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Physiological assessment of Rocha pear trees to agronomic enrichment with $CaCl_2$ and $Ca(NO_3)_2$

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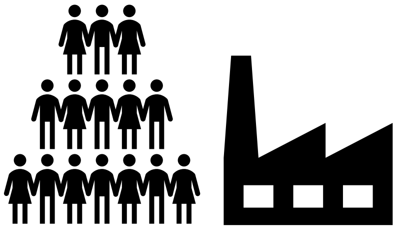
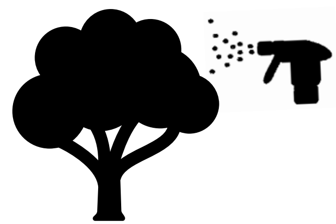


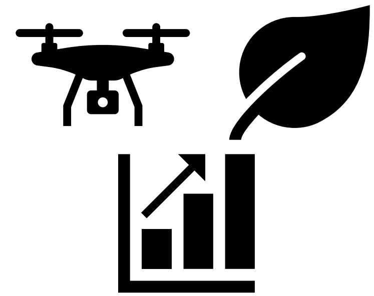
Food sector challenges

- Population increase
- Quantity and quality



Biofortification workflow

- 2 sprays: $CaCl_2$ (0.4 to 1.6 $kg.ha^{-1}$) or $Ca(NO_3)_2$ (0.1 to 0.6 $kg.ha^{-1}$)
- 1 spray: $CaCl_2$ 4 $kg.ha^{-1}$
- 4 sprays: $CaCl_2$ 8 $kg.ha^{-1}$



Analysis

- NDVI (UAVs)
- Leaf gas parameters (portable open-system infrared gas analyzer)
- Ca content in leaves and fruits (XRF analyzer)

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Abstract: The exponential increase of the world`s population is a major concern for the food sector since quantity and quality of food products needs to be ensured for consumers. Thus, in an orchard of pears located in Portugal, a total of seven foliar sprays, using $CaCl_2$ and $Ca(NO_3)_2$ were performed. The first two sprays with three different concentrations each ($CaCl_2$ - 0.4, 0.8 and 1.6 $kg.ha^{-1}$; $Ca(NO_3)_2$ – 0.1, 0.3 and 0.6 $kg.ha^{-1}$), the third with $CaCl_2$ 4 $kg.ha^{-1}$ and the remaining four with $CaCl_2$ 8 $kg.ha^{-1}$. During the workflow, normalized difference vegetation index (NDVI) was attained with unmanned aerial vehicle (UAV) and later correlated with photoassimilates synthesis (assessed by a portable open-system infrared gas analyzer) and Ca content in leaves and fruits (assessed by X-Ray fluorescence analysis). Regarding NDVI values, the exclusive use of $CaCl_2$ presented slightly inferior values, however no major signs of disrupted vegetation were detected. For leaf gas exchange, only minor changes occurred (namely E and iWUE parameters), while calcium content in leaves during the workflow and fruits at harvest increased. In conclusion smart farming techniques can be correlated with *in situs* analysis to monitor Rocha pear trees and the concentrations used in this study increased Ca content in fruits without reaching toxicity levels.

Keywords: Calcium; Foliar sprays in pears; Leaf gas exchange; NDVI; X-Ray fluorescence analysis

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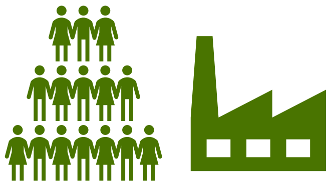
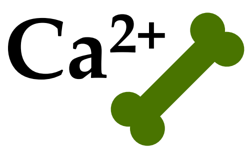
Introduction

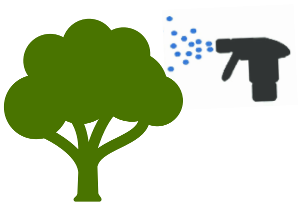
Rocha pears are a variety of *Pyrus communis* largely produced in Portugal, and it contributes to the country`s fruit sector since up to 60% of the total production is exported (ANP, 2021).



When considering the exponential growth of the world's population (FAO, 2021), agroindustry`s will face challenges related to the production of food, but also maintaining its quality to assure the nutritional needs of the human body (FAO, 2017).



In this regard, calcium (Ca) is a macronutrient performing both structural and signaling functions on the body, and its deficits are associated with pathologies such as osteopenia and osteoporosis, increasing the risk of fractures (EFSA, 2015).



Agronomic enrichment of plants with minerals, focuses on the use of soil or spray fertilizers in order to increase a certain mineral in its comestible parts (Singh *et al*., 2016).

This study thus aimed to apply agronomic enrichment practices to increase Ca content in pears and simultaneously monitor its effects on the orchard with UAVs and *in situ* analysis.

