

## Response of wheat to foliar application of zinc

### Resposta do trigo à aplicação foliar de zinco

Tiago Zoz<sup>1\*</sup> Fábio Steiner<sup>1</sup> Rubens Fey<sup>11</sup> Deise Dalazen Castagnara<sup>11</sup> Edleusa Pereira Seidel<sup>11</sup>

#### - NOTE -

#### ABSTRACT

Wheat is grown in Brazil, mostly in no-till, a system in which the zinc can become potentially deficient, due to excessive application of acidity corrective and phosphate fertilizers in surface and, or at shallow depths. This study aimed to evaluate the effect of foliar application of zinc in agronomic characteristics and yield of wheat. The experimental design was randomized blocks with five replications. Treatments consisted of four doses of zinc (0, 54, 108 and 216g ha<sup>-1</sup> Zn), divided into two foliar applications, the first at tillering (18 days after plant emergence) and the second at the boot stage (65 days after emergence). Foliar application of zinc increased the number of fertile tillers and yield of wheat, however, have little effect on the agronomic characteristics of no-tilled crop with high nutrient content in soil.

**Key words:** *Triticum aestivum*, plants nutrition, tillering, foliar fertilization.

#### RESUMO

O trigo é cultivado, no Brasil, predominantemente, em semeadura direta, sistema em que o Zn pode tornar-se potencialmente deficiente, em decorrência da aplicação excessiva de corretivos da acidez e de fertilizantes fosfatados em superfície e/ou em pequenas profundidades. Este estudo teve como objetivo avaliar o efeito da aplicação foliar de zinco nas características agrônomicas e produtividade do trigo. O delineamento experimental utilizado foi em blocos casualizados, com cinco repetições. Os tratamentos constituíram-se de quatro doses de zinco (0; 54; 108 e 216g ha<sup>-1</sup> de Zn), divididas em duas aplicações foliares: a primeira no aphilamento (18 dias após a emergência das plantas) e a segunda no início do emborrachamento (65 dias após a

emergência das plantas). A aplicação de Zn, via foliar, aumentou o número de aphilos férteis e a produtividade de trigo, porém tem pouco efeito nas características agrônomicas da cultura em sistema de semeadura direta com teor alto de nutriente no solo.

**Palavras-chave:** *Triticum aestivum*, nutrição de plantas, aphilamento, adubação foliar.

In Brazil, wheat is mainly grown in no-till system in which zinc can become potentially deficient, mainly due to the increasing nutrient critical level in the soil (MOTTA et al., 2007). The increase in the critical Zn level in no-tillage is due to higher levels of pH, organic matter and available P in topsoil acting antagonistic to Zn (SINGH & CHOUDHARY, 2002). In some wheat crops from central southern Paraná, Zn deficiency has occurred in the early stages of plant growth, which in most cases disappear with crop development. Such symptoms of deficiency have as possible causes the initial growth of roots near the fertilization line where there is higher P concentrations, higher pH in the surface layer and higher organic matter content. Spontaneous disappearance of symptoms and disability indicates the importance of the available Zn concentration in lower soil layers (MOTTA et al., 2007).

Considering these problems, plus the difficulty of distributing small quantities of fertilizer in the field, alternative methods have been sought for Zn

<sup>1</sup>Departamento de Produção Vegetal, Faculdade de Ciências Agrônomicas (FCA), Universidade Estadual Paulista Júlio de Mesquita Filho (UNESP), Rua José Barbosa de Barros, 1780, CP 237, 18610-307, Botucatu, SP, Brasil. E-mail: tiagozoz@fca.unesp.br.

\*Autor para correspondência.

<sup>11</sup>Centro de Ciências Agrárias, Universidade Estadual do Oeste do Paraná (UNIOESTE), Marechal Cândido Rondon, PR, Brasil.

application, as apply it to seeds and leaves (ORIOLO JUNIOR et al., 2008). However, the effectiveness of foliar application depends on processes of nutrients penetration through the cuticle, foliar uptake by cells and transport via phloem for preferential drains (RODRIGUES et al., 1997). For this reason, Zn uptake by leaves will depend on several factors such as: leaves characteristics, particularly regarding the cuticle thickness; spraying techniques; climatic conditions; chemical characteristics of the applied solution and also, the plant's internal ionic state (MARTINEZ et al., 2005).

