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CULTIVAR AND NITROGEN FERTILISER EFFECTS ON FRESH AND STORED WINTER WHEAT GRAIN QUALITY INDICES

Anda Liniņa and Antons Ruža

Faculty of Agriculture, Latvia University of Agriculture, Lielā iela 2, Jelgava, LV-3001, LATVIA;
anda.linina@llu.lv; antons.ruza@llu.lv

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*Field experiments with winter wheat (*Triticum aestivum *L.) cultivars 'Bussard' and 'Zentos' using four nitrogen top application rates (N60, N90, N120 and N150) were conducted at the Latvia University of Agriculture, Study and Research farm "Pēterlauki" in 2010 and 2011. The objective of this study was to determine effect of nitrogen (N) fertiliser on quality indices of fresh and stored grain (60–120 days) for two different winter wheat cultivars. Highly significant effect of cultivars and nitrogen fertiliser were detected for quality traits: protein content, wet gluten and sedimentation value. For the grain stored for 60–120 days, protein content was variable, sedimentation values decreased, the falling number increased, the content of wet gluten declined, and the quality of gluten improved. For 'Zentos', close positive correlation was found between gluten content and protein content, and between sedimentation value and protein, high positive correlation was found, and between sedimentation value and gluten content for both cultivars.*

Key words: *wheat, grain, quality, storage, nitrogen fertiliser.*

INTRODUCTION

Winter wheat is one of the most productive and important cereal species for food grain production used in Latvia . The yield and baking quality parameters depend on meteorological conditions, fertiliser treatment, and the cultivar (Šip *et al*., 2000; Stankovski *et al*., 2004; Koppel and Ingver, 2008; Kreita and Ruža, 2008).

Quality parameters of winter wheat are not stable between production years because of changes in factors such as initiation of the growing season, distribution of rainfall and heat units available for crop growth during corresponding phases of plant growth and development (Cesevičienė *et al*., 2009). Addition of nitrogen fertiliser in accordance with the plant requirement is necessary to attain high yields and quality of winter wheat (Ragasits, 2000; L-Baeckström *et al*., 2006).

Protein is a direct indicator of flour strength and bread-baking potential (Anjum and Walker, 2000). The dough-forming protein of wheat flour (gluten) is the key to the unique ability of wheat to suit the production of leavened products (Day *et al*., 2006).

Grain protein content significantly varies depending on the cultivars. Protein accumulation in bred wheat largely depends on the weather conditions of the year and distribution of nitrogen rates during the growing season (Panozzo, 2000; Fowler, 2003; Krejčirova *et al*., 2006). Warm weather and nitrogen fertilisation increases grain protein and wet gluten content, while high temperature decreases these grain quality indices (Triboi, 2003). Muchova (2003), who tested 22 indicators of bred wheat grain and flour, suggested that weather conditions of the year had the greatest effect on baking qualities, whereas the effect of fertiliser and other factors was insignificant. Moisture is a critical factor for the formation of final compounds. The ripening process is severely hindered when plants are deficient in water during the period of 1–14 days after grain setting. Cobellini *et al*. (1997) concluded that high air temperatures at the beginning of grain ripening does not affect protein accumulation in grain, but in the middle and end of ripening the damage done by high air temperatures is considerable.

Sedimentation value provides an indication of protein quality. Flour of the first quality class (60 cm^3) is very hard and useful when mixed with comparatively weak flour. Second class (40–60 cm^3) flour is hard and useful for direct baking or mixing with comparatively weak flour. Third-class (22–40 cm^3) flour is useful for direct baking, and fourth (cm^3) class flour is very weak flour (Ruža, 1998). Sedimentation declines due to drought but not due to heat stress at the end of grain ripening (Gooding *et al.,* 2003).

Wet gluten content and index data are in the focus of bakers' and millers' interests. Gluten content depends on the ratio of protein fractions in grain, which is affected both by plant supply with nutrients at the grain ripening stage and wetter conditions at the same stage (Triboi, 2003).

