Effect of pH and calcium base saturation on clubroot severity, Holland Marsh, 2023–2024.

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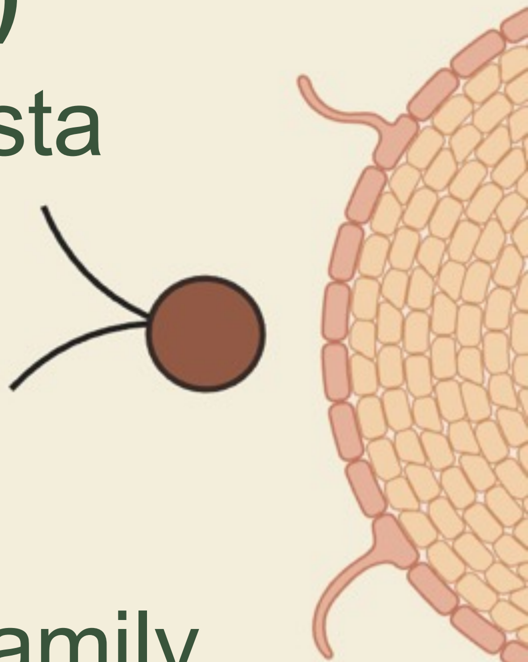
Clubroot

Pathogen: ***Plasmodiophora brassicae*** **(Woronin)**

- Kingdom Chromista
- obligate parasite
- soil-borne

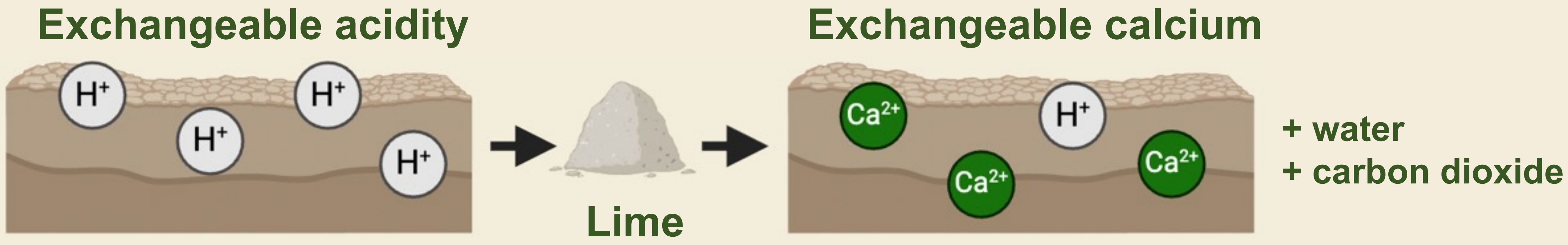


Host: Brassicaceae family

Calcium, pH, and calcium base saturation

Calcium soil amendments used to reduce clubroot in brassica vegetables usually increase Ca levels and increase pH.

Calcium base saturation: the percentage of the total cation exchange capacity of soil that is occupied by calcium cations.



Soil Amendments – Ca vs pH

Alkaline pH

- reduces root hair infection
- slows pathogen maturation

Calcium

- increases spore dormancy
- inhibits plasmodia development into sporangia

Reduced clubroot symptoms

Hypotheses and Objective

Hypotheses: a) increasing both pH and calcium content reduces clubroot severity.
b) elevating soil calcium base saturation above 80% reduces clubroot.

Objective

1) To determine the separate effects of calcium and pH on suppression of clubroot.

