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**RESEARCH ARTICLE**

# TECHNOLOGICAL QUALITY OF WHEAT UNDER NITROGEN MANAGEMENT

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**ABSTRACT**

The improving wheat technological quality constitutes an aspect of fundamental importance in the search for products derived of high quality. This study aimed to analyze the technological quality of different wheat genotypes for the use of different nitrogen managements in coverage and sources of nitrogen fertilization. The experimental design was randomized blocks, arranged in a factorial design with three genotypes (Fundacep 52, TBIO Mestre and TBIO Itaipu) x two nitrogen sources (UR: urea - 45% nitrogen and AN: ammonium nitrate - 33.5 % nitrogen) x four managements (NN: no nitrogen, TIL: tillering, TLF: tillering and flowering and TBF: tillering, booting and flowering) arranged in three repetitions. The analysis of variance showed significance for genotype x nitrogen source x management for the characters tenacity (P), extensibility (L) P/L, gluten strength (W), falling number (NQ) and wet gluten (GU). Technological quality parameters are influenced by the managements, nitrogen sources and genotypes. Nitrogen management with urea and ammonium nitrate has no influence in protein content. TbioMestre genotype has higher gluten content, tenacity and extensibility when urea is applied at tillering and flowering, for the ammonium nitrate the best responses are obtained for dropping numbers.



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## INTRODUCTION

Wheat *(Triticumaestivum* L.) is considered a major source of energy for human beings for providing the necessary carbohydrates and protein levels. It is consisted of 55% starch, 12% protein, 1.5% fat and 1.5% mineral material (Rostagno *et al.*, 2011), being important in yield systemsdue to compose human and animal feeding. Wheat is used as raw material for biscuits, cakes, pasta and breads (Scheuer *et al.*, 2011). This is possible due to the protein fraction of the grains present gliadin and glutenin, which when hydrated form the gluten that is responsible for the doughelasticity and fermentation. The quality of food products from wheat depends onflour, protein ratio, gluten strength, extensibility, toughness, and gluten dropping number. Therefore, the quantity and quality of protein contained in the grains become dependent on the soil and climate conditions of environment, and the management techniques used (Mac Ritchie and Gupta, 1993). Research indicates that the cultivar, time and sowing density, water management, fertilizers, and genotype x environment interaction are crucial to the quality of wheat flour. The genotypes are more productive and technically demandingandinthis way, the genetic improvement search for quantitatively superior genotypes with high bakery quality (Wrigley, 1994). Among the available resources to improve the quality of grains produced, the fertilizer management is efficient, thus nitrogen is essential for increasing grain yield, crucial for the protein synthesis and the grain industrial quality (Sousa and Lobato, 2004).

Among the available nitrogen sources, urea is the principal fertilizer used in agriculture; however, it has great loss by the $NH_3$volatilization and leaching (Civardi*et al.*, 2011; Silva *et al.*, 2012). On the other hand, the ammonium nitrate is an alternative to reduce losses and increase the efficiency of these nitrogen fertilizers on wheat culture (Yano *et al.*, 2005). Given the importance of the technological aspects of wheat grain, and inorder to increase quality, this study aimsat analyzing the wheat technological quality due to the use of different sources and nitrogen managements.

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## MATERIAL AND METHODS

The experiment was conducted in FredericoWestphalen – RS, in the experimental area of the Laboratory for Genetic Improvement and Plant ProductionoftheUniversidade Federal de Santa Maria, under the coordinates: 27°23’48.17”S and 53°25’34.82”W and 460 meters of altitude. The soil is classified as Red Dystrophic Latosol (Embrapa, 2006), and climate is characterized as humid subtropical by Köppen (Sema, 2005). The experimental design was randomized in blocks, arranged in a factorial scheme: three genotypes (Fundacep 52, TbioMestreandTbioItaipu) x two nitrogen sources (UR: urea - 45% nitrogen and AN: ammonium nitrate - 33.5% nitrogen) x four managements (NN: no nitrogen, TIL: tillering, TLF: tillering and flowering and TBF: tillering, booting and flowering), arranged in three replications. Each plot consists of 12 lines, 0.17 mspaced and 3.5 m length, totaling 7.14 m². For the evaluationseight central rowswere sampled and 0.5m of each edge was eliminated. It was based on direct seeding system in the first half of July 2013. The base fertilizationused was 200 kg ha-1 of NPK (08-24-12) bycoverage and it was applied 115 kg ha -1 of nitrogen as pre-established treatments. The established population density was 310 plants m-2. The management of weeds, insect pests and diseases were carried out according to the need of the crop.

