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Regolith as baseline to a future space farm

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DIPARTIMENTO DI AGRARIA

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Abstract:

Heavy pay attention and investment of resources attended to space colonization were shown in the last decade. Many space agencies, first upon all NASA which have set programs to create a stable settlement on Moon (in the next years) looking at the future with a first manned mission to Mars. Because providing all consumables for the crew members from Earth becomes un-realistic, so, to reduce the payloads and the support delivery can be mandatory. In this perspective, a key role going to be played by *in situ* resource utilization (ISRU), specifically, improving the use of regolith (the “soil” of a planet) and promoting the re-use of waste materials produced. Nowadays few works have investigated the feasibility of use of these resources for crop productions and the effects on crop. Our work contributes to fill this gap, by using regolith simulant mixed at different rates with an amendment as plant growth substrates in a phytotron open gas exchange growth chamber, to evaluate their effects on lettuce (*Lactuca sativa* L.) under unfertilized conditions. Our results showed an increase of fresh biomass up to 23.6% in comparison with the control (pure simulant), while the nitrate amount resulted very low in all mixtures tested.

Keywords: ISRU; lettuce; regolith simulant

Material and Methods

The plant substrates were formed using Mojave Mars Simulant (MMS-1, The Martian Garden, Austin, Texas, USA) mixed at three different rates with monogastric manure (Jolly Pellet, Agraria Di Vita srl, Pistoia, Italy) sieved to 2 mm.

3 Substrate mixtures

Silicates	49.40%
Aluminum Oxide	17.1%
Iron III Oxide	10.87%
Magnesium Oxide	6.08%
Calcium carbonate	10.45%
Other	6.1%

MMS-1

(w:w)

100:0
70:30
50:50

Monogastric manure

Humidity	18%
Total Nitrogen (N)	2%
Total Carbon (C)	25
C/N ratio	12.5%

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Results and Discussion

In the current study, no fertilizers were delivered to plants and only osmotized water was used.
As shown in table 1, the pure simulant can be used as a substrate to germinate plants with 97.3% of seeds germinated compared to the control, while the mixtures showed that there is an inhibiting effect due to the presence of the manure that did not allow germination, this was associated with the high values of electrical conductivity recorded. Figure 1 shows the effect of monogastric manure which improves the fresh yield by 23% and 17% for 30% and 50% of amendment treatments respectively as compared to pure simulant

Control	MMS1 0%	MMS1 30%	MMS1 50%
50 ± 0.00	48.7 ± 0.33	n.g .	n.g.

Table 1. Evaluating MMS-1 effects on germination. 50 seeds of *L. sativa* were placed on the surface of the indicated substrate in Petri dishes and the germination of samples were evaluated 15 days after sowing . The treatment are: control, pure simulant and simulant mixed with manure 30 and 50 % (w/w). the study was performed in triplicate and the results are expressed as the average with standard error, n.g = not germinated.