Treatments

An **untreated control** is compared to:

1. **Gypsum ($CaSO_4$)**
   - (Rate 2023: 1.7 t/ha, Rate 2024: 1.3 t/ha)
2. **Potassium Bicarbonate ($KHCO_3$)**
   - (Rate 2023: 5.4 t/ha, Rate 2024: 2.1 t/ha)
3. **Potassium Bicarbonate + Gypsum (combo)**
4. **Wollastonite ($CaSiO_3$)**
   - (Rate 2024: 9.5 t/ha)
5. **Hydrated Lime ($Ca(OH)_2$)**

- (Rate 2023: 4.3 t/ha, Rate 2024: 1.5 t/ha)

Alters CBS (1)

Alters pH (2)

Alters CBS and pH (3–5)

Note on Wollastonite

4. **Wollastonite ($CaSiO_3$)**
   - (Rate 2024: 9.5 t/ha)
   - Alters the pH, CBS, and adds silica to soil
   - Carbon Capture Project

Canadian Wollastonite. Carbon Capture Project.
https://canadianwollastonite.com/

Field Trial

- Treatments applied and rototilled to 15 cm depth
- L233P InVigor canola (*B. napus*) planted 1.5 weeks later
- Soil sampling to determine pH and CBS changes

Assessment

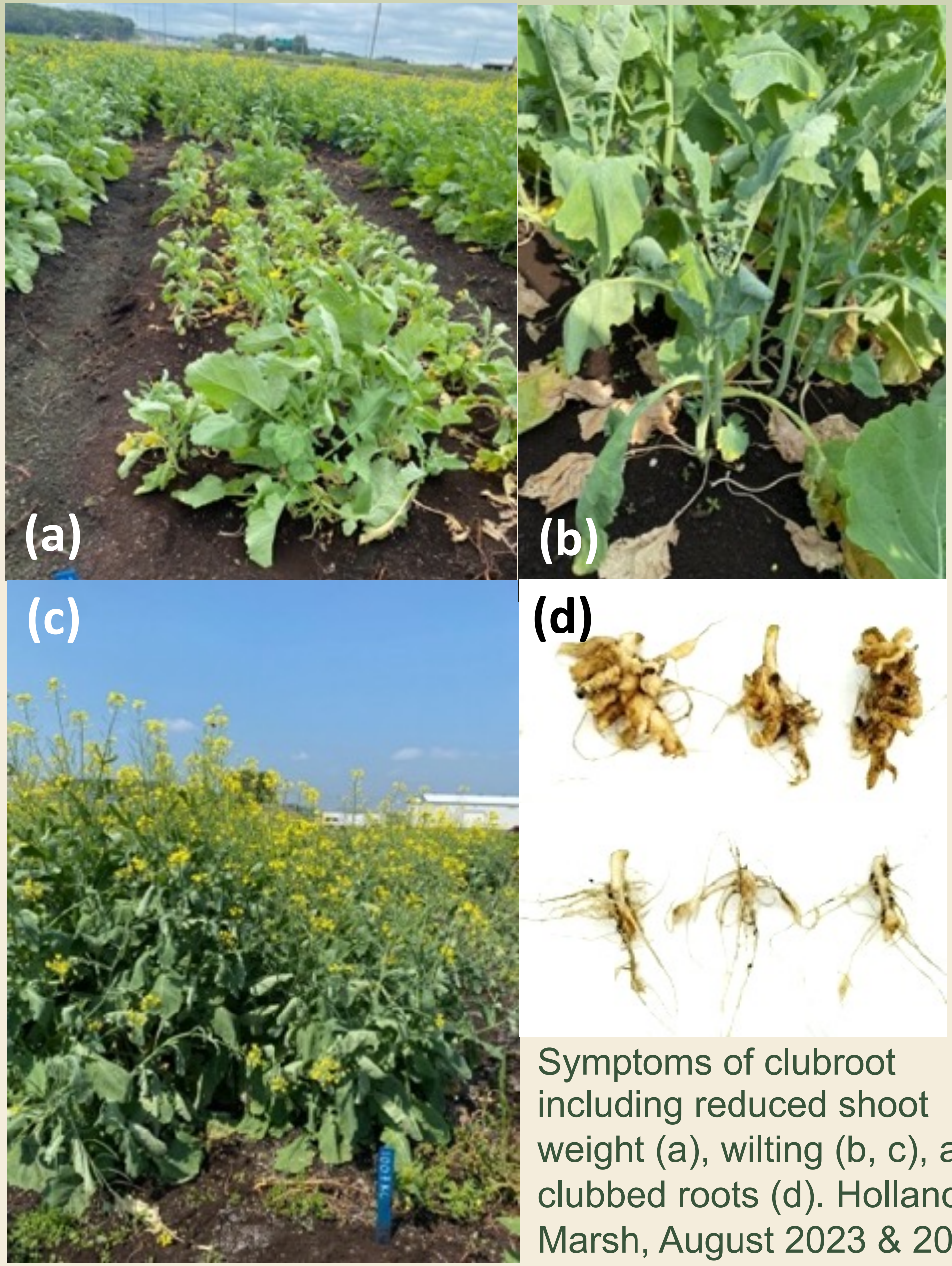
Harvested 6 weeks post-seeding

Wilting index during growth

- (0 – 5 scale, 20 plants / plot)

- Disease severity index (0 – 3 scale, 50 plants / plot)

- Plant shoot weight (10 plants / plot)



Symptoms of clubroot including reduced shoot weight (a), wilting (b, c), and clubbed roots (d). Holland Marsh, August 2023 & 2024.


