Can we increase the nitrogen fixation efficiency of *Sinorhizobium meliloti?*

Justin Bower — Department of Ecology, Evolution, and behavior: University of Minnesota, Twin Cites

Introduction

Rhizobia are soil bacteria that can grow and reproduce in legume root nodules (Fig. 1). They use carbohydrates from their host plant for reproduction and also to fix nitrogen (N2 → NH3) for the host. The amount of nitrogen fixed per its carbon cost is defined as nitrogen fixation efficiency.

Nitrogen fixation can amount up to $37.50 per acre. However, rhizobia are not always fixing nitrogen at maximum efficiency. In alfalfa nodules, nitrogen-fixing rhizobia lose the ability to reproduce and don't hoard carbon. However, they may divert resources from nitrogen fixation to rhizopine production, which can be used as an additional carbon source for still-reproductive rhizobia in the same nodule. Consequentially, these rhizopine producing rhizobia might thrive at the host's expense and harm agriculture.

Fig 1. Alfalfa nodules on a root: Copyright Inga Spence

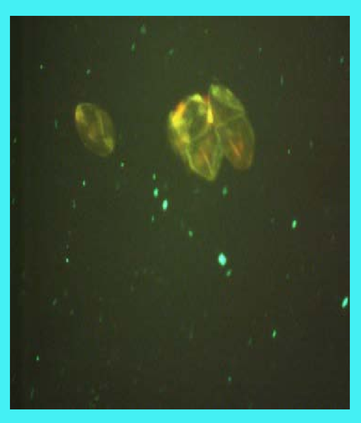


Fig. 2. GFP rhizopine (-) rhizobia clustered around plant material (large amber clumps). Image captured with florescent microscopy in the program ImageJ

Materials and Methods

I measured the nitrogen-fixation efficiency of four genetically different strains of rhizobia to see if it's actually affected by rhizopine production. Of the four strains of rhizobia tested, two strains synthesized rhizopines and two strains did not. To test the efficiency of a strain, I measured how much carbon dioxide (from respiration) and atmospheric hydrogen (a byproduct of nitrogen fixation) were released by nodules as a function of oxygen concentration.

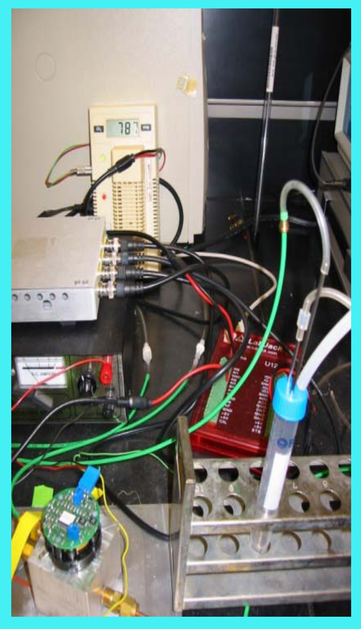


Fig. 3. Hydrogen gas sampling apparatus: front left. Carbon dioxide gas sampling apparatus: back left

