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EFFECT OF GENOTYPE AND SOWING DATE ON YIELD AND YIELD COMPONENTS OF FACULTATIVE WHEAT IN TRANSYLVANIA PLAIN

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Abstract

Field experiments were conducted for two successive seasons during 2017/2018 and 2018/2019 at ARDS Turda to asset the performance of three different facultative wheat genotypes under different sowing dates. The experiment was laid out in split plot design with three replicates and comprised of five dates of sowing, noted I to V (I-III sown in autumn, IV - V sown in spring), in main plots and three facultative wheat genotypes (Taisa, Ciprian and Lennox) in subplots. Two years results revealed that in autumn sowing conditions, facultative wheat sown at the end of Oct. - beginning of Nov. performed better in number of productive tillers/plant, number of grains/spike, weight of grains/spike and grain yield. In the 1st season, Taisa had the highest grain yield (7.80 t ha^{-1}), but in the 2nd Ciprian performed better (7.63 t ha^{-1}). In spring sowing conditions, the facultative wheat needs to be sown as early as possible, especially Taisa (long growth cycle, later heading time). A delay in spring sowing tends to decrease number of tillers/plant, number of productive tillers/plant, weight of grains/spike and grain yield. Lennox performed better than Taisa and Ciprian in both seasons.

***Key words**: facultative wheat, sowing date, yield components.*

INTRODUCTION

Following Olesen et al. (2011) and Valizadeh's et al. (2014) research, it was concluded that the wheat cultivation period, in all climate change scenarios, will be reduced, compared to the current situation. Possible reasons are the increase of the temperature rate and the acceleration of the wheat growth stages. In 2016, Bing et al. have shown that a global increase in temperature of 1^{0}C would lead to an overall decrease in wheat production by 4.1-6.4%. So, the researchers must be prepared to provide the main source of food for mankind. For that, they must know the genetic materials and the proper sowing conditions for each genotype and “cultivation strategies have to be developed based on each site’s characteristics” (Eriksson & Magnusson, 2015).

The grain yield of wheat is “affected by environmental conditions” (Pereira Costa et al., 2013) and “can be regulated by sowing time” (Ozturk et al., 2006; Aslani & Mehrvar, 2012).

In the world cultivation of cereals we can distinguish typical spring wheat genotypes sown in spring, typical winter wheat genotypes sown in autumn, and transitional wheat forms (facultative genotypes), sown both in autumn and spring (Wyzińska and Grabiński, 2018). Facultative wheat can be sown both autumn and spring and its requirements for vernalization (Muterko & Salina, 2018) are satisfied in 5-30 days to 5-10°C (Ceapoiu et al., 1984).

Optimum sowing dates provide favorable temperature to obtained maximum yield (Muhammad et al., 2015). In autumn, at tillering stage, optimum sowing date could produce good crop growth that increases the cold tolerance (Safdar et al., 2013). Fall - developed tillers contribute more to grain yield than do tillers developed in the late spring (Ozturk et al., 2006).

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. Late sowing of wheat causes reduction in number of tillers/m^2 (Muhammad et al., 2015), in plant height (Tahir et al., 2009), in days to heading and maturity (Sial et al., 2005), in number of kernel per spike (Refay, 2011), of thousand kernel weight (Wajid et al., 2004; Muhammad et al., 2015) and consequently causes lower grain yield (Sial et al., 2005; Tahir et al., 2009; Yajam & Madani, 2013; Sohail et al., 2014; Tadeusz, 2014; Muhammad et al., 2015). In spring, late sowing wheat causes a low density, so it is more exposed to the grassy weed infestations and the vegetation is prolonged in summer (Ion, 2010).

Early sowing wheat increase the risk of excessive growth in autumn and prolongs the duration of tillering (Aslani & Mehrvar, 2012). Early planting produce greater number of spikes/square meter, heavier grains and highest grain yield (Wajid et al., 2006). It can also leads 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.

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" (Koppel, 2008; Wyzińska & Grabiński, 2018). 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).

Sown in autumn, facultative wheat suffers like spring wheat because of low winter temperatures, but less than the typical spring wheat, giving superior outputs to spring wheat. Sown in spring, facultative wheat turned out to be more late and sensitive to drought and high temperatures (Ceapoiu et al., 1984).

In Transylvania Plain, the optimum sowing date of wheat in autumn is between 25 of September and 10 of October and in spring the second half of March (Muntean et al., 2014). So, the present study was conducted to evaluate the genetic yield potential of three facultative wheat genotypes under different sowing dates (in autumn and spring).

MATERIALS AND METHODS

Materials and methods

Field experiments were carried out during 2017/2018 (1st) and 2018/2019 (2nd) seasons at ARDS Turda on latitude 46° 35′ N, longitude 23° 47′ E and altitude of 345-493 m above Adriatic Sea level (Grecu et al., 2007), in Transylvania Plain, Romania. The experiment was established on a typical clay Chernozem soil, typical for the forest steppe encountered over half of the Transylvanian Plain. The agrochemical indexes for this soil type, in the arable layer, were determined by OSPA Cluj (2014). The average values of these indexes are: the soil reaction is neutral (pH = 6.81-6.84), humus content = 3.36-3.73%, total nitrogen content = 0.177-0.205%, potassium content = 220 -320 ppm in Amp, mobile phosphorus = 11-35 ppm in Amp.

