Zinc Fact Sheet: Sugarcane

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Introduction

Brazil has become the most important sugarcane producer in the world. In recent years, sugarcane has been highlighted internationally for the capability of ethanol to substitute the use of fossil fuels, thus promoting the use of cleaner energy. This capability prompted an increase in planted areas in Brazil, and consequently of sugarcane production. However, the average crop production continues to be around 80 t ha-1, which is considered low compared to other recently launched varieties on the market.[1] The main reason for low productivity is crop expansion, not only in traditional areas of cultivation, but also in areas of low-fertility soil. To help ensure proper development and growth, as well as to generate sugar and ethanol of good quality and in quantities enough to make its industrial process economically viable, sugarcane needs adequate nutritional support. Therefore, these soils require more refined handling of fertilization. Although the majority of Brazilian production units manage macro-nutrition of sugarcane well, most of these units have an insufficient supply of essential micronutrients, such as zinc, boron, copper, manganese, and molybdenum.

Topographical map of Brazil. This fact sheet focuses primarily on sugarcane production in the region of São Paulo (circled).

Zinc Deficiency in Sugarcane

Among these micronutrients, zinc is arguably the most important, since its deficiency poses greater risk to plant production. A study that evaluated the zinc leaf contents in 890 diagnostic leaves of sugarcane specimens collected in the state of São Paulo, in cultivated areas with or without stillage, found that more than 70% of the sample presented zinc contents below the considered critical levels to the crop.[2]

Zinc deficiency directly affects the sugarcane plant's tillering, growth, and ratoon longevity. In the plant's metabolism, zinc is essential for tryptophan synthesis, the precursor of indoleacetic acid (AIA), responsible for the enzyme production that promotes the lengthening and growth of cells. Zinc is also involved in the activation of several enzymes.[3,4]

1. Mellis, E.V.; Quaggio, J.A. & Cantarella, H. Micronutrientes. In: Dinardo-Miranda, L.L.; Vasconcellos, A.C.M. & Landell, M. G. de A. Cana-de-açúcar,: Instituto Agronômico. Campinas. 331-336. 2008.
2. Vale, F. Araujo, M.A.G., Vitti, G.C. Avaliação do estado nutricional dos micronutrientes em áreas com cana-de-açúcar. In: FERTBIO 2008, Londrina-PR. 2008.
3. Orlando Filho, J. Rosseto, R. Casagrande, A. A. Cana-de-açúcar. In: Ferreira, M. E.; Cruz, M.C.P.; Raij, B. Van; Abreu, C A. (Eds). Micronutrientes e elementos tóxicos na agricultura. CNPq/FAPESP/POTAFOS. Jaboticabal: 335-369. 2001.
4. Taiz, L.; Zeiger, E.; Santarém, E.R. Fisiologia vegetal – 3 ed. - Porto Alegre: Artmed. 719p. 2004.

Zinc deficiency will first occur in the younger leaves. When sugarcane is deficient in zinc, it presents the following visual aspects: chlorotic stripes on the leaf blade; shortening of internodes in the stalks, the formation of "reels," reduction of tilling, and thinner stalks that may lose turgidity. In more severe situations, there is necrosis of leaves from the tip. Additionally, sugarcane plants deficient in zinc are more susceptible to fungus attacks, which can lead to the appearance of red stains on the leaves (Figure 1).[5]

Unfortunately, zinc deficiency does not always show visible symptoms. "Hidden" deficiency can also occur when plants are deficient in zinc without showing outward signs of it.[3] The occurrence of hidden deficiency underlines the importance of using diagnostic methods, such as soil and leaf analyses, to aid the nutritional handling of sugarcane.

