DOI: 10.5965/223811711722018182

Revista de Ciências Agroveterinárias 17(2): 2018
Universidade do Estado de Santa Catarina

Productivity parameters and protein quality characteristics of wheat cultivars in response to nitrogen fertilization

Parâmetros de produtividade e características de qualidade protéica de cultivares de trigo em resposta à adubação nitrogenada

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Submission: 27/03/2017 | Acceptance: 09/05/2018

ABSTRACT

Nitrogen fertilization strategies using increasing dosages demonstrate favorable effects on grain yield and quality; however, differences in results have been reported in relation to the effect of dosages, times and application schedules throughout the development cycle of the crop. The objective of this study was to evaluate the productivity and protein quality characteristics in response to nitrogen fertilization management applied to the cultivars TBIO Itaipu, TBIO Pioneiro, TBIO Quartzo and TBIO Seleto. The experimental design in randomized blocks with three replications, in a factorial scheme (4 cultivars x 7) handlings was used. The experiment was conducted in Coxilha, RS, during the agricultural years of 2012 and 2013. The total dose of N used in the present work was 140 kg ha^{-1}, with 30 kg ha^{-1} of N being applied at sowing and remainder in coverage, for the time defined in each treatment. The grain yield of the studied cultivars was increased with the nitrogen fertilization applied in a concentrated way in the treatment T2 and showed a negative correlation with the protein content, showing that the genotypic superiority to the yield of grains can negatively affect the protein ratio. Of the cultivars studied TBIO Pioneiro stood out from the others regarding the general gluten strength in the 2012 crop and the TBIO Seleto was superior in the 2013 crop, however, the protein content did not show a significant association with the gluten strength, revealing that the concentration was not efficient to predict industrial quality.
KEYWORDS: *Triticum aestivum*, grain yield, commercial quality, gluten strength.

RESUMO

Estratégias de fertilização nitrogenada com o emprego de dosagens crescentes demonstram efeitos favoráveis sobre a produtividade e qualidade dos grãos, entretanto têm sido reportado divergências em resultados com relação ao efeito de dosagens, épocas e parcelamentos de aplicação ao longo do ciclo de desenvolvimento da cultura. O objetivo deste estudo foi avaliar a produtividade e características de qualidade protéica em resposta ao manejo de adubação nitrogenada aplicada em cobertura nas cultivares TBIO Itaipu, TBIO Pioneiro, TBIO Quartzo e TBIO Seleto. O experimento foi conduzido em Coxilha – RS, nos anos 2012 e 2013. O delineamento experimental utilizado foi em blocos casualizados com três repetições, em esquema fatorial (4 cultivares x 7 manejos). A dose total de N utilizada no trabalho foi de 140 kg ha^{-1}, sendo 30 kg ha^{-1} de N aplicados na semeadura e o restante em cobertura, conforme a época definida em cada tratamento. A produtividade de grãos das cultivares estudadas foi incrementada com a adubação nitrogenada aplicada de forma concentrada no tratamento T2 e manifestou correlação negativa com o conteúdo de proteínas, revelando que a superioridade genotípica para o rendimento de grãos pode afetar negativamente a proporção protéica. Das cultivares estudadas a cultivar TBIO Pioneiro se destacou das demais quanto a força geral de glúten na safra 2012 e a TBIO Seleto foi superior na safra 2013, entretanto, o conteúdo de proteína não evidenciou associação significativa com a força de glúten, revelando que a concentração de proteínas não foi eficiente para predizer a qualidade industrial.
PALAVRAS-CHAVE: *Triticum aestivum*, rendimento de grãos, qualidade comercial, força de glúten.

