‘The biochemistry of silicon *in planta* is a riddle wrapped in a mystery inside an enigma.’

Epstein, 2001

What is Soluble Silicon?

Soluble Silicon (Mono-Silicic Acid) is the plant-available portion of the silica that makes up over 40% of soil chemistry. It is generally present in plant tissues in amounts similar to that of macronutrients (N, P, K, Ca, Mg, S) and in some grasses and grass family crops, often at higher levels than other macronutrients.

In addition:

- Plants grown in soils with low soluble silicon levels have a greater susceptibility to disease, drought stress and other plant stresses
- Silicon has been shown to reduce phosphorus leaching while at the same time increasing phosphorus plant availability.
- Silicon's activity in the soil matrix has been proven to improve micronutrient uptake (boron, copper, iron, manganese, zinc) and reduce toxic metal uptake (aluminum) as well as sodium.

Biochemical/genetic role of silicon?

- Silicic acid is absorbed by plants to be continuously transformed into insoluble polymers
- Soluble silicon has been detected inside the cell, in the cytosol, in chloroplastic membranes as well as in association with RNA and DNA.
- This information suggests that silicon can have a series of intracellular sites of action to explain its stimulating properties in plant disease resistance

Where does soluble Si come from, and why do deficiencies occur?

- In the soil, Silica is generally abundant as mineral quartz and clays, but its abundance in soluble form (mono-silicic acid) is highly variable.
- Continuous cropping of land, natural weathering, or inherently deficient soils can be causes of deficiency.
- Plants take up silicon into their root and shoot tissue, but it is not returned through biodegradation.

AAPFCO News

- AAPFCO approval as a beneficial substance: any substance or compound other than primary, secondary, and micro plant nutrients that can be demonstrated by scientific research to be beneficial to one or more species of plants, when applied exogenously.

Known Impacts on Plant Health

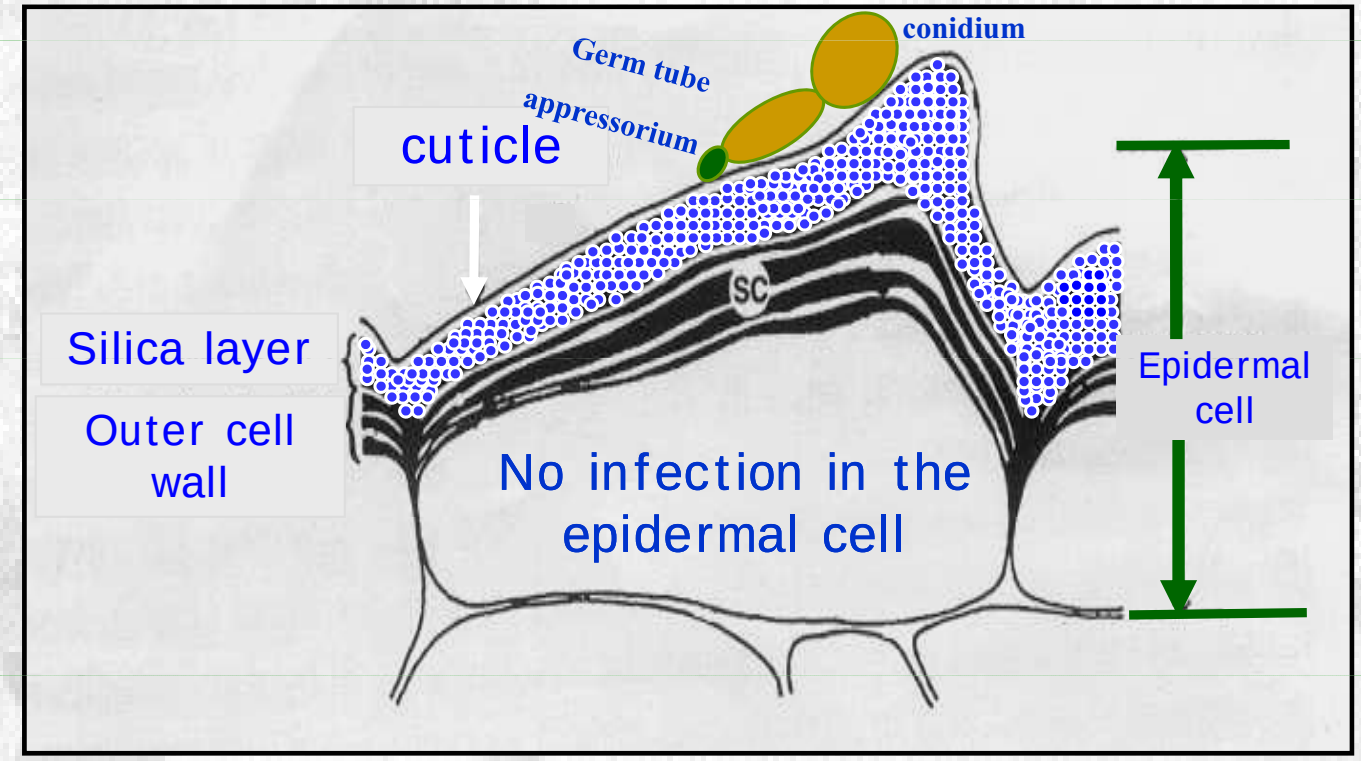
- Increases cell wall strength
  - Results in increased wear tolerance
  - Disease resistance
  - Insect resistance
  - More upright growth and rigidity
  - Increased shoot and root density, resulting in higher yields
- Regulates uptake of toxic elements
- Increases heat tolerance
- Slows transpiration
- Increases CEC making other nutrients more available