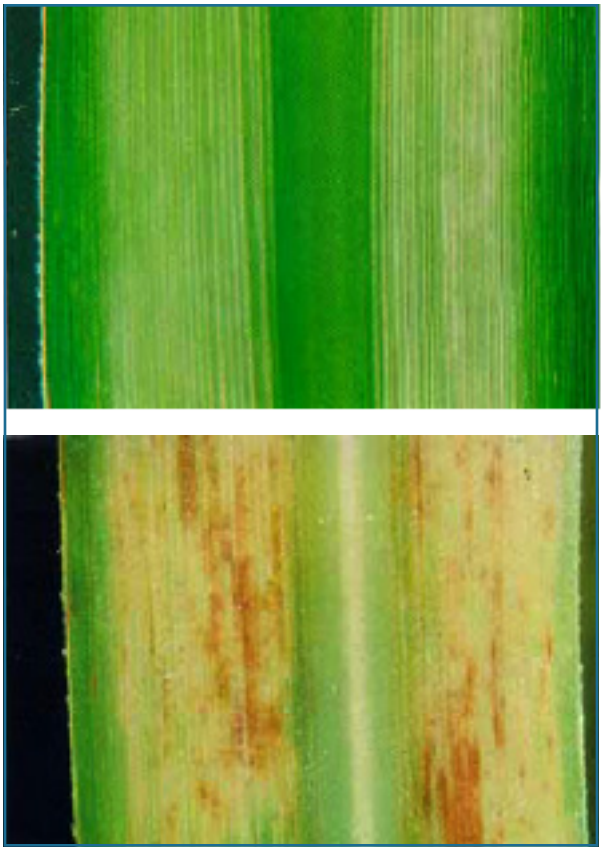

FIGURE 1. Zinc deficiency in sugarcane: chlorotic stripes in the leaf blade (top), and red stains on the leaves due to fungus attack (bottom). (Original: J. Reghenzani)

Zinc in Sugarcane Production

Although the importance of zinc is widely recognized, research with this micronutrient in sugarcane is scarce. Several studies have shown significant gains in sugarcane productivity with zinc application. A study with zinc application in the Northeastern Brazilian coastal tableland soils reported gains up to 40 t ha-1 with zinc applications of up to 25 kg ha-1 in the plantation furrow.[6] The authors of the study began to recommend the application of this zinc dose in soils in which the available Zn contents were less than 0.5 mg dm-3.

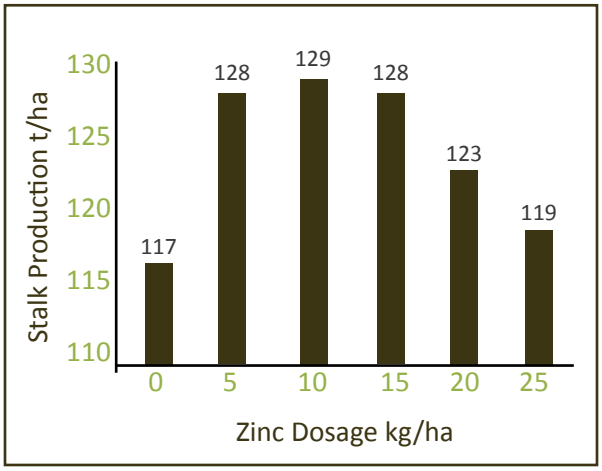

FIGURE 2. Sugarcane answer to zinc dose application in a Red Yellow Oxisol in the West of São Paulo State.

A subsequent study found positive responses of sugarcane crops to the zinc application in an Oxisol with low available zinc content. They determined that the highest level of production was reached when zinc doses were around 10 kg ha-1, applied in the plantation furrow as sulphate (Figure 2).[7]

Another study showed that applying doses of F.T.E./BR12 (Fritted Trace Elements) furnished the following zinc amounts: 2.7, 4.5 and 6.3 kg ha-1 in three varieties of sugarcane (Sp 70-1143, SP 79-1011, and RB 72454) cultivated in a typical quartzipsamment soil of natural low fertility. The study verified an increase in productivity in the varieties SP 79-1011 and RB 72454. [8] Still another study that applied zinc sulphate doses of 0, 4.4, 8.9, 17.9, and 33.8 kg ha-1 in the plantation furrow and 1.3 kg ha-1 through foliar application in acid and calcareous soils obtained responsive results in sugarcane production, in the doses of 4.4 and 8.9 kg ha-1. [9]

5. International Plant Nutrition Institute (IPNI). http://brasil.ipni.net
6. Marinho, M.L. & Albuquerque, G.A.C. Efeito do cobre e do zinco na produção de cana-de-açúcar em solos de tabuleiros de Alagoas. Brasil Açucareiro, 98:41-50. 1981.
7. Cambria, S.; Boni, P.S. & Strabelli, J. Estudos preliminares com micronutrientes-zinco. Boletim Técnico Coopersucar, 46: 12-17. 1989.
8. Korndörfer, G.H.; Benedini, M.S.;Rocha, A.C.; Ferreira Neto, D.A. Avaliação de três variedades de cana (Saccharum officinarum) submetidas a adubação com micronutrientes. STAB Açúcar, Álcool e Subprodutos, v. 14, n.1, p.23-26. 1995.
9. Wang, J.J., Kennedy, C.W., Viajator, H.P., Arceneaux, A.E.; Guidry, A.J. Zinc fertilization of sugarcane in acid and calcareous soils. Journal American Society Sugar Cane Technologists, v.25, p. 49-61. 2005.

