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TECHNOLOGICAL VALUE OF SPRING WHEAT GRAIN IN DEPEDENCE ON NITROGEN FERTILIZATION

WARTOŚĆ TECHNOLOGICZNA ZIARNA PSZENICY JAREJ W ZALEŻNOŚCI OD NAWOŻENIA AZOTEM

Abstract: Field experiment was carried out in 2002–2004 at the Experimental Station in Zawady, belonging to the University of Podlasie. Two factorial experiments were intended in method of random blocks in three variants. The size of field to collect was 18 m^2. Two factors were taken into consideration: I factor – fertilization rate of nitrogen: a) 0 – control object, without nitrogen fertilization, b) 40 kg N · ha^{-1} (20 kg N · ha^{-1} before sowing, 20 kg N · ha^{-1} in the phase of shooting), c) 80 kg N · ha^{-1} (40 kg N · ha^{-1} before sowing, 40 kg N · ha^{-1} in the phase of shooting), d) 120 kg N · ha^{-1} (60 kg N · ha^{-1} before sowing, 60 kg N · ha^{-1} in the phase of shooting), e) 160 kg N · ha^{-1} (80 kg N · ha^{-1} before sowing , 80 kg N · ha^{-1} in the phase of shooting), II factor – spring wheat cultivars: Henika, Banti, Jasna. The harvest of spring wheat was made in the stage of full maturity of grain. The results pointed that the rates of technological value of spring wheat grain changed in dependence on nitrogen fertilization doses. The increase of dose to 160 kg N · ha^{-1} caused important increase in gluten number and falling number but it caused the drop of gluten density. Gluten deliquescence was the highest after using the dose of 120 kg N · ha^{-1}. Cultivars which were taken into consideration in this experiment had significant influence on increase of contents which determined technological value of spring wheat grain.

Keywords: spring wheat, nitrogen fertilization, cultivars, quality of grain

The main directions of spring wheat use are its consumable purposes, for example the processing of spring wheat into flour, which is later used for production of bread, pasta, culinary and cake products. The grain which is used to those purposes must characterize with high technological value. The main factor which decides about baking value are genetic properties of cultivars [1]. All the same natural environment diversifies technological value of consumer cereals. It could be also modified by conditions of cultivation, for example nitrogen fertilization. It plays a fundamental role in shaping the quality of obtained yield of spring wheat grain [2]. It is important not only to quantify of total nitrogen, but also the manner and date of its application [3]. Current researches show that increase of nitrogen dose has favourable influence on

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physical properties and chemical composition of grain, so it influences on its quality [4,5]. Determination of optimal level of nitrogen fertilization for new cultivars of spring wheat has big meaning from the point of view of important influence of this nutrient, not only on yield height but also on its quality [6]. In assessing the quality of spring wheat grain a lot of attention is paid to the enzymatic properties, especially on the amylolytic activity, on which opinion is divided. Some authors have shown that with increasing of nitrogen fertilization occurs the decrease in activity of alpha-amylase, while others are of the opinion that high doses of nitrogen can cause an increase in amylolytic activity [7, 8]. A negative consequence of the marginal increase in nitrogen fertilization in the spring wheat crop is lower gluten content. By contrast, application of nitrogen transfer to a later date increases the protein content in grain, and thereby worsening its nutritional value [9, 10].

The purpose of this study was to determine the effects of various doses of nitrogen applied before sowing in the shooting phase and the beginning of heading on the amount and quality of the grain yield of three varieties of spring wheat.