The experiment was laid out in split plot design with three replicates. Sowing date (E) was the main plot factor and the genotype (S) was the subplot factor (Taisa, Ciprian and Lennox). In the two experimental years, the climatic conditions did not allow the sowing of experiences to take place on the same date (Table 1).

Table 1. Sowing date

Season \ Sowing date	Autumn			Spring	
	I - control	II	III	IV - control	V
2017-2018	10.10.'17	02.11.'17	06.12.'17	15.03.'18	04.04.'18
2018-2019	10.10.'18	30.10.'18	16.11.'18	04.03.'19	18.03.'19

If in the 1st season we respected the optimal sowing period of wheat in spring, in the 2nd season we decided to rush it because of the high temperatures and the lack of precipitations from 2018 during April and May (Table 2), which affected the emerged and tillering of facultative wheat sown in April 4 (especially Taisa genotype).

Nitrogen fertilization was applied in two phases: N_{36} kg ha^{-1} in autumn and N_{105} kg ha^{-1} before heading.

All other agronomic practices (e. g. method of planting, seeding rate, planting depth, weeding and harvesting) were kept constant for all treatments. 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 observations were recorded for plant height, flag leaf area, number of tillers per plant, productive tillers per plant, days to physiological maturity (to determinate the length of growing season), number of grains per spike, weight of grains per spike, thousand grains weight (TKW) and grain yield.

To determinate flag leaf area, the measurements were made according to the classical method, at the flowering stage, on samples of 30 wheat plants from each plot that were marked. For that, we used the formula:

$A = b \times$ leaf length $\times$ max leaf width (Montgomery, 1911, cited by Chanda and Singh in 2002), where b is a coefficient (b = 0.75).

The number of tillers per plant was determined at the end of tillering stage for each genotype by using a sample of 30 plants.

Productive tillers/plant was obtained by dividing number of spike m^{-2} to number of emerged plants m^{-2}.

Before harvesting, the marked wheat plants were taken to the laboratory in order to determine the number of grains per spike, weight of grains per spike and thousand grains weight (TKW).

Using Wintersteiger microbatosis, each spike was beaten individually. The grains resulted from each spike were counted manually, then weighed with a high precision balance. The thousand grains weight (TKW) was determined by dividing the grains weight to the numbers of grains and then multiplying by 1000.

The grain yield obtained from each plot (kg/7.5 m^2) was weighed with a high precision balance, reported at uniform moisture content (14%) and then estimated in t ha^{-1}.

Climatic conditions

Climatic data during the investigated period (2017-2019) indicate that the years when the researches were conducted were different, both in rainfall quantities and level of temperatures (Table 2), as compared with a long term average (1957-2017).

Statistical analysis

The collected data were analysed statistically by the standard analysis of variance (ANOVA), using the Polifact program.

Table 2. Climatic conditions of the experimental area

Month	2017 - 2018				2018 – 2019				60 years average	
	Rainfall (mm)		Temperatures (°C)		Rainfall (mm)		Temperatures (°C)		Rainfall (mm)	Tempera-tures (°C)
	m.a.*	dev.**	m.a.*	dev.**	m.a.*	dev.**	m.a.*	dev.**		
August	36.1	-20.5	22.3	3.0	38.2	-18.4	22.3	3	56.5	19.3
Sept.	56.2	13.7	15.8	0.7	29.8	-12.7	16.7	1.6	42.5	15.1
Oct.	49.2	13.6	11.6	2.1	26.8	-8.8	12.7	3.2	35.6	9.5
Nov.	30.8	2.3	4.9	1.0	29.6	1.1	6.0	2.1	28.5	3.9
Dec.	20.7	-6.4	1.0	2.4	58.3	31.2	-0.9	0.5	27.1	-1.4
Jan.	16.7	-5.1	0.2	3.6	46.0	24.2	-2.2	1.2	21.8	-3.4
Feb.	33.4	14.6	-0.3	0.6	14.7	-4.1	1.7	2.6	18.8	-0.9
March	40.9	17.3	3.3	-1.4	12.3	-11.3	7.3	2.6	23.6	4.7
April	26.2	-19.7	15.3	5.4	62.6	16.7	11.3	1.4	45.9	9.9
May	56.8	-11.9	18.7	3.7	152.4	83.7	13.6	-1.4	68.7	15.0
June	98.3	13.5	19.4	1.5	68.8	-16.0	21.8	3.9	84.8	17.9
July	85.7	8.6	20.4	0.7	35.0	-42.1	20.4	0.7	77.1	19.7
August	38.2	-18.4	22.3	3.0	63.8	7.2	22.1	2.8	56.5	19.3

*monthly average; **deviation;

