laboratory at A.R.D.S. Secuieni during 2018-2020. Following the interaction of factors, row spacing and plant spacing, it was found that the variant sown at 50 cm between rows and 25 cm between plants per row showed the highest seed production of 648 kg/ha. As for dry herb production, it ranged between 9103 kg/ha in the variant sown in the third decade of March and 10236 kg/ha in the variant sown in the second decade of April.

Cuvinte cheie: *mătăciune, sămânță, herba*

Key words: *moldavian dragonhead, seed, herb*

INTRODUCTION

The moldavian dragonhead is an annual species native to the Himalayas, which is cultivated for its aerial part (herb) which contains a volatile oil similar to lemon balm oil, rich in citral a and b (up to 80%), geranyl acetate, linalool, nerol etc. Among the chemical elements contained are: gallo-tannins (5-10%), salicarin, ferric hydroxide, flavonoid substances, heterosides, orientin, anthocyanin pigments-diglycosides of malvidol and galactosides of cyanidol, choline, glucose, starch, choline, a phytoncide with antibiotic activity, antibiotic substances, pectins, carotenoids, mineral substances, traces of volatile oil. The butterbur is part of some medicinal teas used in diseases of the digestive system and the nervous system (Abedi et al.,2015; El-Baky et al., 2007).

The species *Dracocephalum moldavica* L. has antimicrobial and antibacterial properties, being widely used in the pharmaceutical, cosmetic, food and perfumery industries. In the form of tea it is used to alleviate headaches, abdominal pain, remedy in treating flu, nervous system pain, kidney pain, gastrointestinal and tooth pain. This plant can also be used as a poultice in rheumatic pain (Galambosi, 1989; Hassani, 2006; Omidbaigi, 2006).

The research was conducted between 2018-2020 at the Agricultural Research and Development Station Secuieni and aimed to establish the optimal sowing time and the optimal nutrition space for the *Dracocephalum moldavica* L. species in order to develop cultivation technology in an ecological system.

The research was carried out between 2018 and 2020, in the experimental field of the Agricultural Research and Development Station Secuieni, on a typical cambic phaeozem (chernozem) soil with a medium to neutral texture (pH/H2O – 7.26). The soil on which the experiment was located was characterized as being well supplied in active humus (2.33%), very well supplied in phosphorus (189 mg/kg), potassium (304 mg/kg), excessively supplied in Mg (253 mg/kg) and Mn (369 mg/kg), poorly supplied in nitrogen (9.4 mg/kg N – NO3) and Zn (1 mg/kg). The area where the unit is located has a temperate continental climate (D.f.b.x. Köppen), characterized by short springs, cool summers and harsh winters, with an average annual temperature of 10.1°C and an annual amount of precipitation of 537 mm (Trotuş et al., 2020).

For the *Dracocephalum moldavica* species (Moldavian dragonhead), the establishment of technological links in the organic farming system was aimed at represented by the sowing period and the establishment of the optimal nutrition space.

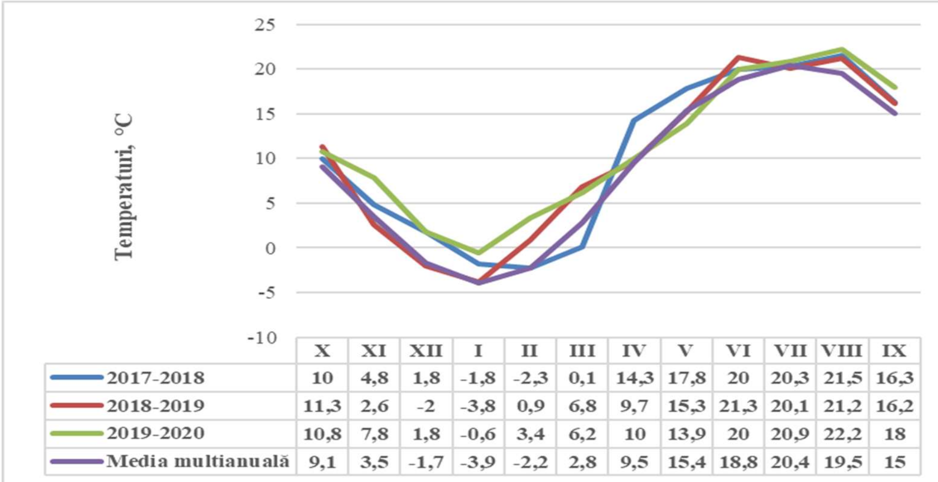
Under the conditions at A.R.D.S. Secuieni, three sowing periods were experimented in a monofactorial experiment:
V1 – Epoch I - sowing in the first emergency (third decade of March - beginning of April - control);
V2 – Epoch II - sowing in the second emergency (second decade of April - third decade of April);
V3 – Epoch III - late sowing (last decade of April - beginning of May).

In order to establish the optimal nutrition space, a bifactorial experiment was set up according to the method of plots subdivided into 3 repetitions in which the following factors were experimented:

Factor A – distance between rows, with 3 graduations:
a1 – 25 cm,
a2 – 50 cm,
a3 – 70 cm.

Factor B – distance between plants per row, with 3 graduations:
b1 – continuous row (approx. 5 cm between plants/row),
b2 – 15 cm,
b3 – 25 cm.

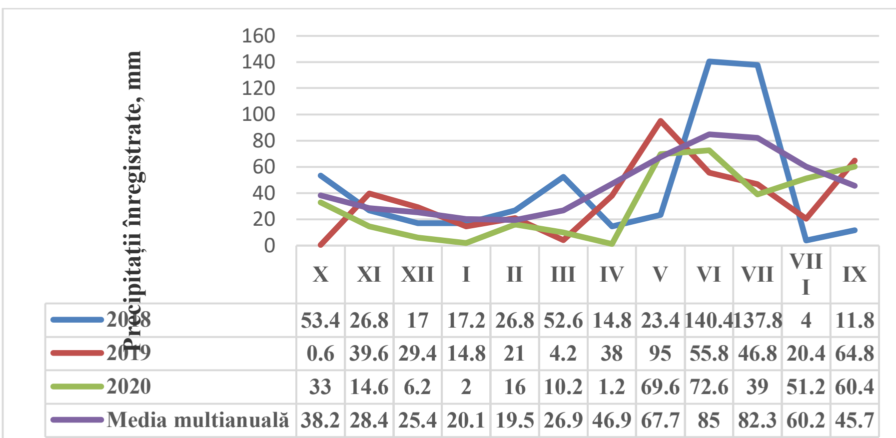
The 2017/2018 agricultural year was characterized by a late spring as a result of the negative average temperatures recorded in the first decade of March (-3.1ºC), as well as precipitation in the form of snow. The 2018/2019 agricultural year was characterized as warm in terms of temperatures and dry in terms of the annual amount of precipitation that was unevenly distributed during the plant vegetation period.



	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX
2017-2018	10	4,8	1,8	-1,8	-2,3	0,1	14,3	17,8	20	20,3	21,5	16,3
2018-2019	11,3	2,6	-2	-3,8	0,9	6,8	9,7	15,3	21,3	20,1	21,2	16,2
2019-2020	10,8	7,8	1,8	-0,6	3,4	6,2	10	13,9	20	20,9	22,2	18
Media multianuală	9,1	3,5	-1,7	-3,9	-2,2	2,8	9,5	15,4	18,8	20,4	19,5	15

Figure 1 Temperatures recorded at A.R.D.S. Secuieni in the period 2018-2020// Temperaturile înregistrate la S.C.D.A Secuieni în perioada 2018-2020

The 2019/2020 agricultural year was characterized by an early spring as a result of the high average temperatures recorded in March (6.2ºC), as well as the precipitation deficit of only 10.2 mm, with a deviation from the multiannual average of 26.2 mm. April was with 0.5 ºC warmer and 45.7 mm less in precipitation, while May was with 1.5 ºC colder than normal. Land preparation and sowing were difficult, with plant emergence being staggered and uneven.



	X	XI	XII	I	II	III	IV	V	VI	VII	VIII	IX
2018	53.4	26.8	17	17.2	26.8	52.6	14.8	23.4	140.4	137.8	4	11.8
2019	0.6	39.6	29.4	14.8	21	4.2	38	95	55.8	46.8	20.4	64.8
2020	33	14.6	6.2	2	16	10.2	1.2	69.6	72.6	39	51.2	60.4
Media multianuală	38.2	28.4	25.4	20.1	19.5	26.9	46.9	67.7	85	82.3	60.2	45.7

Figure 2 Precipitation recorded at A.R.D.S. Secuieni in the period 2018-2020// Precipitațiile înregistrate la S.C.D.A. Secuieni în perioada 2018-2020

RESULTS AND DISCUSSION

Following the determinations made on the plants from the three sowing periods, it was found that the average height of the plants was between 60.50 cm at the 3rd sowing period and 86.12 cm at the 2nd sowing period. The average number of branches/plant ranged between 12.3 at the 3rd sowing period and 15.1 at the 2nd sowing period. Distinctly significant positive differences compared to the control (13.6) were recorded for the variant sown in the 2nd decade of April (1.5) (table 1).

Table 1. Biometric determinations of the species *Dracocephalum moldavica* L. in the period 2018-2020// Determinări biometrice la specia *Dracocephalum moldavica* L. în perioada 2018-2020

Variant	Average plant height (cm)	%	Diff. (cm)	Sign.
Epoch I	78.92	100	Ct.	
Epoch II	86.12	109.12	7.2	*
Epoch III	60.50	76.65	-18.42	ooo
LSD 5%= 5.2 cm 1%= 10.63 cm 0.1%= 17.41 cm				
Variant	Average number of branches/plant (no.)	%	Diff.	Sign.
Epoch I	13.6	100	Ct.	
Epoch II	15.1	111.02	1.5	**
Epoch III	12.3	90.44	-1.3	oo
DL5%= 0.52 1%= 1.15 0.1%=2.17				
Variant	Average plant weight (g)	%	Diff. (g)	Sign.
Epoch I	78.14	100	Ct.	
Epoch II	89.13	114.06	10.99	**
Epoch III	72.00	92.14	-6.14	o
LSD 5%= 4.86 g 1%= 8.04 g 0.1%=14.04 g				

Analyzing the influence of the sowing season on the average dry herb production, under the conditions at A.R.D.S. Secuieni, it is observed that it oscillated between 9103 kg/ha (epoch I) and 10236 kg/ha (epoch II) (table 2).

Table2. The influence of the sowing season on the production of dry herb at *Dracocephalum moldavica* species in the period 2018-2020 // Influenţa epocii de semănat asupra producţiei de herba uscată la specia *Dracocephalum moldavica* în perioada 2018-2020

Variant	Average dry herb yield (kg/ha)			
	Kg/ha	%	Diff. (kg/ha)	Sign.
Epoch I	9103	100	Ct.	
Epoch II	10236	112.44	1133	*
Epoch III	9538	104.77	435	
	LSD 5%= 894 (kg/ha) ; LSD 1%= 1436 (kg/ha) ; LSD 0,1%= 2347 (kg/ha)			

During the period under study, the average seed production varied between 750 kg/ha in the third epoch of sowing and 850 kg/ha in the variant sown in the second epoch. A statistically significant increase was obtained in the variant sown in the second decade of April (115 kg/ha) (table 3).

Table 3. The influence of the sowing season on the production of seed at *Dracocephalum moldavica species* in the period 2018-2020 // Influenţa epocii de semănat asupra producţiei de sămânţă la specia *Dracocephalum moldavica* în perioada 2018-2020

Variant	Average seed yield (kg/ha)			
	Kg/ha	%	Diff. (kg/ha)	Sign.
Epoch I	778	100	Ct.	
Epoch II	850	109.25	115	*
Epoch III	750	96.40	-63	
	LSD5%= 75 (kg/ha); LSD 1%= 136 (kg/ha): LSD 0,1%= 205 (kg/ha)			

Table 4. The influence of the interaction between the distance between rows and the distance between plants in a row on the average production of dry herb at moldavian dragonhead in the period 2018-2020 // Influenţa interacţiunii dintre distanţa între rânduri şi distanţa între plante pe rând asupra producţiei medii de herba uscată la mătăciune în perioada 2018-2020

Distance between rows (A)	Distance between plants/rows(B)	Average dry herb yield (kg/ha)	%	Diff.	Sign.
a1-25 cm	b1-cca. 5 cm	9531	100	Ct.	
	b2-15 cm	9647	101,21	116	
	b3-25 cm	9822	103,05	291	
a2-50 cm	b1-cca. 5 cm	10360	108,69	829	**

Distance between rows (A)	Distance between plants/rows(B)	Average dry herb yield (kg/ha)	%	Diff.	Sign.
	b2-15 cm	10486	110,01	955	**
	b3-25 cm	10566	110,85	1035	**
a3-70 cm	b1-cca. 5 cm	10423	109,35	892	**
	b2-15 cm	10375	108,85	844	**
	b3-25 cm	10241	107,44	710	*
LSD 5%= 542 kg/ha LSD 1%= 821 kg/ha L 0.1%= 1318 kg/ha					

The interaction of the studied factors influenced the average dry herb production within limits ranging from 9531 kg/ha for the a1xb1 variant (25 cm between rows x 5 cm between plants/row) and 10566 kg/ha for the a2xb3 variant (50 cm between rows x 25 cm between plants/row) (table 4).

Regarding the average seed production at the tiller, positive, significant and distinctly significant differences were obtained for the variants sown at 50 cm and 70 cm between rows, the statistically assured production increases were between 137 kg/ha and 495 kg/ha (table 5).

Table 5. The influence of the interaction between the distance between rows and the distance between plants in a row on the average production of seed at moldavian dragonhead in the period 2018-2020 // Influenţa interacţiunii dintre distanţa între rânduri şi distanţa între plante pe rând asupra producției medii de sămânță la mătăciune în perioada 2018-2020

Distance between rows (A)	**Distance between plants/rows(B)**	**Average seed yield (kg/ha)**	**%**	**Diff.**	**Sign.**
a1-25 cm	b1-cca. 5 cm	876	100	Ct.	
	b2-15 cm	833	95,09	-43	
	b3-25 cm	894	102,05	18	
a2-50 cm	b1-cca. 5 cm	1136	129,68	260	***
	b2-15 cm	1245	142,12	369	***
	b3-25 cm	1371	156,51	495	***
a3-70 cm	b1-cca. 5 cm	1236	141,10	360	***
	b2-15 cm	1115	127,28	239	***
	b3-25 cm	1013	115,64	137	*
LSD 5%= 77 kg/ha LSD 1%= 140 kg/ha LSD 0,1%= 210 kg/ha					

CONCLUSION

1. At the *Dracocephalum moldavica* L. species, the highest production of dry herb and seed was recorded in the variant sown in the second decade of April.
2. Analyzing the interaction of the studied factors on the average production of dry herb and seed, it was found that in the variants sown at distances of 50 cm and 70 cm between rows, the production differences were positive compared to the experimental control sown at 25 cm between rows.

