Evaluation of the yield and baking quality of winter wheat (*Triticum aestivum* L.) varieties in different cropyears

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SUMMARY

We have investigated the effect of the cropyear, the genotype, the nutrient supply and their interactions on the yield and the quality parameters of three different winter wheat genotypes in three different cropyears. The most disadvantageous influence on the yield averages was caused by the moist weather of 2010, when yield results fell behind the mean of the two other examined years and the nutrient optimum was around low doses. The optimal cropyear turned out to be the ordinary 2011, the best yield results were experienced during this cropyear. Although the drier periods in 2012 decreased the yield values, the varieties could realize high yield maximum values. Considering the yield results, Genius turned out to be the best variety.

In respect of the quality traits, 2010 turned out to be the best cropyear in case of all the three varieties. Despite the dry weather of the spring of 2012, the precipitation fell during flowering and ripening phases had positive impact on the grain-filling processes and contributed to the development of better quality. As a consequence of the significantly lower amount of precipitation during the generative phenological phases, the worst quality parameters were realized by the varieties in 2011. In respect of crop year effect, 2010 was unfavourable for the amount of yield, but the most beneficial for the quality. 2011 was the most advantageous for the yield amounts but disadvantageous for the quality parameters. Although in 2012 extreme crop year effects were experienced after each other (dry and warm spring, moist and warm summer), the yield average and quality trait values were close to the yield averages of 2011 and quality parameters of 2010. Analyzing our results we can state that the average crop year was favourable rather for the yield. The appropriate amount of precipitation during the whole 2010 and that during the generative phenophases in 2012 favoured the development of good quality.

Consequently, the appropriate amount of precipitation is essential for the development of good quality during the grain-filling period. The negative crop year effects were only compensated but not eliminated by the good nutrient supply. Genius achieved excellent yield averages but performed worse quality parameters than Mv Toldi, whose quality parameters were outstanding but the yield averages fell slightly behind those of Genius. Considering the yield results, the variety Genius turned out to be the best, while Mv Toldi was the best in quality.

Keywords: *winter wheat, fertilization, genotypes, cropyear*

ÖSSZEFOGLALÁS

Az évjárat, a genotípus és a tápanyagellátás hatását vizsgáltuk három különböző genotípusú őszi búza fajta termésmennyiségére és minőségi paramétereire, három különböző évjáratban. A termésátlagok tekintetében a legkedvezőtlenebb hatást a 2010. évi csapadékos időjárás fejtette ki, ahol a terméseredmények elmaradtak a másik két vizsgált tenyészév átlagaitól, illetve a tápanyag optimum is a kisebb tápanyag dózisok körül mozgott. Míg optimálisnak a 2011. átlagos évjárat bizonyult, a legjobb terméseredményeket a fajták ebben az évjáratban realizálták. A 2012. év szárazabb időjárási periódusai bár csökkentették termésmennyiségek értékét, a fajták még így is jó termésmaximumokat voltak képesek realizálni. A terméseredményeik alapján a Genius fajta bizonyult a legjobbnak.

A minőségi tulajdonságokat vizsgálva mindhárom vizsgált fajta esetében a legjobb tenyészévnek 2010. bizonyult. 2012-ben a száraz tavaszi idő ellenére, a virágzáskor és az érési fázisok folyamán lehullott csapadék pozitívan befolyásolta a szemtelítődési folyamatokat és ezzel hozzájárult a jobb minőség kialakításához. A leggyengébb minőségi mutatókat 2011-ben realizálták a fajták, magyarázható ez azzal, hogy a generatív fenológiai fázisokban jelentősen kisebb mennyiségű csapadék hullott. Évjárathatás szempontjából a 2010. év kedvezőtlen volt a termésmennyiségre, de a legkedvezőbb a minőség tekintetében. A 2011. év legkedvezőbb volt a termésnagyságok esetében, de kedvezőtlen a minőségi mutatókra nézve. Míg a 2012. évben bár szélsőséges évjárati hatások váltották egymást (száraz meleg tavasz, csapadékos meleg nyárelő), mégis a fajták termésátlagai, illetve minőségi tulajdonságainak értékei megközelítették a 2011. év termésnagyságait, és a 2010. évi minőségi mutatatók értékeit. Eredményeink alapján megállapítható, hogy az átlagos évjárat inkább termésnek kedvezett. A jó csapadék ellátottságú 2010. évjárat, illetve 2012-ben a generatív fenofázisokban a megfelelő csapadék mennyiség kedvezett a jó minőség kialakulásnak.

