Plants prefer ammonium as a N source under elevated CO_2: Implications for space crop production.

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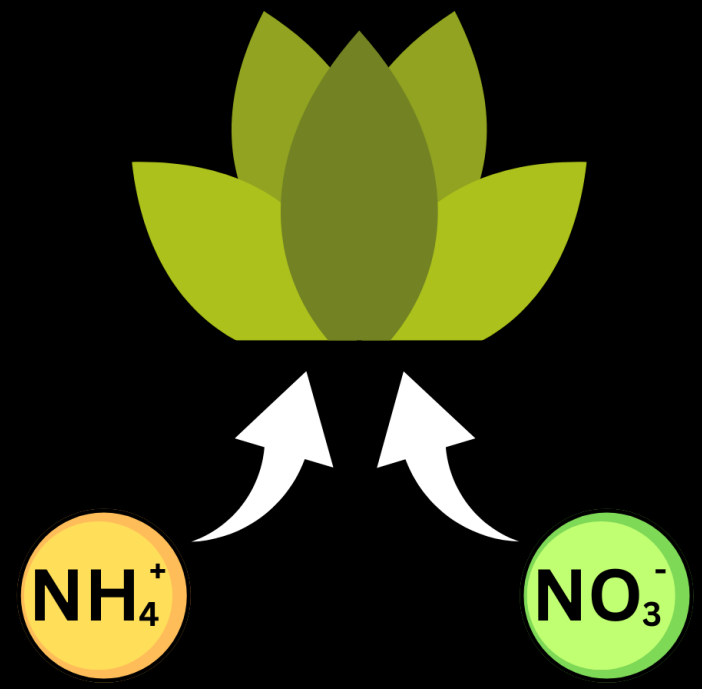
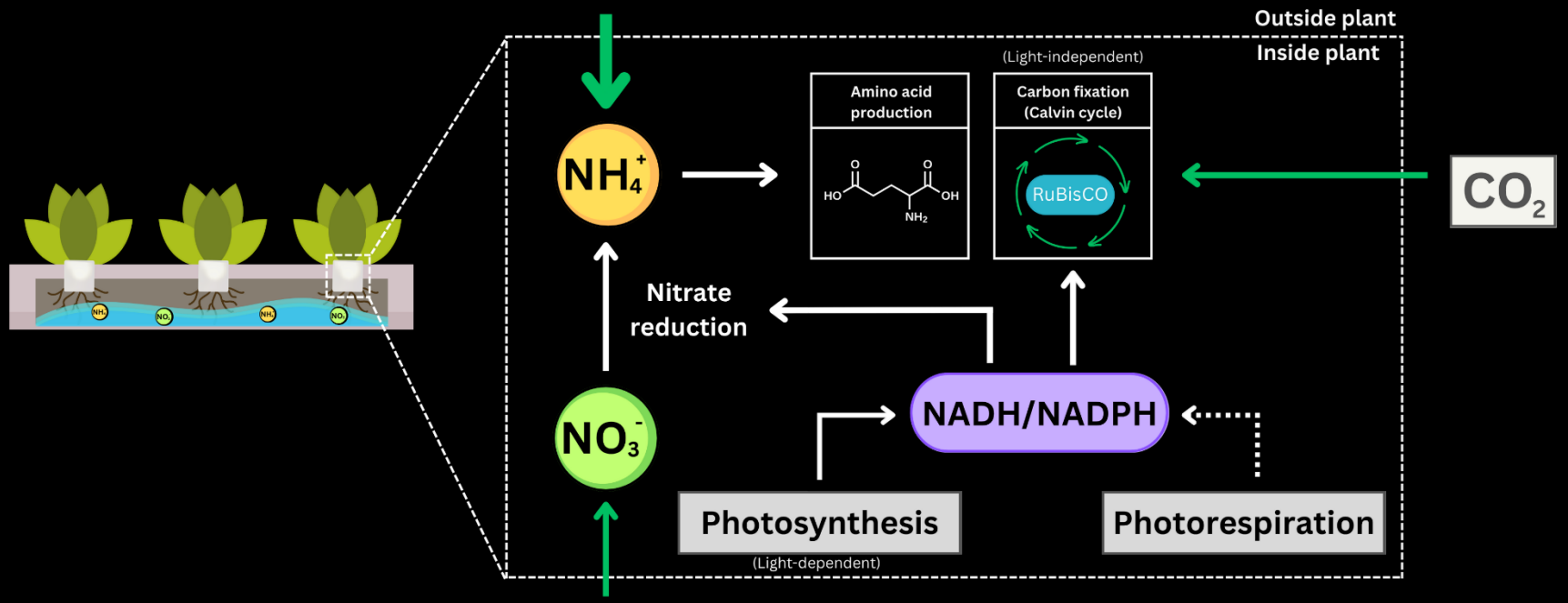
Nitrogen (N) uptake and preference

- Crucial nutrient for plant survival
- Inorganic forms used in agriculture
- Major inorganic forms include ammonium (NH_4^+) and nitrate (NO_3^-)
- Plants can show preference for different N forms
- Key factors include environment, physiology and growth substrate



