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Monitoring a calcium biofortification workflow in orchard of *Pyrus communis* var. Rocha applying precision agriculture technology

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Abstract: Smart farming techniques can be used to maximize food production. This can be achieved by rapid detection of variations in crops and clever use of resources such as water and fertilizers, which might minimize crop stress through direct target practices. In an orchard located in the West region of Portugal (GPS coordinates 39°23’28.997’’N; 9°4’52.483’’W), a Ca biofortification workflow with 7 foliar sprays of $CaCl_2$ (4 $kg.ha^{-1}$ and 8 $kg.ha^{-1}$) was used to increase Ca contents in “Rocha” pear trees. During the biofortification process, an Unmanned Aerial Vehicle synchronized by GPS, was used to characterize the orchard regarding it`s morphology (slope) and to monitor trees (NDVI - Normalized Difference Vegetation Index). These data were correlated with Ca content (assessed by X-Ray fluorescence analysis) and photoassimilates synthesis (assessed by leaf gas exchange measurements). The orchard showed no major slopes and after 4 sprays with $CaCl_2$, NDVI values revealed no major differences between the control and sprayed trees. Accordingly, leaf gas exchange parameters did not reveal negative impacts in the photoassimilates synthesis of the sprayed trees, although in the leaves Ca content significantly increased. The use of precision agriculture techniques in correlation to other analysis to assess plant stress is discussed.

Keywords: Biofortification; Calcium; Leaf gas exchange; NDVI; Pears; Precision Agriculture; X-Ray fluorescence analysis

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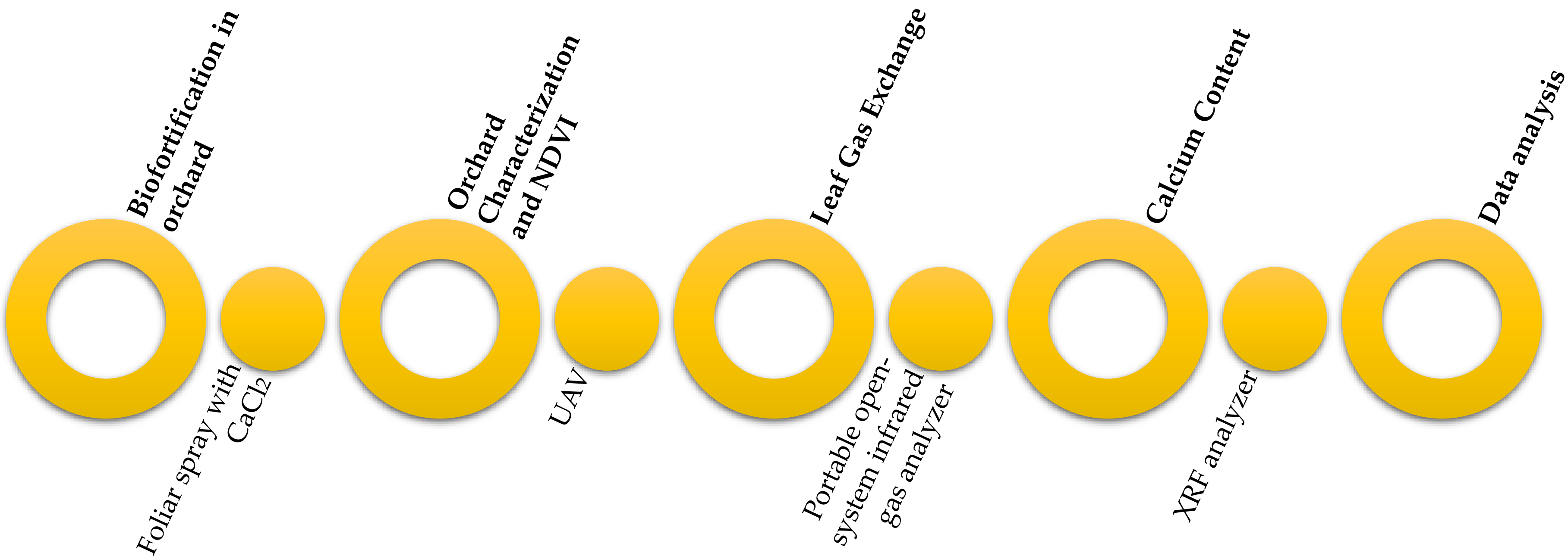
Materials and Methods



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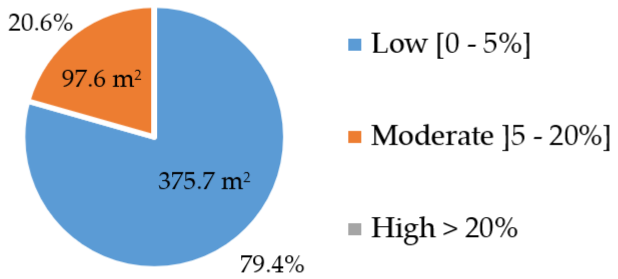
Results and Discussion

Nearly 80% of the total area of the orchard presents a low drainage surface.