The characters were measured at Laboratory of Cereals of Food Research Center of the Universidade de Passo Fundo - RS, namely:

i. Percentage of total protein (PTP): measured by INFRATEC™ 1241 *Grain Analyzer* apparatus using eight subsamples of 100 g, results in percentage (%).
ii. Number of drops (ND): measured by *Falling Number* apparatus based on the method 56-81B of Aacc (2000), seven gramsofsample with 14% humidity was used, results in seconds (s).
iii. Humid gluten (HG): measured by Glutomatic apparatus according to the method 38-12 of Aacc (1995), using 10 gram of sample, results in a percentage (%).
iv. Gluten strength (W) corresponding to the necessary mechanical work to expand the dough until breaking, expressed as 10-4Joules.
v. Tenacity (P): corresponding to the measure of maximum overpressure in the dough expansion, results in mm.
vi. Extensibility (L): corresponding to measure of the curve length, predicts bread volume, results in mm.
vii. P/L Ratio: obtained through the ratio between tenacity and extensibility, results in mm mm -1.
viii. Data were submitted to analysis of variance by F test. By revealing significant interaction between genotype x nitrogen sources x managements dismembered up to simple effects, variables that showed no significant interactions were dismembered to the main effects. Means were compared by Tukey test at 5% probability. Analyses were performed by Genes software (Cruz, 2013).

## RESULTS AND DISCUSSION

The variance analysis showed significance for the genotype x nitrogen source x management interaction for tenacity (P), extensibility (L), P/L ratio, gluten strength (W), number of drop (ND) and humid gluten (HG). The TbioMestre genotype showed protein contenthigherthan those ofFundacep 52 and TbioItaipu (Table 1). The total protein percentage had no influence under the tested nitrogen sources. The protein content cannot be evaluated as a wheat quality indicator in isolation, thus extensibility and tenacityare added. Schmidt *et al*. (2009) reveal that the protein content was not enough to predict the wheat industrial quality. Regarding the management of nitrogen fertilization performed at the TIL, TLF, TBF, there was increased total proteinofgrainawhencompared to the lack of nitrogen fertilization. Boehm *et al*. (2004) showed that increased grain protein content is related to nitrogen, which is the basic constituent of proteins and amino acids (Malavolta, 1981).

**Table 1. Average results for the total protein percentage (PPT) to the factors cultivar, management and nitrogen source**

| | |
|---|---|
| *Management* | |
| No nitrogen | 13.76 b |
| Tillering | 15.42 a |
| Tillering and flowering | 15.66 a |
| Tillering, booting and flowering | 15.74 a |
| *Genotype* | |
| TbioMestre | 15.74 a |
| Fundacep 52 | 15.30 b |
| TbioItaipu | 14.40 c |
| *Nitrogen source* | |
| Urea | 15.21 a |
| Ammonium nitrate | 15.08 a |
| CV (%) | 2.54 |
| R² | 0.87 |

*Means followed by the same letter (or) in the column do not differ statistically to Tukey at 5% probability of error.*CV* – coefficient of variation and *R²* – determination coefficient.

The Fundacep 52 genotype expressed gluten strength for the TLF management superior to the other managements when using the ammonium nitrate, reaching 241 x 10 -4 J (Table 2) and can be framed in the bread class, according to Normative Instruction 38 (Brasil, 2010). The behavior of this character may be related to the greater availability of nitrogen in the grains formation process, increased qualitative and quantitative of proteins, resulting in strong gluten (Fuertes-Mendizábal*et al.,* 2010). There were no significant differences for gluten strength amongnitrogenous managements for Fundacep 52 genotype. The urea application under ideal conditions of air temperature, precipitation, and air and soilhumidity minimizes NH3 volatilization and utilization efficiency was incremented. The TbioMestre genotype revealed higher magnitudes of gluten strength for TIL and TBF managements whenurea and ammonium nitrate were used. Increased gliadin and glutenincontents in grainsenhancegluten strength. Regarding to sources, urea expresses superiority for this character in the TBFmanagement, since nitrogen is more quickly available and absorbed by the plant asNO3 or NH4 (Cantarella, 2007). The ammonium nitrate expressed this effect on the TIL and TLFmanagements, because it provides slownitrogenrelease, and reduces losses (Mesquita, 2007).

The TbioItaipu genotype shows higher magnitudes of gluten strength for TLFmanagementfor urea, while the nitrogen supply increases gluten strengthin the reproductive phase for TBF management using ammonium nitrate.

