

The Cultivation of Three Varieties of *Solanum tuberosum* L. in Substrates Containing Waste from an Abandoned Polymetallic Sulfide Mine: Effects on Phenological Development and Metal Accumulation in Potatoes

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INTRODUCTION & AIM

Potato (*Solanum tuberosum* L.) is one of the most widely produced and consumed crops worldwide and can easily be cultivated in different locations and climates. Given its importance for food and nutritional security, an experimental trial was conducted to evaluate the impact on the phenological development and accumulation of potentially contaminating metals in the vegetative organs by cultivating three varieties (Red Lady, Agria, and Désirée) in substrates containing slag and waste from the Caveira polymetallic sulfide mine, located in Grândola (Beja, Portugal), at proportions of 10:0, 10:1, 10:2, and 10:3.

METHOD

Waste samples were collected from the Caveira mine, located in Grândola, Beja, Portugal (Fig. 1) on April 28 of 2023. Substrates were formulated according to the proportions indicated in Table 1 with the mine waste from the three sites. The study was designed in 27 pots, with three varieties of *Solanum tuberosum* L. - Agria, Désirée and Red Lady.

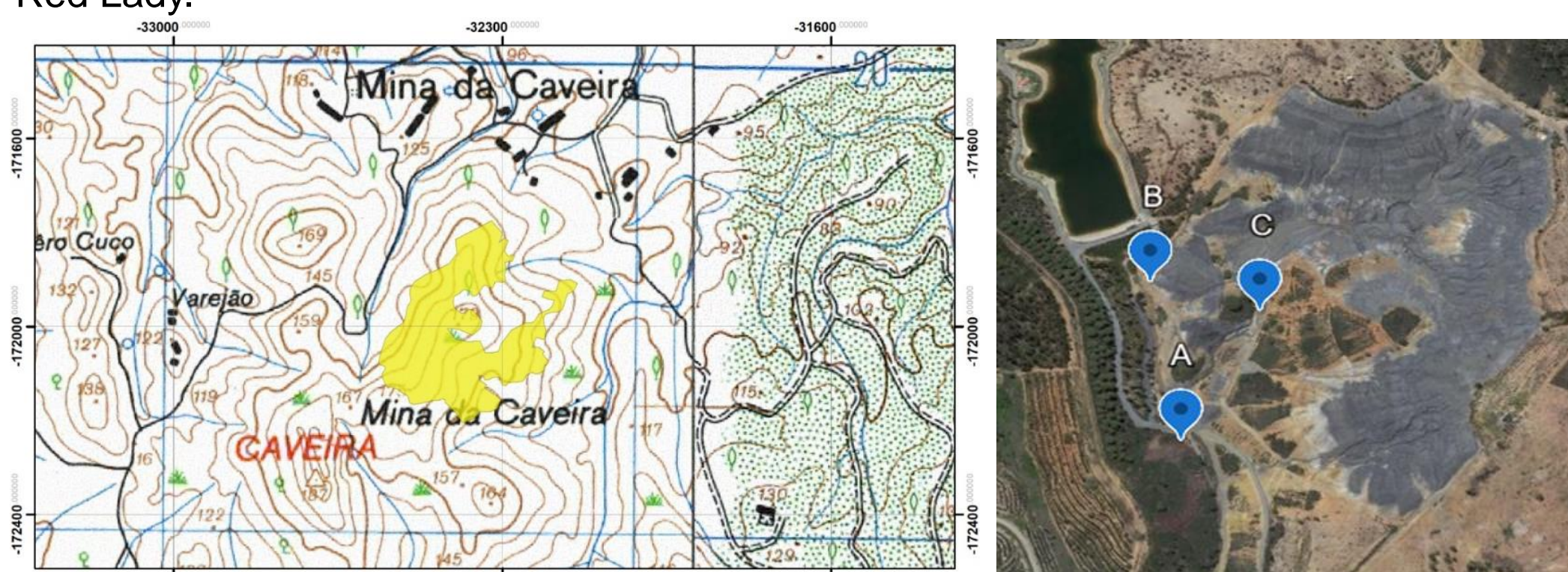


Fig. 1 - Regional location of the old Caveira mines, Grândola (Portugal) (indicated at yellow at scale of 1:2500, extract from the Military Maps of Portugal) and location of the three sampling sites in aerial image from Google Earth.

