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STUDY OF THE ELEMENTS OF THE PRODUCTIVITY OF OLD COMMON WINTER WHEAT VARIETIES UNDER CHANGING ENVIRONMENTAL CONDITIONS

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Abstract

The experiment was conducted in the experimental field of IPGR - Sadovo in the period 2018-2020. Biometric analysis was performed on the sixteen old varieties of common winter wheat created in IPGR. The following traits were taken: yield, productive tillering, central spike length, spikelets number in centaral spike, grains number in central spike, grain weight in central spike, grains number in other spikes, grains weight in other spikes, grains number of 1 plant and grains weight of 1 plant. The data are processed by statistical methods – variance (ANOVA), variation and principal component analysis. The results show that the influence of the genotype and the interaction of the genotype x environment was proved in all the monitored traits. In terms of traits, the influence of the environment is unproven only in 3 traits – grains weight in 1 plant, grains weight in the other spikes and spikelets number in the central spike. The aim of the study is to test the effect of climate change on the structural elements of the yield of old varieties of common winter wheat, as the main food crop.

Key words: *common winter wheat, old varieties, climate change, structural elements.*

INTRODUCTION

The productive potential of cereals is very variable depending on the specific growing conditions. Agro-ecological and climatic conditions in certain regions of the country affect the growth, development and productivity of wheat (Bazitov, 2000; Tsenov et al., 2004; Delibaltova & Ivanova, 2006). The variety is one of the main components in the technological solutions of any crop. The construction of a proper varietal structure, depending on the specific agro-ecological conditions of the region can significantly increase yields and product quality (Ilieva, 2011). The successful implementation and use of each wheat variety is related to its behavior in different environmental conditions (Van Ittersum et al., 2013). Unlike other field crops, wheat varieties are characterized by relatively low ecological plasticity, which necessitates the creation of new varieties adapted to individual agro-ecological areas and therefore the correct selection of varieties is crucial for yield and quality of production. The specific conditions in our country are a challenge to the selection of productivity in this crop (Panayotov & Rachinski, 2002).
The aim of the study was to test the effect of climate change on the structural elements of the yield of old varieties of common winter wheat, as a major food crop.

MATERIALS AND METHODS

The experiment was conducted in the experimental field of IPGR - Sadovo in the period 2018-2020. The structural elements of the productivity of the sixteen old varieties of common winter wheat, created in IPGR, were studied. Varietal experiments were performed on a block diagram in four replications, with a size of the experimental plot of 10 m^2 according to the cultivation technology adopted in IPGR.
Biometric measurements were made on the following productivity traits: grain yield - kg/da, total tillering (TT), productive tillering (PT), central spike length (CSL) - cm, spikelets number in central spike (SNCS), grains number in central spike (GNCS), grains weight in central spike (GWCS) - g, grains number in

other spikes (GNOS), grains weight in other spikes (GWOS), grains number per plant (GN1P) and grains weight per plant (GW1P). The percentage ratio of grain weight in the central spike to the grain weight of 1 plant (GWCS/GW1P) was calculated. The degree of variation of each of the traits of productivity is determined by calculating a coefficient of variation.

The level of variation has been assumed to be weak if the coefficient of variation is up to 10%, on average - when it is greater than 10%, and less than 20% and strong - when it is over 20% (Dimova & Marinkov, 1999). Mathematical data processing is performed by applying variation, variance and analysis of the main components. The programs SPSS 19 and Microsoft excel for Windows were used. The general statistical assessment of the presence or absence of differences between the variants was determined by the ANOVA method (Dimova & Marinkov, 1999).

RESULTS AND DISCUSSIONS

The agro-climatic conditions during the study are represented by the main meteorological factors for the growth and development of the crop: average monthly air temperature (Figure 1) and average values of the amount of precipitation (Figure 2).

The years in which the survey was conducted (2018/2019 - 2019/2020) are different in terms of climate. There is a variation of climatic factors, both by months and by years, which affects the yield and elements of crop productivity.