**Table 2. Average results of genotype x management x nitrogen source for the character gluten strength (W)**

| Management | Genotype | | | | | |
|---|---|---|---|---|---|---|
| | Fundacep 52 | | TbioMestre | | TbioItaipu | |
| | Nitrogen source | | | | | |
| | UR | AN | UR | AN | UR | AN |
| NN | 219.5 a A γ | 202.5 b A γ | 381.5 c A α | 396.5 d A α | 269.0 d A β | 254.0 c A β |
| TIL | 217.0 a A γ | 217.0 b A γ | 449.0 a B α | 477.5 a A α | 297.5 c B β | 351.5 b A β |
| TLF | 235.5 a A γ | 241.0 a A γ | 416.5 b B α | 446.5 b A α | 352.0 a A β | 367.5 b A β |
| TBF | 229.0 a A γ | 220.5 b A γ | 465.5 a A α | 423.5 c B α | 327.0 b B β | 387.5 a A β |
| CV (%) | 2.89 | | | | | |
| $R^2$ | 0.99 | | | | | |

* Means followed by the same letter (a) in the column for management, capital (A) in line for nitrogen and Greek source (α) for genotype did not differ statistically by Tukey test at 5% probability of error. Where *UR* – urea; *AN*– ammonium nitrate; *NN*– no nitrogen;*TIL* – tillering;*TLF* – tillering and flowering;*TBF* –tillering, booting and flowering; *CV* – coefficient of variation and *R²* – determination coefficient.

**Table 3. Average results of genotype x management x source for the character tenacity (P)**

| Management | Genotype | | | | | |
|---|---|---|---|---|---|---|
| | Fundacep 52 | | TbioMestre | | TbioItaipu | |
| | Nitrogen source | | | | | |
| | UR | AN | UR | AN | UR | AN |
| NN | 88.0 a A γ | 87.5 a A γ | 128.5 a B α | 136.5 a A α | 121.5 a A β | 107.5 ab B β |
| TIL | 77.0 b A γ | 87.5 a B γ | 121.0 b B α | 129.0 b A α | 95.0 d B β | 110.0 a A β |
| TLF | 86.5 a A γ | 82.5 b B γ | 111.5 d B α | 126.0 b A α | 106.5 b A β | 105.5 bc A β |
| TBF | 78.5 b B γ | 86.5 a A γ | 115.5 c A α | 109.5 c B α | 98.0 bc B β | 103.0 c A β |
| CV (%) | 1.83 | | | | | |
| $R^2$ | 0.99 | | | | | |

* Means followed by the same letter (a) in the column for management, capital (A) in line for nitrogen and Greek source (α) for genotype did not differ statistically by Tukey test at 5% probability of error. Where *UR* – urea; *AN*– ammonium nitrate; *NN*– no nitrogen;*TIL* – tillering;*TLF* – tillering and flowering;*TBF* –tillering, booting and flowering; *CV* – coefficient of variation and *R²* – determination coefficient.

**Table 4. Results average of genotype x management x source for the character extensibility (L)**

| Management | Genotype | | | | | |
|---|---|---|---|---|---|---|
| | Fundacep 52 | | TbioMestre | | TbioItaipu | |
| | Nitrogen source | | | | | |
| | UR | AN | UR | AN | UR | AN |
| NN | 84.0 c A α | 69.5 c B α | 79.5 c A α | 72.5 c B α | 53.0 c A β | 57.5 d A β |
| TIL | 102.0 a A α | 78.5 b B β | 99.5 b A α | 98.5 a A α | 80.5 b A β | 85.0 c A β |
| TLF | 91.0 b B β | 106.5 a A α | 99.0 b A α | 91.5 b B β | 86.5 ab A β | 92.0 b A β |
| TBF | 105.5 a A α | 80.0 b B β | 109.5 a A α | 104.5 a A α | 89.5 a B β | 99.5 a A α |
| CV (%) | 3.82 | | | | | |
| $R^2$ | 0.97 | | | | | |

* Means followed by the same letter (a) in the column for management, capital (A) in line for nitrogen and Greek source (α) for genotype did not differ statistically by Tukey test at 5% probability of error. Where *UR* – urea; *AN*– ammonium nitrate; *NN*– no nitrogen;*TIL* – tillering;*TLF* – tillering and flowering;*TBF* –tillering, booting and flowering; *CV* – coefficient of variation and *R²* – determination coefficient.