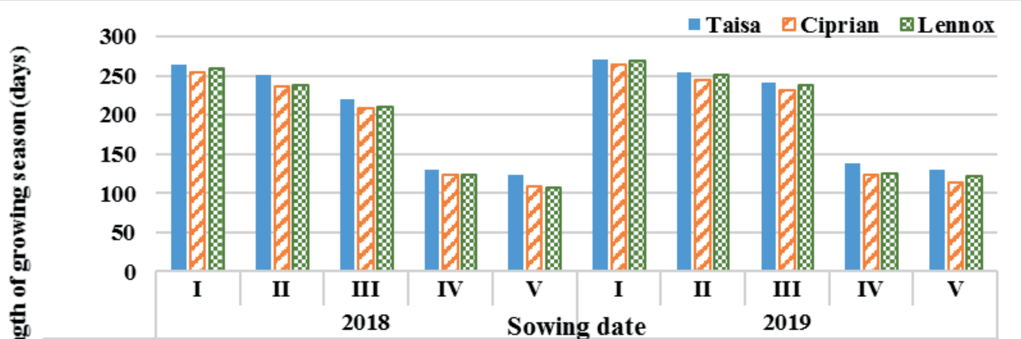
RESULTS AND DISCUSSIONS

Length of growing season

In order to establish the precocity of studied facultative wheat genotypes, we determined the length of growing season which is presented in Figure 1. It is obviously that, it decreases when the sowing date is delayed, regardless of the sowing time (autumn or spring).

If in the spring of 2018, respectively in April and May, we have experienced an acute lack of precipitations (deviation of -19.7 and -11.9 mm compared to the m.a.) and high temperatures (deviations of +5.4 and 3.7°C compared to the m.a.) which determined the acceleration of growth and development stages of wheat, the physiological maturity was reached in a shorter time, in 2019, in the same months, we were confronted with an excess of precipitation (deviation of +16.7 and +83.7 mm compared to the m.a.) and slightly lower temperatures (deviations of +1.4 and -1.4°C compared to the m.a.), so the growing season was longer. A shorter number in days to maturity caused by high temperature was also reported by Nahar et al. in 2010.

Analysing Figure 1, it can be recorded that Taisa is a facultative wheat genotype with a longer growth cycle, being followed by Lennox and Ciprian. Depending on the climatic conditions and sowing date, Taisa can reach a length of growing season of 220-271 days sown in autumn and 123-138 days sown in spring. Lennox can reach a length of growing season of 211-270 days sown in autumn and 107-126 days sown in spring. Ciprian can reach a length of growing season of 208-264 days sown in autumn and 109-123 days sown in spring.



Sowing date	2018 I	2018 II	2018 III	2018 IV	2018 V	2019 I	2019 II	2019 III	2019 IV	2019 V
Taisa	265	251	220	130	123	271	255	241	138	130
Ciprian	255	236	208	123	109	264	244	231	123	114
Lennox	259	239	211	123	107	270	251	238	126	122

Figure 1. Length of growing season

Plant height

In both seasons, in autumn/spring sowing conditions, the plant height of facultative wheat was significantly influence by genotype (Table 3). Sown in autumn, the wheat plants were higher than sown in spring (Table 4). Lennox was the highest genotype, being followed by Ciprian and Taisa, in both seasons.

In the 1st season, sowing date had a very significant influence on plant height when facultative wheat was sown in autumn and a significant one, when it was sown in spring. In the 2nd season, at both sowing conditions, sowing date and the double interaction (S x E) had no influence on plant height (Table 3). So, the observed differences could be referred to environmental effect. In autumn sowing conditions, the highest difference (14.56 cm) was recorded in the 1st season (Table 5). A decrease of plant height in late autumn sowing can be attribute to a shorter growing period. The earliest sowing date may have enjoyed the better environmental conditions which resulted into the tallest plants. Similar results were reported by Sial et al. (2005). Also, Muhammad et al. (2015) reported that "late sowing of wheat caused reduction" in plant height.

Sown in mid-March, the plant height increased in the 2nd season with 17.78 cm because of the rains that fell in April-May (Table 5).

Flag leaf area

It is considered that the flag leaf has an essential role in the total productivity of the wheat plant, being the last to dry. The flag leaf can intercept a considerable amount of light energy which it converts into carbohydrates which will be translocated to the grain (Dobre & Lazăr, 2014).

The analysis of variance indicates significant differences for flag leaf area among the facultative wheat genotypes in both seasons (Table 3). For all genotypes, the highest values for flag leaf area were recorded in the 2nd season (Table 4). Sown in autumn, Taisa had the highest flag leaf area (30.10 cm^2) being followed by Lennox (26.08 cm^2) and Ciprian (25.10 cm^2). Sown in spring, Ciprian (34.13 cm^2) and Taisa (33.63 cm^2) had the highest values of flag leaf area and Lennox had the lowest (24.49 cm^2). In both seasons, sown in spring, the values of flag leaf area are slightly increased in Taisa and about the same in Lennox. Ciprian genotype had a different behaviour due to its short growth cycle and climatic conditions. So, in the 1st season, sown in spring, Ciprian genotype had the value of flag leaf area lower with 5.28 cm^2 than sown in autumn. In the 2nd season, sown in spring, the same genotype had the value of flag leaf area higher with 9.03 cm^2 than sown in autumn.

