Fertilization with ZnO and ZnSO4: Mineral analyses in Vitis vinifera grapes cv. Fernão Pires

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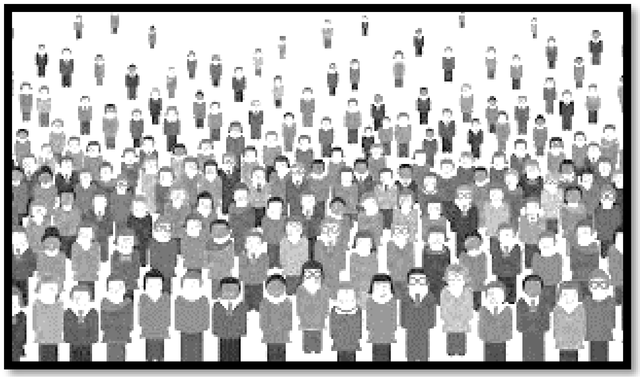
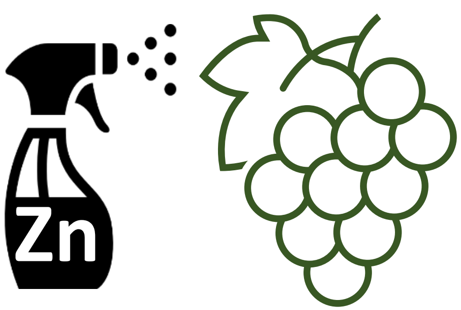


Growth of population → Need to increase crop production

Nutrients influence crops growth



Zn is an essential nutrient for crops

- Deficiency is associeted with losses in yield and quality
- Vine is susceptible to Zn deficits

Fertilizers provide a supply of nutrients namely Zn

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Abstract: Nutrition of the world population has become a concern, making research for strategies to enhance crop production necessary. Thus, the study of nutrients and the interactions between them is highly necessary since they are important for plant physiology and influence the growth of crops. Zinc is an essential micronutrient required for normal function of plants. Its deficiency is associated with losses in yield and nutritional quality. Vine, being a crop susceptible to Zn deficits, is among the most cultivated fruit plants in the world. In this study, the reactions of the variety Vitis Vinifera Fernão Pires, located in a field in Palmela, Portugal (N 38º 35'41.467 '' W 8º 50'44.535”), to three foliar sprays of ZnO and $ZnSO_4$ with concentrations of 150 g ha^{-1} and 450 g ha^{-1} were studied. Using a X-ray fluorescence analyzer (XRF), the mineral content of the grapes and leaves was determined, which showed increases in the contents of Zn. It was found that the highest concentration (450 g ha^{-1}) of $ZnSO_4$ and ZnO, led to increases of 1.3 and 1.9-fold respectively, compared to the control (untreated plants). Importantly, XRF analysis confirmed that K and P contents of ZnO and $ZnSO_4$-treated plants are similar to controls, indicating that there are no significant antagonistic and/or synergistic effects. Furthermore, to study the conditions of nutrient availability in the soil, parameters such as pH, organic matter and humidity were evaluated. This work showed that fertilization with $ZnSO_4$ and ZnO was effective in increasing the concentration of Zn, without negatively affecting the contents of the crucial nutrients K and P, which is important to improve crop quality.

Keywords: Nutrient’s interactions; Vitis vinifera; Zn deficits.

Introduction

Agricultural production is expected to increase with population growth, requiring the use of fertilizers to be sufficient in quantity and quality (Fróna et al., 2019). The use of fertilizers, have already demonstrated results, being found an increase of 50 % on crop yields during the 20th century (Fageria et al., 2008). Soil composition must be considered for proper crop nutrition, as nutrient deficiencies occur in soils around the world (Baligar et al., 2001). These deficiencies negatively affect metabolic processes, leading to adverse changes in crop growth and development (Kumar et al., 2021).

In this context, Zn is one of the nutrients whose deficiency in agricultural soils is common, leading to a shortage of this micronutrient in plants (Sadeghzadeh, 2013) and consequently, reducing growth, tolerance to stress and chlorophyll synthesis (Sharma et al., 2013). This micronutrient has important functions related with gene expression, photosynthesis, structure of enzymes, auxin metabolism, membrane permeability and protein synthesis (Hacisalihoglu, 2020).

On an economic level, the vine is a fruit species with a high importance world-wide [9], being a common target of Zn deficiency (Sabir and Sari, 2019).

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Results and Discussion

Grapes (ppm)				
Control (0 g ha^{-1})	ZnO (150 g ha^{-1})	ZnO (450 g ha^{-1})	$ZnSO_4$ (150 g ha^{-1})	$ZnSO_4$ (450 g ha^{-1})
9.12 ± 0.20c	10.78 ± 0.13bc	17.69 ± 1.17a	10.10 ± 0.36bc	12.21 ± 0.49b
Leaves (ppm)				
32.76 ± 4.36c	110.30 ± 1.39bc	176.98 ± 32.37b	91.75 ± 13.45c	297.47 ± 20.03a

- The mineral analysis of this study demonstrated a positive response increasing Zn amount, through foliar fertilization with $ZnSO_4$ and ZnO, being more pronounced in the higher concentration of both treatments in leaves and grapes.

