THE BEHAVIOR OF SEVERAL FACULTATIVE WHEAT GENOTYPES SOWN IN SPRING

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Abstract. *Facultative wheat can be sown both autumn and spring and it can easily adapt to climate change because of its intermediate requirements for vernalization. These requirements for vernalization are satisfied in 5 - 30 days to 5 - 10°C, compared to typical winter wheats (witch need low temperatures, 1-3 °C, for approx. 30 - 60 days) or typical spring wheats (witch need a few days of exposure to temperatures of 5 - 20°C). In 2018, for the first time, at ARDS Turda, the researchers started a study on the behavior of several facultative wheat genotypes sown in spring. Using the subdivided plots method, into three replication, there were studied six genotypes of wheat (Taisa, Ciprian and Lennox – facultative wheat; Pădureni, Granny and Triso – spring wheat) in terms of production and quality. The influence of the sowing date (E), the row spacing (D) and the applied fertilizer dose (F) were the main technological elements pursued in this experience. The aim was to establish an optimal sowing date for facultative wheat in spring and to see the difference of yield and grain protein content of facultative wheat in comparison with spring wheat. The interaction E x S has significantly influenced (p > 0.1%) yield, thousand kernel weight (TKW) and test weight (TW). The grain protein content, the gluten content and Zeleny test (sedimentation index) were significantly influenced by the genotype, row spacing and fertilization. The sowing date had a significantly influence on TW, while the fertilization had no statistical influence on this parameter. Sown in 15 of March, Taisa (the new facultative wheat cultivar created at ARDS Turda) exceeded Pădureni (a typical spring cultivar) with 419 kg/ha, which means an important progress in wheat breeding. The research is on the beginning, but is useful and very important in order to improve the cultivation technology of facultative wheat in Transylvania Plain.*

Keywords*: facultative wheat, quality, sowing date, spring wheat, yield*

INTRODUCTION

Wheat is one of the main sources of food for mankind. Researchers must ensure this source even in the context of climate change and they must consider all possibilities for this. In order to improve the cultivation technology of facultative wheat we started this experience in 2018. At ARDS Turda, research on sowing conditions was carried out between 1973 and 1980 by BILAUS et al.(1980).

The grain yield of wheat is „affected by environmental conditions" (RITA PEREIRA COSTA et al., 2013) and „can be regulated by sowing time" (OZTURK et al., 2006). In the world cultivation of cereals we can distinguish spring forms sown in spring, winter forms sown in autumn, and transitional forms (facultative genotypes), sown both in autumn and spring (MARTA WYZIŃSKA and GRABIŃSKI, 2018). The grain yield of spring wheat is reduced in comparison to the winter forms because of a shorter growing season and less resistance to spring drought. But it has a very important asset "its higher grain quality then of winter wheat" (MARTA WYZIŃSKA and GRABIŃSKI, 2018; Reine Koppel, 2008). In 1995, Morison and Long showed that winter wheat is more vulnerable to climate changes due to its higher sensitivity to temperatures for proper flowering time and successful grain reproduction. So, higher temperatures in a winter season will lead to insufficient or failed vernalization and therefore to a lower grain yield of winter wheat (Yan et al., 2015).

Facultative wheat can be sown both autumn and spring and its requirements for vernalization (Muterko and Elena Salina, 2018) are satisfied in 5 – 30 days to 5 - 10°C (Ceapoiu et al., 1984) . In the first year of our research (2018) we wanted to see if the optimal sowing time of facultative wheat (especially Taisa – a new facultative wheat cultivar created at ARDS Turda) is the same as that of spring wheat and to compare their grain yields and grains quality.

MATERIAL AND METHODS

Using the subdivided split - plots method, into three replication, at ARDS Turda were studied six genotypes of wheat in terms of production and quality. The main technological elements pursued in this experience were:

- Sowing date (E): I – 15.03.2018 (control); II – 04.04.2018;
- Row spacing (D): D_1 = 12.5 cm (control); D_2 = 25.0 cm;
- Nitrogen fertilization, $kg \cdot ha^{-1}$ active substance (F): F_1 = 36, $F_2 = F_1 + 50$, $F_3 = F_1 + 100$;

  Nitrogen fertilization was applied in two phases: F_1 – in autumn, F_2 and F_3 – in spring, before heading.
- Wheat genotypes (S): facultative varieties: Taisa, Ciprian and Lennox and spring varieties: Pădureni, Granny and Triso.