Cereals maturation and harvesting can occur during rainfall periods, which often can be a reason for lower grain quality and even grain sprouting in ears. Cereal grain has the highest quality during the growth period between wax maturity and full maturity. During this period, formation of the cereal harvest is already finished and, in case of unfavourable weather conditions, grains can start sprouting, which can result in reduced falling number. Under very wet harvesting conditions wheat can attain alpha-amylase activity that is considered to be too high (Kettlewell and Cashman, 1997; Kettlewell, 1999; Kunkulberga *et al*., 2007).

Producers with wheat stored for a few months have observed change in what grain qualities (Mašauskiene and Cesevičiene, 2005), which can affect the price of wheat and consumer acceptance of finished products. The aim of this investigation was to determine grain quality indices during storage in relation to different rates of nitrogen fertiliser application.

MATERIAL AND METHODS

Field experiments. Field experiments in 2010 and 2011 were conducted at the Latvia University of Agriculture, Study and Research farm "Pēterlauki" on silt loam brown podzolic soil with near neutral acidity (pH KCl 6.9), medium high available phosphorus and potassium content (P_2O_5 182 mg kg^{-1} and K_2O 171 mg kg^{-1}, respectively) and humus content 27 g kg^{-1}. Registered winter wheat (*Triticum aestivum* L.) bread cultivars from Germany 'Bussard' and 'Zentos' were sown after black fallow. Both cultivars have high bread-making quality (Elite cultivars). These cultivars were grown in four replications with plot size 36 m^2. The crop was sown at a rate of 400 germinating seeds per m^2. The fertiliser background NPK (6 : 26 : 30) was 250 kg ha^{-1} applied in autumn. Nitrogen was applied in spring after resumption of vegetative growth. Nitrogen top application rates were as follows: N60, N90, N120 and N150. All the necessary plant protection measures were performed. Grain was harvested at full ripeness from each replication separately. The sampling procedure for grain quality evaluation was performed according to standard ICC 101/1 for obtaining an average sample. Grain with a moisture content exceeding 14% was dried. Freshly harvested grain of each variety was placed into separate bags. Grain samples for analyses were taken three times: fresh and stored grain — 60 and 120 days after harvest. The air temperature and relative air humidity in the storage house depended on the outdoor conditions.

Weather data collection. In 2010 and 2011, the air temperature in spring was close to long-term average observations (norm), which promoted plant growth and development. Mean May temperature was +12.6 ^oC in 2010 and +13.9 ^oC in 2011, compared to the long-term average of +13.0 ^oC. Average daily temperature in June was close to normal in both investigation years. Temperature in the grain filling period (July), which is most decisive for grain quality formation, was similar in both years — 21.2 ^oC or by 4.4 ^oC warmer than the long-term average in 2010 and 19.9 ^oC or by 3.3 ^oC warmer in 2011.

Water availability has effect on wheat yield (Gooding *et al*., 1997; Povilaitis and Lazauskas, 2010). May in 2010 was wet, when precipation was 84.6 mm, or 179% higher than the long-term average for this month. In 2011, extremely dry conditions occurred during the third decade in April and first decade in May. In the second decade of May, precipitation was 49 mm, or 296% of the long-term average for this decade.

Precipitation in June 2010 and 2011 was close to normal; July in 2010 and 2011 was very rainy with total precipitation 298 mm and 179 mm (318% and 217% compared with the long-term averages). The rainy weather delayed ripening of grain. Precipitation was lower in the beginning of August. Winter wheat was harvested on 4 August in 2010, and on 5 August in 2011.

Technological properties of wheat. The technological properties of wheat were determined at the Latvia University of Agriculture, in the Grain and Seed Research laboratory. Grain was milled to wholemeal flour using a Perten Laboratory Mill 3100 with 0.8 mm sieve. Grain protein content (PC) was calculated by multiplying total nitrogen content by a factor of 5.7. Total N was determined by Kjeldahl method (ICC 105/2; Kjeltec system 1002, Foss Tecator AB, Sweden). Sedimentation (SED) was measured according to Zeleny (ICC116/1, ICC 118) and falling number (FN) as alpha-amylase activity by Hagberg–Perten method (ICC 107/1, Falling Number 1500, Perten instruments, Sweden). Wet gluten content (WG) was washed from whole meal flour (14%) and the gluten index (GI) was measured according to Perten (ICC 155, Glutomatic 2100, Centrifuge 2015, Perten Instruments, Sweden).