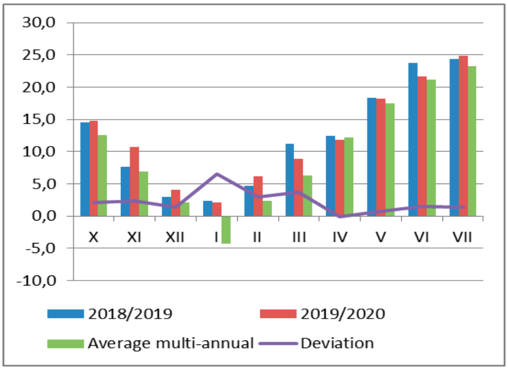

Figure 1. Average temperature sum T°C of months during vegetation years 2018/2019-2019/2020

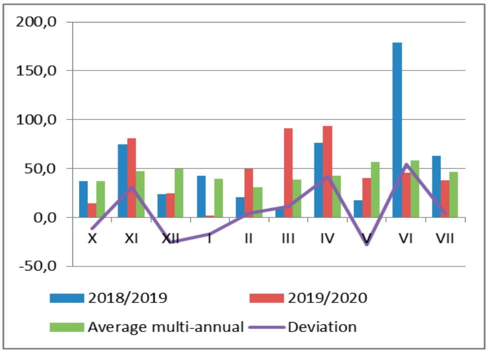

Figure 2. Sums of month rainfall (mm) during vegetation years 2018/2019-2019/2020

For the vegetation year 2018/2019, we can summarize that the average monthly air temperatures are higher than the multi-year values, and the amount of precipitation is unevenly distributed in the individual months of crop development. The precipitation in November was higher than the multi-year values and favored the development of wheat. There is a secondary weeding of crops in June, due to the large amount of rainfall that month.

The meteorological conditions during the vegetation year 2019-2020 differ from those in the previous year. Conditions during the period from sowing to the end of March were not the most favorable for the development of wheat due to the snowfall in late March and early April. On average, the monthly air temperatures were higher than the multi-year values, with the only exception having been observed in April.

Moisture deficiency was not observed during the stem elongation, heading and grain filling phases. The rainfall in April led to the formation of a higher stem compared to the typical height of the varieties. The second growing season of the study can be defined as more favorable for winter common wheat. Confirmation of this was the higher yields obtained compared to the first growing season.

The results of the biometric measurements of the structural elements of the productivity of the studied wheat varieties are presented in Tables 1, 2 and 3. The size of the yield is closely related to the variety, the level of applied agricultural techniques and the soil-climatic conditions of the region (Delibaltova & Ivanova, 2006; Tsenov et al., 2006).

Table 1. Results of the biometric measurements of the structural elements of the productivity of common winter wheat varieties for the period 2018-2020