The surface of the harvestable plot had 7.5 m^2 and the seeding rate was 550 germinable seeds/square meter. Plots were harvested individually by Wintersteiger Plot Combine and grain yield was reported at uniform moisture content (14%). The protein content, gluten content and Zeleny test were determined with Inframatic 9500 analyzer by using the whole grain.

The climate conditions during the experimental year 2018 are presented in table 1. It was an year characterized by drought in April and May. In the 3rd decade of July, the temperatures were higher than normal with 2.3°C and the rainfall were lower than the long term average with 5.6 mm. So, these conditions affected the filling of grains with consequences on thousand kernel weight and yield.

Table 1

The climate conditions in growing season of 2018

Growing season's months	Rainfall (mm)			Temperatures (°C)		
	Monthly average	60 years average	Deviation	Monthly average	60 years average	Deviation
March	40.9	23.6	+17.3	3.3	4.7	-1.4
April	26.2	45.9	-19.7	15.3	9.9	+5.4
May	56.8	68.7	-11.9	18.7	15.0	+3.7
June	98.3	84.8	+13.5	19.4	17.9	+1.5
July	85.7	77.1	+8.6	20.4	19.7	+0.7
August	38.2	56.6	-18.4	22.3	19.3	+3.0

To estimate the main effects of experimental factors and the interaction among them, we used the analysis of variance.

RESULTS AND DISCUSSIONS

Length of wheat growing season

In order to establish the precocity of studied wheat genotypes, we determined the length of growing season which is presented in table 2. It is obviously that, in spring, it decreases when the sowing date is delayed. The earliest variety of spring wheat was Triso.

Sown in 15 of March (2018), Ciprian and Lennox (both facultative wheat) had the same length of growing season as Triso (spring wheat). Compared to the first sowing date (I), the length of growing season decreased by 7 days (Taisa) to 20 days (Triso). So, it can be recorded that Taisa is a genotype with a longer growth cycle.

Table 2

Length growing season of studied varieties in function of sowing date

Genotype	Spring wheat			Facultative wheat		
	Pădureni	Granny	Triso	Taisa	Ciprian	Lennox
Sowing date I	15.03.2018					
Emergence	05.04.18	04.04.18	04.04.18	05.04.18	04.04.18	04.04.18
Heading	01.06.18	29.05.18	30.05.18	06.06.18	25.05.18	30.05.18
Physiological maturity	18.07.18	18.07.18	16.07.18	23.07.18	16.07.18	16.07.18
Lgs*	125 days	125 days	123 days	130 days	123 days	123 days
Sowing date II	04.04.2018					
Emergence	12.04.18	11.04.18	11.04.18	12.04.18	11.04.18	11.04.18
Heading	04.06.18	31.05.18	03.06.18	20.06.18	02.06.18	02.06.18
Physiological maturity	22.07.18	20.07.18	16.07.18	05.08.18	22.07.18	20.07.18
Lgs*	109 days	107 days	103 days	123 days	109 days	107 days

***** Length of growing season

Grain yield, thousand kernel weight and test weight

Grain yield was significantly influenced by genotype, row spacing and interaction between sowing date (E) and genotype (S). Sowing date (E), N fertilization (F) and the other interactions (D x S, F x S, E x D x S, E x F x S) significantly influenced grain yield (table 3).

Thousand kernel weight (TKW) and test weight (TW) were significantly influenced by genotype and interaction between sowing date (E) and genotype (E). Similar results for test weight were obtained by Rita Pereira Costa et al. in 2013. If row spacing (D) had no influence on thousand kernel weight, it had a significant effect on test weight. Also, in table 3, we can observe that N fertilization (F) had no significant influence on test weight.