Materials and methods

This paper presents researches from years 2002–2004 which were carried out at the Experimental Station in Zawady, belonging to the University of Podlasie. The experiment was a three-replicate split blocks design and the size of field to collect was 18m^2. Two factors were taken into consideration: I factor – fertilization rate of nitrogen: a) 0 – control object, without nitrogen fertilization, b) 40 kg N · ha^{-1} (20 kg N · ha^{-1} before sowing, 20 kg N · ha^{-1} in the phase of shooting), c) 80 kg N · ha^{-1} (40 kg N · ha^{-1} before sowing, 40 kg N · ha^{-1} in the phase of shooting), d) 120 kg N · ha^{-1} (60 kg N · ha^{-1} before sowing, 60 kg N · ha^{-1} in the phase of shooting), e) 160 kg N · ha^{-1} (80 kg N · ha^{-1} before sowing , 80 kg N · ha^{-1} in the phase of shooting), II factor – spring wheat cultivars: Henika, Banti, Jasna. Selecting fields in different years of experience has been made taking into account the possible slight differences in terms of soil physico-chemical properties. A field experiment was conducted to the soil which was classified to chapter – autogenic soil, row – brown earth soil, type – sandy soil. Terrain was flat, there was no water erosion. Topsoil granulometric composition was as follows [%]: sand (1.0–0.1) – 53, dust (0.1–0.02) – 27, fine particles (< 0.02) – 20. Selected topsoil properties were considered: organic matter content – 1.57 %, the content of available forms of mg on 100 g of soil: P_2O_5 – 4.6; K_2O – 13.3; Mg – 3.5; pH in 1 M KCl – 6.5. Sorption capacity of soil was T – 89 mmol(+) · kg^{-1}, amount of alkaline cations S – 69 mmol(+) · kg^{-1} analytical acidity Hh – 20 mmol(+) · kg^{-1}, and the degree of saturation of the soil was V – 77.5 %. In terms of the suitability of the farming land is classified to a very good cereal complex soil, belonging to the quality class IVa with a slightly neutral pH, high abundance of zinc, average abundance of potassium, magnesium, copper, iron, low abundance of boron, very low in phosphorus and decay. Spring wheat was cultivated on the position after potatoes, after its collection winter ploughing was made, prefaced with harrowing. Early spring, in the term of fortnight before sowing of spring wheat P, K fertilizers were spread, which amount was: P – 100 kg · ha^{-1} in the form of triple superphosphate 46 % and K – 120 kg · ha^{-1} in the form of potassium salt 60 %. Potassium fertilization was applied in the form of: before sowing – nitro-chalk 26 %, in the phase of shooting – ammonium sulphate 34 %. Sowing of spring wheat was made in the first decade of April in the quantity of 250 kg · ha^{-1}, with rows spaced 12 cm and depth of cover seeds 3 cm. Before sowing the seed grain was resined by mortar Raxil Gel 206 (500 cm^3/100 kg of grain). In chemical protection Aminopielik D 450 SL (3 $dm^3 \cdot ha^{-1}$) herbicide was used in fully promoting and insecticide Decis 2.5 EC (0.25 $dm^3 \cdot ha^{-1}$) in the initial period of leaf beetles larvae. In years 2002 and 2003 wheat harvest was made in the first decade of August, and in 2004 a collection was held in the third decade of July. Immediately after harvesting the average grain samples were collected in order to comply with the determinations in the laboratory. Technological value of spring wheat seeds was identified by determining gluten deliquescence, falling number, the gluten number and density of grains. For the determination of gluten deliquescence 5 g of wet gluten was weighed and formed into a ball, which was placed in a Petri dish and placed for 60 minutes in a drier at 300 °C.

The size of ball was measured on the graph paper. The difference in the size of gluten balls before putting to the dryer and after removing it meant gluten deliquescence [11]. The falling number was determined by Hagberg method, which involves the use of alpha-amylase, as more resistant to the effects of increased temperature. The fall time of mixer in seconds, expresses directly the falling number [12]. The gluten number was determined by the formula: $LG = X \cdot (2 - R \cdot 0.065)$, where X is the amount of wet gluten in %, R – deliquescence of wet gluten in mm, and 0.065 is the constant conversion coefficient. The density of grain in volume weight was determined in accordance with the standard [13]. Received results of researches were drawn up statistically by carrying out for all of researched features the analysis of variations for two-factorial experiments in split blocks design. For comparison of average the Least Significant Difference (LSD) were calculated by using the Tukey test by the level of significance $\alpha = 0.05$ [14]. The years of conducting researches characterize with considerable diversity of weather conditions (Table 1).

