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Changes of quality properties of spring wheat grain resulting from some agrotechnical factors

H. Borkowska[1] *and S. Grundas*[2]*

[1]Department of Cultivation and Plant Production, University of Agriculture, Akademicka 15, 20-950 Lublin, Poland
[2]Institute of Agrophysics, Polish Academy of Sciences, Doświadczalna 4, P.O. Box 201, 20-290 Lublin 27, Poland

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A b s t r a c t. Technological value of grain of two cultivars of spring wheat (cv. Broma and cv. Torka), cultured in years 2002-2004 with two levels of N-fertilization applied, was tested. Yield, thousand kernel weight, bulk density, protein content, wet gluten content, gluten index and falling number were estimated. Influence of weather conditions in each of vegetation period on quality of grain was analysed.

Results showed higher yield of grain of Broma cultivar. Significant differences between years of experiment were observed. Higher level of N-fertilization caused increase of protein content in grain of both cultivars; higher protein content and gluten index for Torka was observed. Weather conditions in 2003 caused decrease of grain quality.

K e y w o r d s: spring wheat, cultivars, N-fertilization, protein, gluten, falling number

INTRODUCTION

The technological quality of grain of spring wheat causes a growth of interest of farmers in the cultivation of this form of wheat. Grain of spring wheat has higher protein content and is a very valuable supplement of feed. Grain quality of the various cultivars depends on genetics, although agrotechnics may modify its properties (Brzozowska *et al*., 1997; Brzozowski *et al*., 2001; Fotyma, 2003; Frant and Bujak, 2004; Jędruszczak and Antoszek, 2004; Lemańczyk *et al*., 2001; Liszewski, 1997).

The principal factor which influences yield and quality of crop is N-fertilization (Borkowska *et al*., 2000; Parades-Lopes *et al*., 1985; Peltonen and Virtanen, 1994; Rachoń, 2001). According to other authors, differentiation of levels of N-fertilization did not cause any change of yield, however it did cause some changes in the quality of grain (Achremowicz *et al*., 1995; Borkowska *et al*., 1999; 2000; Chwil, 2004). Most often it changed the thousand kernel weight, protein content and gluten. To a certain extent the gluten index changed as well. Frequently the expected effects of N-fertilization may be reduced by environmental factors, for example unfavourable weather conditions (Ciaffi *et al*., 1996; Fotyma, 2003; Gaines *et al*., 1996). Cultivars were also susceptible, to a varying extent, to the effect of external factors (Borkowska *et al*., 2003; Rachoń, 2001).

This article deals with results of examination of quality changes of spring wheat (two cultivars: Broma and Torka) grain, resulting from the application of two levels and two times of N-fertilization.

MATERIALS AND METHODS

A random blocks experiment was conducted in 2002-2004 at the Experimental Station in Felin, belonging to the University of Agriculture in Lublin. Each combination were replicated 4 times. The area of the plots was 13.8 m^{-2}. The factors of the experiment were two cultivars of spring wheat (cv. Broma and cv. Torka), two levels of N-fertilization (50 and 150 kg ha^{-1}) and two times of fertilizer application (the spread and the stalking). P_2O_5 (80 kg ha^{-1}), K_2O (100 kg ha^{-1}) and a half-dose of N-fertilization were applied before sowing of wheat. Grain of wheat (6 10^6 seeds ha^{-1}) was sown in April (4th in 2002, 17th in 2003 and 16th in 2004), and crop was collected on 31st of July of 2002, 7th and 17th of August, in 2003 and 2004, respectively. The yield, thousand kernels weight (TKW) and bulk density (weight of 1 hl) were estimated.