Significant increases in grain yield with foliar Zn application have been reported in other crops such as rice (CAKMAK, 2008), triticale (CAKMAK et al., 1997), common beans (TEIXEIRA et al., 2004) and maize (POTARZYCKI & GRZEBISZ, 2009). The nutritional requirement of zinc is specific to each culture (MOTTA et al., 2007), but cereals are more responsive. For wheat crop studies involving foliar Zn application are incipient in Brazil. One of the few studies addressing the issue under Brazilian conditions was performed by ORIOLO JUNIOR et al. (2008) in a green house but not evaluating productivity. This study aimed to evaluate the effect of foliar zinc application in agronomic characteristics and yield of wheat in no-till system.

The experiment was carried out in Maripá, Parana, Brazil (24°22' S, 53°44' W, altitude of 380m). The soil is a Rhodic Hapludox (Latossolo Vermelho eutroférico in the Brazilian classification), with 775g kg<sup>-1</sup> of clay, 125g kg<sup>-1</sup> of silt, and 100g kg<sup>-1</sup> of sand. Samples were taken from the arable layer (0-20cm), air dried, sieved through a 2.0mm mesh, and analyzed as in PAVAN et al. (1992). Soil chemical analysis showed pH (CaCl<sub>2</sub> 0.01M): 5.0, O.M.: 28g dm<sup>-3</sup>, P<sub>Mehlich-1</sub>: 15mg dm<sup>-3</sup>, H+Al: 5.4cmol<sub>c</sub> dm<sup>-3</sup>, K: 0.7cmol<sub>c</sub> dm<sup>-3</sup>, Ca: 7.0cmol<sub>c</sub> dm<sup>-3</sup>, Mg: 1.5cmol<sub>c</sub> dm<sup>-3</sup>, CEC: 14.7cmol<sub>c</sub> dm<sup>-3</sup>, 63% of base saturation, Cu<sub>Mehlich-1</sub>: 15mg dm<sup>-3</sup> and Zn<sub>Mehlich-1</sub>: 1.8mg dm<sup>-3</sup>. The area has been cultivated in no-till since 1996 and the area was planted to soybeans/winter corn and soybean/wheat, in the harvests 2006/07 and 2007/08, respectively.

The experimental design was randomized blocks with five replications. Treatments consisted of four zinc doses (0, 54, 108 and 216g Zn ha<sup>-1</sup>), divided into two foliar applications, the first one at tillering (18 days after plants emergence) and the second at booting (65 days after plants emergence). The Zn source used was Ubyfol ML-Zn<sup>®</sup> liquid fertilizer [10% Zn (ZnCl<sub>2</sub>) and 90% inert material]. Doses were defined according to the recommended product application to the wheat crop (108g ha<sup>-1</sup>). Applications were performed with a CO<sub>2</sub> pressurized sprayer with 0.8MPa working pressure

capacity, equipped with flat fan nozzle, adjusted to apply 165L ha<sup>-1</sup> broth. Applications were performed at dusk due to a lower likelihood of drift by wind speed reduction and higher relative humidity. After each application, a minimum period of 72 hours without rain was observed, enabling the best use of the product. Each experimental plot consisted of ten 6.0m long rows, considering the six central lines as floor area, ignoring 1.0m from the ends of each row.

Wheat sowing, CD 104 cultivar (medium cycle and low stature) was performed on 04/26/2008 with moto-mechanized planter in 0.15m spaced rows, using 350 seeds m<sup>-2</sup>. The basic fertilization at wheat sowing was carried out by applying 500kg ha<sup>-1</sup> 04-20-20 formulation and 80kg ha<sup>-1</sup> N topdressing at the beginning of plant's tillering as urea. Pests and diseases control was carried out with two applications of azoxystrobin + cyproconazole, methamidophos and lufenuron at 60g a.i. ha<sup>-1</sup> + 24g a.i. ha<sup>-1</sup>, 120g a.i. ha<sup>-1</sup> and 5g a.i. ha<sup>-1</sup>, respectively.

