



Assessing the Host-Sanctioning Abilities of Soybean (*Glycine max*) Cultivars

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Background

Legumes form symbiotic relationships with bacteria called rhizobia through special organs called nodules. It has previously been found that host plants are able to sanction their rhizobia symbionts to 'weed out' worse partners¹. This project focuses on the symbiosis between *Glycine max*, the soybean plant, and rhizobia strain USDA 110. USDA 110 is the commonly used wild type strain of *Bradyrhizobia diazoefficiens* (*B. japonicum*)². This strain was selected as it and its non fixing mutant have been previously used to highlight host sanctions^{2,3}.

This project aims to see if the degree of host sanctions varies between cultivars of *G. max*. Cultivars were selected from those available from the Soybean Breeding and Genetics Project here at the UofM. The cultivars are: Flambeau(1946), Norchief(1959), McCall(1979), Traill(2000), MN0095(2010). These cultivars were selected for their varied creation dates, and because they are all in maturity groups 0 and 00⁴. Identifying a cultivar with strong sanctions would mean that in an agricultural setting, the plant is able to get the most benefit out of the native rhizobia.

Research Question

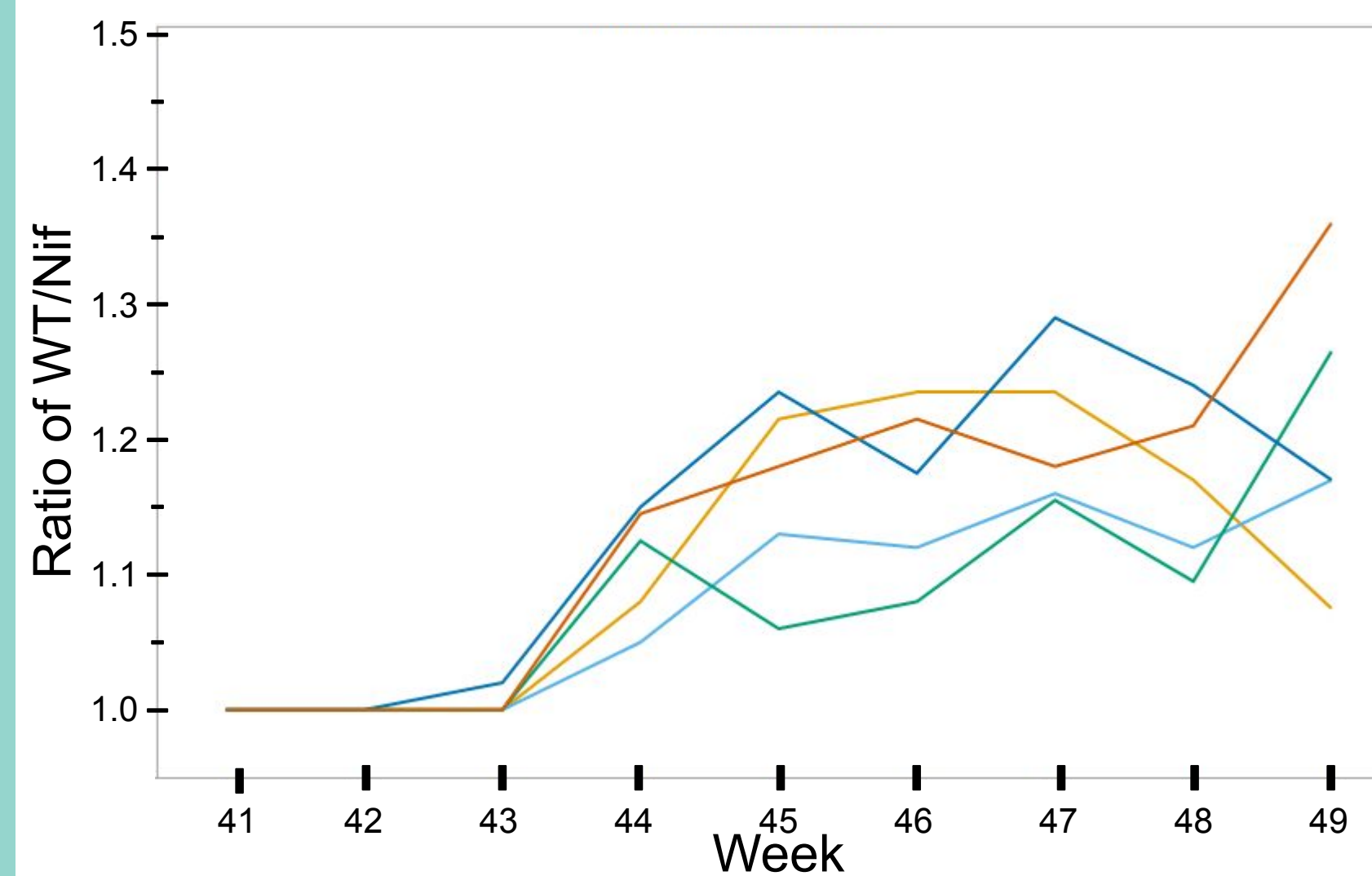
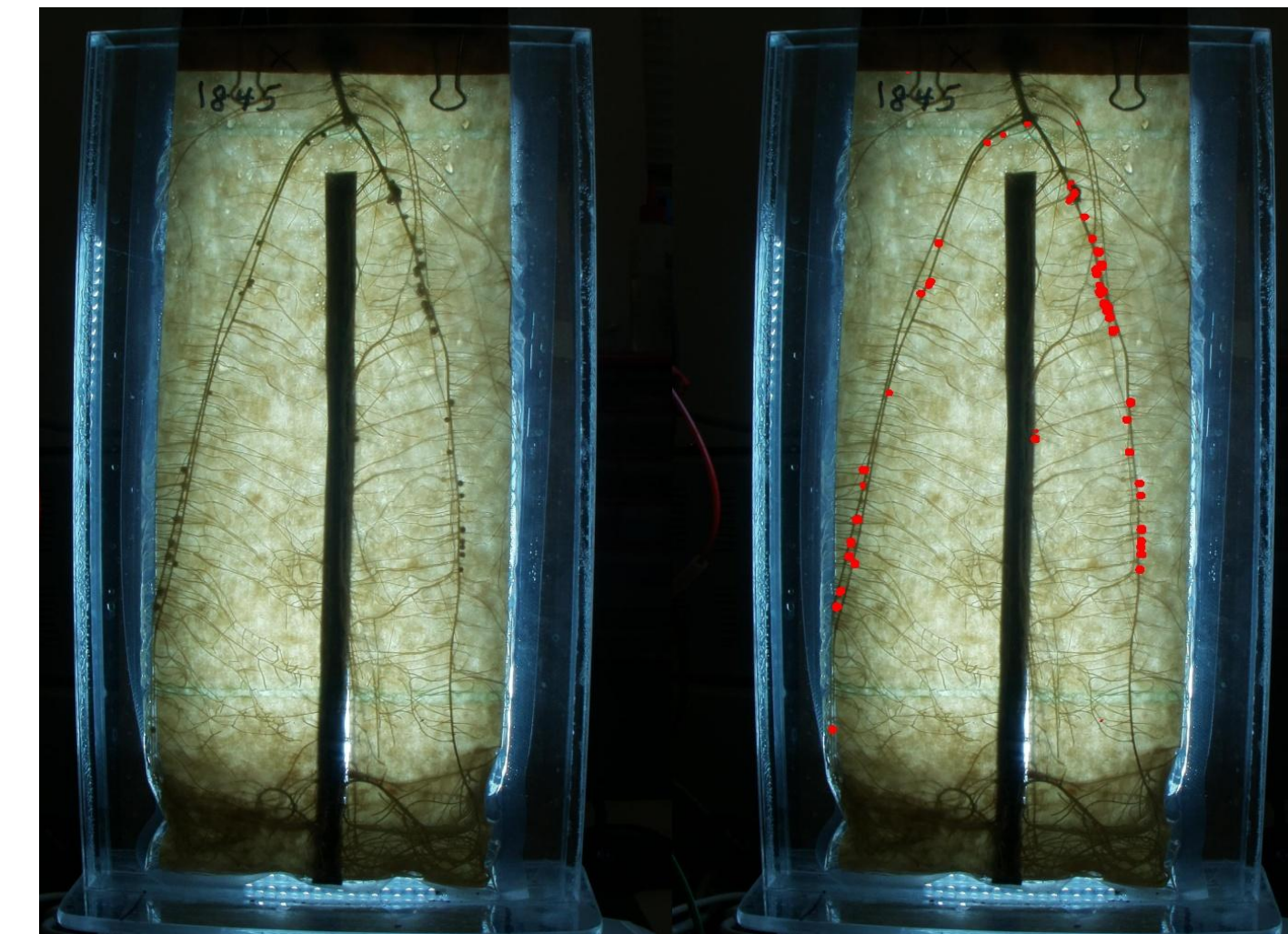
Will there be a measurable difference in the host sanctioning ability between the selected soybean cultivars?

Methods

- 15 split root pouches were started for each cultivar, with. The left side was inoculated with non-fixing USDA 110 mutant, the right side was inoculated with wild type USDA 110³.
- Plants were watered M,W,F. Fujikake nutrient solution⁵ + 0.2g/mL NO₂NH₄ was added on Monday.
- At time of watering, plants were weighed and photos were taken of their root systems.