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RESEARCH ON AGROTECHNICAL FEATURES OF CICHORIUM INTYBUS, PALATABILITY AS COWS' FEEDSTUFF AND THE EFFECTS ON MILK PRODUCTION

CERCETĂRI PRIVIND ASPECTELE AGROTEHNICE ALE CICORII FURAJERE, PALATABILITATEA ÎN FURAJAREA VACILOR ȘI EFECTELE ASUPRA PRODUCȚIEI DE LAPTE

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Abstract

The current study aimed to assess the Cichorium intybus agrotechnical and nutritional features, also the impact of it on milk production related to perennial gramineous and legumes. The agrotechnical evaluation based on the Braun-Blanchet scale was performed in the sequence of three vegetative cycles. Palatability was assessed based on analysis of variance. No significant differences (p>0.05) were recorded between alfalfa and chicory (90.14% vs. 87.56%). The lowest palatability was associated to gramineous (71.35%, p≤0.001). The chicory shown an increased preferability degree in the sequence of daily feeding bouts, compared to alfalfa (82% vs 78%, p≤0,05) also compared to gramineous or their mixtures (82% vs. 66%, p≤0.001). The effects on milk production was assessed according to botanically structures. Comparable productions were recorded for alfalfa and chicory (17.5 kg vs. 17.2 kg, p>0.05). Positive effects were associated to chicory comparing to gramineous (17.5 kg vs. 14.6 kg, p≤0.001) or its mixtures (17.5 kg vs. 15.5 kg, p≤0.01). Chicory proved it efficiency in cows feeding comparing to legumes and gramineous, by an increased palatability and preferability degree. The positive effects on milk yield were comparatively evaluated according to the other botanically species. In this respect, based on the obtained results, the chicory proved to be rightfully considered as an alternative forage for dairy cows.

Rezumat

Studiul a urmărit aspectele agrotehnice, nutriționale și productive ale cicorii în raport cu gramineele și leguminoasele perene. Evaluarea agrotehnică în baza scalei Braun-Blanchet, s-a efectuat în succesiunea a trei cicluri vegetative. Palatabilitatea a fost evaluată pe baza analizei varianței. Nu s-au înregistrat diferențe semnificative (p>0.05) între lucernă și cicoare (90.14% vs. 87.56%). Cea mai redusă palatabilitate a fost asociată gramineelor (71.35%, p≤0.001). Cicoarea a prezentat un grad ridicat de preferabilitate în succesiunea tainurilor zilnice, comparativ cu lucerna (82% vs. 78%, p≤0,05) dar și cu gramineele sau amestecuri ale acestora (82% vs. 66%, p≤0,001). Efectele asupra dinamicii producției de lapte au fost evaluate în raport cu structura botanică. S-au înregistrat producții comparabile în cazul lucernei și a cicorii (17,5 kg vs. 17,2 kg, p>0,05). Efecte pozitive au fost asociate cicorii furajere comparativ cu gramineele (17,5 kg vs. 14,6 kg, p≤0,001) sau amestecuri ale acestora (17,5 kg vs. 15,5 kg, p≤0,01). Cicoarea și-a dovedit eficiența în cultură în relație cu leguminoasele și gramineele uzuale, fiind caracterizată și de un grad ridicat de palatabilitate și preferabilitate în furajarea vacilor de lapte. Efectele pozitive asupra dinamicii *producției lactate au fost evaluate comparativ între speciile botanice studiate, drept pentru care cicoarea furajeră se recomandă ca un furaj alternativ în dieta vacilor de lapte.*

Keywords: *agro technics, chicory, cows, milk yield, nutrition*
Cuvinte cheie: *agrotehnică, cicoare, nutriție, producție lapte, vaci*

INTRODUCTION

Chicory was first mentioned as a forage plant early in 1915 in New Zealand, after which it remained understudied for a long time until 1978, when the chicory was defined as an excellent ruminant feed [Lancashire, 1978]. Drought-resistant, especially improved cultivars, among which the Puna variety stands out, have been licensed for commercialization in 1985. The research primarily focused on the agro-technics required for crops, their management and the chemical composition compared to other grasses, and to a lesser extent on the effects exerted on cow's production performances. Chicory is a perennial plant with an excellent harvest index [Lancashire, 1983; Hare *et al*., 1987], increased feed quality [Arnold, 1985; Hopkins *et al.*, 1995; Hoskin *et al.*, 1995; Nwafor *et al*., 2017;] and great results in animals fed with this fodder crop.

Chicory has long been an integral part of natural pastures in many parts of the world, but it only recently became a forage plant cultivated solely for this purpose. Numerous varieties have been created due to the implementation of genetic improvement programs for this species [David and Sears, 2007; Waugh *et al.*, 1998]. The average daily gain (ADG) of calves fed wiyh pure chicory crops in New Zealand was higher (900 g/day) [Han *et al.*, 2009] than the rate achieved in a conventional crop of perennial ryegrass (Lolium perenne L.), or white clover (Trifolium repens L.) and were similar to those obtained on some leguminous pastures such as alfalfa (Medicago sativa L.) [Ifeoma *et al.*, 2017].

Chicory for livestock forage has significantly expanded worldwide during the last decades [Sanderson *et al.*, 2003]. There is a lack of knowledge in the literature related to nutritional aspects of chicory, as well as the effects on the cow's feeding behaviour. An important aspect seems to be chicory's ability to mobilize soil resources and maintain higher levels of protein and dry matter in simple or complex mixtures. In terms of nutrition, chicory has a higher mineral content (with the exception of Ca) compared to other leguminous and gramineous plants. Reduced lignin content (15-20 g/kg DM) compared to alfalfa (70-75 g/kg DM) provides chicory a higher digestibility (70-85%) than alfalfa (50-70%). The high prevalence of lactones and chicory acid contributes to significant anthelmintic potential. However, the taste and smell associated with lactones could decrease palatability of chicory. According to Foster *et al.* (2006), a 0,58% lactone content is associated with Puna chicory variant compared to other floristic species with higher values ranging from 0.79% to 1,52 %, [Foster *et al*., 2006]. In light of these findings, Foster *et al.* (2002) highlights the anthelmintic activity of lactones in his research [Foster *et al*., 2002].

The use of chicory in cows' nutrition recorded positive results in terms of milk production. In this respect, an increased milk yield by 10-12% was observed compared to an alfalfa-based diet. Also, use of chicory in cows' diet lead to a different shape of the lactation curve, resulting in an early upward trend even from the beginning of lactation. Cows with an alfalfa diet have shown a constant milk yield. Compared to alfalfa, chicory has higher palatability (91-94% vs. 87-92) [Neciu, 2018]. The protein content of chicory is closely correlated with agro-technical and environmental factors, varying in relatively wide limits 10-18% according to Crush J.R. and Evans J.P.M. (1990) or 25% according to Wang Q. and Chiu J. (2010) [Crush and Evans, 1990; Wang and Ciu, 2010]. An important aspect is the quality of the available protein which proves to be superior to other plants, due to the 17 amino acids of which 9 are essential for animals and humans [Wang and Ciu, 2011]. The increased consumption of chicory in animal feed also comes from a lower lignin content (20 g / kg DM) compared to alfalfa (75 g / kg DM) with beneficial effects on digestibility (86% vs. 55%) [Terill *et al.*, 1992]. However, the effects on growth vary according to the morpho-productive type of cattle. In this respect, beef cattle recorded a higher weight gain (1-1.1 kg/day), compared to

Holstein cattle, which reach growth thresholds between 0.4-0.7 kg/day [Christina *et al.*, Laws and Genever, 2016]. Unrestricted administration of chicory has led to an increase in voluntary consumption from 1.7 to 3.6 kg / DM / hour. The structure of the chicory and especially its availability as fodder, can influence the feeding behaviour of the animals, with implications on the daily activity budget and implicitly on the productive performances. Unrestricted administration of chicory did not show an increase in the frequency of seizures, only in the quantity of forage associated with them, with the immediate effect of increasing the intake of dry matter and protein [Mc Coy *et al.*, 1997].

Plant diversity is progressively dwindling, due to the extended collapse of the processing industries. Each species plays a role in sustaining a productive ecosystem, supporting the increase of soil fertility and biomass production, according to several previous studies regarding plant biodiversity. The use of relatively new plants introduced into animal feed without being well known from a scientific point of view generates a certain reluctance from farmers. In general, chicory, viewed through the prism of different levels of knowledge (agro-technical, nutritional, chemical, morphological) still remains an unknown plant with tremendous potential, being a real alternative to the particularly conditions of soil, climate and agro-technics as well as the nutritional needs of cattle.

MATERIAL AND METHOD

The current study was performed at the Research and Development Station for Bovine Arad, Romania. This research was observational and non-invasive. Ethical considerations of this study were evaluated according to the European Union's Directive for animal experimentation (Directive 2010/63/EU) and the study was approved by the Scientific Council at the Research and Development Station for Bovine Arad.

Six botanical structures were included in the current study being allocated 4 ha/species. In this respect, in the study were included the following botanical structures:

1-Medicago sativa (100%)

2-Cichorium intybus (100%)

3-Medicago sativa+Cichorium intybus (50% / 50%)

4-Mixed gramineous (Dactylis glomerata 30%+Festuca arundinacea 30%+Loliun perenne 20%+Festuca pratensis 20%)

5-Dactylis glomerata 20%+Festuca arundinacea 20%+Loliun perenne 15%+Festuca pratensis 15%+ Medicago sativa 30%

6-Dactylis glomerata 20%+Festuca arundinacea 20%+Loliun perenne 15%+Festuca pratensis 15%+ Cichorium intybus 30%

The degree of emergence of the botanical structures was assessed by direct counting, using the geobotanical method based on the implementation of 1 m^2 grids. Five grids were placed for each hectare of crop. The direct counting allowed the evaluation of the botanical structure related to each phytocenosis and implicitly the expression in percentages and the reporting to the initial participation after sowing. The Braun –Blanchet scale (BB) was performed in each phytocenosis in order to assess the abundance and the dominance. The current evaluation involves the characterization of the botanical structures based on the 5 value points, as follows:

1 = numerous individuals, but with low soil coverage (1-10%);

2 = numerous individuals with soil coverage range between 11-25%;

3 = numerous individuals with soil coverage range between 26-50%;

4 = numerous individuals with an increase soil coverage range between, 51-75%;

5 = numerous individuals with highly soil coverage range between 76-100%.

The persistence of different botanical species in the culture was evaluated using the grid method, counting the individuals associated with different botanical species, reporting to their initial share. This study included 3 vegetative cycles. The palatability was evaluated based on the consummability but especially the preferability to the administered forage structures. The studies were conducted on randomized batches of 30 cows each. The first 10 days of feeding were considered as a period of adaptation to the new feeding structures. Daily feeding during the 3 repetitions of 7 testing days assessed the palatability, both in the control group (with alfalfa) and in the experimental groups. Daily feeding was divided out in 3 meals, included in the following time interval: meal 1 between 8.00 - 11.00, meal 2 between 11.00 - 16.00 and meal 3 between 16.00 - 19.00. The experimental feeding consisted in the daily administration of 70 kg/head/day of green fodder from the experimental crops as well as from the control crop (alfalfa). Every day, after each feeding, the uneaten feed residues were weighed and related to the initial amount administered. The obtained data were the basis of the palatability calculation system, for each dose of feed administered, for each feeding day and for the average of the experimental period.

The effects of botanical structures on milk yield were assessed using a factorial ANOVA protocol. Differences were tested using Tukey's test. The analysed data were expressed as least square means and standard errors of the mean. All the statistical inferences were carried out using the software package Statistica (StatSoft Inc., Tulsa, OK USA) [Hill and Lewicki, 2007].

RESULTS AND DISCUSSIONS

Emergence

Alfalfa registers an 88% of emergence, which is reduced to 76% in the succession of vegetation years. The total depreciation rate is 12% with an annual average of 4%. Chicory has an emergence rate of 87% and is already known as a late growing plant. During the 3 vegetative cycles, it proves to be a dominant plant, so that at the end of the period, a superior persistence compare to alfalfa (88%) was recorded, as well as a degree of appreciation of 1%. The mixt of the two species highlights varying percentages at emergence, with 48%/40% in favor of alfalfa. This ratio varies quickly, with alfalfa's presence declining at a total rate of 8% (2.7%/year) while chicory's presence increases moderately at a total rate of 10% (3.3%/year). Grasses enter the culture well (85%) but over time they reach their physiological limits quickly under the action of drought. The total depreciation rate was 15% with an annual average of 5%. The mixture of grasses and alfalfa enters the vegetation in a ratio of 60/27%, registering at the end of the cycles different losses between 8% for grasses and 6% for alfalfa, the average annual depreciation rates being 2.66% for grasses and 2% for alfalfa. The introduction of chicory in the mixture with grasses shows a good emergence of 62/26%, with chicory exerting severe dominance relationships and inducing grasses a decline rate of 13% (4.3%/year). Chicory dynamics register a slower pace defined by a total rate of 1% with an annual average of 0.33%.

Table 1 Comparative evaluation of the germination capacity of botanical structures// *Evaluarea comparativă a capacității de răsărire a structurilor botanice*

Botanical structure	Share at sowing (%)	Share at emergence (%)	Weeds (%)	Abundance (1-5)	Dominance (1-5)	Braun –Blanchet scale (1-5)
Medicago sativa	100	88	12	4	2	3
Chicorium intybus	100	87	13	4	3	3
Medicago sativa+Chicorium intybus	50/50	48/40	12	3	2	3
Gramineous	100	85	15	3	2	3
Gramineous +Medicago sativa	70/30	60/27	13	3	3	3
Gramineos+Chicorium intybus	70/30	62/26	12	3	4	4

Table 2 Comparative evaluation of persistence according to botanical structure// *Evaluarea comparativeă a persistenței în cultură a structurilor botanice*

Botanical structure	Share at sowing (%)	Share of species after 3 vegetative cycles (%)	Weeds (%)	Braun – Blanchet scale
Medicago sativa	100	76	12	**2!!!!!**
Chicorium intybus	100	88	9	**4!!!!!**
Medicago sativa+Chicorium intybus	50/50	40/50	8	3

Botanical structure	Share at sowing (%)	Share of species after 3 vegetative cycles (%)	Weeds (%)	Braun – Blanchet scale
Gramineous	100	70	9	2
Gramineous +Medicago sativa	70/30	52/21	8	2
Gramineos+Chicorium intybus	70/30	49/28	8	3

Palatability

The palatability of alfalfa is very high and is shown on an upward curve throughout the experimental period. The minimum value of 88.57% is associated with the first day of feeding, the upward trend being noted from that moment. The maximum value is quickly reached, even from the 3rd day, a sign that this type of forage is known and preferred by cattle. On average, the consumption of alfalfa is 89.14%. Chicory does not benefit from the previously acquired cognitive element, so in this sense, although registered on an upward tendency, it presents a lower initial palatability, with a minimum value of 77.14%, the maximum being reached only on the 8th day of trial. As cognitive relationships are established, chicory shows a significant increase in consumption, the average value reaching 94.26%. The mixture of alfalfa and chicory is preferred by cattle, the minimum palatability recorded in the first 2 days (73%) it increases and reaches the maximum threshold of 97.14% on the 8th day. The average consumption was 89.26%, a slightly increase compared to alfalfa, possibly due to the presence of chicory in the mixture. Grasses have the lowest palatability, with values range between 68.57-82.85% and with an average value of 71.35%. The dynamic over time is sinuous, a sign that cattle show a low preference for this type of fodder (only 66.23% at the terminal taint). The inclusion of alfalfa and chicory in the mixture of grasses improves the palatability. The presence of alfalfa increases the value to a maximum of 73% while chicory is preferred by animals, the degree of palatability being slightly higher (76.7%) due to the bitter taste conferred by the presence of tannins. At the same time, the presence of alfalfa or chicory in grass mixtures increases the preferability of the fodder structure, an increase consumptions at the terminal bout being registered compared to that associated with perennial grasses in simple mixtures.

