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Doses and Stages of Application of Nitrogen In The Wheat Culture

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ABSTRACT

Triticum aestivum is considered a high yield crop, climate factors, handling and nutrition can compromise its yield. Regarding the nutrition of *T. aestivum*, nitrogen is a limiting factor in production, being one of the most absorbed and required elements. Nitrogen deficiency interferes with the growth and development of the plant, because this element is fundamental in the formation of compounds, like all proteins and nucleic acids. The objective of this research was to evaluate the wheat production components with the application of nitrogen in different doses and times and thus to indicate the appropriate management for the application of this nutrient in the crop under the edaphoclimatic conditions of the Southwest region of Paraná. The experiment was carried out in a randomized block design, with plots subdivided into five replicates. The treatments were composed of four nitrogen doses (0, 50, 100, 200 kg ha⁻¹) and three application stages (tillering, booting and grouting). The variables evaluated were the severity of the disease (%), plant height (cm), fresh plant mass (kg ha⁻¹), plant dry mass (kg ha⁻¹), number of growing spikes (m²), yield (ha⁻¹), number of spikelets per ear, weight of grain and weight of hectoliters. The results were submitted to analysis of variance using the Assistat statistical program for later comparison of the means by regression analysis. There was interaction between treatments for fresh and dry mass varied. The number of cultivars, plant height (cm), spikelets per spike, peaks per m² and yield (ha⁻¹) were significant for the doses. As to the severity of the diseases and the weight of the hectoliters, they did not present any significance. The highest productivity was obtained with the application of 110.4 kg ha⁻¹ in the cropping of the crop. However, the need to develop further studies to suit the most ideal phenological stage for nitrogen application as well as the dose.

INTRODUCTION

Belonging to the Poaceae family, *Triticum aestivum* has great importance in human and animal feeding since the beginnings of civilizations. Considered a high-yielding crop, climate factors, management and nutrition may compromise its yield. Regarding nutrition of *T. aestivum*, nitrogen is a limiting factor in production, being one of the elements most absorbed and required.

Nitrogen deficiency interferes with the growth and development of the plant, because this element is fundamental in the formation of compounds, like all proteins and nucleic acids. The symptoms of lack of nitrogen are presented with yellowing, especially in older leaves, called chlorosis. The intensification of their

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deficiency can lead to leaf fall (Lacerda, EneasFilho and Pinheiros, 2007).

The application of nitrogen at the right moment and in adequate doses in wheat improves the efficiency of its yield components, maximizing the number of grains per spike and the number of spikes per area (Sangoi *et al.*, 2007). However, the application of nitrogen early or at later stages of the phenology can be less utilized by the plants, consequently affecting the yield components, demonstrating that during the plant cycle there are more suitable phenological stages for the application of this nutrient (Silva *et al.*, 2005).

In wheat cultivation the nitrogen is the mineral element of greater cost. However, it is observed that almost all of the wheat producers in the Southwest of Paraná do not have adequate technical and scientific parameters to follow, and that it is necessary to develop efficient nitrogen application protocols for the crop in question.

In this sense, it is not known about the nitrogen dose and the ideal phenological stage of application so that the best results can be achieved, since there is no specific research for the southwestern region of the state of Paraná.

Thus, the objective of this research was to evaluate the wheat production components with the application of nitrogen in different doses and times and, thus, to indicate the appropriate management for the application of this nutrient in the crop under the edaphoclimatic conditions of the Southwest region of Paraná.

MATERIAL AND METHODS

The experiment was conducted at the Experimental Farm of União de Ensino do Sudoeste do Paraná - UNISEP, located in Dois Vizinhos - PR. The region covers the third paranaense plateau, with an average altitude of 520m. The predominant climate in this region is the mesothermic wet subtropical (Cfa), according to Koppen classification (Alvares *et al.*, 2014). The soil is classified as red dystroferric nitosol, wavy relief and clay texture (Bherring *et al.*, 2008).