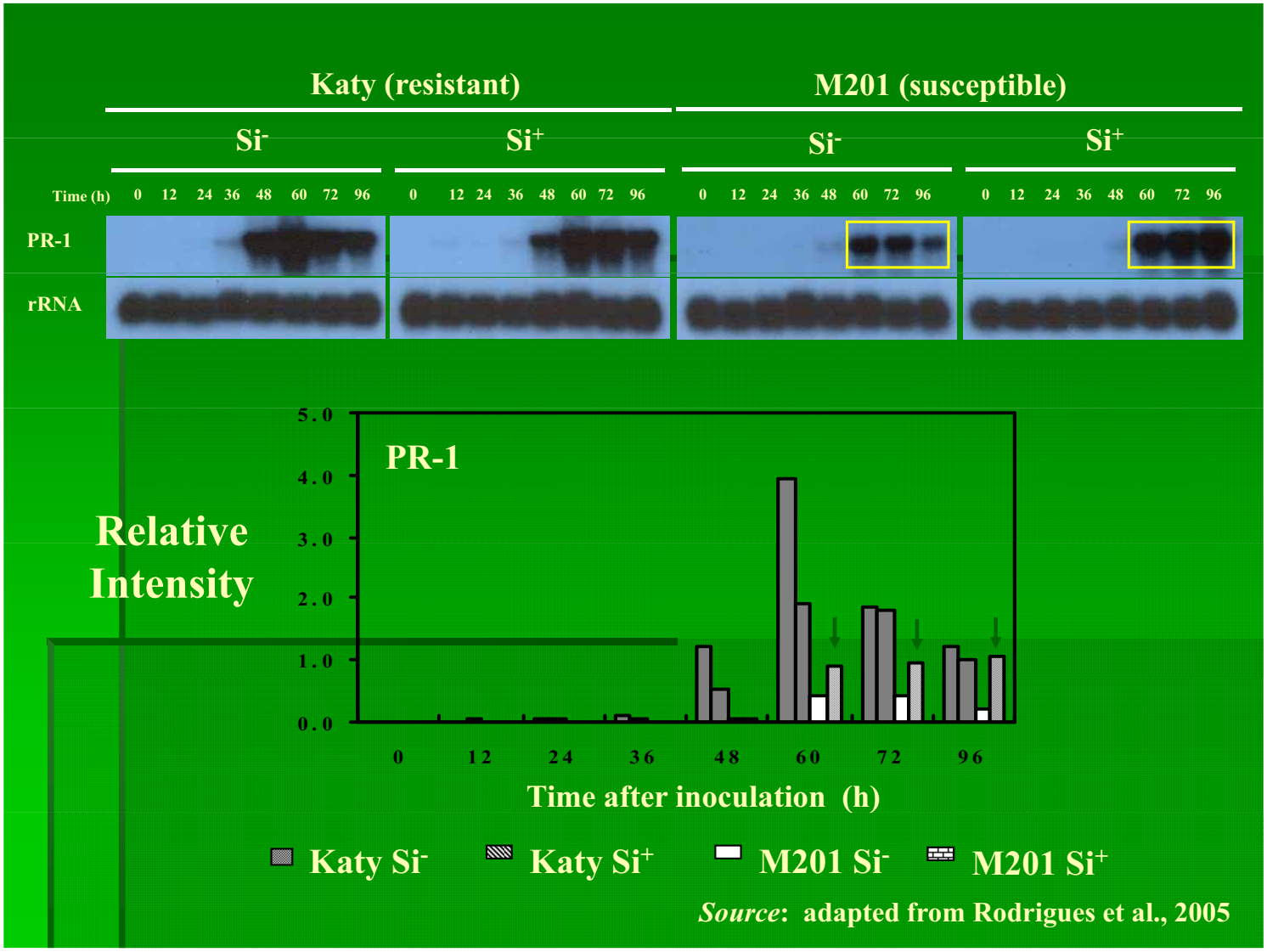
Direct Role of Silicon in Plant Health

- Tissue analysis indicates that silicon makes up between 0.2 and 10% of a plants dry weight.
- Its association with cell wall proteins indicates an active biochemical function.