Leaf Wilting
Lack of Wilting
Low shoot weight
Infected, Untreated Control
Minimal infection, Potassium bicarbonate

Statistical Analysis

- RCBD with 3 blocks
- ANOVA with Tukey's HSD
- Pearson correlations on disease severity vs pH and CBS

Soil Characteristics

	Pre-Amendment	
Year	Treatment	Untreated
2023	pH	6.4
	CBS (%)	85
2024	pH	7.0
	CBS (%)	86

- CBS was already elevated ~85% pre-amendment in 2023 and 2024
- Pre-amendment pH higher in 2024

Soil Characteristics

		Pre-Amendment	Post-Amendment					
Year	Treatment	Untreated	Untreated					
2023	pH	6.4	6.4					
	CBS (%)	85	81					
2024	pH	7.0	7.0					
	CBS (%)	86	85					

- Post-Amendment untreated is consistent

Soil Characteristics

	Pre-Amendment		Post-Amendment					
Year	Treatment	Untreated	Untreated	Gypsum				
2023	pH	6.4	6.4	6.5				
	CBS (%)	85	81	83				
2024	pH	7.0	7.0	6.9				
	CBS (%)	86	85	84				

- No effect on pH or CBS

Soil Characteristics

		Pre-Amendment	Post-Amendment					
Year	Treatment	Untreated	Untreated	Gypsum	Potassium Bicarbonate			
2023	pH	6.4	6.4	6.5	7.7			
	CBS (%)	85	81	83	70			
2024	pH	7.0	7.0	6.9	7.6			
	CBS (%)	86	85	84	78			

