Effect of MX-3 FulviCal and MX3 Gold on plant development

Why are We Interested in Testing the Effect of Organic Acids on Crop Development?

- Agricultural practices have grown more intense to keep up the growing global population
- Use of unsustainable, chemical fertilizers have resulted in local air, soil, and water pollution
- Globally there's been a growing need for more sustainable agriculture
- Organic acid fertilizers have proven to be effective in both promoting agricultural stability and improving crop quality

What are the Products We're Interested in Testing?

- The organic acid products we’re interested in testing is MX-3 **Gold + Calcium (fulvical)**
- The concentrations we’re testing these products at are:
  - 1, 2, 3, and 5X the recommended dosage
- The application rate tested is seed treatment
  - 1X the recommended dosage is 27.5 µl per 10 grams of seed

How would MX-3 Gold (FulviCal) Benefit Crop Development?

- Fulvic acid increases the available nitrogen and potassium content in soil
- Fulvic acid chelates minerals and nutrients, increasing nutrient uptake
- Fulvic acid enhances carbon and nitrogen metabolic processes
- Fulvic acid enables greater water retention in roots and soil

How would Calcium Benefit Crop Development?

- Rhizosphere calcium promotes uptake of essential plant ions
- Cytosolic calcium is required for elongation of root hairs
- Cytosolic calcium also act as secondary messengers in responses to low temperature and membrane repair
- Calcium strengthens plant cell walls and promote synthesis of cell wall precursors
- Calcium amplified plant hormone signals to improve growth and protect the plant from stress

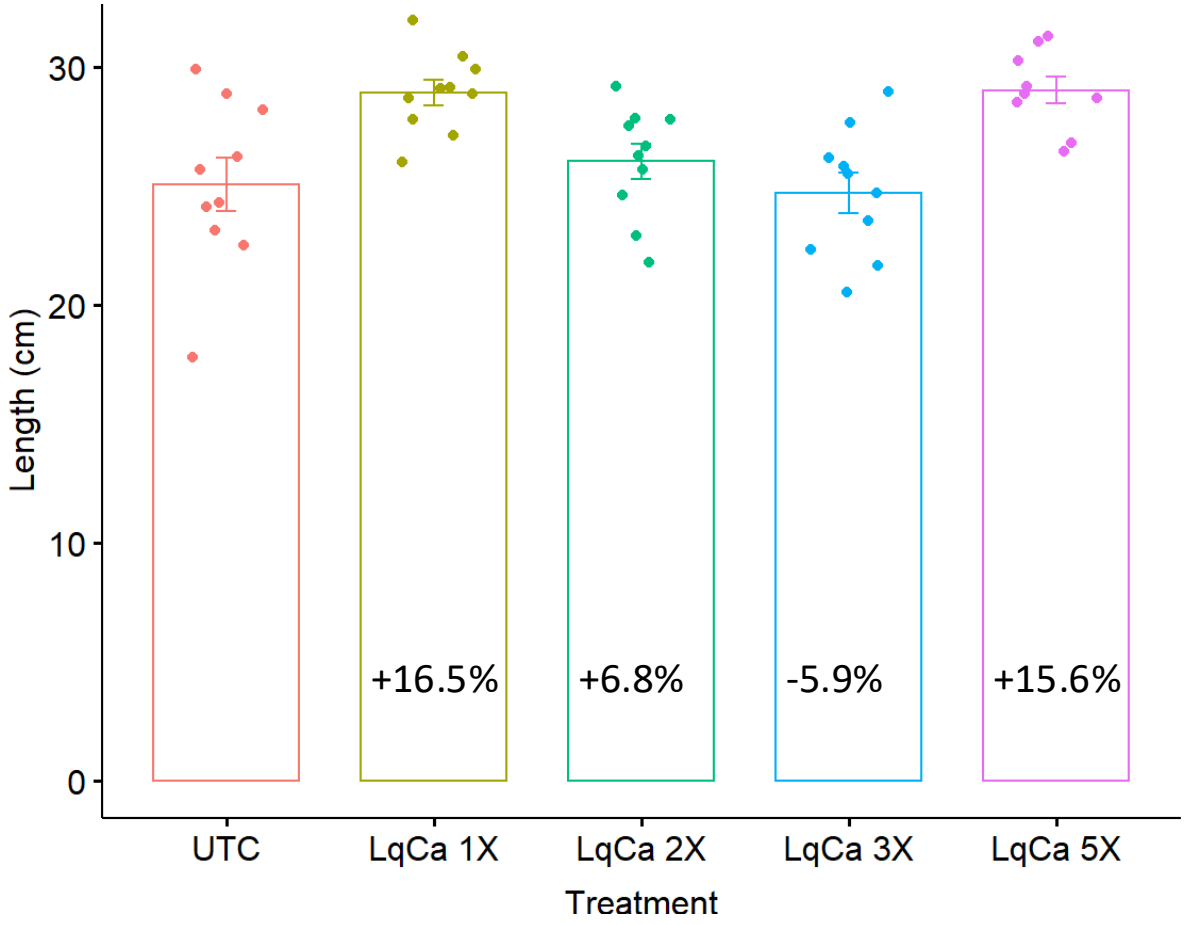
Why Study the Effects of Different Application Rates on Crop Development?

- Efficient organic acid application varies depending on the pairing of application rate and crop
- The application rates used in this study:
  - Seed treatment: Coating the seed with the organic acid product
  - Soil drench: Pouring organic acid product into the soil
  - Foliar spray: Spraying organic acid product onto the leaves
- The crops used in this study:
  - Canola
  - Soybean
  - Corn

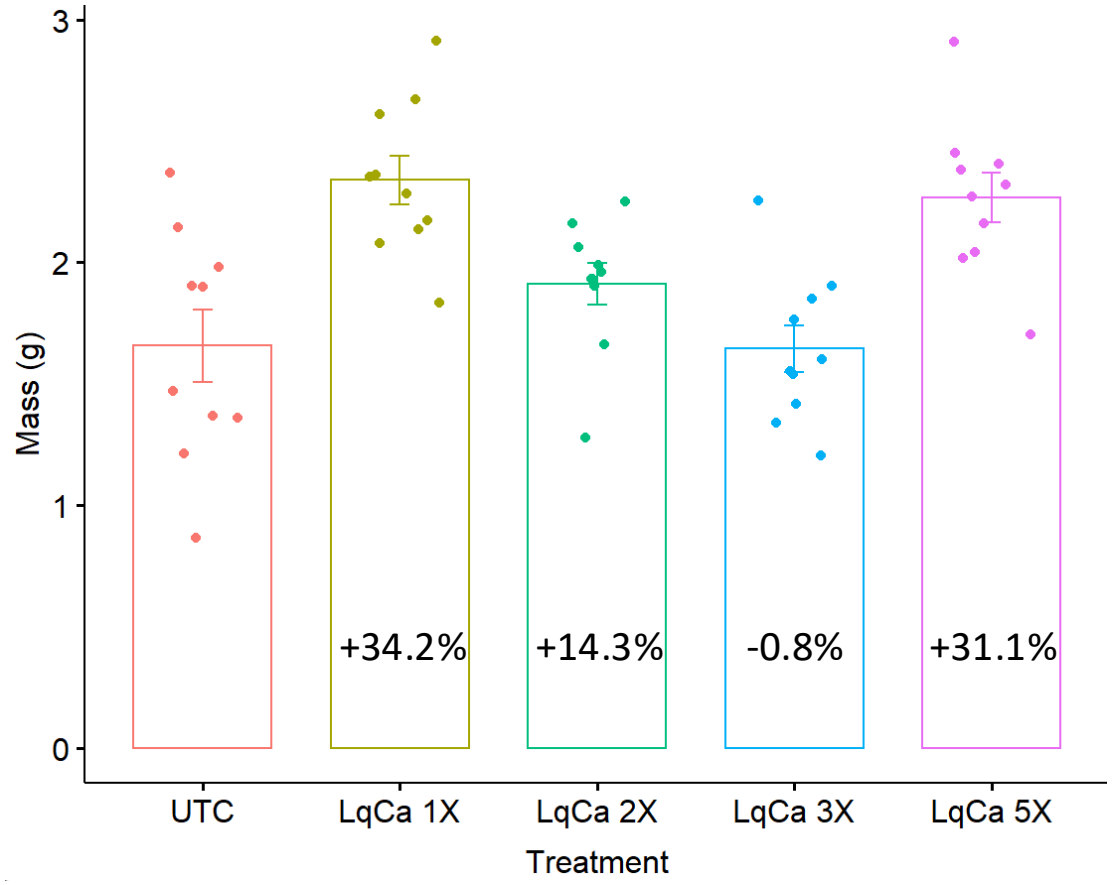
Corn Seed Coat Treatment – LqCa Treatments

UTC LqCa 1X LqCa 2X LqCa 3X LqCa 5X

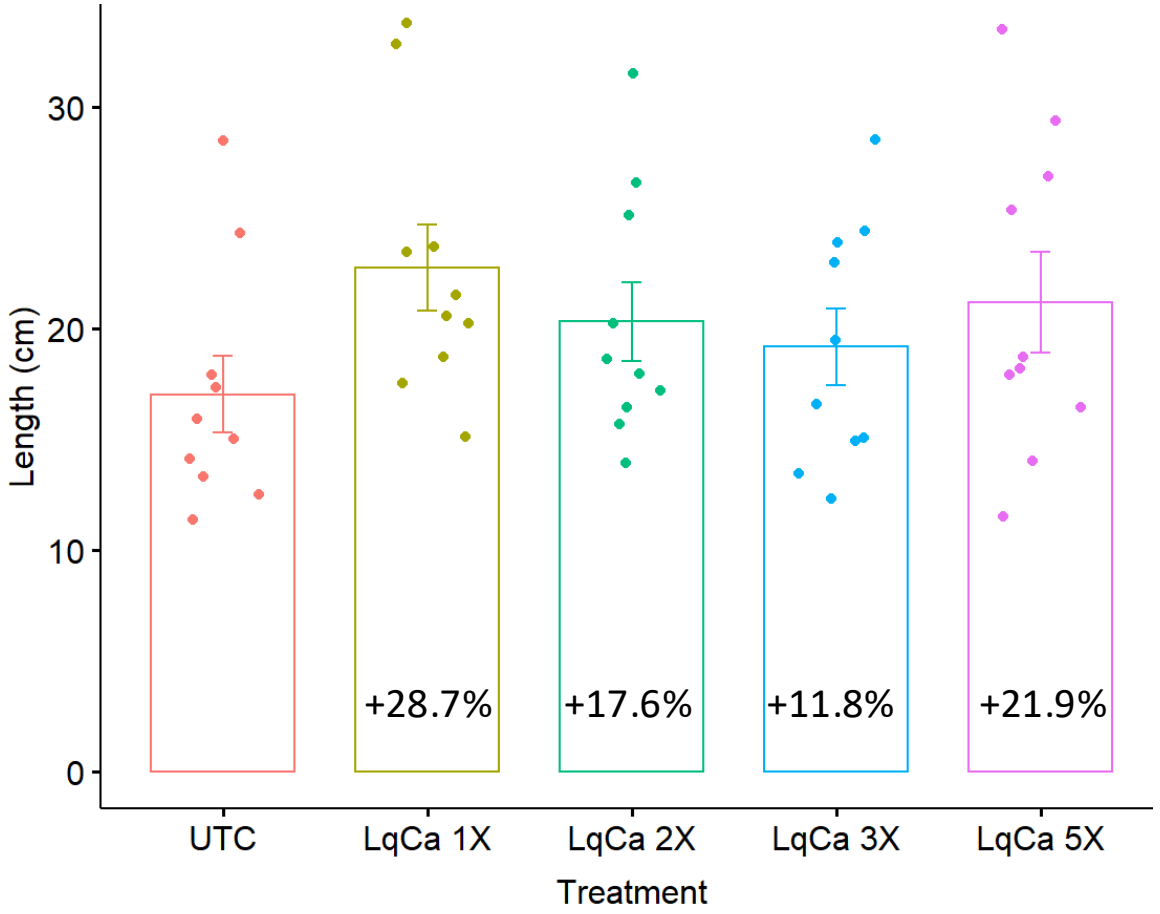
Corn Seed Coat Treatment – Average Shoot Length wrt. LqCa Treatment