INTRODUCTION

The demand for flour with technological quality has been increasingly considered by the consumer markets in the purchase of wheat. Based on the wheat technical regulation established by the Ministry of

Agriculture, Livestock and Food Supply, through Normative Instruction 38, dated November 30, 2010 (BRASIL 2010), the industrial quality of wheat grain may have an impact on the Commercial use and economic value. In wheat crop, grain yield and quality are associated with the interactions of the genetic characteristics of the cultivar, environmental conditions and handling practices (TEIXEIRA FILHO et al. 2007). Among the handling practices, nitrogen fertilization has been one of the main strategies to improve wheat production in relation to obtaining higher yields and better grain quality (FUERTES-MENDIZÁBAL et al. 2010).

VIANA & KIHL (2010) affirm that nitrogen (N) is the nutrient of greater interference in the composition of wheat plant and the most demanded during its development. The release of nitrogen by the soil depends on the amount and type of organic matter present, as well as its degree of mineralization. This process involves the microbial action, which releases nitrogen in the ammoniacal form (NH_4^+), which in the soil goes through the oxidation process and transforms to nitric form (NO_3^-) (DA ROS et al. 2003). However, the nitrogen supply from the organic matter does not satisfy the requirement of the wheat crop, making complementation necessary through the practice of nitrogen fertilization that can be in the nitric form of potassium nitrate, sodium nitrate ($NaNO_3$, KNO_3), ammonium sulfate [$(NH_4)_2SO_4$], ammonium nitrate (NH_4NO_3) and amide (urea) (MIELNICZUK1982).

Urea is the most used nitrogen source in Brazilian agriculture, presenting advantages due to high nitrogen content (45%), lower cost, high solubility, lower corrosivity, high foliar absorption rate, and handling ease, besides casing less acidification in the soil (YANO et al. 2005). However, it has as an unfavorable characteristic such as high losses due to immobilization and volatilization and these are increased by the presence of straw in the soil and by the lack of rain for its incorporation (CANTARELLA et al. 2007).

Nitrogen application strategies in wheat cultivation are major challenges that need to take into account that cultivars differ substantially in their capacity of absorption, assimilation and conversion of nitrogen to grain production. In addition, each year new genotypes are introduced, which, because of their differentiated genetic base, may present a distinct response to the dose and to the time of nitrogen application. Although many studies have already investigated the effect of nitrogen fertilization on wheat crop, a clear view of this effect has not yet been presented. Nitrogen application strategies using increasing dosages have shown favorable effects on grain quality, as these increase protein concentration (LÓPEZ-BELLIDO et al. 2001, GARRIDO-LESTACHE et al. 2005). However, different results on quality and productivity parameters of grain and flour have been reported in relation to the effect of the division of the dosages, seasons and nitrogen application schedules throughout the wheat development cycle. AYOUB et al. (1994) observed that when performing nitrogen fertilization, the protein contents are affected, but not their quality. GARRIDO-LESTACHE et al. (2004) and FUERTES-MENDIZÁBALET et al. (2010) observed an improvement in quality parameters when the nitrogen dose is applied in a splitmanner.

Therefore, the decision about the N management strategy in wheat crop is a big challenge that has different dimensions and characteristics, and should be defined by taking into account that the cultivars respond differently to the application of nitrogen and that fertilization can provide changes in yield and commercial quality. Within this context, the objective of this study was to evaluate the productive performance and the quality characteristics of proteins and gluten strength in response to the proportions of nitrogen fertilization applied to the wheat cultivars TBIO Itaipu, TBIO Pioneiro, Quartzo and TBIO Seleto during two crop years.