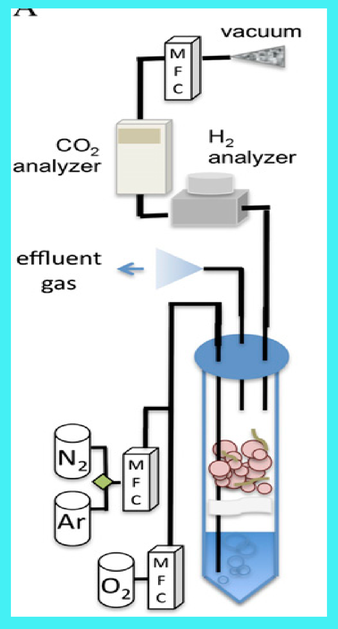
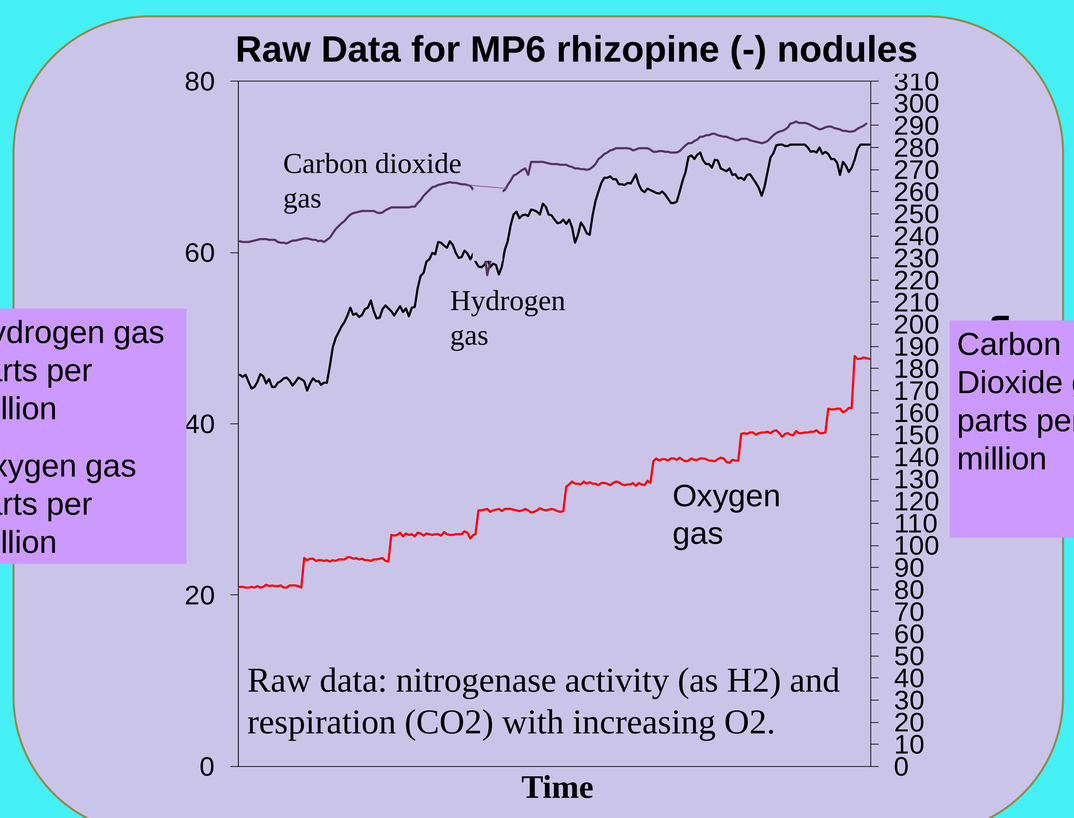
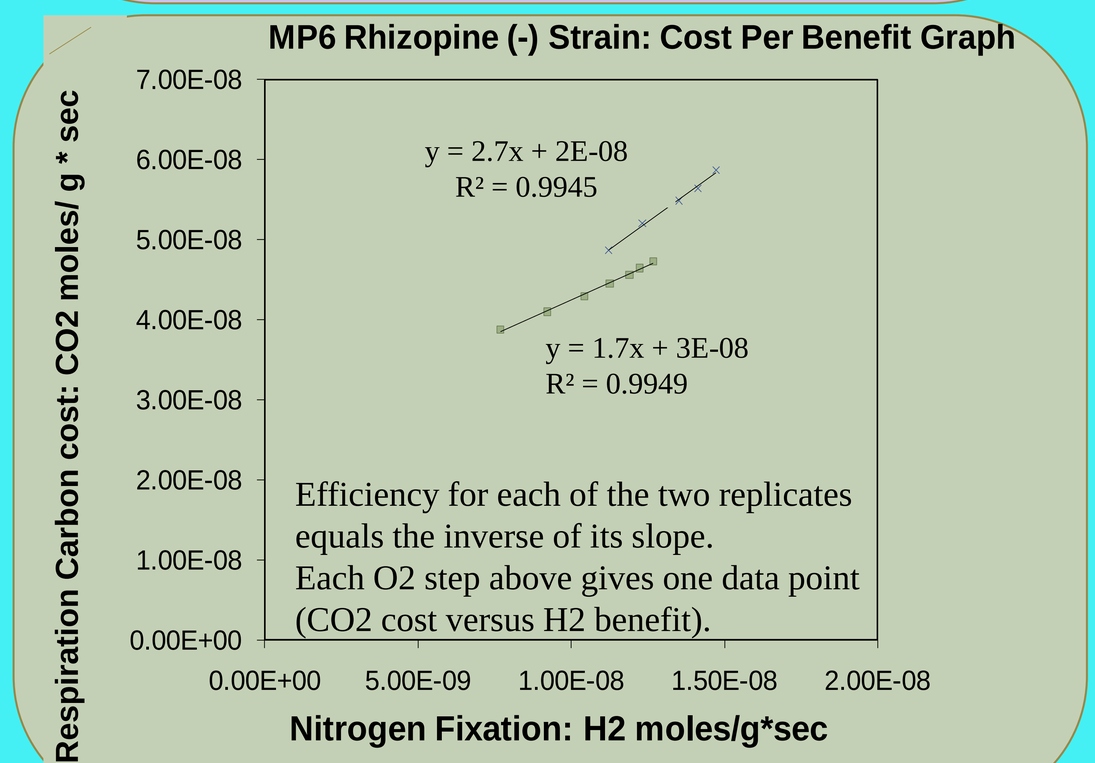