Table 3 Comparative assessment of botanical structure palatability // *Evaluarea comparativă a palatabilității structurilor botanice*

Botanical structure	Palatability (%)	Preferability (%)		
		Bout I	Bout II	Bout III
Medicago sativa	89,14	100	87,83	**78,6**
Chicorium intybus	94,26	100	86,73	**82,97**
Medicago sativa + Chicorium intybus	89,26	96,25	85,01	80,53
Gramineous	71,35	79,16	66,66	66,23
Gramineous+Medicago sativa	73	81,5	70,83	**69,66**
Gramineous+Chicorium intybus	76,7	82,9	79,6	**76,7**

Milk production

A total number of 60 multiparous cows were randomly divided into 6 feeding groups of 10 heads/group, in order to estimate the effects of the studied botanical structures in the dairy cows feeding.

Feeding was carried out differently, each group of cows getting a particularly botanical structure. Feeding was carried out in 3 repetitions of 20 feeding days/plant. The efficiency of feeding with the new improved cultivars was studied according to the induced effects on milk yield as well as on its chemical composition.

In this respect, the analysis recorded a comparative production in the case of cows fed with alfalfa and chicory in pure culture, even if the gains obtained at the end of the study period was insignificant. The mixture of alfalfa and chicory maintains the productive level at comparable values to those associated with individual crops. Feeding with a mixture of grasses does not allow a high productive level, the differences generated compared to chicory being significant. The inclusion of legumes in the mixture of grasses comes opportunely in the recovery of productive thresholds, although the performances obtained in the case of fodder with alfalfa or chicory could not be matched.

Table 4 The effects of botanical structures in milk yield // *Efectele structurilor botanice asupra producției de lapte*

Botanical structure	Daily milk yield (kg/day/period)	Dynamic of milk yield in the studied period (%)	Daily gain in milk (%)
Medicago sativa	17,2	+18,63	+1,33
Chicorium intybus	17,5	+19,1	+1,36
Medicago sativa + Chicorium intybus	16,6	+17,4	+1,24
Graminee	14,6	-13,92	-0,99
Graminee+Medicago sativa	15,7	-7,28	-0,52
Graminee+Chicorium intybus	16,7	-5,26	-0,37

Health status

Feeding with the new feed structures did not lead to abortions and did not disrupt reproductive activity in the experimental groups. Feeding with the new feed structures did not lead to the appearance of tympanums and did not facilitate the appearance of any other condition specific to this physiological and age category in the experimental groups.

CONCLUSIONS

1. Chicory has been shown to be a plant with an emergence capacity comparable to alfalfa and clearly superior to perennial grasses.
2. Related to the weeds, chicory proved a good dominance, largely inhibiting their excessive development.
3. Over time, chicory persistence in crops was superior to alfalfa and perennial grasses. Including it in cows diet proved a highly palatability, also high degree of preferability.
4. The highly nutritional value conferred by the increase protein content allowed to obtain an increased quantities of milk.
5. Last but not least, the administration of chicory as green forage eliminated the risks of specific nutritional disease in cattle.

ACKNOWLEDGMENT

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ESTIMATION OF CHLOROPHYLL CONCENTRATION IN POTATO LEAVES BASED ON SPAD MEASUREMENTS UNDER CONTROLLED CONDITIONS

ESTIMAREA CONCENTRAŢIEI DE CLOROFILĂ DIN FRUNZELE DE CARTOF BAZATĂ PE MĂSURĂTORI SPAD ÎN CONDIŢII CONTROLATE

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Abstract

The conventional potato breeding process has led toapproach this crop plant also under the implementation of modern biotechnology methods.Due to its capacity for in vitro regeneration, the potato has a rich history in tissue culture experiments.Micropropagation techniques are the safest, most elaborate and fastest way to provide planting material for a seed potato crop andalso for consumption.Laboratory monitoring, control in a protected space (insect-proof spaces), regarding the growth and development status of plantlets determines the assurance of phytosanitary quality according to the established standard.Biometric observations were made on the biological material taken into study,for three Romanian potato varieties - Asinaria, Darilena and Foresta, regarding the average height of the plant, the average number of shoots and leaves, and by using the SPAD device, measurements were made on the chlorophyll content of potato leaves at the time of transplanting the vitroplants and after the acclimatization period.

Key Words: *biotechnology, potato, protected space, chlorophyll index, SPAD*

Rezumat

Procesul de ameliorare convenţională a cartofului a condus la necesitatea abordării acestei plante de cultură şi prin prisma implementării metodelor moderne de biotehnologie. Datorită capacităţii sale de regenerare in vitro, cartoful are un istoric bogat în cadrul experimentelor bazate pe culturi de ţesuturi. Tehnicile de micropropagare constituie modul cel mai sigur, elaborat şi rapid pentru asigurarea materialului săditor necesar producerii cartofului pentru sământă şi, implicit producţiei destinate consumului. Monitorizarea în laborator, controlul în spaţiu protejat (solar), privind starea de creştere şi dezvoltare a plantulelor determină asigurarea calităţii fitosanitare conform standardului stabilit. Asupra materialului biologic luat în studiu, trei soiuri româneşti de cartof - Asinaria, Darilena şi Foresta, s-au făcut observaţii biometrice, referitoare la înălţimea medie a plantei, numărul mediu de lăstari şi frunze, iar cu ajutorul dispozitivului SPAD s-au făcut măsurători privind conţinutul de clorofilă al frunzelor de cartof, în momentul transplantării vitroplantelor şi după perioada de aclimatizare.

Cuvinte cheie: *biotehnologie, cartof, spaţiu protejat, indice de clorofilă, SPAD*

INTRODUCTION

Currently, the potato (*Solanum tuberosum* L.), due to its high adaptability to different pedoclimatic conditions, is cultivated in over 120 countries worldwide, with potato tubers being consumed daily by over one billion people (Faostat, 2023).Furthermore, this species is considered the fourth most cultivated crop plant in the world (Ceci et al., 2022), after maize (*Zea mays* L.), rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.). Potatoes are cultivated throughout Romania, but the largest areas are cultivated in the closed zone for the production of seed potatoes: Brasov, Covasna, Harghita, Bacau, Neamt, Suceava, Botosani counties.

Starting from the current state of research in the field of *in vitro* plant cultures, future development will be oriented, under the conditions of internal and international competition imposed by the market on seed potato producers, to ensure appropriate material (from all points of view: virological, physiological age, agronomic characteristicsetc.), which will also be accompanied by economic effects that create profit (Chiru, 2002).

Starting from the current state of research in the field of *in vitro* plant cultures, future development will be oriented, under the conditions of internal and international competition imposed by the market on seed potato producers, to ensure appropriate material (from all points of view: virological, physiological age, agronomic characteristics, etc.), which will also be accompanied by economic effects that create profit (Chiru, 2002).

Maximum production potential depends on an early development of source organs (leaf area) for optimal light interception and photosynthesis and sink organs (both initiation and extension of storage roots or tubers) in root crops (tubers) (Farooq, 2009).

By using the SPAD 502 device, the chlorophyll index was determined in potato seedlings under *in vitro* and *in vivo* conditions. This method, being an approach that presents advantages in experiments in which the leaf surface is small and the plants do not suffer mechanical and chemical accidents, and at the same time, extended determinations can be made on the same individual throughout development under different conditions and environmental factors.

The objective of this study was to establish a correlation between the SPAD 507 device readings of the potato varieties under study, at the time of transplantation from *in vitro* to *in vivo*, and at the same time performing biometrics regarding the height, number of shoots and number of leaves.

MATERIAL AND METHOD

The experience has as a starting point meristems of Romanian varieties Asinaria, Darilena and Foresta created at NIRDPSB Brasov. Meristems taken from potato sprouts are inoculated *in vitro* for obtaining a healthy pre-basic material. After a period of 6-9 months from meristems are developing plantles. To ensure phytosanitary accuracy is made ELISA test and infected clones are removed, continuing multiplication from healthy ones. The developed plantlets are cut to each internode level into minicuttings. The nutrient medium used was Murashige-Skoog including vitamins(supplemented with sucrose 2%, agar 0.85%, NAA 0.5 mg/l, and antimicrobial agent PPM 3 ml/l -Plant Preservation Mixture), the pH was reduced to 5.6-5.8, before sterilizing the culture medium in an autoclave. After preparing the culture medium, potato plantlets obtained from meristems were multiplied in order to obtain a stock of initial material. The culture recipients were incubated in the growth chamber, ensuring a photoperiod of 16 hours light/8 hours dark and a temperature of 19-21 ºC. For potato plantlets were made SPAD measurements. The potato plantlets were transplanted from *"in vitro"* conditions to *"ex vitro"*afterMay19, 2024.

They were planted in black plastic pots with 20 cm in diameter, filled with a substrate containing red peat, black peat and perlite (4:2:1), NPK 16:16:16 fertilizer was added to the composition. During the growing season treatments with foliar fertilizers were applied. After 2 months from the transfer of the plantlets to the protected space, determinations were made regarding growth and development parameters and also SPAD mesurements.

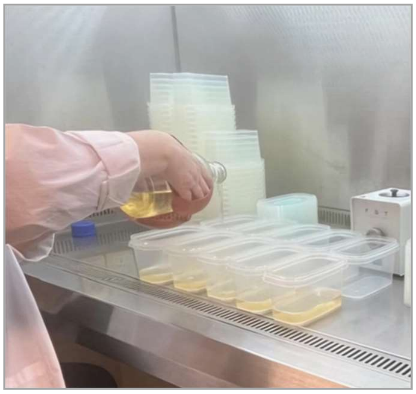

Fig. 1. Distribution of nutrient medium
Distribuirea mediului nutritiv

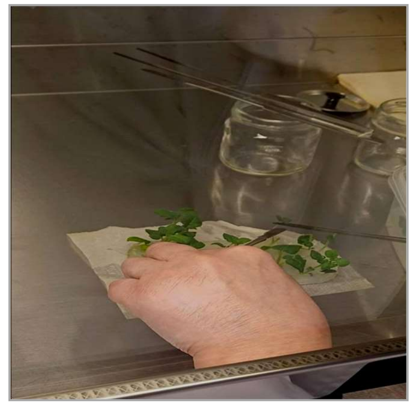

Fig. 2. Inoculation of mini-cuttings
Inocularea minibutasilor

Fig.3. Plantlets incubated in the growth chamber
Plantule incubate în camera de creştere

Fig.4. Acclimatized vitroplants
Vitroplante aclimatizate

Fig. 5 Potato plants in the protected space // *Plante de cartof în spaţiu protejat*

RESULTS AND DISCUSSION

Fig. 6 Biometrics// *Biometrizări*

Fig.7 SPAD device *//mAparatul SPAD*

Table 1. The influence of variety on the average plantlets height (cm) *in vitro*// *Influenţa soiului asupra înălţimii mediia plantulelor (cm) dezvoltate in vitro*

Variety	The plantlets height (cm)	Diff.	Sign.
Asinaria	8.90	0.8	ns
Darilena	12.03	3.88	*
Foresta (Ct.)	8.15	-	-
DL 5%=2.38 cm// DL 1%=5.50 cm// DL 0.1%=17.49 cm			

The statistical analysis performed for each varieties shows that plantlets height is bigger for Darilena variety, with a positive difference (3.88 cm) comparative with control variety (Foresta).

Table 2. The influence of variety over the number of leaves*in vitro*// *Influenţa soiului asupra numărului mediu de frunze alplantulelor dezvoltate in vitro*

Variety	Number of leaves	Diff.	Sign.
Asinaria	8.60	0.77	ns
Darilena	9.09	1.26	*
Foresta (Mt.)	7.83	-	-
DL 5%=1.17// DL 1%=2.70// DL 0.1%=8.58			

Analysis of the varieties used in the experiment shows that the best results were achieved for Darilena variety with a number of leaves by 9.09 and with a with positive difference of 1.26 leaves, comparative with control variety.

Table 3. The influence of variety on the average plants height*in vivo*// *Influenţa genotipului asupra înălţimii medii a plantelorin vivo*

Variety	The plantlets height	Diff.	Sign.
Asinaria	36.90	4,10	ns
Darilena	41.00	8,20	ns
Foresta (Mt)	32.80	-	-
DL 5%=9.93// DL 1%=13.67// DL 0.1%=18.82			

Table 4. The influence on variety on the average plants number of shoots*in vivo* // *Influenţa genotipului asupra numărului mediu de lăstari/planta in vivo*

Variety	Number of shoots	Diff.	Sign.
Asinaria	2.50	-0.80	ns
Darilena	2.10	-1.20	ns
Foresta (Mt)	3.30	-	
DL 5%=0.88// DL 1%=1.21// DL 0.1%=3.30			

Regarding the influence of genotype on the average height and number of shoots of plants acclimatized in the greenhouse, no significant differences were recorded compared to the control variety Foresta (Table 3 and 4).

The study of the influence of the variety on the number of leaves is highlighted with a very significant positive difference for the Darilena variety (45.20) (Table 5). The statistical interpretation of the results obtained highlighted the influence of the three potato genotypes on the growth and development rate, both *in vitro* and *in vivo*, where the Darilena variety stood out in particular.