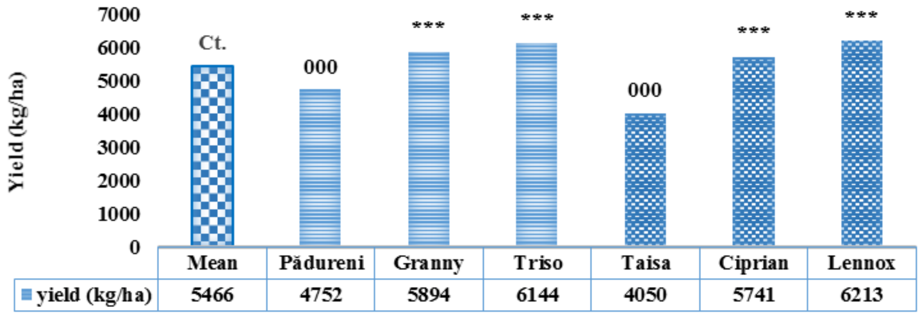
Table 3

Analysis of variance for grain yield, thousand kernel weight and test weight

Source of variance	Df	Yield (q/ha)		TKW (g)		TW (kg/hl)	
		MS	p	MS	p	MS	p
Sowing date (E)	1	3411.584	0.01	134.774	0.05	360.375	0.01
Row spacing (D)	1	994.722	0.0001	9.685	NS	54.802	0.01
N fertilization (F)	2	1284.414	0.01	15.771	0.05	2.829	NS
Genotype (S)	5	2729.217	0.0001	134.583	0.0001	214.684	0.0001
E x D	1			58.990	0.01	13.499	0.05
E x S	5	936.477	0.0001	140.531	0.0001	93.970	0.0001
D x S	5	72.914	0.01	22.914	0.01	16.487	0.01
F x S	10	12.825	0.01	6.469	0.05	1.700	0.01
E x D x S	5	33.945	0.01			3.948	0.01
E x F x S	10	10.673	0.05				
Error E	2	5.310		4.294		0.505	
Error D	4	2.646		1.511		1.008	
Error F	16	17.096		3.680		1.758	
Error S	120	5.365		2.776		0.660	

Note: NS – not significant at the $p \leq 0.05$ level;

In figure1, we can notice that the most productive genotypes were Lennox and Ciprian and from the spring wheat the higher values for yield were obtained at Triso and Granny.



LSD 5% = 108, LSD 1% = 143, LSD 0.1% = 184;

Note: Ct. – control;

Fig.1.The influence of genotype on grain yield

The 1st sowing date in spring (15 of March, 2018) promoted a higher expression of grain yield potential to all genotypes (table 4). Lennox (facultative wheat) stands out with a grain yield of 6523 kg/ha, exceeding Triso and Granny (spring wheat) with 148, respectively 445 kg ha^{-1}.

The 2nd sowing date in spring (April 4, 2018) showed to be an advantage for grain yield of wheat genotypes (spring and facultative) with short growth cycle and earlier heading time. Because of a height yield loss (2815 kg/ha) obtained to the 2nd sowing date, Taisa genotype is restricted in spring, so it can be sown until 15 of March. This major yield decrease can be explained by the poor filling of grains due the long growth cycle. But, sown to an optimal time, Taisa (facultative wheat, long growth cycle, later heading time) exceeds Pădureni (typical spring wheat, short growth cycle, earlier heading time) with almost 420 kg/ha, which is an important progress in wheat breeding.

In table 4, we can observe that a bigger row spacing cause a very significant decrease of yield, except Pădureni genotype.

Related to fertilization, in comparison with N 36 dose of nitrogen, by applying the highest doses were obtained grain yields increased with 616 $kg \cdot ha^{-1}$ at Pădureni, 986 $kg \cdot ha^{-1}$ to Granny, 944 $kg \cdot ha^{-1}$ at Triso, 648 $kg \cdot ha^{-1}$ to Taisa, 634 $kg \cdot ha^{-1}$ to Ciprian and 985 $kg \cdot ha^{-1}$ for Lennox. Unfortunately, by applying high rates of nitrogen fertilizer we cannot cover the yield losses caused by delayed sowing time. It is a conclusion that has been demonstrated in the past by Bilaus et al. (1980), but for the winter wheat.