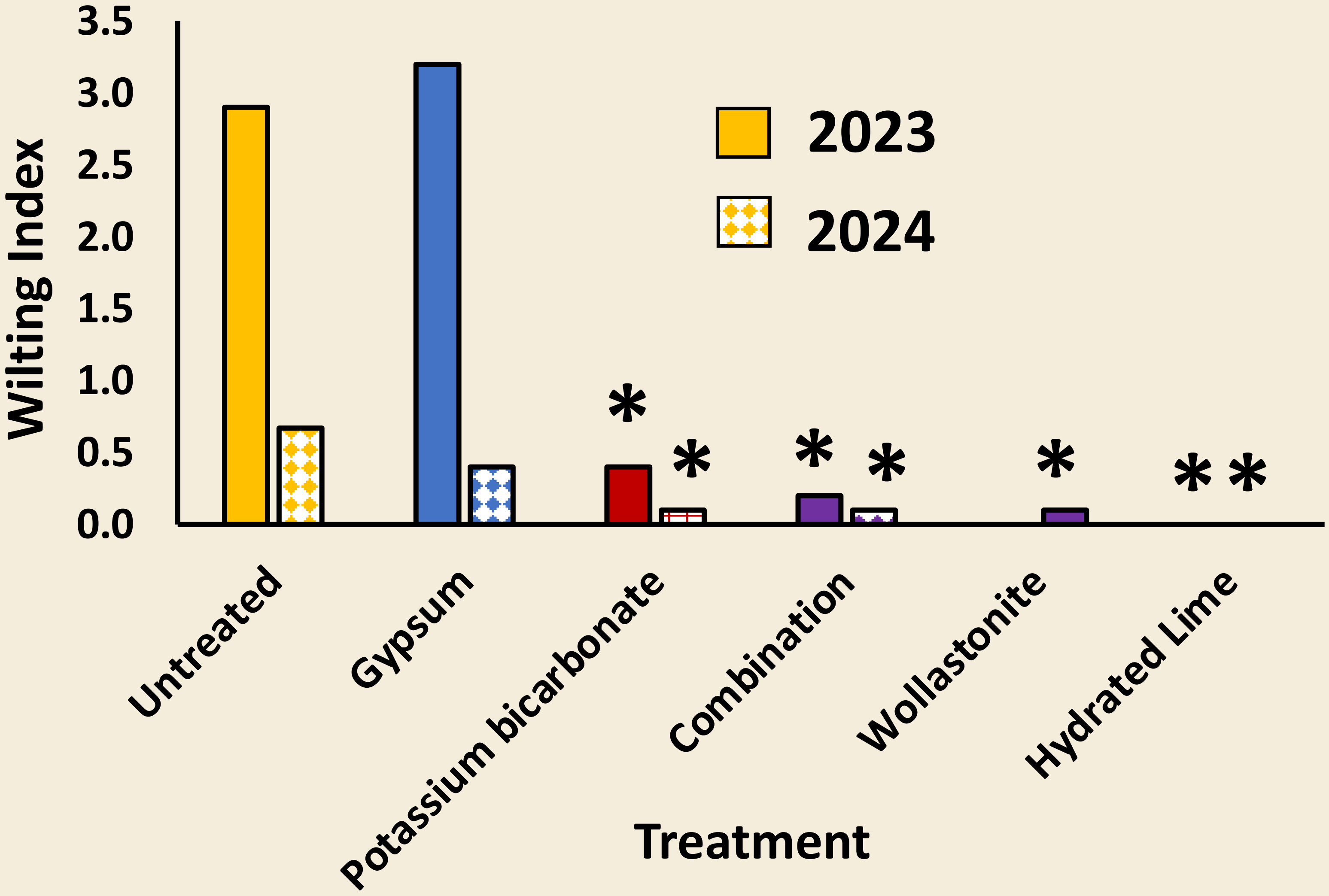
- pH elevated
- CBS lowered

Soil Characteristics

		Pre-Amendment	Post-Amendment					
Year	Treatment	Untreated	Untreated	Gypsum	Potassium Bicarbonate	Combo	Wollastonite	Hydrated Lime
2023	pH	6.4	6.4	6.5	7.7	8.1	-	7.4
	CBS (%)	85	81	83	70	67	-	85
2024	pH	7.0	7.0	6.9	7.6	7.5	7.2	7.2
	CBS (%)	86	85	84	78	78	86	86

- pH elevated
- CBS slightly elevated (except Combo treatment)