Table 5. The influence of variety over the number of leaves/plant*in vivo*// *Influenţa genotipului asupra mediei numărului de frunze/plantă in vivo*

Variety	Number of leaves	Diff.	Sing.
Asinaria	42.00	-13.00	ns
Darilena	100.20	45.20	***
Foresta (Mt)	55.00	-	-
DL 5%=23.48// DL 1%=32.34 // DL 0.1%=44.52			

Following measurements of the chlorophyll concentration in the leaves of the seedlings of the varieties studied, at the time of preparation for transplantation, the average values recorded highlighted the Darilena variety (52.43), then the Asinaria variety (44.59) compared to the control variety Foresta (38.73).

Following the first measurements of chlorophyll concentration in leaves, carried out in a protected space, the recorded values are decreasing in all varieties, namely Darilena (51.06), Asinaria (38.64) and Foresta (34.44).

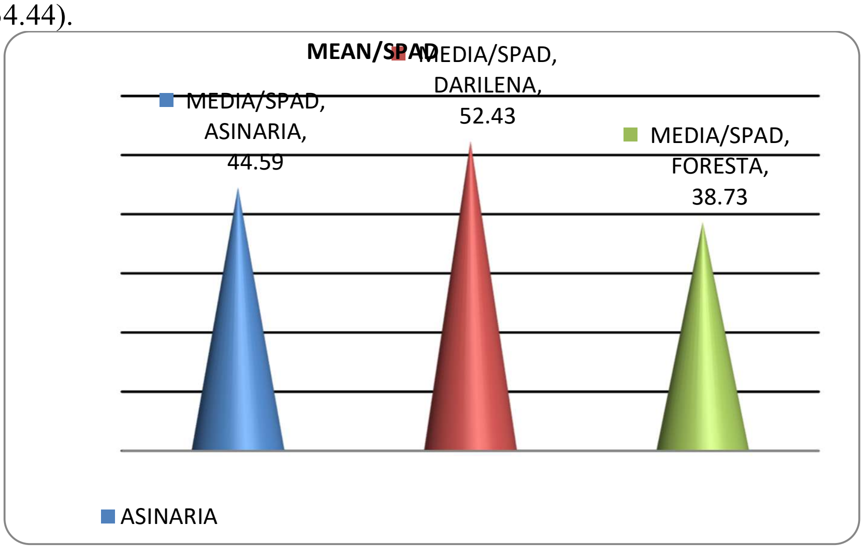

Fig . 8. SPAD values recorded *in vitro* plantlets (ready for transplanting) // *Valori SPAD înregistrate la plantulele din in vitro (pregătite pentru transplantare)*

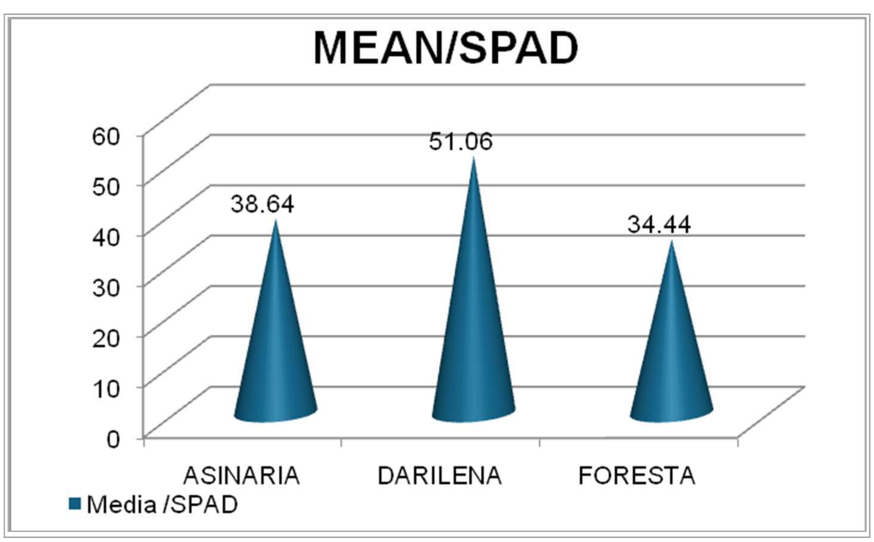

Fig. 9. Comparison of SPAD values of potato plants grown in greenhouse (after the acclimatization period) // *Comparaţia valorilor SPAD ale plantelor de cartofi cultivate în seră (după perioada de aclimatizare)*

The chlorophyll content of the leaves evaluated with the SPAD 502 equipment, at the time of the second measurement, in the solarium, similar to the first measurements, the readings taken again show a decrease in the average values for the varieties Darilena (42.8), Asinaria (37.26), only for the variety Foresta the average values show an increase (35.9).

The determination of the chlorophyll concentration at leaf level, through the measured values, provided us with a good assessment of the changes given by the acclimatization conditions and the health status of the plantlets in the protected space. Analyzing the results obtained, it is found that the Darilena variety has a better adaptation capacity, compared to the other varieties studied. Knowing the biological potential of potato varieties is an important aspect in breeding programs.

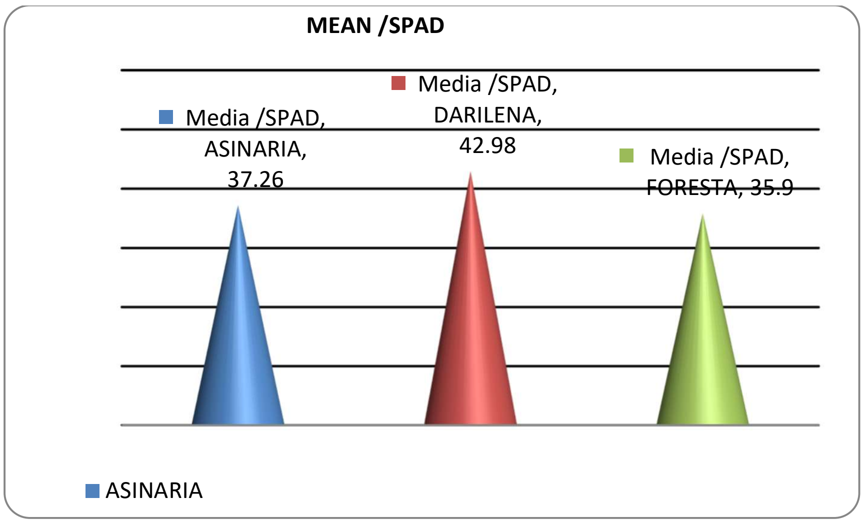

Fig. 10. Comparison of SPAD values of potato plants grown in protected space (after flowering) // *Comparaţia valorilor SPAD ale plantelor de cartofi cultivate în seră (după înflorire)*

CONCLUSIONS

1. Maximum acclimatization potential depends on early leaf development for optimal light interception;
2. Differences in chlorophyll index values between potato varieties act as a key factor in plant growth and development;
3. These experiments were performed to model the relationship between chlorophyll concentration measured both *in vitro* and *in vivo*.

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ANALYSIS OF FARMERS' PERSPECTIVE ON THE USE OF BIOTECHNOLOGIES AND IMPACT ON NATIONAL FOOD SECURITY

ANALIZA PERSPECTIVEI FERMIERILOR CU PRIVIRE LA UTILIZAREA BIOTEHNOLOGIILOR SI IMPACTUL ASUPRA SECURITĂȚII ALIMENTARE NAȚIONALE

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Rezumat: *Într-un context agricol tot mai complex, marcat de schimbările climatice, scăderea fertilității solului, presiuni economice și incertitudini pe piețele de desfacere, biotehnologiile apar ca o opțiune strategică pentru creșterea sustenabilă a productivității și consolidarea securității alimentare la nivel național. Aceste tehnologii moderne, incluzând organisme modificate genetic, biofertilizanți, biopesticide și tehnici avansate de ameliorare genetică, pot contribui semnificativ la reducerea pierderilor din producție, optimizarea resurselor și adaptarea culturilor agricole la stresul abiotic. În acest context, înțelegerea modului în care fermierii percep și se raportează la biotehnologie devine esențială pentru succesul oricărei strategii de inovare în agricultură. Acceptarea socială a acestor tehnologii nu depinde exclusiv de eficiența lor agronomică, ci și de nivelul de încredere, informare și de percepția riscurilor asociate. Astfel, prezentul studiu propune o analiză detaliată a opiniilor fermierilor români cu privire la adoptarea biotehnologiilor agricole, investigând trei dimensiuni cheie: beneficiile percepute, obstacolele întâmpinate și gradul de cunoaștere a tehnologiilor disponibile. Prin această cercetare, se urmărește identificarea profilului fermierului deschis la inovație, precum și a factorilor care frânează tranziția către practici agricole moderne. Rezultatele obținute pot contribui la fundamentarea unor politici publice mai bine adaptate realităților din teren și la dezvoltarea unor programe eficiente de informare, formare și sprijin pentru adoptarea tehnologiilor biotehnologice în mediul rural.*

Abstract
*In an increasingly complex agricultural context, marked by climate change, declining soil fertility, economic pressures and uncertainties in markets, biotechnologies are emerging as a strategic option for sustainable productivity growth and strengthening food security at the national level. These modern technologies — including genetically modified organisms, biofertilizers, biopesticides and advanced genetic improvement techniques — can significantly contribute to reducing production losses, optimizing resources and adapting agricultural crops to abiotic stress. In this context, understanding how farmers perceive and relate to biotechnology becomes essential for the success of any innovation strategy in agriculture. The social acceptance of these technologies does not depend exclusively on their agronomic efficiency, but also on the level of trust, information and perception of the associated risks. Thus, this study proposes a detailed analysis of Romanian farmers' opinions on the adoption of agricultural biotechnologies, investigating three key dimensions: perceived benefits, obstacles encountered and the degree of knowledge of available technologies. Through this research, the aim is to identify the profile of the farmer open to innovation, as well as the factors that hinder the transition to modern agricultural practices. The results obtained can contribute to the foundation of public policies better adapted to the realities on the ground and to the development of effective information, training and support programs for the adoption of biotechnological technologies in rural areas.***

Cuvinte cheie: fermieri, biotehnologie, OMG, agricultură,
Keywords: farmers, biotechnologies, agriculture, GMO

INTRODUCTION

Biotechnologies play an increasingly essential role in transforming the modern economy, through their application in various industrial sectors and by capitalizing on the results of research and innovation. This strategic integration not only brings added value, but also directly contributes to economic growth (Pokataiev et al., 2023). The ecosystem formed by raw material suppliers, research actors and biotech investors is becoming a central pillar of the bioeconomy, stimulating sustainable development and global competitiveness (Lokko et al., 2018).

Biotechnology is a multidisciplinary field that uses biological processes, living organisms or their components to develop useful products and technologies in various sectors such as agriculture, medicine, industry and the environment (Munaweera et al., 2022). It combines knowledge from biology, genetics, chemistry, computer science and engineering to provide innovative solutions to some of humanity's most pressing challenges. Essentially, biotechnology involves controlled intervention in biological processes to obtain results of practical value, be it improving agricultural crops, producing medicines, treating waste or creating biodegradable materials (Harfouche et al., 2021; Gupta et al., 2017).

Contemporary agriculture is facing major challenges generated by climate change, global population growth and the need to ensure food security in an increasingly volatile economic context. In this regard, agricultural biotechnologies are promoted as innovative solutions that can contribute to increasing agricultural yields, reducing pesticide use and improving crop resistance to abiotic and biotic stress conditions (Das et al., 2023). For example, in the agricultural and agro-industrial sectors, biotechnology applications play a significant role. These applications range from increasing the productivity of primary production to processed finished products with increased added value, based on biotechnological processes (Hesham et al., 2021; Tyczewska et al., 2023).

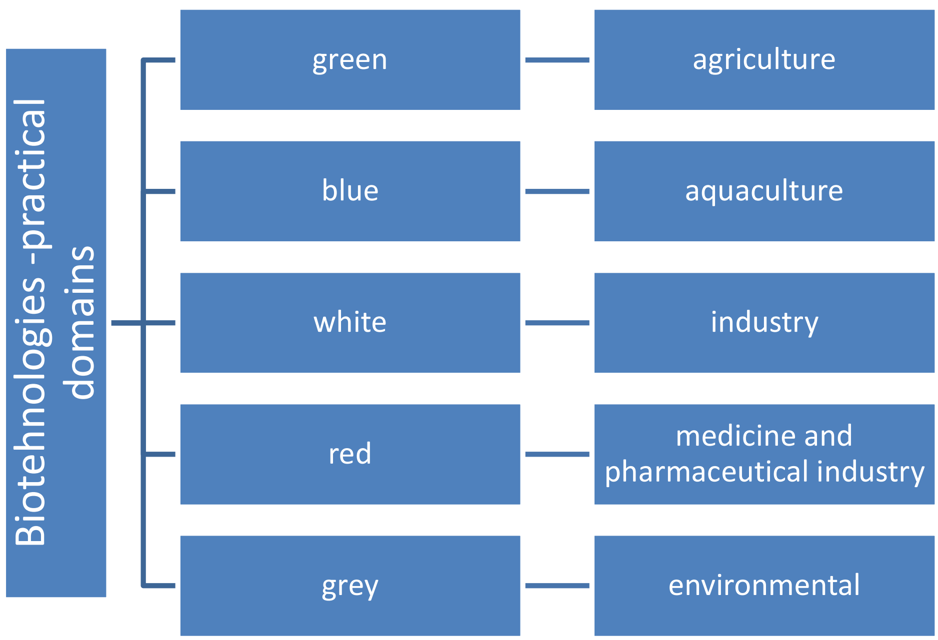

Figure 1. Practical domains of biotechnological applications // Domenii de aplicare ale biotehnologiei (Source: authors'own drawing)

Biotechnological applications (Figure 1) can be classified into the following areas, each representing a distinct domain of innovation with specific goals and impacts across various sectors: medical biotechnology (commonly referred to as red biotechnology), which focuses on pharmaceutical development and healthcare solutions; agricultural biotechnology (green biotechnology), dedicated to improving crop productivity, pest resistance, and environmental sustainability; industrial biotechnology (white biotechnology), which involves the use of enzymes and microorganisms in manufacturing processes to reduce environmental impact and increase efficiency; marine biotechnology (blue biotechnology), which explores oceanic and aquatic resources for novel compounds and genetic materials. and environmental biotechnology (grey biotechnology), which is aimed at bioremediation, waste management, and pollution reduction (Gupta et al., 2017) (Table 1) .