*Corresponding author's e-mail: grundas@ipan.lublin.pl

Measurements of quality properties of grain were conducted at the laboratory of the Institute of Agrophysics, PAS, in Lublin. Protein content, wet gluten content, gluten index and falling number were estimated. Protein content was determined using the TREBOR-90XL tester. Wet gluten content and gluten index were determined by means of Glutomatic 2200 (Perten Instruments), according to ICC Standard Method No. 155, and falling number (FN) measurement was carried out with the help of the Falling Number apparatus (Perten Instruments), according to standard of ICC No. 107/1. The results obtained were then statistically processed using variance analysis in accordance with Tukey's test. Significant differences at $P<0.05$ between values of measured parameters are marked by letters.

Mean temperatures of air and sum of precipitation in the period of the experiment were diverse (Table 1). In 2002 the mean temperature was higher and precipitation was lower than typical. For example, temperature in May was higher by 4.3°C while the sum of precipitation was equal to 49% of the mean of last 50 years. In 2003, the temperature was not that high, however in each month the temperature was higher, except in April, and the sum of precipitation did not reach 90% of long-term mean value. In 2004, the mean temperature in the period of vegetation of wheat was equal to the long-term mean temperature and a precipitation shortage occurred. In May and June (period of intensive growth and development of wheat), precipitation reached, respectively, 65.2 and 75.8% of the long-term mean for the years 1951-2000.

RESULTS AND DISCUSSION

The results of yield measurements (Table 2) did not show any influence of the time and level of N-fertilization on measured feature. Results of research by other authors suggested different effects of high-dose N-fertilization, from increase (Fotyma, 2003; Liszewski, 1997), through lack of influence (Borkowska *et al*., 2002), to decrease of yield (Chwil, 2004; Rachoń, 2001). Between the two cultivars, according to the results of other experiments (Borkowska *et al*., 2002), Broma produced a significantly higher yield in comparison to Torka. Significant differences in yield of grain occurred between the years of the experiment. The least favourable meteorological conditions for yield occurred in 2004, when the sum of precipitation in the period of vegetation of spring wheat amounted to 85% of the long-term mean.

The factors applied in this experiment did not influence the values of physical properties of grain. Changes in the values of measured properties were significant only as a result of meteorological conditions. Similar changes were observed in research by Rachoń (2001), Jędruszczak and Antoszek (2004), Borkowska *et al.* (2002; 2003). During 2002 and 2003, when mean air temperatures were significantly higher than the long-term mean, TKW of wheat was lower than in 2004. In the last year of the experiment, temperatures were similar to the long-term mean, with a lower level of precipitation at the same time. The highest bulk density was that of grain from 2003, when the mean temperature was higher by about 1.4°C and mean precipitation was lower by about 11.4 % than the long-term means, when the value of the Sielianinov coefficient was the lowest (Achremowicz *et al*., 1995; Liszewski, 1997).

Increase of N-fertilization dose from 50 to 150 kg ha^{-1}, as in studies by other authors (Borkowska *et al*., 2002; Liszewski, 1997; Rachoń, 2001), caused an improvement of grain quality, expressed as protein content, wet gluten content and gluten index; the falling number value did not change (Table 3). The earlier application of fertilizers (in the spread period) caused a negative influence on most of the measured features. No significant differences were observed between the gluten index values of the two cultivars, however a clearly noticeable tendency of this factor to increase as a result of subsequent N-fertilization was observed. Significant differences were recorded in the values of the described quality features between the two examined cultivars. Attention should be paid to lower content of gluten in Broma than in grain of the elitist cultivar Torka (with higher protein content than in Broma), however the quality of gluten of Torka was significantly higher (gluten index values of 27.57 and 97.83 for Broma and Torka, respectively). Elitist cultivars are generally more resistant to sprouting, which may lead to decrease of the falling number values. The results showed that the mean falling number was high (454s), nevertheless the values of the measured feature were significantly lower for Torka compared to the grain of Broma.