Table 1

Mean air temperature and rainfalls according to the Zawady Meteorological Station

Year	Month						Average
	III	IV	V	VI	VII	VIII	
Temperature [°C]							
2002	3.9	9.0	17.0	17.2	21.0	20.2	14.7
2003	1.3	7.0	15.5	18.3	20.0	18.4	13.4
2004	8.0	11.7	15.4	17.5	18.9	13.0	14.0
Average 1951–1990	7.2	13.2	16.2	17.6	16.9	12.7	14.0
Rainfalls [mm]							
2002	15.8	12.9	51.3	61.1	99.6	66.5	307.2
2003	7.0	13.6	37.2	26.6	26.1	4.7	115.2
2004	35.9	97.0	52.8	49.0	66.7	19.5	320.9
Sum from 1951–1990	29.4	54.3	69.3	70.6	59.8	48.2	331.6

The growing season in 2002 should be defined as wet and very warm year, it is indicated by value of hydrotermic index K = 1.1. When the course of weather condition was analysed in year 2003 it was claimed that this year was not in favour to correct development of plants, and in the same time it was not in favour to achieve high grain yield of spring wheat. It was the year of drought with the value of hydrotermic index K = 0.6. Vegetation period of 2004 characterized with favourable conditions for growth and development of spring wheat. The value of hydrotermic index K = 1.2.

Results and discussion

Protein, which content vary in dependence of fertilization level, is important component of wheat grain [15]. The content of this compound, as well as gluten contents and its quality have significant influence on wheat grain technological value. Gluten deliquescence is one of more important parameters which determine gluten quality. Variation analysis showed important influence of nitrogen fertilization on gluten deliquescence of spring wheat grain (Table 2).

Table 2

Gluten deliquescence in spring wheat grain, mean from years 2002–2004

Cultivars	Nitrogen fertilization [kg · ha^{-1}]					Average
	0	40	80	120	160	
Banti	10.0	14.0	15.0	15.0	13.0	13.4
Henika	13.0	14.0	14.0	14.0	14.0	13.8
Jasna	14.0	14.0	14.0	15.0	13.0	14.0
Average	12.3	14.0	14.3	14.7	13.3	13.7
$LSD_{0.05}$ between: rates of nitrogen fertilization = 1.6 cultivars = not exist in comparison: rates of nitrogen fertilization × cultivars = 2.8						

Table 3

Falling number of gluten in spring wheat grain, mean from years 2002–2004, [s]

Cultivars	Nitrogen fertilization [kg · ha^{-1}]					Average
	0	40	80	120	160	
Banti	322.0	321.0	327.0	302.0	319.0	318.2
Henika	427.0	414.0	405.0	444.0	428.0	423.6
Jasna	421.0	409.0	415.0	435.0	405.0	417.0
Average	390.0	381.3	382.3	393.7	384.0	386.3
$LSD_{0.05}$ between: rates of nitrogen fertilization = not exist cultivars = 15.6 in comparison: rates of nitrogen fertilization × cultivars = 34.7						

Not important was the influence of cultivars on researched feature, but there was a cooperation of nitrogen fertilization with cultivars. The highest rate of gluten deliquescence was noted on 120 kg N · ha^{-1} nitrogen level. The lowest gluten deliquescence was noted on control object, which differed importantly from values which were achieved on objects fertilized with the following rates 40, 80, 120. The influence of nitrogen fertilization on gluten deliquescence depended on researched cultivars, which showed the interaction of cultivars with rates of nitrogen fertilization. Banti cultivar reacted with important increase of gluten deliquescence after using the nitrogen rate of 40 kg N · ha^{-1}. Henika and Jasna cultivars did not react significantly on changing rates of nitrogen fertilization. The interaction of cultivars with rates of nitrogen fertilization was proved. Henika cultivar had significant increase of researched feature in combination fertilized with rate of 120 kg N · ha^{-1}. Banti and Jasna cultivar did not react on increasing nitrogen fertilization. The significant effect of nitrogen fertilization and variety on the value of the number of gluten was proved in the investigation of spring wheat grain (Table 4).