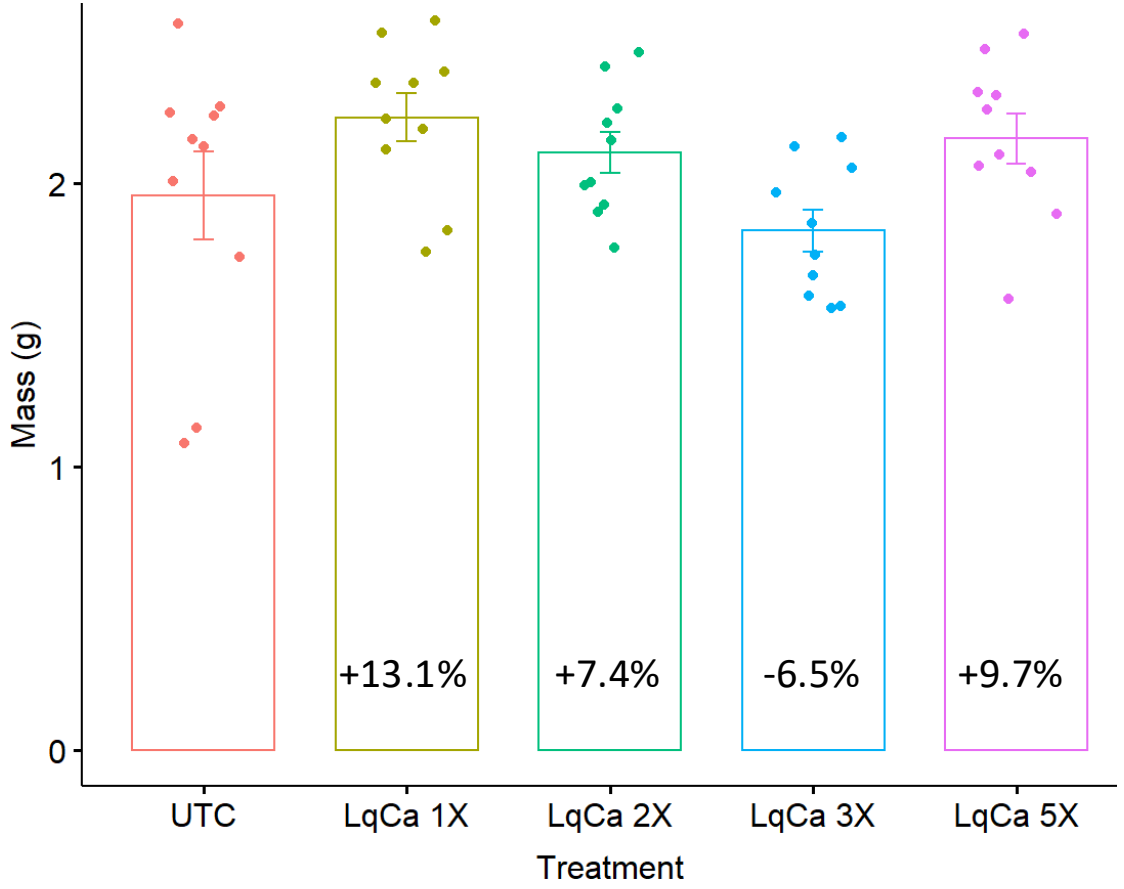
Corn Seed Coat Treatment – Average shoot mass wrt. LqCa Treatment



Corn Seed Coat Treatment – Average root length wrt. LqCa Treatment

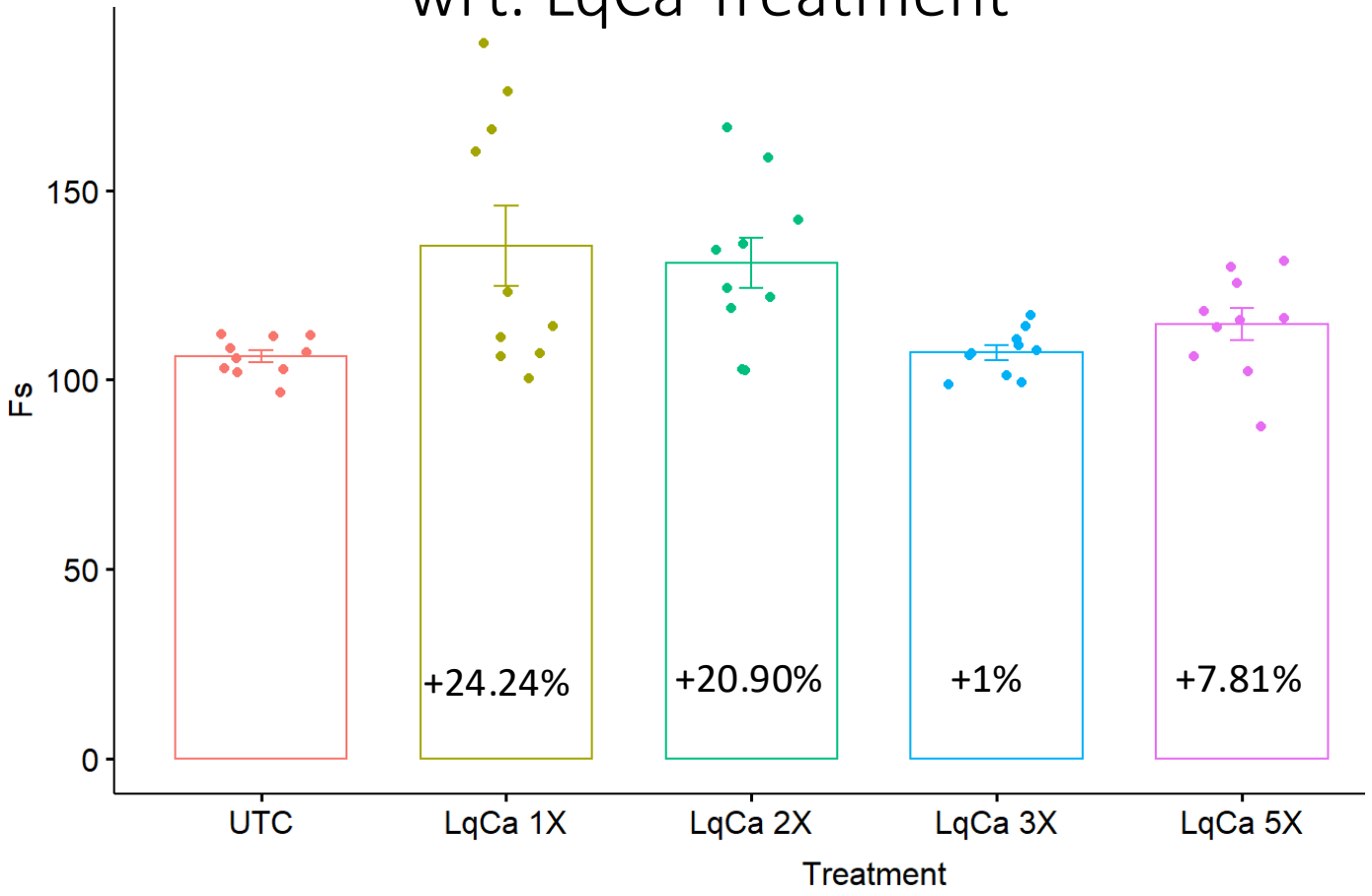


Corn Seed Coat Treatment – Average root mass wrt. LqCa Treatment



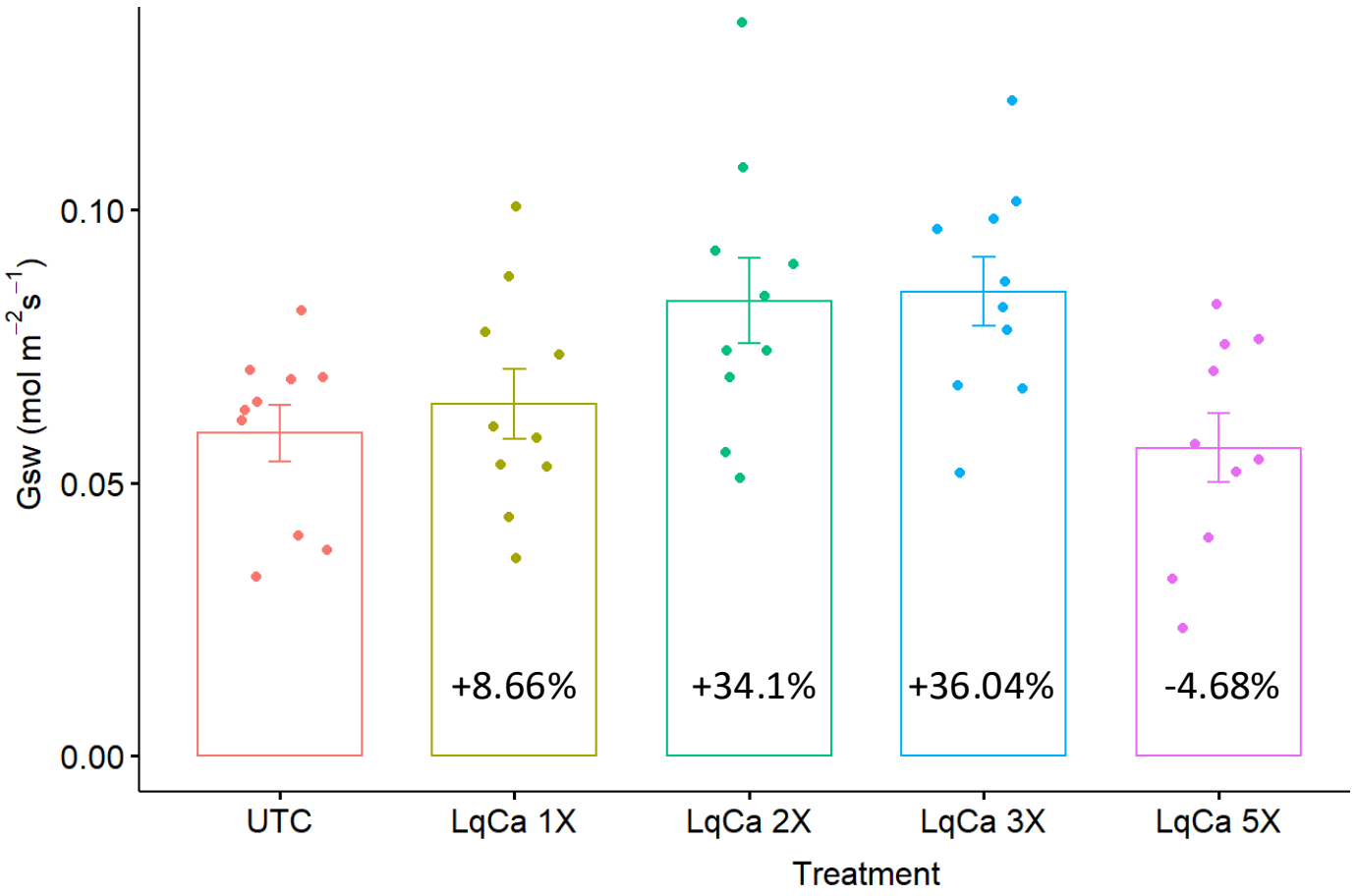
Corn Seed Coat Treatment – Steady State Fluorescence of Chlorophyll a wrt. LqCa Treatment

LqCa 1X and 2X were successful treatments with statistically significant differences.



An ANOVA test and a Tukey HSD test revealed statistical significance between LqCa 1X and LqCa 3X ($P<0.05$), UTC and LqCa 1X ($P<0.05$), and UTC and LqCa 2X ($P<0.05$).

Corn Seed Coat Treatment – Stomatal Conductance wrt. LqCa Treatment



An ANOVA test and a Tukey HSD test revealed statistical significance between LqCa 2X and LqCa 5X ($P<0.05$), and LqCa 2X and LqCa 3X ($P<0.05$).