Table 1- Experimental design and respective substrate formulation in each pot.

Pot	Variety	Soil	Substrate formulation
1	Agria	Control	100% agricultural substrate SIRO HORTA (proportion 10:0)
2	Désirée		
3	Red Lady		
4	Agria	Cu-enriched substrate	Proportion 10:1 (with 500 ml of mine waste from site A)
5	Désirée		
6	Red Lady	Substrate less enriched in Cu and Pb	Proportion 10:1 (with 500 ml of mine waste from site C)
7	Agria		
8	Désirée		
9	Red Lady	Substrate enriched in Pb and Hg	Proportion 10:1 (with 500 ml of mine waste from site B)
10	Agria		
11	Désirée		
12	Red Lady	Composite 1	Proportion 10:1 (with 500 ml of 33% of mine waste from site A, 33% from site B and 33% from site C)
13-14	Agria		
15-16	Désirée		
17-18	Red Lady	Composite 2	Proportion 10:2 (with 1000 ml of 33% of mine waste from site A, 33% from site B and 33% from site C)
19-20	Agria		
21-22	Désirée		
23-24	Red Lady	Composite 3	Proportion 10:3 (with 1500 ml of 33% of mine waste from site A, 33% from site B and 33% from site C)
25	Agria		
26	Désirée		
27	Red Lady		

Copper, Hg, As and Pb were quantified in the three sites of sampling, in the substrate formulations and in the different organs of plants (tubers, roots, stems and leaves) of the three varieties by X-ray fluorescence (XRF) – with a portable Olympus Vanta XRF device. Productivity was evaluated considering the size, and the number of tubers produced in each pot. Pearson and Spearman coefficients, were used to determine correlations between concentrations of toxic metals in the substrates and in the vegetative organs of plants.



Fig. 2 – Culture development of the three varieties of *Solanum tuberosum* L., Agria, Désirée and Red Lady, in the Department of Earth Sciences at NOVA FCT.

RESULTS

Mine leachate was analyzed, presenting a pH of 3.03 and an electric conductivity of 1240 mS/cm. No influence was observed regarding the phenological development (Fig. 3). Copper, Pb, Hg and As content were quantified in the three sampling sites and in the different substrate formulations (Fig. 4).

In the three varieties, the number of tubers per plant increased in the substrates that contained mine waste compared to the control substrate (Fig. 5).

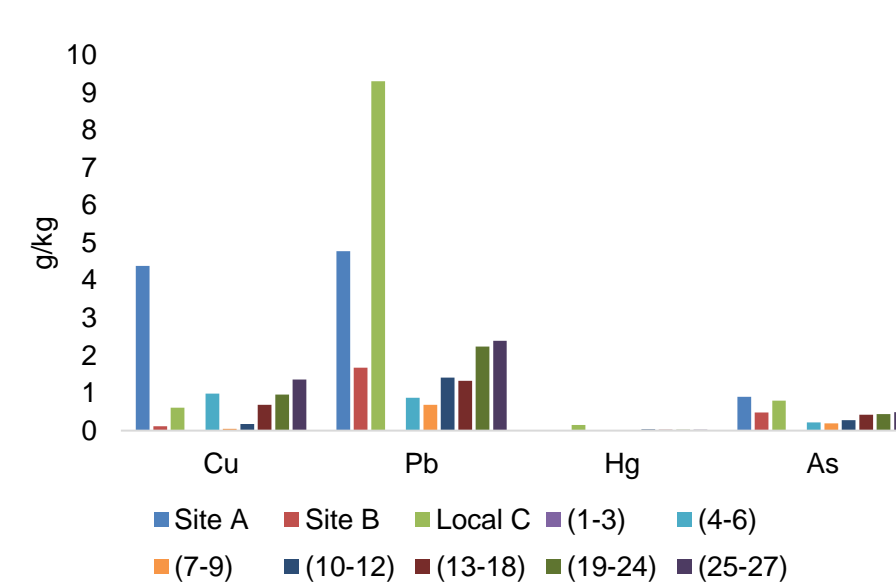


Fig. 4 – Cu, Pb, Hg and As (n=4) contents (g/kg) of the three sampling sites (A, B and C) and substrate formulations in the pots (1-27) before planting.

