Biomimicry of the Growth of a Desert Plant as an Approach for Extractions of Phosphorus & Minerals from Martian Regolith

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Introduction and Background

- ❑ Space missions are extremely costly and in situ resource utilization can reduce this cost [1].
- ❑ Current in situ resource utilization processes requires hazardous materials and high energy input which severely restricts their use in space [2].
- ❑ Many desert plants such as Paloverde survive on rocks by excreting biomaterials from roots to solubilize phosphorus and minerals from rocks (Fig. 1) [3].
- ❑ Rhizosphere microbes also excrete soluble microbial products (SMPs) and extracellular polymeric substances (EPS) which aid in the dissolution process.

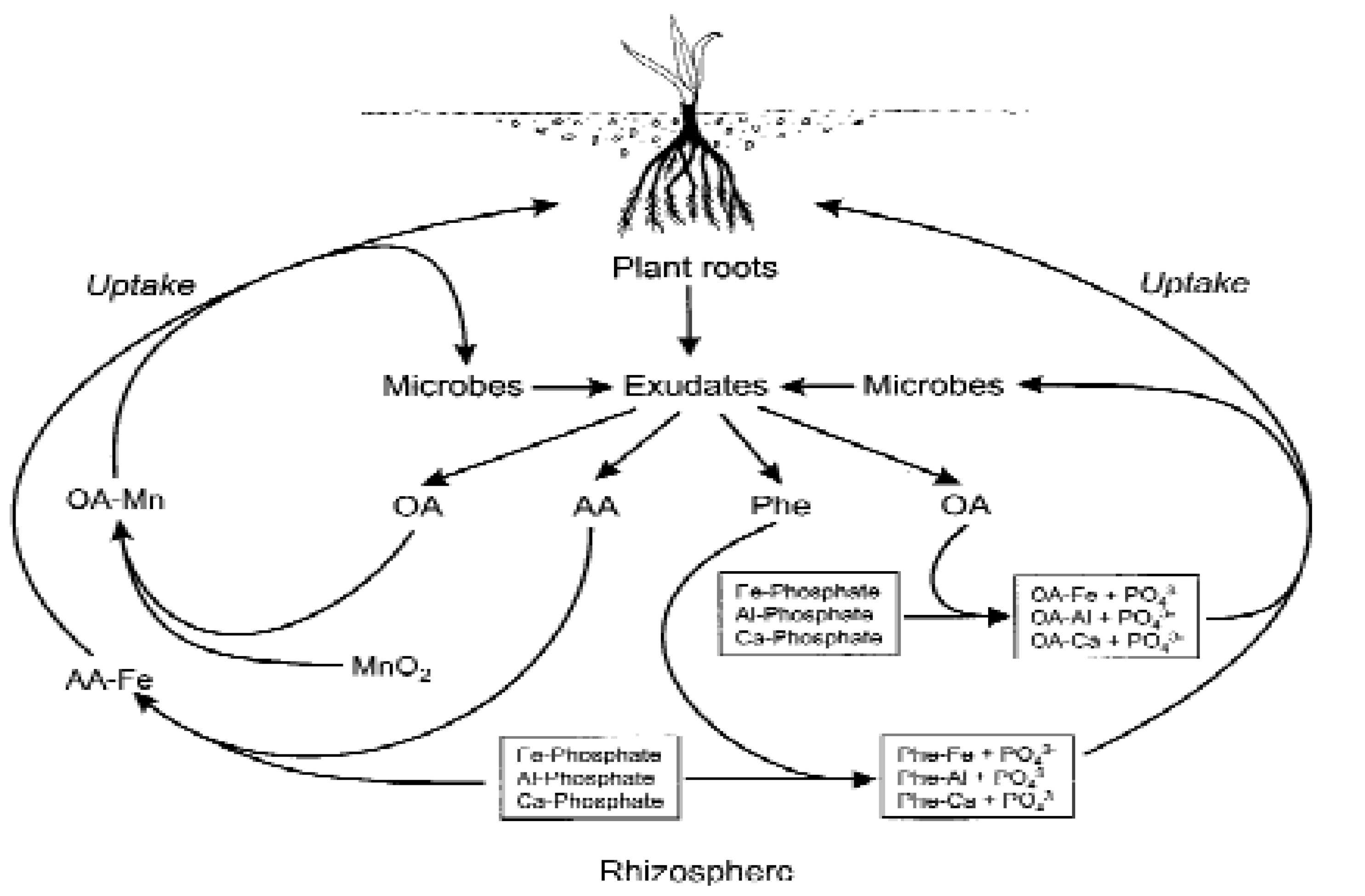

Figure 1: Effects of root exudate components on nutrient availability and uptake by plants and rhizosphere microbes [4]

Objectives

- ❑ Identify phosphorus and mineral extraction biomechanisms utilized by Paloverde grown on crushed granite.
- ❑ Identify and characterize biomaterials and their sources.
- ❑ Characterize rhizosphere microbial communities and their roles.