Effect of MX-3 Calcium Foliar Spray on Root Biomass/Length in Canola Under Greenhouse Conditions

UTC

x1 Calcium

x2 Calcium

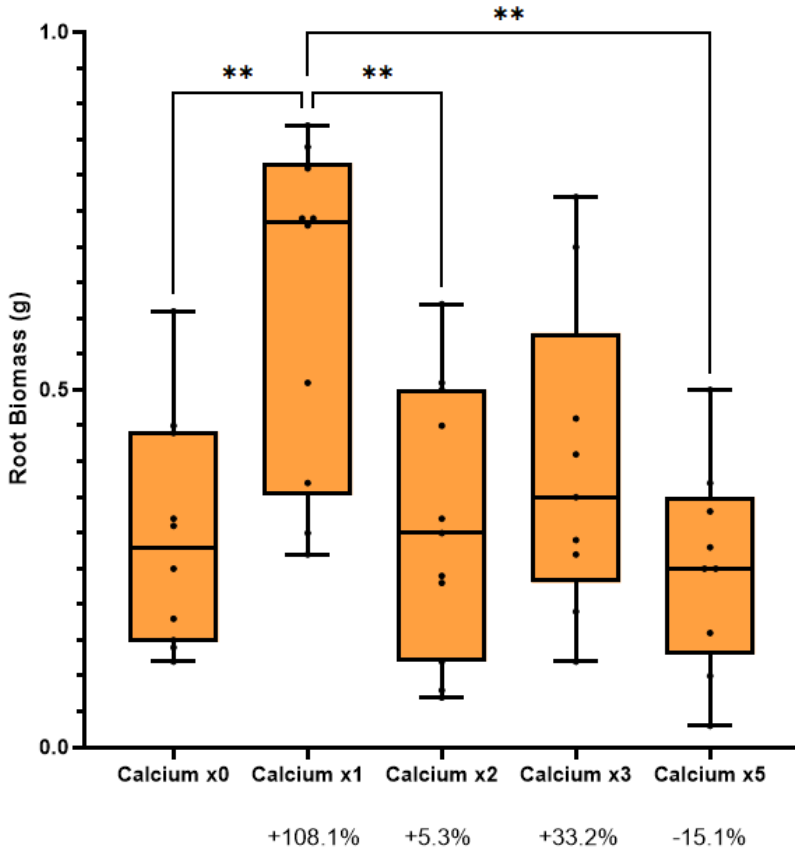
x3 Calcium

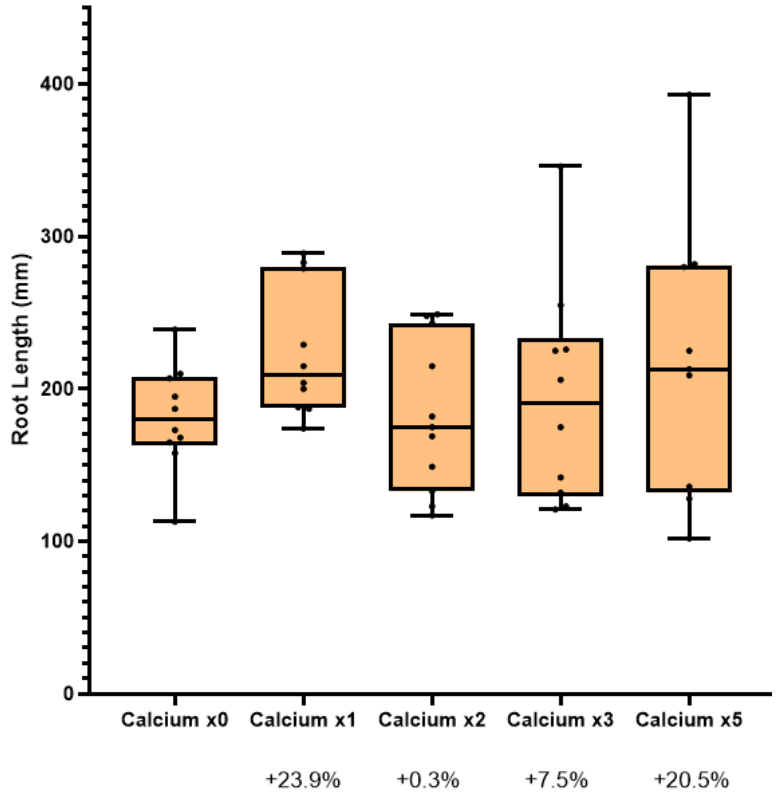
x5 Calcium

30 cm

Effect of MX-3 Calcium Foliar Spray on Root Biomass/Length in Canola Under Greenhouse Conditions

- Grown in greenhouse conditions
- Sample size: n=12
- Grown for 21 days
  - Sprayed on day 14
- **Root Biomass**
  - 108.1% increase of x1 calcium compared to x0
- **Root Length**
  - 23.9% increase of x1 calcium compared to x0 (Not statistically significant)
    - P =0.1970





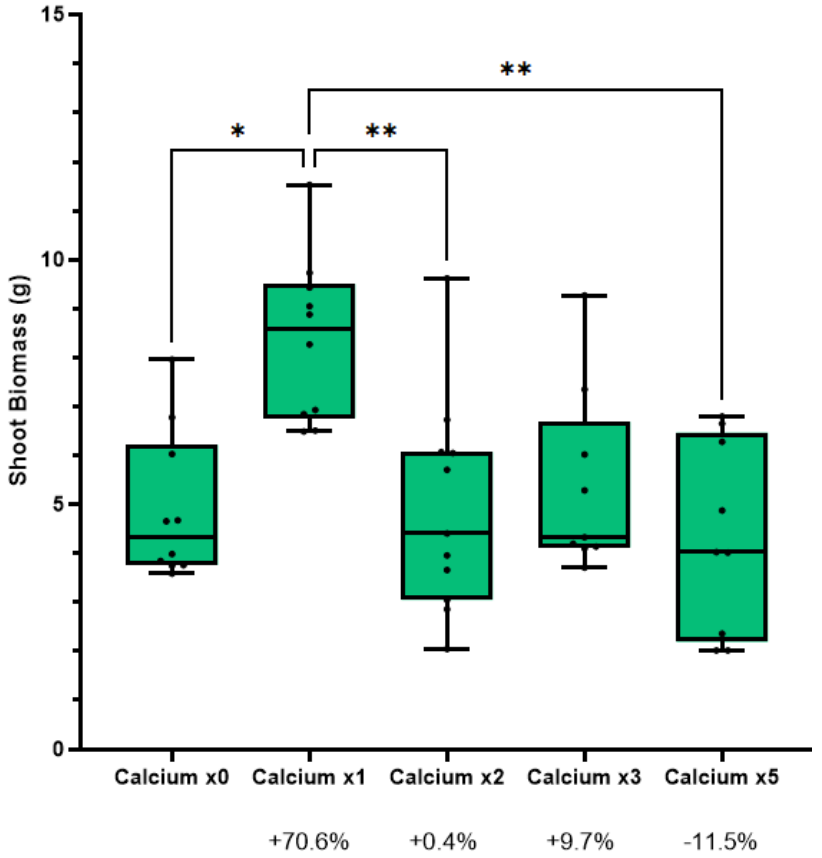
Percents on graph indicate an increase or decrease compared to control

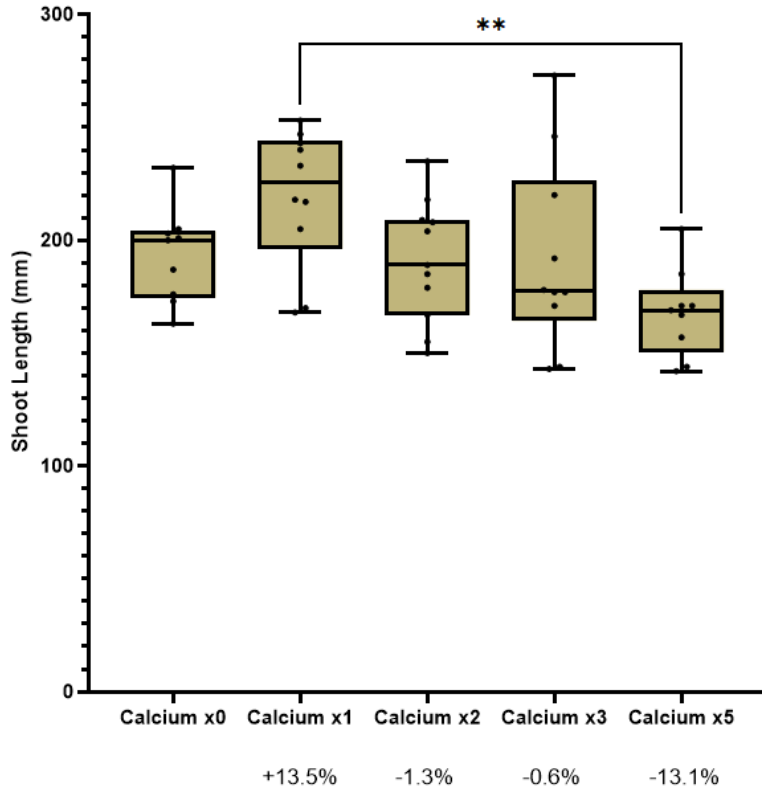
Root biomass variation analysed analyzed using one-way ANOVA with *post-hoc* Tukey. Root length variation using Brown–Forsythe one-way ANOVA with *post-hoc* Dunnett T3

P ≤ 0.05	*
P ≤ 0.01	**
P ≤ 0.001	***
P ≤ 0.0001	*** *

Effect of MX-3 Calcium Foliar Spray on Shoot Biomass/Length in Canola Under Greenhouse Conditions

- Grown in greenhouse conditions
- Sample size: n=12
- Grown for 21 days
  - Sprayed on day 14
- **Shoot Mass**
  - 70.6% increase of x1 calcium compare to x0
- **Shoot Length**
  - 13.5% increase of x1 calcium compare to x0 (Not statistically significant)
    - P =0.3187





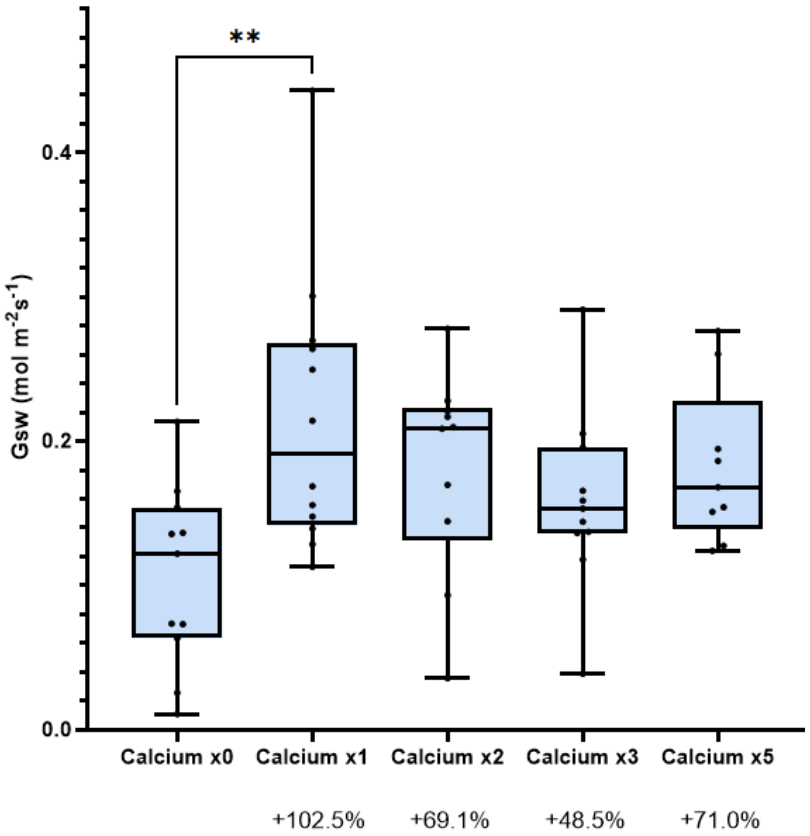
Percents on graph indicate an increase or decrease compared to control

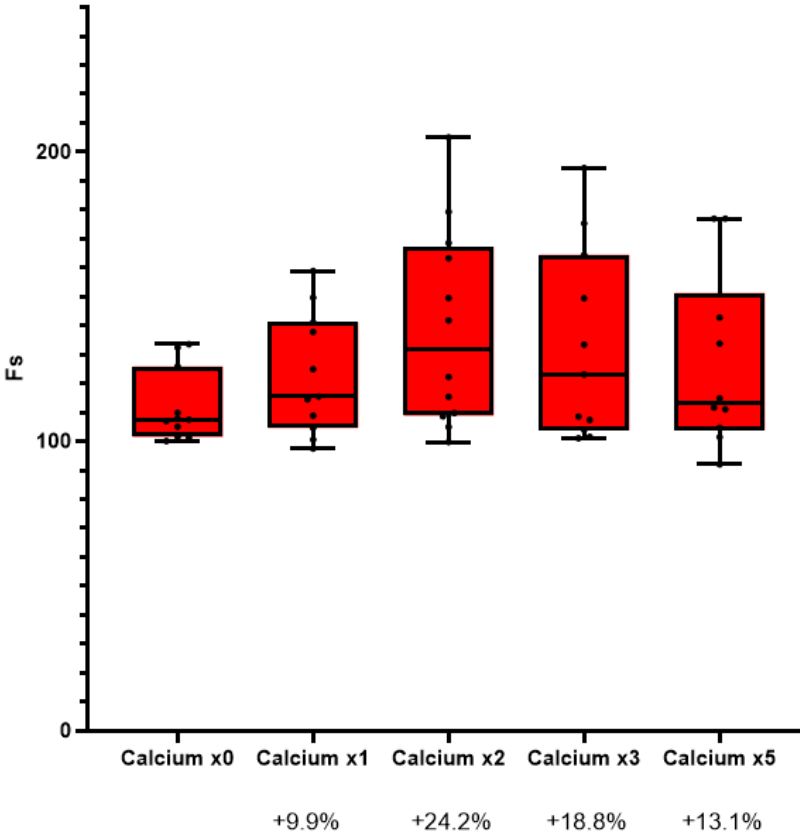
Shoot biomass variation analysed using Kruskal-Wallis one-way ANOVA with *post-hoc* Dunn. Shoot length variation analyzed using one-way ANOVA with *post-hoc* Tukey