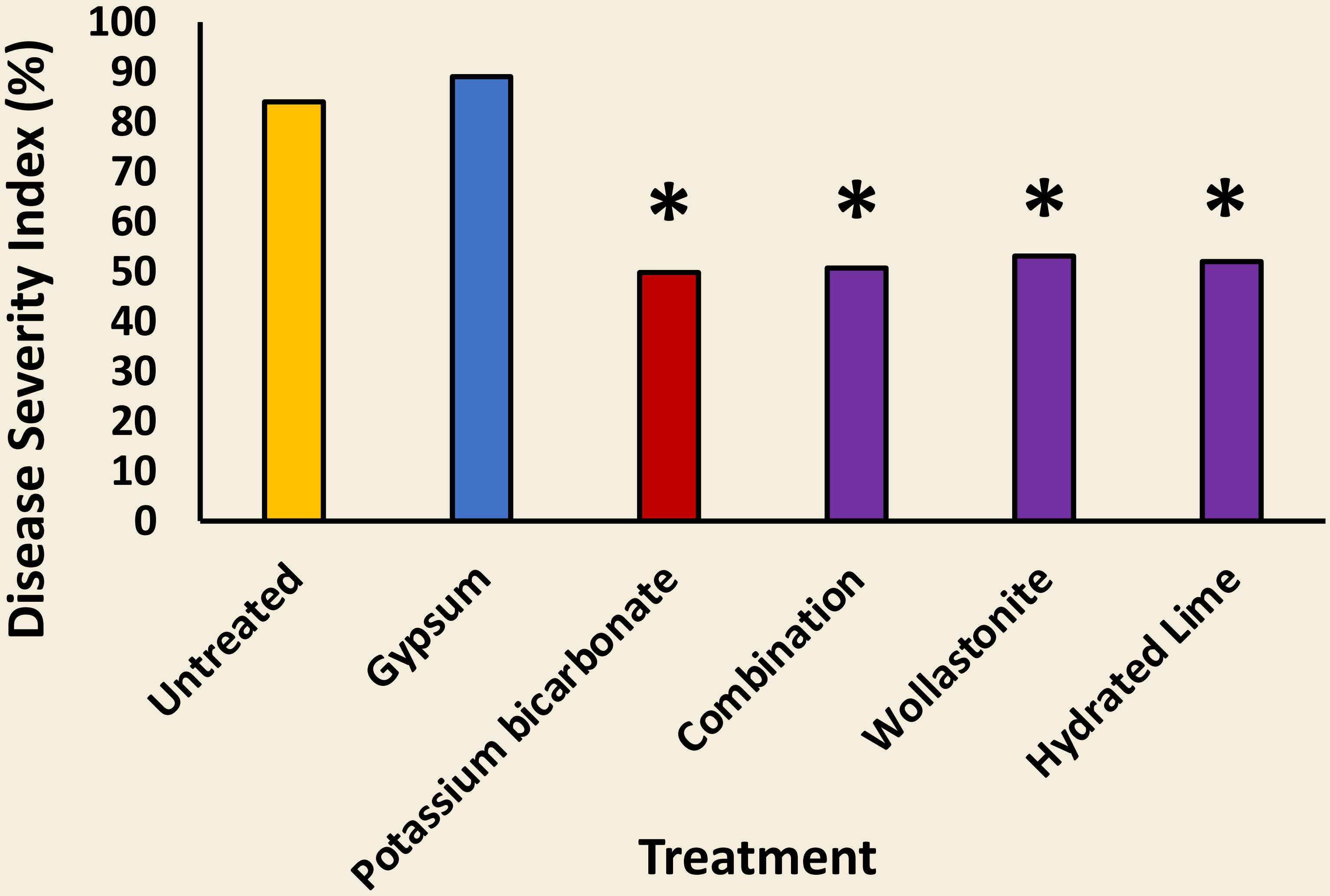
Wilting Index



*Treatments that differed from the control (*P* > 0.05).

Wilting in untreated (front) versus hydrated lime (back) Holland Marsh, August 2024.