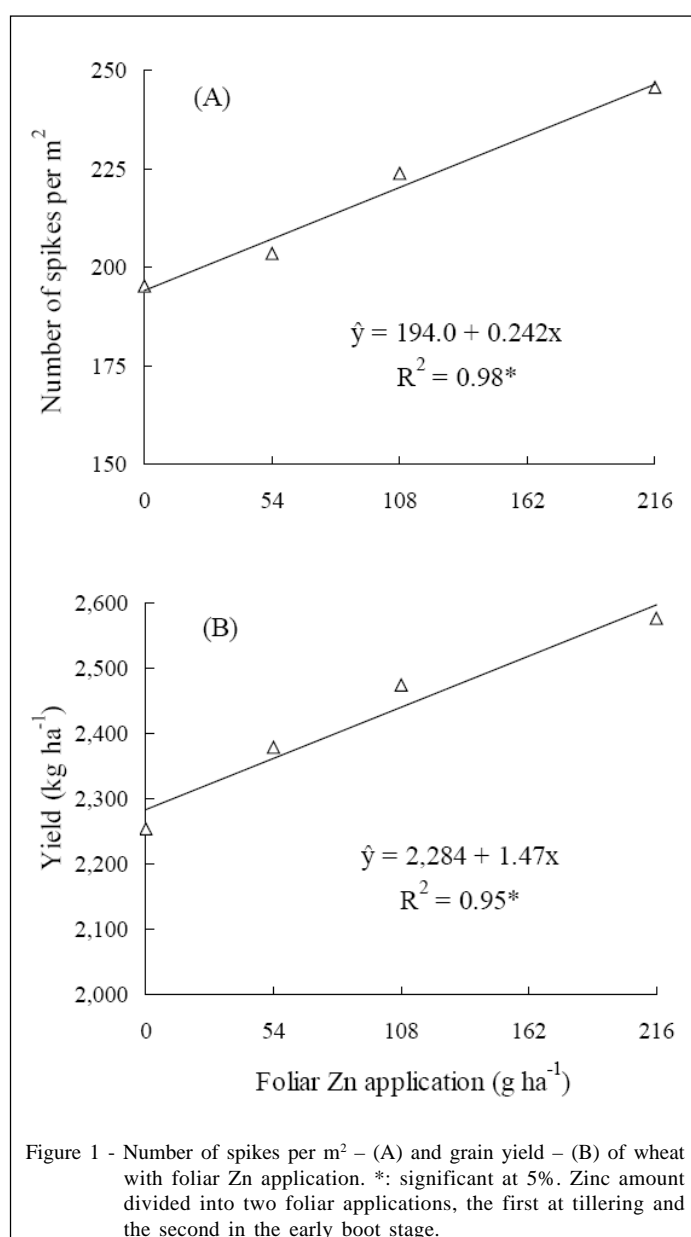
Wheat harvest was performed manually on 08/27/2008, collecting all plants contained in the working area. Agronomic characteristics of the crop were assessed against the following variables: plant height, flag leaf insertion height, stem diameter, number of spikes per square meter, length and spike mass, grain mass per spike, hectoliter weight, thousand grain mass and grains yield corrected to 130g kg<sup>-1</sup> water content - wet basis. Data were subjected to analysis of variance and regression, choosing the significant model with higher coefficient of determination.

Foliar zinc application did not affect most of agronomic features of wheat crop. The plant height, flag leaf insertion height and stem diameter were 79.4±2.6cm, 55.6±3.9cm and 3.80±0.18mm, respectively. Spike length, spike mass, number of grains per spike, hectoliter weight and thousand grains mass were 8.74±1.98cm, 3.68±1.14g, 45.1±5.8unit, 79.4±0.7g and 52.2±3.2g, respectively. The little effect of foliar Zn application on the agronomic characteristics of wheat crop observed in this study can be attributed to the appropriate content on soil (2.4mg dm<sup>-3</sup>). According to BORKERT et al. (2006), soils with Zn content above 1.5mg dm<sup>-3</sup> determined by Mehlich<sup>-1</sup> extractor can be considered adequate for plant growth. This statement is in line with the results of ZEIDAN et al. (2010), who found that wheat response to Zn fertilization in soil, in which this nutrient content was 0.13mg dm<sup>-3</sup> rated as deficient. If wheat plants can absorb enough zinc in soil solution, foliar Zn possibly has little effect on the agronomic and nutritional features of the crop (ZHAO et al., 2011). However, such inference will depend on whether the Zn supply in the soil is sufficient for plants.