- Although, Zn inorganic source more used is $ZnSO_4$ because is more soluble in water and cheaper (Fu et al., 2016), in this study the treatment ZnO revealed the highest increase in Zn in Fernão Pires grapes.

- Zn foliar fertilization as observed in other studies have benefits in growth and development of fruit trees (*i.e*, mandarin, orange, and grapefruit) (Fu et al., 2016), additionally reducing Zn deficiency in crops and enhancing the uptake of other nutrients, as reported in (Erdem and Sahin, 2021).

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Results and Discussion

			Grapes		
Treatments	Control (0 g ha^{-1})	ZnO (150 g ha^{-1})	ZnO (450 g ha^{-1})	$ZnSO_4$ (150 g ha^{-1})	$ZnSO_4$ (450 g ha^{-1})
			%		
Ca	0.38 ± 0.04a	0.20 ± 0.01b	0.34 ± 0.04a	0.27 ± 0.02ab	0.31 ± 0.02ab
K	1.82 ± 0.12a	1.93 ± 0.02a	1.93 ± 0.05a	2.07 ± 0.09a	2.16 ± 0.21a
S	0.19 ± 0.01ab	0.15 ± 0.00c	0.21 ± 0.00a	0.17 ± 0.01bc	0.19 ± 0.01ab
P	0.16 ± 0.01ab	0.13 ± 0.00b	0.18 ± 0.01a	0.15 ± 0.01ab	0.17 ± 0.00a
			Leaves		
			%		
Ca	3.86 ± 0.16ab	4.40 ± 0.02a	4.17 ± 0.15a	2.94 ± 0.27c	3.26 ± 0.25bc
K	2.17 ± 0.05a	2.20 ± 0.20a	2.60 ± 0.23a	2.12 ± 0.17ab	1.37 ± 0.12b
S	0.87 ± 0.03ab	0.94 ± 0.11ab	1.06 ± 0.05a	0.93 ± 0.15ab	0.58 ± 0.03b
P	0.26 ± 0.00bc	0.32 ± 0.01ab	0.36 ± 0.03a	0.27 ± 0.03bc	0.18 ± 0.01c

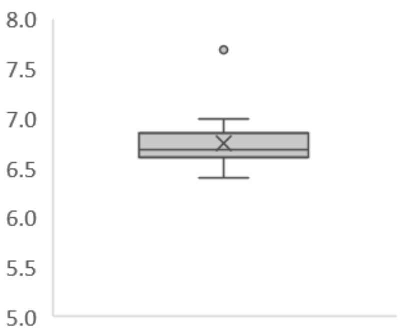
- In this context, the response to treatments in the leaves was better with ZnO, as it had a positive trend (except for Ca) and with $ZnSO_4$ 150 and 450 g ha^{-1} an inhibitory response was observed for Ca and K, respectively (although no significant differences were observed).

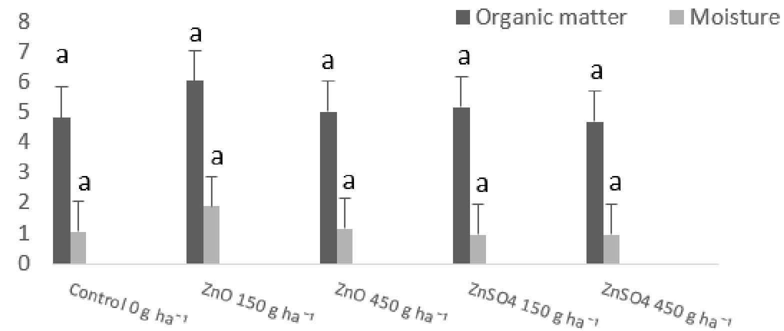
- As for grapes, it was observed in our data for Ca and S, a negative response, diminishing the concentration with the application of the lowest concentration of treatment ZnO (150 g ha^{-1}).

- Contrarily, it was observed a positive tendency in K, S and P in grapes subjected to ZnO and $ZnSO_4$ fertilizers, in the higher concentration (450 g ha^{-1}), but no significative antagonistic and/or synergistic relationships were observed.

- Although in this concentration didn't interfere significatively with these nutrients, Zn fertilization is a strategy to enhance the yields of crops and avoid the need to use more fertilizers, consequently being more sustainable to the environment (El-Ramady, 2014).

Results and Discussion





- Soil pH demonstrated a range approximatively between 6.4 and 7, although one sample presented more alkalinity (7.6).

- For the production of vines, a suitable soil has a range between 5.5 - 8 (*i.e.*, slightly acid and neutral), which the values of Fernão Pires field are within the desired for the performance of this study.
- Organic matter and moisture data of this study showed no significant differences in the soil samples. Thus, these two soil parameters did not influence the differences observed with Zn fertilization in this experimental study.

Conclusions

Application of Zn fertilizers such as $ZnSO_4$ and ZnO at concentration of 150 and 450 g ha^{-1} was efficient increasing the Zn amount in Fernão Pires grapes. With ZnO fertilizer showing greater ability to increase the amount of Zn, although it is less soluble than $ZnSO_4$. Additionally demonstrating that the higher concentration does not interfere negatively with other essential nutrients such as K, P and S, since no antagonistic or synergistic relationships were observed. Since fertilization with Zn is related to benefits in the growth and development of fruit trees, the results of this study show potential benefits in crop productivity.

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