Facilitative and Competitive Nutrient Interactions with Changing Crop Spacing and Density in a Broccoli and Fava Intercropping System

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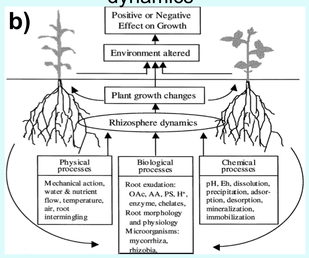
Introduction

- **Intercropping** is the growth of two or more crops simultaneously in the same field (Fig. 1), commonly with legumes. Intercropping can facilitate crop nutrition by increasing soil N and/or P[1], however, it can also have detrimental effects on crops due to competition for nutrients and root space.
- **We designed an experiment changing spacing and density** in a broccoli/fava intercropping system to determine the optimization threshold for whether fava intercropping is facilitative or competitive.
- **Significance:** Increased understanding of crop nutrient interactions can better inform future agricultural management to utilize biological processes in place of fertilizers, which are expensive economically and environmentally.

Figure 1: (a) Broccoli and fava intercropping in the field and **(b)** diagram of rhizosphere dynamics[2]



Objectives

(i) Quantify the effects of crop spacing and fava density on broccoli yield and P content.
(ii) Link effects to crop nutrient uptake and soil characteristics such as pH.

Hypothesis: Increased fava density and decreased spacing will decrease rhizospheric pH thereby increasing Leaf P and yield through facilitation of increased soil P solubility.

Methods

Field Site: Oxford Tract agricultural research field in Berkeley, California characterized by a Mediterranean climate.

Experimental Design: Two spacing (10 and 15 cm) between crops and three fava density (2, 4, 6 fava) were tested. A broccoli and fava monoculture were used as the control.

Data Analysis: At maturity, non-diseased plants were harvested into three composite samples. Measurements included broccoli yield, most recently mature broccoli leaf, rhizospheric soil of broccoli and fava, and bulk soil. Broccoli leaves were analyzed using ICP analysis at UMASS for phosphate. The pH was measured in triplicate bulk soil and rhizospheric soil.

Figure 2: Field experiment three weeks after transplanting

References

[1] Li L, Zhang F, Li X, Christie P, Sun J, Yang S, Tang C. 2003. *Nutrient Cycling in Agroecosystems.* 65(1):61-71.
[2] Zhang F, Shen J, Li L, Liu X. 2004. *Plant Soil.* 260(1-2):89-99.

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Results

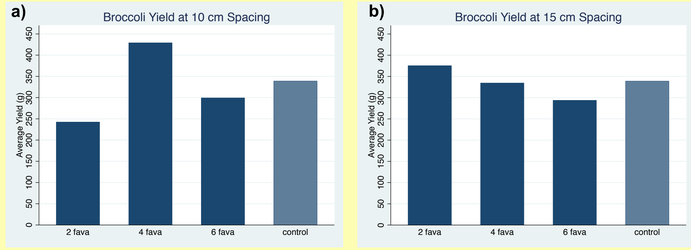

Figure 3: **Average broccoli head yield**. Spacing at **(a)** 10 cm and **(b)** 15 cm. Broccoli intercropped with 4 fava spaced at 10 cm and 2 fava spaced at 15 cm had the highest yield. The 2 fava spaced at 10 cm and all 6 fava treatments demonstrated lower yield than the monoculture control. Therefore the intermediate treatment is optimal.

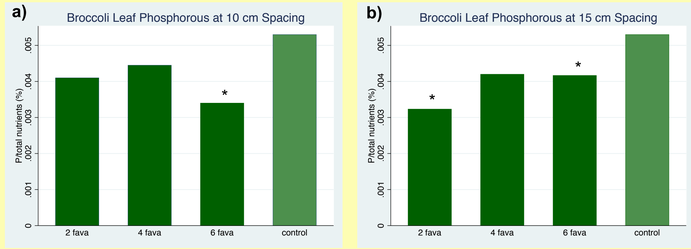

Figure 4: Phosphorous in broccoli leaves collected at harvest. Spacing at **(a)** 10 cm **(b)** 15 cm. All treatments demonstrated lower leaf P compared to the control, which suggests that intercropping with fava is not facilitating broccoli P nutrition.

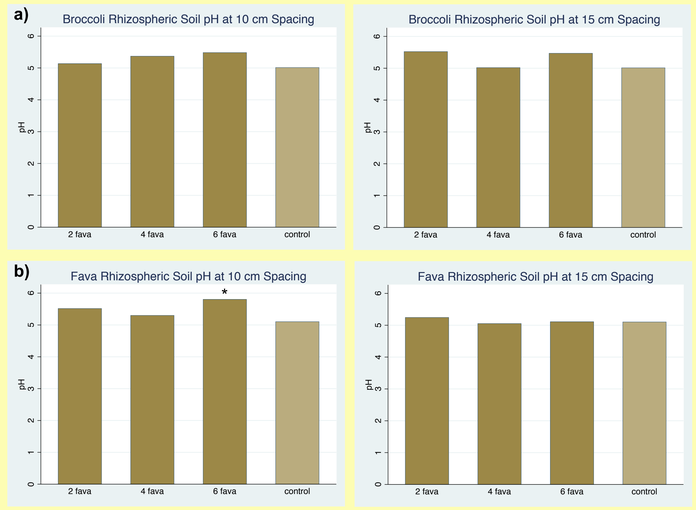

Figure 5: Soil pH measurements. Average pH values for rhizospheric soil of **(a)** broccoli and **(b)** fava. All soil pH are lower than samples taken prior to transplanting, but are surprisingly higher than pH in the rhizospheric soil of a broccoli monoculture.

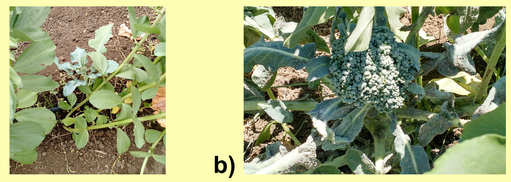

Figure 6: High fava density treatment. (a) stunted growth due to shading and competition from fava and **(b)** broccoli heavily infested by aphids

Conclusion

- Intercropping broccoli and fava did not demonstrate a decrease in pH nor an increase in P uptake, therefore the hypothesis is rejected.
- However, an increase in yield was demonstrated in some treatments which needs to be further investigated.
- At high fava density, the broccoli was outcompeted which resulted in stunted growth and increased incidence of disease.
- At low fava density, the broccoli was located too far away from the fava to be beneficially impacted.
- The intermediate fava density treatment was optimal in balancing competitive and facilitative effects of fava.

Work in Progress

- Replicate experiment with an increased number of treatment replication
- Perform analysis to determine extractable P and total N in soil samples
- Determine bioavailable Nitrogen (i.e. ammonium and nitrate) in new soil samples