

Productivity and quality of grain of hybrid wheat depending on the selected agro-environmental factors

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Abstract

The aim of this study was to assess the effect of three cultivation technology levels on the grain yield and quality of hybrid wheat cultivated in Poland. The field experiments were conducted over 2011-2014 in south-east Poland. Presents the morphological characteristics, productivity and grain quality, with special attention to protein content and composition, were determined. The main experimental factors were cultivation technology levels: low input (LI), medium input (MI) and high input (HI). It has been found that for the technology level HI there were obtained a higher grain yield (7.83 tha^{-1}) and significantly higher content of protein (15.0%) and fractions of low molecular glutenins (LMW) and all subunits of gliadins. Lower total precipitation (598.7 mm) during the growth period caused an increase in grain quality parameters and gluten proteins, but they reduced the grain yield. The cv. Hybred was characterized by a higher yield (6.97 tha^{-1}) but a lower grain quality and moreover the grain contained less subunits α/β , γ , ω -gliadins as well as LMW and HMW glutenins. The cv. Hystar obtained grain with higher parameters, grain yield was 6.32 tha^{-1} and the total gluten proteins 55.5 mAU. The lowest share in the total protein of grain had the fraction of albumins and globulins, while the highest storage proteins, with the predominance of gliadins in relation to glutenins.

Keywords: *Triticum aestivum* L, fertilization, climatic conditions, yield, protein fractions

1. Introduction

In Poland wheat (*Triticum aestivum* L.) is the staple cereal, occupying the largest cropping area of 2.1 million ha grain production to more than 9.0 million tons, from which about a half is intended for consumption (FAOSTAT [1]). Longer period of growth, and therefore a higher yielding potential, tolerance to low temperatures in the autumn and winter period, and avoiding drought stress in summer cause that winter wheat is more commonly cultivated than spring one (SANDVE & al. [2], VÁGÚJFALVI & al. [3]). The basic criterion determining the usefulness of wheat grain for consumption is protein quantity and quality (DANIEL&TRIBOŤ [4]). Protein properties vary depending on factors during the growth of wheat plants the grain maturation, and after the harvest, during its drying, storing and processing (DUCSAY&LOŽEK [5]). The cultivar genotype, mineral fertilization, including nitrogen, and plant protection have the strongest effect on the content of gluten proteins, differentiating the amount of gluten and the content of gliadins, particularly those of ω and γ type and glutenin HMW (high molecular weight) subunits (KONOPKA & al. [6]; STEPIEN&WOJTKOWIAK [7]). Wheat grain quality does not depend solely on protein content, but it is also determined by the composition of gluten proteins, including the amount of subunits with high and low molecular weight (HMW and LMW) as well as monomeric α/β , γ and ω -gliadins. Gliadins give gluten properties of viscous liquid and contribute to increasing its stretchability, so an increase in gliadin content exerts a negative effect on

resistance to stretching and elasticity of gluten and dough (SHEWRY [8]). Glutenins, on the other hand, are responsible for the elasticity and strength of gluten, and an increase in their proportion contributes to increasing dough resistance to stretching, prolonging the time of dough development and growing the bread volume. HMW glutenins have a substantially greater role in shaping desired properties of gluten than LMW ones, and a higher share of HMW increases dough strength and bread volume (SHEWRY & HALFORD [9]). However, gliadin fractions of α/β , γ and ω -gliadins also determine baking properties (MALIK & al. [10]).

Biological progress and more advanced techniques of plant breeding allow the introduction of new wheat cultivars to agricultural practice, the ones which have better agronomic properties. The cropping area of hybrid wheat in Europe amounts to about 250 thous. ha, of which most hybrid cultivars are grown in France (160 thous. ha), Germany (25 thous. ha) and Hungary, Italy, Czech Republic, Slovakia and Portugal, and according to the estimations more than 1 thous. ha also in Poland (MÜHLEISEN & al. [11]; ZHAO & al. [12]). Hybrid wheat cultivars in comparison with the population ones are characterized by a higher grain yield (from 3.5 to 15.0%) and tolerance to cultivation in monoculture and to other climatic and soil stresses. However, the effect of some agronomic factors on the yield and especially grain quality of those cultivars, is little known (PLESSIS & al. [13]; WHITFORD & al. [14]).

The main aim of this study was to assess the effect of three levels of cultivation technology (cultivar and year of cropping) on the grain yield and quality of hybrid wheat grown under the condition of Poland.