- It is prominent in cell walls as solid amorphous silica, providing a structural barrier to pathogens.
- Studies suggest it is translocated from roots to shoots.

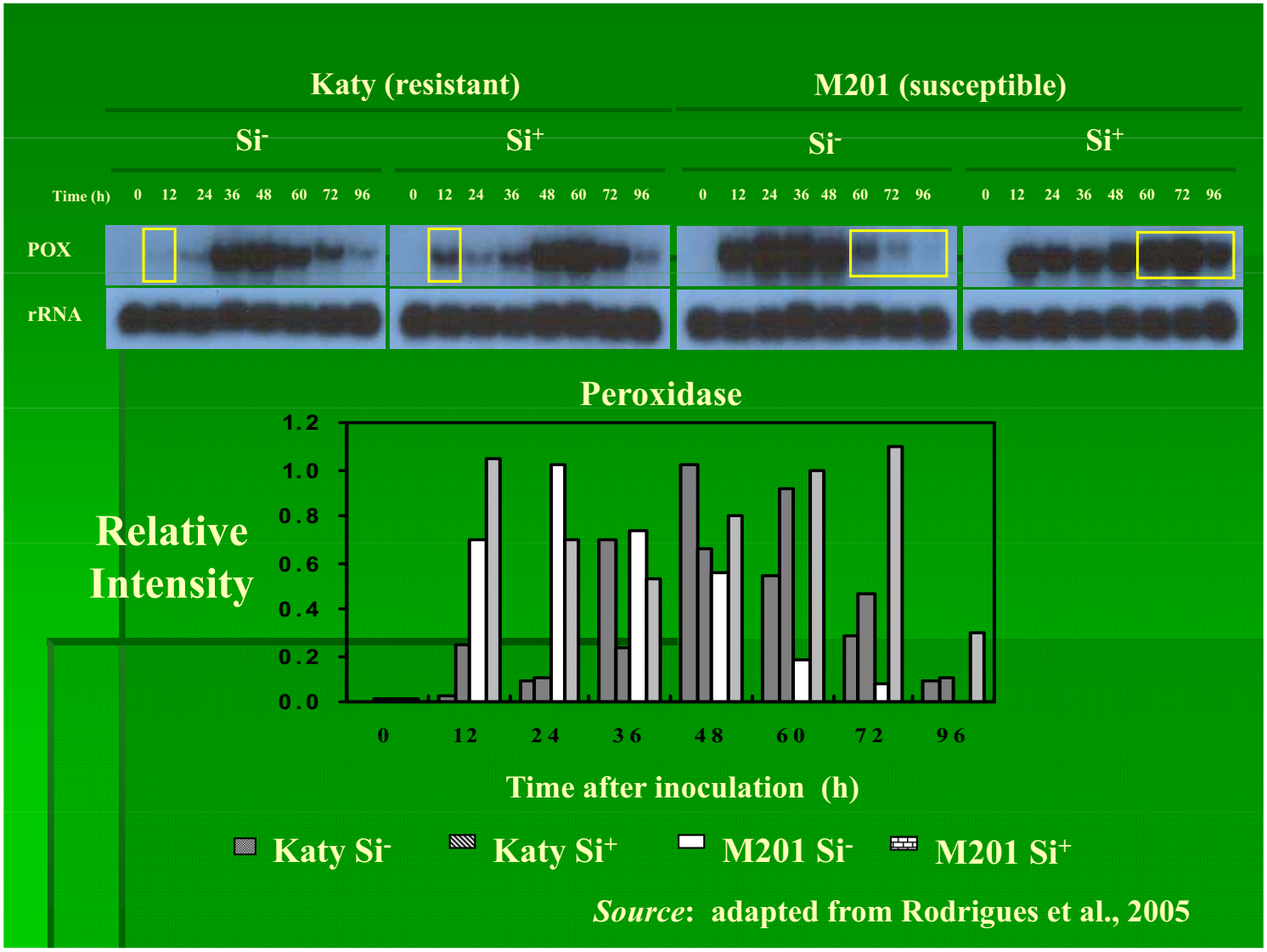
The mechanical barrier hypothesis

Cuticle-silica double layer (Yoshida et al., 1962)