Table 1 Biotechnological applications// Aplicații biotehnologice

Classification	Description
green biotechnology	is biotechnology applied to agricultural processes, for example, obtaining transgenic plants resistant to adverse environmental conditions, adaptable to different soils, as well as plants resistant to diseases and pests.
blue biotechnology	includes marine and aquatic applications of biotechnology; this branch of biotechnology deals with the development of aquaculture, the care of marine creatures, the treatment of polluted or waste waters and the production of foods derived from the sea.
white biotechnology	is applied exclusively to the improvement of industrial processes; it uses yeast, molds, bacteria and enzymes with applications in industry. For example, engineering an organism to produce a useful chemical; the use of enzymes as industrial catalysts, either to produce valuable chemicals or to destroy dangerous and/or polluting chemicals;
red biotechnology	is applied to medical processes, e.g. engineering organisms to produce antibiotics; regenerative therapies and the application of genetic engineering to cure diseases.
grey biotechnology	Include environmental application of the biotechnology aimed to bioremediation, wast management pollution, reduction with other words, maintaining soil fertility and environmental health.

By using genetically modified organisms (GMOs), genome editing (such as CRISPR-Cas9) and biocontrol technologies, farmers can grow plants that are more resistant to disease, drought or salinity, thereby reducing dependence on pesticides and losses due to abiotic stress (FAO, 2021;Singh et al., 2025;Rasheed et al., 2021). At the same time, biotechnologies contribute to extending the shelf life of agricultural products through methods such as genetically modifying fruits to delay ripening or applying bioactive packaging, leading to more efficient resource management and reduced food waste (EuropaBio, 2023; OECD, 2022).

However, the adoption of agricultural biotechnologies remains a controversial topic, especially in Europe, where strict regulations, skeptical public attitudes and health and environmental concerns significantly limit the integration of these technologies into agricultural practices (Tunbull et al., 2021). In Romania, a country with considerable agricultural potential and a rural structure dominated by small farms, the debate on biotechnologies is marked by polarization and, possibly, lack of adequate information.

In particular, the potential impact of biotechnologies on farmers is twofold: on the one hand, these technologies could offer significant economic benefits, by increasing efficiency and reducing losses; on the other hand, they could increase dependence on global suppliers of seeds and inputs, creating the risk of concentration of economic power in agriculture. In this context, it is essential to understand the perspectives of farmers, the main actors of the agri-food system, on the opportunities and risks associated with biotechnologies.

Analyzing farmers' perspectives on the use of biotechnologies is essential for understanding the level of acceptance and challenges associated with their implementation in agriculture. In a context where biotechnologies are becoming increasingly relevant for food security and agricultural sustainability (Ranja et al., 2022), it is important to investigate not only the technological impact, but also the perception of the direct users, namely the farmers (Wozniak et al., 2022).

In this regard, this article aims to conduct a comprehensive analysis of farmers' opinions on the adoption of biotechnologies, focusing on three major areas: perceived benefits (such as increased productivity and reduced losses), barriers encountered (including lack of information, implementation costs or reluctance to change) and the level of knowledge of available technologies. The overall goal of the approach is to highlight the dynamics of perception among farmers, to identify obstacles that hinder the widespread adoption of biotechnologies and to propose directions for action for more effective agricultural policies and information programs. This approach contributes to a more nuanced understanding of the context in which technological innovation meets realities on the ground.

RESEARCH METHODOLOGY

To conduct the analysis of farmers' perceptions of the use of biotechnologies in agriculture, a quantitative approach was adopted, based on the application of a standardized questionnaire. The study was conducted between January and March 2025. The sample consisted of 103 active farmers.

The questionnaire included both closed questions (with Likert-type answers) and open questions, targeting the following dimensions:

- level of knowledge of biotechnologies;
- general attitude towards their use;
- perception of benefits (production, climate resilience, economic efficiency);
- barriers encountered in the adoption process;
- information sources

RESULTS AND DISSCUSSIONS

This study analyzed farmers' perception, level of knowledge and openness towards agricultural biotechnologies, based on a questionnaire applied to a sample of 87 respondents. General data on the profile of the participants indicate a predominance of male farmers, aged between 35 and 60. Most of them own medium-sized farms and have high school or post-high school education, working predominantly in vegetable agriculture.

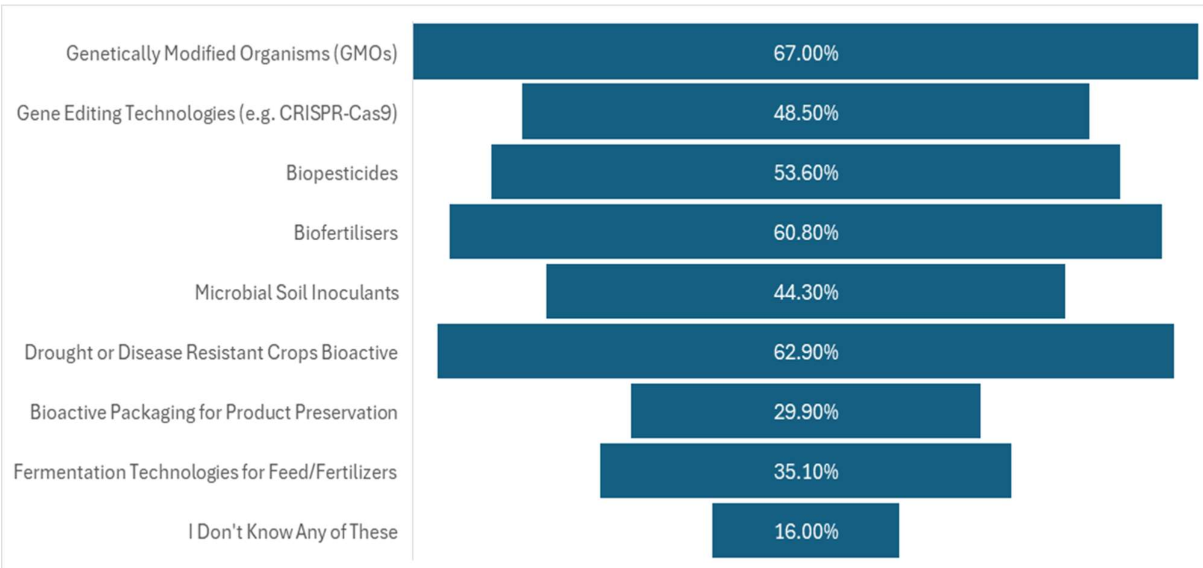

Figure 2. Awareness of Agricultural Biotechnologies Among Farmers // Biotehnologii agricole cunoscute de fermieri

The majority of respondents (64%) stated that they had heard of agricultural biotechnology. Next, to assess the level of detailed knowledge of farmers regarding agricultural biotechnology, one of the questions in the questionnaire asked to identify, from a list of options, technologies that can be considered biotechnology (Figure 2) . The list included concrete and relevant examples, such as genetically modified organisms (GMOs), gene editing technologies (e.g. CRISPR-Cas9), biopesticides, biofertilizers, microbial soil inoculants, drought or disease resistant crops, bioactive packaging and fermentation technologies applied in the production of feed and fertilizers. Each of these options represents valid and current categories of biotechnology used in agriculture, either for the genetic improvement of plants or for the optimization of resources and reduction of environmental impact. The analysis of the responses revealed that, although a significant number of farmers declare that they are familiar with the term “biotechnology”, many of them fail to correctly recognize all the concrete examples, especially in the case of small farms or those with less experience.

This discrepancy highlights the difference between declarative familiarity and applied knowledge, suggesting the need for better targeted information campaigns adapted to the profile of the Romanian farmer. Therefore, the most recognized examples of biotechnologies are genetically modified organisms (GMOs) and drought- or disease-resistant crops, a sign that more publicized terms are better associated with the idea of agricultural innovation.

However, more recent or specialized biotechnologies, such as CRISPR-Cas9, bioactive packaging or fermentation for feed, are significantly less known. This distribution suggests that although there is a general awareness of biotechnologies, the degree of detail and accuracy of knowledge remains low.

An interesting element is the fact that approximately 16% of respondents ticked “I don’t know any of these”, even in combination with other options, which indicates either conceptual confusion or lack of confidence in their own knowledge. Also, farmers with small farms (under 5 ha) and with little experience (under 10 years) are predominantly those who provide wrong or incomplete answers.

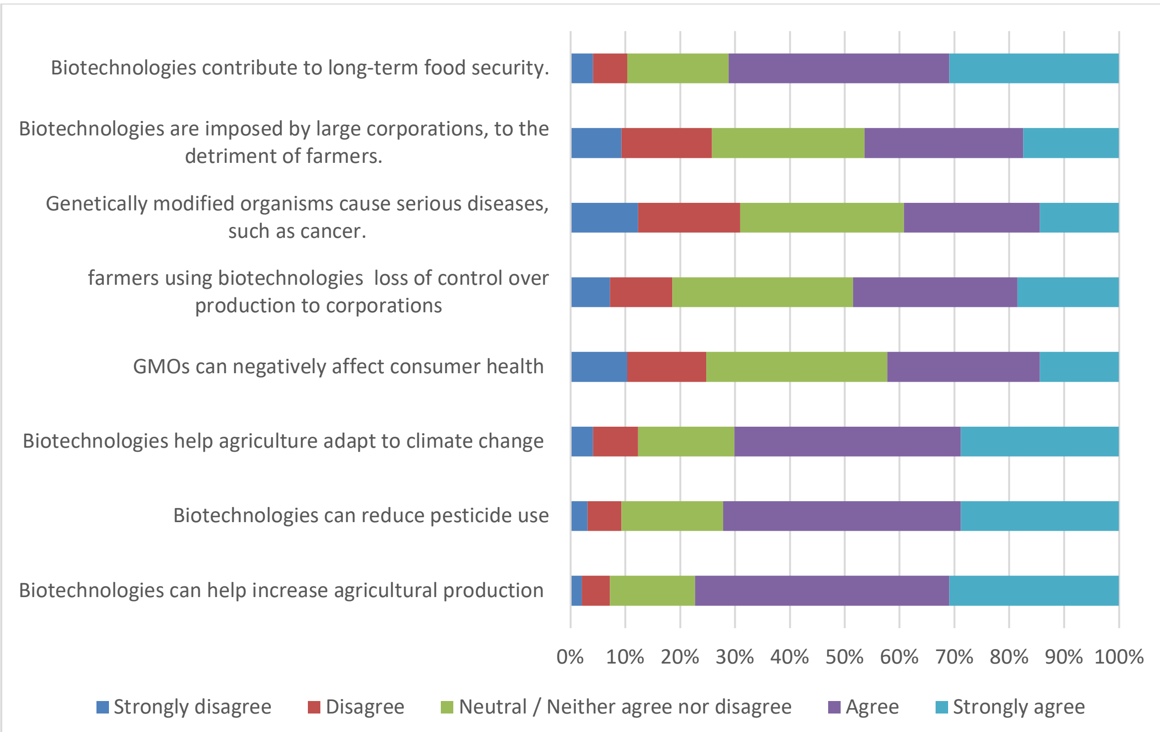

Figure 3. Distribution of responses regarding the perception of biotechnologies // Distribuția răspunsurilor privind percepția biotehnologiilor

The results analyzed indicate that Romanian farmers have a predominantly favorable perception of agricultural biotechnologies, but not without reservations. Regarding the benefits, 77% of respondents agree or strongly agree that biotechnologies can contribute to increasing agricultural production, while only 2% strongly disagree, reflecting a high level of confidence in their agronomic potential. Similarly, 72% of farmers believe that these technologies can reduce the use of pesticides, and 70% agree that biotechnologies help agriculture adapt to climate change. A consistent percentage, 71%, believes that biotechnologies contribute to long-term food security.

On the other hand, the analysis also highlights a number of persistent concerns. Approximately 42% of participants agree that genetically modified organisms can negatively affect consumer health, while 24% declare themselves in total or partial disagreement with this statement, suggesting a clear polarization of opinion.

Also, 48% believe that the use of biotechnologies can lead to the loss of control over production in favor of large corporations, a perception supported by the 47% who state that biotechnologies are imposed by industrial actors, to the detriment of farmers. Regarding one of the most problematic perceptions – that GMOs cause serious diseases, such as cancer – 39% of respondents agreed and 31% disagreed, which suggests the significant presence of misinformation.

Romanian farmers have a largely positive attitude towards the benefits of biotechnology, especially in terms of productivity, sustainability and food security. However, concerns persist regarding perceived health risks and control over production, indicating that full acceptance is still conditional on accurate information and institutional transparency.

Among the main perceived benefits, farmers mentioned: increased yield per hectare (54%), reduced losses caused by pests and diseases (46%) and reduced costs of chemical inputs (38%) (Figure 4).

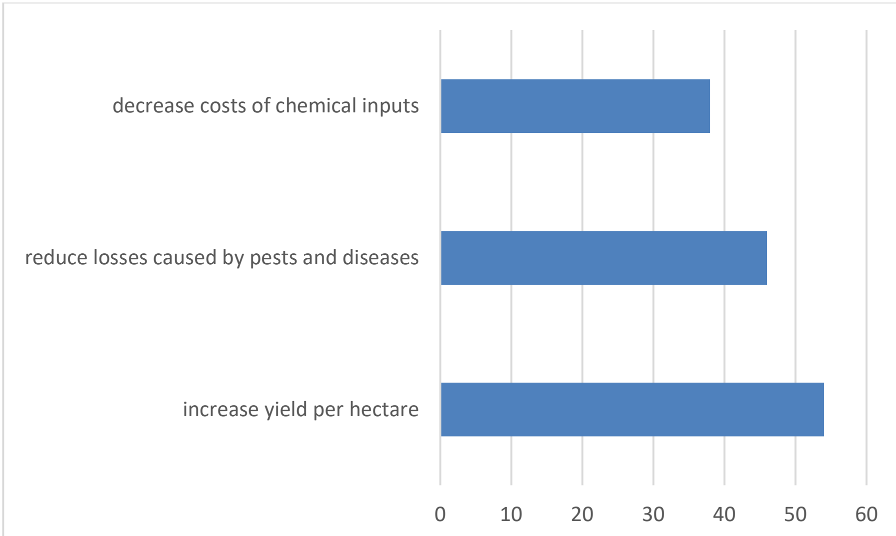

Figure 4. Farmers' perception on advantages that biotechnologies may bring// Percepția fermierilor asupra beneficiilor biotehnologiilor

Notably, farmers with medium and large holdings were more open to adopting biotechnologies, considering them a necessary tool for competitiveness in the agricultural market. These data align with the conclusions of other European research (EuropaBio, 2023), which shows a positive correlation between farm size and openness to innovation.

Regarding the obstacles to the adoption of these technologies, the most frequently mentioned barriers are the lack of clear information, high costs and difficulty in accessing the technology. Also, concerns about health or environmental impact continue to influence farmers' decisions. Despite these challenges, about half of the respondents said they were willing to test or adopt a biotechnology on their farm.

The highest interest is expressed for technologies such as biofertilizers, biopesticides and microbial inoculants, which are perceived as more environmentally friendly and less invasive solutions compared to GMOs.