2. Materials and Methods

The three-factorial field experiment was conducted in 2011-2014 at the Experimental Station of Cultivar Assessment in Lubliniec, Poland (50°16' 10" N, 23°06' 09"E).

2.1. Field experiment and plant material. The soil of the experimental area is with texture of loamy sand, rich in available phosphorus and potassium and a slightly acidic pH (Table 1).

Table 1. Physicochemical soil properties

Traits	Value
Soil type (FAO [8])	Haplic Luvisol
Soil textural class	loamy sand
Organic C (g kg^{-1} d.m.)	10.11
N_{\min} 0–0.6 m (kg ha^{-1})	56.3
pH in KCl	6.07
P (mg kg^{-1})	183.11
K (mg kg^{-1})	228.30
Mg (mg kg^{-1})	93.01

According to the classification by the IUSS Working Group WRB this soil was classified as haplic luvisol (FAO [15]). Analysis of soil samples was performed at the accredited laboratory of Chemical and Agricultural Station in Rzeszow, according to the Polish Standards methods. Soil samples were collected by a sampling stick to a depth of 0–30 cm and 30–60 cm.

The experiment was set up as a split-plot design with 4 replications. Material to this study comprised two winter wheat cultivars, including the hybrid cultivar Hybred (Hy) and Hystar (Hm) breeder Saaten-Union GmbH, France. These cultivars are classified at the Common Catalogue of Varieties of Agricultural Plant Species. Furthermore, the experimental design includes three levels of cultivation technology (LI – low input, MI – medium input, HI – high input). The applied technology levels differed in NPK fertilization rates and chemical plant protection (Table 2).

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N fertilization was performed after the start of growth and at the stages of stalk shooting (32-33 BBCH) and earing (54-56 BBCH). P and K fertilization was applied under pre-sow ploughing. Nitrogen was applied as NH_4NO_3 , and phosphorus and potassium as $\text{Ca}(\text{H}_2\text{PO}_4)_2$ and KCl. The preparations were used in accordance with the producer's instructions at appropriate wheat developmental stages according to the BBCH scale (BLEINHOLDER & al. [3]). Herbicides were used at the wheat spreading stage (21-22 BBCH), fungicides at the stages of stalk shooting (32-33 BBCH) and earing (54-56 BBCH), insecticides at the stage of earing (54-56 BBCH) and at the stalk shooting (32-33 BBCH) a growth retardant.

Table 2. Characteristic of compared technologies of wheat cultivation

Agronomic factors		Technology		
		LI	MI	HI
Fertilizers, dose (kg ha^{-1})				
N fertilization		60	90	120
P+K fertilization		15+30	35+60	55+90
Pesticides, dose (L ha^{-1})				
Insecticide	Bi 58 Nowy EC 400	–	0.5	–
	Karate Zeon 050 CS	–	–	0.1
	Chwastox Turbo 340 SL	2.0	2.0	–
Herbicide	Puma Uniwersal 069 EW	–	–	1.2
	Sekator 125 OD	–	–	0.15
Fungicide	Juwel TT 483 SE	–	1.2	1.2
	Swing Top 183 SE	–	–	1.2
Growth regulator	Moddus 250 EC	–	–	0.4

2.2. Climatic conditions. The climate of the region is moderate, of a transitional type between the marine type of Western Europe and the continental type of Eastern Europe. The weather conditions data were obtained from a local observation measurement unit located at the Experimental Station. Total precipitations were more differentiated in the years of the study than the average air temperatures (Table 3).

Table 3. Weather conditions for three growing seasons

Specification	Years			
	2011-2012	2012-2013	2013-2014	*1975-2010
Air temperature ($^{\circ}\text{C}$)				
¹ September–November	8.3	9.9	9.2	8.2
² December–February	–2.9	–2.3	–0.4	–2.0
³ March–August	19.4	19.0	18.2	18.3
M/S	8.6	8.6	9.2	8.2
D	0.4	0.4	1.0	–
Precipitation (mm)				
¹ September–November	52.5	124.9	173.5	143.3
² December–February	129.6	144.3	93.6	96.0
³ March–August	258.7	205.8	304.0	251.0
M/S	598.7	712.8	804.8	643.1
D	–44.4	+69.7	+161.7	–

¹Autumn vegetation period, ²Winter rest, ³Spring–summer vegetation period, M/S – mean/sum (from sowing to harvest), D – deviations from *multi-annual mean temperature ($^{\circ}\text{C}$)/sum precipitation (mm).