The cultivar of wheat used was Mestre, of the company Biotrigo®. among the main characteristics of this cultivar we can mention the high productivity and industrial quality, due to the high percentage of protein in the grain, besides good gluten strength. Being classified as breeder wheat, it produces gluten without the need for differentiated N management. It is a medium-cycle cultivar (Biotrigo, 2012).

The sowing of wheat was performed on July 4th (2014), with a density of 450 plants per m² and spacing between rows of 0,17m. The seeder used for planting has a continuous flow system. The seeds used were treated using commercial dose of the insecticidal product, systemic based on imidacloprid + thiodicarb.

The experimental area was dried 40 days before planting. The soil was corrected based on soil analysis performed in the area. The base fertilization used was 8-20-18 (NPK), with 292 kg ha⁻¹.

The statistical design used was a randomized block design, in a split - plot factorial scheme, with five replications. The plots, of 10m x 3m were constituted of three application stages being tillering, booting and grouting. The 2,5m x 3m subplots consisted of treatments with different doses of N (0, 50, 100, 200 kg ha⁻¹), using urea as the N source, thus totaling 15 main plots and 60 subplots.

Cultural managements were made according to the need of the crop. The control of weeds was carried out with herbicide of the class sulfonylurea based on iodosulfuron-methyl at the dose of 0,1 kg ha⁻¹, insecticides with active principle based on imidacloprid + beta-cyfluthrin (0,75 L ha⁻¹), and triflumuro (0,03 L ha⁻¹), respectively, were used to control pest insects such as leafhopper (*Metopolophium dirhodum*), green belly bug (*Dichelops melacanthus*) and wheat caterpillar (*Pseudaletia sequeax*). Fungicides based on trifloxystrobin + prothioconazole (0,5 L ha⁻¹) and trifloxystrobin + tebuconazole (0,75 L ha⁻¹), together with the soybean oil methyl ester adjuvant (0,25% (250 ml / 100 L of water)) were used to prevent and control diseases such as wheat rust (*Puccinia triticina*), giberela (*Gibberellazeae*) and brusone (*Byricularia grisea*).

In order to compare the effect of treatments on crop development and productivity, disease severity (%), plant height (cm), fresh plant mass (kg ha⁻¹), dry plant mass (kg ha⁻¹), number of tillers (m²), number of spikes (m²), yield (ha⁻¹), number of spikelets per spike, grain weight and hectoliter weight were measured.

The severity of diseases was evaluated three times, these being always done before the application of chemical products, pulling off three plants per subplot, respecting 0,20m of border for further evaluation. For a better understanding of the results, the diagrammatic scale of the Empresa Brasileira de Pesquisa Agropecuária (Embrapa, 2014) was used.

The tiller count was performed at the tillering stage of the crop, along with the first green mass collection, where 0,25m² of plants were collected from each subplot, counted manually.

With the aid of a ruler, the height of 20 plants per plot was randomly collected at three stages of development of the tillering, booting and grouting. These collections were carried out according to the application schedule of N.

For the evaluation of fresh mass, 0,25m² of plants were collected and packed in paper bags. The data was obtained after the collection with the help of a precision scale. The collected material was taken for drying in a continuous air flow oven where it remained for three days, with a fixed temperature of 55°C, for later weighing of dry mass.

The main parameters of productivity were evaluated when the culture presented the physiological maturation, and for the analysis of spikelets per spikes and number of spikes (m^2), were collected $0,25\text{m}^2$ of plants, for later manual counting. For final yield, $2,0\text{m}^2$ of plants were collected from the area of each plot, where they were manually traced and then weighed.

After collecting all data previously mentioned, the hectoliter weight classification was based on the productivity of each plot.

The results were submitted to variance analysis using the software Assistat (Silva and Azevedo, 2009), for later average comparison by regression analysis.