Table 4

Gluten number of spring wheat, mean from years 2002–2004

Cultivars	Nitrogen fertilization [kg · ha^{-1}]					Average
	0	40	80	120	160	
Banti	38.09	43.32	46.05	44.41	49.68	44.31
Henika	39.22	38.04	40.25	39.55	44.75	40.36
Jasna	46.65	46.62	45.89	44.07	45.60	45.76
Average	41.32	42.66	44.06	42.67	46.67	43.48
$LSD_{0.05}$ between: rates of nitrogen fertilization = 3.60; cultivars = 3.82; in comparison: rates of nitrogen fertilization × cultivars = 6.76						

The largest number of gluten have been reported on object fertilized with dose of 160 kg N · ha^{-1}, and it was significantly higher compared with the control object, and fertilized with dose of 40 and 120 kg N · ha^{-1}. The lowest value of the characteristic was noted on the control object. The difference between the extreme values was 6.35. The greatest value of the number of gluten was found in Jasna cultivar (45.76), while the smallest in Henika cultivar (40.36). The influence of nitrogen fertilization on the number of gluten varied depending on the cultivar, as evidenced by the interaction of nitrogen doses with the cultivar. In Banti cultivar gluten number was significantly lower on control object in comparison with combinations 80 160 kg N · ha^{-1} Henika and Jasna cultivars did not react significantly on increasing rates of nitrogen fertilization. The density of grain when it was built depended on grain lushness, its structure and fillness, the thickness of fruit-seed cover and amount and qualities of pollutant. Variation analysis showed the interaction between cultivars and nitrogen fertilization (Table 5). The highest grain density was achieved in Henika cultivar, on control object. The grain from object fertilized with rate of 160 kg N · ha^{-1} characterized with significantly the lowest grain density in comparison with control object. Banti cultivar was characterized with the lowest grain density. In comparison with Henika and Jasna it was significantly different. The results of analysis of variance showed the interaction of nitrogen fertilization and cultivars on tested features which shows that the density of grain of tested cultivars depending on the applied doses of nitrogen.

Table 5

Density of spring wheat grain mean from years 2002–2004, [kg · hl^{-1}]*

Cultivars	Nitrogen fertilization [kg · ha^{-1}]					Average
	0	40	80	120	160	
Banti	76.7	74.0	74.2	74.5	74.9	74.8
Henika	80.2	77.7	78.1	78.2	76.1	78.0
Jasna	77.7	77.3	76.6	76.3	77.2	77.0
Average	78.2	76.3	76.3	76.3	76.0	76.6
$LSD_{0.05}$ between:	rates of nitrogen fertilization = 1.6 cultivars = 1.2 in comparison: rates of nitrogen fertilization × cultivars = 2.8					

* hl = 100 dm^3.