A jó minőség kialakításához tehát elengedhetetlen a megfelelő mennyiségű csapadék a szemtelítődéskori időszakban. A negatív évjárati hatásokat a megfelelő tápanyag ellátottság kompenzálni tudta, de megszüntetni nem. A Genius fajta kiváló termésátlagokkal rendelkezett, de minőségi mutatói gyengébbek voltak, mint az Mv Toldi fajtáé, mely kiváló minőségi mutatókkal bírt, de terméseredményei kissé elmaradtak a Genius fajtától. Terméseredmények tekintetében a Genius fajta bizonyult a legjobbnak, míg minőségben az Mv Toldi.

Kulcsszavak: *őszi búza, műtrágyázás, genotípusok, évjárat*

INTRODUCTION

In winter wheat production, an ever-increasing emphasis is growing on the qualitative approach beside the quantitative one. Nowadays, in addition to high yields good quality of winter wheat is of great importance. These two values are influenced by several factors; among them we have investigated the crop year effect, the genotype, the nutrient supply and their interactions. Gutierrez et al. (2010) found differences between

the average yields of varieties due to differences in genotypes. The average yields are modified significantly by the crop year and big differences may occur between the values of two years on the same field (Láng and Bedő, 1997). Mengistu et al. (2010) found strong significant interaction amongst the genotype, the environment and the yield amount. The different wheat varieties responded with different yields to the specific environmental factors. Márton (2002) concluded that in drought cropyears on the control fields the wheat produced 30% less grain than in the average ones. In years with more precipitation, the yield decrease was beyond drought damage. The control plots produced above 80% less than in an average year. According to Tóthné Lőkös (1999) the crop year plays more significant role in yield production than the genotype. The genotype x environment interaction has statistically significant effect on both yield quantity and quality (Borghi et al., 1997). Har Gil et al. (2011) found the genotype, the crop year and the agrotechnique as important influencing factors of wheat quality. Somnez (2007) concluded that the yield quantity and the protein content of grain were determined by the crop year, the genotype and the nutrient supply. With the increase of the nitrogen doses, the protein contents of grains were increased proportionally but the varieties responded differently to the increase of the nitrogen doses. Luo et al. (2000) found the winter wheat genotype as a highly significant influencing factor on the protein content of grain and rheological characteristics of dough. They also experienced that the interaction between nutrient doses and genotypes made significant impact on quality traits. The genotype crop year interaction is a very important factor in wheat production (Maric et al., 2007). The crop year may influence the quality significantly and the unfavourable effects can be reduced by the application of appropriate agrotechniques (Sipos et al., 2006; Pongráczné et al., 2008). According to Weightman et al. (2008) the drought reduces the leaf area, limits the incorporation of dry matter, which results in higher protein content during the grain-filling period. Vajdai et al. (1989) found that precipitation above 3–4 mm during the full maturation period of the grain made adverse effect on yield quality. The temperature during the grain-filling period (June and July) significantly influences the raw protein content of the grains (Smith and Gooding, 1999). The protein content of the grains correlates with the nitrogen intake, when the nitrogen supply is the main limiting factor (Debaeke et al., 1996). The N+PK fertilizers significantly increased the gluten and protein contents and the valorigraphic value. The crop year influenced the valorigraphic value of wheat varieties to a much greater extent than any other quality parameters and the $N_{120-150}$+PK nutrient level was found to be as the optimal nutrient dose (Pepó, 2003). In contrast, Győri et al. (2003) found that the alveographic parameters were mainly influenced by the genotype, but the effects of both fertilization and crop year were also significant. According to Kindred et al. (2008) the amount of nitrogen influences the protein content of grain to a greater extent than variety effect. Stoeva and Ivanova (2009) found that the significant differences in the gluten content were caused by fertilization and crop year effect. Positive correlation was experienced between the wet gluten content and the nutrient supply (Alda et al., 2010). The crop year also influenced the wet gluten content. Zecevic et al. (2010) found that nitrogen fertilization significantly increased the wet gluten content. The highest increase was found at the dose of N_{120} kg ha^{-1}. The varieties responded to the increase of nitrogen doses in a different manner. Lerner et al. (2006) found the nitrogen supply as a significant influencing factor of the rheological properties of flour. According to the results of Pedersen and Jorgensen (2007) nitrogen supply was found to be the main influencing factor of protein and gluten contents. Protein and gluten contents increased with the raise of nitrogen levels.

