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Foliar application of zinc fertilizer on different schedules of application, as cover in the winter maize

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Corn is the most important crop in the world market, being greatly used for human and animal nourishment. Corn has limited production with the zinc deficiency of the Brazilian soils which requires proper and correct application for optimizing its productivity. This study aims to evaluate the foliar application of zinc at different times in the corn variety RB 9110 PRO. Analyzing zinc absorption with influecia temperature and relative humidity. The experiment was conducted in the village of Corbélia – PR in Brazil. The used design was completely randomized, consisting of 4 treatments: Treatment 1 - Control without zinc; Treatment 2 - application of zinc at 08 h:00 min; Treatment 3 - Zinc application at 16 h:00 min; Treatment 4 - application of zinc at 20 h:00 min was used in the basic fertilization formulated 10-15-15. The weight of a thousand grains and the productivity was assessed. Treatment 2 was statistically superior to all treatments producing 360 kg / ha^{-1} higher than the witness, as the spike in size only witness was lower than the others, weight of 1000 grains there was no difference.

Key words: Productivity, *Zea mays*, Zn.

INTRODUCTION

Corn (*Zea mays*) belongs to the family of poaceas. It is a monocot plant of highest importance to the world market, of American origin, it has high importance for being used in many different ways, from animal and human food to the industries (Embrapa 2014). The corn crop in Brazil is highlighted as one of the most important ones, with a cultivated area estimated at 12 million hectares (Agrianual, 2008). As reported by Pinazza (1995), the corn is a plant which presents a cycle of 110 to 180 days, differentiated by the characterization of hybrids, as very early, early, and normal.

The second harvest, called “safrinha”, is of great importance in the Brazilian scenario, where it optimizes the use of the property. It began in the 80s in the state of Paraná, standing out as an alternative (Pitol et al., 1996). In Brazil, the first report of zinc deficiency in corn was made by Igue and Gallo (1960). According to Büll (1993), zinc is a limiting micronutrient corn production in Brazil, with common deficiency in all regions, as corn is a crop that responds well to the application ofzinc, where

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many studies have shown greater efficiency corn plants, on the application in the corn through the foliar system than through the ground.

Its most common form in the soil solution is Zinc $(Zn)^{2+}$cation which moves in the soil by diffusion, walking in favor of the concentration gradient that is, from a region of higher concentration to another of lower concentration (Malavolta, 2006).

Considering the many problems regarding Zn, plus the difficulty of distributing small quantities of fertilizer on the field (Lopes and Guilherme, 1992), alternative methods to the application of zinc have been sought, among these methods are the seed treatment and the foliar application.

Sakal et al. (1983) found that the foliar application of zinc obtained similar results to soil and to sowing furrows applications, where it is difficult to perform a uniform application on the soil, turning the foliar application into an alternative, although there is the disadvantage of low mobility of zinc via phloem.

According to Borkert et al. (1989), zinc performs one of the most important functions in corn. It takes part as a component of enzymes as the dehydrogenases, proteinases, peptidases. It is also related to the metabolism of phenols and the formation of starch, increasing and multiplication of cells and the fertility of the pollen grain. Decaro et al. (1983) mention that obtained results show positive effects of zinc in the corn, from plant growth, grains and fodder production, increasing of the protein content on the grains, thus having a significant increase in the production of corn crop. The function of the microelements is related to the metabolism of carbohydrates, proteins and also to the formation of auxin, RNA and ribosomes (Thorne, 1957).

The answer to the foliar application depends on several determining factors, where it happens in the process of penetration of the element through the cuticle, of the absorption of the leaf cells and in the transportation via phloem to the preferential drains, the main factors that could be stressed being the environmental and climatic factors (Ribeiro and Santos, 1996). This study aims to assess responses of the corn crop with different foliar schedules of application, when it will be evaluated, the weight of a thousand grains, the number of cobs and the productivity in bags / ha^{-1}.

