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Monitoring of a calcium biofortification workflow for tubers of *Solanum Tuberosum* L. cv. Picasso using smart farming technology

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Abstract: Due to the rapid growth of the population worldwide and the need of providing food safety in large crop productions, UAVs (Unmanned Aerial Vehicles) are being used in agriculture to provide valuable data for decision making. Accordingly, through precision agriculture, an efficient management of resources, using data obtained by the technologies, is possible. Through remote sensed, data collected in a crop region, it is possible to create NDVI (Normalized Difference Vegetation Index) maps, which are a powerful tool to detect, namely stresses in plants. Accordingly, using some Smart Farm technology, this study aimed to access the impact of Ca biofortification process in leaves of *Solanum tuberosum* L. cv. Picasso. As such, using as a test system, an experimental production field of potato tubers (GPS coordinates - 39º 16′ 38,816′′ N; 9º 15′ 9,128′′W), plants were submitted to a Ca biofortification workflow through foliar spraying with $CaCl_2$ or, alternatively, chelated calcium (Ca-EDTA) at concentrations of 12 and 24 kg.ha^{-1}. It was found a lower average of NDVI in Ca(EDTA) 12 kg.ha $^{-1}$ treatment after the 4th foliar application, which through the application of the CieLab scale correlated with a lower L (darker color) and hue parameters, regarding control plants. Additionally, a higher Ca content was quantified in the leaves. The obtained data is discussed, being concluded that Ca(EDTA) 12 kg.ha $^{-1}$ triggers a lower vigor in Picasso potatoes leaves.

Keywords: Calcium biofortification; NDVI; Precision Agriculture; *Solanum Tuberosum* L.

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Materials and Methods

- Biofortification Itinerary – Foliar spraying with $CaCl_2$ and Ca(EDTA)
- NDVI of the experimental field (through the data obtained by UAV)
- Calcium content in leaves (through XRF analyzer)
- Colorimetric parameters (using a Minolta CR 400 colorimeter)
- Data analysis

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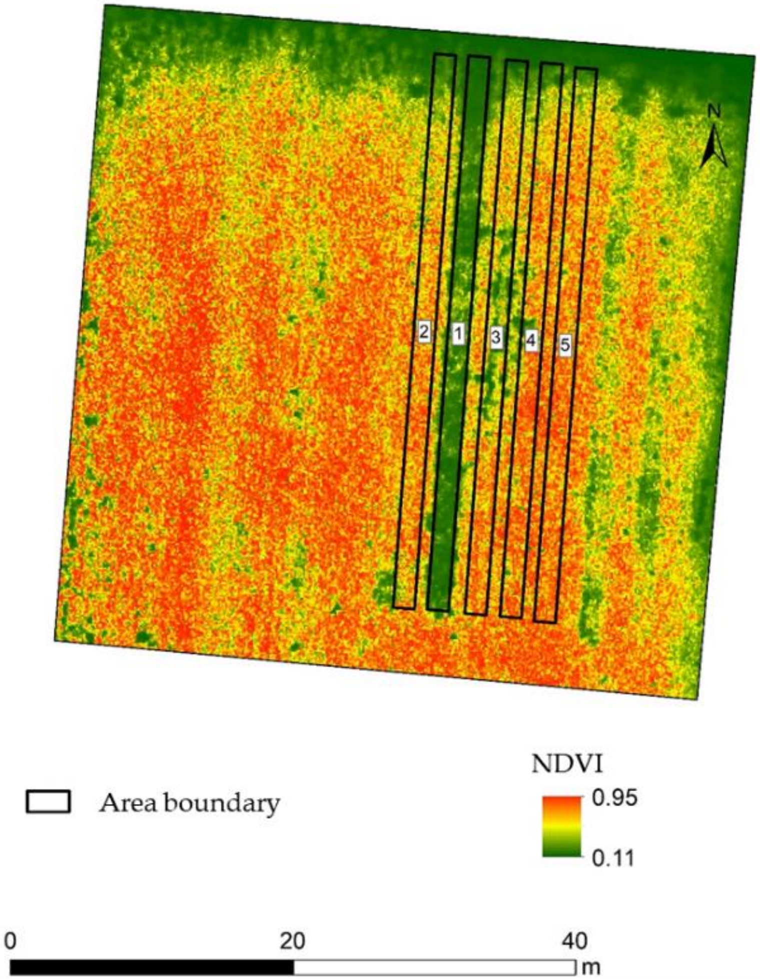
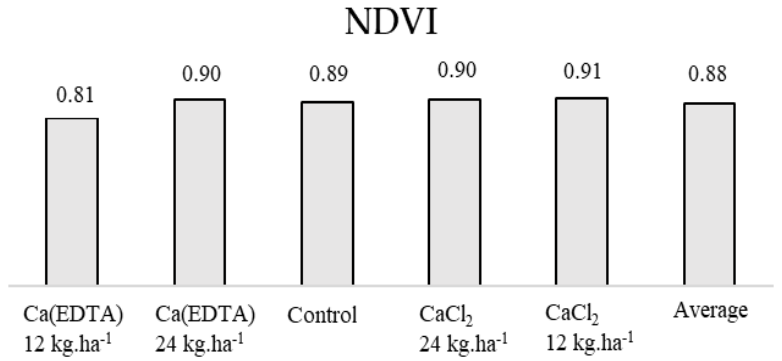
Results and Discussion