Statistical analysis. Experimental data evaluation was conducted using two-factor analysis of variance (ANOVA). Mean, standard error of the mean, coefficients of variation and least significant difference ($LSD_{0.05}$) were determined. Correlation analysis between measured grain quality indices was also carried out.

RESULTS

Average grain yield in 2010 was higher for cultivar 'Bussard' (6.39 t ha^{-1}) than for 'Zentos' (6.42). The respective values in 2011 were 5.19 t ha^{-1} and 6.24 t ha^{-1}.

Grain qualities of the cultivars differed. 'Bussard' grain had higher protein content, wet gluten, sedimentation value and lower falling number, compared with 'Zentos' grain. High-quality wheat grain is required for the milling and baking industries. The coefficient of variation (CV%) of the grain quality indices was as follows: grain protein content (CV% up to 6.5), wet gluten and Zeleny sedimentation value (CV 6.4–8.2), falling number CV 7.4 for 'Zentos' and 10.6 for 'Bussard' (Table 1).

Table 1

WINTER WHEAT GRAIN QUALITY INDICES

Quality indices	PC g kg $^{-1}$	WG g kg^{-1}	GI	SED cm ^{3}	FN s
Cultivar 'Bussard'					
Mean ±standard error	152.9 ± 1.1	296.1 ± 4.0	81.7 ± 1.1	59.2 ± 0.8	357.1 ± 7.7
Range	145.0 – 160.0	262.0 – 335.0	71.0 – 92.0	51.5 – 64.5	282.0 – 443.0
Coefficient of variation (CV)%	3.6	6.6	6.8	6.4	10.6
Cultivar 'Zentos'					
Mean ±standard error	132.0 ± 1.7	250.6 ± 4.2	61.9 ± 1.1	45.0 ± 1.4	380.7 ± 5.8
Range Coefficient of variation (CV)%	117.5 – 143.5	220.0 – 288.5	51.0 – 72.0	35.0 – 59.0	336.5 – 431.5
	6.5	8.2	8.9	6.4	7.4

PC, protein content; WG, gluten content,; GI, gluten index; SED, sedimentation value; FN, falling number

We compared the quality of the studied grain to quality requirements set by the grain processing company "Dobeles dzirnavnieks" (Anonīms, 2011). In that company, thresholds for protein contents are: Elite and A quality class > 145 g kg^{-1} first class > 140 g kg^{-1}, second class > 130 and third class > 120 g kg^{-1}.

The average range of protein content in 'Bussard' grain was higher than 21.0 g kg $^{-1}$ compared with 'Zentos' (Table 2). Nitrogen fertilisation led to a significant increase of protein content for both cultivars. Protein content in 'Bussard' grain in both years exceeded 145 g kg^{-1}, thus corresponding to the Elite class, while 'Zentos' mostly corresponded only to the first and second class. The first class quality was reached only in plots in 2011 fertilised with N120 and N150. Protein content in 'Bussard' and 'Zentos' did not significantly differ (1.3 g kg^{-1}) depending on storage.

Sedimentation value is a protein quality attribute. A measure of the sediment that results when lactic acid is added to a sifted ground wheat sample can be used as an indicator of gluten quality, and thus, the baking quality of wheat flour. Nitrogen fertiliser had a significant effect on sedimentation value (Table 3). Wheat fertilised with higher nitrogen