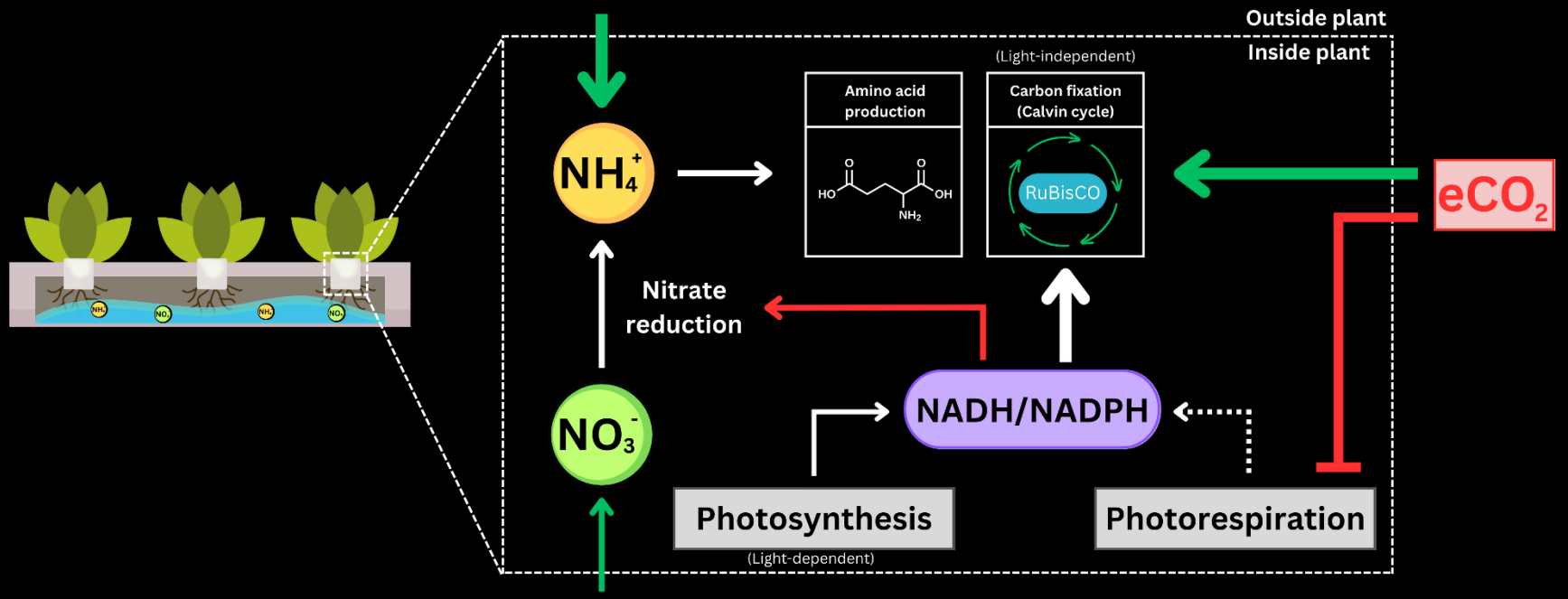
Plant growth at eCO_2 under varying N nutrition



- Reductant (NADH) used during C fixation.
- Surplus reducing power available for NO_3^- reduction.

Fountain *et al.* (in prep.)

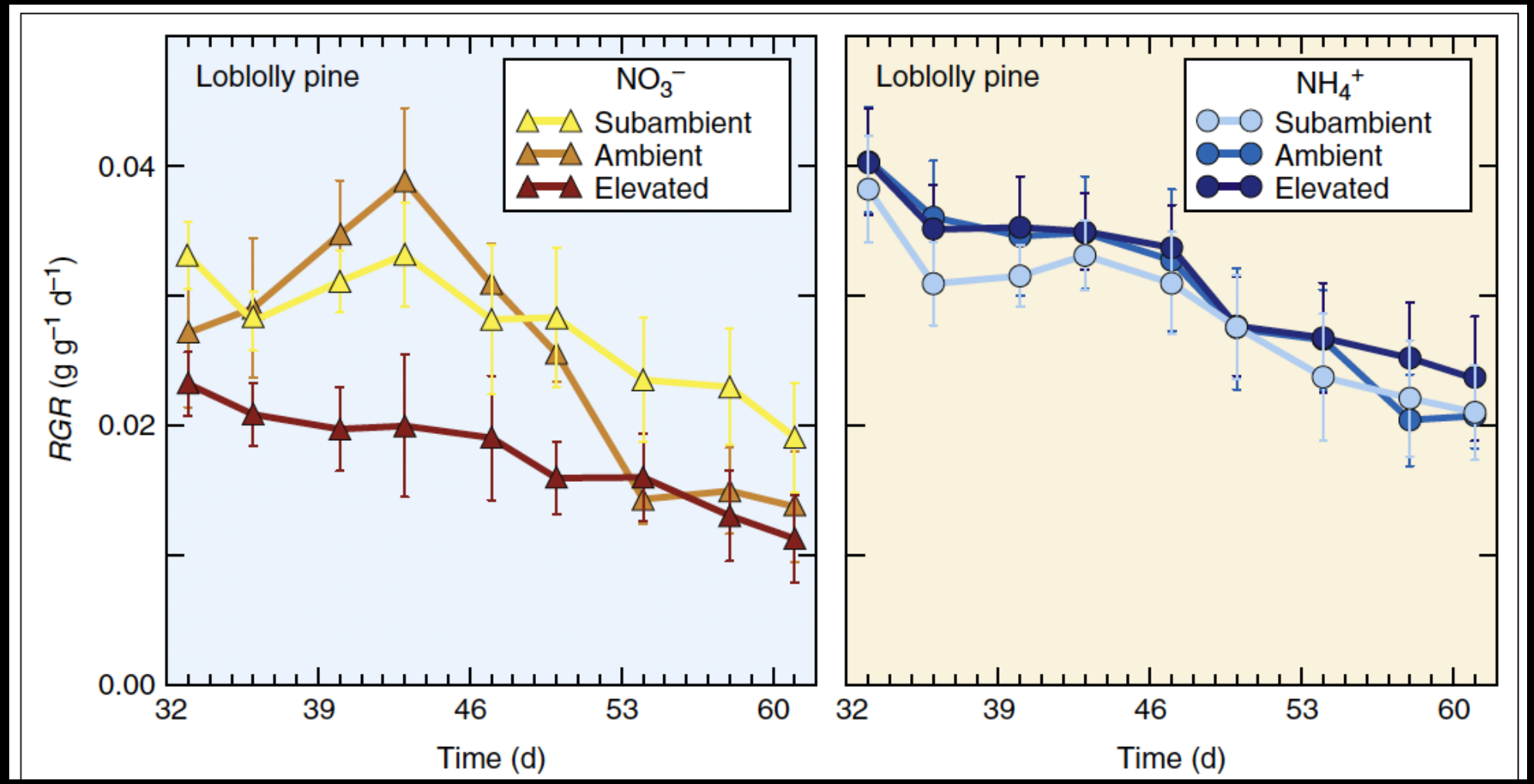
Plant growth at eCO_2 under varying N nutrition