Hypotheses

- ❑ Paloverde releases organic acids to dissolve phosphorus and minerals in crushed granite.
- ❑ Paloverde releases phosphatase to dissolve organic phosphorus in nursery soil.
- ❑ Bacteria produce EPS that aids in the dissolutions of phosphorus and minerals in crushed granite.

Materials and Experimental Setup

Plant: Blue Paloverde (*Parkinsonia florida*).
Growth Media: Crushed granite, nursery soil, and sand.
Growth Period: 11 months.
Target Minerals: P, K, Na, Al, Mg, Ca, Fe and Mn.
❑ Figs. 2-5 show the experimental setup and analysis.

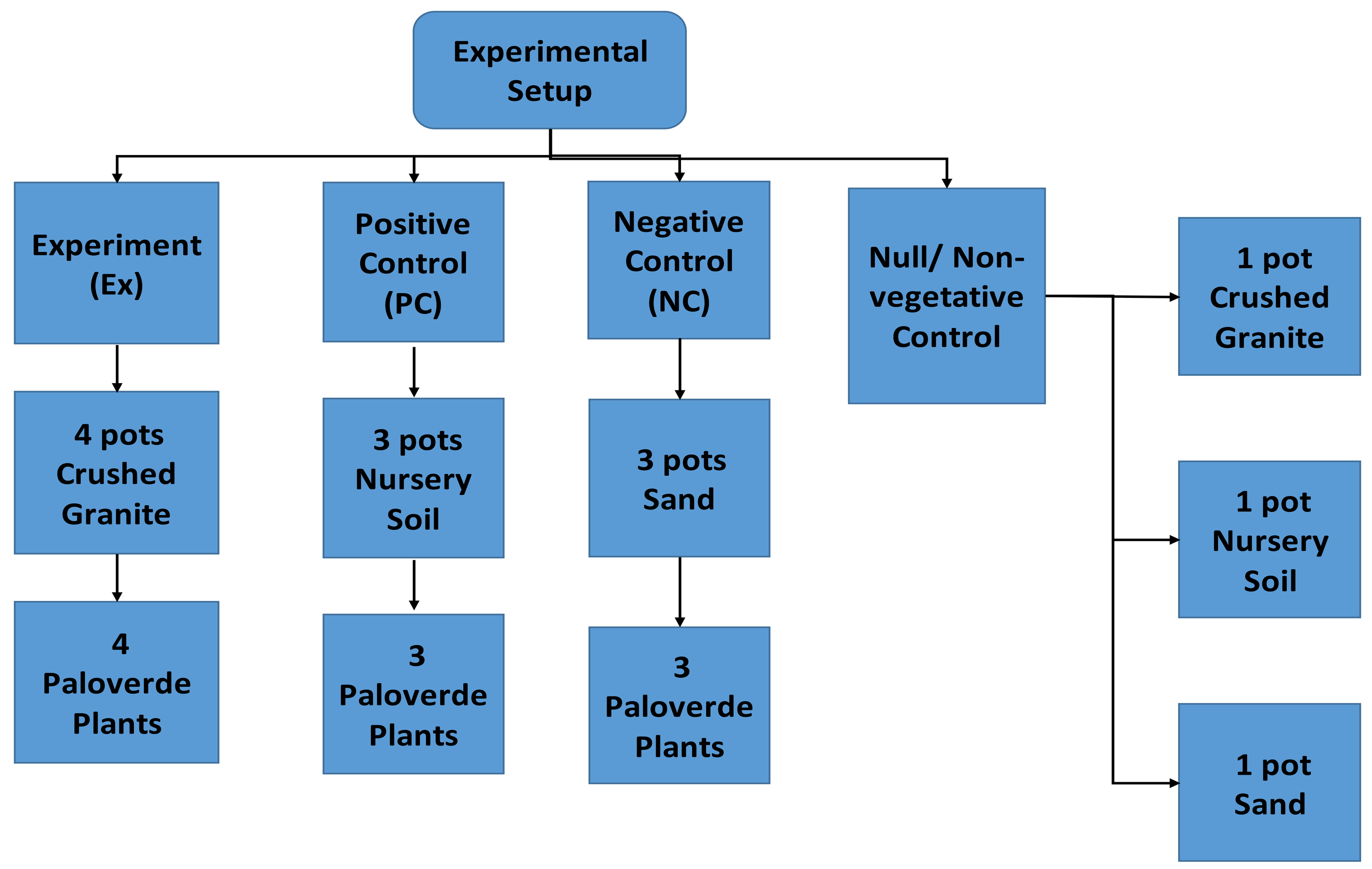