TKW is a measurement indicator directly related to the grain yield and milling quality of grains (Protic et al., 2007, Wenhua Wu et al., 2018). Sowing date II (April 4, 2018) caused decrease of thousand kernel weight to Taisa and this can be explained by shorter grain-filling period. So, to this genotype, thousand kernel weight was markedly reduced, with almost 10 grams. Results that the optimal sowing date is important for a good harvest.

The influence of interaction between row spacing and genotype on thousand kernel weight of spring is significant.

A delay in sowing tends to decrease test weight of spring and facultative wheat. Similar results were obtained by SPANER et al. (2000) and OZTURK et al. (2006). RITA PEREIRA COSTA et al. (2013) reported that varieties with longer growth cycle (like Taisa, in our case) had a significant reduction on test weight in 2nd sowing date. Triso and Lennox responded positively to the Nitrogen fertilizer application (F_3) by increasing their test weight with 1.29 kg/hl, respectively 1.05 kg/hl.

Table 4

The influence of experimental factors on yield, thousand kernel weight and test weight

Experimental factors		Pădureni	Granny	Triso	Taisa	Ciprian	Lennox
Yield (kg ha^{-1})							
Sowing date	I (Ct.)	5039	6078	6375	5458	5706	6523
	II	4466^{00}	5711^{00}	5914^{00}	2643^{000}	5775^{NS}	5903^{000}
		LSD 5% = 182; LSD 1% = 295; LSD 0,1% = 620;					
Row spacing	D_1 (Ct.)	4759	6192	6357	4482	5915	6378
	D_2	4746^{NS}	5597^{000}	5931^{000}	3619^{000}	5567^{000}	6048^{000}
		LSD 5% = 152; LSD 1% = 207; LSD 0,1% = 284;					
Nitrogen fertilizer	F_1 (Ct.)	4340	5343	5603	3677	5332	5648
	F_2	4961^{***}	6011^{***}	6283^{***}	4149^{***}	5924^{***}	6329^{***}
	F_3	4956^{***}	6329^{***}	6547^{***}	4325^{***}	5966^{***}	6633^{***}
		LSD 5% = 225; LSD 1% = 302; LSD 0,1% = 400;					
Thousand kernel weight (grams)							
Sowing date	I (Ct.)	40.00	36.30	38.48	39.41	39.01	38.96
	II	40.58^{NS}	37.49^{NS}	37.74^{NS}	29.92^{000}	38.25^{NS}	38.72^{NS}
		LSD 5% = 1.47; LSD 1% = 2.52; LSD 0,1% = 5.82;					
Row spacing	D_1 (Ct.)	39.21	36.13	37.31	35.62	38.98	38.91
	D_2	41.38^{***}	37.66^{**}	38.91^{**}	33.70^{00}	38.29^{NS}	38.77^{NS}
		LSD 5% = 1.10; LSD 1% = 1.50; LSD 0,1% = 2.07;					
Nitrogen fertilizer	F_1 (Ct.)	39.68	37.10	37.44	34.89	37.92	38.15
	F_2	39.85^{NS}	36.20^{NS}	37.53^{NS}	35.35^{NS}	38.84^{NS}	38.80^{NS}
	F_3	41.35^{*}	37.38^{NS}	39.37^{**}	33.75^{NS}	39.14^{NS}	39.58^{*}
		LSD 5% = 1.40; LSD 1% = 1.87; LSD 0,1% = 2.45;					
Test Weight (kg/hl)							
Sowing date	I (Ct.)	77.36	76.50	76.84	74.71	75.31	77.52
	II	75.35^{000}	75.24^{00}	75.77^{00}	65.67^{000}	75.14^{NS}	75.56^{000}
		LSD 5% = 0.61; LSD 1% = 0.95; LSD 0,1% = 1.89;					
Row spacing	D_1 (Ct.)	76.42	76.22	76.47	72.06	75.57	76.77
	D_2	76.29^{NS}	75.52^{0}	76.14^{NS}	68.32^{000}	74.88^{0}	76.31^{NS}
		LSD 5% = 0.61; LSD 1% = 0.87; LSD 0,1% = 1.30;					
Nitrogen fertilizer	F_1 (Ct.)	76.15	75.66	75.57	70.58	75.16	76.03
	F_2	76.54^{NS}	75.88^{NS}	76.49^{*}	70.11^{NS}	75.37^{NS}	76.51^{NS}
	F_3	76.38^{NS}	76.07^{NS}	76.86^{**}	69.88^{NS}	$75.16^{Ct.}$	77.08^{**}
		LSD 5% = 0.76; LSD 1% = 1.02; LSD 0,1% = 1.35;					