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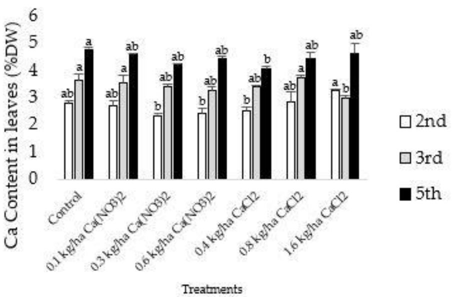
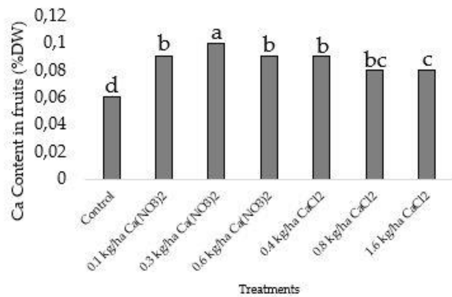
Results and Discussion

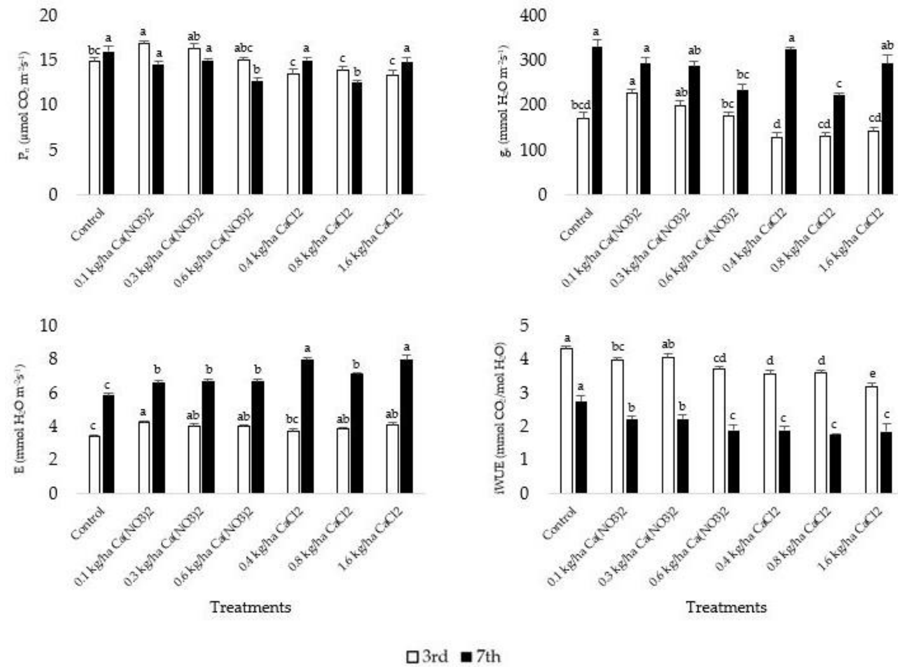
Treatments	Mean ± SD	Maximum	Minimum
Control	0.94 ± 0.02	0.97	0.79
0.1 kg.ha^{-1} $Ca(NO_3)_2$	0.94 ± 0.02	0.97	0.84
0.3 kg.ha^{-1} $Ca(NO_3)_2$	0.94 ± 0.02	0.97	0.81
0.6 kg.ha^{-1} $Ca(NO_3)_2$	0.94 ± 0.03	0.97	0.77
0.4 kg.ha^{-1} $CaCl_2$	0.91 ± 0.06	0.96	0.63
0.8 kg.ha^{-1} $CaCl_2$	0.88 ± 0.08	0.96	0.56
1.6 kg.ha^{-1} $CaCl_2$	0.89 ± 0.09	0.96	0.53
Field mean value	0.92 ± 0.05	0.91	0.70

All mean values attained in this study were higher than 0.85, being in accordance with the absence of toxicity signals indicating a healthy orchard.





Regarding Ca, the absence of significantly higher levels of this mineral in leaves after sprays indicates a translocation to other plant tissues like fruits.



The external application of Ca may have led to minor differences in leaf gas exchanges parameters, due to its role in stomatal closure, non-photochemical quenching and photosystems function (Hochmal *et al*., 2015; Wang *et al*., 2019), however, accumulation of Ca in fruits was not affected. Additionally, for the concentrations applied in this field trial, no toxicity signs such as leaf injuries occurred.

Conclusions

The implemented workflow increased Ca content in fruits at harvest and concentrations up to 8 kg.ha^{-1} $CaCl_2$ did not have negative impacts on pear trees. Additionally, *in situ* and precision agriculture techniques can be used complementary to assess orchards health, during the different phases of production.

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