Source: adapted from Rodrigues et al., 2005



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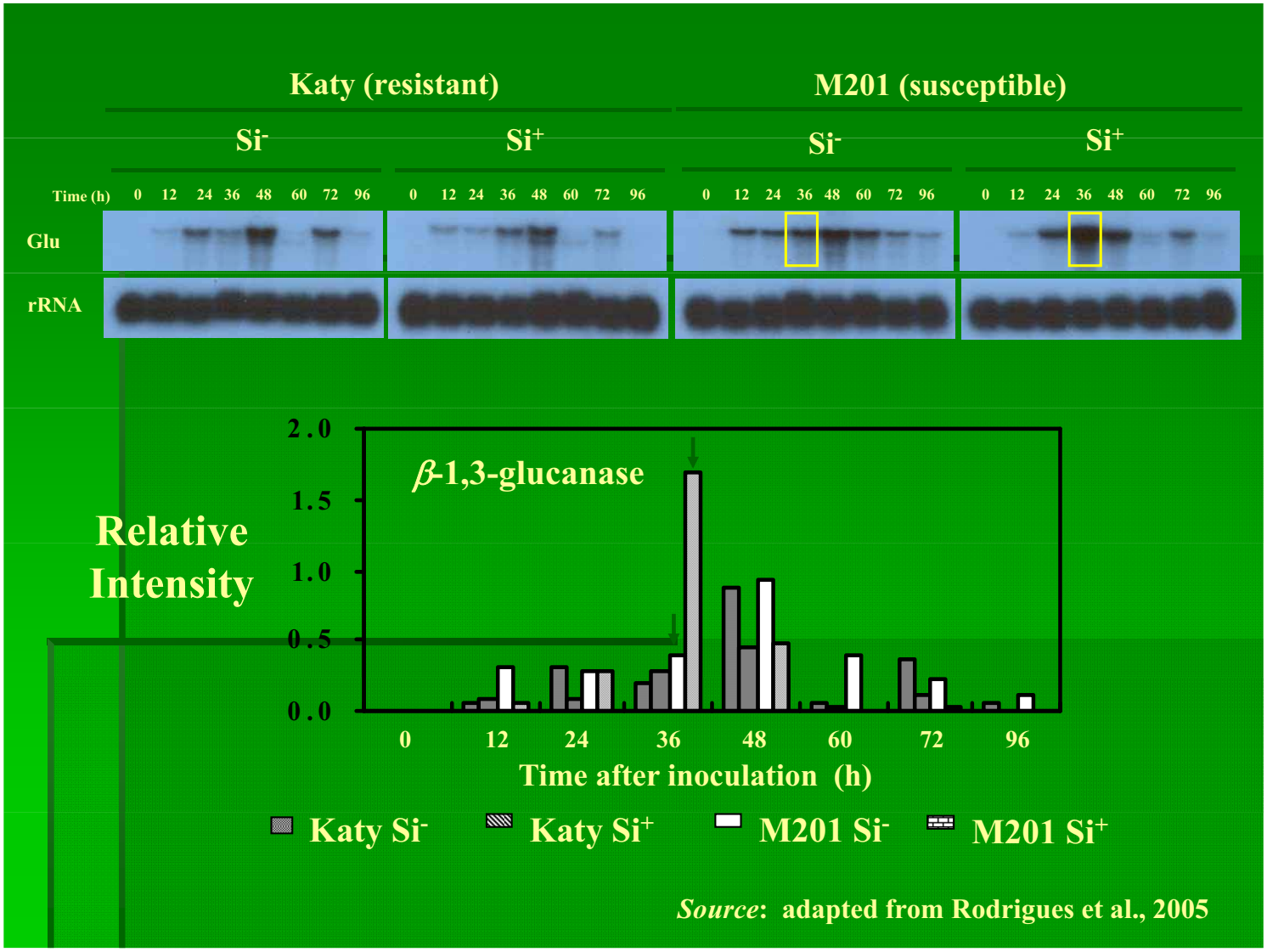
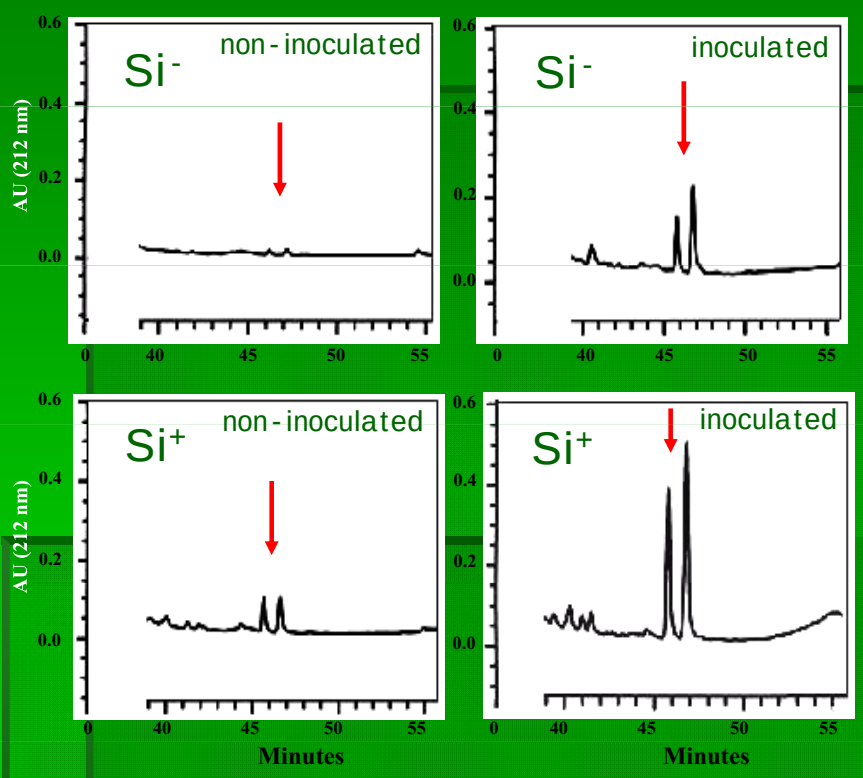
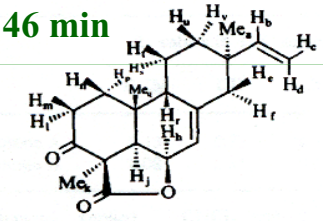