Table 2

PROTEIN CONTENT (g kg $^{-1}$) IN WINTER WHEAT GRAIN DEPENDING ON NITROGEN FERTILISATION TREATMENT AND STORAGE PERIOD

Year	Storage (A)	Nitrogen fertiliser treatment(B)				
		N60	N90	N120	N150	Average
Cultivar 'Bussard'						
2010	Fully ripe	144.0	146.5	154.0	156.0	150.1
	After 60 d.	143.0	145.5	155.0	154.5	149.5
	After 120 d.	146.5	148.0	157.0	157.5	152.3
	Average	144.5	146.7	155.3	156.0	150.6
	LSD $_{0.05}$	A = 1.7	B = 2.0	AB = 3.5		
2011	Fully ripe	148.0	157.0	157.0	159.0	155.3
	After 60 d.	146.0	156.0	156.5	160.0	154.6
	After 120 d.	149.0	157.0	158.0	159.0	155.8 155.2
	Average	147.7	156.7	157.2	159.3	
	LSD 0.05	A = 2.0	B = 2.3	AB = 3.9		
Cultivar 'Zentos'						
2010	Fully ripe	120.0	127.0	137.5	141.5	131.5
	After 60 d.	119.5	124.5	134.0	140.0	129.5
	After 120 d.	117.5	127.5	135.0	143.0	130.8
	Average	119.0	126.3	135.5	141.5	130.6
	LSD $_{0.05}$	A = 1.6	B = 1.9	AB = 3.3		
2011	Fully ripe	123.5	128.5	139.5	143.5	133.8
	After 60 d.	122.5	127.5	138.0	143.0	132.8
	After 120 d.	124.0	129.0	139.5	141.5	133.5
	Average	123.3	128.3	139.0	142.7	133.3
	LSD $_{0.05}$	A = 1.7	B = 2.0	AB = 3.4		

Table 3

SEDIMENTATION VALUE (cm^3) OF WINTER WHEAT GRAIN DEPENDING ON NITROGEN FERTILISATION TREATMENT AND STORAGE PERIOD

Year	Storage (A)	Nitrogen fertiliser (B)				
		N60	N90	N120	N150	Average
Cultivar 'Bussard'						
2010	Fully ripe	57.0	60.5	64.0	64.5	61.5
	After 60 d.	55.6	58.5	62.6	63.1	60.0
	After 120 d.	54.5	56.8	60.5	61.3	58.3
	Average	55.7	58.6	62.4	63.0	59.9
	$LSD_{0.05}$	A = 0.5	B = 0.6	AB = 1.0		
2011	Fully ripe	61.7	63.7	63.5	63.9	63.2
	After 60 d.	58.7	59.7	58.5	57.9	58.7
	After 120 d.	54.7	54.7	53.5	51.9	53.7
	Average	58.4	59.4	58.5	57.9	58.5
	$LSD_{0.05}$	A = 1.3	B = 1.5	AB = 2.6		
Cultivar 'Zentos'						
2010	Fully ripe	37.5	41.5	49.0	51.6	44.9
	After 60 d.	34.5	37.8	47.6	50.4	44.9
	After 120 d.	35.5	36.2	46.8	49.1	44.9
	Average	35.8	38.5	47.8	50.3	44.9
	$LSD_{0.05}$	A = 0.6	B = 0.6	AB = 1.1		
2011	Fully ripe	43.1	45.9	54.6	59.4	50.7
	After 60 d.	41.1	43.9	51.6	55.4	48.0
	After 120 d.	38.1	40.9	47.6	51.4	44.5
	Average	40.8	43.5	51.3	55.4	47.7
	$LSD_{0.05}$	A = 0.4	B = 0.4	AB = 0.7		

amounts had a higher sedimentation value. The average range of sedimentation value in 'Bussard' grain was higher than 14.2 cm^3 compared with 'Zentos'. Cultivar 'Bussard' grain had sedimentation values exceeding 60 cm^3, corresponding to the first class while value of 'Zentos' grain corresponded to the second class. The sedimentation value of grain significantly declined during storage. In 2010, during 120-day storage, the sedimentation value of wheat grain declined by 2.5–5.3 and in 2011 by 5.1–12.0 cm^3.

According to requirements of the grain processing company "Dobeles dzirnavnieks", wet gluten can be classified into six classes. The Elite class, A class and first class are referred to as very good with wet gluten above 280 g kg^{-1}, the second class is referred to as good with wet gluten above 260 g kg^{-1}, the third is considered wet gluten above 240 g kg^{-1} and the fourth class is referred to as low with wet gluten below 200 g kg^{-1}.

Nitrogen fertilisation significantly increased wet gluten content in both cultivars (Table 4). In both experimental years wet gluten content in 'Bussard' grain corresponded to Elite class (> 280 g kg^{-1}) and 'Zentos' grain corresponded to the third quality group (> 240 g kg^{-1}) in plots with N90, N120, N150 applied. The differences in gluten content among different samples can be explained by genetic variation in the wheat cultivars (Panozzo, 2000; Ruza *et al*., 2002).