Based on this research, the standard recommended application of zinc is 5 kg ha-1 in plantations in Brazil with soils in which available Zn contents are under 0.5 mg dm-3. However, the Agronomic Institute of Campinas (IAC) has been conducting a broad experiment network with micronutrients in sugarcane since 2005, and are obtaining results that indicate that the current recommendation is too low for the crop to reach its full growth potential.

An evaluation in 2011 of the effect of a zinc application of 10 kg ha-1 in a plantation furrow in sulphate form in areas with soils that were mostly sandy with natural low fertility revealed a significant increase in stalk production in 7 of 11 areas.[10] Stalk increase ranged from 11 to 34 t ha-1 (Table 1). The average increase in sugarcane productivity was 16 t ha-1 with a zinc application of 10 kg ha-1. Besides increasing the number of stalks, zinc application increased the capacity of sugarcane production per hectare in two places, also indicating improvement in sugarcane quality.

Table 1. Sugarcane response to zinc application in different places and kinds of soil in the State of São Paulo

Treatment	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11
	Tillering (mil till ha^{-1})										
Control	66.0	81.8	82.2	163.2	78.7	48.5	106.0	105.3	79.1	94.7	78.2
Zn	71.6	87.1	80.2	173.8	84.4	**66.6**	109.2	110.2	79.1	96.4	77.6
	Stalk Production (t ha^{-1})										
Control	86	114	64	144	103	86	123	128	152	105	177
Zn	**111**	**125**	**91**	**158**	110	99	**157**	**158**	**163**	114	174
	Total Sugar Recovered (Kg of sugar T^{-1})										
Control	135.4	152.2	163.4	172.4	132.4	166.2	146.2	161.8	131.8	150.6	148.2
Zn	136.8	151.8	156.8	170.0	133.8	163.8	157.0	160.0	132.4	147.2	147.8
	Total Sugar (t/ha^{-1})										
Control	11.6	17.7	11.4	22.4	11.5	14.7	18.3	20.7	20.0	15.8	26.2
Zn	15.4	19.4	13.5	23.6	12.5	16.8	**24.0**	25.3	21.6	16.8	25.7
Zn Content in Soil	0.2	0.2	0.4	0.4	0.4	0.1	0.5	0.5	0.2	0.3	1.4

Due to the residual effect, this zinc dosage applied in the plantation furrow is also able to increase ratoon productivity. A study by the same authors evaluated the residual effect of 10 kg ha-1 zinc application on the plantation furrow in six out of the 11 areas mentioned and noted an increase in the tilling and stalk production of the first ratoon. On average, the increase in productivity due to the residual effect was 10 t ha-1 (Table 2).[11]

Table 2. Residual effect of zinc application on plantation furrow on tilling, stalk production, and industrial quality of first ratoon in 6 production units from the State of São Paulo.

Treatment	Tilling (thousands ha^{-1})	Total Stalk per hectare (t ha^{-1})	Total Sugar Recovered (kg t^{-1})
Control	76.2	76.9	159.2
10 kg/ha Zn	**92.5**	**86.7**	158.6

Zinc Application in Sugarcane

Although zinc application doses of 10 kg ha-1 on the plantation furrow considerably increase sugarcane productivity and promote the residual effect, it is difficult to apply these doses in practice due to financial and opera-

10. Mellis, E.V. ; Quaggio, J. A. ; Teixeira, L. A. J.; Heitor Cantarella; Sugarcane response to zinc application. In: 3rd International Zinc Symposium, Hyderabad, India. 2011.
11. Mellis, E.V. ; Quaggio, J. A. ; Teixeira, L. A. J. ; Becari, G. R. G. ; Fábio Luis Ferreira Dias ; Heitor Cantarella ; Efeito residual da aplicação de micronutrientes em cana-de-açúcar. In: FERTBIO 2010, Guarapari-es. Fertbio 2010 Anais. Guarapari : Tec Art Editora. 2010.