**Table 5. Results average of genotype x management x source for the character relationship tenacity / extensibility (P / L)**

| Management | Genotype | | | | | |
|---|---|---|---|---|---|---|
| | Fundacep 52 | | TbioMestre | | TbioItaipu | |
| | Nitrogen source | | | | | |
| | UR | AN | UR | AN | UR | AN |
| NN | 1.04 a B γ | 1.26 a A β | 1.61 a B β | 1.88 a A α | 2.29 a A α | 1.87 a B α |
| TIL | 0.76 b B β | 1.11 b A β | 1.22 b A α | 1.31 b A α | 1.18 bc A α | 1.29 b A α |
| TLF | 0.95 a A β | 0.77 c B γ | 1.12 bc B α | 1.38 b A α | 1.23 b A α | 1.15 c A β |
| TBF | 0.74 b B β | 1.08 b A α | 1.05 c A α | 1.05 c A α | 1.09 c A α | 1.03 c A α |
| CV (%) | 4.77 | | | | | |
| $R^2$ | 0.99 | | | | | |

* Means followed by the same letter (a) in the column for management, capital (A) in line for nitrogen and Greek source (α) for genotype did not differ statistically by Tukey test at 5% probability of error. Where *UR* – urea; *AN*– ammonium nitrate; *NN*– no nitrogen;*TIL* – tillering;*TLF* – tillering and flowering;*TBF* –tillering, booting and flowering; *CV* – coefficient of variation and *R²* – determination coefficient.

**Table 6. Results average of genotype x management x source for the character falling number (NQ)**

| Management | Genotype | | | | | |
|---|---|---|---|---|---|---|
| | Fundacep 52 | | TbioMestre | | TbioItaipu | |
| | Nitrogen source | | | | | |
| | UR | AN | UR | AN | UR | AN |
| NN | 364.5 b A α | 363.0 b A α | 366.5 c A α | 366.5 c A α | 370.5 a A α | 371.0 b A α |
| TIL | 364.0 b A β | 362.0 b A γ | 382.0 b B α | 426.0 a A α | 375.0 a B αβ | 393.0 a A β |
| TLF | 384.5 a B α | 369.5 a A β | 396.5 a A α | 400.0 b A α | 384.0 a A α | 385.0 a A αβ |
| TBF | 384.5 a A β | 377.5 a A β | 379.0 c B α | 393.5 b A α | 380.5 a A α | 387.0 a A αβ |
| CV (%) | 1.77 | | | | | |
| $R^2$ | 0.99 | | | | | |

* Means followed by the same letter (a) in the column for management, capital (A) in line for nitrogen and Greek source (α) for genotype did not differ statistically by Tukey test at 5% probability of error. Where *UR* – urea; *AN*– ammonium nitrate; *NN*– no nitrogen;*TIL* – tillering;*TLF* – tillering and flowering;*TBF* –tillering, booting and flowering; *CV* – coefficient of variation and *R²* – determination coefficient.

**Table 7. Results average results of genotype x management x source for the character wet gluten (GU)**

| *Management* | *Genotype* | | | | | |
|---|---|---|---|---|---|---|
| | Fundacep 52 | | TbioMestre | | TbioItaipu | |
| | *Nitrogen source* | | | | | |
| | UR | AN | UR | AN | UR | AN |
| NN | 32.81 c A α | 33.58 b A α | 31.20 b A β | 31.84 b A β | 21.85 d A γ | 21.00 c A γ |
| TIL | 40.80 b A α | 40.38 a A α | 37.64 a A β | 36.03 a B β | 29.33 b A γ | 28.86 b A γ |
| TLF | 40.86 b A α | 40.71 a A α | 38.18 a A β | 36.14 a B β | 30.35 a A γ | 29.28 b B γ |
| TBF | 42.79 a A α | 40.84 a B α | 38.36 a A β | 36.92 a B β | 26.66 c B γ | 31.40 a A γ |
| CV (%) | 1.29 | | | | | |
| $R^2$ | 0.99 | | | | | |

* Means followed by the same letter (a) in the column for management, capital (A) in line for nitrogen and Greek source (α) for genotype did not differ statistically by Tukey test at 5% probability of error. Where *UR* – urea; *AN*– ammonium nitrate; *NN*– no nitrogen;*TIL* – tillering;*TLF* – tillering and flowering;*TBF* –tillering, booting and flowering; *CV* – coefficient of variation and $R^2$ – determination coefficient.