During the wheat growth period, the season 2013-2014 was warmer in the years of the study, with the average temperature higher than the long-term temperature by 1.0°C.

Also temperatures in the months of autumn and spring-summer growth in the other two years of the study were higher than those in the long-term period. The season 2011-2012 with the average total precipitation 598.7 mm was characterized by the highest rainfall deficiency (44.4 mm). Higher (by 161.7 mm) amount of rainfall in comparison with the total precipitation from the long-term period occurred in the third season of the study (2013-2014), particularly in the period of spring and summer growth.

2.3. Analytical methods and quality analysis. The experiment evaluate the productivity parameters: grain yield (GY) and its components, the quality parameters of grain and composition of protein (Table 4). Then yield at 14% moisture content of grain, number of spikes (NS), thousand grain weight (TGW) 2×500 grains, as well as the weight (WGS) and number of grain from spike (NGS) and coefficient of productive tillering (CPT) were determined.

Collected samples of wheat grain were analysed in the laboratory, and the following were determined, in accordance with the standards: protein content (PC), ICC 105/2 (1994), wet gluten (WG) content in the grain, ICC 155 (1994), falling number (FN), ISO 3093 (2009), Zeleny test (ZT), ISO 5529 (2010) and test weight (TW), ISO 7971-3 (2009). The ash content was determined with the NIRS (near infrared) method on the apparatus Bruker FT-NIR (Bruker, Billerica, USA).

Table 4. Basic parameters of the examined traits

Group of traits and abbreviation			
Productive characteristics		Grain quality	
Grain yield (tha ⁻¹)	GY	Protein content (%)	PC
Number of spikes (m ²)	NS	Wet gluten (%)	WG
Number of grains from spike	NGS	Falling number (s)	FN
Weight of grain from spike (g)	WGS	Zeleny test (ml)	ZT
Thousand grain weight (g)	TGW	Ash (%)	A
Coefficient of productive tillering	CPT	Test weight (kg hl ⁻¹)	TW
Protein characteristics			
Total albumins + globulins	A+B	Ratio HMW/LMW	H/L
High molecular weight	H	Ratio gliadins/glutenins	G/G
Low molecular weight	L	Sum	Σ

The quantitative and qualitative protein in the grain characteristics were determined with the RP-HPLC technique according to KONOPKA & al. [16] and WIESER & al. [17]. The content of albumins and globulins, gliadins and glutenins was analysed. Albumins were extracted with the use of distilled water, globulins with a mixture of NaCl and HKNaPO₄, gliadins with 60% ethanol, and glutenins in the mixture consisting of 50% propanol⁻¹ + 2 m of urea + tris-HCl and 1% DTE under nitrogen. Detection was carried out with the wave length of 210 μm. The results were analysed with the use of a computer program HPLC 3D ChemStation (Palo Alto, USA) and was presented in mAUs, which expresses an area of chromatographic peaks.

2.4. Statistical analysis. Results achieved were elaborated statistically with the analysis of variance (ANOVA), whereas the significance of differences between mean values was evaluated with the Tukey's LSD test, P≤0.05. The computations were done using the Statistica 8.0 software (StatSoft, Tulsa, USA).

3. Results and Discussions

3.1. Productive characteristics. The lowest grain yield was obtained for technology LI, higher for MI and the highest for HI (Table 5). This confirms belonging of winter wheat to the group of plants strongly responding to growth conditions and particularly to fertilization with nitrogen (ABEDI&KAZEMEINI [18]; VARGA&SVEČNJAK [19]). No significant difference was found in yield between technology levels MI and HI. In contrast, a large difference in yield occurred between technology LI and technology levels MI and HI (29.8 and 48.6%). The lowest productivity (GY) of wheat for technology LI was caused by a lower number of spikes (NS), the weight (WGS) and number of grain from spike (NGS) and a low coefficient of productive tillering (CPT).