During storage wet gluten content in grain declined. Change of wet gluten content after 60 days was most significant for both 'Bussard' 2–11 g kg^{-1} and for 'Zentos' 2–9 g kg^{-1}. After 120 days wet gluten content decreased by 7–25 and 8–17 g kg^{-1}, respectively. During the initial 60 days of storage, gluten became stronger (Table 5). In 2010, the difference in gluten index between freshly harvested grain and the grain stored for 60 or 120 days for 'Bussard' was from 2.0 to 8.5, and in 2011 from 2.0 to 9.5 units. For 'Zentos', from the respective values were 2.5 to 8.5 and 2.0 to 8.0.

Gluten quality was determined by centrifugation method. A higher gluten index indicates stronger gluten. The first quality group (60–90) of gluten is very good, the second group (40–60) is satisfactory, the third (> 90) is unsatisfactory strong, and the fourth (< 40) is unsatisfactory weak. Only grain containing gluten of the first or second gluten quality group is suitable for bread production (Ruza, 1998).

In both experimental years the wet gluten index for 'Bussard' grain corresponded to the first quality group (71–90 units) and 'Zentos' grain to the first and second group (52–68 units). Nitrogen fertilisation did not significantly affect gluten index.

The winter wheat was harvested in optimal time and the maturation phase (91 stages) was reached, indicating that the weather conditions were favourable. The Hagberg falling number for both studied varieties was high: average for cultivar 'Bussard' was 357 s, and for 'Zentos' — 438 s (Table 6), thus reaching standards of the Elite, A and first class) of food grain quality exceeding 270 s. The activity of al-

Table 4

WET GLUTEN CONTENT (g kg^{-1}) IN WINTER WHEAT GRAIN DEPENDING ON NITROGEN FERTILISATION TREATMENT AND STORAGE PERIOD

Year	Storage (A)	Nitrogen fertiliser (B)				
		N60	N90	N120	N150	Average
Cultivar 'Bussard'						
2010	Fully ripe	270.0	303.0	321.0	335.0	307.3
	After 60 d.	267.5	298.5	314.5	324.0	307.3
	After 120 d.	262.5	290.5	301.5	312.5	307.3
	Average	266.7	297.3	312.3	323.8	307.3
	$LSD_{0.05}$	A = 2.9	B = 3.4	AB = 5.8		
2011	Fully ripe	286.5	305.5	304.0	308.5	301.1
	After 60 d.	284.0	302.0	300.0	305.5	297.9
	After 120 d.	262.0	280.5	280.0	288.5	277.8
	Average	277.5	296.0	294.7	300.8	292.3
	$LSD_{0.05}$	A = 2.5	B = 2.9	AB = 5.0		
Cultivar 'Zentos'						
2010	Fully ripe	233.5	250.5	280.0	288.5	263.1
	After 60 d.	230.0	245.5	274.5	279.5	257.4
	After 120 d.	226.0	241.5	268.0	271.5	251.8
	Average	229.8	245.8	274.2	279.8	257.4
	$LSD_{0.05}$	A = 5.2	B = 6.1	AB = 6.5		
2011	Fully ripe	229.5	238.0	259.0	272.0	249.6
	After 60 d.	228.5	232.0	252.0	267.5	245.0
	After 120 d.	220.0	227.0	243.0	257.5	236.9
	Average	226.0	232.3	251.3	265.7	243.8
	$LSD_{0.05}$	A = 3.0	B = 3.5	AB = 6.1		