N°	VARIETY	Grain yield, kg/da			TT, number			PT, number			CSL, cm		
		$\bar{x}$	± D	Sig.	$\bar{x}$	± D	Sig.	$\bar{x}$	± D	Sig.	$\bar{x}$	± D	Sig.
1	Sadovo 1-st	431.5			3.5			3.7			11.6		
2	Bononia	527.6	96.0	+++	4.2	0.7	+	3.5	-0.2	n.s.	11.2	-0.4	n.s.
3	Niky	531.0	99.5	+++	3.5	0.0	n.s.	3.5	-0.2	n.s.	12.2	0.6	n.s.
4	Lucille	619.7	188.2	+++	3.8	0.3	n.s.	3.3	-0.3	n.s.	11.3	-0.3	n.s.
5	Sad. Belya 1	573.1	141.6	+++	3.2	-0.3	n.s.	3.5	-0.2	n.s.	11.4	-0.2	n.s.
6	Tsarevets	526.3	94.8	+++	3.5	0.0	n.s.	4.3	0.7	+	11.4	-0.2	n.s.
7	Pobeda	515.2	83.6	+++	4.3	0.8	++	3.5	-0.2	n.s.	11.5	-0.1	n.s.
8	Mustang	607.2	175.6	+++	3.8	0.3	n.s.	3.3	-0.3	n.s.	12.2	0.6	n.s.
9	Geya 1	604.7	173.1	+++	3.3	-0.2	n.s.	3.8	0.2	n.s.	11.3	-0.3	n.s.
10	Diamond	613.1	181.6	+++	3.8	0.3	n.s.	3.8	0.2	n.s.	11.0	-0.6	n.s.
11	Murgavets	594.9	163.3	+++	3.8	0.3	n.s.	4.0	0.3	n.s.	12.3	0.7	n.s.
12	Sadovo 552	532.4	100.8	+++	4.0	0.5	n.s.	4.0	0.3	n.s.	12.7	1.1	+
13	Sadovo 772	527.4	95.9	+++	4.0	0.5	n.s.	3.8	0.2	n.s.	12.1	0.5	n.s.
14	Guinness	612.0	180.5	+++	3.8	0.3	n.s.	3.8	0.2	n.s.	11.1	-0.5	n.s.
15	Yoana	651.5	219.9	+++	3.8	0.3	n.s.	3.3	-0.3	n.s.	12.8	1.2	+
16	KM 135	628.8	197.3	+++	3.2	-0.3	n.s.	3.2	-0.5	n.s.	11.1	-0.5	n.s.
Mean		568.5			3.7			3.7			11.7		
Minimum		431.5			3.2			3.2			11.0		
Maximum		651.5			4.3			4.3			12.8		
Std. dev.		57.7			0.3			0.3			0.6		
Coef. Var.		10.2			9.1			8.6			4.9		
Standard error		14.4			0.1			0.1			0.1		
GD 5.0%		11.0			0.6			0.7			0.9		
GD 1.0%		14.6			0.8			0.9			1.3		
GD 0.1%		18.9			1.0			1.1			1.6		

+ -,+ + - -,+ + + - - -, significant at GD 5.0 %, GD 1.0 % GD 0.1 %; n.s. - non-significant

Table 2. Results of the biometric measurements of the structural elements of the productivity of common winter wheat varieties for the period 2018-2020

N°	VARIETY	SNCS, number			GNCS, number			GWCS, g			GNOS, number		
		$\bar{x}$	± D	Sig.	$\bar{x}$	± D	Sig.	$\bar{x}$	± D	Sig.	$\bar{x}$	± D	Sig.
1	Sadovo 1-st	20.0			52.8			2.73	0.00		96.2		
2	Bononia	19.8	-0.2	n.s.	44.5	-8.3	n.s.	1.75	-0.98	---	84.8	-11.3	n.s.
3	Niky	19.5	-0.5	n.s.	52.0	-0.8	n.s.	2.46	-0.26	n.s.	89.8	-6.3	n.s.
4	Lucille	19.0	-1.0	n.s.	52.2	-0.7	n.s.	2.33	-0.40	n.s.	102.0	5.8	n.s.
5	Sad. Belya 1	21.2	1.2	n.s.	60.0	7.2	n.s.	1.65	-1.08	+++	92.2	-4.0	n.s.
6	Tsarevets	20.0	0.0	n.s.	63.5	10.7	+	2.54	-0.19	n.s.	120.2	24.0	n.s.
7	Pobeda	19.0	-1.0	n.s.	45.5	-7.3	n.s.	1.99	-0.74	-	99.2	3.0	n.s.
8	Mustang	21.7	1.7	+	52.8	0.0	n.s.	2.48	-0.25	n.s.	116.2	20.0	n.s.
9	Geya 1	18.8	-1.3	n.s.	50.5	-2.3	n.s.	2.42	-0.30	n.s.	85.7	-10.5	n.s.
10	Diamond	20.6	0.6	n.s.	46.7	-6.2	n.s.	1.85	-0.88	--	90.8	-5.3	n.s.
11	Murgavets	20.9	0.9	n.s.	61.5	8.7	n.s.	2.90	0.18	n.s.	142.5	46.3	++
12	Sadovo 552	20.8	0.8	n.s.	45.7	-7.2	n.s.	2.05	-0.67	-	104.0	7.8	n.s.
13	Sadovo 772	20.7	0.7	n.s.	52.0	-0.8	n.s.	1.75	-0.98	--	114.0	17.8	n.s.
14	Guinness	20.2	0.2	n.s.	47.5	-5.3	n.s.	1.63	-1.10	---	102.7	6.5	n.s.
15	Yoana	21.8	1.8	+	50.7	-2.2	n.s.	2.11	-0.62	-	98.2	2.0	n.s.
16	KM 135	19.7	-0.3	n.s.	50.8	-2.0	n.s.	2.38	-0.35	n.s.	84.7	-11.5	n.s.
Mean		20.2			51.8			2.19			101.4		
Minimum		18.8			44.5			1.63			84.7		
Maximum		21.8			63.5			2.90			142.5		
Std. dev.		0.9			5.7			0.40			15.5		
Coef. var.		4.6			10.9			18.17			15.3		
Standard error		0.2			1.4			0.10			3.9		
GD 5.0%		1.7			10.3			0.59			27.9		
GD 1.0%		2.2			13.7			0.78			37.1		
GD 0.1%		2.8			17.8			1.01			48.2		

