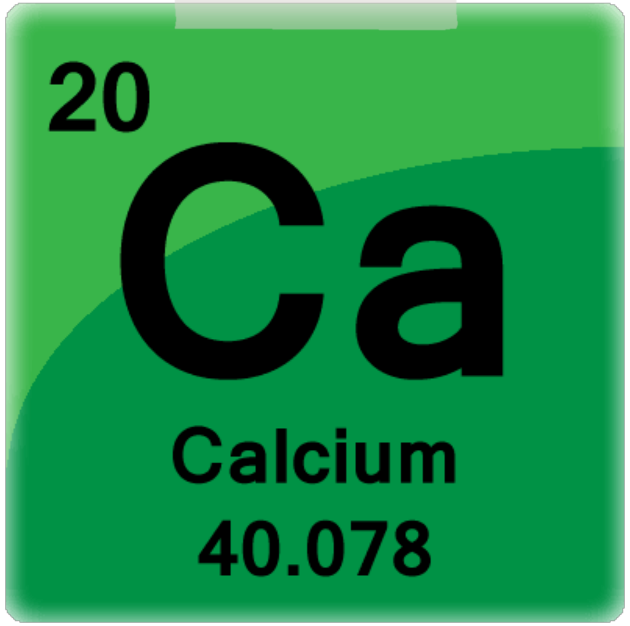
CALCIUM DEFICIENCIES IN LANDSCAPES: ITS EFFECTS AND ITS SOLUTIONS.

By Amaya Opalka



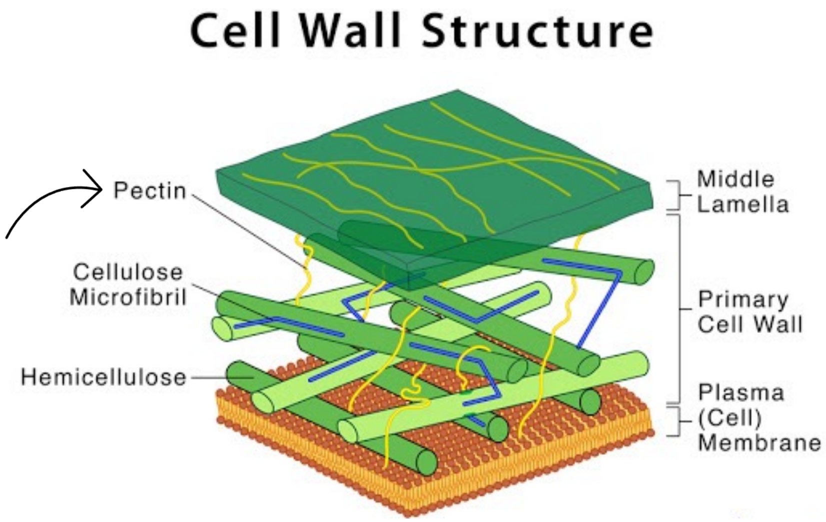
OVERVIEW:

- Calcium's Importance
- Calcium's biochemical role/ mechanisms
- Calcium in symbiosis
- Calcium deficiency as a result of human impacts on the environment
- Solutions to address deficiency
- Non Industrial Wood Ash

BACKGROUND AND THE IMPORTANCE

- Calcium (Ca^{2+}) is an essential ***macronutrient***
- Used in plants as a signalling molecule and to respond to stress and stimuli
- However, around the world, calcium is in short supply, largely as a result of human-induced environmental change.
- There are 30+ calcium-related plant diseases/deficiencies
- Solutions require understanding of calcium's biochemical mechanisms and its importance for plant health

