THE INFLUENCE OF SOWING DATE ON YIELD AND QUALITY OF WINTER WHEAT

HIRIŞCĂU[1,2] Diana, Adina VARADI[1,2)*], Marcel M. DUDA[2)], Rozalia KADAR[1)], Ionuţ RACZ[1,2)], Adrian CECLAN[1)]

[1)]*Agricultural Research and Development Station Turda, 27 Agriculturii, Turda, Cluj, Romania*
[2)]*University of Agricultural Sciences and Veterinary Medicine, Faculty of Agriculture, Department of Plant Culture, 3-5 Calea Mănăştur, 400372, Cluj-Napoca, Cluj, Romania*
**Corresponding author: adina_presecan@yahoo.com*

Abstract: To study the effect of sowing dates on the grain yield and grain quality of three different winter wheat cultivars, an experiment was conducted at ARDS Turda during 2017-2018. By delaying the sowing date, the winter wheat grain yield decreases, while the grain protein content increases. The biggest loss of grain yield by delaying sowing date was noted to Andrada on sowing date III (6 of Dec. 2017), production decreasing with 1316 kg/ha-1 in comparison with optimal for this variety. Arieşan had the highest grain protein content (16.42 %) and Codru had the highest grain yield in all three experimental sowing dates.

Keywords: winter wheat, optimal sowing time, yield, quality

INTRODUCTION

The sowing date is a critical component for achieving wheat crop success. The main factor that dictates the sowing date of winter wheat is the soil temperature (GH. and ELENA PETCU, 2008). The time of sowing should be adjusted based on the temperature to allow rapid germination and give the seedlings time to establish well before winter. Since winter wheat is grown on large areas under very varied conditions worldwide, varieties and cultivation strategies have to be developed based on each site's characteristics (ERIKSSON and MAGNUSSON, 2015).

To have maximum resistance at winter conditions, winter wheat plants need to get a sum of biologically active temperatures (sum of temperatures higher than 0° C) of 400- 500 ° C, which allow wheat plants to have 2-3 tillers and 4-5 leaves.

The optimal sowing season for winter wheat in our country is between 1 and 10 of October for the southern, western and Transylvanian Plain, and between 25 of September and 5 of October for the hilly area and the northern area of the country. Tillers formats in the spring contribute less to yield potential than tillers formats in autumn, so it is important to have 3 to 5 tillers before winter sets in.

Early sowing increase the risk of excessive growth in autumn and excessive tillers until the winter sets in, which leads to sensitivity to the frost and thick snow layer (the asphyxiation phenomenon). It can also lead to an increased incidence of autumn pest infestation (as flies), diseases transmitted by certain vectors such as wheat curl mites (wheat streak mosaic) and aphids (barley yellow dwarf). Another problem that can arise from sowing too early is the control of grassy weed infestations.

Late sowing wheat has negative consequences such as a poorer field emergence (SPINK et al., 2000). In this case, the winter wheat plants have a low resistance to winter frost, resulting loss density. Sowing into colder soils delay wheat emergence, so that the seed treatment with fungicide is really necessary. In the spring, can have a low density, more exposed to the grassy weed infestations, and the vegetation is prolonged in summer (ION V., 2010).

Early planting produce greater number of spikes/square meter, heavier grains and highest grain yield, while late planting affected these characters negatively (WAJID A.S. et al., 2006).

The choice / setting of the sowing date cannot be made through a simple analysis of the calendar period. Thus, depending on the evolution of the climatic conditions around the sowing date, it can be earlier or delayed by 5-7 days (GH. and ELENA PETCU, 2008).

MATERIALS AND METHODS

A field experiment to study the effect of sowing dates on the yield and grains quality of three different winter wheat cultivars was conducted at ARDS Turda (46°35' N; 23°47'E; 345 m above Adriatic Sea), during 2017-2018. The experiment was laid out by using the subdivided split plot design with three replication.