Source: adapted from Rodrigues et al., 2005

HPLC analysis of SF5 from FII of non-inoculated and inoculated plants amended or not with silicon



46 min



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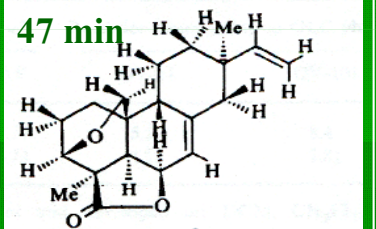
Momilactone A

47 min



2

Momilactone B

***Source*: adapted from Rodrigues et al., 2004**

Bioassay of the five FII sub-fractions against:

SF1 SF2 SF3 SF4 SF5

Si⁻ *M. grisea* +

Si⁺ *M. grisea* +

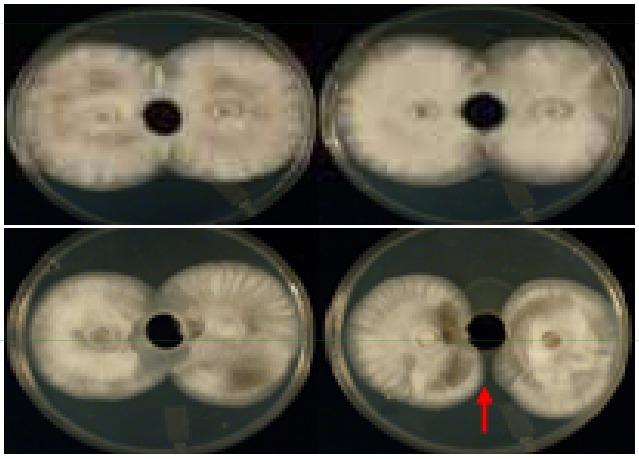