P ≤ 0.05	*
P ≤ 0.01	**
P ≤ 0.001	***
P ≤ 0.0001	***
	*

Effect of MX-3 Calcium Foliar Spray on Gsw and Fs in Canola Under Greenhouse Conditions

- Grown in greenhouse conditions
- Sample size: n=12
- Grown for 21 days
  - Sprayed on day 14
  - LICOR recorded on day 20
- **Gsw**
  - 102.5% increase of x1 calcium compared to x0
- **Fs**
  - 24.2% increase of x2 calcium compared to x0 (Not statistically significant)
    - P =0.3191





Percents on graph indicate an increase or decrease compared to control

Gsw variation analyzed using one-way ANOVA with *post-hoc* Tukey. Fs variation analyzed using Kruskal-Wallis one-way ANOVA with *post-hoc* Dunn

P ≤ 0.05	*
P ≤ 0.01	**
P ≤ 0.001	***
P ≤ 0.0001	***
	*

Effect of MX-3 FulviCal Foliar on Canola Under Greenhouse Conditions

UTC

x1 Ful + Cal

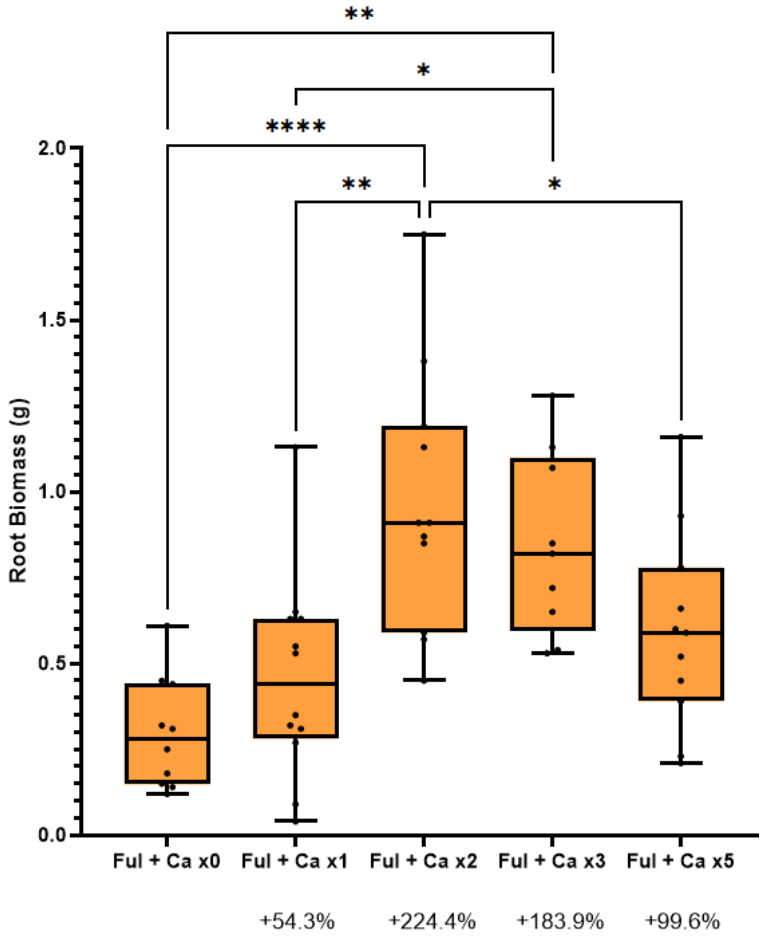
x2 Ful + Cal

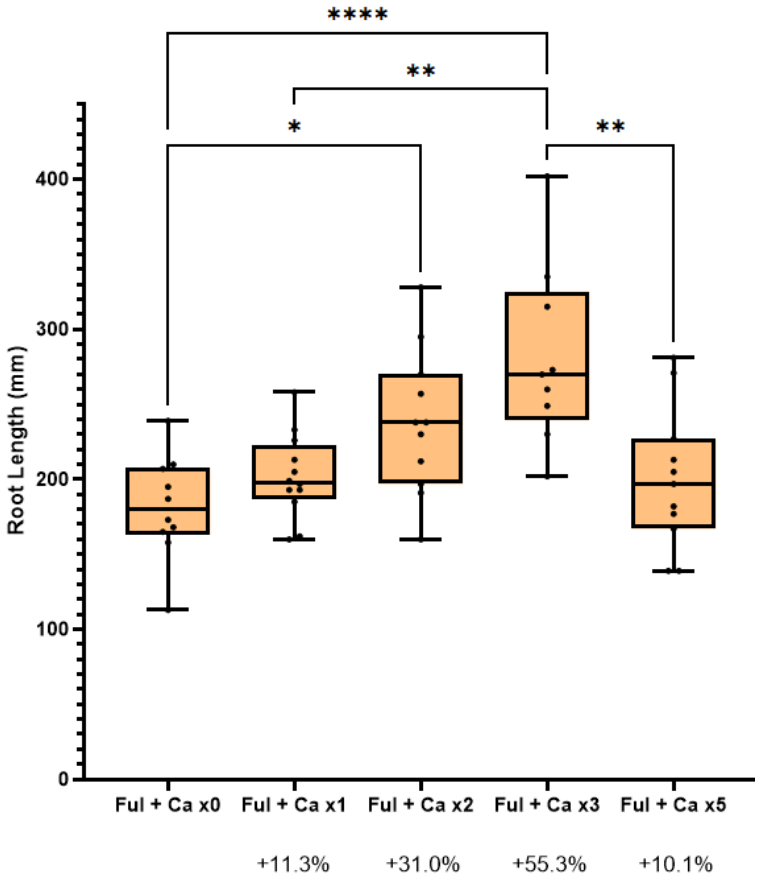
x3 Ful + Cal

x5 Ful + Cal

Effect of MX-3 FulviCal Foliar Spray on Plant Biomass and Length in Canola Under Greenhouse Conditions

- Grown in greenhouse conditions
- Sample size: n=12
- Grown for 21 days
  - Sprayed on day 14
- **Root Biomass**
  - 224.4% increase of x2 fulvic + calcium compared to x0
- **Root Length**
  - 55.3% increase of x3 fulvic + calcium compared to x0





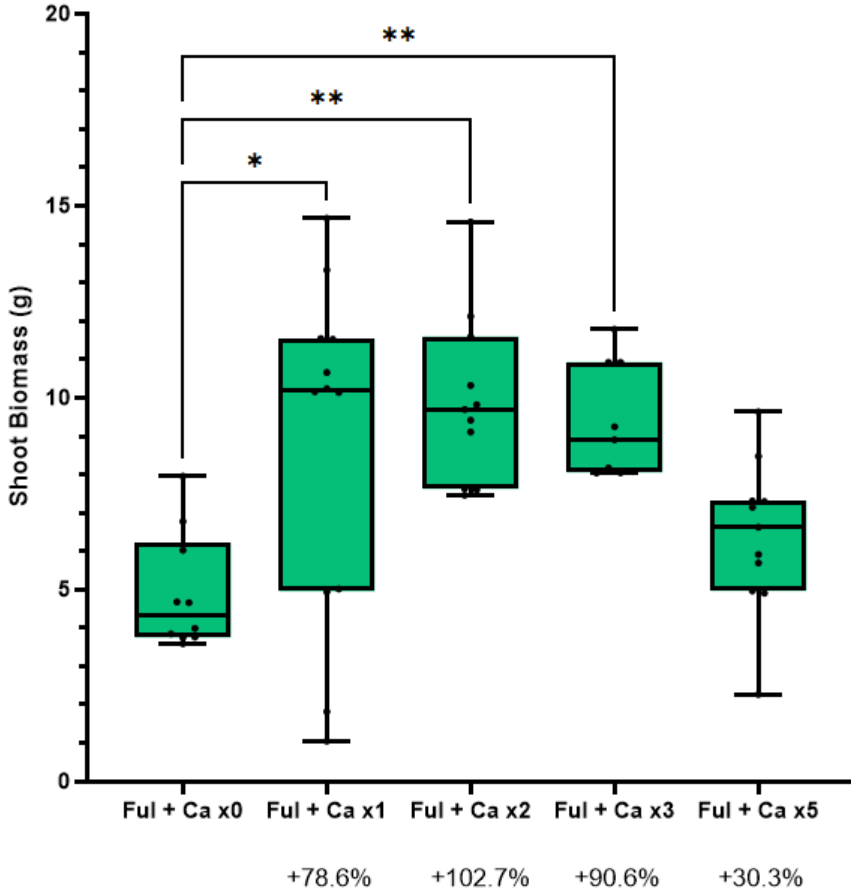
Percents on graph indicate an increase or decrease compared to control

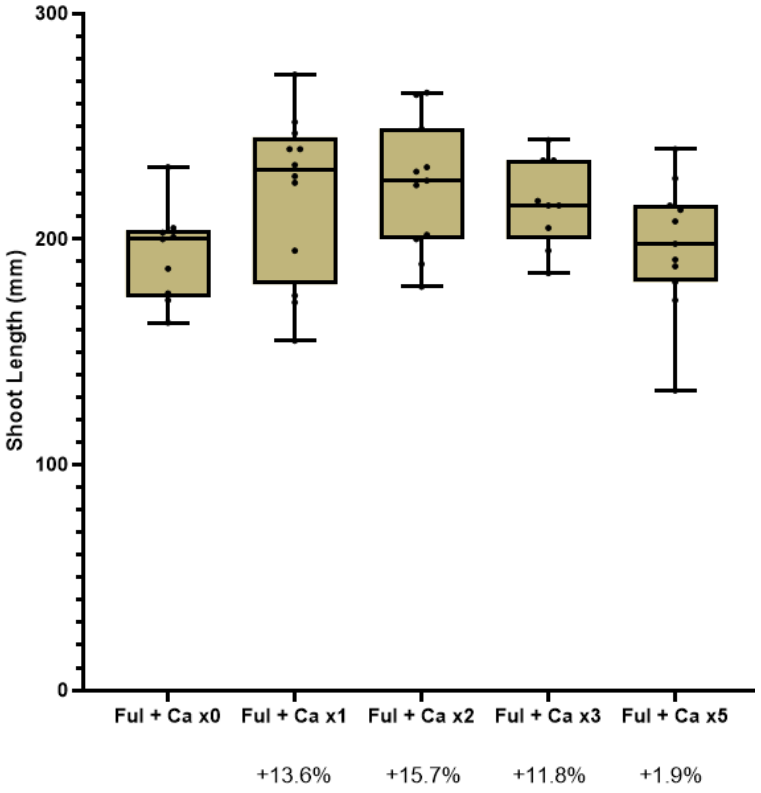
Root biomass and length variation analysed analyzed using one-way ANOVA with *post-hoc* Tukey.