The biological material consisted on three winter wheat cultivars created at ARDS Turda: Arieşan, Andrada and Codru. The research had three experiences, corresponding to the three sowing dates. Experimental studied factors were:

→sowing date (E):

-I (control) – 10 of October 2017 (optimal sowing date for winter wheat in Transylvania);

-II – 2 of November 2017 and

-III – 6 of December 2017 (with two weeks later than it was establish – 20 of November).

→row spacing (D):

- D_1=12,5 cm (control);

- D_2=25,0 cm.

→doses of fertilizers:

- F_1 (control) = 200 kg/ha N, P fertilizer (N:P =18:46);

- $F_2 = F_1$ + 50 kg/ ha^{-1} N active substance;

- $F_3 = F_1$ + 100 kg ha^{-1} N active substance.

Nitrogen fertilization was applied in two phases (in autumn – F_1, in spring, before heading, F_2 and F_3, with different rates).

→varieties : Arieşan, Andrada, Codru.

Initially, 20 days within three different sowing dates was established, but because rainfall of November the last sowing date was delayed by two weeks.

High temperatures and low rainfall in the spring (April and May) negatively affected the winter wheat grain yield sown in date III.

The plot surface area was 9 m^2 and the seed density was 550 germinate seed/m^2. Plots were harvested individually by Wintersteiger Plot Combine and grain yield was reported at uniform moisture content (14%). The protein content was determined with Inframatic 9500 analyzer by using the whole grain.

Analysis of variance (ANOVA) was used to estimate the main effects of experimental factors and the interaction among them.

RESULTS AND DISCUSSIONS

The influence of sowing date on length of winter wheat growing season

The length of growing season shortened with every delayed sowing date. So, referring to the length of growing season of winter wheat sown in 10 of Oct. 2018, the winter wheat sown in 2 of Nov. 2018 had a growing season shortened with 20 days (Andrada and Codru) and 22 days (Arieşan) and that sown in 6 of Dec. 2018 growing season shortened with 49 days (Andrada and Codru) and 50 days (Arieşan) (Table 1).

Table 1

Length of growing season

Cultivar	Sowing date	I	II	III
		10.10.2017	02.11.2017	06.12.2017
ARIEŞAN	Emergence	19.10.2017	16.11.2017	20.02.2018
ANDRADA		19.10.2017	16.11.2017	20.02.2018
CODRU		19.10.2017	16.11.2017	21.02.2018
ARIEŞAN	Heading	07.05.2018	11.05.2018	14.05.2018
ANDRADA		09.05.2018	14.05.2018	19.05.2018
CODRU		08.05.2018	13.05.2018	18.05.2018
ARIEŞAN	Physiological maturity	25.06.2018	26.06.2018	02.07.2018
ANDRADA		25.06.2018	28.06.2018	03.07.2018
CODRU		25.06.2018	28.06.2018	03.07.2018
ARIEŞAN	Length of growing season	258 days	236 days	208 days
ANDRADA		258 days	238 days	209 days
CODRU		258 days	238 days	209 days

Table 2

Analysis of variance on the mass of winter wheat plants (grams)

Source of variance	Df	MS	F	p
Sowing date (E)	2	57.697	247.935	0.0001
Row spacing (D)	1	0.107	0.399	NS
Genotype (S)	2	1.407	7.092	0.01
E x S	4	0.992	5.002	0.01
Error E	18	0.232		
Error D	27	0.269		
Error S	108	0.198		

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

The mass of plants at the end of the winter was significantly influenced by the sowing date (Table 2). The row spacing (D) had no influence on this character. Obviously, the mass of winter wheat plants sown in 10 of Oct. was bigger than those sown in 2 of Nov. or 6 of Dec., but will see that it has no connection with the grain yield. It means that under optimal conditions of temperature and humidity winter wheat quickly recovers by accelerating the growth stages.

The influence of sowing date on number of productive tillers

The number of productive tillers at winter wheat was significantly influenced by genotype, while the N fertilization had no influence (*table 3*). A high influence on this character had the interaction between sowing date and genotype and triple interaction E x F x S.