Note: NS – not significant at the $p \leq 0.05$ level; Ct. – control;

Wheat quality

Genotype (S) and row spacing (D) are the main experimental factors that highly influenced the parameters of wheat quality. Sowing date had no statistical influence on gluten content and Zeleny test. The double interactions E x D, E x S and F x S influenced significant quality of wheat (table 5).

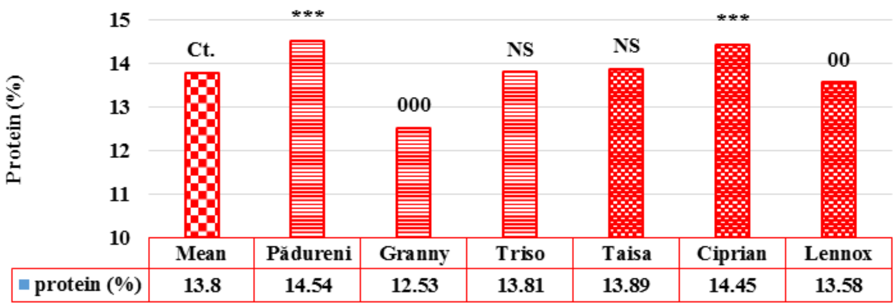
Table 5

Analysis of variance for protein content, gluten content and Zeleny test

Source of variance	Df	Protein (%)		Gluten (%)		Zeleny (%)	
		MS	p	MS	p	MS	p
Sowing date (E)	1	2.240	0.05	10.622	NS	72.685	NS
Row spacing (D)	1	21.914	0.0001	111.083	0.0001	1135.750	0.0001
N fertilization (F)	2	82.839	0.01	417.636	0.01	4514.690	0.01
Genotype (S)	5	18.952	0.0001	96.420	0.0001	1760.068	0.0001
E x D	1	5.415	0.01	26.530	0.01	416.388	0.01
E x S	5	0.260	0.01	1.322	0.01	35.596	0.01
F x S	10	0.555	0.01	2.782	0.01	29.133	0.01
E x D x S	5	0.232	0.05	1.159	0.05	19.232	0.01
Error E	2	0.130		0.730		13.694	
Error D	4	0.109		0.536		5.424	
Error F	16	1.070		5.409		57.304	
Error S	120	0.079		0.405		5.494	

Note: NS – not significant at the p≤0.05 level;

The protein content of wheat grains may vary between 10 and 18% of the total dry matter (Zuzana Šramkováa et al., 2009; Muntean et al., 2014; Ion, 2010). In comparison with the average, Pădureni and Ciprian had the highest grain protein content (fig.2). The lowest protein content was obtained to Granny (only 12.53%).



LSD 5% = 0.13, LSD 1% = 0.17, LSD 0.1% = 0.22;

Note: NS – not significant at the p≤0.05 level; Ct. – control;

Fig.2 The influence of genotype on protein content

The interaction E x S had non – significant influence on protein content of facultative wheat (table 6). A positive reaction of this parameter to the 2nd sowing date was observed at Pădureni and Granny (both spring genotypes).

In table 6, results show that double interactions, D x S and F x S, had a positive influence on protein and gluten content, as well as on Zeleny test. The protein content increased from row spacing 12,5 cm to row spacing 25 cm with 0.54% to Pădureni, 0.52% to Granny, 0.86% to Triso, 0.71% to Taisa, 0.61% at Ciprian, 0.58% to Lennox.

By applying the nitrogen fertilizer doses, all the studied quality parameters increased (table 6). The highest values were obtained to the highest nitrogen fertilizer dose.