MATERIALS AND METHODS

The experiment was conducted in the year 2014, in the city of Corbélia – PR, Brazil, with latitude 24°48'30" south, 53°15'59" west and an altitude of 683 m.

In this study it was used the hybrid RB 9110 PRO, of low scale, high productive potential, having a very early characteristic. The design was done in a completely randomized design (CRD) with fields of 6.3 x 5 m coming to a total of 31.5 m^2. Each field consisting of 7 lines with a spacing of 90 cm between the lines, with 4 treatments and 6 repetitions, coming to a total of 20 plots. Five collections were withdrawn from each field for the analysis of weight of a thousand grains, of productivity and of cob size.The treatments were distributed in the following manner:

Treatment 1Control without Zinc;
Treatment 2 Zinc application at 08 h:00 min; with a temperature of 25°C and RH of 71%.
Treatment 3 Zinc application at 16 h:00 min; with a temperature of 29°C and RH of 59%.
Treatment 4 Zinc application at 20 h:00 min; with a temperature of 24°C and RH of 65%.

The sowing was performed in February of 2014, done through mechanized seeding using a sower of continuous flowing, with a 90 cm spacing between the lines, with 5.4 seed per running meter, and sowing depth of 3 cm. The basic fertilization was conducted with the concentrated formulation 10 – 15 – 15 of NPK, at a dosage of 800 kg ha^{-1}.

The tested treatments were carried out with Zinc (10%), where the recommendation of the product is of 1.5 to 2 l/há-¹, between 30 to 20 days after emergency (DAE). The applications of Zinc were conducted manually diluted in 3 L of water, with a proportion of 35 ml to each treatment, applied on the plot using a machine for applying pesticide, using individual protection equipment. When performing the applications, the relative humidity of the air and the temperature were collected with the suitable equipment.

All the crop cares during the crop cycle were taken with pesticides registered at the Agriculture and Supply Secretary of Paraná (SEAB/PR) for the corn crop, pesticides to control pests, diseases and weeds, through a trailed sprayer. The harvest point was reached in July of 2014, coming to a total of 152 days of cycle.

The harvest was conducted manually, with four samplings being collected randomly in each plot, 1 m each, with five cobs. After the harvest, the sizes of the cobs were assessed, taking the measurements with a ruler. In the sequence, it was done the trail and the cleaning of these grains with a strainer, where all the samples had to undergo a humidity analysis of the grains with universal equipment, where there were no significant differences between them and all were within the commercial parameters.

A volume of 1.000 grain of each of the collected samples was weighted in a precision scale, taking notes of the obtained values on a spreadsheet in order to obtain the productivity in kg/ha^{-1} of each treatment, after getting the total weight of each collected sample.

Thus, the evaluated parameters were: productivity (kg/ha^{-1}), mass of 1.000 grains and cob sizes. The results were submitted to an analysis of variance and the averages compared with Tukey's test at 5% of probability, using the Assistat program 7.7 beta version.

RESULTS AND DISCUSSION

According to Table 1 we can analyze that to the size of tenon T2, T3 and T4 were statistically equal, the witness was significantly lower than the other treatments. For weight in thousand grains no difference significant between treatments, productivity T2 was what had the best result. All data were analyzed with 5% significance using Tukey.

By analysing Figure 1 we can see that there was a big increase in the size of the cobs regarding the treatment of the control and within the treatments with zinc applications at different times of the day, it is proven that there are statistical differences where the treatments produced more when compared to the control; and, by

Table 1. Cob size (cm), Weight of 1000 grains (grs) and productivity (kg /ha^{-1}) on the application of Zinc at different times on the day of the corn harvesting.