Table 3

Analysis of variance on number of productive tillers

Source of variance	Df	MS	F	p
Sowing date (E)	2	0.195	55.879	0.05
N fertilization (F)	2	0.0004	0.068	NS
Genotype (S)	2	0.081	23.311	0.0001
E x S	4	0.024	6.896	0.01
F x S	4	0.015	4.433	0.05
E x F x S	8	0.014	4.149	0.01
Error E	2	0.003		
Error F	6	0.007		
Error S	18	0.003		

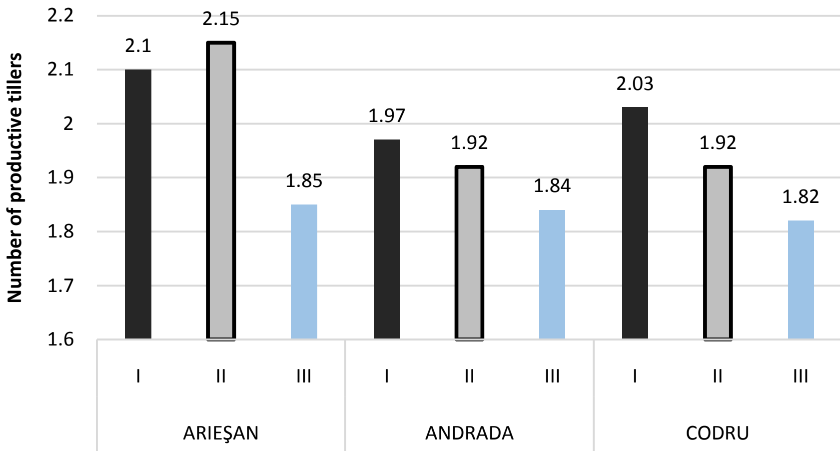
Note: NS – not significant at the $p \leq 0.05$ level;

Arieşan cultivar has the highest number of productive tillers (2.15) at the sowing date II, while Andrada and Codru had the highest number of productive tillers at the sowing date I (Fig. 1). It will be highlighted into a higher grain yield so, it points out that there is a positive correlation between number of productive tillers and the grain yield. The lowest number of productive tillers for all varieties was recorded at the sowing date III.

The influence of sowing date on grain yield

In maximizing grain yield, sowing time has a major importance (OZTURK et al., 2006). Also, in most cropping systems, N fertilization leads to increases in dry matter, grain and protein yield. Biomass and grain yield increase linearly with the amount of N fertilizer until the N effect wears off and a maximum is reached. Additional fertilization only increase the protein content and a higher fertilization can lead to a decrease in dry matter and grain yield (HAY and WALKER, 1989; BELOW, 1995).

The number of tillers that develops depends on the growing conditions, the duration of the tillering period and the plant density (ERIKSSON and MAGNUSSON, 2015). So, tillering is most dependent on environmental conditions and temperature, radiation, water and nutrients, and especially the duration of growing conditions (SPINK et al., 2000).



LSD 5% = 0.10; LSD1% = 0.18; LSD 0.1% = 0.45;

Fig. 1. Number of productive tillers

The sowing date has a great impact on the growing condition in the autumn. Longer days and higher temperature allow early-sown plants to grow and produce more tillers than later emerged plants (WHITE and EDWARDS, 2008).

The grain yield was significantly influenced by all experimental factors, including the interaction between sowing date and genotype (Table 4).

Table 4

Analysis of variance on grain yield (q/ha)

Source of variance	Df	MS	F	p
Sowing date (E)	2	1076.322	42.977	0.0001
Row spacing (D)	1	922.160	65.456	0.0001
N fertilization (F)	2	403.882	12.079	0.0001
Genotype (S)	2	859.665	78.943	0.0001
E x D	2	47.130	3.345	NS
E x F	4	44.107	1.319	NS
E x S	4	105.647	9.702	0.0001
F x S	4	28.613	2.628	0.05
Error E	4	25.044		
Error D	6	14.088		
Error F	24	33.436		
Error S	72	10.889		

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

Analyzing table 5, it can be noted that delaying sowing date, and 25 cm row spacing had a negative influence on grain yield of Andrada and Codru cultivars, especially at the sowing date III.