Fig. 4. Cartoon of sampling apparatus Copyright Ryoko Oono

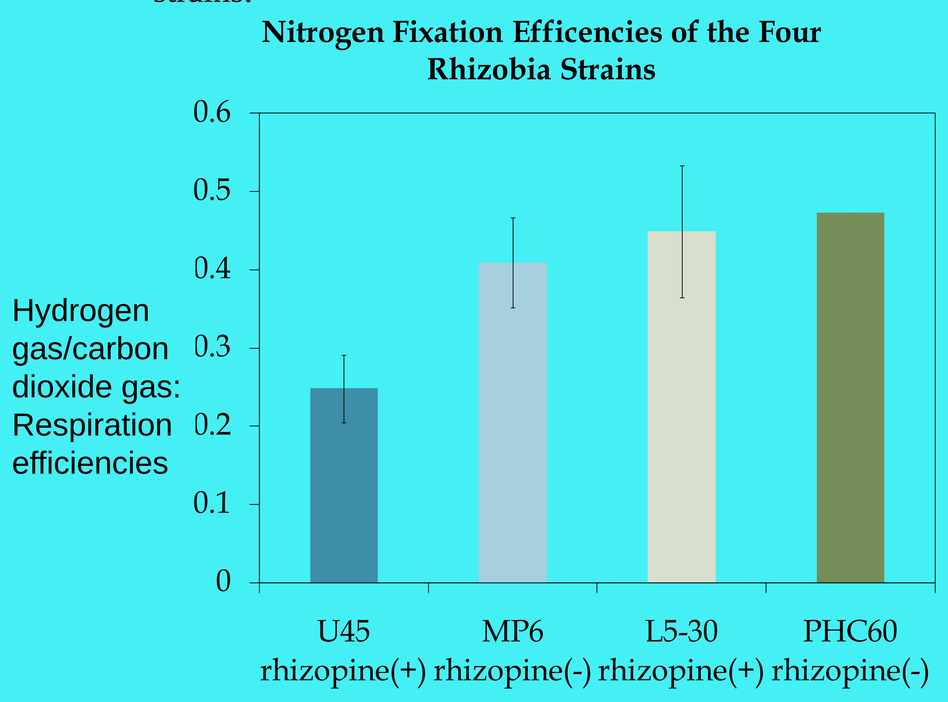
Data





Results

One of the two rhizopine (+) strains had a respiration efficiency (inverse slope) significantly lower than the other strains.



Average nitrogen fixation efficiencies of the four strains with error bars (standard error). U45 has significantly lower efficiency. Not enough PHC60 replicates for statistics

Conclusions

There was a difference in nitrogen fixation efficiency among the strains tested. One rhizopine (+) strain (from the wild) had a lower nitrogen fixation efficiency than the other strains, but a rhizopine(+) lab strain did not. Thus, rhizopine production itself may not divert significant resources from nitrogen-fixation. This could be tested with strains that were genetically identical except for the rhizopine production gene.

Future Research

In the near future, I will evaluate the fitness of nodule-occupying rhizobia from plants that were inoculated with a mixture of rhizopine (+) and rhizopine (-) strains.

Acknowledgments

I would like to thank Ryoko Oono and R Ford Denison for their assistance and for the method used in the experiments.

Literature cited

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