Treatment	Cob size (centimeters)	Weight of 1000 grains (grams)	Productivity (kg /ha^{-1})
(T1) Control	14.22^{b}	305^{a}	7.746^{b}
(T2) Zinc at 08 h:00 min	15.12^{a}	311^{a}	8.142^{a}
(T3) Zinc at 16 h:00 min	14.85^{a}	304^{a}	7.926^{ab}
(T4) Zinc at 20 h:00 min	14.96^{a}	305^{a}	7.986^{ab}
Overall average	14.78	306.25	130.4
CV	1.51	0.79	5.88

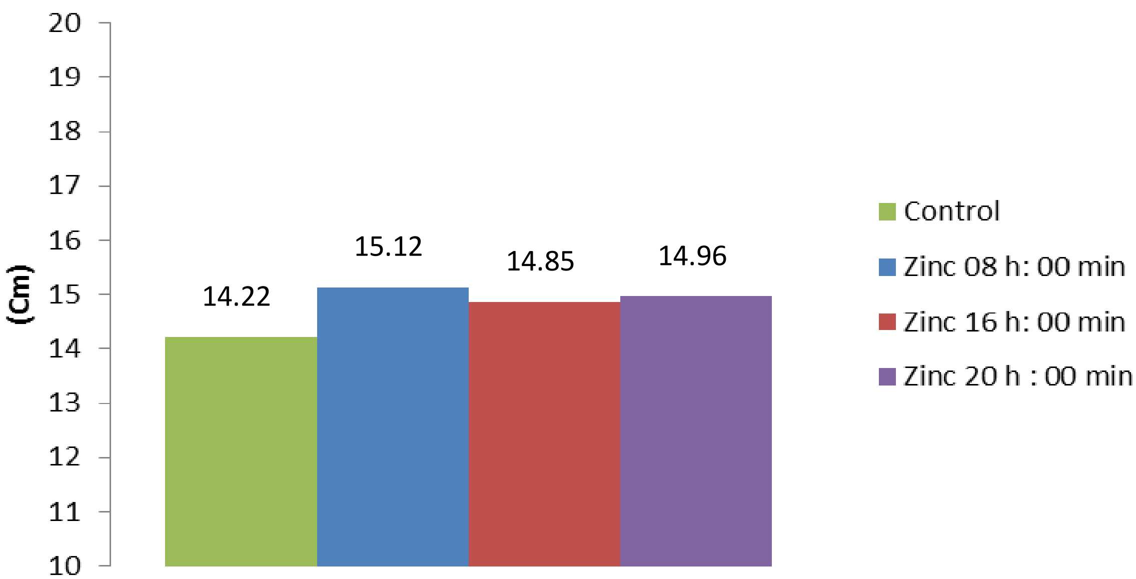

Figure 1. Cob size (cm) regarding the treatments conducted on the corn crop.

applying zinc at 08 h:00 min, the cobs reached to a larger size. These results if differ from the work done by Soares (2003) where there was no significant influence of application of boron and zinc on the cob size variable. According to Figure 2 we can analyze that none of the treatments showed a significant difference of 5%.

Galrão and MesquitaFilho (1981) report that corn is one of the plants that most respond to the application of Zn, providing significant gains in the production of grains and in their weight. According to Ritchey et al. (1986), several studies conducted at greenhouses and on the field have shown that its addition promotes significant gains both in the dry matter and in the production of corn and sorghum grains. Showing that it is relevant the application of zinc on corn crop because it results in a productivity increase and weigth grain. According to Laun et al. (1987) the lack of zinc reaction may be related to liming since we culture had no problems during your cycle. It is shown that the treatment with zinc applied at 08 h:00 min had a better yield to productivity, when the treatments of zinc applications at 16h00 min and at 20 h:00 min obtained statistically equal results when compared their productivity. As for the control, its productivity decreased when compared to the other treatments.

Fageria (2000), when evaluating the seven levels of Zn, concluded that the Zn affected the production of dry matter in the aerial part and the final productivity in the rice, beans, corn, soybean and wheat crops, but the answer varied according to the crop.

Ritchey et al. (1986) obtained corn productions close to maximum yields in the first cultivation, and that yielding continued for four more consecutive harvests, consequence of the residual micronutrient left on the straw and the soil (Table 1 and Figure 3).