MATERIAL AND METHOD

The long-term experiment was carried out at the Látókép Experimental Station of the Institute of Crop Sciences, University of Debrecen. The experimental station is located 15 km west of Debrecen in the Hajdúság. The soil of the experiment is calcareous chernozem and can be classified into the loam category, its pH is near neutral and it has medium humus content. The long-term experiment was set up in 1983. Our study contains the results of the period 2010–2012. The small-plot field experiment was set up in a split-plot design in four replications. Six fertilization levels were applied in the treatments. In addition to the control, the basic dosage of N=30 kg ha^{-1}, P_2O_5=22.5 kg ha^{-1} and K_2O=26.5 kg ha^{-1} and 2-,3-, 4- and 5-fold dosages were applied. The total P and K dosages were applied in the autumn, 50% and 50% of the N fertilizer dosages were applied in the autumn and in the spring. The forecrop was sweet corn. Wet gluten content, valorigraphic value, and the flour protein content were determined according to the standards MSZ ISO 5531:1993, MSZ ISO 5530/3:1995l, ICC 159:1995 respectively.

The precipitation values during the season and the temperature data during the period of 2010–2012 are presented in *table 1*. As a consequence of the dry weather of the first half of October 2009 the tillering was very slow and heterogeneous stands formed. From the middle of October the precipitation was above average and the temperature was advantageous for the development and consolidation of the wheat populations. The mild weather of November also favoured the development of the consolidating homogenous populations. December was moister and milder than the average, too. In January and February the amount of precipitation and the mean temperature also exceeded the average. March was rainless.

The significant precipitation and higher-than-average temperature during April and May considerably favoured the intensive vegetative development of winter wheat. However, the significant amount of precipitation during spring and summer was disadvantageous and thus the yield decreased.

In the 2010/2011 cropyear the seedling emergence was tardy as a consequence of the cooler October. The warmer weather of November favoured the tillering. Because of the excessive precipitation of the previous year the lack of precipitation was compensated by the water reserve of the soil. During spring the warm weather was advantageous for the development of the population and thus its growing accelerated. The low precipitation in June was unfavourable for the grain-

Table 1.

Main meteorological data of the tested vegetation periods (Debrecen, 2010–2012)

	Oct.	Nov.	Dec.	Jan.	Febr.	Marc.	Apr.	May	Jun.	Total/Average
Precipitation (mm) 2009/2010	79.3	78.3	54.9	48.8	58.6	14.4	83.9	111.4	100.9	630.5
30 year's average	30.8	45.2	43.5	37.0	30.2	33.5	42.4	58.8	79.5	400.9
Difference	+48.5	+33.1	+11.4	+11.8	+28.4	-19.1	+41.5	+52.6	+21.4	+229.6
Precipitation (mm) 2010/2011	22.8	52.9	104.2	19.2	16.8	35.1	15.6	52.3	22.0	340.9
30 year's average	30.8	45.2	43.5	37.0	30.2	33.5	42.4	58.8	79.5	400.9
Difference	-8.0	+7.7	+60.7	-17.8	-13.4	+1.6	-26.8	-6.5	-57.5	-60.0
Precipitation (mm) 2011/2012	18.1	0	71.1	28.0	17.8	1.4	20.7	71.9	91.7	320.7
30 year's average	30.8	45.2	43.5	37.0	30.2	33.5	42.4	58.8	79.5	400.9
Difference	-12.7	-45.2	+27.6	-9.0	-12.4	-32.1	-21.7	+13.1	+12.2	-80.2
Temperature (°C) 2009/2010	11.4	7.6	2.3	-1.1	0.5	7.6	11.6	16.6	19.7	8.47
30 year's average	10.3	4.5	-0.2	-2.6	0.2	5.0	10.7	15.8	18.8	6.94
Difference	+1.1	+3.1	+2.5	+1.5	+0.3	+2.6	+0.9	+0.8	+0.9	+1.53
Temperature (°C) 2010/2011	6.9	7.7	-1.7	-1.2	-2.5	5.0	12.2	16.4	20.5	7.03
30 year's average	10.3	4.5	-0.2	-2.6	0.2	5.0	10.7	15.8	18.8	6.94
Difference	-3.4	+3.2	-1.5	+1.4	-2.7	0	+1.5	+0.6	+1.7	+0.09
Temperature (°C) 2011/2012	8.6	0.6	1.5	-0.6	-5.7	6.3	11.7	16.4	20.9	6.63
30 year's average	10.3	4.5	-0.2	-2.6	0.2	5.0	10.7	15.8	18.8	6.94
Difference	-1.7	-3.9	+1.7	+2.0	-5.9	+1.3	+1.0	+0.6	+2.1	-0.31