The gluten strength and protein content are parameters successfully used in the selection of superiorgenotypes for industrial quality Kuchel *et al.*, 2006). It was found that the ammonium nitrate shows superiority to the TIL and TBFmanagements. The Tbio Mestre genotype has superiority for this character. Flour tenacity shows that the Fundacep 52 genotype in the NNandTLF managements have higher magnitudes for this character using ammonium nitrate (Table 3). The nitrogen sources reveal that the urea is higher than the TIL and TLF managements; in contrast, the ammonium nitrate was superior to the TBFmanagement. The TbioMestre genotype revealed for the NNmanagement higher performance for flour tenacity for urea and ammonium nitrate.For this genotype, it determines that the ammonium nitrate is higher in NN, TIL and TLF managements, and urea increases the character for TBF management. The TbioItaipu genotype when used urea the NN management reveals superiority to the tenacity. To the ammonium nitrate the managements NN and TIL were higher (Table 4). The TbioMestre genotypes are higher than the other genotypes.

The Fundacep 52 genotype in TIL and TBFmanagements proved to be superior to the others using urea (Table 4). TLFwasthe highermanagement for ammonium nitrate. The extensibility and the protein content represent the dough ability to expand without breaking it.The greater the extensibility, the lower the flour yield (Módenes*et al.*, 2009). For this genotype urea demonstrates higher for NN,TIL and TBF managements; in contrast, the ammonium nitrate shows better results for the TLFmanagement. The TbioMestre genotype demonstrated higher extensibility for urea and ammonium nitrate to TBF management. For TbioItaipugenotypethe superiorityis givento theextensibility character in TBF management in both sources. Moraes*et al.* (2013), reported that increased nitrogen dose promotes alveography parameters improvement.

The P/L ratio indicates that the Fundacep 52 genotype was higher than the NN and TLF managements using urea and ammonium nitrate (Table 5). This response is linked to glutenin and gliadin content present in gluten, which increase the P/L ratio and predisposes to increasedglutenin (high elasticity proteins) that reduce the extensibility while reduced P/L ratio indicates increased gliadin characterized as low elasticity proteins (Mandarino, 1994). The TbioMestre and TbioItaipu genotypes have the highest P/L ratio due to the lack of nitrogen in coverage, through urea and ammonium nitrate. Cazetta *et al.* (2008) show that increase in nitrogen causes increased general gluten strength and reduced P/L ratio, with improved flourquality for baking. It demonstrates that TbioMestre and TbioItaipu had higher P/L ratio thanthatofFundacep 52.

The Fundacep 52 genotypes in the TLF and TBF managements have the highest number of drop (ND) with urea, to ammonium nitrate the superiority is showedby TBFmanaging (Table 6). The nitrogen supply promoteshigher protein synthesis, and minimizes the effects of α-amylase enzyme when there is excess of humidity after physiological maturation of grains (Derera, 1989). The starchdegradation, protein reserves, such as gliadins, are rapidly degraded by α-amylase when compared to the glutenins. The ammonium nitrate expressed superiority over the urea to TLF management. The TbioMestregeno type in the TLFmanagementwith urea and, the TIL management with ammonium nitrate show dropping number higher than the other treatments.

The TbioItaipu genotype showed up no significant withurea addition, though for ammonium nitrate theTIL, TLF and TBF managements demonstrated largestdroppingnumber, nitrogen coverage resulted in thehighestdropping number, as Miranda *et al.* (2011), found that the nitrogen availability in the soil, did not result in response to wheat technological quality. The Fundacep 52genotype (Table 7) shows that the use of urea allows obtaininghig herhumid gluten for TBF management. Due to the nitrogen supply in the grain filling stage, and result in increased synthesis of forming proteins of gluten, gliadin and glutenin (Fuertes-Mendizábal *et al.*, 2010). The ammonium nitrate expresses greater effect to this characterfor TIL, TLF and TBF managements. The glutenis characterized by being three-dimensional viscoelastic dough, which provides important characteristics of elasticity, plasticity and viscosity for the dough (Costa *et al.*, 2008). The TbioMestre genotype expressed to the TIL, TLF and TBF managements superiority to the humid gluten character (HG) using urea, in contrast, the ammonium nitrate is superior forTIL, TLF and TBF managements. Regarding the sources, urea was superior in TLF management, as well as for the ammonium nitrate in the TBFmanagement. Fundacep 52 Genotype is superior to humid gluten character over other genotypes.

## Conclusions

- Technological quality parameters are influenced by the managements, nitrogen sources and genotypes.

- Nitrogen management with urea and ammonium nitrate has no influence in protein content.
- TbioMestre genotype has higher gluten content, tenacity and extensibility when urea is applied at tilleringand flowering, for the ammonium nitrate the best responses are obtained for dropping numbers.

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