RESULTS AND DISCUSSION

There were no statistical differences in disease severity, showing that there was no influence of the doses and stages of application of N in the culture on this variable Table 1. However, this differs from the results obtained by Tanaka *et al.*, (2008), who in their evaluation of two wheat cultivars, with the use of nitrogen fertilizations, found plants more susceptible to the attack of diseases with the increase of N dose, leading to losses and thus reducing productivity.

The high severity of diseases may be related to planting density, which favors the development of favorable environments for development and diseases. According to Baccar *et al.* (2011), the high density of plants associated with reduced spacing may lead to a higher incidence of diseases. According to EMBRAPA Trigo (2003), the excess of N in plants promotes a significant growth in the foliar area and increase of the tillering of the culture. This may cause foliar self-shading, resulting in the formation of a micro-climate favorable to the appearance and development of fungi. In addition, this situation can cause fungal infection to be potentiated.

Table 1: Severity of diseases (%) in wheat crop with the application of doses of N at different stages. Dois Vizinhos – PR, 2015

Stages	Doses (kg ha^{-1})			
	0 ^{NS}	50 ^{NS}	100 ^{NS}	200 ^{NS}
Tillering	40,73	40	35,53	36,6
Booting	34,87	33,27	40,33	33,07
Grouting	44,07	43,27	41,47	42,27
CV% stages: 41,78	CV% doses: 30,22			

NS: Averages not significant by Tukey's test ($\alpha = 0,05$).

CV (%): Coefficient of variation.

The high value of the CV (%) found (Table 1) is related to the high variation of the data, justifying the non-significance of the results analyzed.

For the analysis of the number of tillers per m^2 , it was observed that there was no interaction between the treatments, however, for N application in the tillering stage the results were adjusted to a linear regression, with a low coefficient of determination of the equation ($R^2 = 0,535$) Figure 1. It is shown that the application at this stage presents a greater number of tillers per m^2 , directly interfering with the final yield, assuming that for each new tiller that completes the crop cycle, a viable spike is obtained.

These results are similar to those found by Zagonel *et al.*, (2002), that also observed an increase in the number of viable tillers per plant with the increase of N, applied in cover, up to the dose of 105 kg ha^{-1} . The results collaborate with EMBRAPA Wheat (2003), which explains that the application of high doses of nitrogen in wheat provides greater leaf area and increase of tillering. Regarding the tillering of grasses, it is related to the use of these as source of energy reserves that can be used by the main plant in case of necessity due to some stress suffered by the crop.

Fig. 1: Number of tillers (m²) in wheat crop with the application of doses of N in different stages. Dois Vizinhos – PR, 2015.

The plant height results were adjusted to a quadratic regression for the application stage of N in the tillering, reaching its maximum technical efficiency (MET) at the dose of 150 kg ha⁻¹. Above this, therefore, the variable had no influence on the treatments performed. For the application during booting and grouting stages, there were no statistical differences among treatments Figure 2. Yano (2005), observed significant results for plant height (cm), when the anticipation of the application of N in wheat favored its development. However, Teixeira Filho *et al.*, (2010) did not found statistical differences with the use of N in wheat crop, where, regardless of the dose used, there was no increase in plant height, final plant stand, number of grains per spike and mass of 1000 grains.

Fig. 1: Plant height (cm) in wheat crop with the application of doses of N in different stages. Dois Vizinhos – PR, 2015

For the variable fresh mass of plant there was interaction between treatments (doses x stages), so the results were represented with the qualitative factors (stages) in each quantitative factor (doses). The results obtained differed statistically for the staging treatments during tillering and booting, and for tillering the regression was adjusted in an increasing linear form, that is, increasing the N dose increases the amount of fresh plant mass by area.

For booting, the values were adjusted to a quadratic regression, where it is observed that this treatment reaches its maximum technical efficiency (MET) with the dose of 114,28 kg ha⁻¹ Figure 3. For Malavolta (2006), the N is the major responsible for the plant growth, reflecting in the increase of the leaf area and,

consequently, in the increase of the mass per plant. This is in accordance with EmbrapaTrigo (2003), which points out that the N supplement promotes the increase in leaf area index.