In terms of information sources, the internet and social networks are the main channels through which farmers access information about agricultural technologies, followed by other farmers, consultants and participation in profile events. However, trust in these sources varies significantly. The most trusted sources are universities and research centers, followed by public institutions. Agricultural technology producers and online press are viewed with more reserve, signaling the need for transparent and scientifically validated communication.

CONCLUSIONS

1. The results of this survey suggest that Romanian farmers generally have a moderately positive attitude towards agricultural biotechnologies, indicating a real potential for integrating these technologies into current agricultural practices. Most respondents recognize the essential benefits offered by biotechnologies, such as increased yield per hectare, reduced losses caused by pests and diseases, and lower costs of chemical inputs. This openness is more pronounced among medium- and large-scale farmers, who are more oriented towards innovation and economic competitiveness.

2. The analysis of perceptions highlights a balance between openness to the benefits of biotechnology and the existence of significant concerns. Respondents tend to agree that biotechnology can contribute to increasing agricultural production, reducing pesticide use and adapting agriculture to climate change. At the same time, a relevant part of the participants expresses fears about the potential negative effects on consumer health, especially in relation to GMOs, as well as a perception that the use of biotechnology may lead to the loss of control over agricultural production by farmers in favor of corporations. However, the degree of acceptance of biotechnologies remains closely linked to several limiting factors. A key element is the level of information: farmers with limited access to credible sources of information or with a lower educational level are more likely to reject or not fully understand the real advantages of these technologies. Also, perceptions of risks — including fears about health effects or the influence of multinational corporations — continue to negatively influence the decision to adopt.
3. Implementation costs and the lack of effective technical and financial support programs are also major barriers reported by respondents. Even among interested farmers, the willingness to adopt biotechnologies is often conditioned by economic accessibility and trust in the legislative and institutional framework.
4. Therefore, for the full potential of biotechnologies to be exploited in Romanian agriculture, it is essential that public policies and science communication initiatives directly target these sensitive points. Investments in training, agricultural advisory services and subsidy programs can contribute to increasing trust and accelerating the transition to a more innovative, resilient and sustainable agricultural system.

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RESULTS OF THE MULTI-YEAR TESTING OF ROMANIAN WINTER WHEAT VARIETIES IN DIFFERENT AREAS OF THE COUNTRY

REZULTATE ALE TESTĂRII MULTIANUALE A SOIURILOR ROMÂNEȘTI DE GRÂU DE TOAMNĂ ÎN DIFERITE ZONE ALE ŢĂRII

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Abstract
Cultivars can play a key role in ensuring high wheat grain yields and reducing its variation under the increasing environmental variability. We analyzed data on grain yield and coefficients of variation from ninety-four yield trials with Romanian winter wheat cultivars, conducted in four regions of the country, under different crop management, for four years (2021-2024). Despite the large variation of environments, we identified cultivars with higher yields in most

conditions and with lower coefficients of variation, which could contribute to higher and more stable yields in farms. Results are also useful for establishing priorities breeding future cultivars.

Rezumat

Soiurile pot juca un rol decisiv în asigurarea unor producţii ridicate şi în reducerea variabilităţii acestora în condiţiile unei variabilităţi tot mai mari a condiţiilor de mediu. Am analizat datele privind producţia de boabe şi coeficienţii de variaţie a producţiilor din nouă zeci şi patru culturi comparative cu soiuri româneşti de grâu de toamnă, efectuate în patru regiuni ale ţării, cu diferite variante tehnologice, vreme de patru ani (2021-2024). Deşi variaţia condiţiilor de mediu a fost foarte mare, am identificat soiuri cu producţii ridicate în majoritatea condiţiilor şi cu coeficienţi de variaţie a recoltelor mai mici, care pot contribui la obţinerea de recolte mai mari şi mai stabile în ferme. Rezultatele sunt deasemenea utile pentru stabilirea priorităţilor pentru ameliorarea viitoarelor soiuri.

Key words: *wheat, yield, variation, ranks*
Cuvinte cheie: *grâu, producţie, variaţie, clasificare*

INTRODUCTION

Most farmers recognize cultivars as one of the most dynamic and economically efficient factors in wheat production, with a decisive influence on yield level and response to environmental conditions. Public breeding programs in Romania have continuously contributed to providing better cultivars to farms (Paraschivoiu et al., 1983; Botezan et al., 1994; Tabără et al., 2008; Bunta and Bucurean, 2010; Mustăţea and Săulescu, 2011; Moldovan et al., 2012; Marinciu et al., 2015; Saulescu et al., 2024.). As a result, from 1971 to present, Romanian wheat cultivars have been grown on about 40 to 69 % or agricultural wheat surface. To promote the best new cultivars, NARDI Fundulea has coordinated, since its foundation, a National uniform yield trial with winter wheat cultivar, at sites all over the country. The present paper analyzes average yields and yield variation recorded in these trials conducted during 2021-2024.

MATERIAL AND METHODS

We analyzed yield trials results obtained in Romanian winter wheat cultivars originated from the National Agricultural Research & Development Institute Fundulea (NARDI), and from the Agricultural Research & Development Stations Turda, Lovrin – Oradea, Șimnic and Caracal, along with the historical check Bezostaya 1. Yield trials were conducted countrywide to test winter wheat yielding ability and adaptation to various regions of Romania. The set of cultivars tested in the Southern and Western regions was different from the set tested in the Central and Eastern regions. Table 1 presents the cultivars tested in the four regions in alphabetical order.

We analyzed yield results grouped as follows:

1. Trials with crop management recommended for each environment, including the recommended Nitrogen fertilization, which varied from 82 to 143 kg. N/ha, conducted at sites in:

1.1. Southern region including:

- Agricultural Research & Development Station (ARDS) Valu lui Traian – Lat. 44º16’ N, Long. 28º51’E;
- National Agriculture Research and Development Institute (NARDI) Fundulea – Lat 44°30`N, Long 26°51`E. At this site two trials with different sowing dates were analyzed;
- ARDS Teleorman (Drăgăneşti-Vlaşca) – Lat. 44°07’N, Long. 25°45’E;
- ARDS Mărculeşti – Lat. 44°25′N, Long. 27°29′E ;
- ARDS Brăila – Lat. 45°16′N, Long. 27°57′E ;
- ARDS Piteşti – Lat 44º81’N, Long.24 º86’E;
- Craiova University - Agricultural Research Station Caracal – Lat. 44º11’N. Long. 24º37’E;

- ARDS Șimnic – Lat 44°20′N, Long. 23°49′E.

1.2. Western region including:
- ARDS Lovrin – Lat 45°57’N, Long. 20°46’;
- ARDS Oradea – Lat. 47°02’N Long. 21°54’E;
- ARDS Livada – Lat. 47°52’N, Long. 23°08’E;

1.3. Eastern region including:
- ARDS Secuieni – Lat. 46ºN, Long. 26º 86’E ;
- [15] Research & Development Station for Soil Erosion Control „Mircea Moţoc” (RDSSEC “MM”) Perieni – Lat. 46°18′N, Lat. 27°37′E.

1.4. Central region including:
- ARDS Turda – Lat. 46º58’ N, Long. 23º78’E ;
- RDSCB Târgu-Mureş – Lat. 46°32’N, Long. 24°33’E.

Table 1. Cultivars tested in yield trials// *Soiurile testate în culturi comparative*

Southern and Western regions				Central and Eastern regions			
	Cultivar	**Breeder**	**Status**	**Nr**	**Cultivar**	**Breeder**	**Status**
1	A 4-10	ARDS Pitești	Breeding line	1	ANDRADA	ARDS Turda	Released 2012
2	AMURG	NARDI Fundulea	Breeding line	2	BEZOSTAYA 1	Russia	Historical check
3	BEZOSTAYA 1	Russia	Historical check	3	CEZARA	ARDS Turda	Released 2020
4	BIHARIA	ARDS Lovrin	Released 2021	4	CODRU	ARDS Turda	Released 2015
5	CAROM	ARDS Caracal	Relased 2024	5	FDL ABUND	NARDI Fundulea	Released 2022
6	DACIC	ARDS Lovrin	Released 2019	6	FDL COLUMNA	NARDI Fundulea	Pending release 2025
7	FDL ABUND	NARDI Fundulea	Released 2022	7	FDL CONSECVENT	NARDI Fundulea	Released 2024
8	FDL COLUMNA	NARDI Fundulea	Pending release 2025	8	FDL MIRANDA	NARDI Fundulea	Released 2011
9	FDL CONSECVENT	NARDI Fundulea	Released 2024	9	GLOSA	NARDI Fundulea	Released 2025
10	FDL MIRANDA	NARDI Fundulea	Released 2011	10	LUMINITA	ARDS Turda	Released 2023
11	GLOSA	NARDI Fundulea	Released 2005	11	OTILIA	NARDI Fundulea	Released 2013
12	IZVOR	NARDI Fundulea	Released 2007	12	PITAR	NARDI Fundulea	Released 2015
13	OTILIA	NARDI Fundulea	Released 2013	13	SEMNAL	NARDI Fundulea	Released 2017
14	PITAR	NARDI Fundulea	Released 2015	14	T. 42-17	ARDS Turda	Breeding line
15	SIMNIC1619	ARDS Simnic	Breeding line	15	T. 61-18	ARDS Turda	Breeding line
16	URSITA	NARDI Fundulea	Released 2021	16	T. 75-16	ARDS Turda	Breeding line
17	VOINIC	NARDI Fundulea	Released 2019	17	T109-12	ARDS Turda	Breeding line
				18	URSITA	NARDI Fundulea	Released 2021
				19	VOINIC	NARDI Fundulea	Released 2019

2. Trials with reduced Nitrogen fertilization (where N fertilizers were only applied in autumn at rates from 0 to 50 kg N s.a./ha), conducted at:
   - ARDS Valu lui Traian
   - NARDI Fundulea
   - ARDS Teleorman (Drăgăneşti-Vlaşca)
   - ARDS Piteşti
   - Craiova University - Agricultural Research Station Caracal.

3. Trials conducted with organic agriculture management for two years at;

- ARDS Valu lui Traian
- NARDI Fundulea

The testing sites covered a large diversity of soils, from chernozems to luvisoils, with pH from 5.02 to 7.6, and humus content from 1.71% to 3.6%. Weather conditions during 2021-2024 at all these sites were diverse and reflected present climate changes, as illustrated by rainfall, which varied from 211.2 to 613.8 mm/year.

We analyzed results from the cultivars tested all testing years and calculated the average yield and the coefficient of variation (s% = standard deviation/grain yield*100), for each cultivar and group of trials.

RESULTS AND DISCUSSION

In thirty-six trials from the **Southern region**, average yields varied from about 5500 kg/ha in Bezostaya1 to more than 7300 kg/ha in FDL Columna, while coefficients of variation varied from 22.1% in FDL Consecvent to 30% in line A4-10 (Table 2). The large variation observed in A4-10 was due to the fact that the region included ARDS Pitesti, where the line is very adapted, but also sites where lodging affected its yields.

Table 2. Average grain yield and coefficients of variation for seventeen wheat cultivars tested in thirty-six trials in the Southern region // *Producţiile medii şi coeficienţii de variaţie pentru 17 soiuri de grâu testate în 36 culturi comparative în zona de Sud*

Cultivar	Average grain yield (kg/ha)	Percentage of Glosa (%)	Coefficient of variation (s%)
FDL COLUMNA	7329	109.6	22.9
URSITA	7255	108.5	23.6
FDL ABUND	7176	107.3	23.9
FDL CONSECVENT	7150	106.9	22.1
BIHARIA	7079	105.9	26.0
CAROM	6820	102.0	25.8
Simnic1619	6816	101.9	24.3
VOINIC	6797	101.7	23.2
GLOSA	6687	100.0	23.2
OTILIA	6644	99.4	23.1
AMURG	6591	98.6	23.6
FDL MIRANDA	6553	98.0	25.2
DACIC	6546	97.9	28.3
IZVOR	6522	97.5	24.7
PITAR	6479	96.9	22.6
A 4-10	6469	96.7	30.0
BEZOSTAYA 1	5538	82.8	27.8
AVERAGE	6732		24.7

Cultivars FDL Consecvent, FDL Columna, Ursita and FDL Abund had highest average yields and above average yield stability, while cultivar Biharia, which was also high yielding, showed higher yield variation.

In twenty trials with **reduced Nitrogen fertilization**, average yields varied from less than 4800 kg/ha in cultivar Bezostaya1, to more than 6600 kg/ha in cultivars FDL Consecvent, FDL Columna and Ursita (Table 3). Cultivar FDL Abund had larger yield variation in these trials. Coefficients of variation varied from about 18% in cultivars Carom and A4-10 to more than 26% in Bezostaya1. The highest yielding cultivars (FDL Consecvent, FDL Columna, Ursita and Biharia) also had better than average yield stability in these conditions.

Table 3. Average grain yield and coefficients of variation for seventeen wheat cultivars tested in twenty trials with reduced Nitrogen fertilization in the Southern region // (*Producţiile medii şi coeficienţii de variaţie pentru 17 soiuri de grâu testate în 20 culturi comparative cu fertilizare redusa cu azot în zona de Sud*

Cultivar	Average grain yield (kg/ha)	Percentage of Glosa (%)	coefficient of variation (s%)
FDL CONSECVENT	6717	111.7	20.50934

Cultivar	Average grain yield (kg/ha)	Percentage of Glosa (%)	coefficient of variation (s%)
FDL COLUMNA	6670	110.9	21.30424
URSITA	6614	110.0	19.69744
BIHARIA	6560	109.1	20.94902
FDL ABUND	6534	108.7	24.47419
A 4-10	6286	104.5	18.1825
VOINIC	6223	103.5	20.08725
CAROM	6131	102.0	17.69162
OTILIA	6097	101.4	19.19114
FDL MIRANDA	6088	101.2	23.99814
Simnic1619	6023	100.2	20.56955
GLOSA	6013	100.0	23.26138
IZVOR	5959	99.1	22.16443
DACIC	5953	99.0	23.97849
AMURG	5929	98.6	20.70563
PITAR	5855	97.4	23.51689
BEZOSTAYA 1	4735	78.7	26.71709
Average	6204.404	102.1	21.6

In twelve trials from the **Western region** average yields were higher, varying from 4928 kg/ha in cultivar Bezostaya1 to 8042 kg/ha in FDL Columna (Table 4).
Coefficients of variation varied from about 29 in cultivars Otilia, Biharia and FDL Consecvent to 37.7% in the breeding line Amurg. High yield variation was also observed in cultivars FDL Miranda and Carom.

It is worth mentioning that cultivars FDL Consecvent and Biharia proved to be at the same time the highest yielding and among the cultivars with smallest yield variation caused by environmental conditions in this region.