As the results show, even to the lowest nitrogen fertilizer dose (F_1), Zeleny test had values between 36.72 ml (Granny) and 54.53 ml (Pădureni). So, we can say that all studied genotypes are good quality for bakery.

Table 6

The influence of experimental factors on tested varieties

Experimental factors		Pădureni	Granny	Triso	Taisa	Ciprian	Lennox
Protein (%)							
Sowing date	I (Ct.)	14.31	12.41	13.69	13.85	14.47	13.46
	II	14.77**	12.66*	13.93^{NS}	13.92^{NS}	14.43^{NS}	13.70^{NS}
		LSD 5% = 0.25; LSD 1% = 0.44; LSD 0.1% = 1.02;					
Row spacing	D_1 (Ct.)	14.27	12.27	13.38	13.53	14.15	13.29
	D_2	14.81***	12.79***	14.24***	14.24***	14.76***	13.87***
		LSD 5% = 0.21; LSD 1% = 0.30; LSD 0.1% = 0.44;					
Nitrogen fertilizer	F_1 (Ct.)	13.24	11.63	12.62	12.80	12.87	12.38
	F_2	14.95***	12.88***	14.20***	14.05***	15.03***	14.01***
	F_3	15.43***	13.10***	14.63***	14.81***	15.46***	14.35***
		LSD 5% = 0.42; LSD 1% = 0.57; LSD 0.1% = 0.78;					
Gluten (%)							
Sowing date	I (Ct.)	24.58	24.58	27.47	27.83	29.23	26.93
	II	25.13*	25.13^{NS}	27.99^{NS}	27.98^{NS}	29.13^{NS}	27.48^{NS}
		LSD 5% = 0.59; LSD 1% = 1.03; LSD 0.1% = 2.45;					
Row spacing	D_1 (Ct.)	28.74	24.27	26.78	27.11	28.51	26.54
	D_2	30.01***	25.44***	28.69***	28.70***	29.85***	27.87***
		LSD 5% = 0.47; LSD 1% = 0.66; LSD 0.1% = 0.97;					
Nitrogen fertilizer	F_1 (Ct.)	26.47	22.83	25.05	25.45	25.63	24.51
	F_2	30.28***	25.60***	28.61***	28.29***	30.46***	28.16***
	F_3	31.38***	26.13***	29.54***	29.98***	31.46***	28.95***
		LSD 5% = 0.95; LSD 1% = 1.29; LSD 0.1% = 1.75;					
Zeleny - sedimentation index (ml)							
Sowing date	I (Ct.)	63.10	44.02	56.21	57.71	62.97	53.51
	II	64.59^{NS}	43.20^{NS}	55.53^{NS}	55.50^{NS}	58.55^{00}	53.18^{NS}
		LSD 5% = 2.40; LSD 1% = 4.41; LSD 0.1% = 11.14;					
Row spacing	D_1 (Ct.)	62.03	41.82	52.80	53.82	58.68	51.13
	D_2	65.66***	45.40***	58.94***	59.39***	62.84***	55.56***
		LSD 5% = 1.65; LSD 1% = 2.30; LSD 0.1% = 3.30;					
Nitrogen fertilizer	F_1 (Ct.)	54.53	36.72	47.24	48.46	48.99	44.43
	F_2	66.89***	46.21***	58.66***	57.83***	64.84***	56.63***
	F_3	70.12***	47.91***	61.72***	63.53***	68.44***	58.98***
		LSD 5% = 3.18; LSD 1% = 4.33; LSD 0,1% = 5.85;					

Note: NS – not significant at the $p \leq 0.05$ level; Ct. – control;

CONCLUSIONS

In spring, when the sowing time is delayed, the length of growing season and yield decrease, but the quality of grains increase. The facultative wheat needs to be sown as early is possible in spring. Taisa, the new facultative wheat cultivar which has a long growth cycle, needs to be sown until 15 of March.

Unfortunately, by applying additional doses of nitrogen fertilizer, we cannot cover the yield losses caused by delayed sowing time. Both, spring wheat and facultative wheat, capitalize better the nutrition space and the nitrogen fertilizer through increasing the protein and gluten content.

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