Meteorological conditions during the years of the experiments caused significant changes of grain quality, which was in agreement with results obtained by other authors (Borkowska *et al*., 2000; 2003; Rachoń, 2001). In 2004 the grain had the highest value of protein content, as a result of mean temperature and sum of precipitation values close to the long-term means in the period of intensive collection of endosperm materials (in July). Wet gluten content and gluten index reached the highest values in 2002, when mean the temperature and sum of precipitation were the highest among the years of research. Weather conditions in 2003, with the lowest coefficient of Sielianinov index, caused a decrease of quality of spring wheat grain.

CONCLUSIONS

1. The highest influence on the yield of spring wheat during the years of the experiment was that of the examined cultivars (higher for Broma than for Torka) and meteorological factors.

T a b l e 1. Means daily temperatures of air and sum of precipitation in vegetation period of spring wheat in 2002-2004 and 1951-2000 according to Agrometeorological Observatory in Felin

Years	Vegetation periods					Means or sum
	April	May	June	July	August	
			Means of temperatures			
2002	8.6	17.3	17.8	21.6	20.5	17.2
2003	6.5	16.3	17.4	19.8	18.9	15.8
2004	7.9	11.9	15.8	18.1	18.3	14.4
1951-2000	7.5	13.0	16.5	17.9	17.3	14.4
			Sum of precipitation			
2002	18.3	28.6	116.8	126.2	18.7	308.6
2003	40.7	71.4	39.6	98.1	27.0	276.8
2004	38.1	38.0	49.9	90.5	48.5	265.0
1951-2000	40.6	58.3	65.8	78.0	69.7	312.4
			Selianinov's coefficient			
2002	0.71	0.53	2.19	1.88	0.29	1.17
2003	2.08	1.41	0.75	1.59	0.46	1.14
2004	1.61	1.03	1.05	1.61	0.85	1.20
1951-2000	1.80	1.44	1.32	1.40	1.29	1.41

T a b l e 2. Yield, TKW and bulk density in dependence of levels and terms of N-fertilization, cultivars and years

Experimantal factors	Yield (t ha^{-1})	TKW (g)	Bulk density (kg hl^{-1})
	Levels of N-fertilization (kg ha^{-1})		
50	6.46a	37.73a	78.92a
150	6.64a	37.11a	78.23a
	Terms of N-fertilization		
Spread	6.56a	37.34a	78.42a
Stalking	6.54a	37.50a	78.73a
	Cultivars		
Broma	6.86a	37.52a	77.54a
Torka	6.25b	37.32a	79.60a
	Years		
2002	6.64a	35.22a	76.88a
2003	6.76a	35.81a	80.67b
2004	6.23b	41.23b	78.16c
Mean values	6.55	37.42	78.57

a, b, c – values followed by the same letters in the same column are not significantly different at $P<0.05$.

T a b l e 3. Protein content, wet gluten content, gluten index and FN in dependence on levels and times of N-fertilization, cultivars and years

Experimantal factors	Total protein content	Wet gluten content	Gluten index	FN (s)
	(%)			
	Levels of N-fertilization (kg ha^{-1})			
50	14.84 a	24.73 a	60.83 a	450 a
150	15.57 b	28.32 b	64.12 b	457 a
	Terms of N-fertilization			
Spread	15.05 a	25.75 a	61.89 a	444 a
Stalking	15.37 b	27.30 b	63.06 a	463 b
	Cultivars			
Broma	15.16 a	28.30 a	27.57 a	459 b
Torka	15.26 b	24.76 b	97.38 b	448 a
	Years			
2002	15.41 b	29.80 c	67.47 c	431 a
2003	14.61 a	23.84 a	58.63 a	486 c
2004	15.60 c	25.94 b	61.34 b	443 b
Mean values	15.21	26.53	62.48	454

a, b, c – values followed by the same letters in the same column are not significantly different at $P<0.05$.

2. The applied times and levels of N-fertilization did not cause any changes in the level of yield. TKW and bulk density were different only between the years, while the factors of the experiment did not influence the measured features.

3. The protein content in the grain was favourably affected by the higher doses of N-fertilization, top-dressing in the stalking phase, by cultivar traits (higher protein content in grain of Torka), and by the weather conditions during 2004.