Table 4. Average grain yield and coefficients of variation for seventeen wheat cultivars tested in twelve trials in the Western region // *Producţiile medii şi coeficienţii de variaţie pentru 17 soiuri de grâu testate în 12 culturi comparative în zona de Vest*

Cultivar	Average grain yield (kg/ha)	Percentage of Glosa (%)	coefficient of variation (s%)
FDL COLUMNA	8042	119.7	32.3
FDL CONSECVENT	7869	117.2	29.6
FDL ABUND	7785	115.9	31.9
BIHARIA	7783	115.9	28.9
URSITA	7367	109.7	34.6
OTILIA	7202	107.2	28.7
VOINIC	7173	106.8	31.5
A 4-10	6953	103.5	34.2
PITAR	6904	102.8	33.7
Simnic1619	6864	102.2	31.3
CAROM	6806	101.3	35.8
IZVOR	6767	100.7	30.7
DACIC	6718	100.0	31.9
GLOSA	6717	100.0	33.1
FDL MIRANDA	6619	98.5	36.0
AMURG	6555	97.6	37.7
BEZOSTAYA 1	4928	73.4	32.3
Average	7003		32.6

Averaged over eleven trials conducted in the **Eastern region**, yields varied from 4826 kg/ha in cultivar Bezostaya 1 to 6756 kg/ha in cultivar FDL Columna (Table 5). Coefficients of variation varied from around 31% in cultivars Pitar and Voinic, to 40% in cultivar Codru. In contrast with other regions, no cultivar combined best values of yield and s%. The highest yielding cultivars (FDL Columna and FDL Consecvent) had average yield variation. The best combination of yield and stability was present in cultivar Voinic, the third highest yielding, which was the second in yield stability. Two lines from the breeding program of ARDS Turda had better than average yield and coefficient of variation, while most cultivars from that breeding program had lower yields and larger yield variation, associated with their relative lateness and lodging susceptibility, which had a negative influence on yield in this region.

Table 5. Average grain yield and coefficients of variation for nineteen wheat cultivars tested in eleven trials in the Eastern region // *Producţiile medii şi coeficienţii de variaţie pentru 19 soiuri de grâu testate în 11 culturi comparative în zona de Est*

Cultivar	Average grain yield (kg/ha)	Percentage of Glosa (%)	coefficient of variation (s%)
FDL COLUMNA	6756	116.2	34.8
FDL CONSECVENT	6638	114.2	35.3
VOINIC	6315	108.7	31.5
SEMNAL	6298	108.4	36.1
FDL ABUND	6255	107.6	34.8
URSITA	6148	105.8	37.5
T. 75-16	6122	105.3	34.6
T. 61-18	6062	104.3	34.4
OTILIA	5990	103.1	35.2
CODRU	5877	101.1	40.0
CEZARA	5863	100.9	38.1
GLOSA	5812	100.0	33.7
ANDRADA	5800	99.8	35.6
T109-12	5738	98.7	38.7
PITAR	5701	98.1	30.6
T. 42-17	5696	98.0	37.9
LUMINITA	5680	97.7	37.3
FDL MIRANDA	5678	97.7	33.5
BEZOSTAYA 1	4827	83.0	31.3
Average	5961	102.6	35.3

In the eleven trials conducted in the **Central region** (Transylvania) yields were highest of all regions, average yields varying from 6617 in cultivar Bezostaya1 to 8842 kg/ha in cultivar FDL Consecvent (Table 6). Coefficients of variation varied from 8.5% in cultivar FDL Consecvent to 19.5% in cultivar FDL Miranda.

More cultivars than in the other regions, such as FDL Consecvent, FDL Abund, Luminiţa, Semnal, Ursita and FDL Columna, combined high yields with low yield variation.
Cultivars Glosa and Pitar, showed good yield stability but lower yields in this region, related to their earliness, which does not allow full use of the available weather resources.

Table 6. Average grain yield and coefficients of variation for nineteen wheat cultivars tested in eleven trials in the Central region // *Producţiile medii şi coeficienţii de variaţie pentru 19 soiuri de grâu testate în 11 culturi comparative în zona de Centru*

Cultivar	Average grain yield (kg/ha)	Percentage of Glosa (%)	coefficient of variation (s%)
FDL CONSECVENT	8842	112.8	8.5
T. 75-16	8739	111.4	15.2
T. 42-17	8724	111.3	12.9
FDL ABUND	8687	110.8	9.8

Cultivar	Average grain yield (kg/ha)	Percentage of Glosa (%)	coefficient of variation (s%)
LUMINITA	8658	110.4	10.2
SEMNAL	8633	110.1	9.4
URSITA	8580	109.4	10.9
FDL COLUMNA	8572	109.3	8.8
T109-12	8571	109.3	13.6
CEZARA	8530	108.8	16.5
CODRU	8507	108.5	13.9
OTILIA	8497	108.4	10.3
T. 61-18	8434	107.6	16.5
VOINIC	8390	107	9.1
ANDRADA	8184	104.4	16.4
PITAR	8148	103.9	9.4
FDL MIRANDA	7920	101	19.5
GLOSA	7842	100	10.9
BEZOSTAYA 1	6617	84.4	17.1
Average	8372	106.8	12.6

In the four trials conducted in **organic agriculture**, yields were lower and average yields varied from 2935 kg/ha in Bezostaya1 to 4374 kg/ha in FDL Consecvent (Table 7).
Yield variation was larger than with conventional crop management, coefficients of variation varying from 36.2% in cultivar Carom to 56.1% in cultivar Glosa.

Results obtained by cultivar FDL Consecvent were outstanding, as it was the highest yielding in organic agriculture and had lower than average variation of yields, it is also bunt resistant, an important trait in organic agriculture.

Table 7. Average grain yield and coefficients of variation for eighteen wheat cultivars tested in four trials under organic agriculture system.//
Producţiile medii şi coeficienţii de variaţie pentru 18 soiuri de grâu testate în 4 culturi comparative în sistem de agricultură ecologică

Cultivar	Average grain yield (kg/ha)	Percentage of Glosa (%)	coefficient of variation (s%)
FDL CONSECVENT	4374	130.1	43
FDL EMISAR	4258	126.7	50.7
URSITA	4185	124.5	46.2
FDL DARNIC	4088	121.6	53.3
FDL ABUND	4085	121.5	45.4
FDL MIRANDA	4046	120.3	55
OTILIA	3997	118.9	45.3
FDL EVIDENT	3877	115.3	46.7
FDL COLUMNA	3860	114.8	46
CAROM	3849	114.5	36.2
BIHARIA	3806	113.2	40.5
SIMNIC 1619	3770	112.1	46.4
DACIC	3729	110.9	51.9
PITAR	3604	107.2	38.3
A 4-10	3589	106.7	53.8
GLOSA	3362	100	56.1
VOINIC	3227	96	49.2
BEZOSTAYA 1	2935	87.3	47.2
Average	3813	113.4	47.3

To summarize the cultivar behavior, we analyzed their ranking in each group of trials. Rankings can facilitate conclusions about cultivar suitability to environments and can also provide information about their stability.

Table 8 presents the rankings of cultivars based on average yields in the analyzed trial groups.

Table 8. Cultivar ranking for yield in the analyzed groups of trials.// *Clasificarea soiurilor în grupele de culturi comparative analizate*

Cultivar	South		West	Average	Cultivar	East	Central	Average
	Full N	Reduced N						
FDL COLUMNA	1	2	1	1.3	FDL CONSECVENT	2	1	1.5
FDL CONSECVENT	4	1	2	2.3	FDL COLUMNA	1	8	4.5
URSITA	2	3	5	3.3	FDL ABUND	5	4	4.5
FDL ABUND	3	5	3	3.7	T 75-16	7	2	4.5
BIHARIA	5	4	4	4.3	SEMNAL	4	6	5.0
VOINIC	8	7	7	7.3	URSITA	6	7	6.5
OTILIA	10	9	6	8.3	VOINIC	3	14	8.5
CAROM	6	8	11	8.3	T 42-17	16	3	9.5
Simnic1619	7	11	10	9.3	OTILIA	9	12	10.5
A 4-10	16	6	8	10.0	CEZARA	11	10	10.5
GLOSA	9	12	14	11.7	CODRU	10	11	10.5
FDL MIRANDA	12	10	15	12.3	T 61-18	8	13	10.5
IZVOR	14	13	12	13.0	LUMINIȚA	17	5	11.0
DACIC	13	14	13	13.3	T 109-12	14	9	11.5
PITAR	15	16	9	13.3	ANDRADA	13	15	14.0
AMURG	11	15	16	14.0	GLOSA	12	18	15.0
BEZOSTAYA1	17	17	17	17.0	PITAR	15	16	15.5
					FDL MIRANDA	18	17	17.5
					BEZOSTAYA 1	19	19	19.0

If we compare the cultivar ranking in different conditions, it is obvious that despite the strong effect of environments, cultivars FDL Columna and FDL Consecvent ranked on the top for yield, while Bezostaya1 and Pitar had low rankings in most environments.

Cultivar rankings for yield in the four trials conducted in organic agriculture were highly variable and differed from those observed under recommended crop management. However, cultivars Ursita and FDL Consecvent had better rankings than other tested cultivars (Table 9).

Table 9. Cultivar ranking in organic agriculture.// *Clasificarea soiurilor în agricultura ecologică*

Cultivar	Fundulea 2024	Valu Traian 2024	Fundulea 2023	Valu Traian 2023	Average
URSITA	4	4	7	6	5.2
FDL CONSECVENT	1	14	1	7	5.7
FDL ABUND	16	2	5	5	7.0
OTILIA	7	8	8	9	8.0
CARO	8	18	3	4	8.2
MIRANDA	2	7	13	14	9.0
BIHARIA	14	12	11	3	10.0
A 4-10	10	11	20	2	10.7
SIMNIC 1619	5	16	12	11	11.0
FDL COLUMNA	11	10	4	19	11.0
PITAR	18	17	6	15	13.2
GLOSA	20	5	14	20	13.5
VOINIC	15	19	16	17	17.5
BEZOSTAYA1	19	20	19	16	18.7

CONCLUSIONS

Testing wheat cultivars in ninety-four yield trials conducted during four years in diverse conditions allowed identification of cultivars able to provide higher yields, with smaller variation induced by environmental conditions.

1. Data included in this paper can facilitate a better choice of cultivars for each of the analyzed regions and this could contribute to higher and more stable wheat production in farms.
2. Presented results can also be useful for establishing priorities in breeding future cultivars.

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MORPHOLOGICAL ASPECTS ON THE *IN VITRO* DEVELOPMENT OF THE PLANTLETS FROM THE LOCAL POTATO VARIETIES COLLECTION, PRESERVED IN *SLOW GROWTH* CONDITIONS AT SUCEAVA GENEBANK

ASPECTE MORFOLOGICE ALE DEZVOLTĂRII *IN VITRO* A PLANTULELOR DIN COLECȚIA LOCALĂ DE VARIETĂȚI DE CARTOF, CONSERVATE ÎN CONDIȚII DE *CREȘTERE LENTĂ* LA BANCA DE GENE SUCEAVA

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Abstract

Based on the phenotypic evaluation of the over 100 potato genotypes from the "in vitro" collection, the analysis of the modes of manifestation for the main morphological aspects of the plantlets (type of shoots, leaflets and roots, generation of microtubers etc.), a large number of reactions to slow growth conservation conditions were identified. Variability appeared mainly through the way of reaction of different genotypes, the morphological appearance of the plantlets for the same genotype, on different culture media, being relatively similar.

Rezumat

Pe baza evaluării fenotipice a celor peste 100 de genotipuri de cartof din colecția "in vitro", a analizei modurilor de manifestare a principalelor aspecte morfologice ale plantulelor (tipul lăstarilor, al frunzulițelor și rădăcinițelor, generarea de microtuberculi etc.), a fost identificat un număr mare de reacții la condițiile de conservare prin creștere lentă. Variabilitatea a apărut mai ales prin modul de reacție a diferitelor genotipuri, aspectul morfologic al plantulelor la același genotip, pe diferite medii de cultură, fiind relativ similar.

Keywords: *potato, Solanum tuberosum, "in vitro culture", osmotic stress, slow growth*
Cuvinte cheie: *cartof, Solanum tuberosum, cultură "in vitro", stres osmotic, creștere lentă*

INTRODUCTION

The collection of local potato populations (*Solanum tuberosum* L.), maintained in the experimental field, in the *in vitro* growth and conservation chambers of the Suceava Gene Bank, includes mainly old varieties, collected especially from mountainous areas of Romania, the potato being, along with peas and faba beans, among the few crops that reach maturity in these areas with short vegetation periods.

The development of micropropagation techniques through *in vitro* cultures responded to practical needs, including the rescue of species that are "recalcitrant" to seed conservation, or those with vegetative multiplication, such as the potato (CIP Training Manual; 2014).

In vitro culture is, in itself, a method of conservation and conservative propagation, through cloning. However, the method involves material costs, energy consumption, and labour and presents the risk of accidental contamination and, over time, possible genetic changes. Typically, a culture must be re-subcultured on fresh medium at least once every 2-3 months, which justifies the efforts directed towards finding methods to reduce growth, increase the intervals between two subcultures, which is the objective of *in vitro* conservation, thus reducing costs and eliminating the various deficiencies that can be caused by frequent manipulations of the preserved biological material.

The *in vitro* reactivity of potato is generally very good, but that of local genotypes can be quite different, in terms of growth rate, leaf size, plantlets vigour or how it reacts to the stressful conditions of *slow-growing* conservation. (Ibănescu M., Constantinovici D. and Strajeru S., 2007).

The main objective of the work, at this moment, is to preserve the inoculums in the collection by *slow growth*. In this context, the beneficial effects of combining 2 limiting factors of development were found. In order to generate plantlets, the uninodal microcuttings are periodically subcultured on media with higher osmotic pressure, by adding mannitol, sorbitol, sucrose, or in other substances with a retardant effect (daminozide, cycocel) are introduced, simultaneously with a decrease in the ambient temperature from 22^0C to 6 – 10^0C.

MATERIAL AND METHOD

All the experiments were carried out on the basis of the subcultivation of uninodal microcuttings, resulting from the plantlets of local potato varieties collection, previously regenerated *in vitro* (Constantinovici D., 2005).

The culture media were based on the MURASHIGE-SKOOG recipe (MS-1962) (Murashige T., Skoog F., 1962). The growth regulators used were kinetin (K), benzyladenine (BA) and μ naphthyl acetic acid (ANA) in low concentrations, so as not to stimulate the growth of the inoculums. To extend the time between two subcultures, the osmotic pressure was increased by adding 40 g of mannitol in $\mathbf{C_1}$ medium, and sorbitol to the second culture media, $\mathbf{C_2}$.