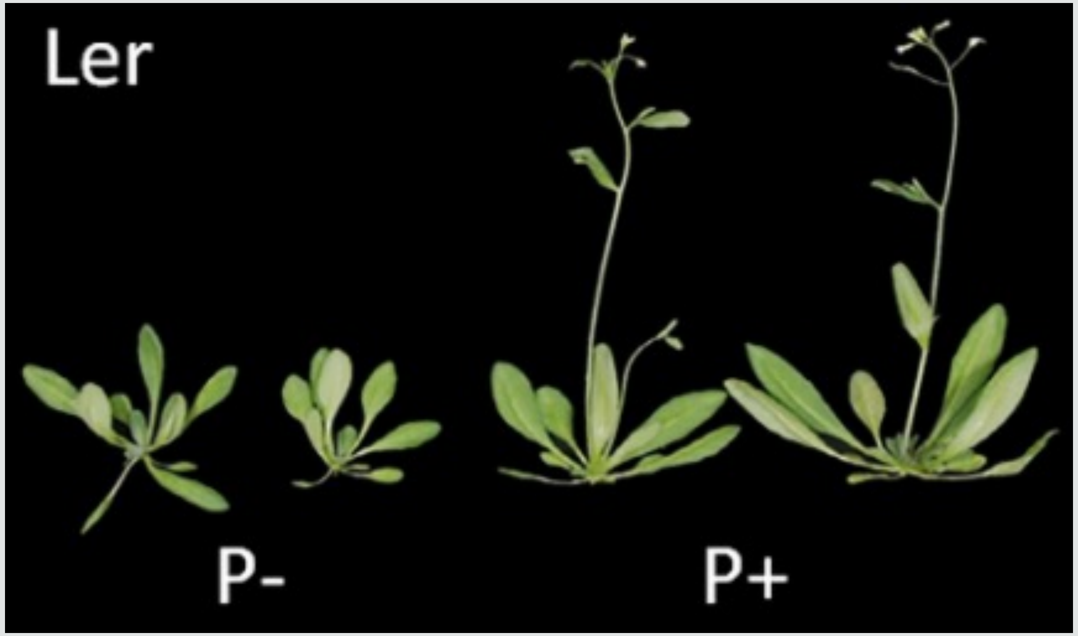
UNDERSTANDING CALCIUM'S BIOCHEMICAL MECHANISMS/ROLE



- Calcium binds to cell walls improving integrity
- If infected, Ca2+ influx into ***cytosol*** from ***apoplastic pool***- detected by ***Calmodulin*** triggers signalling cascades for responses:
  - setting up electrochemical gradients
  - pheromone secretion
  - plugging the plasmodesmata
- To stop pathogen spread Ca2+ and calmodulin cause ***callose*** deposition and ***lignin*** build up
- E.g Feeding of Balsam Woolly Adelgid, on fir trees. (Eastern Canada)

CALCIUM IN SYMBIOSIS

- Vital for improving symbiotic relationships
- $Ca2+$ enables signalling for mutualistic interactions so the plant recognises the organisms as commensal.
- E.g *Piriformospora indica* (***endophytic*** fungus) involved in root growth.
  - *Arabidopsis Thaliana* calcium impaired mutants were used to show ca2+ signalling importance.
  - No relationship with *P. indica* was found in the mutated plants, and the lack of calcium was deemed responsible.



EFFECTS OF CALCIUM DEFICIENCY AS A RESULT OF HUMAN IMPACTS ON THE ENVIRONMENT

- Acid rain is leaching Ca2+ out of soils, affecting plants and soil chemistry
- Climbing trends of emitted gases from ***anthropogenic*** sources, so great concern for forest health
- Calcium leaching affects other ecosystems e.g freshwater lakes
- Species with calcified exoskeletons are being jeopardised- water fleas are undergoing "***jellification***", - Daphnia are being displaced by Holopedium, a species with a gelatinous mantel instead of a calcified exoskeleton, so don't rely on Ca2+.
- Bird eggs are also becoming more fragile.

POTENTIAL SOLUTIONS TO ADDRESS CALCIUM DEFICIENCY

- Long term use of fertilisers has led to excessive availability of elements in ecosystems, causing eutrophication and soil pollution.
- Natural methods should increase Ca^{2+} soil content, but not harm the environment.
- Non Industrial Wood Ash (NIWA) has aided ion & pH restoration in forest soils harmed by acid rain.
- Findings from NIWA studies: Often, root & stem [Ca^{2+}] increased, pH increased but particular progress with sugar maple seedlings
- NIWA richer in nutrients than fertilisers, and doesn’t forgo secondary nutrients.
- NIWA can be up to 30% calcium- higher than many fertilisers

FURTHER NIWA CONSIDERATIONS

- NIWA strategy could be achieved in most woodland areas but needs community participation
- In Ontario, those generating NIWA (homes, bakeries, etc.) often willing to donate and transport it for forest use. The district of Muskoka in Ontario can approximately deliver 235 tonnes of wood ash.
- Method has been used in Scandinavia for decades.
- NIWA composition varies- can be trace of heavy metals, however analysis and screening can occur to quantify elements and ensure it is safe.



The Team currently aiming to save Muskoka:

Dr. Norman Yan

Past-Chair

Peter Kelley

Chairman

Doug Clark

Vice Chair

FINAL CONSIDERATIONS

- Calcium is vital as a macronutrient and messenger.
- Calcium deficiency is a factor that can gravely affect forest health.
- Ecosystems are complex, a Ca2+ soil deficiency can affect lakes too
- A lack of calcium leaves plants & animals vulnerable to disease & deficiency disorders that can cause tissue collapse and cell death.
- Subsequent research should include expanding on natural solutions like NIWA to target deficiencies but not harm the environment- this should be a priority as some calcium damage will be irreversible.

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