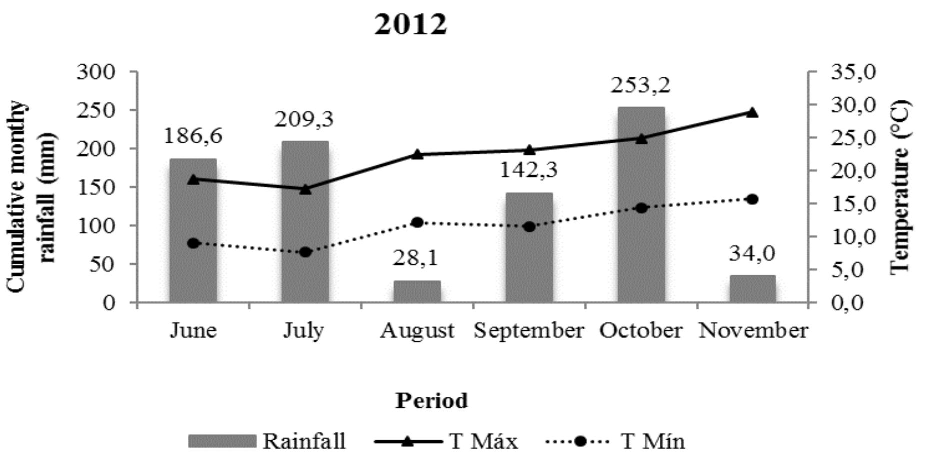
MATERIAL AND METHODS

The field experiment carried during the agricultural years 2012 and 2013, in Coxilha, RS, located at geographical coordinates: latitude 28°13’21.63” and longitude 52°23’02.60”. The soil of the experimental area classified as typical dystrophic red latosol (EMBRAPA 2006) had the following properties as chemical attributes in the 0.0-0.15 m depth layer prior to the experiment: pH (water) = 5.7; M.O. = 27 g kg^{-1}; Al^{3+} = 0.0 cmolc L^{-1}; Ca^{2+} = 5.0 cmol L^{-1}; Mg^{2+} = 2.2 cmol L^{-1}; P = 12 mg L^{-1}; K = 68 mg L^{-1} and S = 13 mg L^{-1}. Cumulative monthly rainfall data with temperature variation during the experiment are shown in Figure 1.

The sowing of the wheat cultivars TBIO Itaipu, TBIO Pioneiro, Quartzo and TBIO Seleto was performed mechanically on June 20, 2012 and June 23, 2013, using plots measuring 12.0 m^2 of total area and 10.8 m^2 of working area with three replicates. The spacing used between rows was 0.17 m, depth of 5 cm and density of 300 seeds m^2, in the no-till, on the remains of the soybean crop during the two growing years.

The basal fertilization used for the cultivars was composed of 75 kg ha^{-1} of potassium chloride (KCl) in pre-sowing and 167 kg ha^{-1} of di-ammonium phosphate (DAP) at sowing, the latter providing 30 kg ha^{-1} of N and 77 kg ha^{-1} of phosphorus pentoxide (P_2O_5). Basal fertilization was conducted in the control management, called treatment (T1). The cover fertilization was applied in split form (Table 1), which combined with base fertilization, completed the total dose of 140 kg ha^{-1} of N from treatments T2 to T7. The N application scheduling times were: sowing (S), tillering (T), elongation (E) and heading (H). Nitrogen was applied to the managements as follows: T1 = 30 kg ha^{-1} of N at sowing; T2 = 30 kg ha^{-1} of N at sowing + 110 kg ha^{-1} of N at tillering; T3 = 30 kg ha^{-1} of N at sowing + 110 kg ha^{-1} of N at elongation; T4 = 30 kg ha^{-1} of N at sowing + 110 kg ha^{-1} of N at heading; T5 = 30 kg ha^{-1} of N at sowing + 55 kg ha^{-1} of N at tillering + 55 kg ha^{-1} of N at elongation; T6 = 30 kg ha^{-1} of N at sowing + 55 kg ha^{-1} of N at elongation + 55 kg ha^{-1} of N at heading; T7 = 30 kg ha^{-1} of N at sowing + 37 kg ha^{-1} of N at tillering + 37 kg ha^{-1} of N at elongation + 37 kg ha^{-1} of N at heading.