+ -,+ + - -,+ + + - - -, significant at GD 5.0 %, GD 1.0 % GD 0.1 %; n.s. - non-significant

Table 3. Results of the biometric measurements of the structural elements of the productivity of common winter wheat varieties for the period 2018-2020

N°	VARIETY	GWOS, g			GN1P, number			GW1P, g			GWCS/GW1P
		$\bar{x}$	± D	Sig.	$\bar{x}$	± D	Sig.	$\bar{x}$	± D	Sig.	$\bar{x}$
1	Sadovo 1-st	5.11			149.0			7.84			34.8
2	Bononia	2.69	-2.43	---	129.3	-19.7	n.s.	4.43	-3.41	---	39.4
3	Niky	4.34	-0.78	n.s.	141.8	-7.2	n.s.	6.80	-1.04	n.s.	36.2
4	Lucille	4.69	-0.42	n.s.	154.2	5.2	n.s.	7.02	-0.81	n.s.	33.2
5	Sad. Belya 1	3.21	-1.90	--	152.2	3.2	n.s.	4.86	-2.98	---	33.9
6	Tsarevets	4.22	-0.89	n.s.	183.7	34.7	+	6.76	-1.08	n.s.	37.5
7	Pobeda	3.57	-1.54	-	144.7	-4.3	n.s.	5.56	-2.28	--	35.8
8	Mustang	4.52	-0.60	n.s.	169.0	20.0	n.s.	6.99	-0.85	n.s.	35.4
9	Geya 1	4.47	-0.65	n.s.	136.2	-12.8	n.s.	6.89	-0.95	n.s.	35.2
10	Diamond	4.06	-1.05	n.s.	137.5	-11.5	n.s.	5.91	-1.93	-	31.3
11	Murgavets	5.85	0.73	n.s.	204.0	55.0	++	8.75	0.91	n.s.	33.2
12	Sadovo 552	4.85	-0.26	n.s.	149.7	0.7	n.s.	6.90	-0.93	n.s.	29.7
13	Sadovo 772	3.48	-1.63	-	166.0	17.0	n.s.	5.23	-2.61	--	33.4
14	Guinness	3.29	-1.82	--	122.8	-26.2	n.s.	4.92	-2.92	---	33.1
15	Yoana	3.07	-2.04	--	148.8	-0.2	n.s.	5.18	-2.66	--	40.7
16	KM 135	4.00	-1.11	n.s.	135.5	-13.5	n.s.	6.38	-1.46	n.s.	37.3
Mean		4.09			151.5			6.28			35.0
Minimum		2.69			122.8			4.43			29.7
Maximum		5.85			204.0			8.75			40.7
Std. dev.		0.84			20.8			1.19			
Coef. var.		20.51			13.7			18.90			
Standard error		0.21			5.2			0.30			
GD 5.0%		1.34			34.0			1.59			
GD 1.0%		1.78			45.2			2.12			
GD 0.1%		2.31			58.8			2.75			

For this reason, in order to make the most efficient use of the productive potential of the variety, the correct choice of suitable varieties for each individual agro-ecological region is of great importance as a factor for obtaining a high yield. In the case of grain yield, the data show that the highest average yield was reported for the varieties Joana (651.5 kg/da), KM 135 (628.8 kg/da) and Lucille (619.7 kg/da), and the lowest yield met the standard. Geya 1 (431.5 kg/da). For seven varieties of wheat, the reported average yield is over 600 kg/da, and their difference with the standard is mathematically proven.