filling processes. The moist, cool weather at the beginning of July benefited the translocation processes but delayed the harvest.

The 2011/2012 cropyear was extreme considering the winter wheat production. In October and November 2011 precipitation was low, therefore the seedling and the initial development slowed down. As a consequence of the higher amount of precipitation in winter the populations consolidated but the subsequent dry and warmer-than-average spring adversely effected the vegetative development. The rainy, warm weather in May and June 2012 positively influenced the grain-filling processes.

RESULTS AND DISCUSSION

We have examined three winter wheat varieties of different genotypes in three cropyears. The yield results are presented in *table 2*. As a consequence of the moist weather of 2010, yield maximums were low and realized at lower nutrient levels. These observations are explained by the high nutrient recovery and uptake and that lodging and fungal diseases caused by the higher nutrient doses resulted in considerable yield depression. The lowest yield, 3110 kg ha^{-1}, was experienced in the case of the control (Lupus). Mv Toldi performed 3812 kg ha^{-1} as yield which meant 7% excess, while Genius produced the maximum yield average (4275 kg ha^{-1}) which meant 8% yield access compared with the average of the three years, demonstrating its excellent natural nutrient utilizing ability. The optimal nutrient doses varied between the levels of N_{30-60}+PK. Yield maximum was 5986 kg ha^{-1} (5% yield excess) in the case of Genius, while in the case of Lupus it turned out to be 5675 kg ha^{-1} (7% yield excess). The lowest yield maximum was realized by Toldi (5196 kg ha^{-1}) that meant 2% yield drop compared with the average of the three years. In 2011 in case of the control, Lupus produced the average of only 3102 kg ha^{-1}, Mv Toldi performed 7% decline (3316 kg ha^{-1}) compared with the three-year average, while the yield average of Genius was the highest again (4019 kg ha^{-1}), achieving only 1% yield excess.

The nutrient optimum was low in the case of Lupus, the lowest maximum yield (6150 kg ha^{-1}) among the three studied varieties was measured at the nutrient dose of N90+PK. In case of the other two varieties the nutrient optimum was the level of N_{150}+PK. Mv Toldi achieved 18% yield excess (7620 kg ha^{-1}), while Genius realized a 25% excess with the yield maximum of 8462 kg ha^{-1} compared with the three-year average. In the year 2012 the yield varied between 3132 kg ha^{-1} (Lupus) and 3610 kg ha^{-1} (Genius) in the cases of the control, untreated plots. At the optimal nutrient dose of N_{150}+PK Lupus performed the lowest yield maximum (6408 kg ha^{-1}), Mv Toldi produced 6868 kg ha^{-1} (6%), while Genius achieved the maximum yield average of 7209 kg ha^{-1} (7%). To interpret these findings we conclude that the crop year had modifying effect on the yield.