The number of spikes per unit area was affected by the application of Zn concentrations in leaves (Figure 1A). The application of 216g Zn ha<sup>-1</sup> allowed to obtain 26% increase in the number of wheat spikes per square meter compared to non-supply of nutrient. The increase in the number of spikes per unit area was due to the higher number of fertile tillers per plant at the end of the cycle. Similarly, SEADH et al. (2009) showed that foliar Zn application provided 21% increase in the number of wheat spikes per m<sup>2</sup>. The lowest Zn supply to wheat plants promotes reduction in the number of tillers mainly because stems become

thinner and lose their turgidity, a phenomenon called soft stems (RÖMHELD, 2001). The emergence, development and survival of tillers are of extreme importance for the crop. This character is directly related to the number of spikes per unit area and indirectly to yield components: number of grains per spike and grain mass (DAVIDSON & CHEVALIER, 1990).

Wheat yield increased with zinc application to leaves (Figure 1B). The application of 216g ha<sup>-1</sup> Zn allowed obtaining 14% increase in wheat yield compared to the absence of Zn supply. The highest wheat yield with foliar Zn application can be attributed to the



increased number of spikes per unit area (Figure 1A), due to higher number of fertile tillers per plant. According to OZTURK et al. (2006), the highest wheat yield is closely related to the cultivar potential to produce fertile tillers, which also influences directly the number of spikes produced per unit area.

Significant increases in wheat grains yield to foliar Zn application were reported in other countries including Egypt (SEADH et al., 2009; ZEIDAN et al., 2010) and China (ZHAO et al., 2011) corroborating data obtained in this study to the Brazilian conditions. Such effects of foliar Zn application may be due to its role in crop growth (CAKMAK, 2008), involving processes of photosynthesis, nitrogen assimilation, respiration and activation of other biochemical and physiological processes and hence their importance in obtaining greater yields. It is noteworthy also that Zn translocation applied to leaves depends on the plant nutritional status (MARTINEZ et al., 2005). Thus, it can be inferred that due to the high micronutrient availability in the soil, there was greater use and Zn translocation applied to wheat leaves.

Zinc application to leaves increased the number of fertile tillers and wheat yield; however, it had no effect on the agronomic characteristics of crop in no-till system with high nutrient content in soil.