Tillering as a biological feature of cereals is determined by the hereditary qualities of the varieties, but it is also strongly influenced by the growing conditions. It has been established that when sowing in the optimal time, a large part of the tillers are formed in the autumn, and when sowing late, the fraternization takes place exclusively during the winter-spring period (Kasimov, 1976). The total tillering of the varieties varies from 3.2 (KM 135, Sadovska Belia 1) to 4.3 number (Bononia). Ten samples fall above the level of the standard, and in two of them the difference with Sadovo 1 is mathematically supported.In addition to the formation of the tillers, it is important for the realization of grain production to turn them into productive ones. According to Tsenov et al. (2009) the appropriate combination between more classes per unit area in combination with a larger number of grains is a prerequisite for increasing the productivity of wheat varieties.

On the other hand, greater productive tillering leads to increased plant tolerance to drought. The cultivars Tsarevets (4.3), Murgavets (4.0) and Sadovo 552 (4.0) are characterized by the largest number of productive tillers, and the smallest number of productive tillers was reported to the variety KM 135 (3.2).

The spike, as a symbol of yield, has always been a major organ of wheat morphology, subject to selective influence. Spike size is not only a morphological trait, but is also one of the factors for increased photosynthesis. In our study, the length of the central spike ranged from 11.0 (Diamant) to 12.8 cm (Joanna). A higher length of the central spike compared to the standard was reported for six varieties of common wheat. The number of spikeles in a spike is a factor that determines the spike density. In the particular case they vary from

18.8 (Gaia 1) to 21.8 (Joanna). Exceeding the trait compared to the standard is observed in eight varieties.

The increase of the grains number in the central spike is directly related to the increase in yield. In general, varieties with more grains have a higher breeding value (Tsenov & Tsenova, 2004). The largest grains number in the central spike was reported for the cultivars Tsarevets (63.5), Murgavets (61.5) and Sadovska Belia 1 (60.0), and the smallest grains number in the cultivars Bononia (44.5) and Pobeda (45.5). On nine genotypes the reported grains number is in the range of 50-60 numbers.

Biometric data reflecting the grains weight in the central spike, as a direct component of the yield show that the highest values of the trait were reported for the following varieties: Murgavets (2.90 g), Sadovo1 - st. (2.73 g) and Nicky (2.46 g). At the last place for this trait are Guinness (1.63 g) and Sadovska Belia 1 (1.65 g). Fourteen wheat genotypes are below the standard level, and in seven of them the difference with Sadovo 1 is mathematically supported.

The grains number in the other spikes has a minimum of 84.7 (Bononia) and a maximum of 142.5 (Murgavets). In seven varieties the reported grains number is over 100, and exceeding the trait compared to the standard is observed in nine wheat varieties . The best results in terms of grain weight in other spikes were shown by the varieties Murgavets (5.85 g) and the standard Sadovo 1 (5.11 g). In six genotypes, the value of the studied trait was below 4.0 g, with the lowest value obtained in the Bononia variety (2.69 g).

The grains number in one plant is in the range from 122.8 (Guinness) to 204.0 (Murgavets). Exceeding the trait compared to the standard was reported in five wheat varieties , and only in two (Murgavets and Tsarevets) of them the difference with Sadovo 1 is mathematically significant. The grain weight of a plant was determined by a number of authors (McMaster et al., 1987; Fufa et al., 2005; Leilah & Al-Khateeb, 2005) as one of the most important breeding traits in the selection of breeding materials. In our study, the grain weight of one plant varies from 4.43 g (Guinness) to 8.75 g (Murgavets). Only the Murgavets variety falls above the level of Sadovo 1 according to this trait.