P ≤ 0.05	*
P ≤ 0.01	**
P ≤ 0.001	***
P ≤ 0.0001	***
	*

Effect of MX-3 FulviCal Foliar Spray on Shoot Biomass/Length in Canola Under Greenhouse Conditions

- Grown in greenhouse conditions
- Sample size: n=12
- Grown for 21 days
  - Sprayed on day 14
- **Shoot Biomass**
  - 102.7% increase of x2 fulvic + calcium compared to x0
- **Shoot Length**
  - 15.7% increase of x2 fulvic + calcium compared to x0 (Not statistically significant)
    - P =0.1427





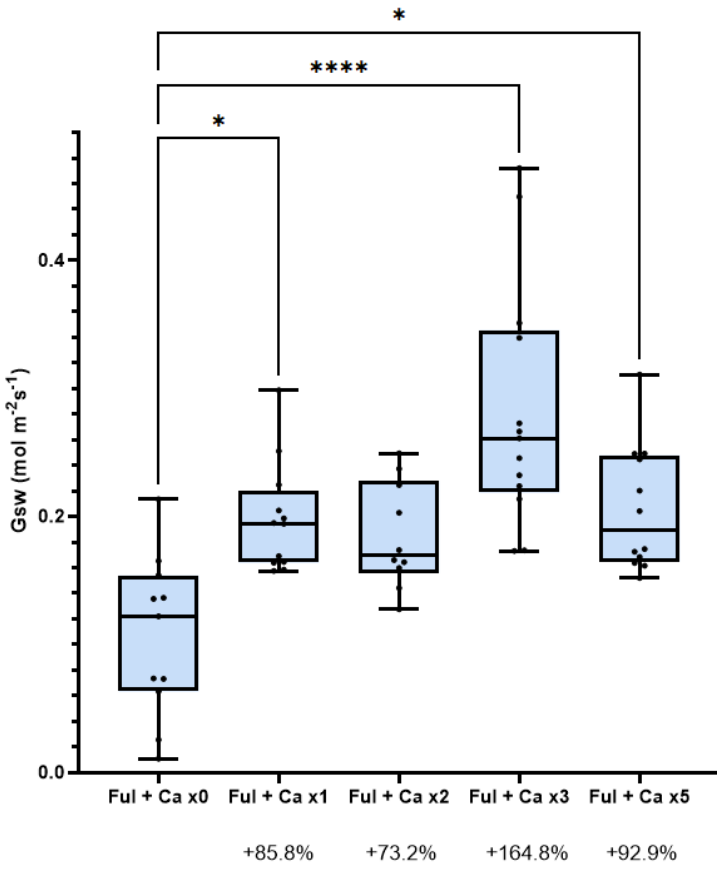
Percents on graph indicate an increase or decrease compared to control

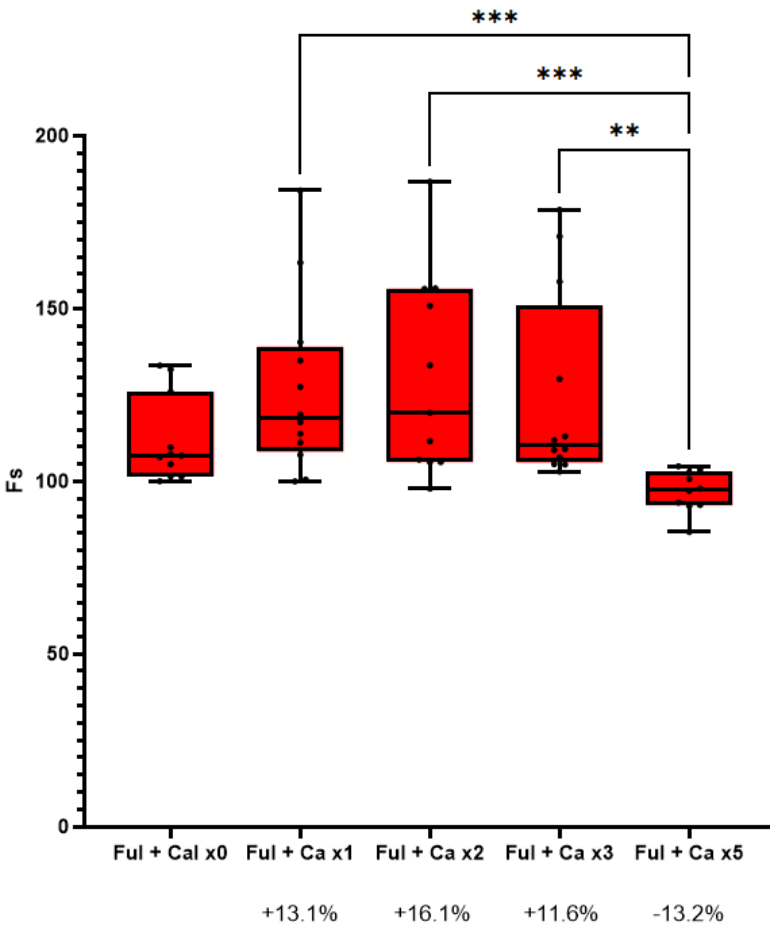
Shoot biomass variation analysed using Kruskal-Wallis one-way ANOVA with *post-hoc* Dunn. Shoot length variation analyzed using one-way ANOVA with *post-hoc* Tukey

P ≤ 0.05	*
P ≤ 0.01	**
P ≤ 0.001	***
P ≤ 0.0001	***
	*

Effect of MX-3 FulviCal Foliar Spray on Gsw and Fs in Canola Under Greenhouse Conditions

- Grown in greenhouse conditions
- Sample size: n=12
- Grown for 21 days
  - Sprayed on day 14
  - LICOR recorded on day 20
- **Gsw**
  - 164.8% increase of x3 fulvic + calcium compared to x0
- **Fs**
  - 16.1% increase of x2 fulvic + calcium compared to x0 (Not statistically significant)
    - P =>0.9999





Percents on graph indicate an increase or decrease compared to control

Gsw and Fs variation analyzed using using Kruskal-Wallis one-way ANOVA with *post-hoc* Dunn.

P ≤ 0.05	*
P ≤ 0.01	**
P ≤ 0.001	***
P ≤ 0.0001	***
	*

What Are the Effects of MX-3 FulviCal Soil Drench on Soybean Shoot Biomass Under Greenhouse Conditions?

*30 cm ruler

UTC

Fulvic + Calcium
x1

What Are the Effects of MX-3 FulviCal Soil Drench on Soybean Shoot Biomass Under Greenhouse Conditions?

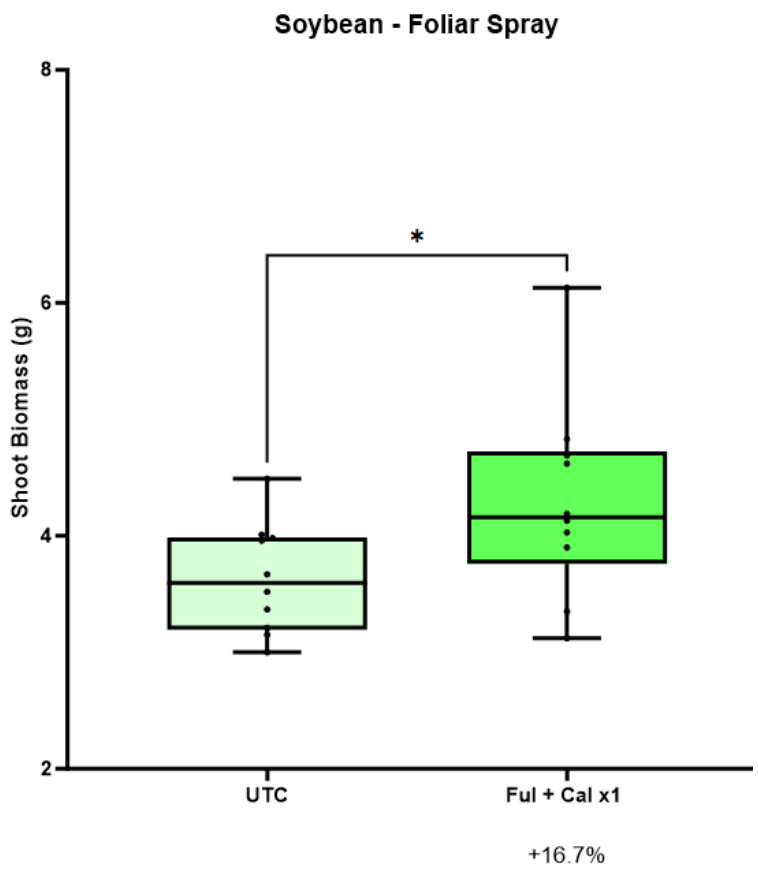
*Scale bar: 16cm

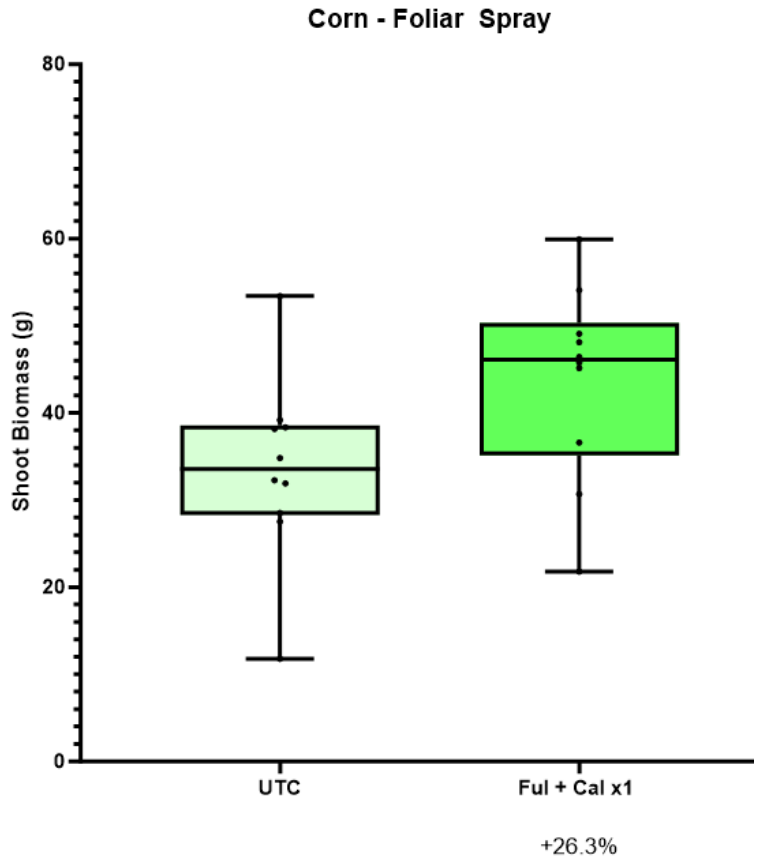
UTC

Fulvic + Calcium
x1

What Are the Effects of MX-3 FulviCal Foliar Spray on Crop Shoot Biomass Under Greenhouse Conditions?

- Grown in greenhouse conditions for 45 days
- n=10
- **Shoot Biomass Soybean:**
  - 16.7% increase of fulvic + calcium x1 compared to UTC
- **Shoot Biomass Corn:**
  - 26.3% increase of fulvic + calcium x1 compared to UTC (Not statistically significant)
    - P: 0.1488





Percents on graph indicate an increase or decrease compared to control

Wet weight variation analysed using unpaired t-test

P ≤ 0.05	*
P ≤ 0.01	**
P ≤ 0.001	***
P ≤ 0.0001	*** *

What Are the Effects of MX-3 FulviCal Foliar Spray on Corn Shoot Biomass Under Greenhouse Conditions?