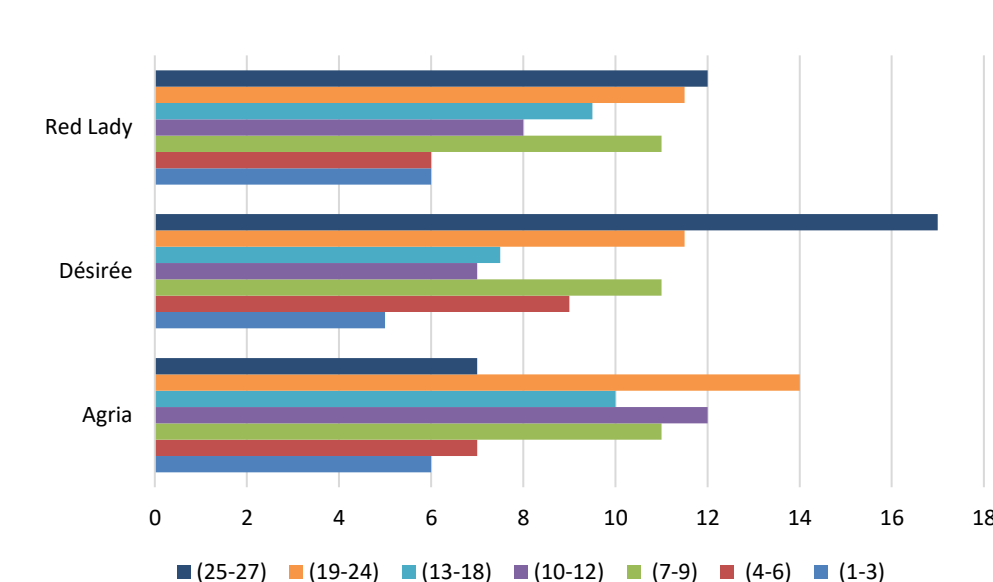


Fig. 5 – Average number of tubers produced per variety in the pots (1-27).

Tubers from Désirée variety showed greater accumulation in tubers compared to Agria and Red Lady. Tubers of the three varieties revealed the presence of Cu, Pb, and As, varying between 17.3 and 32, <5 and 27.6, and <5 and 14.8 mg/kg, respectively (Fig. 5).