Table 5. Grain yield and biometric traits of hybrid wheat

Factors		GY	NS	NGS	WGS	TGW	CPT
Technology (T)	LI	5.27 ^a	522 ^a	33.9 ^a	1.13 ^a	33.4 ^a	2.27 ^a
	MI	6.84 ^b	613 ^b	35.0 ^b	1.21 ^b	34.8 ^a	2.64 ^b
	HI	7.83 ^b	674 ^b	37.4 ^c	1.25 ^b	33.7 ^a	2.81 ^b
<i>LSD 5%</i>		<i>1.10</i>	<i>84</i>	<i>0.9</i>	<i>0.07</i>	<i>ns</i>	<i>0.30</i>
Cultivar (C)	Hy	6.97 ^a	613 ^a	36.6 ^a	1.27 ^a	34.9 ^a	3.41 ^a
	Hm	6.32 ^b	593 ^b	34.3 ^b	1.12 ^b	33.0 ^a	1.73 ^b
<i>LSD 5%</i>		<i>0.49</i>	<i>15</i>	<i>1.2</i>	<i>0.11</i>	<i>ns</i>	<i>0.22</i>
Year (Y)	2012	6.38 ^a	539 ^a	34.5 ^a	1.09 ^a	31.0 ^a	2.49 ^a
	2013	6.61 ^{ab}	631 ^b	35.6 ^a	1.22 ^a	35.5 ^b	2.60 ^a
	2014	6.95 ^b	651 ^b	36.6 ^a	1.28 ^a	35.5 ^b	2.62 ^a
<i>LSD 5%</i>		<i>0.35</i>	<i>90</i>	<i>ns</i>	<i>0.21</i>	<i>3.9</i>	<i>ns</i>

The yield of cv. Hybred was 10.3% higher than this of cv. Hystar. The high grain yield (GY) of cv. Hybred was connected with a higher number of spikes (NS), the weight (WGS) and number of grain from spike (NGS) and a very high coefficient of productive tillering (CPT). WEBER & al. [20], reports that the yield quantity of wheat is determined by the proper soil humidity and quality, and particularly the cultivar genotype. ZAKIZADEH & al. [21], found that the wheat grain yield is closely dependent on the number of spikes, the weight and number of grains and the harvest index. MOCHAMMADI & al. [22], in turn showed a relationship between the grain yield and the plant height, thousand grain weight and grain test weight in conditions of wheat irrigation. According to ANDERSON & al. [23], even at large rainfall deficits during wheat growth, can be obtained higher yields. However, a higher yield of cv. Hybred and cv. Hystar was obtained in 2014 with the total precipitation during the growth period amounting to 804.8 mm.

3.2. Grain quality. The presented study indicated significant differentiation of values of grain quality parameters in respect of cultivation technology and wheat cultivar as well as the year of the study (Table 6). The highest contents of protein (PC) and gluten (WG), falling number (FN) and grain test weight (TW) were obtained in grain from HI technology level. Except for protein content (PC), the value of the mentioned parameters did not differ significantly between technology MI and HI. Also no statistic differences were proved between technology level LI and MI and between MI and HI for Zeleny test (ZT) and ash (A) content. Similar results were obtained by ŠIP & al. [24], who proved that varied technology levels did not have the same effect on quality traits in all wheat cultivars. FAMĚRA & al. [25], reports that the difference in protein and gluten contents and falling number between the application of N in wheat in a rate of 90 and 120 kg·ha⁻¹ was statistically non-significant and amounted to 0.4%, 1.8% and 10 s, respectively.

Table 6. Quality parameters of hybrid wheat

Factors		PC	WG	FN	ZT	A	TW
Technology (T)	LI	11.5 ^a	23.4 ^a	275 ^a	25.4 ^a	1.32 ^a	76.1 ^a
	MI	13.2 ^b	27.0 ^b	315 ^b	29.8 ^{ab}	1.43 ^{ab}	78.2 ^b
	HI	15.0 ^c	28.9 ^b	305 ^b	37.0 ^b	1.53 ^b	79.0 ^b
<i>LSD 5%</i>		<i>0.6</i>	<i>2.0</i>	<i>20</i>	<i>10.1</i>	<i>0.08</i>	<i>1.3</i>
Cultivar (C)	Hy	12.7 ^a	23.8 ^a	278 ^a	27.9 ^a	1.40 ^a	77.9 ^a
	Hm	13.8 ^b	29.1 ^b	318 ^b	33.6 ^a	1.46 ^a	77.7 ^a
<i>LSD 5%</i>		<i>0.2</i>	<i>3.7</i>	<i>32</i>	<i>ns</i>	<i>ns</i>	<i>ns</i>
Year (Y)	2012	13.4 ^a	30.1 ^a	312 ^a	35.2 ^a	1.57 ^b	77.2 ^a
	2013	13.4 ^a	26.5 ^b	297 ^a	30.1 ^b	1.47 ^b	77.8 ^a
	2014	12.9 ^a	23.0 ^c	285 ^a	27.1 ^b	1.24 ^a	78.3 ^a
<i>LSD 5%</i>		<i>ns</i>	<i>2.8</i>	<i>ns</i>	<i>4.2</i>	<i>0.14</i>	<i>1.0</i>