Cladosporium cucumerinum

and

Si⁻ Si⁺

M. grisea −

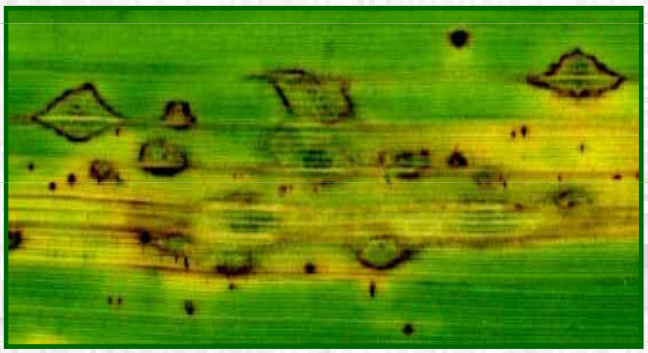
M. grisea +

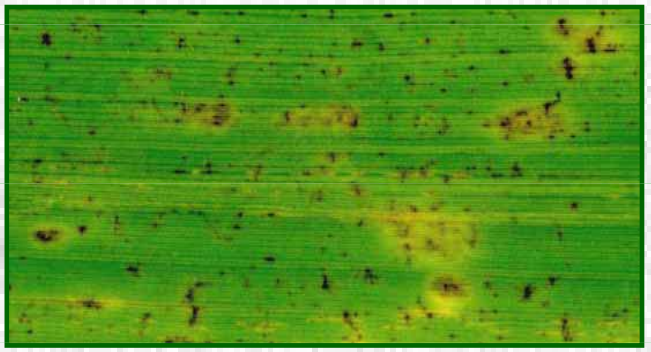


Magnaporthe grisea

Source: adapted from Rodrigues et al., 2004

Conclusion





momilactones

and

<u>High</u> level of blast severity

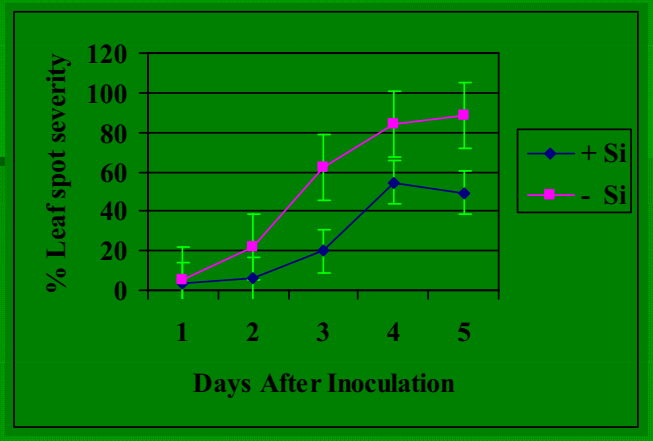
≠

momilactones

and

<u>Low</u> level of blast severity

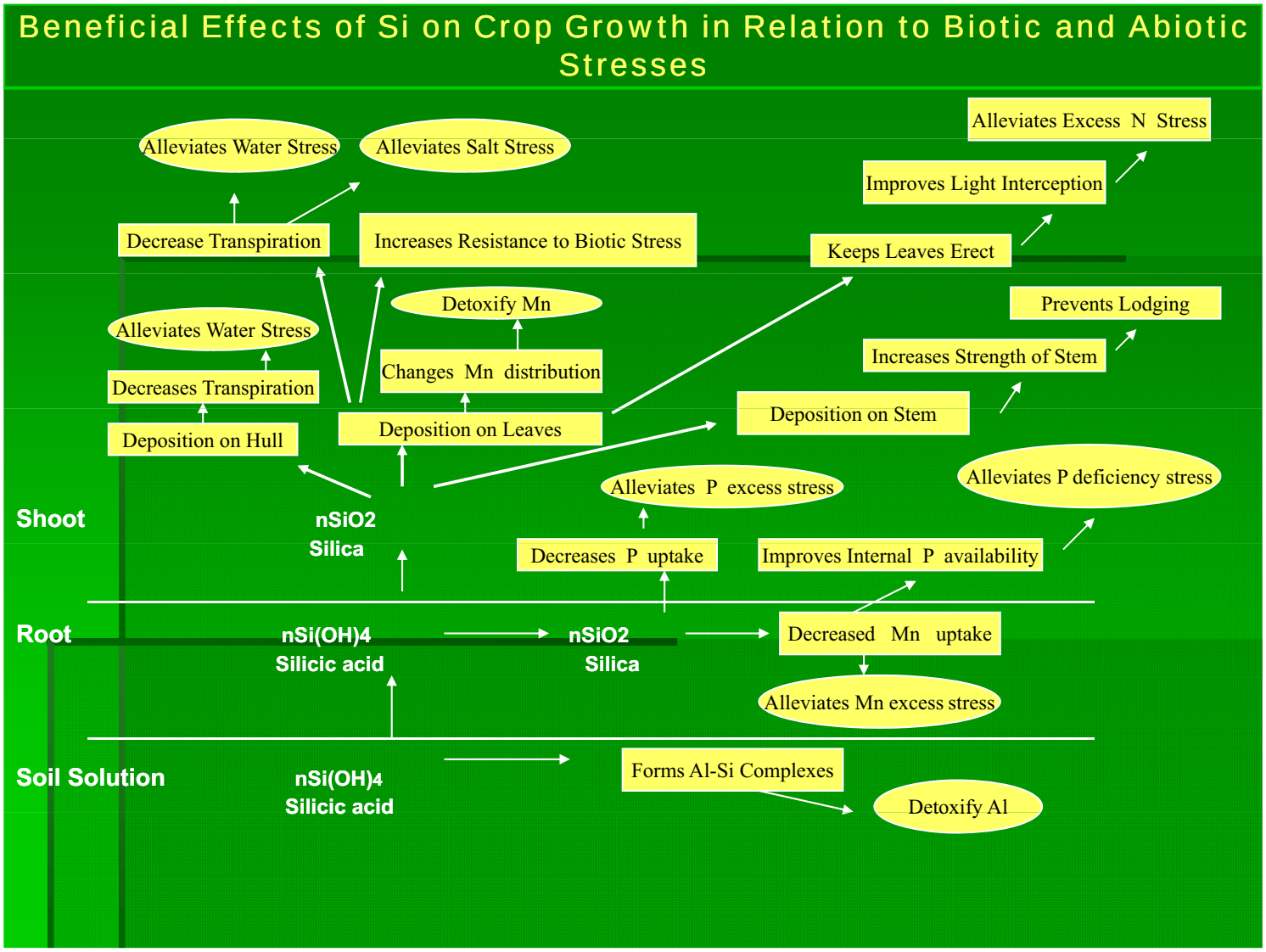
Influence of silicon on *Bipolaris* leaf spot in bermudagrass