- Reducing power diverted to fix additional C.
- Inhibition of photorespiration through altered CO_2:O_2 ratio.
- Less reductant available for NO_3^- reduction.

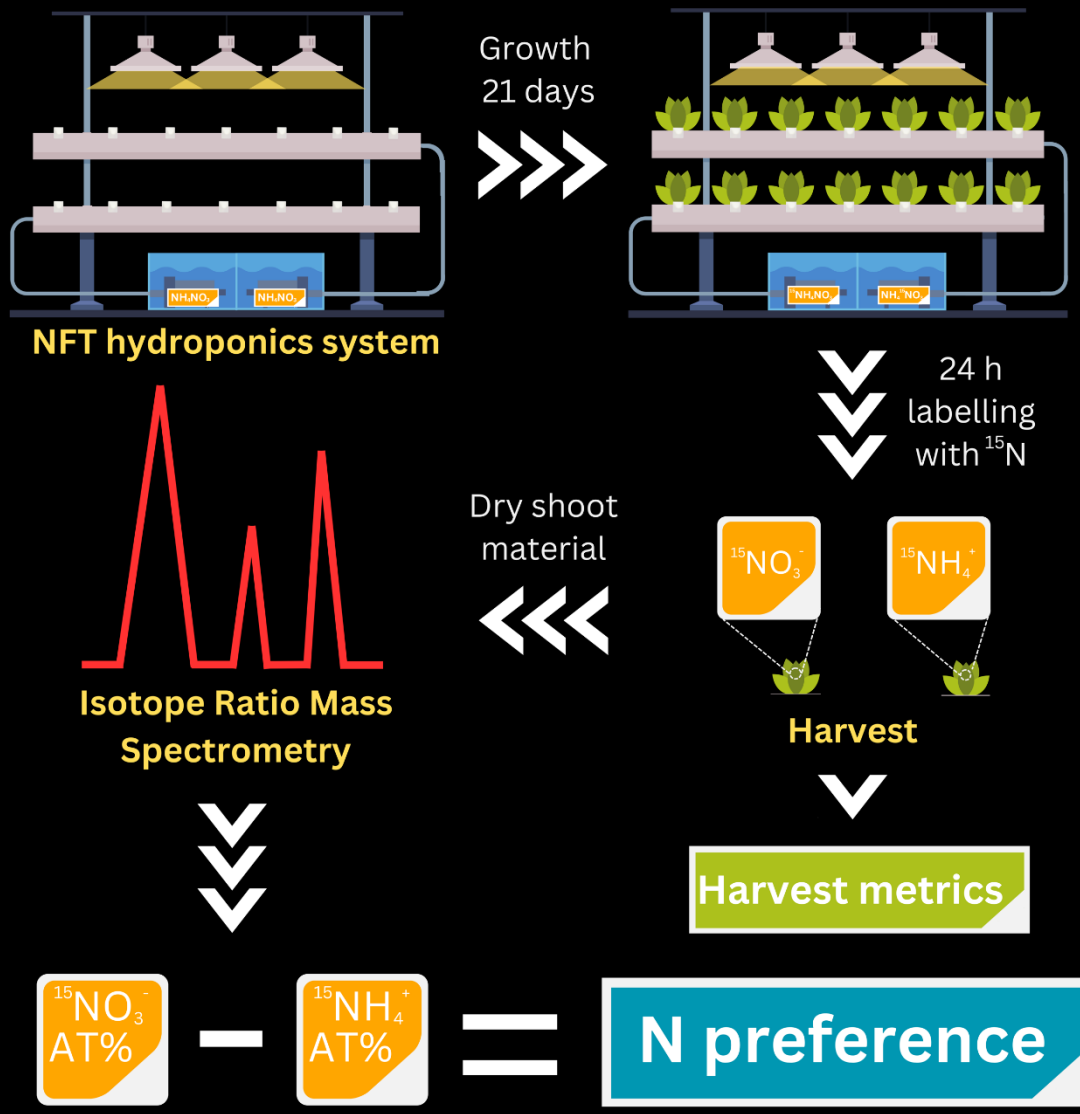
Fountain *et al.* (in prep.)