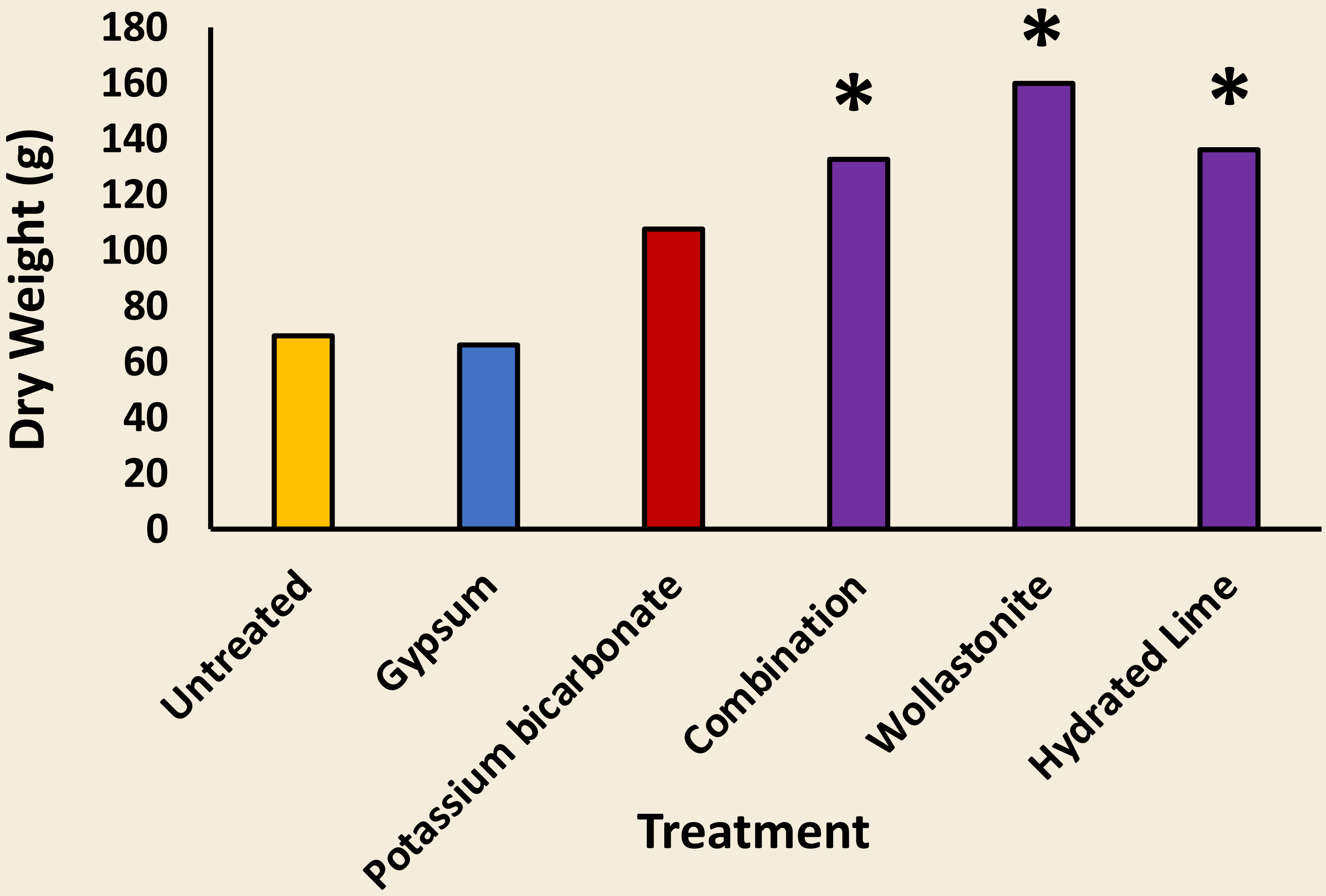
Disease Severity Index



*Treatments that differed from the control ($P > 0.05$).

Clubbed roots from untreated control (a) and potassium bicarbonate (b) treatments. University of Guelph, August 2024.