Table 3 presents the results of the percentage ratio between the grains weight in the central spike and the grains weight from a plant. The data show that the largest share of the central spike in the formation of the grains weight from one plant in the varieties Joanna (40.7%), Bononia (39.4%) and Tsarevets (37.5%). The lowest percentage ratio between these two traits was found in Sadovo 552 (29.7%), Diamant (31.3%) and Guinness (31.3%).

To determine the degree of variation of the studied traits, a coefficient of variation was calculated on the basis of average values for the study period. Tables 1, 2 and 3 present the standard deviation (Std. dev.) and the coefficient of variation (CV) for the different performance elements. According to the importance of CV, the variation of the studied traits is from weak to strong. There is little variation of the spikelets number in the central spikes (C.v. = 4.6%), length of the central spike (C.v. = 4.9%), productive tillering (C.v =8.6%) and total tillering (C.v. = 9.1%). The variation of the yield (C.v. = 10.2%), grains number in the central spike (C.v. = 10.9%), grains number in one plant (C.v. = 13.7%), grains number in the other spikes (C.v. = 15.3%) are estimated as average, grains weight in central spikes (C.v. = 18.2%) and grains weight per plant (C.v. = 18.9%). The most variable is the trait grain weight in the other spikes (C.v. = 20.5%).

To determine whether the variability of the trait depends more on genetic factors or on enviromental conditions, a two-way analysis of variance was applied. It assessed the strength of the influence of the sources of variation - genotype, environment and genotype environment (Table 4). The successful introduction of wheat varieties is related to its behavior in different environmental conditions (Van Itteresum et al., 2013). According to Annicchiarico (2002), the analysis of the genotype x environment interaction is very important for the correct determination of the ecotype for the region. The presented results show that there is a proven influence of genotype, environment and their interaction on the studied indicators.

Table 4. Influence of the sources of variation on the studied traits

Traits	Sources of variation	SS	df	MS	F exp.	F tab.	Ŋ, %	Sig.
Yield	Genotype - factor A	300003.5	15	20000.2	443.5	3.0	10.1	***
	Environment - factor B	2426022.1	1	2426022.1	53793.1	11.9	82.0	***
	Interaction - AxB	230675.8	15	15378.4	341.0	3.0	7.8	***
	Error	2886.3	64	45.1			0.1	
	Total	2959587.7	95				100.0	
TT	Genotype - factor A	10.3	15	0.7	5.5	3.0	38.2	***
	Environment - factor B	1.5	1	1.5	12.0	11.9	5.6	***
	Interaction - AxB	7.2	15	0.5	3.8	3.0	26.6	***
	Error	8.0	64	0.1			29.7	
	Total	27.0	95				100.0	
PT	Genotype - factor A	7.5	15	0.5	3.0	1.8	25.8	***
	Environment - factor B	3.8	1	3.8	22.6	4.0	13.0	***
	Interaction - AxB	7.1	15	0.5	2.8	1.8	24.4	***
	Error	10.7	64	0.2			36.8	
	Total	29.0	95				100.0	
CSL	Genotype - factor A	29.3	15	2.0	5.8	1.8	20.4	*
	Environment - factor B	38.1	1	38.1	113.6	11.9	26.6	***
	Interaction - AxB	54.7	15	3.6	10.9	3.0	38.1	***
	Error	21.5	64	0.3			15.0	
	Total	143.6	95				100.0	
SNCS	Genotype - factor A	78.0	15	5.2	5.1	3.0	34.7	***
	Environment - factor B	0.3	1	0.3	0.3	4.0	0.1	n.s.
	Interaction - AxB	81.1	15	5.4	5.3	3.0	36.1	***
	Error	65.5	64	1.0			29.1	
	Total	224.9	95				100.0	
GNCS	Genotype - factor A	2879.5	15	192.0	4.8	3.0	27.3	***
	Environment - factor B	294.0	1	294.0	7.3	7.0	2.8	**
	Interaction - AxB	4791.7	15	319.4	8.0	3.0	45.5	***
	Error	2568.7	64	40.1			24.4	
	Total	10533.8	95				100.0	
GWCS	Genotype - factor A	14.2	15	0.9	7.4	3.0	34.6	***
	Environment - factor B	0.6	1	0.6	5.0	4.0	1.6	*
	Interaction - AxB	17.9	15	1.2	9.3	3.0	43.7	***
	Error	8.2	64	0.1			20.1	
	Total	41.0	95				100.0	
GNOS	Genotype - factor A	21614.6	15	1441.0	4.9	3.0	30.0	***
	Environment - factor B	1190.0	1	1190.0	4.1	4.0	1.6	*
	Interaction - AxB	30595.0	15	2039.7	7.0	3.0	42.4	***
	Error	18746.0	64	292.9			26.0	
	Total	72145.6	95				100.0	
GWOS	Genotype - factor A	63.3	15	4.2	6.3	3.0	31.7	***
	Environment - factor B	2.5	1	2.5	3.7	4.0	1.3	n.s.
	Interaction - AxB	91.0	15	6.1	9.0	3.0	45.5	***
	Error	43.1	64	0.7			21.6	
	Total	199.9	95				100.0	
GN1P	Genotype - factor A	38832.6	15	2588.8	5.9	3.0	33.2	***
	Environment - factor B	240.7	1	240.7	0.6	4.0	0.2	n.s.
	Interaction - AxB	50006.0	15	3333.7	7.7	3.0	42.8	***
	Error	27862.7	64	435.4			23.8	
	Total	116942.0	95				100.0	
GW1P	Genotype - factor A	126.7	15	8.4	8.9	3.0	34.8	***
	Environment - factor B	5.7	1	5.7	6.0	4.0	1.6	*
	Interaction - AxB	170.6	15	11.4	11.9	3.0	46.9	***
	Error	61.0	64	1.0			16.8	
	Total	363.9	95				100.0	