The medium (20 ml) was dispensed into 170 ml vials of (5.5 cm diameter / 9.5 cm height). The vials were covered with aluminum foil and sterilized in an autoclave for 20 min at 121^0C. After placing the inocula on the medium, the vials were covered with double polyethylene film, fixed with rubber rings and were transferred to the growth chamber at a temperature of 20 – 22^0C, and photoperiod of 16/24 hours, with a light intensity of 2000 - 2500 lx.

After resuming the inoculum growth processes, the vials were transferred to the conservation room, under slightly restrictive conditions, with a temperature varying between 6 and 10^0C, photoperiod 10/24 hours, and the light intensity of 1000 lx, generated by LED tubes.

RESULTS AND DISCUSSION

The potato is a crop of great importance, which multiplies vegetatively and for which rapid micropropagation procedures have been developed. The entire methodology, starting from meristem inoculation and subculture of microcuttings is dependent on the pre-existence of axillary buds. Elongation of shoots could be obtained on a simple medium, while tuberization requires higher concentrations of sucrose, cytokinins and various growth regulators (CachiThe potato genotypes from the collection maintained under *slow growth* conditions, for periods exceeding two years, while preserving viability and vitality, show morphological differences, but the main effect is the reduction of the height of the plantlets (2-4 cm), by shortening the internodes as well as the size of the leaflets. These often become scaly (1.5-2 mm), many of them growing on microshoots developed on the surface of microtubers or some hypertrophied-looking formations. (photo 1 - 3).

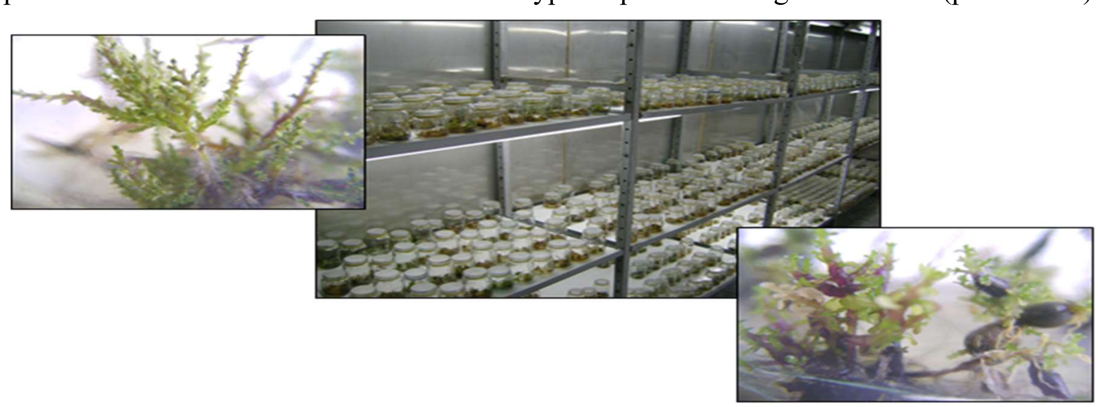

Photo 1 – 3. Plantlets from local potato populations (*Solanum tuberosum* L.) preserved *in vitro* by *slow growth* on mannitol or sorbitol media, with details on the appearance of the inocula after more than 24 months// Foto 1 - 3. Plantule din populații locale de cartof (*Solanum tuberosum* L.) conservate *in vitro* prin *creştere lentă* pe medii cu manitol sau sorbitol, cu detalii privind aspectul inoculilor după mai mult de 24 de luni

The double polyethylene foil ensures, in most cases, sterility and, above all, avoids dehydration of the culture media.

Variability appeared mainly through the way different genotypes reacted, the morphological appearance of the plantlets, of the same genotype, on the two culture media, being relatively similar (photo 4-6)

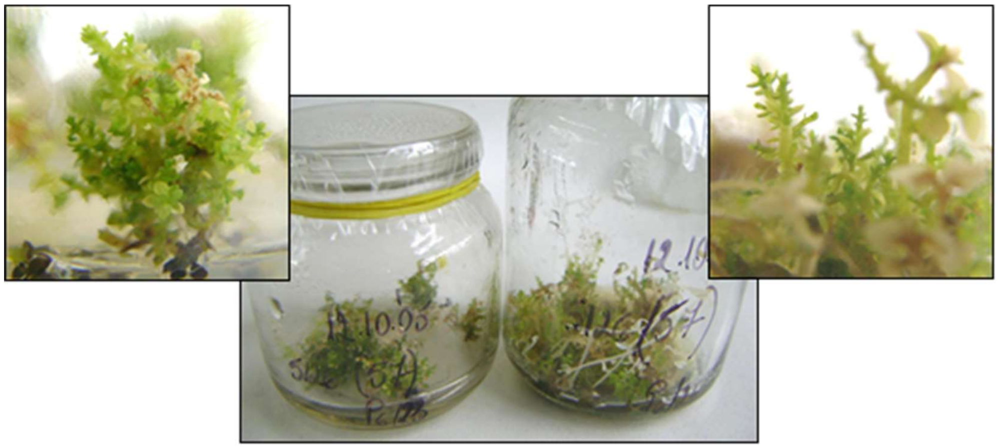

Photo 4 - 6. Potato plantlets of the SVGB-5126 (Ulma, Suceava County), preserved *in vitro* by *slow growth* on mannitol (left) and sorbitol (right) media, with details regarding the appearance of the inocula after more than 24 months.
Foto 4 - 6. Plantule de cartof ale populației SVGB-5126 (Ulma, Județul Suceava), conservate *in vitro* prin *creştere lentă* pe medii cu manitol (stânga) şi sorbitol (dreapta), cu detalii privind aspectul inoculilor după mai mult de 24 de luni.

During the conservation period, the plantlets generate morphological structures that store water and ensure the viability of the buds located at the base of the leaflets (Tanasă A.C., Constantinovici D. and Străjeru S., 2023). The development of microtubers or aerial roots is also stimulated. The shoots of the genotypes in the collection have a wide variety of shapes, being simple or branched and growing both on the surface and inside the culture media. After the end of the conservation period, when performing the apex subcultivation operations, the last observations were made regarding the influence of the conservation media (**C_1** and **C_2**) on the evolution of potato plantlets during *slow growth*. (Photo 7 - 14).

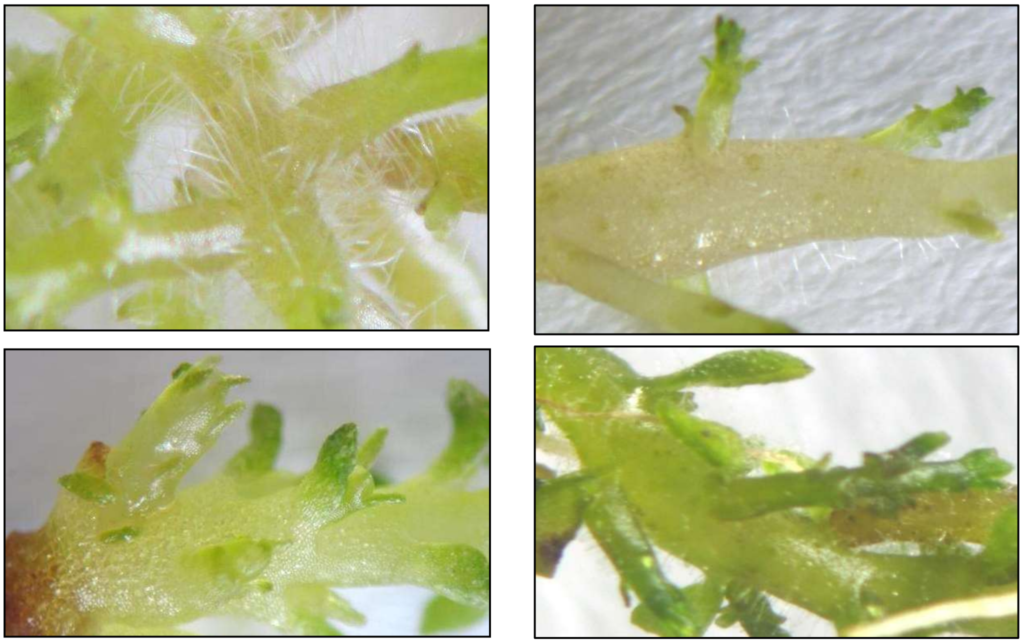

Photo 7 - 14. Shoots developed during the conservation period on culture medium with mannitol (left) and sorbitol (right), in the four potato genotypes: SVGB-12496 (Tupilati, Neamt County), SVGB-15102 (Sânpetru Almasului, Sălaj County), SVGB-15140 (Agarbiciu, Cluj County) and SVGB-15242 (Grosuri, Hunedoara County) //
Foto 7 - 14. Lăstari dezvoltați în perioada de conservare pe mediu de cultură cu manitol la genotipurile (stânga) și sorbitol (dreapta), la patru genotipuri de cartof: SVGB-12496 (Tupilati, județul Neamț), SVGB-15102 (Sânpetru Almasului, județul Sălaj), SVGB-15140 (Agarbiciu, județul Cluj) și SVGB-15242 (Grosuri, județul Hunedoara).

The decrease in the concentration of inorganic compounds in the MS culture media, together with the increase in osmotic pressure, led to the development of plants with reduced height and short internodes, but nevertheless allowed an acceptable evolution of the basal roots, sometimes also of the aerial ones, being favourable for the medium-term conservation of the collection of local genotypes, representing the main concern of the in vitro culture laboratory at the Suceava Gene Bank.

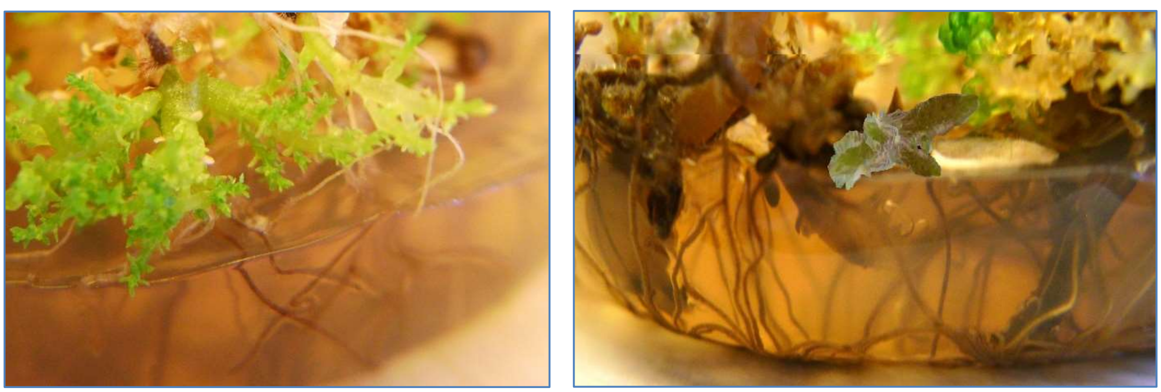

Photo 15 - 16. Basal roots developed during the conservation period on culture medium with sorbitol in the genotype SVGB-15244 (Grosuri, Hunedoara County) //
Foto 15 - 16. Rădăcini bazale dezvoltate în perioada de conservare pe mediu de cultură cu sorbitol la genotipul SVGB-15244 (Grosuri, județul Hunedoara).

The possibility of maintaining all varieties at temperatures between 6 – 10^0C is an element of great importance in extending the time periods between two subcultures and postponing the appearance of senescence phenomena, which have proven to be closely related to the genotype but also to the culture medium.

The apices of potato plantlets grown on the two culture media containing mannitol and sorbitol as inhibitory agents were taken and subcultured on fresh medium. After the regeneration of normally shaped plants, a second subculture followed for the multiplication of the genotypes, starting from young, actively growing tissues.

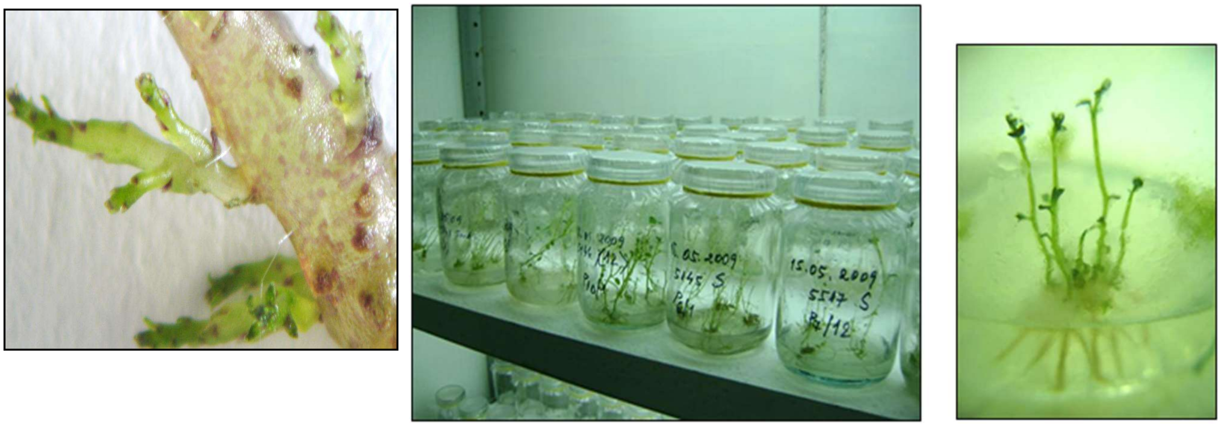

Photo 17 - 18. Plantlets from local potato genotypes, regenerated after "*in vitro*" conservation for over two years through *slow growth*.//
Foto 17 - 18. Plantule din genotipuri locale de cartof, regenerate după o conservare *in vitro* timp de peste doi ani prin *creştere lentă*.

New *in vitro* preservation technologies are always being researched, but the *slow growth* method is accessible in most cases. *In vitro* conservation does not intend to replace the conventional *in situ* and *ex situ* methods of preserving plant genetic resources, being only a complementary methodology.

CONCLUSIONS

6. The composition of culture media influences the *in vitro* development of potato inocula, in all phases helping to extend conservation periods through *slow growth*, and to regenerate plantlets after conservation.
7. The preservation media induced a slowdown in the growth of the inoculums, the preservation of their viability and vitality, the manifestation of some differences in the type of growth of the genotypes, but the main effect is that of reducing the height of the plantlets (2-4 cm), by shortening the internodes, modifying their morphological appearance, as well as the dimensions of the leaflets.
8. The existence of the possibility to reduce the temperature in the preservation room to 6-10^0C, is one of the main beneficial factor for extending the periods of time between two subcultures and postponing the appearance of senescence phenomena.
9. *In vitro* preservation reduces the risk of material loss due to environmental conditions from the experimental field, as it is carried out in laboratory, without the influence of seasons. After eliminating viruses or other infections, cultures can be kept free of pathogens and can be available to users.
10. The *in vitro* conservation method is one of the most effective for a large number of potato genotypes, for a developing collection.

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