Gluten deliquescence is one of parameters which determine gluten quality. Gluten which characterised with good quality should have little deliquescence. The results of Sulek and others [16] did not confirm the influence of nitrogen fertilization on gluten deliquescence. In Knapowski and others researches [17] the 80 kg N · ha^{-1} dose cause significant increase of gluten deliquescence in comparison with control object without nitrogen fertilization but continuing increase of nitrogen doses did not have significant influence on gluten quality. In own researches this feature was different in dependence on nitrogen doses which were used. Gluten with the lowest deliquescence was achieved on control object, but the highest deliquescence had the gluten from grain fertilized with 120 kg N · ha^{-1} rate. The falling number is one of rate which let to claim if we deal with product which came from grain with higher enzymatic activity. From Budzynski and others researches [18] we can see that high rates of nitrogen can cause the increase of alfa-amylasis activity, but Mazurek and Biskupski [5] declared the fall of amylolitical activity with the increase of nitrogen rates. In own researches, similar to Haber and others researches [19] significant relations between rates of nitrogen fertilization and falling number did not appear. In Knapowski and Ralcewicz [17] researches the increase of nitrogen doses from 80 to 120 kg N · ha^{-1} caused significant increase of falling number, and continuing increase of fertilization to the level of 160 kg N · ha^{-1} did not have significant influence on its value. The index which characterize the percentage content of gluten and its deliquescence is the gluten number. In own researches the highest value of researched feature was noted in grain which was cultivated from control object fertilized with the highest dose of nitrogen 160 kg N · ha^{-1}. Stankowski and others [20] researches show similar dependence. The grain density decides about its grinding value. Big value of this feature forecasts high yield of flour, but little provides about shrivelled of grain and bad creation of endosperm. In own researches the density of grain depended on rates of nitrogen fertilization. Similar results noted Achramowicz and others [21].

Conclusion

1. The results pointer that the technological value of spring wheat grain changed according to nitrogen fertilization doses.

2. The increase of dose to 160 kg N · ha^{-1} caused important increase of gluten number and falling number but it caused the drop density of grain. Gluten deliquescence was the highest after applying the dose of 120 kg N · ha^{-1}.

3. Cultivars which were taken into consideration in this experiment had significant influence on increase of indicators which determined technological value of spring wheat grain such as falling number, gluten number and grain density. The amount of this changed in the following cultivars in dependence on nitrogen fertilization level.

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WARTOŚĆ TECHNOLOGICZNA ZIARNA PSZENICY JAREJ W ZALEŻNOŚCI OD NAWOŻENIA AZOTEM

Katedra Szczegółowej Uprawy Roślin
Akademia Podlaska

Abstrakt: Doświadczenie polowe przeprowadzono w latach 2002–2004 w Rolniczej Stacji Doświadczalnej w Zawadach, należącej do Akademii Podlaskiej. Doświadczenie dwuczynnikowe założono metodą losowanych bloków w trzech powtórzeniach. Powierzchnia poletka do zbioru wynosiła 18 m^2. W doświadczeniu badano dwa czynniki: I czynnik – dawki nawożenia azotem: 0 – obiekt kontrolny bez nawożenia azotem, 40 N kg · ha^{-1} (20 kg N · ha^{-1} przed siewem, 20 kg N · ha^{-1} w fazie strzelania w źdźbło), 80 kg N · ha^{-1} (40 kg

$N \cdot ha^{-1}$ przed siewem, 40 kg $N \cdot ha^{-1}$ w fazie strzelania w źdźbło), 120 kg $N \cdot ha^{-1}$ (60 kg $N \cdot ha^{-1}$ przed siewem, 60 kg $N \cdot ha^{-1}$w fazie strzelania w źdźbło), 160 kg $N \cdot ha^{-1}$ (80 kg $N \cdot ha^{-1}$ przed siewem, 80 kg $N \cdot ha^{-1}$ fazie strzelania w źdźbło), II czynnik – odmiany pszenicy jarej: Henika, Banti, Jasna. Zbiór pszenicy jarej przeprowadzono w fazie pełnej dojrzałości ziarna. Z przeprowadzonych badań wynika, że wskaźniki wartości technologicznej ziarna pszenicy jarej zmieniały się w zależności od dawki nawożenia azotem. Wzrost dawki do 160 kg $N \cdot ha^{-1}$ spowodował znaczne zwiększenie wartości liczby glutenowej i liczby opadania, a obniżenie gęstości ziarna. Rozpływalność glutenu była największa po zastosowaniu dawki 120 kg $N \cdot ha^{-1}$. Uwzględnione w doświadczeniu odmiany miały znaczny wpływ na wartości wskaźników określających wartość technologiczną ziarna pszenicy jarej.

Słowa kluczowe: pszenica jara, nawożenie azotem, odmiany, jakość ziarna