SS - sum of squares; gf - degrees of freedom; MS - variance; F exp. - F experimental; F tab. - F tabular; ŋ - force of influence of the factor (%); * - significant at $\alpha = 0.05$;** - significant at $\alpha = 0.01$, *** - significant at $\alpha = 0.001$; n.s. - non-significant

The only exception is observed in SNCS, GWOS and GN1P, where the influence of growing conditions is unproven. The strongest influence of the genotype was found in the total (ŋ=38.2%) and productive tillering (ŋ=28.5 %). Growing conditions are crucial for yield (ŋ=80.1 %). The interaction of the two factors has a leading role on the indicators GW1P (ŋ=46.9 %), GWOS (ŋ=45.5 %), GNCS (ŋ=45.5 %), GWCS (ŋ = 43.7 %), GN1P (ŋ=42.8 %), GNOS (ŋ=42.4 %), CSL (ŋ = 38.1 %) and SNCS (ŋ=36.1 %).

Table 5 presents the results of the performed PC-analysis. The data in the table show that the four main components PC 1, PC 2, PC 3 and PC 4 explain 84.3% of the total variation of all traits, which is large enough. The first component contains 41.2% of the total variation, the second - 59.7%, the third - 73.3% and the fourth - 84.3%.

Table 6 shows that five features are strongly associated with the first component and relate positively to it: GNCS (0.720), GWCS (0.802), GNOS (0.807), GWOS (0.834), GN1P (0.894) and GW1P (0.858). The second component is strongly, positively associated with two traits: CSL (0.595) and SNCS (0.768). The third component is strongly, positively related to the trait Yield (0.699) and negatively to total tillering (-0.653). The fourth component includes PT (-0.593), which is in a negative relation towards it.