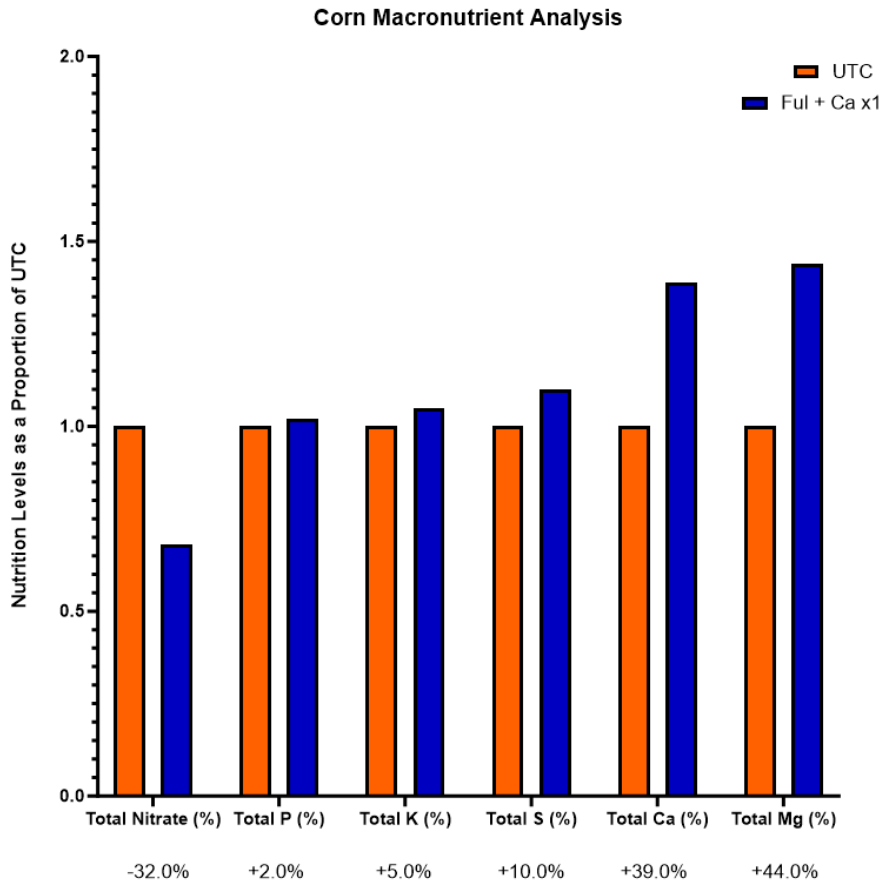
*Scale bar: 16cm

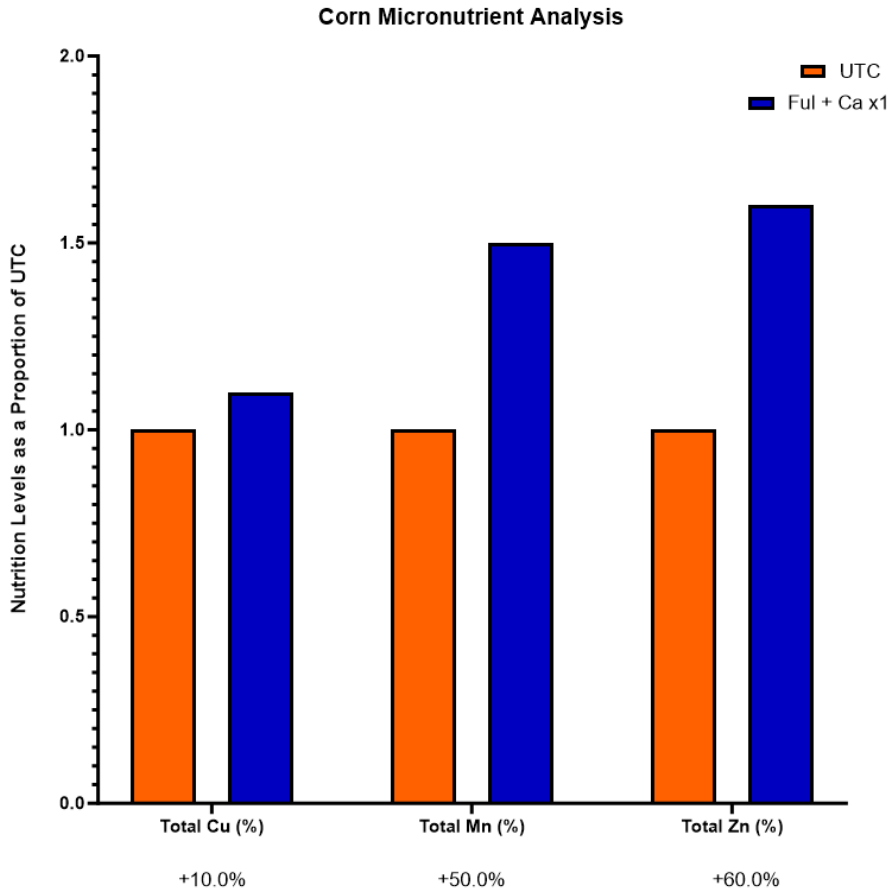
UTC

Fulvic + Calcium
x1

What Are the Effects of MX-3 FulviCal Seed Treatment on Corn Nutritional Content Under Greenhouse Conditions?

- Grown in greenhouse conditions for 19 days
- n=1
- **Macronutrient:**
  - 44.0% increase of Total Mg (%) compared to UTC
- **Micronutrient:**
  - 60.0% increase of Total Zn (%) compared to UTC

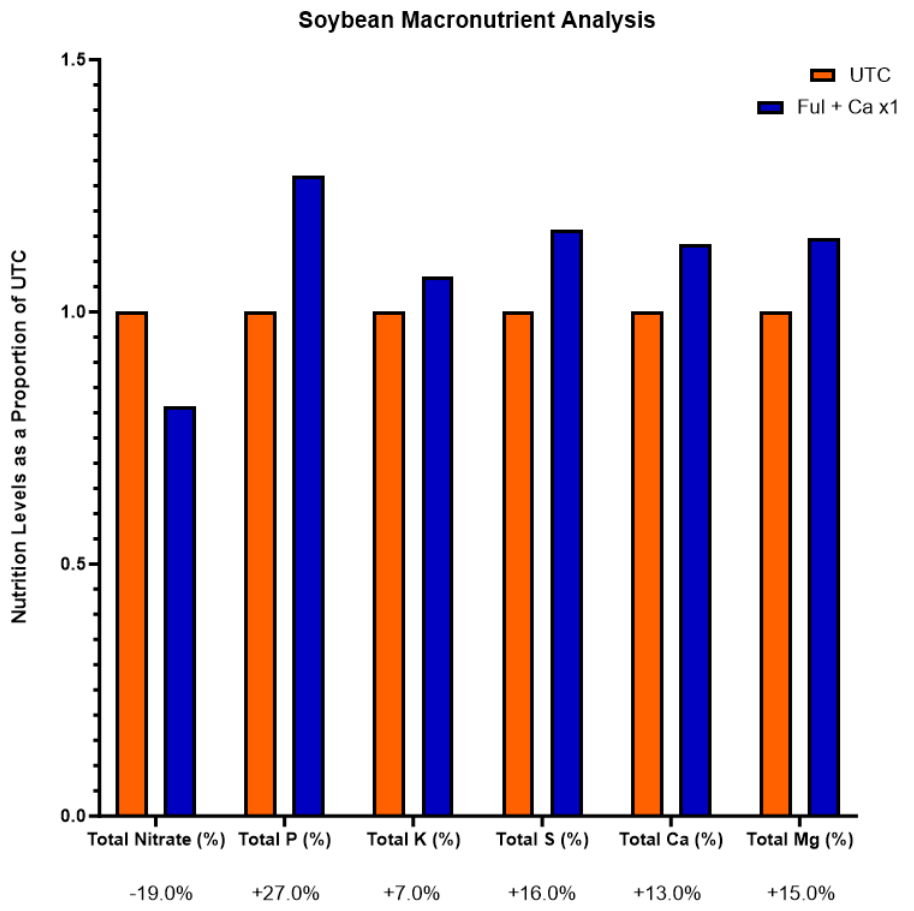


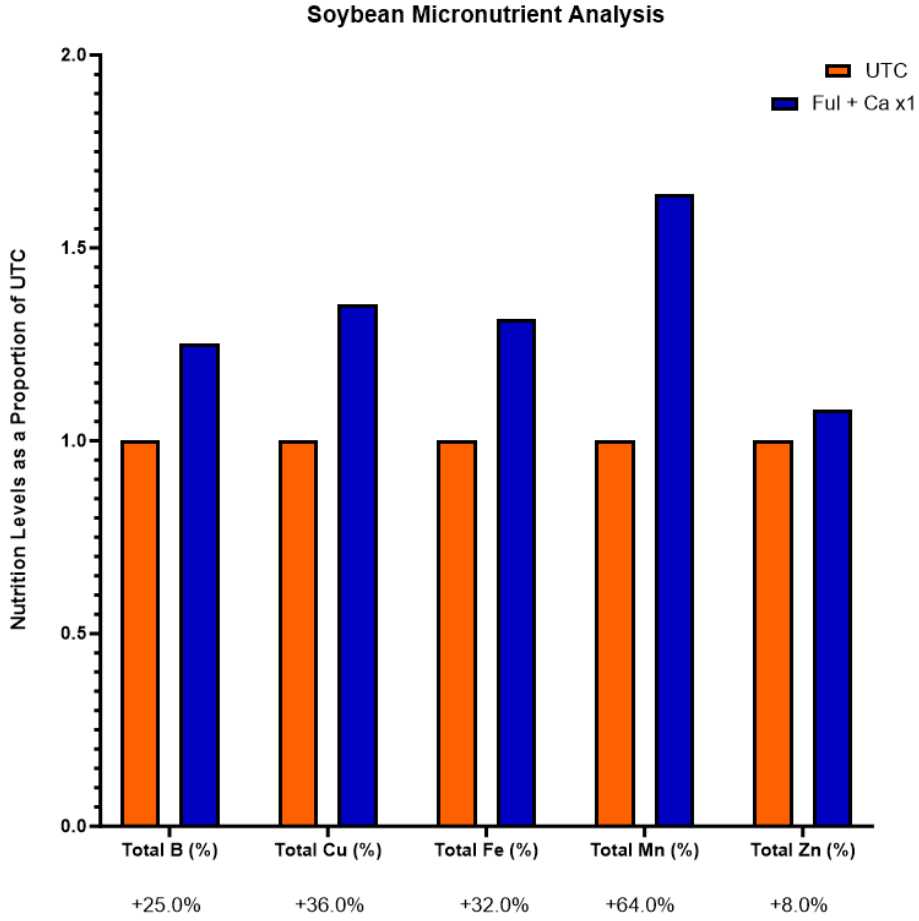


Percents on graph indicate an increase or decrease compared to control

What Are the Effects of MX-3 FulviCal Seed Treatment on Soybean Nutritional Content Under Greenhouse Conditions?

- Grown in greenhouse conditions for 19 days
- n=1
- **Macronutrient:**
  - 27.0% increase of Total P (%) compared to UTC
- **Micronutrient:**
  - 64.0% increase of Total Mn (%) compared to UTC





Percents on graph indicate an increase or decrease compared to control

What Are the Effects of MX-3 FulviCal Foliar Spray on Soybean Shoot Biomass Under Greenhouse Conditions?

*30 cm ruler

UTC

Fulvic +
Calcium x1

What are the Effects of MX-3 FulviCal Seed Treatment on Crop Development Under Cold Conditions?

- Cold temperatures slow plant metabolism and lower nutrient absorption
- Organic acids in our study have been associated with increased nutrient uptake
- Performing experiments at 5, 7, and 10°C to determine if there's a difference in effect
    - Determining if organic acids can mitigate cold stress of our crops at very cold temperatures
    - Understanding why organic acids mitigate cold stress better at certain temperatures

What Are the Effects of MX-3 FulviCal Seed Treatments on Canola Seedling Under Cold Conditions?