The NDVI map was obtained four days after the 4th foliar application (Figure 1), being possible to identify a lower NDVI in area 1, corresponding to the treatment with 12 kg.ha^{-1} Ca-EDTA.



The NDVI map shows the beginning of toxicity symptoms in potato plants with 12 kg.ha^{-1} Ca-EDTA treatment, after four foliar applications. Yet, globally, considering the average of all treatments, potato plants showed a positive response after the 4th foliar application with CaCl2 and Ca-EDTA, showing a medium/high NDVI (>0.8).

Figure 1. NDVI (Normalized Difference Vegetation Index) map in plants of *Solanum tuberosum* L., cv. Picasso (obtained on 25th June 2019), after the 4th foliar application (1- plants sprayed with Ca(EDTA) 12 kg.ha^{-1}; 2- plants sprayed with Ca(EDTA) 24 kg.ha^{-1}; 3- Control plants (not sprayed); 4- plants sprayed with $CaCl_2$ 24 kg.ha^{-1} and 5- plants sprayed with $CaCl_2$ 12 kg.ha^{-1}).

Results and Discussion

Table 1. Mean values ± S.E. (n = 4) of Ca in leaves of *Solanum tuberosum* L., cv. Picasso, after the 4th foliar application.

Treatments	Ca (%)
Control	4.29d ± 0.17
$CaCl_2$ (12 kg ha^{-1})	6.05b ± 0.00
$CaCl_2$ (24 kg ha^{-1})	7.94a ± 0.01
Ca(EDTA) (12 kg ha^{-1})	8.14a ± 0.02
Ca(EDTA) (24 kg ha^{-1})	5.57c ± 0.01

Relatively to the control, the contents of Ca in the leaves (Table 1) was significantly higher in all treatments, with an increase ranging between 29.8 - 89.7%. Besides, the maximum Ca content in the leaves was obtained with 12 kg.ha^{-1} Ca-EDTA, in spite of showing a lower NDVI.

Table 2. Mean values ± S.E. (n = 4) of colorimetric parameters (L, Chroma and Hue) in dry leaves of *Solanum tuberosum* L., cv. Picasso, after the 4th foliar application.

Treatments	L	Chroma	Hue
Control	42.61a ± 0.03	28.77a ± 0.01	112.2a ± 0.02
$CaCl_2$ (12 kg ha^{-1})	33.25d ± 0.00	16.66d ± 0.00	95.66c ± 0.05
$CaCl_2$ (24 kg ha^{-1})	32.62e ± 0.00	14.85e ± 0.00	85.05d ± 0.01
Ca(EDTA) (12 kg ha^{-1})	33.50c ± 0.01	17.68c ± 0.01	83.19e ± 0.04
Ca(EDTA) (24 kg ha^{-1})	38.22b ± 0.01	22.80b ± 0.00	106.3b ± 0.00

Considering the colorimetric parameters (Table 2), control showed significant higher values in L, Chroma and Hue parameter. Regarding L and Chroma, 24 kg.ha^{-1} $CaCl_2$ treatment showed significant lower values, followed by 12 kg.ha^{-1} $CaCl_2$ and 12 kg.ha^{-1} Ca-EDTA. Considering Hue parameter, the 12 kg.ha^{-1} Ca-EDTA treatment showed a significant lower value.

Conclusions

- Biofortification workflow showed an increased in Ca content in leaves for *Solanum tuberosum* cv. Picasso, regarding the control plants.

- NDVI values allowed a more accurate monitoring than the analysis of the colorimetric parameters of the leaves, regarding the beginning of toxicity symptoms (i.e., lower vigor in potatoes leaves).

- In this context, the use of smart farming technology is an important tool for decision making, regarding crop monitoring.

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