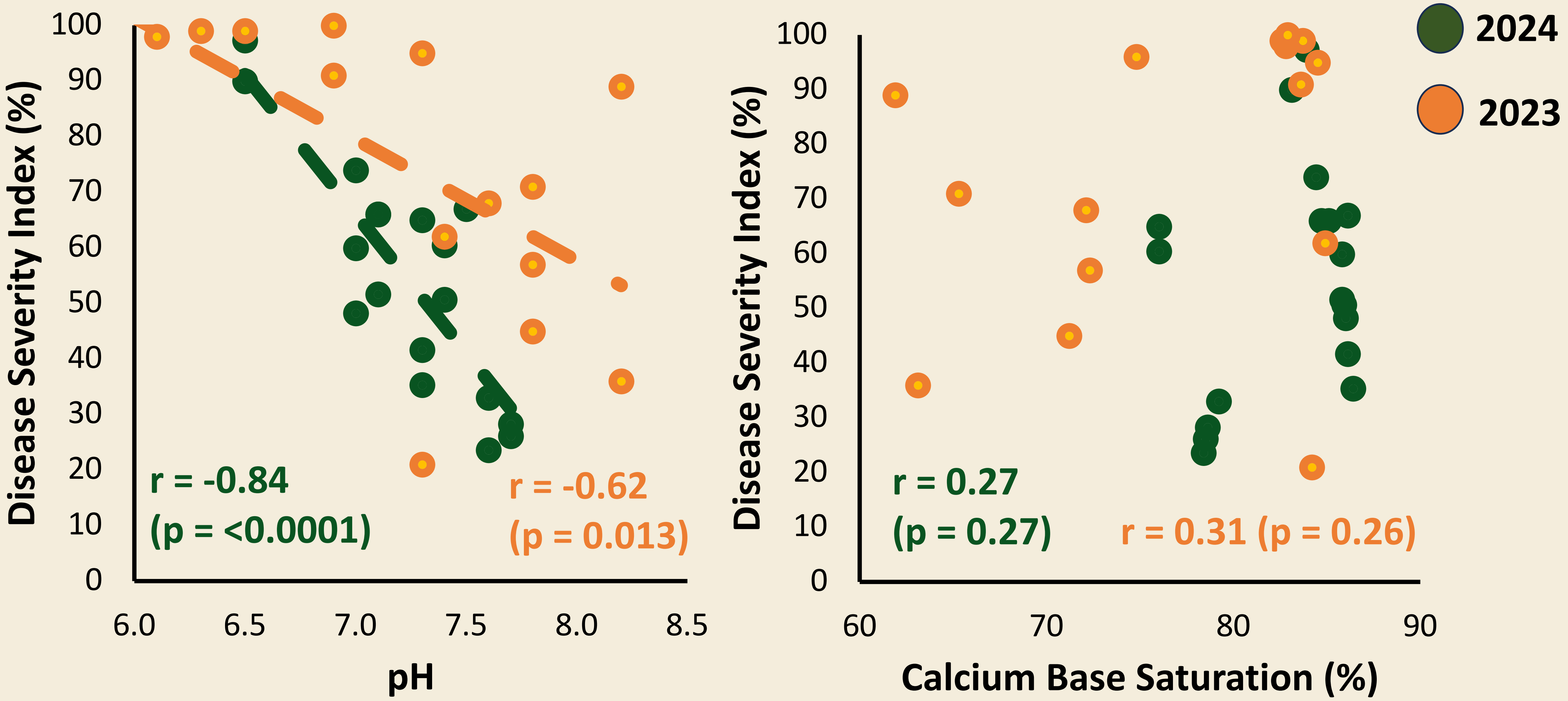
Dry Weight



*Treatments that differed from the control ($P > 0.05$).

Difference in plant weight between gypsum (left) and hydrated lime (right) treatments. Holland Marsh, August 2023.

Pearson Correlations



Conclusions

- CBS was not increased because of the high levels already in the soil. **Clubroot was severe at CBS of 80 – 85%.**
- **Treatments that raised the soil pH reduced clubroot severity and related symptoms.**
- Clubroot severity was only correlated with pH.