4. Higher doses of N-fertilization caused an increase of wet gluten content and gluten index value. Despite the lower wet gluten content in the grain of Torka, its gluten index was significantly higher. Weather conditions in 2003 had a negative influence on the quality of grain of spring wheat.

REFERENCES

Achremowicz B., Borkowska H., Styk B., and Grundas S., 1995. Influence of nitrogen fertilization on gluten quality of spring wheat (in Polish). Biul. IHAR, 193, 29-34.

Borkowska H., Grundas S., and Styk B., 1999. Influence of nitrogen fertilization of winter wheat on its gluten quality. Int. Agrophysics, 13, 333-335.

Borkowska H., Grundas S., and Styk B., 2000. Differentiation of physical and technological properties of winter wheat grain depending on level of N-fertilization (in Polish). Acta Agrofizyka, 37, 7-16.

Borkowska H., Grundas S., and Styk B., 2002. Yield quantity and quality of some varieties of spring wheat in dependence of nitrogen fertilization (in Polish). Annales UMCS, Sec. E, 57, 99-103.

Borkowska H., Grundas S., and Styk B., 2003. Changes of some kernel quality properties of certain spring wheat varieties as influenced by various N-fertilization levels (in Polish). Acta Agrophysica, 98, 717-723.

Brzozowska I., Brzozowski J., and Jastrzębska M., 1997. Influence of protect and fertilize operations on yield and on content and quality protein in winter wheat grains (in Polish). Fragmenta Agronomica, 2, 32-39.

Brzozowski J., Brzozowska I., and Balkiewicz K., 2001. Influence of different protect and fertilize operations on healthy and yield of winter wheat (in Polish). Fragmenta Agronomica, 1, 11-22.

Chwil S., 2004. Estimation of results of winter wheat nitrogen fertilization (in Polish). Fragmenta Agronomica, 1, 19-28.

Ciaffi M., Tozzi L., Borghi B., Corbelini M., and Lafiandra D., 1996. Effect of heat shock during grain filling on the gluten protein composition of bread wheat. J. Cereal Sci., 24, 91-100.

Fotyma E., 2003. Compare of productivity of winter and spring wheats in different agroecological conditions (in Polish). Fragmenta Agronomica, 3, 98-114.

Frant M. and Bujak K., 2004. Influence of simplifications in soil culture and level of mineral fertilization on weeding of winter wheat (in Polish). Fragmenta Agronomica, 3, 31-39.

Gaines S.C., Finney P.L., and Rubenthaler G., 1996. Milling and baking quality of some wheats developed for Eastern and Northwestern regions of United States and grown at both locations. Cereal Chem., 73, 521-525.

Jędruszczak M. and Antoszek R.A., 2004. Yielding of winter wheat cultivated in short time monoculture in dependence on manner of soil culture and level of plant weeding (in Polish). Fragmenta Agronomica, 3, 60-69.

Lemańczyk G., Wenda-Piesik A., and Wasilewski P., 2001. Influence of oats culture in clear and mixed sowing on its healthy and last yield values for winter wheat (in Polish). Fragmenta Agronomica, 4, 65-77.

Liszewski M., 1997. Succession influence of two morphological forms of fababean on yielding of spring wheat (in Polish). Fragmenta Agronomica, 3, 56-62.

Parades-Lopes O., Covarrubias-Alvarez M.M., and Barquin-Carmona J., 1985. Influence of nitrogen fertilization on the physicochemical and functional properties of bread wheats. Cereal Chem., 62, 427-430.

Peltonen J. and Virtanen A., 1994. Effect of nitrogen fertilizers differing in release characteristics on the quantity of storage proteins in wheat. Cereal Chem., 71, 11-17.

Rachoń L., 2001. Study on yielding and quality of durum wheat (*Triticum durum* Desf.) (in Polish). Rozprawy Naukowe, University of Agriculture Press, Lublin, 248, 1-71.