(a)



(b)

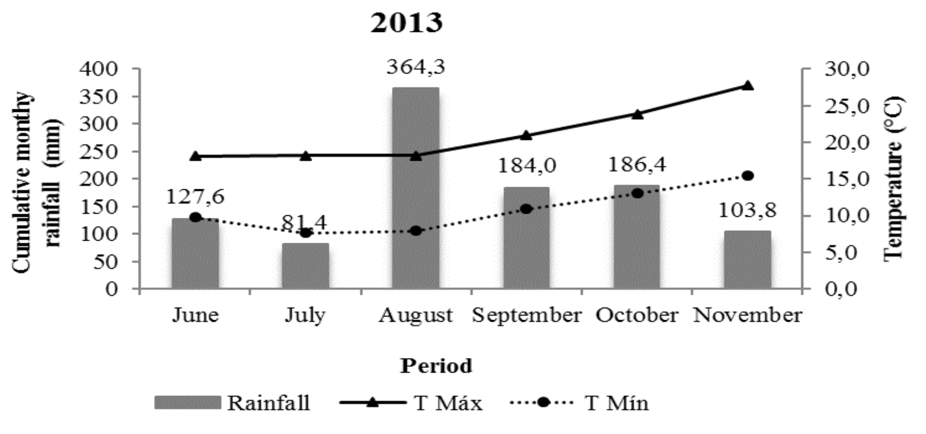


Figure 1. Cumulative monthly rainfall and temperature variation for the trial period in the locations of Coxilha, Rio Grande do Sul during the years 2012 (a) and 2013 (b).
*Data was collected in Passo Fundo (RS) (the weather station nearest Coxilha). Source: EmbrapaTrigo.

In all cover fertilizations, the N was applied as urea. The control of pests and diseases was carried out according to the needs of each year, following the technical information for wheat (EMBRAPA 2012).

At the end of the crop cycle, the experimental plots were mechanically harvested and submitted to the pre-cleaning and drying procedure until a moisture content of 13% was obtained. The grain yield was determined by means of mechanical harvesting and weighing the wheat grains, and the results expressed in kg ha^{-1}. Samples were stored in the chamber at 20 °C and 55% ± 5% relative humidity for three months for grain maturation. Technological quality parameters were performed in the Cereals Laboratory of the Center for Food Research (CEPA) of the University of Passo Fundo, RS.

The wheat samples were conditioned to 15% moisture and milled in a Chopin pilot mill, model CD1, France, according to AACC INTERNATIONAL method 26-10.02 (2010). The resulting flour was used for the determination of total proteins performed according to AACC INTERNATIONAL method 46-10.01 (2010) and the results expressed in g $100g^{-1}$ on a dry basis, in duplicate. The protein content of the grains was obtained by multiplying the concentration of N by the conversion factor 5.7.

The viscoelastic characteristics of the flour were determined in a Chopin alveograph, model NG, France, according to method AACC INTERNATIONAL 54-30.02 (2010), measuring the flour mass of 250 g of flour and volume of 129.4 ml of water, corrected in the base of 14% of moisture content. The parameter used was gluten strength, which corresponds to the mechanical work necessary to expand the bubble until its rupture, expressed in J x 10^{-4}, performed in duplicate.

Data processing and statistical analysis were performed using Sisvar® Statistical Software version 5.0 (FERREIRA 2014). The significance of the data was tested through analysis of variance at $p < 0.01$ and $p < 0.05$, the means were compared by Tukey test, at a 95% confidence interval.

Table 1. Seasons and application schedules of nitrogen cover of wheat cultivars TBIO Itaipu, TBIO Pioneiro, Quartzo and TBIO Seleto during the 2012 and 2013 crops.