Plant growth at eCO_2



Bloom *et al.* (2012), Ecology **93**(2), pp. 355-367.

Measuring N preference using ^{15}N stable isotopes

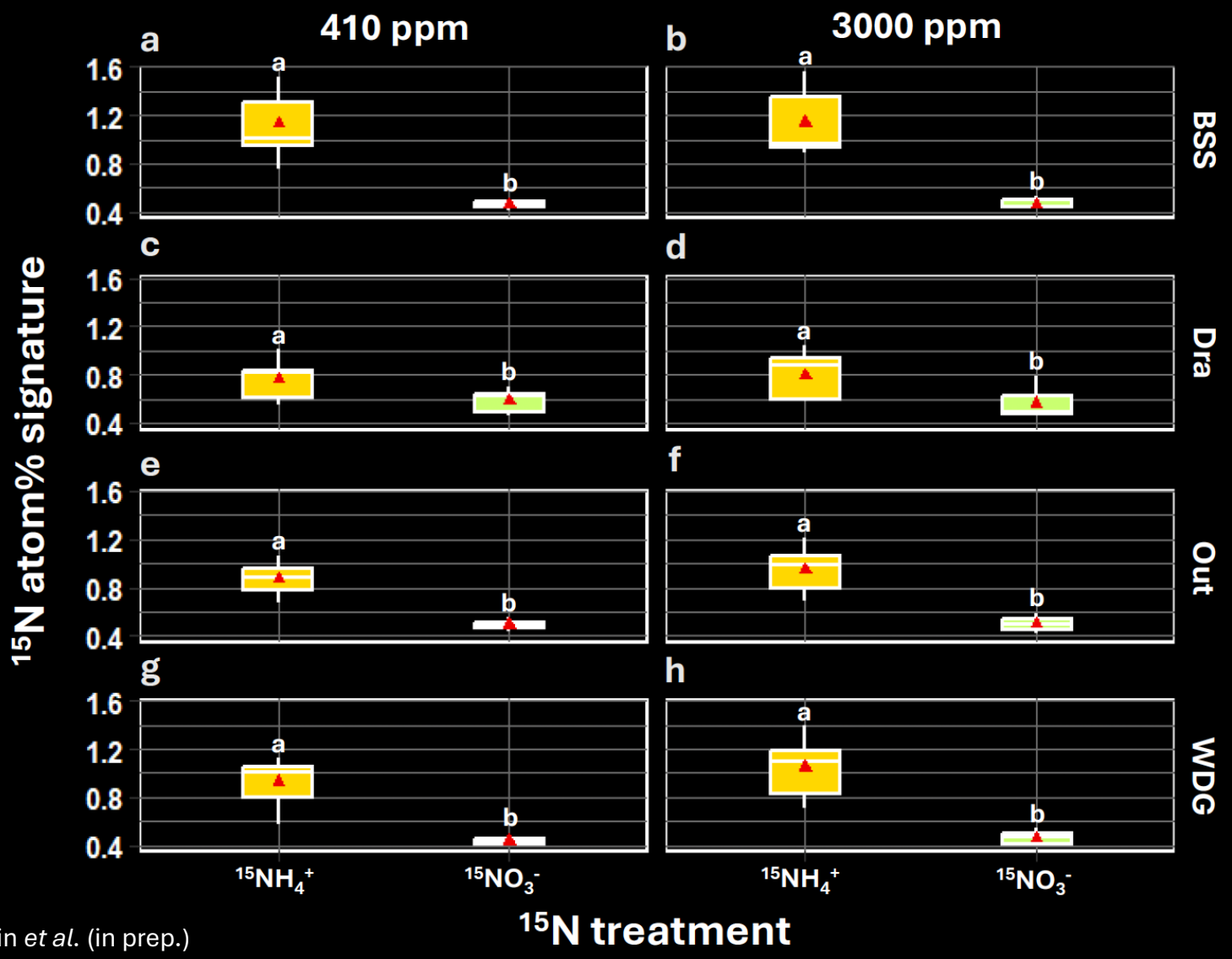


-ve value = ammonium preference

+ve value = nitrate preference

Fountain *et al.* (in prep.)

