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Characterisation of Martian soil simulant MMS-1 in mixture with green compost for future sustainable space agriculture

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The configuration of a biologically active and fertile substrate consisting mainly of Martian regolith to facilitate the growth of edible plants during long-term manned missions to Mars constitutes one of the main challenges in spatial research. Regolith amendment with compost derived from recycled crew effluent crop waste generated by bioregenerative life support systems constitutes a substrate that may contribute to upgrade crew autonomy and long-term survival in space. In this context, the present work aimed to: i) study the geochemical and mineralogical composition of MMS-1 Mars simulant and the physicochemical and hydraulic properties of mixtures obtained by mixing MMS-1 and green compost at varying rates (0:100, 30:70, 70:30, 100:0; v:v); ii) evaluate the potential use of MMS-1 as growing medium of two lettuce cultivars; iii) assess how compost addition may impact on sustainability of space agriculture exploiting local resources. MMS-1 is a coarse-textured alkaline substrate consisting mostly of plagioclase, amorphous material and, to a lesser extent, zeolite, hematite and smectites. Although it can be source of nutrients, it lacks of organic matter, nitrogen (N), phosphorus (P) and sulphur (S), which may be supplied by compost. Both lettuce (Lactuca sativa L.) cultivars were able to grow on all mixtures for 19 days under fertigation. Red Salanova lettuce produced a statistically-greater dry biomass, leaf area and number than green Salanova. Leaf area and plant dry biomass were higher on 30:70 simulant/compost mixture. The shoot/root ratio of plants decreased as simulant in growth substrate increased. Lack of biological fertility and possible salt stress negatively impacted on plants grown in non-amended simulant. Our results show that it is possible to grow crops in Martian simulants adequately amended and fertilized. However, many remaining issue warrant further investigation concerning the dynamics of compost production, standardization of supply during long-term manned missions and representativeness of simulants to real Martian regolith.