Sowing date (E) had a very significant influence on flag leaf area only in the 2nd season, in autumn sowing conditions. It had a non-significant effect on flag leaf area for all the other sowing conditions. On the other hand, the double interaction (S x E) has strongly influenced the flag leaf area in the 2nd season (Table 3).

In the 1st season, in autumn sowing conditions, as the sowing date is delayed, the flag leaf area decreases, but in spring sowing conditions, it increases (Table 5). In the 2nd season, the situation was exactly the opposite: in autumn sowing conditions, as the sowing date was delayed, the flag leaf area increased and in spring sowing conditions, it decreased. Sown in mid-March, the flag leaf area of facultative wheat genotypes increased in the 2nd season with 12.38 cm^2 (Table 5). The results obtained in the 1st season (autumn sowing conditions) may be due to the decrease in temperatures.

Number of tillers/plant

In both seasons, in autumn sowing conditions, number of tillers per plant was highly influenced by the sowing date. The influence of genotype and double interaction (S x E) on number of tillers/plant was significant only for the 2nd season, in autumn sowing conditions. In spring sowing conditions, the genotype and the sowing date had a significant effect on number of tillers/plant for the 2nd season, being non-significant for the 1st, and the interaction between the experimental factors had a significant effect on it just for the 1st season (Table 3).

The tillering ability of the facultative wheat genotypes was expressed in the 2nd season, at both sowing conditions (Table 4). Taisa genotype is the most stable for this character because, sown in autumn or spring, it produces the same number of tillers/plant. Lennox genotype had a different behaviour: in the 1st season, sown in autumn, it produced a higher number of tillers/plant than sown in spring; in the 2nd season was exactly the opposite (because in autumn it was affected by wheat dwarf virus and flies, which were favorited by the high temperatures and lack of precipitations from Oct. and Nov.).

Sown in autumn, the highest number of tillers/plant was obtained in both seasons at sowing date I (10 Oct.). So, a delayed sowing in autumn leads to a smaller number of tillers/plant (Table 5). A less number of tillers/plant in late sowing can be attribute to the fact that the temperature wasn't according to the tillering requirement. Differences in number of tillers/plant among genotypes might be attribute to their genetic diversity. These results are in accordance with those of Tahir et al. (2009).

In spring sowing conditions, the highest number of tillers/plant was obtained in the 2nd season, when the sowing took place at the beginning of March (4.03 tillers/plant). Compared to the 1st season, in the 2nd one, the tillering and the growth of tillers was positively influenced by the rainfall that occurred in April and May. Also, a late sowing of facultative wheat in spring causes a reduction in number of tillers/plant, it decreasing from 4.03 to 3.40 tillers/plant.

Productive tillers/plant

In autumn sowing conditions, the genotype, the sowing date and the interaction between them had a very significant influence on productive tillers/plant. In spring sowing conditions, if the genotype had a very significant influence on this parameter, the sowing date and the S x E interaction had just a significant influence on it (Table 3).

In Table 4, the comparison between the genotypes indicates that sown in autumn, in both seasons, Ciprian genotype had the highest number of productive tillers/plant. Sown in spring, in the 1st season, Ciprian genotype maintains its position, but in the 2nd season, Lennox genotype leads with 2.43 productive tillers/plant. So, the studied genotypes have different capacity of tillering and therefore the obtained grain yield depends on ability of tillers/plant to performed, regardless the climatic conditions.

Analysing Table 5, we can observe that in both seasons, in autumn sowing conditions, the number of productive tillers/plant is higher than in spring sowing time. It is in conformity with Ozturk et al. (2006) who reported that "fall-developed tillers also contribute more to grain yield than do tillers developed in the late spring". Sown in autumn, the best sowing date to obtain the highest number of productive tillers/plant was II (to the end of Oct. - beginning of Nov.), which is reflected in the obtained grain yields. Sown in spring, in both seasons, the best sowing date to obtain the highest number of productive tillers/plant was IV (from the beginning to the middle of March).

Number of grains/spike

Number of grains/spike was significantly influenced by genotype in both seasons and in both sowing conditions (Table 3). In the 1st season, if in autumn sowing conditions, the sowing date and the double interaction had a significant influence on number of grains/spike, in spring sowing conditions these factors had no statistical influence on it. Also, in the 2nd season (both sowing conditions), it was very affected by sowing date and S x E interaction (Table 3).

Analysing Table 4, we concluded that, in the 1st season (both sowing conditions), Taisa genotype produced the highest number of grains/spike (47.07 - sown in autumn, 47.35 - sown in spring), being followed by Lennox genotype (43.19 - sown in autumn, 38.13 - sown in spring) and Ciprian genotype (32.60 - sown in autumn, 37.38 - sown in spring). In the 2nd season, in spring sowing conditions, the order of the genotypes according to the mean values of number of grains/spike was the same as in the 1st season, but in autumn sowing conditions, the order of the genotypes was: Lennox (47.90), Taisa (39.87) and Ciprian (39.00).