For the results of the dry plant mass, interaction between the treatments (doses x stages) also occurred, it is observed that the results referring to the stage of application in the tillering were adjusted to the linear regression and the results referring to the stagebooting to a quadratic regression equation, as was the case with the variable fresh plant mass.

Fig. 2: Fresh plant mass(kg ha⁻¹) in wheat crop with the application of doses of N in different stages. Dois Vizinhas – PR, 2015.

The fresh mass production figure 4 its maximum technical efficiency found at the beginning of the stage was with the dose of 117.2 kg ha⁻¹. Similar results were found by Viana and Kiehl (2010), when they worked with different doses of N and Potassium (K) in wheat growth, where the combined application of higher N and K doses increased the dry matter yield of the aerial part. Espindula (2010) verified an increase in dry matter as the N dose increased, with application of 120 kg N ha⁻¹, yielding a production of 12,000 kg ha⁻¹. On the other hand, Souza *et al.* (2013) obtained the maximum dry matter production of the aerial part occurred in the dose of N 165 mg dm⁻³.

Fig. 3: Dry plant mass (kg ha⁻¹) in wheat crop with the application of doses of N in different stages. Dois Vizinhas – PR, 2015.

For the number of spikelets per spike the values were adjusted to a linear regression. Regardless of the dose of N applied, they stood out in relation to the control (0 kg ha⁻¹) in the three stages evaluated Figure 5. However, for the dose 200 kg ha⁻¹, applied in the tillering, 2% more was obtained than in the booting stage and 3,39% more in the grouting, which reflects directly in the productivity Figure 5. A similar result was found by Benett *et al.* (2011), which found a significant effect on the number of spikelets per spike, number of grains per spike and the hectoliter mass, when N was used as cover.

Fig. 4: Number of spikelets per spike in wheat crop with the application of doses of N in different stages. Dois Vizinhas – PR, 2015

The results obtained regarding the evaluation of the hectoliter weight were not significant. Characterizing the non-influence of this variable in relation to the doses and the stages of application of N in the culture Table 2. The climatic behavior directly influences wheat quality and yield, which may explain the non-significance of the results obtained since the rainfall during the conduction of the experiment was low which positively influenced the quality of the grains raising the pH in the different doses of nitrogen.

Similarly, Ormond *et al.*, (2013) stresses the pH of wheat is what directly reflects the yield of grains in flour or semolina. The higher the pH the higher the yield, there are three types of wheat and each of these types have a specific minimum value ranging from 72 to 78 (Conab, 2016).

Results were different from those found by Coelho *et al.* (1998), where the weight of hectoliter, in two years of evaluation of wheat irrigated with application of N in cover, reduced linearly with the increment of the doses. Experiments conducted by Oliveira *et al.* (2013) point out that they did not obtain differences with different N dosages, and these dosages ranged from 0 to 120 Kg ha⁻¹ of N and the PH remained at 79. However, Trindade *et al.*, (2006) obtained a different result, as the dosage of N increases, linearly decreases the pH of the wheat.

Table 1: Hectoliter weight in wheat crop with the application of doses of N in different stages. Dois Vizinhas – PR, 2015

Stages	N doses (kg ha ⁻¹)			
	0 ^{NS}	50 ^{NS}	100 ^{NS}	200 ^{NS}
Tillering	77,6	75,2	77	77
Booting	76	77,4	77,6	75,2
Grouting	77	76,4	75,2	77,2
CV(%) stages: 3,16		CV(%) doses: 2,85		

NS: Averages not significant by Tukey's test ($\alpha=0,05$).

CV (%): Coefficient of variation.