Lettuce N preference under hydroponic cultivation



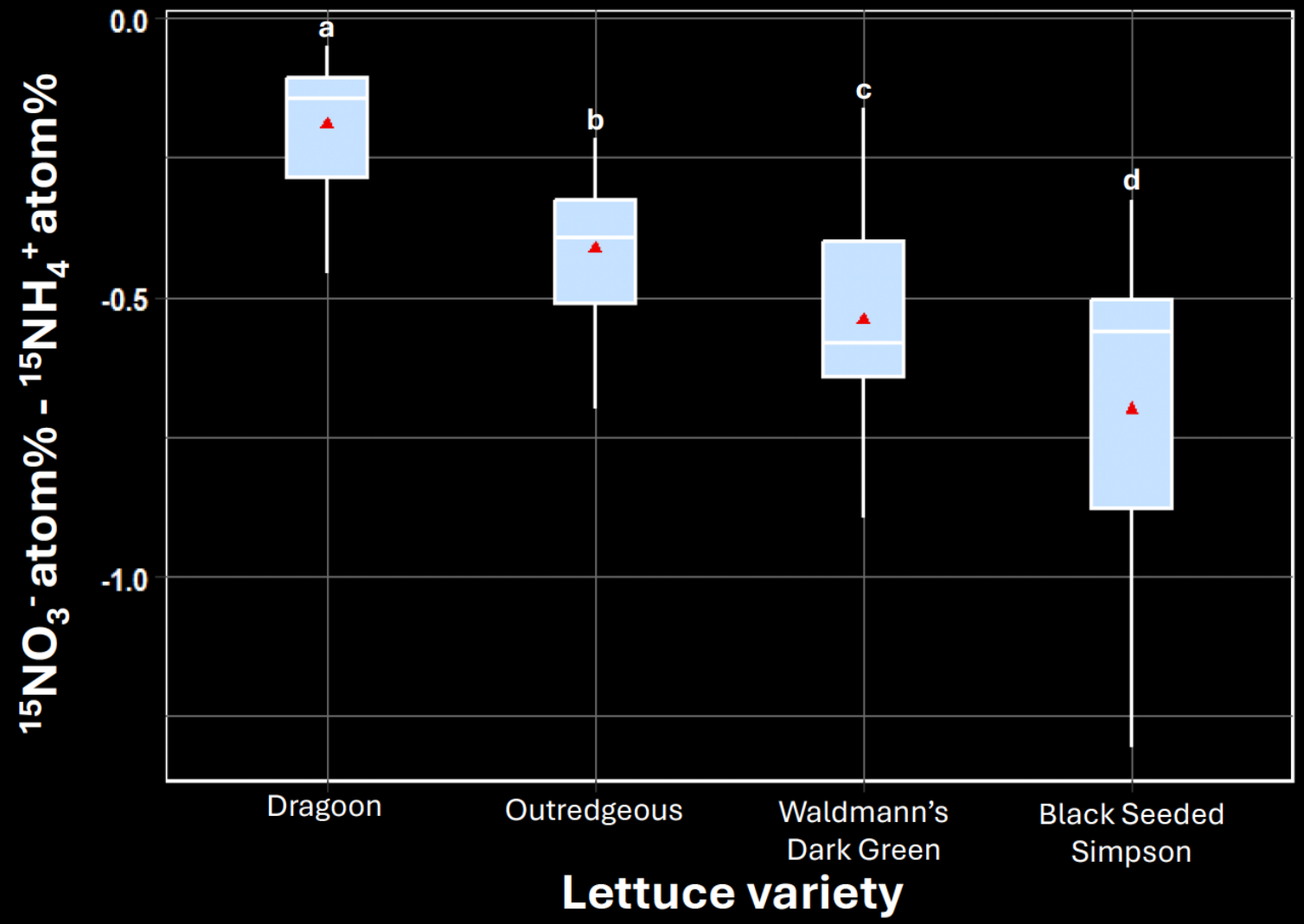
Fountain *et al.* (in prep.)

BSS – Black Seeded Simpson
Dra – Dragoon
Out – Outredgeous
WDG – Waldmann's Dark Green

Heirloom
Grown in space

Groups not sharing a letter are significantly different ($p < 0.05$, Welch's t-test).

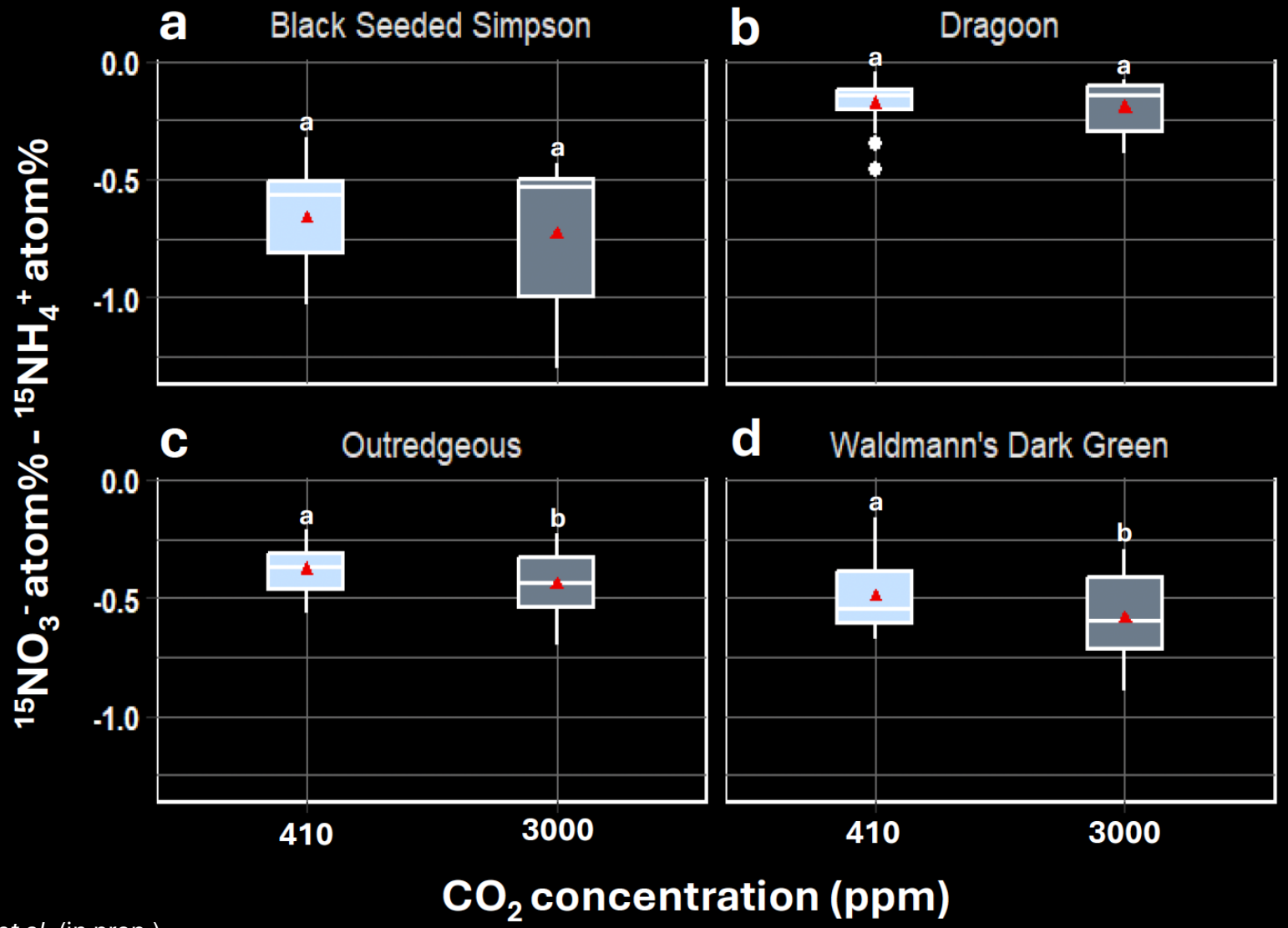
Lettuce N preference varies across varieties