Results

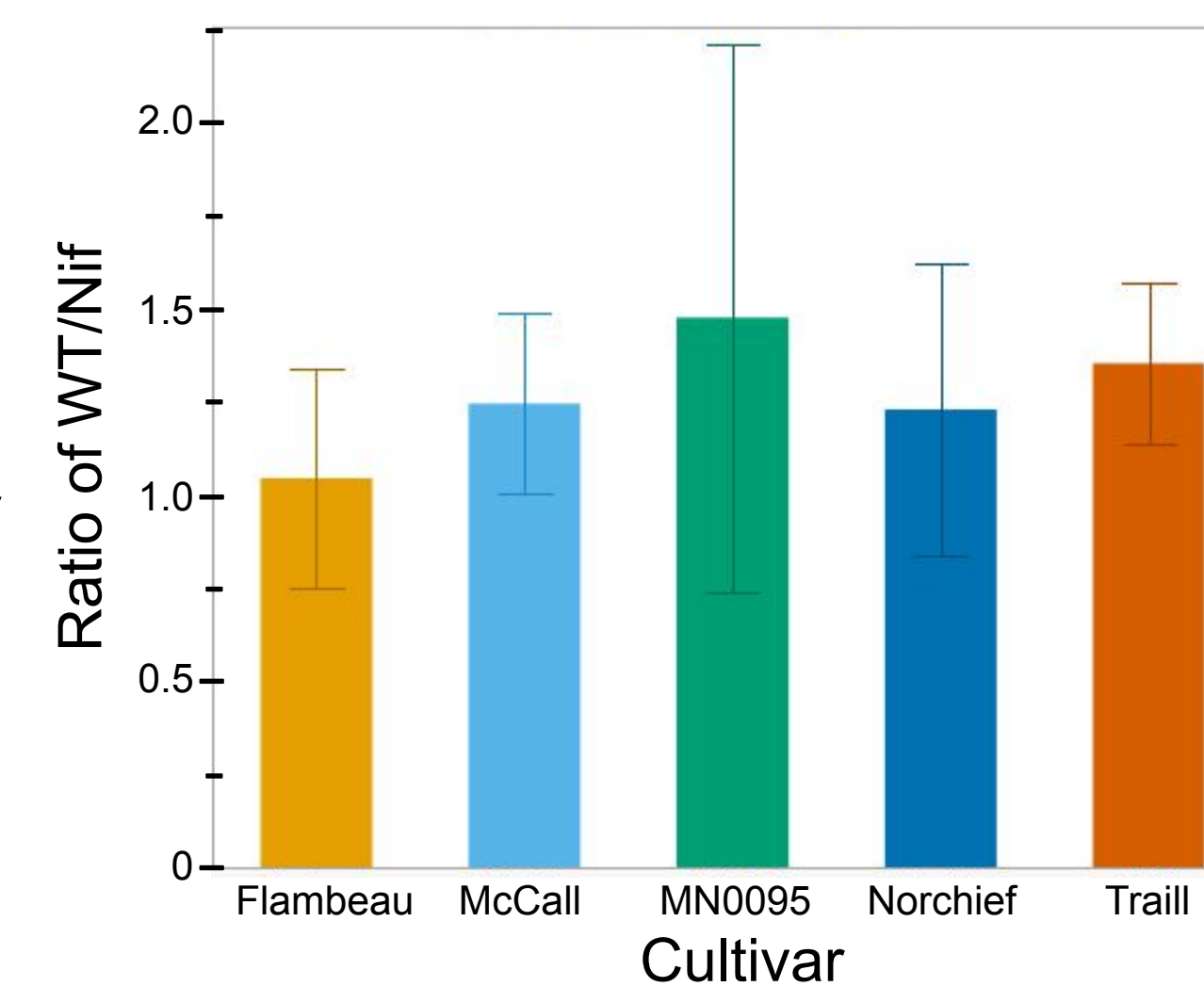
Figure 1. Sample composite overlay from the AI vision model on an image of a split root growth pouch. Left, original image captured of the roots. Right, original image with nodules detected by the AI overlaid in red.



Cultivar
Flambeau
McCall
MN0095
Norchief
Traill

Figure 2. The ratio between nodule diameter of Wild Type and Nif nodules. Graphed over 9 weeks for all 5 cultivars. Summary statistic is median.

Figure 3. The ratio between nodule diameter of Wild Type and Nif nodules at the end of growth, week 49. Summary statistic is mean. Error bars are constructed one standard deviation from the mean.



Discussion

While we did not find statistically significant results, there are still interesting outcomes. One of the biggest is we have an AI/data analysis pipeline to streamline the collection of split root nodule data, highlighted in Figure 1. Under ideal sanctions, one would expect that only the wild type nodules would be able to grow, thus the diameter ratio should be >1 for wt/nif. This is present in all the observed cultivars as shown in Figure 2. Of particular note are Traill for reaching the greatest ratio, aka the strongest sanctions, and Flambeau. While Flambeau did show strong sanctions, it appears that they weakened as the plant aged. Something to note is that the mean was not used for Figure 2 as the number of outliers as the plants aged created inconsistent data.

Future Directions

- Expand the study to include maturity group 1 soybeans to assess if there are broad trends between maturity groups on nodulation
- Develop a program to track individual nodules on a plant over time as a way to potentially work around AI noise
- Utilize more moderate fixing rhizobia strains to see how well the plants are able to distinguish more similar rhizobia
- Investigate if bacteria produced phytohormones have an influence sanctions

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References