tional barriers of incorporating micronutrients into the NPK formulas in use. One way around these barriers is to apply zinc with a phytosanitary treatment performed during plantation covering. However, due to the required dilution of zinc sulphate, it becomes difficult in the syrup volume used in the operation. To solve this problem, IAC and private companies (such as Agroterenas SA and Produquímica) have worked on the development of a furrower, with an exclusive deposit to granulated micronutrients. Such equipment is under test phase on field.

Additionally, with FAPESP sponsorship, the group is studying the effect of different sources (sulphate, oxide and chelate) and zinc doses (0, 5, 10 and 20 kg ha-1) applied on the plantation furrow. This study is ongoing and will conclude by September 2013. Preliminary results indicate 10 kg ha-1 as the ideal zinc dose to sugarcane planted in low-fertility soils.

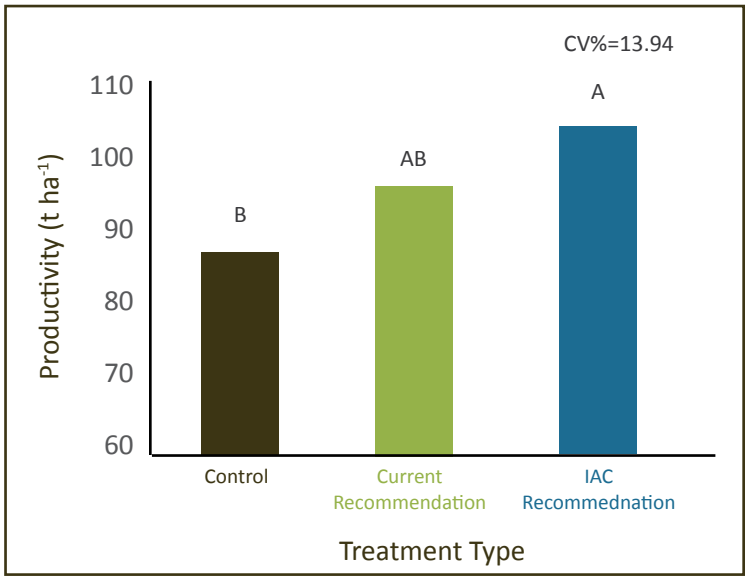

FIGURE 3. Sugarcane productivity due to the combined application of Mo and Zn on the plantation furrow

Anticipating this result, Mellis et al. conducted an experiment in a commercial area of Agroterenas on a 20 ha field cultivated with RB867515 variety sugarcane planted under a Red Yellow Oxisol, sandy texture, and natural low fertility. They used the following treatments: Control, Current Recommendation, and IAC recommendation. The treatments were applied with the insecticide and anti-termite application in the syrup volume of 150 L ha-1 during the stem covering. The stalk production per area with the application of the IAC Recommendation was significantly larger (Figure 3), with 18 tons more than the Control crops. The application of the Current Recommendation also increased the stalk production by 11 tons compared to the Control treatment.[12]

Conclusion

With demand for sugarcane on the rise, it is important the sugarcane crops are utilized to reach their full potential. Many sugarcane crops in Brazil are deficient in essential micronutrients including zinc. Though some studies are still ongoing, initial analyses of varying applications of zinc on sugarcane crops show that zinc fertilizers increases sugarcane production, growth, tillage, quality, longevity, and stalk tonnage. There is an existing recommendation of 5 kg ha-1 for zinc fertilizers, but current studies show that this recommendation may not be high enough to help sugarcane crops reach their full growth potential. It is likely that the recommendation will increase to 10 kg ha-1 based on the success of recent and ongoing studies.

12. Mellis, E.V.; Santana, T. H. ; Luz, A. M.; Campidelli, Smirmaul, C.R.; Luiz Antonio Teixeira, L. A. J.; Quaggio, J. A. Efeito Resposta da Cana-de-Açúcar à Aplicação de Molibdênio e Zinco . In: FERTBIO 2012, Maceió-Al. Fertbio 2012 Anais. Maceió. 2012.