MALIK & al. [10] reports, that the amount of gluten is usually proportional to the content of protein, and the values of those parameters are significantly influenced by a combination of genetic, agricultural and environmental characteristics and their mutual relationships. Significantly higher gluten (WG) content 30.1%, Zeleny test (ZT) 35.2 ml and ash (A) 1.57% were obtained in 2012 which was characterized by the temperature similar to the long-term one and moderate precipitation amounting to 598.7 mm. In 2014, with a higher total precipitation, the values of those traits were the lowest. No statistical variation was found between the years of the study for protein content (PC), the falling number (FN) and grain test weight (TW). DANIEL&TRIBOÏ [26], report that excessive rainfall may cause a higher rate of gliadin synthesis in protein, weakening the mechanical strength of gluten, which is also dependent on the wheat genotype. Among the studied cultivars, the cv. Hystar was particularly characterized by a significantly higher content of gluten (WG) and Zeleny test (ZT) by 5.3% and 5.7 ml, as well as protein content (PC) and falling number (FN) by 1.1% and 33 s, as compared with the cv. Hybred. The content of the above-mentioned qualitative parameters, as well as the ash (A) content and grain test weight (TW), of the studied wheat cultivars did not differ considerably from those given in the studies by ROZBICKI & al. [27] and SHEWRY [8].

3.3. Protein characteristics. Wheat grain quality depends on the amount and composition of storage proteins, especially glutenins, and is determined, among other things, on the environmental conditions or N fertilization, being also a varietal characteristic (KONOPKA & al. [6]; PLESSIS & al. [13]). The cultivation technology levels applied in this experiment resulted in differences in the content of individual protein fractions in wheat grain (Table 7).

An increase of albumins and globulins (A+B) in the grain by 5.9% was observed in technology HI in comparison with technologies MI and LI. STEPIEŃ & al. [28], obtained an increase in fractions of albumins and globulins by 7.6% in the grain of winter triticale fertilized with the rate of 120 N kg·ha⁻¹ as compared with the rate of 80 N kg·ha⁻¹. SHEWRY [8], reports that there is a negative correlation between increasing nitrogen rates and the contents of albumins and globulins in the grain of winter wheat cultivars. The application of technology HI resulted in a significant difference of the content of both gliadins and glutenins. An increase in the amount of gliadins in technology HI in relation to MI and LI was 13.1 and 23.2% and for glutenins it was 16.9 and 36.9%.

FUERTES-MENDIZÁBAL & al. [29], obtained an increase in the content of gliadins (27.0%) and glutenins (23.0%) for the nitrogen rate of 180 kg·ha⁻¹ as compared with the rate of 140 kg·ha⁻¹, and the gliadins to glutenins ratio (G/G) was on average 0.70. The present study showed that the gliadins to glutenins ratio (G/G) amounted to 1.42 for technology LI, reaching lower values 1.30 and 1.29 for technologies MI and LI. These differences, however, were statistically non-significant.

Table 7. Composition of proteins in grain hybrid wheat (mAU)