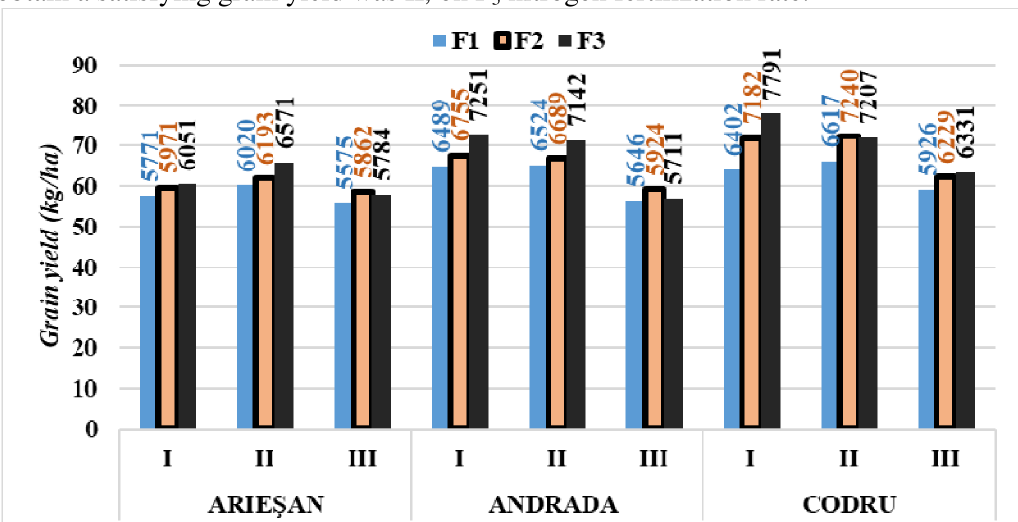
Table 5

The influence of the interaction E x D x S on grain yield (kg/ha)

Cultivar	Sowing date	D_1		D_2	
		Grain yield (kg/ha^{-1})	difference	Grain yield (kg/ha^{-1})	difference
ARIEŞAN	I	6069	Mt.	5792	Mt.
	II	6417	348	6105	313
	III	6048	- 21	5432	- 360
ANDRADA	I	6977	Mt.	6686	Mt.
	II	7130	153	6440	- 246
	III	6151	- 827^{00}	5370	- 1316^{000}
CODRU	I	7323	Mt.	6927	Mt.
	II	7158	- 164	6884	- 43
	III	6490	- 833^{00}	5834	- 1093^{000}

D_1 = 12,5cm; D_2 = 25 cm;
LSD 5% = 404; DL 1% = 599; DL 0.1% = 950;

Under the influence of the triple interaction E x F x S (Fig. 2), at the same sowing distance, the grain yield increased with N fertilization for each genotype. The most productive genotype was Codru at the sowing dates I and II, on F_2 and F_3 nitrogen fertilization rates, being followed by Andrada. The optimal sowing date for Arieşan, to obtain a satisfying grain yield was II, on F_3 nitrogen fertilization rate.



LSD 5% = 518; LSD 1% = 730; LSD 0.1% = 1059;

Fig. 2 The influence of the interaction E x F x S on grain yield (q/ha)