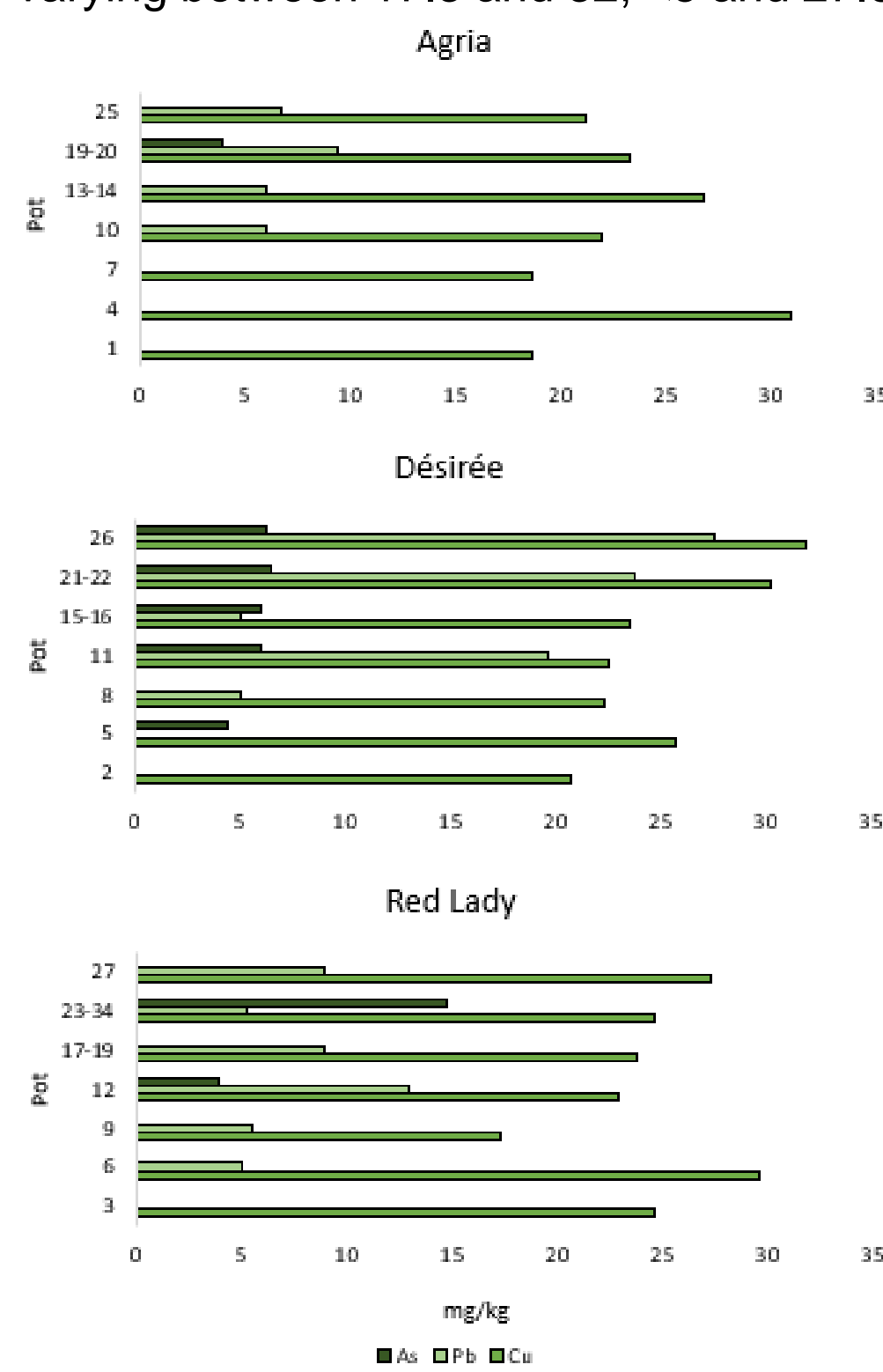


Fig. 6 - Contents of Cu, Pb and As (n=4) (mg/kg) in the tubers of *Solanum tuberosum* L. produced by pot. The values not shown were below the device's detection limit < 5 mg/kg for Cu, Pb and As.

The size of the tubers varied between 5 - 11 cm, 4.1 - 7.3 cm, and 3.9 - 8.1 cm in the Agria, Désirée and Red Lady varieties, respectively (Fig. 7).



Fig. 7 – Agria variety at harvest.

Pearson and Spearman correlations showed that, in the case of Cu, high to medium correlations between the concentration in the substrates and in the roots and tubers. Regarding Pb, high to medium correlations were observed between the concentration in the substrates and in the stems, roots and tubers. In relation to As, average correlations are observed between the concentration in the substrates and in the soil and roots.

CONCLUSION

Considering the results obtained, it was concluded that there was an accumulation of As, Cu and Pb in the tubers. As such, the composition of the substrates had an impact on the mobilization and accumulation of As, Cu and Pb, in the vegetative organs, especially in the edible part. The concentration of these metals varied depending on the variety. It was found that potato production in contaminated soil could pose a danger to human health, with a lower risk for ingesting the Agria variety as it showed less tendency for these metals to accumulate in the tubers.

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