Treatments	Sowing (S)	Tillering (T)	Elongation (E)	Heading (H)
kg ha^{-1}				
T1	30	0	0	0
T2	30	110	0	0
T3	30	0	110	0
T4	30	0	0	110
T5	30	55	55	0
T6	30	0	55	55
T7	30	37	37	37

T1= 30 kg ha^{-1} of N at sowing; T2= 30 kg ha^{-1} of N at sowing + 110 kg ha^{-1} of N at tillering; T3= 30 kg ha^{-1} of N at sowing + 110 kg ha^{-1} of N at elongation; T4= 30 kg ha^{-1} of N at sowing + 110 kg ha^{-1} of N at heading; T5= 30 kg ha^{-1} of N at sowing + 55 kg ha^{-1} of N at tillering + 55 kg ha^{-1} of N at elongation; T6= 30 kg ha^{-1} of N at sowing + 55 kg ha^{-1} of N at elongation + 55 kg ha^{-1} of N at heading; T7= 30 kg ha^{-1} of N at sowing + 37 kg ha^{-1} of N at tillering + 37 kg ha^{-1} of N at elongation + 37 kg ha^{-1} of N at heading.

RESULTS AND DISCUSSION

The annual averages of grain yields reflected the variations of the environmental conditions observed during the years of the experiment (Table 2). The climatic conditions for the year 2013, with a volume of 745.8 mm of well distributed rains (Figure 1) and temperatures varying between sowing and harvesting from 7.6 to 27.8 ºC were favorable for productivity, demonstrating that the N uptake by plants to ensure vegetative growth of the grain was supplied.

The grain yield in the evaluated years was influenced by the treatment x cultivar interaction. Cover fertilization carried out during the crop of 2012/2013 showed that concentrated application in tillering (T2) provided lower yields in TBIO Pioneiro and TBIO Seleto. In the 2013/2014 crop, TBIO Pioneiro presented superior performance. When the application of N occurred in a concentrated way in the later phase of development (T4), the cultivars TBIO Seleto and TBIO Itaipu were more productive during the 2012 crop, however in the 2013 crop these cultivars had lower yields. In the treatment in which N application occurred in the tillering and elongation (T5) phases, the cultivars TBIO Seleto and Quartzo proved to be more productive in the 2012/2013 crop, whereas in 2013/2014, these presented the smallest productivities. In the T6 and T7 treatments, the cultivar TBIO Pioneiro presented lower productivity without differing from TBIO Seletoin T6.

The grain yield of all the cultivars studied in the years 2012 and 2013 presented values as expected and were higher than that obtained in the southern region, where productivity for the State of Rio Grande do Sul was 1941 and 3060 kg ha^{-1}, respectively (CONAB 2013). For grain yield of the 2012/2013 crop, the cultivars TBIO Pioneiro and TBIO Itaipu presented higher values in T2, followed by T5 and T7, occurring in a similarly for TBIO Seleto and Quartzo. The lowest values of productivity occurred in T4, in which the dose of N was concentrated in the heading phase. Logically, higher productivity would be expected in T5 compared to T6 and T7, but this was not confirmed for all cultivars in this experiment. In the 2013/2014 crop, all cultivars presented better productivity responses when the application of N occurred in a concentrated form in the tillering (T2). TBIO Pioneiro and TBIO Itaipu also presented responses with split applications in later phases T5 and T7, phases that contemplate tillering. Similar to the 2012/2013 crop, treatment 4 presented the lowest values of yields.

Table 2. Productivity of wheat cultivars with nitrogen fertilization, applied in cover in two agricultural years.