Factors	A+B	Gliadins				Glutenins			Ratio		
		α/β	γ	ω	Σ	H	L	Σ	H/L	G/G	
(T)	LI	11.9 ^a	14.1 ^a	9.1 ^a	2.7 ^a	25.9 ^a	4.8 ^a	14.0 ^a	18.8 ^a	0.34 ^a	1.42 ^a
	MI	11.9 ^a	15.4 ^a	9.8 ^b	3.0 ^a	28.2 ^b	5.6 ^b	16.3 ^{ab}	21.9 ^b	0.35 ^a	1.30 ^a
	HI	12.6 ^b	18.0 ^b	10.4 ^c	3.5 ^b	31.9 ^c	6.7 ^c	18.8 ^b	25.6 ^c	0.36 ^a	1.29 ^a
<i>LSD 5%</i>		<i>0.5</i>	<i>1.8</i>	<i>0.3</i>	<i>0.3</i>	<i>2.2</i>	<i>0.5</i>	<i>1.8</i>	<i>2.1</i>	<i>ns</i>	<i>ns</i>
(C)	Hy	12.1 ^a	15.0 ^a	8.5 ^a	2.8 ^a	26.3 ^a	5.3 ^a	14.5 ^a	19.8 ^a	0.36 ^a	1.33 ^a
	Hm	12.2 ^a	16.7 ^b	11.0 ^b	3.4 ^b	31.1 ^b	6.1 ^b	18.2 ^b	24.4 ^b	0.34 ^a	1.33 ^a
	<i>LSD 5%</i>		<i>ns</i>	<i>0.6</i>	<i>0.7</i>	<i>0.4</i>	<i>1.3</i>	<i>0.7</i>	<i>2.5</i>	<i>3.1</i>	<i>ns</i>
(Y)	2012	14.6 ^a	18.8 ^b	13.3 ^b	3.7 ^a	35.9 ^b	7.7 ^a	21.0 ^b	28.7 ^b	0.37 ^a	1.27 ^a
	2013	12.4 ^a	14.7 ^a	8.4 ^a	3.2 ^a	26.7 ^a	5.1 ^a	16.0 ^a	21.1 ^a	0.32 ^a	1.29 ^a
	2014	9.4 ^a	13.9 ^a	7.5 ^a	2.2 ^a	23.5 ^a	4.3 ^a	12.1 ^a	16.4 ^a	0.36 ^a	1.46 ^a
	<i>LSD 5%</i>		<i>ns</i>	<i>2.6</i>	<i>3.5</i>	<i>ns</i>	<i>4.7</i>	<i>2.0</i>	<i>4.0</i>	<i>5.9</i>	<i>ns</i>

A higher gliadins to glutenins ratio (G/G) may suggest a worse technological value of protein of those cultivars (DANIEL&TRIBOÏ [4]). ZHANG & al. [30], reports that the ratio of both fractions of gluten proteins depends on the environmental factors and the cultivar genotype and for 33 wheat cultivars this ratio ranged from 2.1 to 6.3. In present study the grain of cv. Hystar contained significantly more gliadins and glutenins, from 18.2 to 23.2%, respectively, however these proteins ratio was 1.33 in both cultivars.

The applied cultivation technologies differentiated the content of protein subunits of monomeric gliadins and polymeric glutenins. The largest accumulation of subunits α/β , γ and ω -gliadins and HMW-glutenins occurred after the use of technology HI. No statistical differences were indicated between the content of LMW-glutenins for technologies HI and MI and for MI and LI. The cv. Hybred accumulated significantly lowest contents of α/β , γ , ω -gliadins and subunits of HMW and LMW-glutenins.

Usefulness of wheat grain for baking purposes is mostly dependent on the fraction of HMW-glutenins and the ratio of subunits HMW to LMW (PLESSIS & al. [13]). The ratio of subunits HMW/LMW was on average level of 0.35, and the differences between the studied cultivars were insignificant. These results are in accordance with those obtained by KONOPKA & al. [6] and MAYER & al. [31], where the HMW/LMW ratio obtained in grain of wheat cultivars stayed within the range from 0.27 to 0.42. A higher contents of protein fractions and their subunits were found in the season 2011/2012 with a total precipitation lower by 44.4 mm from the long-term period and the average temperature during the growth period amounting to 8.6°C. Similar effect of the weather, which differentiating protein composition in wheat grain, is indicated by the studies by MIKHAYLENKO & al. [32] and RHARRABTI & al. [33].

4. Conclusions

Cultivation technology levels and climate conditions had the decisive effect on grain yield and quality of wheat cultivars. The application of technology HI, as compared with MI and LI, affected a higher yield and grain quality parameters of wheat. The grain from technology HI accumulated greater amounts of gliadins and glutenins, not differentiating the fraction of albumins and globulins. The total protein of grain of wheat cultivars was characterized by the lowest share of albumins and globulins, and the highest of gliadins. Lower total precipitation in the years of the study caused an increase in grain quality parameters and gluten subunits in the grain, but they reduced the grain yield. The cv. Hybred was characterized by a higher grain yield, but worse grain quality parameters.

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