Adding calcium without increasing pH had no effect on clubroot severity.

Hypothesis and Objective Re-visited

Hypotheses: a) increasing both pH and calcium content reduces clubroot severity.

- ✓ Treatments meant to elevate both did reduce disease, but calcium was not increased greatly.

Hypothesis and Objective Re-visited

Hypotheses: a) increasing both pH and calcium content reduces clubroot severity.

✓ Treatments meant to elevate both did reduce disease, but calcium was not increased greatly.

b) elevating soil calcium base saturation above 80% reduces clubroot.

✗ CBS > 80% did not reduce disease severity in muck soil.

Hypothesis and Objective Re-visited

Objective

1) To determine the separate effects of calcium and pH on suppression of clubroot.

✓ **Increased soil pH reduced clubroot**

✗ **Added calcium did not reduce clubroot**

Future Research

Future Question: can we properly test the effect of CBS in the field?

Test at a mineral soil site

- Fixes soil chemistry constraints
- Applicable to canola production in Canada

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References

1. Campbell, R. N., Greathead, A. S., Myers, D. F., & de Boer, G. J. (1985). Factors related to control of clubroot of crucifers in the Salinas Valley of California. *Phytopathology*, *75*, 665–670.
2. Culman, S., Mann, M., & Brown, C. (2019). *Calculating Cation Exchange Capacity, Base Saturation, and Calcium Saturation*. Ohio State University Extension. https://ohioline.osu.edu/factsheet/anr-81
3. Dixon, G., & LV, P. (1998). Calcium and nitrogen eliciting alterations to growth and reproduction of Plasmodiophora brassicae (clubroot). *Acta Horticulturae*, *459*, 343–349.
4. Gossen, B. D, Kasinathan, H., Cao, T., Manolii, V. P., Strelkov, S. E., Hwang, S.-F., & McDonald, M. R. (2013). Interaction of pH and temperature affect infection and symptom development of Plasmodiophora brassicae in canola. *Canadian Journal of Plant Pathology*, *35*(3), 294–303. https://doi.org/10.1080/07060661.2013.804882
5. Gossen, B. D, McDonald, M. R., Hwang, S.-F., Strelkov, S. E., & Peng, G. (2013). A comparison of clubroot development and management on canola and Brassica vegetables. *Canadian Journal of Plant Pathology*, *35*(2), 175–191.
6. Karling, J. S. (1968). *The Plasmodiophorales* (2nd ed.). Hafner Publishing Co. Inc.
7. Macfarlane, I. (1970). Germination of resting spores of Plasmodiophora brassicae. *Transactions of the British Mycological Society*, *55*(1), 97–112. https://doi.org/https://doi.org/10.1016/S0007-1536(70)80100-0
8. Myers, D. F., & Campbell, R. N. (1985). Lime and the control of clubroot of crucifers: Effects of pH, calcium, magnesium, and their interactions. *Phytopathology*, *75*(6), 670–673.
9. Murakami, H., Tsushima, S., Kuroyanagi, Y., & Shishido, Y. (2002). Reduction of resting spore density of Plasmodiophora brassicae and clubroot disease severity by liming. *Soil Science and Plant Nutrition*, *48*(5), 685–691. https://doi.org/10.1080/00380768.2002.10409258
10. Wallenhammar, A. (1996). Prevalence of Plasmodiophora brassicae in a spring oilseed rape growing area in central Sweden and factors influencing soil infestation levels. *Plant Pathology*, *45*(4), 710–719.
11. Webster, M. A., & Dixon, G. R. (1991). Calcium, pH and inoculum concentration influencing colonization by Plasmodiophora brassicae. *Mycological Research*, *95*(1), 64–73. https://doi.org/https://doi.org/10.1016/S0953-7562(09)81362-2