Treat-ments	2012				2013			
	Pioneiro	Itaipu	Seleto	Quartzo	Pioneiro	Itaipu	Seleto	Quartzo
	kg/ha							
T 1	A 3172 abc	A 3287 cd	A 3289 ab	A 3372 bc	*D 3399 c	C 3504 f	B 3580 d	*A 3874 c
T 2	B 3336 a	A 3976 a	AB 3785 ab	A 3872 a	*A 4366 a	*B 4181 a	*C 4055 a	C 4068 a
T 3	B 3264 ab	A 3379 bcd	A 3406 ab	AB 3336 c	*A 4006 b	*C 3827 d	*D 3689 c	*B 3886 c
T 4	B 3056 c	AB 3235 d	*A 3266 b	A 3336 c	*B 3431 c	C 3334 g	D 3122 f	*A 3689 f
T 5	C 3185 abc	B 3567 bcd	A 3681 ab	AB 3602 abc	*A 4274 a	*B 4021 b	*D 3741 b	*C 3919 b
T 6	B 3296 ab	A 3655 ab	B 3282 b	A 3608 abc	*A 3942 b	C 3703 e	*D 3570 d	B 3741 e
T 7	B 3143 bc	A 3628 abc	*A 3870 a	A 3800 ab	*A 4308 a	*B 3862 c	D 3523 e	C 3787 d
C.V.	1,33 %	2,51 %	4,22 %	3,27 %	0,64 %	0,21 %	0,15 %	0,1 %

For each year, lower case letters in the same column and upper case in the same row represent, respectively, a significant difference between treatments and cultivars according to the Tukey test at 5% of significance.
For each cultivar * in the same row, represents a significant difference between years of cultivation according to the Tukey test at 5% of significance.
T1= 30 kg ha^{-1} of N at sowing; T2= 30 kg ha^{-1} of N at sowing + 110 kg ha^{-1} of N at tillering; T3= 30 kg ha^{-1} of N at sowing + 110 kg ha^{-1} of N at elongation; T4= 30 kg ha^{-1} of N at sowing + 110 kg ha^{-1} of N at heading; T5= 30 kg ha^{-1} of N at sowing + 55 kg ha^{-1} of N at tillering + 55 kg ha^{-1} of N at elongation; T6= 30 kg ha^{-1} of N at sowing + 55 kg ha^{-1} of N at elongation + 55 kg ha^{-1} of N at heading; T7= 30 kg ha^{-1} of N at sowing + 37 kg ha^{-1} of N at tillering + 37 kg ha^{-1} of N at elongation + 37 kg ha^{-1} of N at heading.

According to SPARKES et al. (2006), the application of nitrogen in the heading stage may contribute to the increase of leaf area index resulting in greater photosynthesis. The greater photosynthetic area contributes to increase the availability of carbohydrates to support the production of tillers and grain mass (ALMEIDA et al. 2004), which explains the positive effect of handling in T2 in which, independently of the Genotype, the early application of N was shown to be important for emission and survival of the tillers. This reinforces the need for nitrogen application in the development stages of the crop, favoring maximum exploitation of the genetic potential of wheat cultivars.

The observed results regarding the variability in the protein content due to the agricultural crops studied showed a negative correlation with the grain yield parameter (Table 3). This data confirmed the observations made by FOWLER (2003) and SILVA (2014), and are explained by the higher energy expenditure that the plant presents for protein formation, which may compromise the accumulation of carbohydrates in the grains. However, the association between productivity and grain proteins cannot be generalized, since in previous studies there have been reports of a negative relationship between grain yield and protein (GUARDA et al. 2004, ŠÍP et al. 2013), increased protein and grain yield (PINNOW et al. 2013) and even lack of correlation between the parameters.

In the 2012 crop, the interaction between treatments x cultivars presented a response in the protein content in T2, T5, T6 and T7 for the cultivars TBIO Seleto and TBIO Pioneiro. The cultivar TBIO Seleto also showed higher protein content with the application of N only in the base, evidencing its genetic classification in the group of cultivars that does not respond to N and has a high percentage of proteins. In the 2013 crop, the cultivar TBIO Seleto showed higher protein content in all treatments except in T7, where the cultivars did not differ significantly between them. For the 2012/2013 crop, in all cultivars studied, treatment 3 showed a better response in the protein content, without significant difference from T5 in the cultivars TBIO Pioneiro and TBIO Itaipu. Among the factors that contributed to these results is the fact that the ammonium ion (NH_4^+) can be strongly adsorbed to the soil particles, reducing N losses through volatilization and leaching (TEIXEIRA FILHO et al. 2010).