Figure 2: Experimental Setup

Figure 3: Negative and Positive Controls

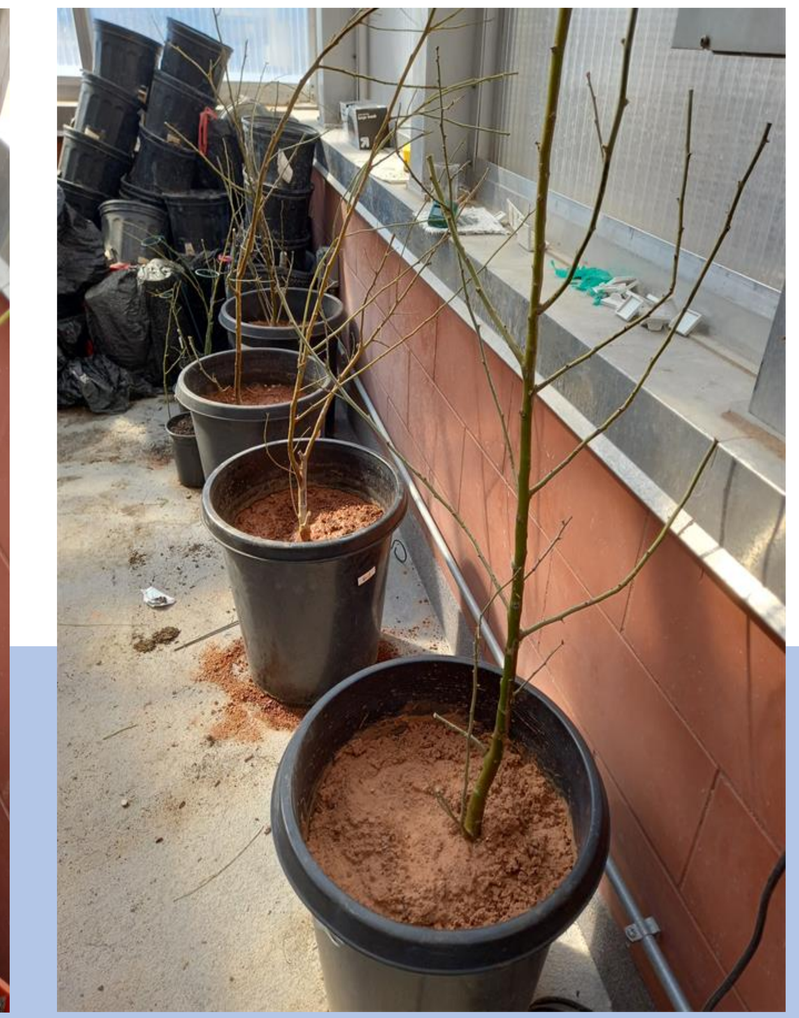

Figure 4: Experiment Plants

Samples and Analysis

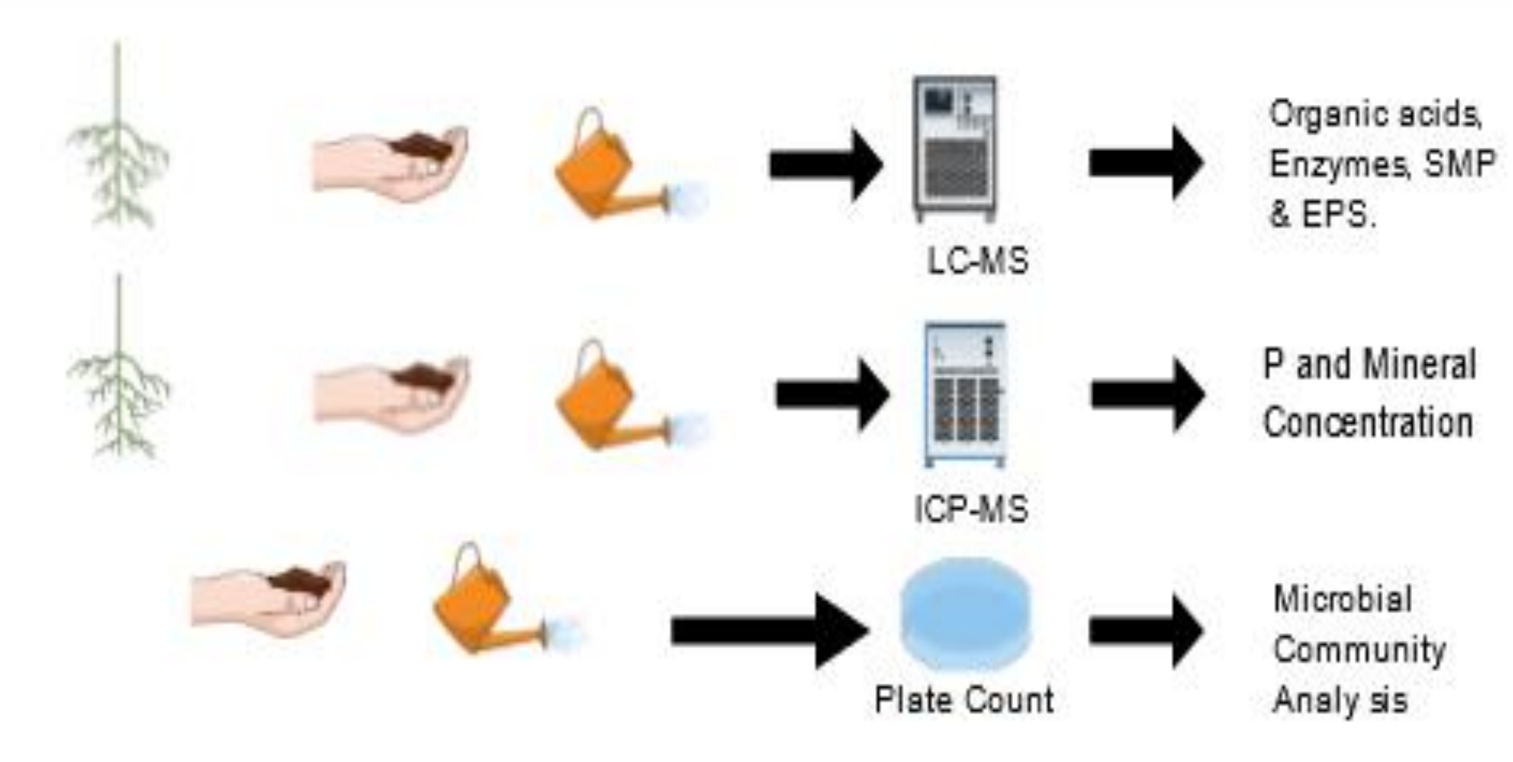

Figure 5: Samples and Analysis Methods

Data

Plant	Growth Media Weight	Plant Weight	Length
Experiment Plants (Paloverde + Crushed Granite			
Ex-1	39.3 kg	0.3 kg	138 cm (21cm+117cm)
Ex-2	40.5 kg	0.4 kg	153 cm (18cm+135cm)
Ex-3	41.1 kg	0.3 kg	127 cm (17cm+130cm)
Ex-4	41.8 kg	0.6 kg	223 cm (27cm+196cm)
Positive Control (Paloverde + Nursery Soi)			
PC-1	11.4 kg	430 g	155 cm (22cm+133cm)
PC-2	12.0 kg	370 g	141 cm (21cm+120cm)
PC-3	13.5 kg	320 g	181 cm (23cm+158cm)
Negative Control (Paloverde + Sand)			
NC-1	44.3 kg	780 g	201 cm (33cm+168cm)
NC-2	33.9 kg	430 g	180 cm (18cm+162cm)
NC-3	31.3 kg	280 g	162 cm (20cm+142cm)

Table 1: Paloverde and Growth Media Data

Anticipated Results and Significance

- ❑ This research will help identify biomaterials for resource extraction.
- ❑ Results will give valuable insight into how to grow plants on rocky planets such as Mars.
- ❑ Results will give us extraction efficiency of Paloverde which can be used for phytoremediation.

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