In the case of the control treatments, the year 2010 turned out to be the best as a consequence of the higher precipitation and nutrient storage. Considering the optimal nutrient levels, 2011 was the best year. While in 2010 the varieties realized 5–7% yield excess at the optimal nutrient doses, in 2011 these values varied between 7 and 25%. In 2012 the yield excess varied between only 6 and 12% compared with the average of the three years. The yield fluctuations in the three years were as follows: Lupus: 1–32%, Mv Toldi: 14–42%, Genius: 10–57%. Although Lupus turned out to be the most stable variety, its yield results fell behind those of the two other ones; the higher interval fluctuations were observed in the case of Mv Toldi and Genius, they achieved the higher yield averages.

Table 2.

The yield of tested winter wheat genotypes in different cropyears (Debrecen, 2010–2012)

Variety	Fertilizer treatment	2010	%	2011	%	2012	%	Average	%	Interval fluctuation of the yield (%)
Lupus	Ø	3110	100	3102	100	3132	101	3115	100	1
	N_{30}+PK	5250	115	3814	84	4610	101	4558	100	32
	N_{60}+PK	5675	107	4873	92	5427	102	5325	100	15
	N_{90}+PK	5350	93	6150	107	5688	99	5729	100	14
	N_{120}+PK	5476	94	5902	101	6129	105	5836	100	11
	N_{150}+PK	5063	88	5718	100	6408	112	5730	100	23
Mv Toldi	Ø	3812	107	3316	93	3607	101	3578	100	14
	N_{30}+PK	4576	93	4542	92	5676	115	4931	100	23
	N_{60}+PK	5196	89	6119	105	6163	106	5826	100	17
	N_{90}+PK	5013	84	6526	110	6307	106	5949	100	25
	N_{120}+PK	4850	80	6938	114	6509	107	6099	100	34
	N_{150}+PK	4927	76	7620	118	6868	106	6472	100	42
Genius	Ø	4275	108	4019	101	3610	91	3968	100	17
	N_{30}+PK	5986	105	5436	95	5751	100	5724	100	10
	N_{60}+PK	5550	88	6717	107	6642	105	6303	100	19
	N_{90}+PK	4972	79	7105	113	6804	108	6294	100	34
	N_{120}+PK	4796	73	7736	118	7127	109	6553	100	45
	N_{150}+PK	4600	68	8462	125	7209	107	6757	100	57
$LSD_{5\%}$ (A)		279		454		371		Variety (A)		
$LSD_{5\%}$ (B)		184		195		246		Fertilizer treatment (B)		
$LSD_{5\%}$ (A×B)		319		337		425		Interaction (A×B)		

Among the quality traits, the lowest valorigraphic values of the controls *(table 3)* were experienced in 2010 in all varieties (Lupus 44.7, Mv Toldi 53.2, Genius 44.9), which were 4–10% lower than the average of the three years. In the case of untreated plots, the best valorigraphic values were measured in 2011 (56.8–60.3) exceeding the three-year average by 4–20%. At the optimal nutrient level of N_{120}+PK the best valorigraphic values were observed in 2012 in the cases of Lupus (69.7) and Genius (63.9), while Mv Toldi achieved the best value in 2010 (71.8). Analyzing the three years altogether, valorigraphic value fluctuations were the following: Lupus: 14–25%, Genius: 9–31%, Mv Toldi: only 8–16%. Among the crop years, 2011 was the best in the case of the controls, the varieties realized 4–20% higher values. In the case of the optimal nutrient doses, 2010 was better for Genius and Lupus since 3–6% increase was experienced, while in the case of Mv Toldi 8% higher value was observed in 2010 compared to the average of the three years.