In Table 5 is presented the influence of sowing date on number of grains/spike. In autumn (both seasons), late sowing caused an increase of number of grains/spike, which is not in accordance with the results obtained by Refay (2011) and Muhammad et al. (2015). It ranged from 35.51 to 46.40 in the 1st season and from 41.57 to 43.10 in the 2nd season. This fact can be attributed to a lower tillering. Sown in spring, the highest number of grains/spike was obtained in the 1st season. In both seasons, the best values of this parameter were obtained when the facultative wheat was sown in mid-March.

Weight of grains/spike

In autumn sowing conditions, in both seasons, genotype and S x E interaction had a significantly influence on weight of grains/spike, while sowing date had low or non-significant influence on it (Table 3). In spring sowing conditions, in the 2nd season, genotype, sowing date and the interaction between them had no influence on weight of grains/spike. In the 1st season, it wasn't influence by genotype and sowing date, but the double interaction recorded a significant one ($p > 5\%$).

Sown in autumn, in the 1st season, Taisa recorded the highest weight of grains/spike (1.88 g), being followed by Lennox (1.77 g) and Ciprian (1.43 g). In the 2nd season, the order of the studied genotypes was another: Lennox (1.86 g), Ciprian (1.66 g) and Taisa (1.43 g). All these results are presented in Table 4. Also, sown in spring, in the 1st season, Taisa had the highest weight of grains/spike (1.63 g) and Ciprian the lowest (1.48 g), but in the 2nd season, Taisa was still the leading one with 1.30 g, while Lennox was the last one with 1.12 g. Obviously, sown in autumn, the facultative wheat plants recorded higher mean values of this parameter than sown in spring.

Analysing Table 5, we can see that a late autumn sowing date leads to an increase of weight of grains/spike with 0.42 g (1st season). In the 2nd season, same conditions, the weight of grains/spike didn't change with the seeding delay (1.64 g). Sown in spring, the facultative wheat genotypes recorded the highest values of this parameter in the 1st season (1.62 g in sowing date IV and 1.47 g in sowing date V).

Thousand kernel weight (TKW)

In the 1st season, in autumn sowing conditions, genotype and sowing date had a significant effect on TKW, while their interaction had no influence on it. On the other hand, in the 2nd season, the experimental factors and their interaction had a very significant influence on this parameter. In spring sowing conditions, TKW was highly influenced by genotype and S x E interaction (in both seasons); sowing date had significantly influenced TKW only in the 2nd season, being non-significant in the 1st (Table 3).

In both seasons, sown in autumn, Ciprian genotype recorded the highest mean values of TKW, being followed by Lennox and Taisa (Table 4). Comparing the results obtained in the 1st season with those obtained in the 2nd (autumn sowing conditions), it can be noted that TKW of the studied genotypes was higher in the 1st season with 4.33 g for Taisa, 1.4 g for Ciprian and 2.09 g for Lennox.

Sown in spring, in the 1st season, Lennox had the best value of TKW (39.90 g), being followed by Ciprian (39.59 g) and Taisa (34.50 g). Sown in spring, in the 2nd season, Ciprian had the higher TKW (34.48 g), being followed by Taisa (30.41 g) and Lennox (28.47 g). The major loss from one season to another was recorded by Lennox (11.43 g). Also, in Table 4, it can be noted that TKW of the studied genotypes was higher in autumn sowing conditions than in spring ones, in both seasons. It can be attributed to a longer growth period.

The fact that Taisa genotype has the lowest TKW is due to its long growth cycle and later heading time, so the filling of grains is affected by drought.

The results from Table 5 shows that, in autumn sowing conditions, the lowest TKW was recorded in sowing date II in the 1st season (40.51 g) and in sowing date III in the 2nd season (38.08 g). In spring sowing conditions, the highest TKW was recorded at mid-March sowing time (39.33 g - 1st season, 31.92 g - 2nd season).

Grain yield

Genotype, sowing date and the interaction between them had highly influenced the grain yield of facultative wheat in both seasons, in autumn sowing conditions ($p > 1\%$). In spring sowing conditions, in the 2nd season, the influence of sowing date (E) and S x E interaction was not significant ($p < 5\%$) on the grain yield; only the genotype had a significant one ($p > 1\%$) on it. In the 1st season, grain yield was significantly influenced by genotype and S x E interaction ($p > 1\%$); also, sowing date had a significant effect on it ($p > 5\%$). All these results are presented in Table 3.

Analysing Table 4, the results shows that in the 1st season, in autumn sowing conditions, Taisa led with a grain yield of 7.27 t ha^{-1}, while in the 2nd season Ciprian stand out with a grain yield of 7.35 t ha^{-1}. In spring sowing conditions, in both seasons, Lennox has recorded the best grain yields (6.79 t ha^{-1} - 1st season, 5.67 t ha^{-1} - 2nd season), being followed by Ciprian (6.13 t ha^{-1} - 1st season, 5.20 t ha^{-1} - 2nd season) and Taisa (4.85 t ha^{-1} - 1st season, 4.20 t ha^{-1} - 2nd season).