## REFERENCES

- BORKERT, C.M. et al. Cálculo do nível crítico de zinco trocável em solos do Paraná. In: CONGRESSO BRASILEIRO DE SOJA, 4., 2006, Londrina, PR. **Resumos...** Londrina: Embrapa Soja, 2006. 4p.
- CAKMAK I. Enrichment of cereal grains with zinc: agronomic or genetic biofortification? **Plant and Soil**, v.302, n.1-2, p.1-17, 2008. Available from: <<http://www.springerlink.com/content/px14153568r06395/fulltext.pdf>>. Accessed: May 12, 2011. doi: 10.1007/s11104-007-9466-3.
- CAKMAK, H. et al. Differential response of rye, triticale, bread and durum wheat to zinc deficiency in calcareous soils. **Plant and Soil**, v.188, n. 1, p.1-10, 1997. Available from: <<http://www.springerlink.com/content/n5514550577g2774/fulltext.pdf>>. Accessed: May 12, 2011. doi: 10.1023/A:1004247911381.
- DAVIDSON, D.J.; CHEVALIER, P.M. Preanthesis tiller mortality in spring wheat. **Crop Science**, v.30, n.4, p.832-836, 1990. Available from: <<http://agris.fao.org/agris-search/search/display.do?f=1990%2FUS%2FUS90419.xml%3BUS9050484>>. Accessed: May 21, 2011.
- MARTINEZ, H.E.P. et al. Translocação e compartimentalização de Zn em função de doses aplicadas em feijoeiro e cafeeiro via radicular. **Ciência Rural**, v.35, n.3, p.491-497, 2005. Available from: <<http://www.scielo.br/pdf/cr/v35n3/a01v35n3.pdf>>. Accessed: May 16, 2011. doi: 10.1590/S0103-84782005000300001.
- MOTTA, A.C.V. et al. **Micronutrientes na rocha, no solo e na planta**. Curitiba: UFPR, 2007. 246p.
- ORIOLO JÚNIOR, V. et al. Modos de aplicação de zinco na nutrição e na produção de massa seca de plantas de trigo. **Revista de la Ciencia del Suelo y Nutrición Vegetal**, v.8, n.1, p.28-36, 2008. Available from: <<http://www.scielo.cl/pdf/rcsuelo/v8n1/art03.pdf>>. Accessed: Apr. 28, 2011. doi: 10.4067/S0718-27912008000100003.
- OZTURK, A. et al. Growth and yield response of facultative wheat to winter sowing, freezing sowing and spring sowing at different seeding rates. **Journal of Agronomy and Crop Science**, v.192, n.1, p.10-16, 2006. Available from: <<http://onlinelibrary.wiley.com/doi/10.1111/j.1439-037X.2006.00187.x/pdf>>. Accessed: May 08, 2011. doi: 10.1111/j.1439-037X.2006.00187.x.
- POTARZYCKI, J.; GRZEBISZ, W. Effect of zinc foliar application on grain yield of maize and its yielding components. **Plant Soil Environment**, v.55, n.12, p.519-527, 2009. Available from: <<http://www.agriculturejournals.cz/publicFiles/13721.pdf>>. Accessed: Apr. 26, 2011.
- RODRIGUES, L.A. et al. Absorção e translocação de zinco em feijoeiro aplicado via foliar. **Revista Brasileira de Fisiologia Vegetal**, v.2, n.2, p.11-15, 1997. Available from: <[www.cnpdia.embrapa.br/rbfv/pdfs/download.php?file=v9n2p111.pdf](http://www.cnpdia.embrapa.br/rbfv/pdfs/download.php?file=v9n2p111.pdf)>. Accessed: Apr. 28, 2011.
- RÖMHELD, V. Aspectos fisiológicos dos sintomas de deficiência e toxicidade de micronutrientes e elementos tóxicos em plantas superiores. In: FERREIRA, M.E. et al. (Ed.). **Micronutrientes e elementos tóxicos na agricultura**. Jaboticabal: CNPq, 2001. p.70-84.
- SEADH, S.E. et al. Influence of micronutrients foliar application and nitrogen fertilization on wheat yield and quality of grain and seed. **Journal of Biological Sciences**, v.9, n.8, p.851-858, 2009. Available from: <<http://scialert.net/qredirect.php?doi=jbs.2009.851.858&linkid=pdf>>. Accessed: Apr. 26, 2011. doi: 10.3923/jbs.2009.851.858.
- SINGH, S.; CHOUDHARY, S.S. Phosphorus, zinc and soil interaction on the uptake of zinc and iron by wheat (*Triticum durum* Desf.). **Research on Crops**, v.3, n.2, p.363-368, 2002. Available from: <<http://www.croprosearch.org>>. Accessed: May 12, 2011.
- TEIXEIRA, I.R. et al. Manganese and zinc leaf application on common bean grown on a "Cerrado" soil. **Scientia Agricola**, v.61, n.1, p.77-81, 2004. Available from: <<http://www.scielo.br/pdf/sa/v61n1/a13v61n1.pdf>>. Accessed: Apr. 26, 2011. doi: 10.1590/S0103-90162004000100013.
- ZEIDAN, M.S. et al. Effect of foliar fertilization of Fe, Mn and Zn on wheat yield and quality in low sandy soils fertility. **World Journal of Agricultural Sciences**, v.6, n.6, p.696-699, 2010. Available from: <[http://idosi.org/wjas/wjas6\(6\)/11.pdf](http://idosi.org/wjas/wjas6(6)/11.pdf)>. Accessed: Apr. 26, 2011.
- ZHAO, A. et al. Zinc fertilization methods on zinc absorption and translocation in wheat. **Journal of Agricultural Science**, v.3, n.1, p.28-35, 2011. Available from: <<http://www.ccsenet.org/journal/index.php/jas/article/view/8232/6979>>. Accessed: Apr. 28, 2011.