Canola Seedlings Under 5°C

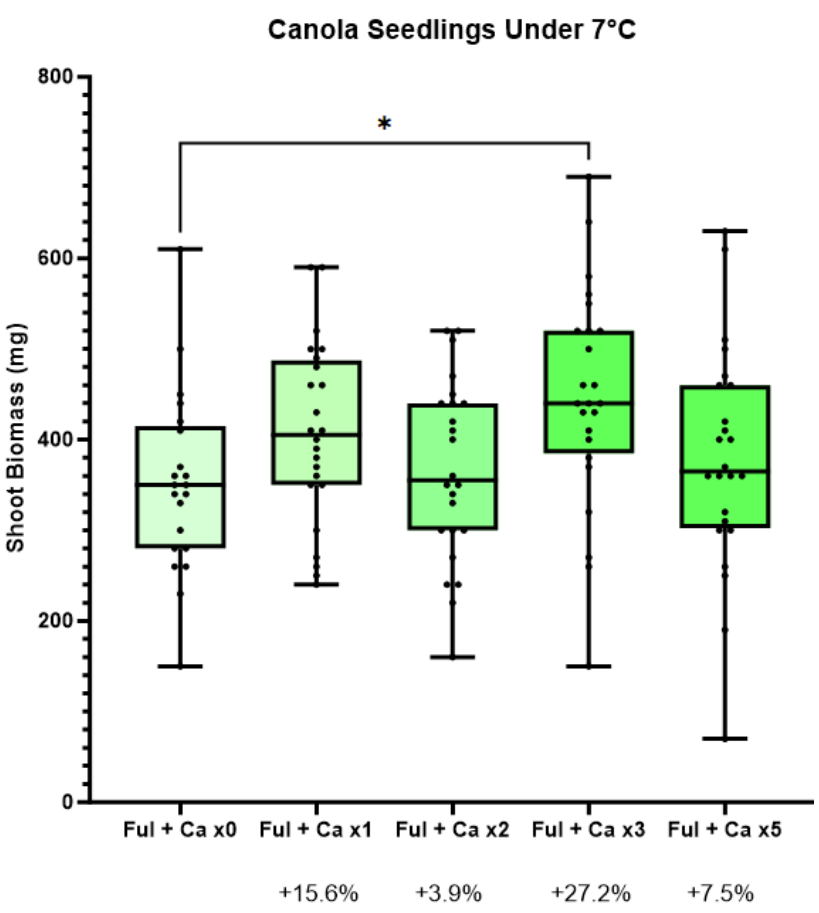
Canola Seedlings Under 7°C

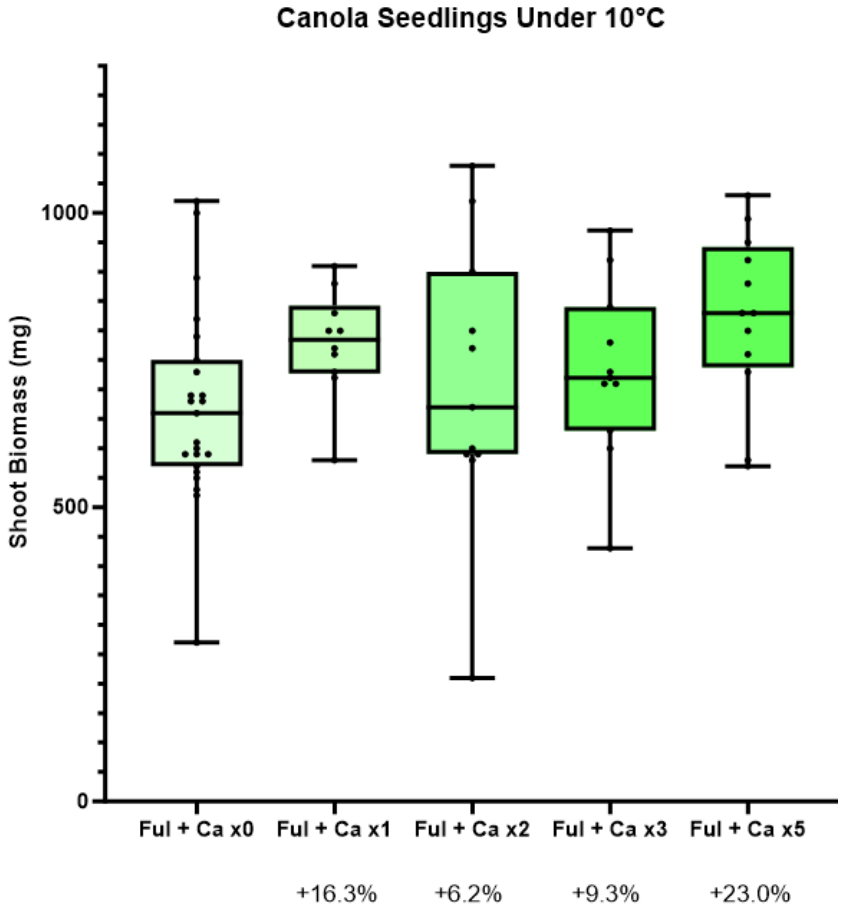
Canola Seedlings Under 10°C

- Grown for three weeks under cold conditions
- 24 seeds per treatment

What Are the Effects of MX-3 FulviCal Seed Treatment on Shoot Biomass on Canola Seedling Under Cold Conditions?

- Grown for three weeks under cold conditions
- n=12
- **7°C Shoot Biomass:** 27.3% increase of fulvic + calcium x3 compared to x0
- **10°C Shoot Biomass:** 23.0% increase of fulvic + calcium x5 compared to x0



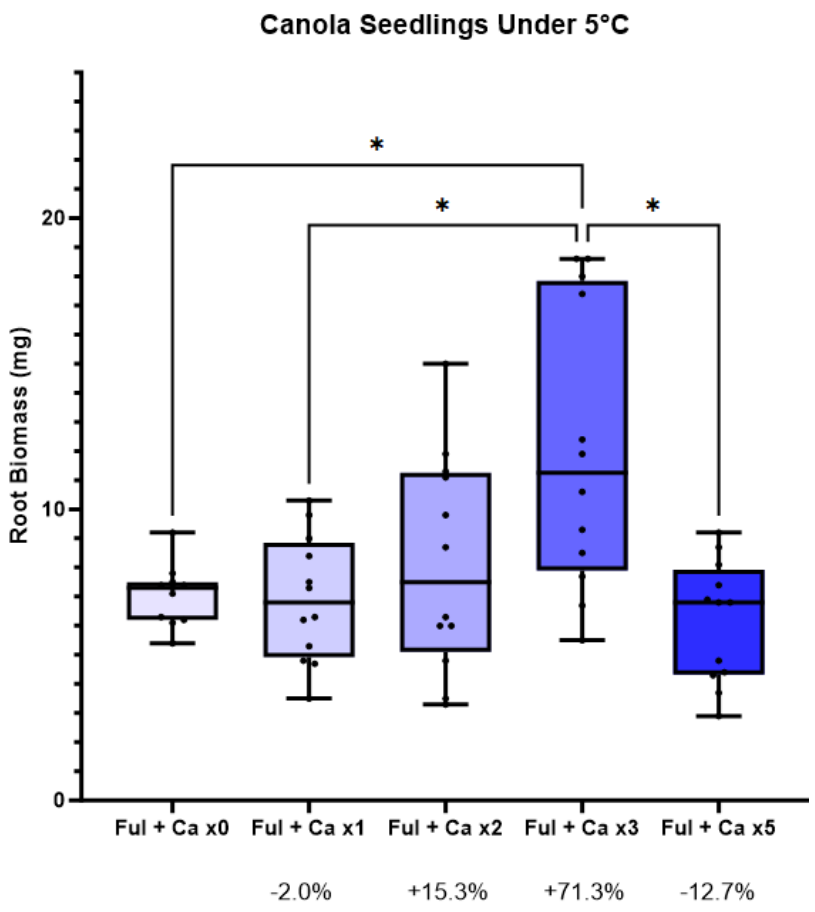


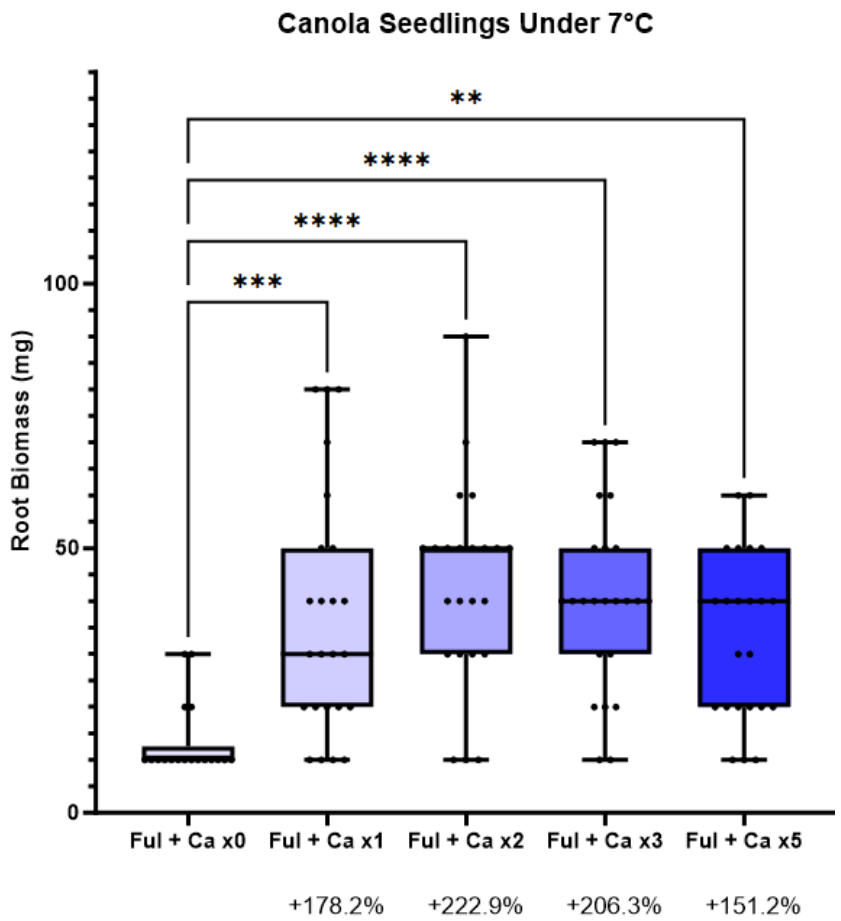
Percents on graph indicate an increase or decrease compared to control

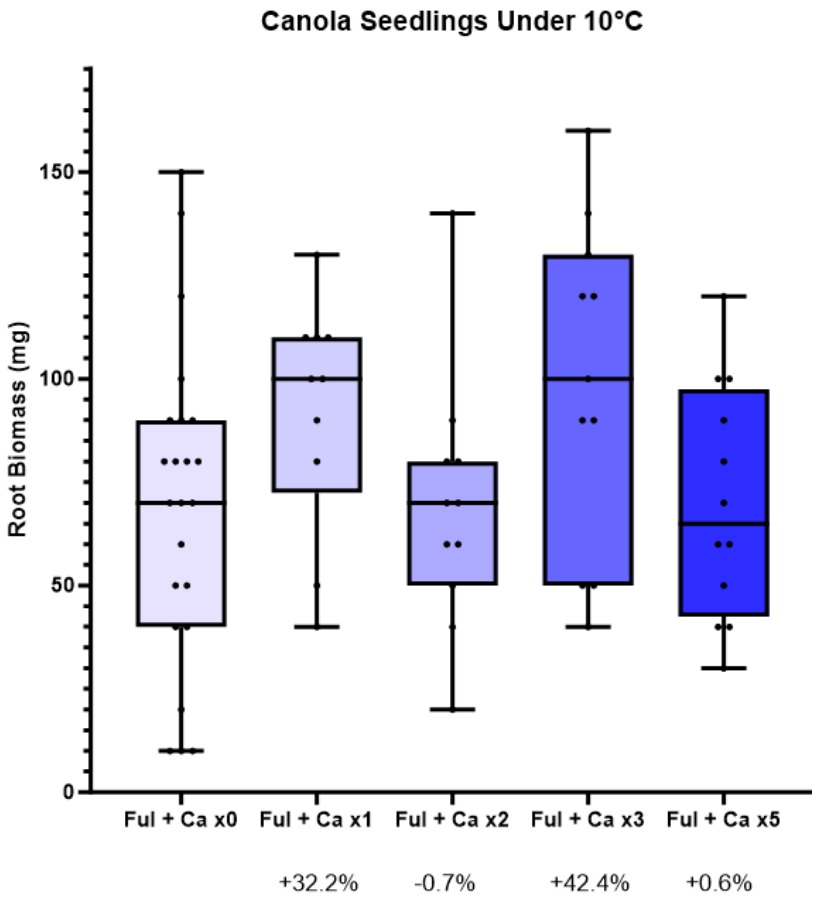
Wet weight variation analyzed using one-way ANOVA with *post-hoc* Tukey

P ≤ 0.05	*
P ≤ 0.01	**
P ≤ 0.001	***
P ≤ 0.0001	***
	*

What Are the Effects of MX-3 FulviCal Seed Treatment on Root Mass on Canola Seedling Under Cold Conditions?