The results presented in Table 6 shows that in both seasons, in autumn sowing conditions, the sowing date II promoted a higher expression of grain yield potential to all genotypes. This is observed very well from the graphical representation of the average yield over the two seasons (Figure 2) resulting from the E x S interaction. The lowest grain yield was recorded in the last sowing date. In spring sowing conditions, in both seasons, the first sowing date (IV) promoted a higher expression of grain yield potential to all genotypes (Table 6 and Figure 3).

The yield decrease of Taisa genotype can be attribute, in both seasons, in both sowing conditions, to a lower number of productive tillers/plant and to a poor filling of grains due the long growth cycle.

Table 3. Mean squares from analysis of variance for various characteristics obtained from three wheat cultivars sown under five sowing dates in 2017/2018 and 2018/2019 seasons at Turda

Source of variance	Genotype (S)		Sowing date (E)		Interaction (S x E)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Sown in autumn						
Plant height (cm)	684.703***	375.111**	574.925***	88.111^{ns}	15.703*	18.055^{ns}
Flag leaf area (cm^2)	104.037**	63.151***	34.291^{ns}	88.134***	9.409^{ns}	36.048***
No. of tillers/plant	3.633^{ns}	10.033**	199.033***	80.033***	2.316^{ns}	6.666**
Productive tillers/plant	0.128***	0.092***	0.282***	0.160***	0.015***	0.059***
No. of grains/spike	504.669**	216.743***	266.778*	5.453***	121.613**	12.383**
Weight of grains/spike (g)	0.508**	0.403***	0.417*	0.001^{ns}	0.222**	0.014*
TKW (g)	34.517*	98.100***	11.325*	6.810***	4.876^{ns}	2.171**
Grain yield (t ha^{-1})	2.017**	11.643***	4.007***	2.632**	0.412**	2.724**
Sown in spring						
Plant height (cm)	289.041**	1165.167***	144.500*	2.722^{ns}	66.291**	7.722^{ns}
Flag leaf area (cm^2)	183.799**	176.719***	36.352^{ns}	1.602^{ns}	87.228*	17.952***
No. of tillers/plant	2.216 ^{ns}	8.016*	0.816 ^{ns}	6.016*	14.516*	5.416^{ns}
Productive tillers/plant	0.119***	0.242***	0.123*	0.242*	0.052**	0.015*
No. of grains/spike	184.843**	72.665***	0.500^{ns}	15.680***	1.545^{ns}	11.285**
Weight of grains/spike (g)	0.036^{ns}	0.158^{ns}	0.099^{ns}	0.228^{ns}	0.152*	0.147^{ns}
TKW (g)	55.110**	56.528***	32.026^{ns}	11.472***	81.416**	6.470***
Grain yield (t ha^{-1})	5.847**	3.351**	6.303*	1.797^{ns}	3.615**	0.119^{ns}

*, **, *** - significant at the 5%, 1% and 0.1% probability levels, respectively; ^{ns} - non significant

Table 4. Mean values of yield components and yield of three facultative wheat cultivars in 2017/2018 and 2018/2019 seasons at ARDS Turda

Source of variation	Taisa		Ciprian		Lennox		LSD 5%	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Sown in autumn								
Plant height (cm)	86.78^{000}	91.00^{00}	88.22^{000}	98.11^{ns}	102.56***	103.89 **	2.02	3.96
Flag leaf area (cm^2)	21.76^{ns}	30.10***	22.33^{ns}	25.10^{000}	16.17^{00}	26.08^{000}	2.31	0.50
No. of tillers/plant	2.97^{ns}	3.63^{ns}	3.03^{ns}	3.27^{ns}	3.60^{ns}	2.50^{0}	0.70	0.59
Productive tillers/plant	2.16^{000}	2.28^{ns}	2.40***	2.35***	2.28^{ns}	2.15^{000}	0.01	0.02
No. of grains/spike	47.07*	39.87^{000}	32.60^{00}	39.00^{000}	43.19^{ns}	47.90***	4.87	0.75
Weight of grains/spike (g)	1.88*	1.43^{000}	1.43^{00}	1.66^{ns}	1.77^{ns}	1.86***	0.14	0.06
TKW (g)	40.27^{ns}	35.94^{000}	43.92^{ns}	42.52***	40.88^{ns}	38.79^{00}	2.54	0.17
Grain yield (t ha^{-1})	7.27**	5.48^{000}	6.39^{000}	7.35***	7.12^{ns}	5.29^{000}	0.20	0.27
Sown in spring								
Plant height (cm)	73.58^{0}	79.00^{000}	72.75^{0}	91.67^{ns}	85.17***	106.83***	3.16	3.60
Flag leaf area (cm^2)	25.83*	33.63***	17.05^{ns}	34.13***	15.59^{ns}	24.49***	4.72	0.38
No. of tillers/plant	3.00^{ns}	3.60^{ns}	2.45^{ns}	3.15^{ns}	2.40^{ns}	4.40^{ns}	0.79	0.89
Productive tillers/plant	1.92^{000}	2.04^{000}	2.20***	2.15^{ns}	2.08^{ns}	2.43***	0.05	0.08
No. of grains/spike	47.35*	42.50***	37.38^{ns}	35.55^{000}	38.13^{ns}	39.35^{ns}	5.34	1.03
Weight of grains/spike (g)	1.63^{ns}	1.30^{ns}	1.48^{ns}	1.23^{ns}	1.52^{ns}	1.12^{ns}	0.19	0.19
TKW (g)	34.50^{000}	30.41^{000}	39.59*	34.48***	39.90*	28.47^{000}	1.46	0.13
Grain yield (t ha^{-1})	4.85^{000}	4.20^{000}	6.13^{ns}	5.20^{ns}	6.79**	5.67**	0.45	0.35