In the 2013/2014 crop, the cultivar TBIO Pioneiro did not present any significant difference in the protein content with the different N handling in coverage. For the other cultivars, T4 presented the best responses, followed by T6 and T7, which contemplated the heading phase in the split application of N. The results of the 2013/2014 crop demonstrated the effect of nitrogen application time on the protein content in the grains of the four cultivars studied. The concentrated covered application in the heading favored the increase of the protein content of the grains. This data confirms the observations of GARRIDO-LESTACHE et al. (2004) that the late application of N favors the increase of the protein content of the wheat grains.

Table 3. Protein values for cultivars TBIO Pioneiro, TBIO Itaipu, TBIO Seleto and Quartzo with nitrogen fertilization in different treatments.

Treat-ments	2012				2013			
	Pioneiro	Itaipu	Seleto	Quartzo	Pioneiro	Itaipu	Seleto	Quartzo
	---- (%) ----							
T 1	*B 15,1 e	*C 13,8 d	*A 15,7 c	*B 14,7 c	B 13,2 a	D 11,8 e	A 14,3 f	C 12,7 f
T 2	*A 16,4 d	*C 14,7 c	*A 16,1 c	*B 15,6 b	B 14,2 a	D 12,8 d	A 14,8 e	C 13,3 e
T 3	*A 17,2 a	*C 15,1 ab	*A 17,3 a	*B 16,5 a	B 15,0 a	D 13,9 c	A 15,9 d	C 14,4 c
T 4	AB 15,3 e	B 15,2 ab	A 15,7 c	C 14,6 c	*B 17,0 a	C 15,4 a	*A 18,0 a	*C 15,5 a
T 5	*A 17,0 ab	*C 15,3 a	*A 16,8 b	*B 15,9 b	B 14,0 a	D 12,9 d	A 14,5 f	C 13,1 e
T 6	*A 16,6 cd	C 14,9 bc	A 16,8 ab	*B 15,6 b	B 15,5 a	D 14,5 b	A 16,7 b	C 14,7 b
T 7	A 16,8 bc	*C 15,3 a	*A 17,0 ab	*B 15,8 b	A 20,4 a	A 13,8 c	A 16,2 c	A 14,0 d
C.V.	0,5 %	0,65 %	0,76 %	0,81 %	16,74 %	0,39 %	0,45 %	0,5 %

For each year, lower case letters in the same column and upper case in the same row represent, respectively, a significant difference between treatments and cultivars according to the Tukey test at 5% of significance.
For each cultivar * in the same row, represents a significant difference between years of cultivation according to the Tukey test at 5% of significance.
T1= 30 kg ha^{-1} of N at sowing; T2= 30 kg ha^{-1} of N at sowing + 110 kg ha^{-1} of N at tillering; T3= 30 kg ha^{-1} of N at sowing + 110 kg ha^{-1} of N at elongation; T4= 30 kg ha^{-1} of N at sowing + 110 kg ha^{-1} of N at heading; T5= 30 kg ha^{-1} of N at sowing + 55 kg ha^{-1} of N at tillering + 55 kg ha^{-1} of N at elongation; T6= 30 kg ha^{-1} of N at sowing + 55 kg ha^{-1} of N at elongation + 55 kg ha^{-1} of N at heading; T7= 30 kg ha^{-1} of N at sowing + 37 kg ha^{-1} of N at tillering + 37 kg ha^{-1} of N at elongation + 37 kg ha^{-1} of N at heading.

Table 4. Gluten strength of wheat cultivars with nitrogen fertilization, applied in two-year agricultural cover.

