

## Plant nitrogen uptake at elevated CO<sub>2</sub>

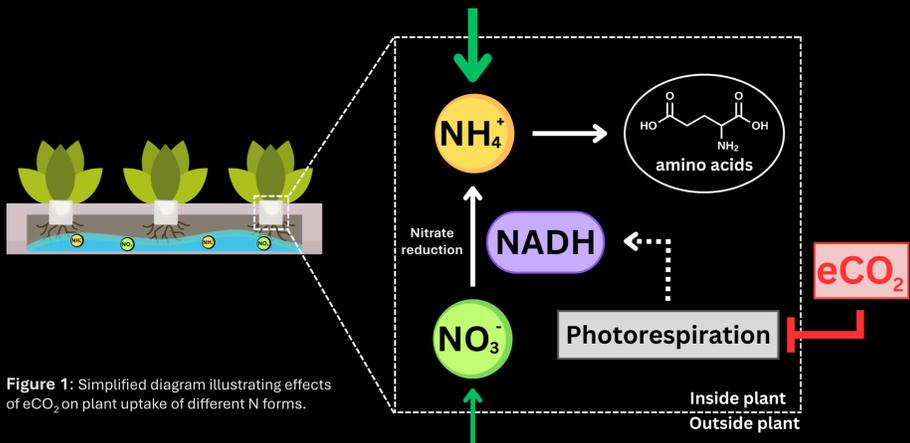


Figure 1: Simplified diagram illustrating effects of eCO<sub>2</sub> on plant uptake of different N forms.

- Carbon dioxide (CO<sub>2</sub>) levels often exceed 3000 ppm on the International Space Station (ISS) <sup>1</sup>.
- Elevated CO<sub>2</sub> (eCO<sub>2</sub>) may increase plant preference for ammonium as a nitrogen (N) source through inhibition of photorespiration <sup>2</sup> (Figure 1).
- Understanding shifts in plant N preference at eCO<sub>2</sub> will inform nutrient optimization for space crop production and wastewater processing system design requirements <sup>3</sup>.

## Differential <sup>15</sup>N labelling approach to determine plant N preference

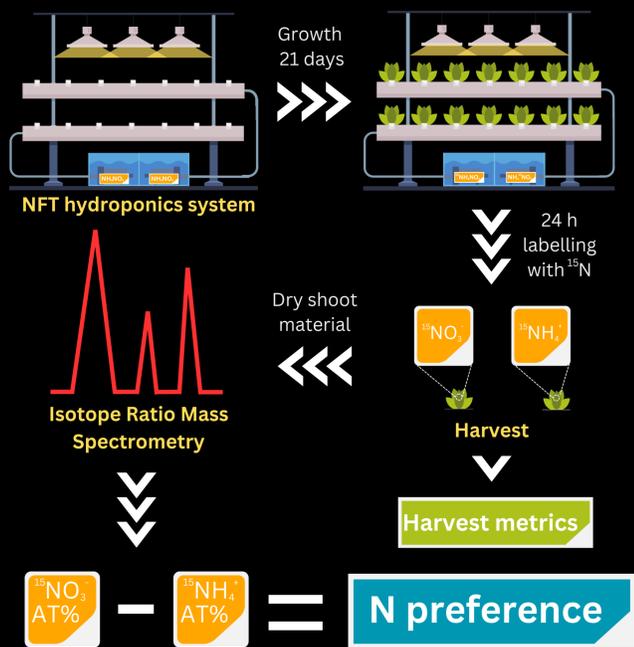


Figure 2: Flowchart detailing the <sup>15</sup>N differential labelling approach taken to characterize plant N preference in the study. Labelling approach and N preference calculation based on <sup>4</sup>, AT% = atom%. The same approach was taken to determine N preference at ambient and elevated CO<sub>2</sub> (410 ppm and 3000 ppm, respectively).

## Lettuce plants display ammonium preference under hydroponic cultivation

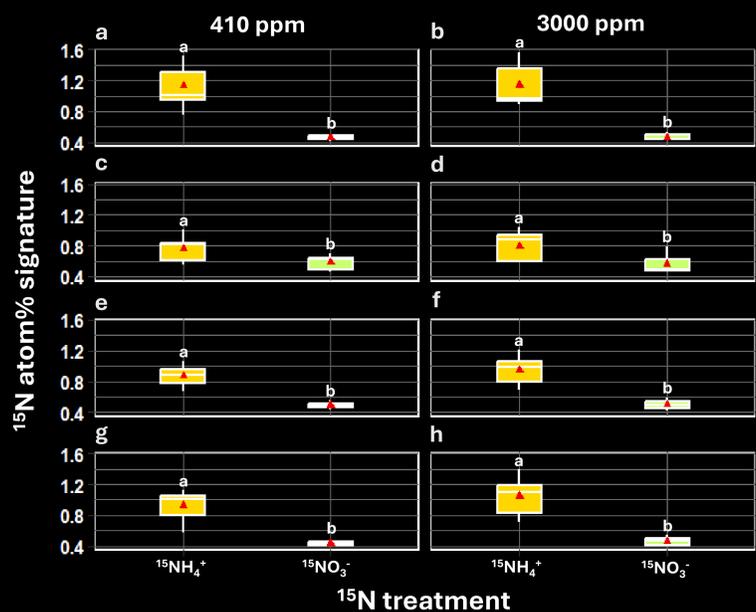


Figure 3: Boxplot of <sup>15</sup>N atom% signatures for ammonium and nitrate labelled lettuce plants of varieties Black Seeded Simpson (BSS, 3a,b), Dragoon (Dra, 3c,d), Outredgeous (Out, 3e,f), and Waldmann's Dark Green (WDG, 3g,h). Boxes represent the interquartile range and whiskers the variability of the data. The median is marked with a horizontal line, and the mean with a red triangle. Groups that do not share a letter within each plot have significantly different means (Welch's *t*-test, *p*<0.05).