Mean values of genotypes were considered control;
*, **, *** - significant at the 5%, 1% and 0.1% probability levels, respectively; ^{ns} – non significant

The highest yield loss of Taisa (2.95 t ha^{-1}) was recorded in spring sowing conditions, 1st season, so it is restricted in spring to be sown in the first half of March.

Analysing the grain yield obtained by Lennox genotype, in the 2nd season, in autumn sowing conditions, we can notice that the lowest value (3.73 t ha^{-1}) was at the sowing date I. This high decrease can be explained by fewer productive tillers/plant and lower TKW. These were caused by barley yellow dwarf disease transmitted by certain vectors such as wheat curl mites and aphids whose flight was favored by climatic conditions (high temperatures and lack of precipitations from Oct. and Nov. - see Table 2). So, Lennox being a foreign genotype, less adapted to our conditions, in the warm autumn it needs to carry out appropriate phytosanitary treatments.

Table 5. Mean values of yield components and yield at different sowing dates in 2017/2018 and 2018/2019 seasons at ARDS Turda

Source of variation		Plant height (cm)	Flag leaf area (cm^2)	No. of tillers/ plant	Productive tillers/plant	No. of grains/ spike	Weight of grains/spike (g)	TKW (g)	Grain yield (t ha^{-1})
Sowing date		Sown in autumn							
I Ct*	1st season	97.89	21.61	6.03	2.38	35.51	1.51	42.74	7.37
	2nd season	100.33	24.38	4.97	2.11	41.57	1.64	39.58	5.72
II	1st season	96.33^{ns}	20.76^{ns}	2.57^{000}	2.38^{ns}	40.94^{ns}	1.64^{ns}	40.51^{00}	7.26^{ns}
	2nd season	98.44^{ns}	26.38^{***}	2.60^{000}	2.30^{***}	42.10^{*}	1.66^{ns}	39.59^{ns}	6.66^{**}
III	1st season	83.33^{000}	17.89^{ns}	1.00^{000}	2.07^{000}	46.40^{*}	1.93^{*}	41.83^{ns}	6.16^{000}
	2nd season	94.22^{ns}	30.52^{***}	1.83^{000}	2.37^{***}	43.10^{***}	1.64^{ns}	38.08^{000}	5.73^{ns}
LSD 5%	1st season	1.71	4.62	0.61	0.04	7.31	0.28	1.28	0.24
	2nd season	7.53	0.21	0.72	0.05	0.45	0.15	0.28	0.45
		Sown in spring							
IV Ct*	1st season	74.33	18.07	2.50	2.15	41.12	1.62	39.33	6.51
	2nd season	92.89	31.04	4.03	2.32	38.20	1.15	30.32	5.34
V	1st season	80.00^{*}	20.91^{ns}	2.73^{ns}	1.99^{0}	40.79^{ns}	1.47^{ns}	36.66^{ns}	5.33^{0}
	2nd season	92.11^{ns}	30.45^{ns}	3.40^{0}	2.09^{0}	40.07^{***}	1.28^{ns}	31.92^{***}	4.71^{ns}
LSD 5%	1st season	2.90	5.63	0.71	0.09	9.02	0.32	2.82	0.58
	2nd season	1.26	0.63	0.58	0.10	0.23	0.13	0.18	0.66

*Ct – control; *, **, *** - significant at the 5%, 1% and 0.1% probability levels, respectively; ns – non significant;

Table 6. Interaction between sowing date and genotype on grain yield t ha^{-1} in 2017/2018 and 2018/2019 at ARDS Turda

Sowing date	Genotype	1st season	2nd season	Average
	Sown in autumn			
I Ct*	Taisa	7.76	5.87	6.815
	Ciprian	6.44	7.55	6.995
	Lennox	7.90	3.73	5.815
II	Taisa	7.80^{ns}	5.98^{ns}	**6.890**
	Ciprian	6.77^{ns}	7.63^{ns}	**7.200**
	Lennox	7.20^{00}	6.37^{***}	**6.785**
III	Taisa	6.26^{000}	4.58^{00}	5.420
	Ciprian	5.95^{0}	6.86^{0}	6.405
	Lennox	6.27^{000}	5.76^{***}	6.015
	LSD 5%	0.37	0.59	
	Sown in spring			
IV Ct*	Taisa	6.32	4.68	5.500
	Ciprian	6.15	5.42	5.785
	Lennox	7.07	5.92	6.495
V	Taisa	3.37^{00}	3.73^{0}	3.550
	Ciprian	6.11^{ns}	4.97^{ns}	5.540
	Lennox	6.51^{ns}	5.42^{ns}	5.965
	LSD 5%	0.74	0.74	