Table 5

GLUTEN INDEX OF WINTER WHEAT GRAIN DEPENDING ON NITROGEN FERTILISATION TREATMENT AND STORAGE PERIOD

Year	Storage (A)	Nitrogen fertiliser (B)				
		N60	N90	N120	N150	Average
Cultivar 'Bussard'						
2010	Fully ripe	83.5	82.0	83.0	82.0	82.6
	After 60 d.	85.5	85.0	85.5	84.0	85.0
	After 120 d.	92.0	88.0	88.5	90.0	89.6
	Average	87.0	85.0	85.7	85.3	85.8
	$LSD_{0.05}$	A = 4.4	B = 3.5	AB = 4.7		
2011	Fully ripe	75.5	71.0	74.0	76.0	74.1
	After 60 d.	78.0	74.0	76.0	80.5	77.1
	After 120 d.	83.0	77.0	82.0	85.5	81.9
	Average	78.8	74.0	77.3	80.7	77.7
	$LSD_{0.05}$	A = 2.1	B = 2.4	AB = 4.2		
Cultivar 'Zentos'						
2010	Fully ripe	52.0	54.0	58.0	55.0	54.8
	After 60 d.	55.0	57.0	62.0	57.5	57.9
	After 120 d.	57.5	61.0	66.5	61.0	61.5
	Average	54.8	57.3	62.2	57.8	58.0
	$LSD_{0.05}$	A = 4.9	B = 3.7	AB = 4.9		
2011	Fully ripe	60.0	65.5	61.5	63.0	62.5
	After 60 d.	62.5	67.5	64.0	68.5	65.6
	After 120 d.	66.0	72.0	68.5	71.0	69.4
	Average	62.8	68.3	64.7	67.5	65.8
	$LSD_{0.05}$	A = 2.2	B = 2.5	AB = 2.4		

Table 6

FALLING NUMBER (s) OF WINTER WHEAT GRAIN DEPENDING ON NITROGEN FERTILISATION TREATMENT AND STORAGE PERIOD

Year	Storage (A)	Nitrogen fertiliser (B)				
		N60	N90	N120	N150	Average
Cultivar 'Bussard'						
2010	Fully ripe	383.0	349.5	331.0	358.5	355.5
	After 60 d.	395.0	365.0	350.0	376.5	371.6
	After 120 d.	443.0	408.5	385.5	406.0	410.8
	Average	407.0	374.3	355.5	380.3	379.3
	$LSD_{0.05}$	A = 8.6	B = 9.9	AB = 17.1		
2011	Fully ripe	282.0	305.0	315.0	323.5	306.4
	After 60 d.	299.5	330.0	345.0	365.5	335.0
	After 120 d.	344.5	359.5	372.0	378.0	363.5
	Average	308.7	331.5	344.0	355.7	335.0
	$LSD_{0.05}$	A = 11.8	B = 13.6	AB = 18.6		
Cultivar 'Zentos'						
2010	Fully ripe	379.5	380.5	373.0	377.0	377.5
	After 60 d.	404.5	402.5	405.0	405.0	404.3
	After 120 d.	431.5	428.5	411.5	418.5	422.5
	Average	405.2	403.8	396.5	400.2	401.4
	$LSD_{0.05}$	A = 12.0	B = 13.8	AB = 17.0		
2011	Fully ripe	337.5	336.5	340.0	348.5	340.6
	After 60 d.	350.5	353.5	364.0	367.5	358.9
	After 120 d.	367.5	380.0	385.0	390.0	380.6
	Average	351.8	356.7	363.0	368.7	360.0
	$LSD_{0.05}$	A=9.5	B = 11.0	AB = 19.1		

pha-amylase declined during grain storage. The falling number after 60 days stored wheat grain was by 12–42 s higher compared with freshly harvested grain and by 30–62 s higher in grain stored for 120 days.

DISCUSSION

Our experiment confirmed the investigations of Hruskova *et al*. (2004) and Mašauskiene and Cesevičiene (2005) who observed only slight changes in protein content during grain storage.

Increase of gluten index during storage of 'Zentos' freshly harvested grain in 2010 raised quality from the second class to the first quality group, as it became stronger and the index was above 60 units. Hruskova *et al*. (2004) also reported a significant increase of grain gluten index after two months of storage.

Falling number indirectly indicates alpha-amylase activity, which results from sprout damage. A high falling number value indicates low alpha-amylase activity. Alpha-amylase activity depends on weather conditions and, particularly, precipitation and mineral fertilisation (McDonald an Vaidyanathan, 1987; Janusauskaite, 1999; Triboi-Blondel, 2001; Cesevičiene and Mašauskiene, 2007). Kettlewell (1999) observed that less active alpha-amylase, which causes pre-harvest grain sprouting, dominates among the alpha-amylases in the grain of wheat fertilised with low nitrogen rates. In our experiment, the grain falling number for cultivar 'Zentos' was higher (non-significantly) in plots fertilized with nitrogen at the highest rate, but only in 2010. Thus, we found that nitrogen fertiliser did not affect the falling number, in contrast to other studies (Janusauskaite 1999, Cesevičiene and Mašauskiene 2005, Stankovski et al., 2004) in which the falling number was dependent on the dose of nitrogen fertiliser.