Considering the wet gluten values we conclude that on the control plots each variety realized the lowest gluten contents in 2012 (Lupus 20.3%, Mv Toldi 25.0%, Genius 20.2%), while the highest values were measured in 2011 (Lupus 28.3%, Mv Toldi 30.0%, Genius 27.9%). The best wet gluten content was performed by Mv Toldi (25.0–30.0%), while the lowest by Genius (20.2–27.9%). The lowest values in the case of the optimal nutrient level (N_{120}+PK) were experienced in 2011 (Lupus 32.8%, Mv Toldi 36.0%, Genius 32.5%), while the highest gluten contents were measured in 2010 (Lupus 38.5%, Mv Toldi 40.0%, Genius 39.7%). The lowest wet gluten contents were performed by Genius (33.9–39.7%), while the highest value was achieved again by Mv Toldi (36.0–40.0%). In the case of the control treatments, 2012 turned out to be the worst year, the varieties realized 10–18% lower wet gluten contents, while 8–17% higher values were measured in 2011. At the nutrient level of N_{120}+PK, the lowest wet gluten contents were obtained in 2011, the varieties performed 7–9% lower values than the three-year average. The best gluten contents were achieved in 2012, the varieties performed 4–12% higher values than the average of the three years. The lowest fluctuation was observed in the case of Mv Toldi (10–18%), while Lupus and Genius performed higher ones, 12–33% and 20–31%, respectively. On the control plots, the lowest protein contents were performed by Lupus (10.4%) and Genius (11.6%), while Mv Toldi realized the lowest value in 2012 (12.3%) but low content was measured also in 2010 (12.4%). The highest protein contents in the case of the untreated controls were measured in 2011 in each variety (Lupus 12.8%, Mv Toldi 12.9%, Genius 11.9%). The best protein contents of the controls were achieved by Mv Toldi (12.3–12.9%), while the worst values were measured in the case of Lupus (10.4–12.8%). At the nutrient level of N_{120}+PK, each varieties performed the lowest protein contents in 2011 (Lupus 13.9%, Mv Toldi 15.4%, Genius 14.1%), while the highest values were observed in 2010 (Lupus 16.1%, Mv Toldi 17.0%, Genius 16.8%). The highest protein contents were achieved by Mv Toldi both at control (12.3–12.9%) and optimal (N_{120}+PK) nutrient levels (15.4–17.0%). The lowest protein contents were measured in the case of Lupus both at control (10.4–12.8%) and optimal (N_{120}+PK) nutrient levels (13.9–16.1%). On the control plots we measured 2–11% higher protein contents, while the varieties realized 1–10% lower values in 2010. At the optimal nutrient level of N_{120}+PK, in 2010 5–10% higher, while in

Table 3.

The quality parameters of tested winter wheat genotypes in different cropyears (Debrecen, 2010–2012)

Quality parameter	Variety	Fertilizer treatment	2010	%	2011	%	2012	%	Average	%	Interval Fluctuation (%)
Valorigraphic value	Lupus	Ø	44.7	92	56.8	116	44.9	92	48.8	100	25
		N_{60}+PK	60.9	100	64.9	107	56.6	93	60.8	100	14
		N_{120}+PK	60.2	92	67.1	102	69.7	106	65.6	100	14
	Mv Toldi	Ø	53.2	96	57.5	104	55.0	100	55.2	100	8
		N_{60}+PK	68.8	108	62.9	99	59.2	93	63.6	100	15
		N_{120}+PK	71.8	108	66.2	100	61.2	92	66.4	100	16
	Genius	Ø	44.9	90	60.3	120	45.1	90	50.1	100	31
		N_{60}+PK	62.4	102	60.4	99	61.0	100	61.3	100	3
		N_{120}+PK	62.9	102	58.6	95	63.9	103	61.8	100	9
$LSD_{5\%}$ (A)			4.05		6.84		8.05		Variety (A)		
$LSD_{5\%}$ (B)			1.98		2.98		2.00		Fertilizer treatment (B)		
$LSD_{5\%}$ (A×B)			3.43		5.16		3.47		Interaction (A×B)		
Quality parameter	Variety	Fertilizer treatment	2010	%	2011	%	2012	%	Average	%	Interval Fluctuation (%)
Wet gluten content (%)	Lupus	Ø	23.9	99	28.3	117	20.3	84	24.2	100	33
		N_{60}+PK	33.9	107	30.2	96	30.8	97	31.6	100	12
		N_{120}+PK	38.5	107	32.8	91	36.4	101	35.9	100	16
	Mv Toldi	Ø	28.0	101	30.0	108	25.0	90	27.7	100	18
		N_{60}+PK	36.9	104	32.1	90	37.5	106	35.5	100	15
		N_{120}+PK	40.0	104	36.0	93	39.8	103	38.6	100	10
	Genius	Ø	26.2	106	27.9	113	20.2	82	24.8	100	31
		N_{60}+PK	37.2	111	30.3	91	32.8	98	33.4	100	20
		N_{120}+PK	39.7	112	32.5	92	33.9	96	35.3	100	20
$LSD_{5\%}$ (A)			1.40		1.90		3.28		Variety (A)		
$LSD_{5\%}$ (B)			0.46		0.93		1.60		Fertilizer treatment (B)		
$LSD_{5\%}$ (A×B)			0.80		1.61		2.77		Interaction (A×B)		
Quality parameter	Variety	Fertilizer treatment	2010	%	2011	%	2012	%	Average	%	Interval Fluctuation (%)
Flour protein content (%)	Lupus	Ø	10.4	90	12.8	111	11.6	100	11.6	100	10
		N_{60}+PK	14.9	107	13.2	95	13.7	98	13.9	100	13
		N_{120}+PK	16.1	107	13.9	93	15.1	100	15.0	100	14
	Mv Toldi	Ø	12.4	99	12.9	103	12.3	98	12.5	100	5
		N_{60}+PK	16.4	108	13.6	90	15.4	102	15.1	100	18
		N_{120}+PK	17.0	105	15.4	95	16.2	100	16.2	100	10
	Genius	Ø	11.6	99	11.9	102	11.6	99	11.7	100	3
		N_{60}+PK	16.3	111	13.4	91	14.3	97	14.7	100	20
		N_{120}+PK	16.8	110	14.1	93	14.8	97	15.3	100	18
$LSD_{5\%}$ (A)			0.77		0.91		0.70		Variety (A)		
$LSD_{5\%}$ (B)			0.37		0.44		0.34		Fertilizer treatment (B)		
$LSD_{5\%}$ (A×B)			0.65		0.77		0.60		Interaction (A×B)		