*Ct – control; *, **, *** - significant at the 5%, 1% and 0.1% probability levels, respectively; ns – non significant

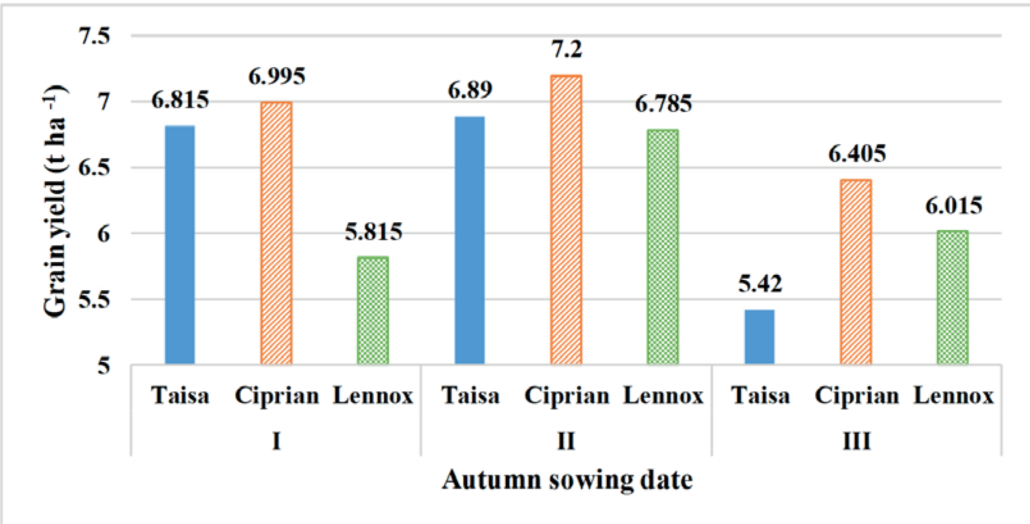


Figure. 2 Average yield in autumn sowing conditions

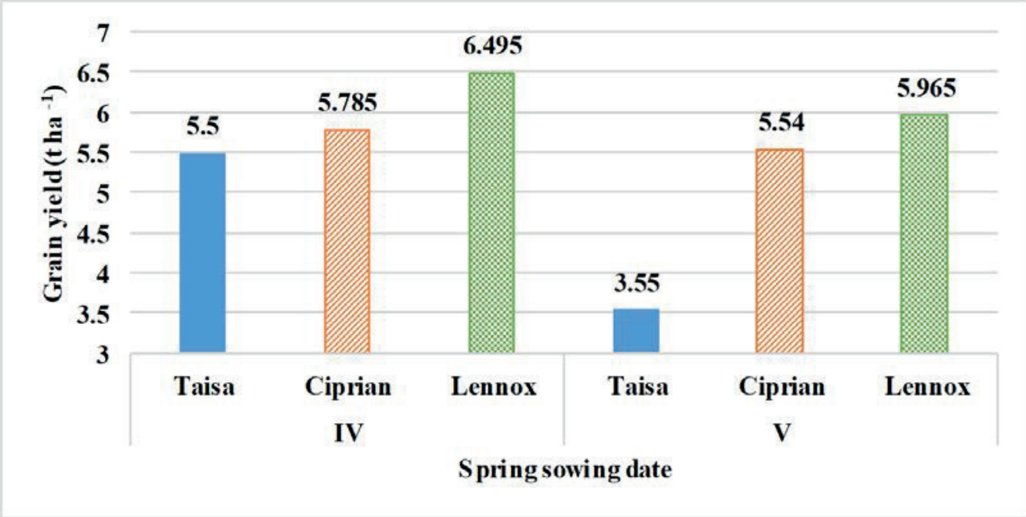


Figure. 3 Average yield in spring sowing conditions

CONCLUSIONS

In autumn sowing conditions, to get the best grain yields, the facultative wheat genotypes are suitable to be sown at the end of October – beginning of November. A delay in sowing tends to decrease the plant height, number of tillers/plant, number of productive tillers/plant, TKW and grain yield. On the other hand, the number of grains/spike and the weight of grains/spike tend to increase.

In spring, to get an appropriate grain yield, the facultative wheat needs to be sown as early as possible, especially Taisa (long growth cycle, later heading time). This genotype is restricted in spring to be sown until 15 of March. A delay in sowing tends to decrease number of tillers/plant, number of productive tillers/plant, weight of grains/spike and grain yield.

In unappropriated climatic conditions, each genotype response on its owns ways to achieve the best grain yield. So, Ciprian had a higher tillering and productive tilers/plant and obtained the highest TKW because of its short growth cycle, early heading time and Taisa and Lennox had a lower productive tillers/plant, but a higher number of grains/spike.

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