Treat-ments	2012				2013			
	Pioneiro	Itaipu	Seleto	Quartzo	Pioneiro	Itaipu	Seleto	Quartzo
	---- Jx104 ----							
T 1	*A 306 cd	*B 255 b	A 318 bc	*B 250 c	B 234 c	BC 208 d	A 302 d	C 197 de
T 2	A 295 d	A 283 b	A 290 d	*A 259 bc	B 313 b	C 270 c	*A 338 cd	D 194 e
T 3	A 323 bc	*A 325 a	A 318 bc	B 270 abc	B 323 b	B 291 bc	*A 415 ab	B 316 a
T 4	B 293 d	B 279 b	A 350 a	C 247 c	*A 400 a	B 310 ab	B 322 d	*C 278 b
T 5	*A 360 a	*B 322 a	B 328 bc	*C 281 ab	B 221 c	B 205 d	A 339 cd	B 232 cd
T 6	A 339 ab	B 316 a	AB 331 b	C 272 abc	B 326 b	*B 334 a	*A 426 a	*B 318 a
T 7	A 338 ab	A 341 a	AB 313 c	B 288, a	B 321 b	BC 296 b	A 378 bc	C 268 bc
C.V.	2,14 %	2,37 %	1,34 %	2,73 %	1,82 %	2,34 %	3,38 %	3,47 %

For each year, lower case letters in the same column and upper case in the same row represent, respectively, a significant difference between treatments and cultivars according to the Tukey test at 5% of significance.
For each cultivar * in the same row, represents a significant difference between years of cultivation according to the Tukey test at 5% of significance.
T1= 30 kg ha^{-1} of N at sowing; T2= 30 kg ha^{-1} of N at sowing + 110 kg ha^{-1} of N at tillering; T3= 30 kg ha^{-1} of N at sowing + 110 kg ha^{-1} of N at elongation; T4= 30 kg ha^{-1} of N at sowing + 110 kg ha^{-1} of N at heading; T5= 30 kg ha^{-1} of N at sowing + 55 kg ha^{-1} of N at tillering + 55 kg ha^{-1} of N at elongation; T6= 30 kg ha^{-1} of N at sowing + 55 kg ha^{-1} of N at elongation + 55 kg ha^{-1} of N at heading; T7= 30 kg ha^{-1} of N at sowing + 37 kg ha^{-1} of N at tillering + 37 kg ha^{-1} of N at elongation + 37 kg ha^{-1} of N at heading.

The results of the general gluten strength of the flour mass from the cultivars studied in the years 2012 and 2013 are presented in Table 4. In the 2012/2013 crop, no significant difference was observed in T2, with the lowest values verified in T1 and the highest in treatments that the N dose was applied in coverage. In the 2013/2014 crop, all treatments varied significantly, and similarly, higher values were observed in treatments with late application of N, especially in T6.

The cultivar TBIO Pioneiro stood out from the others regarding the general gluten strength in the 2012/2013 crop and TBIO Seleto in the 2013/2014 crop. The cultivar TBIO Itaipu was the one with the lowest general gluten strength. According to WIESER et al. (2004) and DUPONT & ALTENBACH (2003), environmental factors have a significant influence on the quality of the flour, partly due to the quantity of gluten proteins, proportions of protein fractions and the degree of polymerization of glutenins.

The general gluten strength variables found in this work are directly related to the handling group in which the cultivars are classified by the funder. TBIO Pioneiro belongs to the group of cultivars that when subjected to N handling, responds in the form of greater gluten strength. TBIO Seleto includes the group of cultivars with greater stability of gluten strength since the characteristic is genetic. TBIO Itaipui classified as being dependent on the N handling to present a response regarding gluten strength.

CONCLUSION

Early application of nitrogen at the stage of development of the crop (T2), independently of the cultivar, maximized the exploitation of the genetic potential of the cultivars and increased grain yield during the two years of cultivation.

In the 2013 crop, it was possible to observe the effect that the application in the hedge concentrate favored the increase of the protein content of the grains of the four cultivars studied. In the gluten strength parameter of the studied cultivars, the TBIO Pioneiro cultivar stood out from the others with greater gluten general strength in the 2012 crop and the cultivar TBIO Seleto was superior in the 2013 crop.

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