The influence of sowing date on grain quality

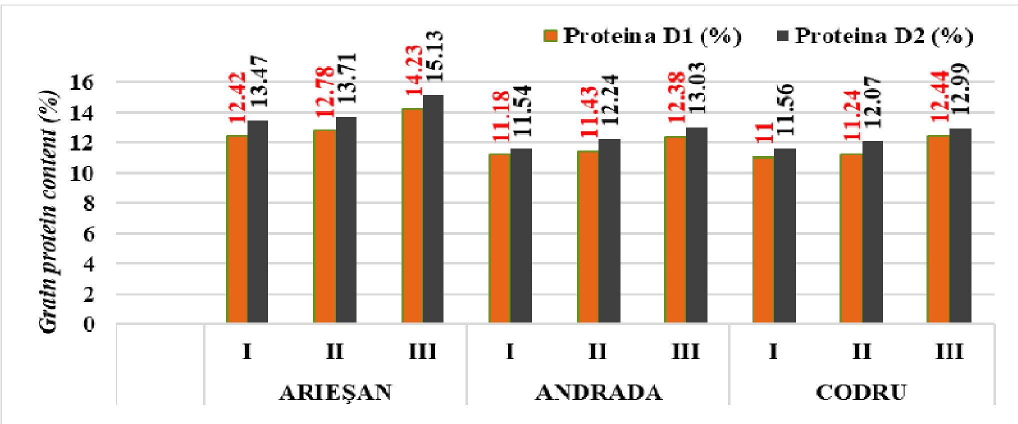
The protein content was significantly influenced by all experimental factors (Table 6). A high influence had the interaction between N fertilization and genotype. Also, the triple interaction E x F x S had a high influence on this character.

Table 6

Analysis of variance on grain protein content (%) of winter wheat

Source of variance	Df	MS	F	p
Sowing date (E)	2	33.120	153.081	0.0001
Row spacing (D)	1	22.000	125.187	0.0001
N fertilization (F)	2	138.243	184.195	0.0001
Genotype (S)	2	52.004	316.780	0.0001
F x S	4	0.608	3.706	0.01
E x F x S	8	0.524	3.193	0.01
Error E	4	0.216		
Error D	6	0.175		
Error F	24	0.750		
Error S	72	0.164		

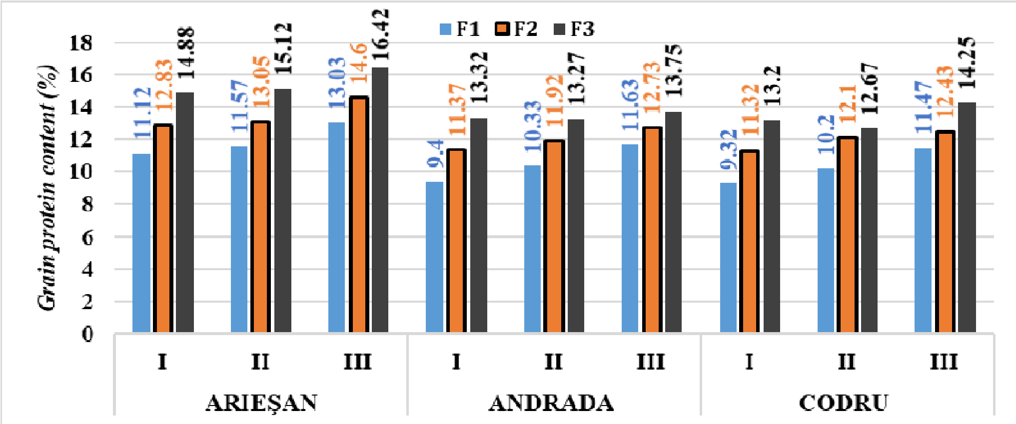
At all three different sowing dates, at the distance between rows D_2 (25.0 cm), the grain protein content was higher because of a better efficiency in the absorption, metabolism and translocation of nitrogen in kernel (fig.3). Arieşan had the higher protein content (15.13%), being followed by Andrada (13.03%) and Codru (12.99%).



LSD 5% = 0.44; LSD 1% = 0.64; LSD 0.1% = 0.97;

Fig. 3. The influence of the interaction E x D x S on grain protein content (%) of winter wheat

By applying different rates of N fertilizer, the protein content increases. In the fig.4 can be observed that at same sowing date, each genotype recorded increases of protein content by application of nitrogen fertilizers. Tracking the evolution of protein content from one sowing date to another, we notice that it grows with the late date of sowing while yield decrease.



LSD 5% = 0.66; LSD 1% = 0.91; LSD 0.1% = 1.27;

Fig. 4. The influence of the interaction E x F x S on grain protein content (%) of winter wheat

Thousand kernel weight (TKW) is also a parameter for grain quality assessment. It was significantly influenced by all experimental factors and by the interaction between these (Table 7).