The studied wheat varieties relate differently to the four main components (Table 7). The first main component includes seven genotypes, four of which are positive with PC 1 (Murgavets, Sadovo 1, Lucille and Niki), and the other three are negative (Guinness, Bononia and Diamant). In the positive values of PC 2 are the varieties Joanna (1.671) and Mustang (1.394), and in the negative values of PC 2 is the variety Geya 1 (-1.453). The smallest number of samples of studied materials are related to PC 3. These include Tsarevets (2.132) and Sadovo 772 (1.038), located in the positive values of the component. The fourth main component is represented by three varieties, as Sadovska Belia 1 (1.988) is positively connected to PC 4, and Pobeda (-1.621) and Sadovo 552 (-1.561) fall into the negative values of the component. The varieties Tsarevets (2.132), Sadovska Belya 1 (1.988) and Murgavets (1.988), which are the most remote, can be mentioned as sources of the greatest variation in order to create a variety of starting material and enrichment of the gene pool in ordinary winter wheat, compared to other wheat varieties.

Table 5. Component analysis of the variance in the studied traits

Comp.	Total	% of Variance	Cumulative (%)
1	4.5	41.2	41.2
2	2.0	18.6	59.7
3	1.5	13.5	73.3
4	1.2	11.0	84.3
5	0.8	7.0	91.3
6	0.5	4.6	96.0
7	0.3	2.3	98.3
8	0.1	1.0	99.3
9	0.1	0.5	99.8
10	0.0	0.2	100.0

Table 6. Explained significant components by traits

N°	Traits	Component			
		1	2	3	4
1	Grain yield	-0.134	0.146	0.699	0.210
2	TT	-0.153	0.583	-0.653	0.264
3	PT	0.450	0.107	-0.444	-0.593
4	CSL	0.437	0.595	-0.004	0.460
5	SNCS	0.221	0.768	0.408	0.032
6	GNCS	0.720	-0.049	0.413	-0.486
7	GWCS	0.802	-0.426	0.042	0.303
8	GNOS	0.807	0.446	-0.096	-0.135
9	GWOS	0.834	-0.339	-0.143	0.277
10	GN1P	0.894	0.288	0.05	-0.161
11	GW1P	0.858	-0.382	-0.087	0.297

Table 7. Explained significant components by variety

N°	Variety	Component			
		1	2	3	4
1	Sadovo 1st	1.376	-1.002	0.620	-0.219
2	Bononia	-1.336	-0.746	0.235	-1.090
3	Niky	0.778	-0.606	-0.494	-0.208
4	Lucille	0.814	-0.572	-0.672	-0.067
5	Sadovska Belya 1	-1.470	0.305	-0.220	1.988
6	Tsarevets	0.052	0.219	2.132	1.625
7	Pobeda	-0.258	-0.700	0.562	-1.621
8	Mustang	0.614	1.394	-1.043	-0.189
9	Geya 1	0.588	-1.453	-0.208	0.638
10	Diamond	-0.645	-0.381	-0.005	-0.052
11	Murgavets	1.767	1.694	0.798	0.479
12	Sadovo 552	0.417	0.614	0.414	-1.561
13	Sadovo 772	-0.961	0.879	1.038	-0.446
14	Guinness	-1.366	-0.314	0.268	0.006
15	Yoana	-0.700	1.671	-1.724	-0.324
16	KM 135	0.332	-1.002	-1.700	1.040

CONCLUSIONS

The highest average yield for the studied period was found in the varieties Joana and KM 135. The highest value of the indicators grain mass in the central class and grain mass per plant is characterized by the variety Murgavets, and the highest productive brotherhood and the biggest number of grains in the central class was reported for Tsarevets.

Slight variation of the studied traits was found in the number of spikelets in the central class and the length of the central, and the most variable is the sign of grain mass in the residual classes

The most significant and proven is the influence of growing conditions on yield. The genotype factor is of a paramount importance on the general and productive brotherhood, and the interaction between the two genotype factors is crucial for the mass of grains in the central class and the mass of grains from a plant.

The varieties Tsarevets, Sadovska Belya 1 and Murgavets are distinguished by great variation.

From a practical point of view, the most valuable varieties are Joanna, Km 135, Murgavets, Tsarevets and Sadovska Belya 1. The local farmers can be supplied with seeds from those varieties. These varieties can be used as parent pairs in the breeding and improvement work of winter wheat to create new and highly productive varieties.

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