Source: adapted from Datnoff and Rutherford, 2004

Conclusions

☞ In Si^+ plants of M201, a differential accumulation of transcripts from glucanase, peroxidase and PR-1 besides the participation of phenolics counteracted the spread of the invading fungus and the damage that it caused to the leaf tissues.


Beneficial Effects of Si on Crop Growth in Relation to Biotic and Abiotic Stresses
Alleviates Excess N Stress
Alleviates Water Stress
Alleviates Salt Stress
Improves Light Interception
Decrease Transpiration
Increases Resistance to Biotic Stress
Keeps Leaves Erect
Detoxify Mn
Prevents Lodging
Alleviates Water Stress
Increases Strength of Stem
Changes Mn distribution
Decreases Transpiration
Deposition on Stem
Deposition on Hull
Deposition on Leaves
Alleviates P excess stress
Alleviates P deficiency stress
Shoot
nSiO2
Silica
Decreases P uptake
Improves Internal P availability
Root
nSi(OH)4
Silicic acid
nSiO2
Silica
Decreased Mn uptake
Alleviates Mn excess stress
Soil Solution
nSi(OH)4
Silicic acid
Forms Al-Si Complexes
Detoxify Al

Introducing

EXCELL MINERALS

About Excell Minerals

- Privately held global corp. with new ownership since 2003.
- Headquartered in Pittsburgh, PA.
- Excell Minerals is a worldwide leading producer of products for the agricultural, metals, turf, and cement industries.

EXCELLERATOR

Excellerator Chemical Analysis:

- Silicon Supplement: 39.3%
- $CaMgSiO_4$ - 5.8%
- $Ca_3Mg(SiO_4)_2$ - 17.9%
- Ca_2MgSiO_7 - 8.0%
- Ca_2SiO_4 - 7.6%
- Micronutrient Package:
- Calcium (Ca) – 24%
- Iron (Fe) – 1.8%
- Copper (Cu) – 0.05%
- Boron (B) – 0.02%
- Magnesium (Mg) – 6%
- Manganese (Mn) – 0.7%
- Zinc (Zn) – 0.05%
- Molybdenum (Mo) - 0.004%

- Granular product
- SGN 100 and 200
- Readily soluble
- Silicon, Calcium, and Magnesium driven
- Higher in Silicon (39%) than any known competitor

What Makes EXCELLERATOR Unique?

- Excellerator's custom blend of nutrients enhances any turf fertility program.
- The high level of soluble silicon in Excellerator is its truly unique attribute.