Table 7

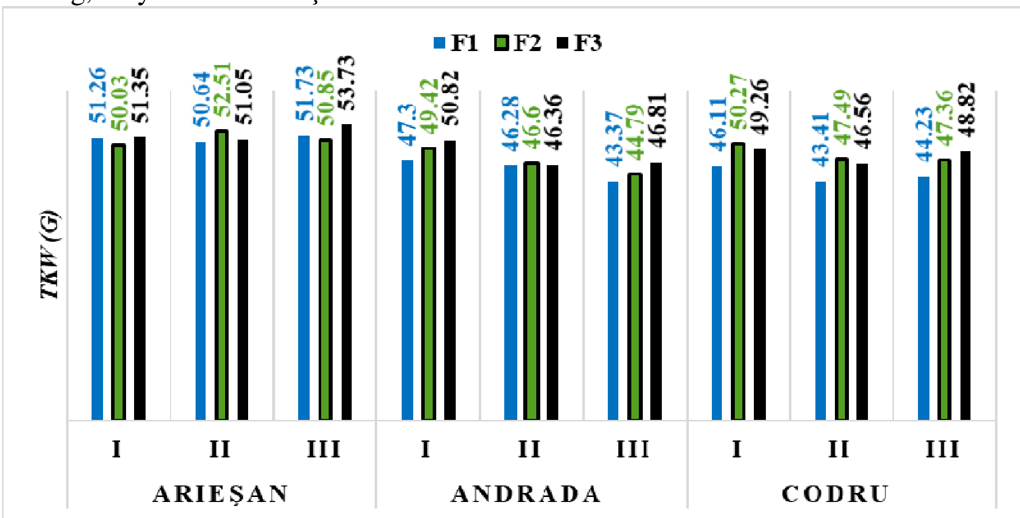
Analysis of variance on TKW (g) at winter wheat

Source of variance	Df	MS	F	p
Sowing date (E)	2	46.946	36.164	0.0001
Row spacing (D)	1	96.898	53.082	0.0001
N fertilization (F)	2	74.576	27.510	0.0001
Genotype (S)	2	365.126	165.795	0.0001
E x D	2	23.255	12.740	0.01
E x F	4	10.737	3.961	0.05
E x S	4	37.897	17.209	0.0001
D x S	2	10.594	4.811	0.05
F x S	4	18.728	8.504	0.01
E x D x F	4	12.623	4.657	0.01
E x D x S	4	8.532	3.874	0.01
D x F x S	4	6.999	3.174	0.05
E x D x F x S	8	6.989	3.174	0.01
Error E	4	1.298		
Error D	6	1.825		
Error F	24	2.710		
Error S	72	2.202		

Analyzing the influence of the interaction E x F x S on TKW (Fig. 5), we can notice that Arieşan has the highest value of this parameter (53.73 g) at sowing date III, on F_3 nitrogen fertilization rate. Arieşan is characterized by a high value of TKW and easily can reach 50 – 51 g even on the lowest N fertilization rate (F_1).

The values of TKW (g) for Andrada genotype were between 43.37 g (sowing date III, on F_1 nitrogen fertilization rate) and 50.82 g (sowing date I, on F_3 nitrogen fertilization rate).

At sowing date I, on F_2 nitrogen fertilization rate, Codru reaches values of 50.27 g, very close to Arieşan.



LSD 5% = 1.77; LSD 1% = 2.42; LSD 0.1% = 3.31;

Fig. 5. The influence of the interaction E x F x S on TKW (g) of winter wheat

CONCLUSIONS

Even if the sowing date of winter wheat is delayed, it recovers fast in spring by accelerating the growing and developing stages.

In all three different sowing dates, at the distance between rows of 25.0 cm, the grain yield was lower, but the grain protein content was higher because of space nutrition which offer a better efficiency in absorption, metabolism and translocation of nitrogen in kernel.

The optimal sowing date of all tested winter wheat genotypes seems to be between 10 of October and 2 of November in the conditions of Transylvania Plain.

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