2011 5–7% lower protein contents were measured compared with the three-year average. Lupus and Genius turned out to be the most stable varieties with 10–14% and 5–18% fluctuation of the values, respectively. Genius performed 3–20% fluctuation through the years.

CONCLUSIONS

We have experienced different tendencies during the analyses of the yield results and quality parameters. The most disadvantageous influence on the yields was caused by the moist weather of 2010, when yield results fell behind the mean of the two other examined years and the nutrient optimum was around low doses. The optimal cropyear turned out to be the ordinary 2011, the best yield results were experienced during this cropyear. Although the drier periods in 2012 decreased the yield values, the varieties could realize good yield maximum values. Considering the yield results, Genius turned out to be the best variety. The results of Mv Toldi were behind those of Genius minimally, while the lowest averages were observed in the case of Lupus.

In respect of the quality traits, 2010 turned out to be the best cropyear in the case of all the three varieties. Despite the dry weather of the spring of 2012, the precipitation fell during flowering and the ripening phases had positive impact on the grain-filling processes and contributed to the development of better quality. As a consequence of the significantly lower amount of precipitation during the generative phenological phases, the worst quality parameters were realized in 2011. In respect of crop year effect, 2010 was unfavourable for the amount of yield, but the most beneficial for the quality. 2011 was the most advantageous for the yield amounts but disadvantageous for the quality parameters. Although in 2012 extreme crop year effects were experienced after each other (dry and warm spring,

moist and warm summer), the yield average and quality trait values were close the yield averages of 2011 and quality parameters of 2010. Analyzing our results we can state that the average crop year was favourable rather for the yield. The appropriate amount of precipitation during the whole 2010 and that during the generative phenophases in 2012 favoured the development of good quality. Consequently, the appropriate amount of precipitation is essential for the development of quality during the grain-filling period. The negative crop year effects were only compensated but not eliminated by the good nutrient supply.

Among the varieties Lupus performed the worst values regarding both the yield average and quality in each cropyear and nutrient level. Genius achieved excellent yield averages but performed worse quality parameters than Mv Toldi, whose quality parameters were outstanding but the yield averages fell slightly behind those of Genius. Considering the yield results, the variety Genius turned out to be the best, while Mv Toldi was the best in quality. By now, quality in winter wheat production became as valuable as yield quantity, thus the selection of the genotype appropriate for the aims of the production is of great importance. The variety Genius fits rather in the plant production model that prefers yield, while Mv Toldi in the one that favours the quality instead.

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