Impacts of climate change on an insect herbivore with an aboveground-belowground lifecycle

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By 2080, it is predicted that atmospheric carbon dioxide (CO_2) concentrations will be almost double present levels. Such changes could undermine many environmentally driven management practices, for instance by making minor pest species more prolific.[1] Studies have conventionally focussed on aboveground insect herbivores to the comparative neglect of those that live belowground. We report on how elevated CO_2 concentrations [CO_2] affected the clover root weevil (*Sitona lepidus*) - an insect herbivore with an aboveground-belowground lifecycle. Adult insects feed on white clover (*Trifolium repens*) leaves, while their soil-dwelling offspring graze on *T. repens* roots and N_2-fixing *Rhizobium* root nodules[2]

Experiments

- Experiments were conducted in chambers (Fig. 1)[3] that allowed soil temperature gradients to follow a lag function of air temperature. Air temperature followed a sine function, having a midday peak of 25°C decreasing to 15°C at night.

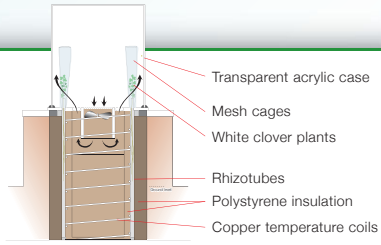

Fig. 1. Climate chambers used in this study

- Twenty nine *T. repens* plants were grown under [CO_2] of 380 and 700 µmol mol^{-1}. A single ovipositing female *S. lepidus* was caged on 14 *T. repens* plants, with the remaining 15 *T. repens* remaining insect-free. After four weeks, aboveground-belowground insect and plant responses were quantified.

Results

Aboveground

- Leaf area increased significantly with elevated [CO_2] (Fig. 2a) as did foliar C:N ratio (Fig. 2b), due to reduced N and increased C. Insect presence significantly increased the C:N ratio further (Fig. 2b).
- No changes were seen in stem length, fresh mass or leaf number.
- Adults consumed significantly more foliage at elevated [CO_2] but laid significantly fewer eggs (Fig. 2c).

Belowground

- Elevated [CO_2] increased the number of root nodules (Fig. 2d), with accompanying significant increases in root depth, root mass and nodule size.
- C:N ratios also increased with elevated [CO_2]. The presence of *S. lepidus* was associated with even greater increases in this ratio due a substantial decrease in root N levels.
- The number of nodules damaged by *S. lepidus* larvae increased significantly in elevated [CO_2], which was associated with significantly enhanced survival (Fig. 2f) and faster rates of development.

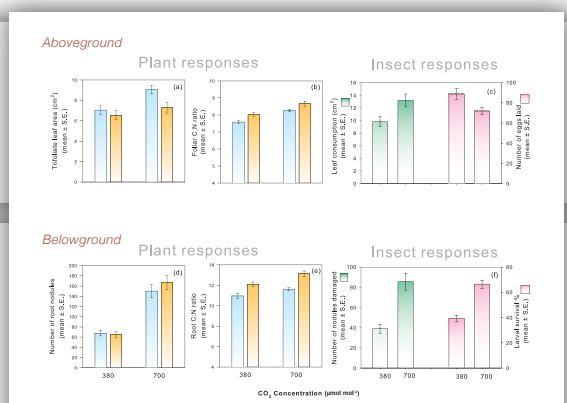

Fig. 2. Examples of plant and insect responses (above and belowground) to elevated [CO_2]. (□ insect-free, ▫ *S. lepidus* treatments)

Conclusions

- Elevated [CO_2] affected *T. repens* in several ways, most notably in the root system which had 230% more nodules than plants grown at ambient [CO_2]. When reared on less nutritious foliage (e.g. higher C:N) at elevated [CO_2], adult *S. lepidus* consumed more foliage (probably due to compensatory feeding) but laid fewer eggs.
- Even though fewer eggs were laid into the soil, *S. lepidus* larvae survived and performed much better at elevated [CO_2], possibly due to the increased levels of nodulation.[2] Increased nodule herbivory, however, exacerbated C:N root increases due to an even greater reduction in root N.
- Climate change may increase nodulation in *T. repens* under certain conditions, but potential benefits (e.g. provision of N without chemical fertilization), could be undermined by larger *S. lepidus* populations belowground.

Acknowledgements

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References

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