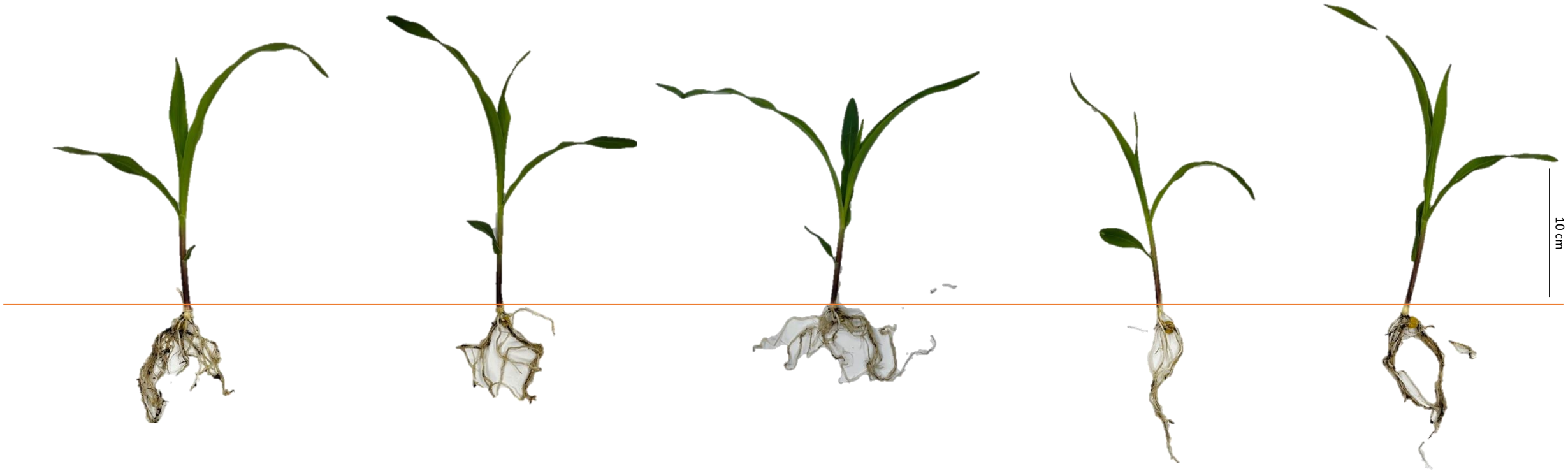
- Grown for three weeks under cold conditions
- n=12

Percents on graph indicate an increase or decrease compared to control

5°C wet weight variation analyzed using Brown–Forsythe one-way ANOVA with *post-hoc* Dunnett T3. 7°C wet weight variation analyzed using Kruskal-Wallis one-way ANOVA with *post-hoc* Dunn. 10°C wet weight variation analyzed using one-way ANOVA with *post-hoc* Tukey

P ≤ 0.05	*
P ≤ 0.01	**
P ≤ 0.001	***
P ≤ 0.0001	***
	*

What Are the Effects of MX-3 FulviCal Seed Treatment on Corn Root Length Under Greenhouse Conditions?



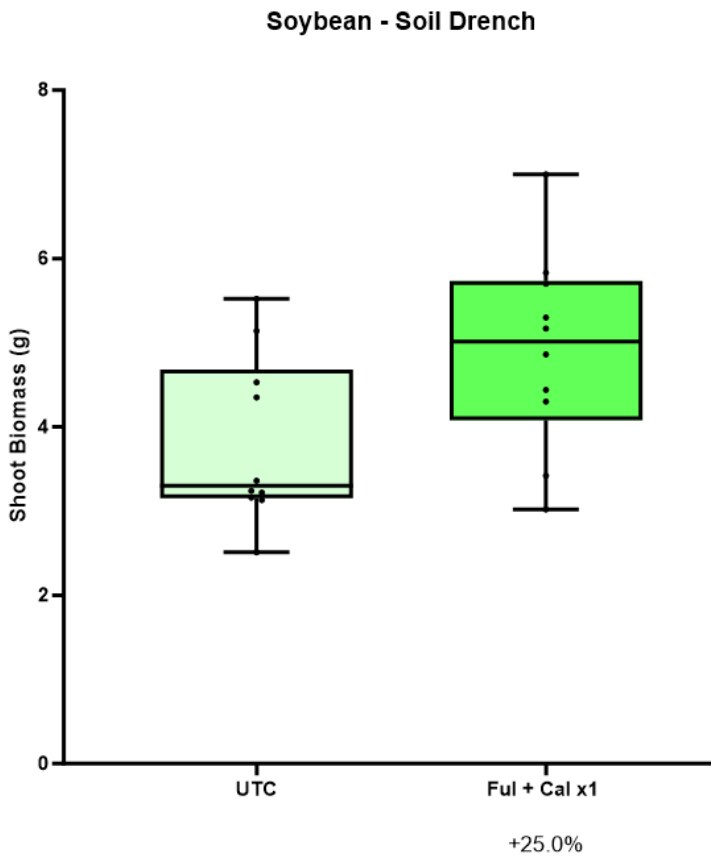
UTC | Ful + Ca 1X | Ful + Ca 2X | Ful + Ca 3X | Ful + Ca 5X

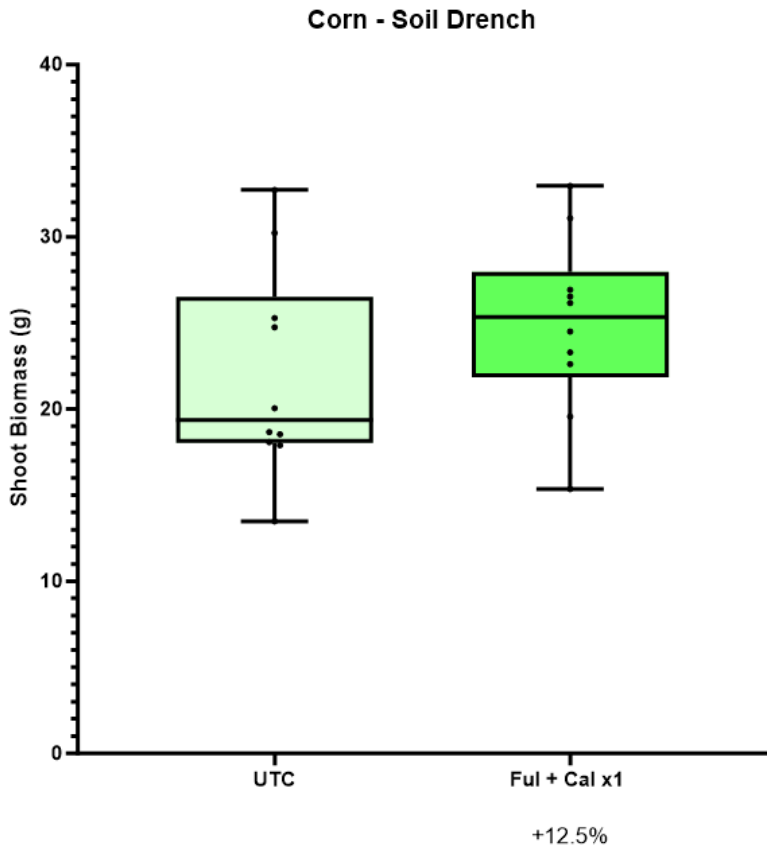
What Are the Effects of MX-3 FulviCal Seed Treatment on Soybean Root Length Under Greenhouse Conditions?

UTC Ful + Ca 1X Ful + Ca 2X Ful + Ca 3X Ful + Ca 5X

What Are the Effects of MX-3 FulviCal Soil Drench on Crop Shoot Biomass Under Greenhouse Conditions?

- Grown in greenhouse conditions for 45 days
- n=10
- **Shoot Biomass Soybean:**
  - 25.0% increase of fulvic + calcium x1 compared to UTC (Not statistically significant)
    - P: 0.0552
- **Shoot Biomass Corn:**
  - 12.5% increase of humic x1 compared to UTC (Not statistically significant)
    - P: 0.6809





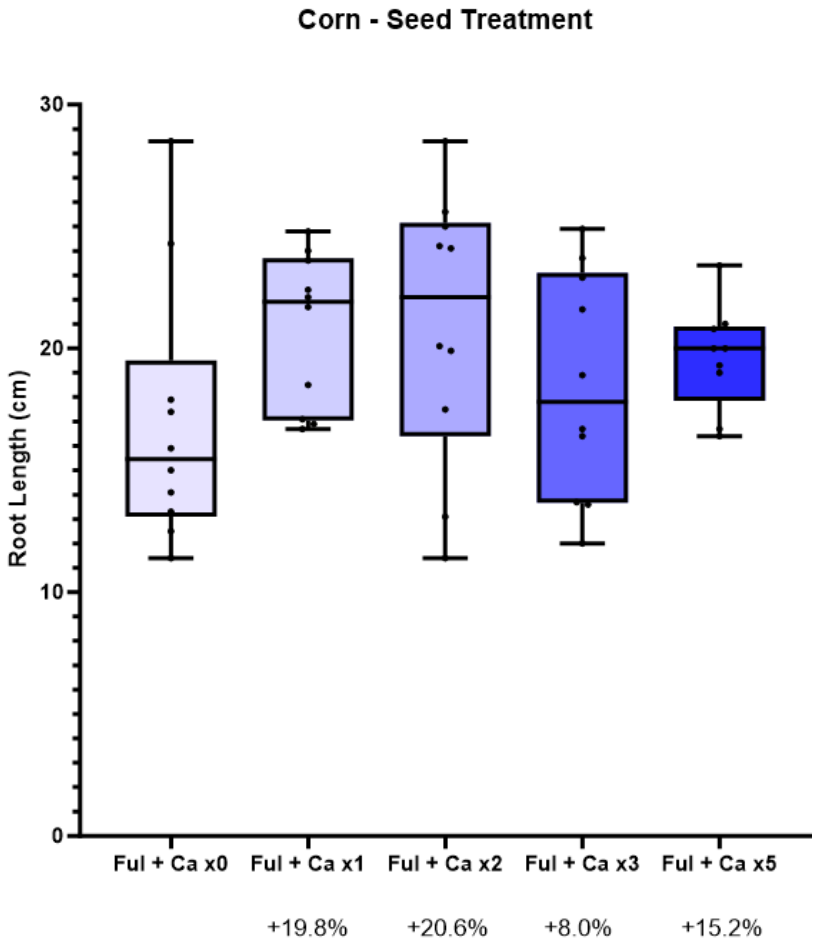
Percents on graph indicate an increase or decrease compared to control

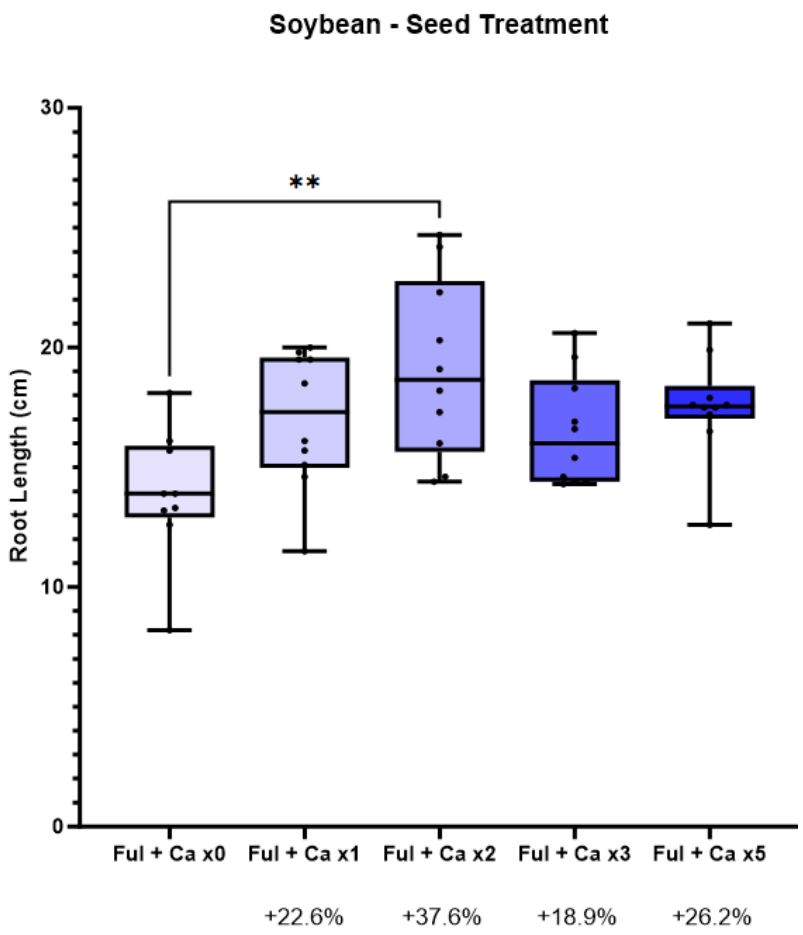
Wet weight variation analysed using unpaired t-test

P ≤ 0.05	*
P ≤ 0.01	**
P ≤ 0.001	***
P ≤ 0.0001	***
	*

What Are the Effects of MX-3 FulviCal Seed Treatment on Crop Root Length Under Greenhouse Conditions?

- Grown in greenhouse conditions for 19 days
- n=10
- **Root Length Corn:**
  - 20.6% increase of fulvic + calcium x2 compared to x0 (Not statistically significant)
    - P: 0.2986
- **Root Length Soybean:**
  - 37.6% increase of fulvic + calcium x2 compared to x0





Percents on graph indicate an increase or decrease compared to control

Root length variation analysed using one-way ANOVA with *post-hoc* Tukey

P ≤ 0.05	*
P ≤ 0.01	**
P ≤ 0.001	***
P ≤ 0.0001	***
	*