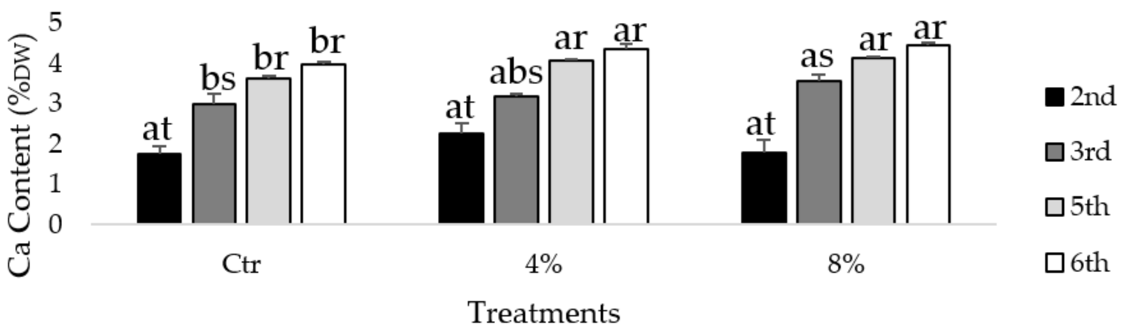
The orchard presents mostly a smooth slope morphology. Thus, water was not a conditional factor for nutrient absorption from soils.

The mean NDVI value of control trees was slightly higher than sprayed trees. Minimum and maximum values varied between 0.420 - 0.440 and 0.906 - 0.914, respectively.

Treatments	Minimum	Maximum	Mean ± SD
Ctr	0.440	0.914	0.800 ± 0.093
4%	0.440	0.906	0.781 ± 0.111
8%	0.420	0.914	0.797 ± 0.110

Since all trees presented mean NDVI values higher than 0.75, at this point of the workflow, no signs of disrupted vegetation were detected.

This study also showed an increase of Ca content in leaves after foliar sprays, and the slightly higher values of treatment 8% relates to the increase of $CaCl_2$ concentration to double after the 3rd spray.



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Results and Discussion

For the last two dates of analyses, trees sprayed with 8% revealed a slight tendency for higher P_n, g_s and E values and minor iWUE in comparison to the control.

Leaf gas exchanges and NDVI indexes support the absence of toxicity signs throughout the workflow, with sprayed trees revealing similar values to the control.

Treatments	12th June	26th July	12th September
P_n (µmol CO_2 $m^{-2}s^{-1}$)			
Ctr	17.69±0.24a,r	16.09±0.55as	7.77±0.25at
4%	17.70±0.13a,r	15.49±0.23as	7.47±0.39at
8%	17.85±0.19a,r	16.49±0.32as	8.37±0.33at
g_s (mmol H_2O $m^{-2}s^{-1}$)			
0%	255.6±6.8ar	199.0±10.9bs	68.5±3.8at
4%	252.4±5.1ar	221.1±4.9bs	65.5±5.1at
8%	245.2±3.9ar	269.0±8.8ar	76.6±5.5as
E (mmol H_2O $m^{-2}s^{-1}$)			
0%	3.27±0.06ar	2.21±0.07bs	2.03±0.09bs
4%	3.38±0.04ar	2.40±0.05bs	2.17±0.13bs
8%	3.24±0.03ar	3.29±0.09ar	2.53±0.15as
iWUE (mmol CO_2 mol^{-1} H_2O)			
0%	5.43±0,06as	7.29±0.17ar	3.95±0.15at
4%	5.26±0.05as	6.53±0.17br	3.51±0.07abt
8%	5.51±0.06ar	5.08±0.12cr	3.41±0.09bs

The results are in accordance with this mineral`s role in the preservation of photosynthetic capacity and high stomatal opening linked to the stabilization of chlorophyll complexes and the maintenance of high photochemical efficiency of PSII.

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Conclusions

- Foliar applications of $CaCl_2$ in concentrations of 4 and 8 $kg.ha^{-1}$, increased Ca contents in leaves of *Pyrus communis* L., variety Rocha.

- Vigor and respective photosynthesis mechanism of sprayed trees were not affected by the applied workflow. These interactive factors can also be due to the terrain morphology, which promotes identical water supply to plants.

- The use of precision agriculture techniques (namely UAVs), was successfully used with other analyses, not only to characterize the terrain, namely to monitor plants during their productive cycle.

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