In relation to the number of spikes per m², linear regressions were adjusted to the data for the grouting stage ($R^2 = 0,65$) and for tillering ($R^2 = 0,84$) Figure 6. Negative effects of doses of N were observed. The dose 0 kg ha⁻¹ presented the highest values of spikes per m² and the dose of 100 kg ha⁻¹ showed the lowest results. Based on these results, there is a negative relation between the increase in N doses and the number of spikes per m². This can be explained by the fact that the crop in question has undergone a considerable period of lack of rain in the months of August and September, providing a period of stress for the plants when the spikes were in formation.

In turn, Gross *et al.*, (2012) verified when, in addition to sowing density, a linear reduction occurred in the values, a fact explained by the greater intra-specific competition of the resources of the environment, especially in the higher density of sowing evaluated.

Fig. 5: Number of spikes (m²) in wheat crop with the application of doses of N in different stages. Dois Vizinhos – PR, 2015

When in periods of stress, the tillers can be used as reserves for the plants and do not develop spikes, which confirms the result obtained. Different results were found by Yano *et al.* (2005), where there was no significance for the number of spikes per m² applying different doses of N. In relation to the stages of application there were no statistical differences. A similar result to that found by Megda *et al.*, (2009), where no significant effects were verified when the sources and stages of application of N in wheat in the Cerrado were studied.

For yield (kg ha⁻¹), in the tillering stage the data adjusted to a linear regression. This fact demonstrates that higher doses of N could be tested, since 3093,06 kg ha⁻¹ was produced with the dose of 200 kg ha⁻¹ of N Figure 7. During the early stages of the crop, the nutrient is needed to increase the maximum number of spikelets per spike and consequently increase productivity (Bredemeier and Mundstock, 2001).

Fig. 6: Yield (kg ha⁻¹) in wheat crop with the application of doses of N in different stages. Dois Vizinhos – PR, 2015

For the booting stage no regression equation was fitted to the data. For the grouting, a quadratic adjustment was observed, where the maximum technical efficiency (MET) was with the dose of 110,4 kg ha⁻¹ of N, corresponding to a yield of 3018,54 kg ha⁻¹. This shows that the use of N dosages greater than this will not result in gains for the crop at this time under the conditions tested. This result is in agreement with the data of Teixeira Filho *et al.* (2010), where N rates influenced wheat grain yield in 2006 and 2007, and adjusted to the quadratic functions, with the maximum productivity reached, respectively, with the estimates of 122 and 121 kg ha⁻¹ of N under irrigated production conditions.

If in the tillering this dose was used, only 2747,76 kg ha⁻¹ would be produced, that is, 270,78 kg ha⁻¹ less, which demonstrates greater effectiveness in the use of this element in the grouting. This is due to the nitrogen fertilization during grouting to increase the N availability before filling the grains, and thus, to provide a greater synthesis of proteins, resulting in increased productivity and industrial quality of the grain (Rosso *et al.*, 2014).

The average productivity of the Southwest region of Paraná is 3220 kg ha⁻¹, but the use of urea is 250 kg ha⁻¹ max, corresponding to 112,5 kg ha⁻¹ N. On the basis of these results, this dose used in the tillering stage would achieve a productivity of 9,3% less than if used in the grouting stage.

Conclusions:

The different N application times did not influence the wheat production parameters, which were influenced only by the different doses tested.

Disease severity was not influenced by the treatments tested under the conditions tested.

The application of N in the Tillage in the wheat crop linearly increased productivity. Therefore, larger doses should be tested

For the variable plant height, the maximum technical efficiency (MET) was found with the dose of 150 kg ha⁻¹.

There was interaction between the treatments for the green and dry mass variables.

The weight of the hectoliter was not influenced by the treatments tested.

The increase in N rates reduced the number of spikes per m² and increased the number of spikelets per spike.

The highest yield was obtained with the application of 110.4 kg ha⁻¹ in the crop gutting.

However, the need to develop further studies to suit the most ideal phenological stage for nitrogen application as well as the dose.

Future Work:

To evaluate the application of different doses of nitrogen in the double ring stage - DR and terminal spikelet - TS, as they are phenological stages that have great relation in yield and final quality of the grains in an attempt to maximize productivity.

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