# A simulated high CO<sub>2</sub> spaceflight environment increases plant preference for ammonium as a nitrogen source.

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## N preference varies across lettuce varieties

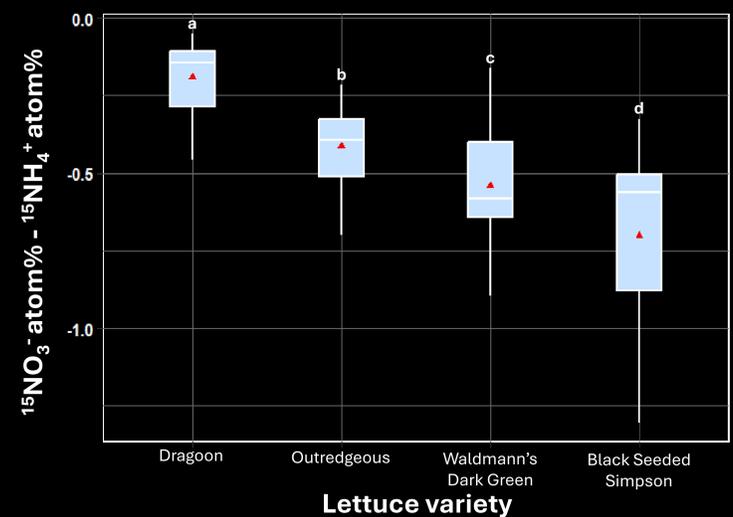


Figure 4: Boxplot of N preference values for the 4 lettuce varieties first described in Figure 3. N preference was calculated as described in Figure 2. Negative values indicate ammonium preference, positive values indicate nitrate preference. A value of 0 indicates no N preference. Boxes represent the interquartile range and whiskers the variability of the data. The median is marked with a horizontal line, and the mean with a red triangle. Groups that do not share a letter have significantly different means (one-way ANOVA following mixed effects modelling, *p*<0.05).

## eCO<sub>2</sub> increases plant preference for ammonium

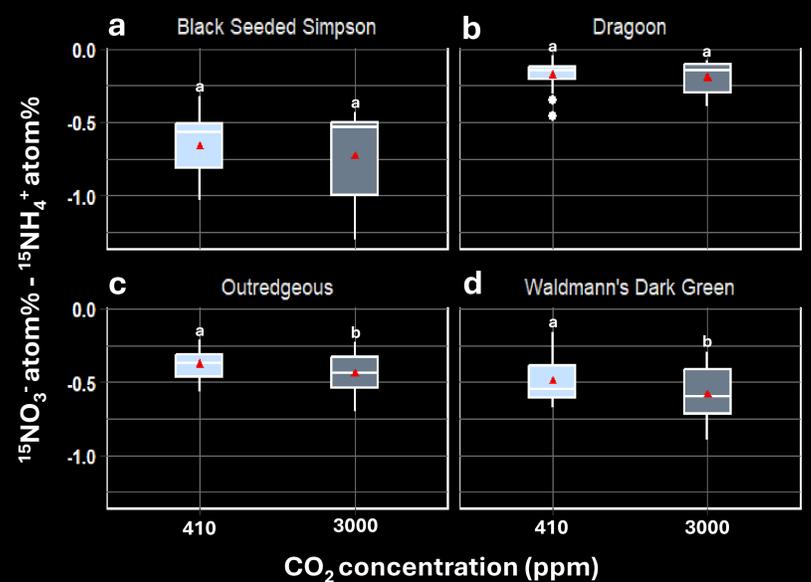


Figure 5: Boxplot of N preference values at ambient CO<sub>2</sub> (410 ppm) and eCO<sub>2</sub> (3000 ppm) for Black Seeded Simpson (5a), Dragoon (5b), Outredgeous (5c), and Waldmann's Dark Green (5d). N preference was calculated as described in Figure 2. Negative values indicate ammonium preference, positive values indicate nitrate preference. A value of 0 indicates no N preference. Boxes represent the interquartile range and whiskers the variability of the data. The median is marked with a horizontal line, and the mean with a red triangle. Groups that do not share a letter have significantly different means (one-way ANOVA following mixed effects modelling, *p*<0.05).

## Summary

- Lettuce plants displayed ammonium preference under hydroponic cultivation (Figure 3), though the extent of ammonium preference differed across varieties (Figure 4).
- ISS-level eCO<sub>2</sub> increased ammonium preference, but to differing extents depending on the variety (Figure 5).
- Future nutrient formulations for space crop production should favor ammonium as a dominant N source.

## Future work

- Assess whether plants display increased ammonium preference at eCO<sub>2</sub> in spaceflight hardware (e.g. arcillite substrate).
- Determine the optimum ratio of ammonium : nitrate to maximize productivity for space crop production.
- Characterize changes in N preference at eCO<sub>2</sub> in other candidate space crops.



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### References

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