Groups not sharing a letter are significantly different ($p < 0.05$, one-way ANOVA following mixed-effects modelling).

Fountain *et al.* (in prep.)

eCO_2 increases lettuce preference for ammonium



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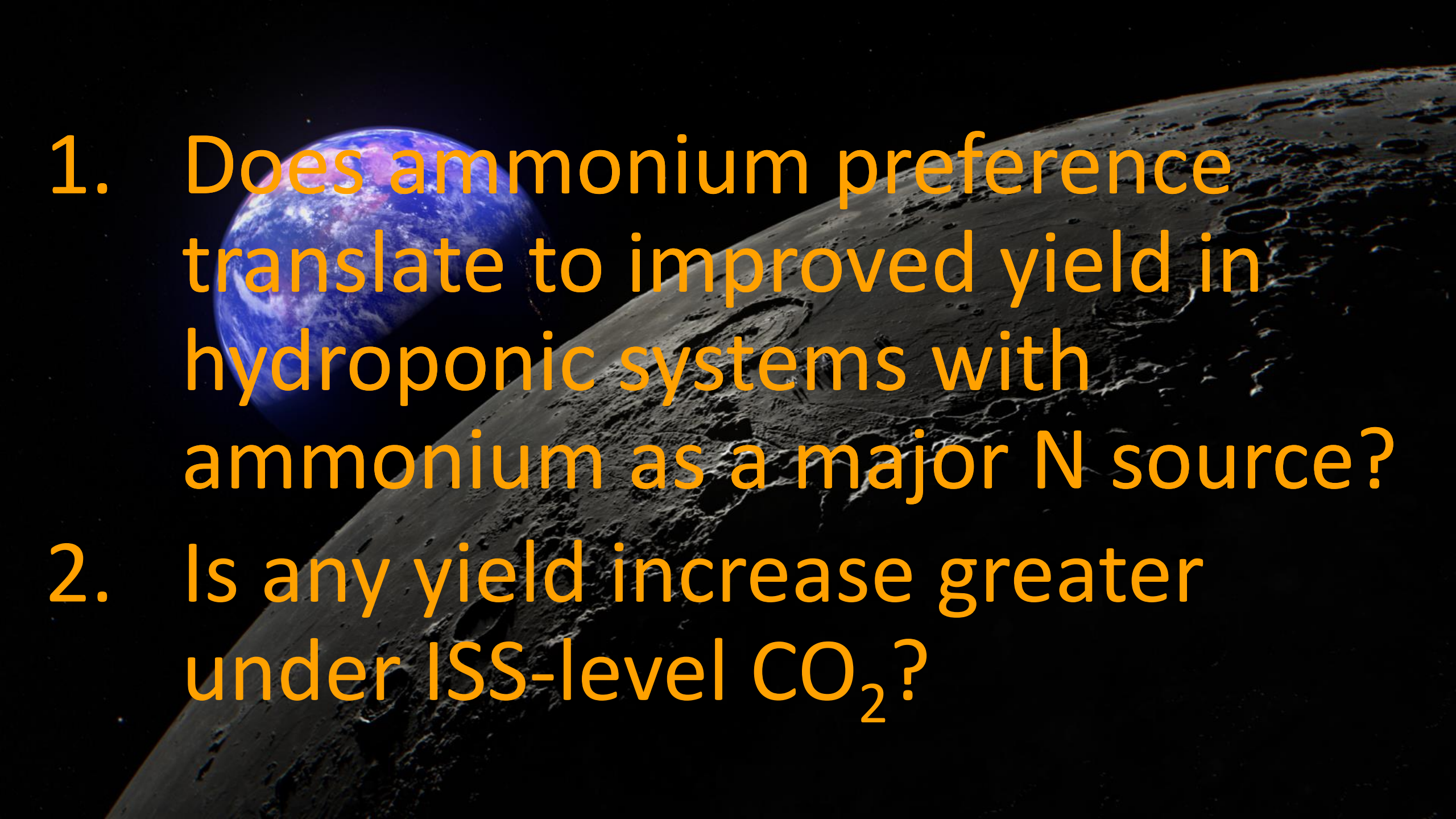
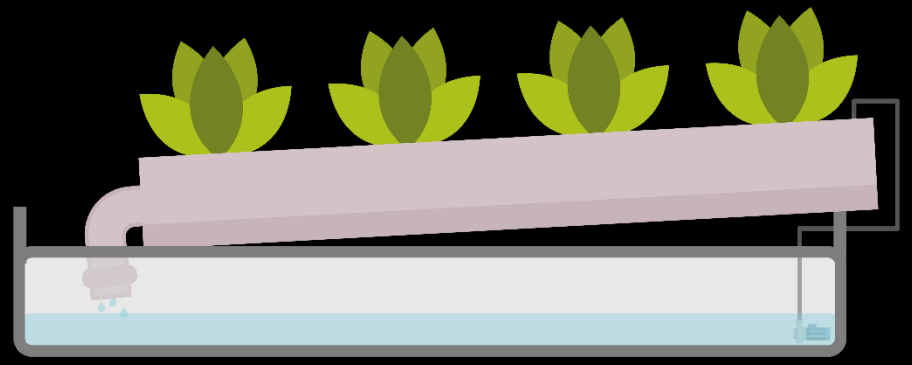