Falling number increased during grain storage, as previously observed (Mašauskiene and Cesevičiene 2005) trials. The reason for the increase in the falling number during grain storage could be a reduction in pericarp alpha–amylase activity (Lunn *et al*., 2001). The falling number values during storage were not related to the nitrogen fertiliser use.

The significant high positive correlation for cultivar 'Zentos' between protein content and wet gluten ($r = 0.82$; $n = 24$, $\alpha_{0.05} = 0.404$, $\alpha_{0.01} = 0.515$) is in agreement with the findings of other researchers (Grausgruber *et al*., 2000; Mladenov *et al*., 2001). The high positive correlation between protein content and sedimentation value for 'Zentos' ($r = 0.91$) is in close agreement with that reported previously (Mladenov *et al*., 2001, Gaile and Kopmanis 2002). Significant high positive correlation was observed between wet gluten and sedimentation value for both 'Bussard' ($r = 0.80$) and Zentos' ($r = 0.74$). The observed correlations between traits depend on both genetic and environmental factors.

The effect of nitrogen fertilisation rate and its distribution on grain qualities depends on weather conditions during the grain ripening period. Cultivar 'Bussard' grain had higher quality indices in both years of trials, suggesting that the variety can more effectively utilize nitrogen fertiliser. A cultivar depends not only on its genetic potential for particular characters but also on its ability to realize this potential in actual production and under different environmental conditions (Dotlacil and Toman 1991; Mladenov *et al.*, 2001; Teesalu and Leedu, 2001). Wheat varieties differ significantly in their grain quality. Nonetheless, environmental factors play a major role in the expression of genotype characteristics (Lucov and McVetty 1991).

In conclusion, nitrogen fertilisation had significant effect on grain protein and gluten content, gluten index, and sedimentation, but not on falling number. During both trial years, the quality of the studied winter wheat grain met demands set for food grain. Differences in grain qualities were observed after storage for 60 and 120 days. Protein content in 'Bussard' and 'Zentos' was not affected by storage. During the storage period, Zeleny sedimentation values significantly decreased by up to 5.7 cm^3. Significant reductions in wet gluten content by 15.8 g kg^{-1} and increase in gluten index by 7 units also occurred. The falling number increased by up to 49.0 s during 120 days of storage.

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ZIEMAS KVIEŠU GRAUDU KVALITĀTES RĀDĪTĀJU IZMAIŅAS ATKARĪBĀ NO SLĀPEKĻA MĒSLOJUMA UN GRAUDU UZGLABĀŠANAS ILGUMA

Lauka izmēģinājumi ar divām ziemas kviešu šķirnēm 'Bussard' un 'Zentos' četros slāpekļa mēslojuma variantos — N60, N90, N120 un N150 ierīkoti Latvijas Lauksaimniecības universitātes mācību pētījumu saimniecībā „Pēterlauki" 2010. un 2011. gadā. Darba mērķis — analizēt graudu kvalitātes rādītāju izmaiņas atkarībā no slāpekļa mēslojuma tikko novāktiem graudiem, kā arī tos glabājot 60 un 120 dienas. Noskaidrots, ka graudu kvalitātes rādītājus — proteīna saturu, mitro lipekli un sedimentācijas vērtību — būtiski ietekmē šķirne un slāpekļa mēslojums. Graudus uzglabājot 60–120 dienas, proteīna saturs graudos būtiski nemainījās, bet palielinājās krišanas skaitlis, sedimentācijas vērtība un mitrā lipekļa saturs samazinājās, tomēr lipekļa indekss (lipekļa kvalitāte) uzlabojās. Šķirnei 'Zentos' starp graudu mitro lipekli un proteīnu, kā arī starp sedimentācijas vērtību un proteīna saturu konstatēta cieša pozitīva korelācija. Abām izmēģinājumā iekļautajām šķirnēm pastāv pozitīva korelācija starp sedimentācijas vērtību un mitrā lipekļa saturu.