EXCELLERATOR

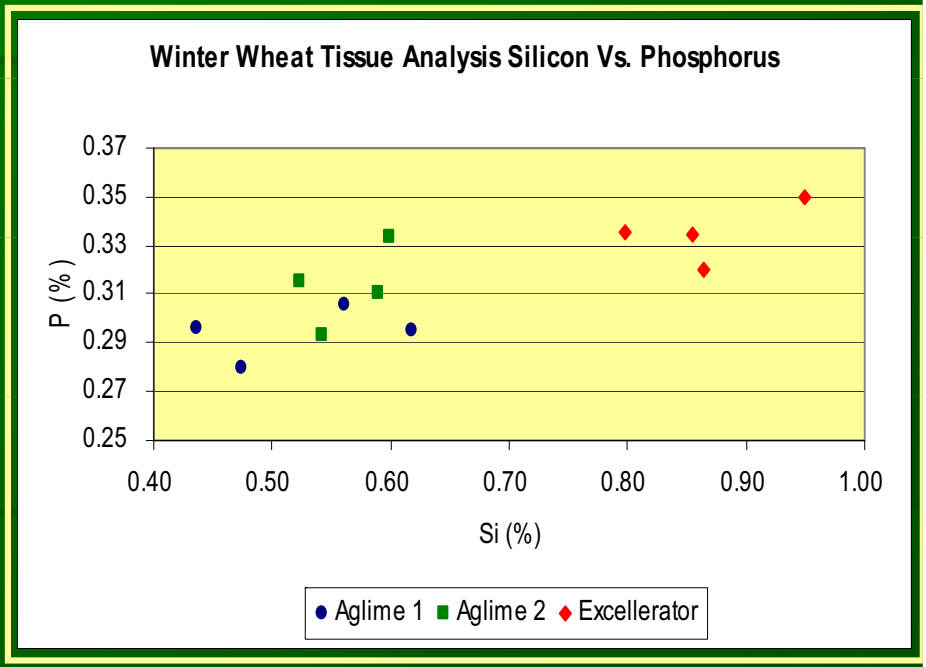
- Hydrolyzes in the soil to form mono and poly-salicic acids, which is the form the plant takes up
- Available in the soil for 12 months, although the majority is taken up in the first 6 months

Toxic Elements

- Mn uptake is not affected, but distribution is
  - Mn deposits can cause spotting on leaves
  - Si prevents this by distributing it throughout the plant
- Sodium toxicity reduced

Improved Nutrient Uptake

- Monosilicic acid concentrations in some soils have been associated with a 10-80% increase in available P and increased plant P uptake and yield.
- Reduces phosphorus run off in sandy soils.
- Improves CEC



Effect of Silicon Fertilizer on the Root Zone

Dr. V. Matichenkov—University of Florida Rice And Citrus Studies

Protection Against Temperature Extremes

Photograph of creeping bentgrass exposed to high temperature. Plants had been grown for 55 days at 20 °C , and then exposed to a temperature of 35 -40 °C under constant light and humidity for 20 days. The growth of creeping bentgrass applied silicon sources was similar. However, most of the control plants grown 35 °C above had died by day 20.

***Source*: adapted from Lijun, et. al. 2004.**

Application Recommendations

- Soil testing should be done
- Standard rates: Initial application of 25lb/M on greens tees, fairways and sports turf.
- Follow with 10 lbs. topdressing 30 days apart to achieve 50lb/M per year


Marketing EXCELLERATOR

EXCELLERATOR Added Selling Points

- Disease resistance
- Reduced chemical applications?
- Reduced water needs
- Increased wear tolerance
- Saves labor in other areas

Marketing *EXCELLERATOR*

- Excellerator is 39.3% soluble Silicon
- Competition is much lower in silicon content (33%)
- Breaks down easier than competitor
- Available in 50 lb bags and 1000# bulk bags
- Increases nutrient availability while cutting other fertilizer costs

Research

The evaluation of Silicon has been ongoing for the past 30 years.

- Dr. G. Korndörfer, University of Uberlandia, Brazil working on wet-land rice in Florida concluded:
  - In 19 out of 28 field experiments silica had a positive effect on yield.
  - Considering only sites with Si response, average increased yield was 1007 Kg/ha (932 lbs/A)

- Dr. Emanuel Epstein, University of California (Davis) has published extensively on silica and plant health and has verified that silicon absorbed by plants:
  - Is deposited in and strengthens cell walls
  - Results in plants being more resistant to insect attack, disease, and lodging
  - Increases yields

- Dr. J Chen- University of Florida
- Dr. James Menzies- University of Laval, CA
- Dr. Lawrence Datnoff- University of Florida
- Dr. Wakar Uddin- Penn State University

Questions?