1. Does ammonium preference translate to improved yield in hydroponic systems with ammonium as a major N source?
2. Is any yield increase greater under ISS-level CO_2?

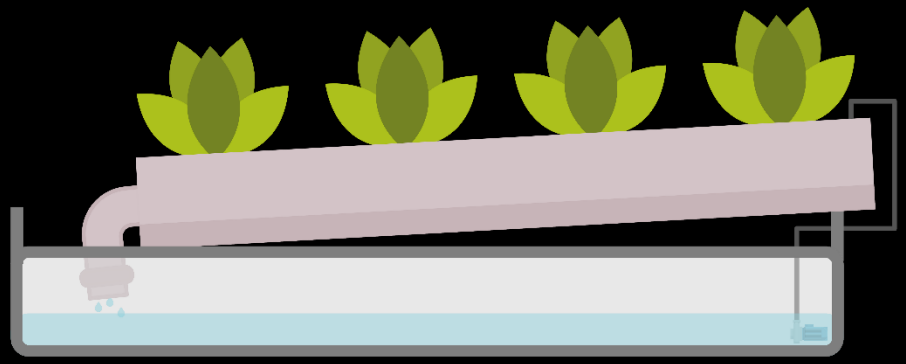
Lettuce cultivation under varying ammonium : nitrate ratios

- Two NH_4^+:NO_3^- ratios.
- Two lettuce varieties; ‘Outredgeous’ and ‘Dragoon’.
- 28 day growth cycle.
- Ambient (420 ppm) and elevated (3000 ppm) CO_2.

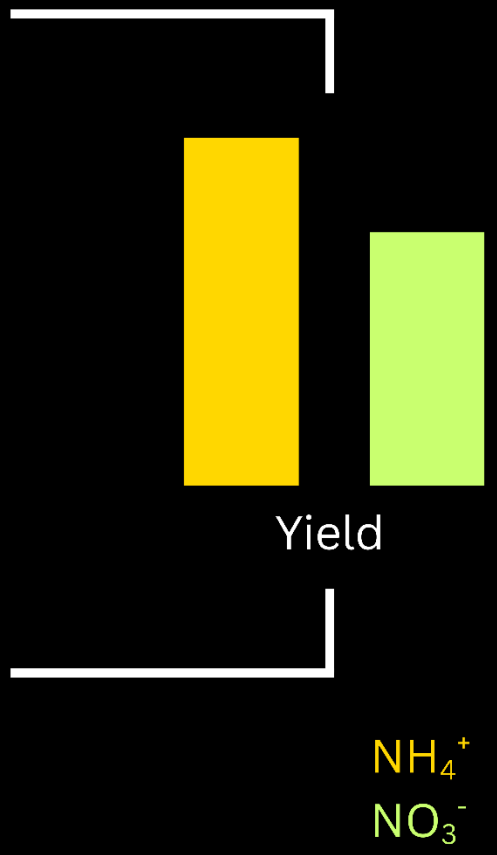


0% NH_4^+ : 100% NO_3^-

½ Strength Hoagland’s [control]