Conclusion

It can be concluded thatT2: the application of zinc at

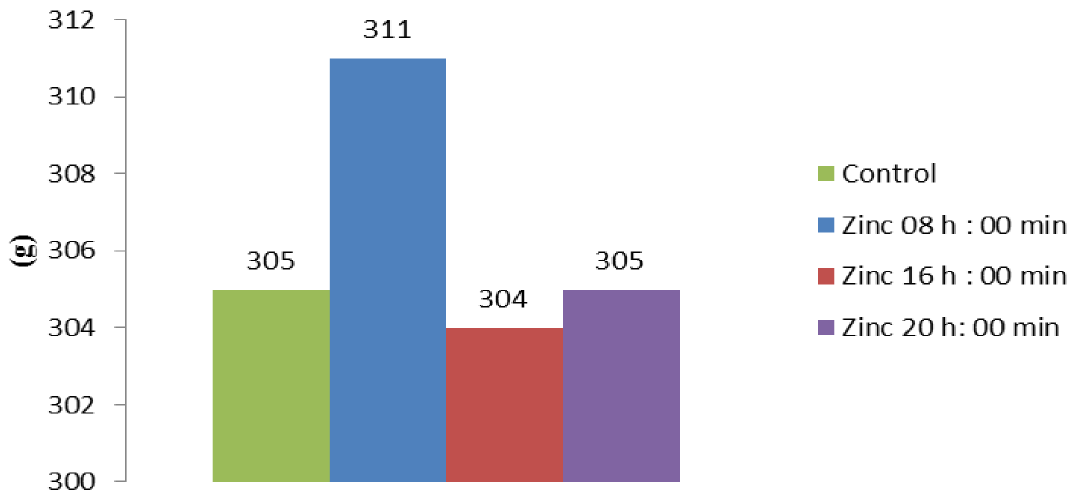

Figure 2. Weight of 1.000 grains (g) regarding the treatments conducted on the corn crop.

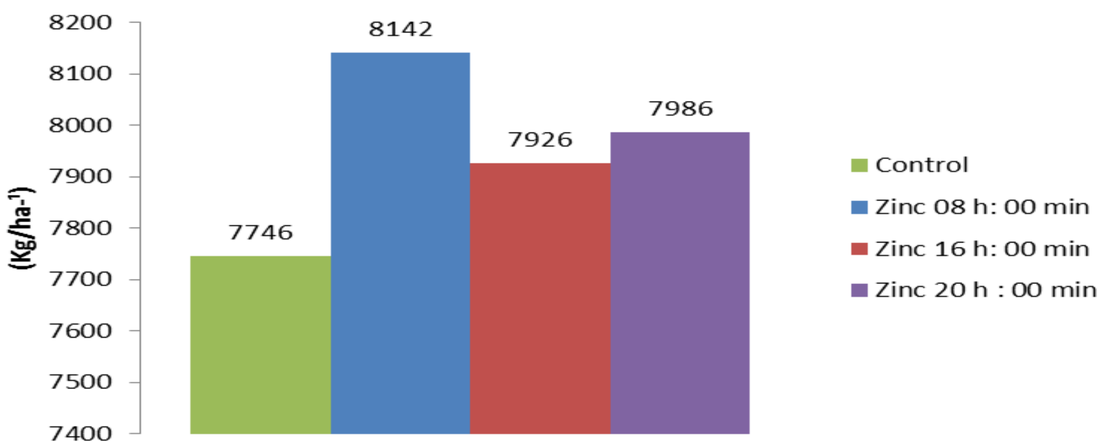

Figure 3. Productivity (Kg/ ha^{-1}) regarding the treatments conducted on the corn crop.

08h:00 min with a environment temperature 25°C at a RH of 71% with the the size of the larger tenon and higher productivity it was the best treatment, with a difference of 360 kg/ha^{-1} compared to the control. For the weight of 1000 grains all the treatments were statistically equal, on the evaluation of the cob size only the witness without the use of zinc has a size statistically below the other treatments.

Conflict of Interest

The authors have not declared any conflict of interests.

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