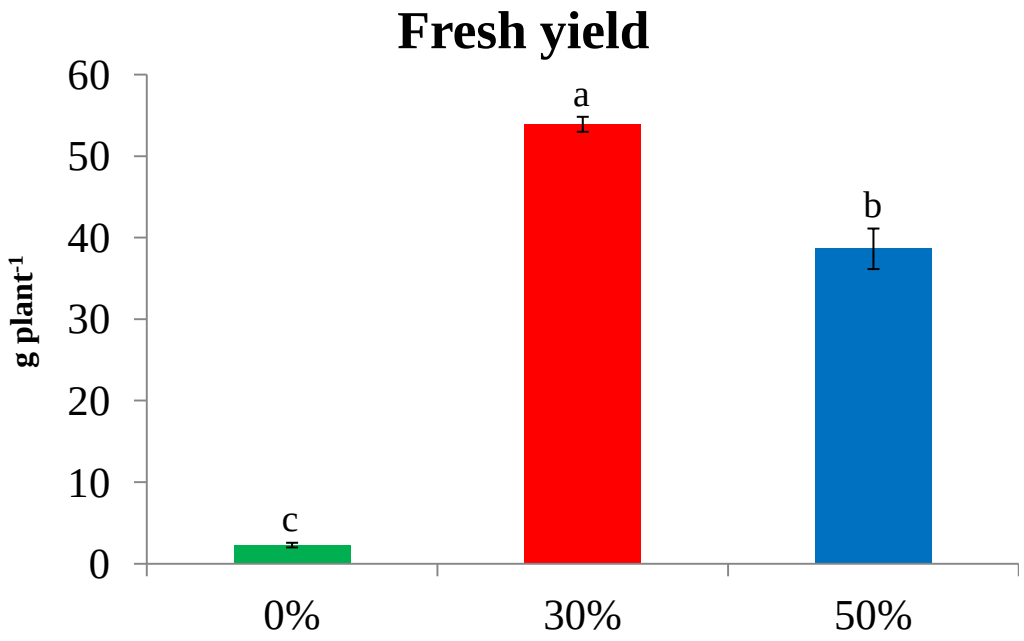

Figure 1. Fresh yield of lettuce, as influenced by substrate mixtures (three different rates of MMS-1 simulant:manure w:w). Different letters above bars indicate significant mean differences according to Duncan's multiple range tests ($P \leq 0.05$). Vertical bars indicate ± SE (standard error) of means.

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Results and Discussion

Concerning the leaf dry matter percentage (Fig.2a) a significant and negative correlation was observed with the amount of manure (r=-0.97). The high percentage of the dry matter recorded on plants grown on pure simulant can be could be attributed to nutritional stress which displayed itself with an advanced state of senescence at the time of harvesting. The previous results are also supportedby the low nitrate content (Fig.2b) in lettuce leaves. That is significantly correlated with the increasing percentage of soil amendment (r=0.94), with values of 1.9 and 2.6 times higher than pure simulant.

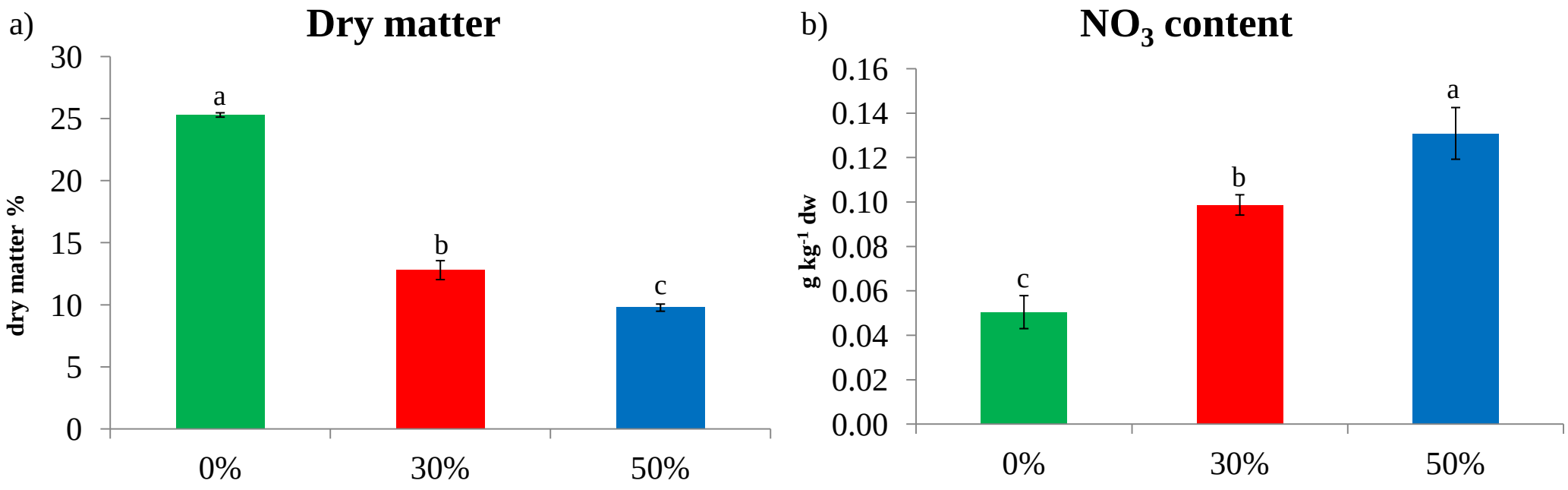

Figure 2. Dry matter (**a**) and Nitrate content (**b**) of lettuce, as influenced by substrate mixtures (three different rates of MMS-1 simulant:manure w:w). Different letters above bars indicate significant mean differences according to Duncan's multiple range tests ($P \leq 0.05$). Vertical bars indicate ± SE (standard error) of means.

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Conclusions

To summarize no phytotoxic effects associated with the simulant were found on the tested lettuce plants. Cultivation of lettuce plants under pure simulants conditions is actually not feasible and it is important the amendment of 30% or 50% of manure in order to alleviate the detrimental effects on crop performance and resilience. In perspective of a future manned mission to colonize Mars further studies need to be conducted to improve the chances of success.