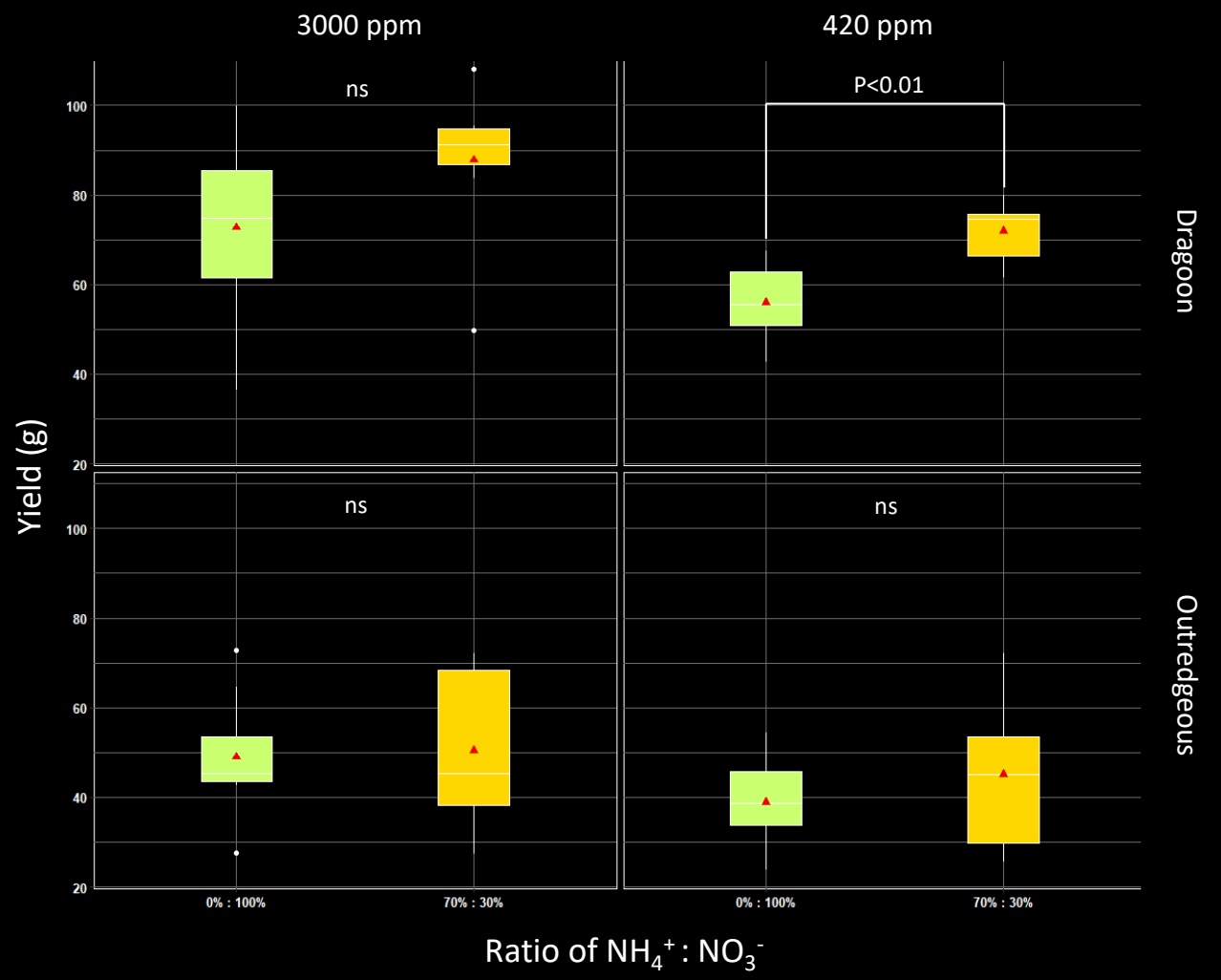


70% NH_4^+ : 30% NO_3^-



NH_4^+ nutrition increases lettuce yield

- Yield increase of ~28 % in Dragoon, irrespective of CO_2 concentration.
- Yield increase of ~16 % in Outredgeous at 420 ppm, no change at 3000 ppm.



Summary

- Plants take up a small baseline amount of nitrate but display significant ammonium preference when cultivated hydroponically.
- Degree of ammonium preference varies significantly across varieties, likely linked to plant size and total nitrogen content.
- Plants with higher N demand typically source the additional N as ammonium.
- Ammonium preference may be further exacerbated by ISS-level CO_2.
- Ammonium-dominant nutrient solutions increase yield of hydroponically-grown lettuce, though this is dependent on variety and CO_2 concentration.

Ammonium should be considered as a dominant N source for plants grown hydroponically and/or at high CO_2 in future space crop production scenarios.

Future Directions

- Determine advantages of NH_4^+ provision in other candidate space crops.
- Explore potential use of plant N uptake strategies to:
  - Minimize nitrate accumulation in salad crops.
  - Manage pH of hydroponic nutrient solutions.

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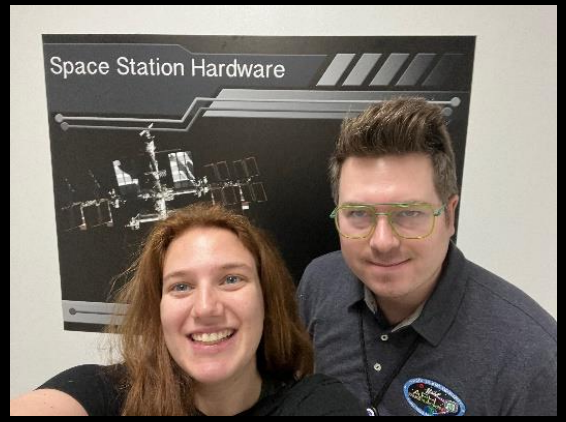
Space Biology



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Any questions?

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