Relaciones entre la nutrición y las defensas vegetales

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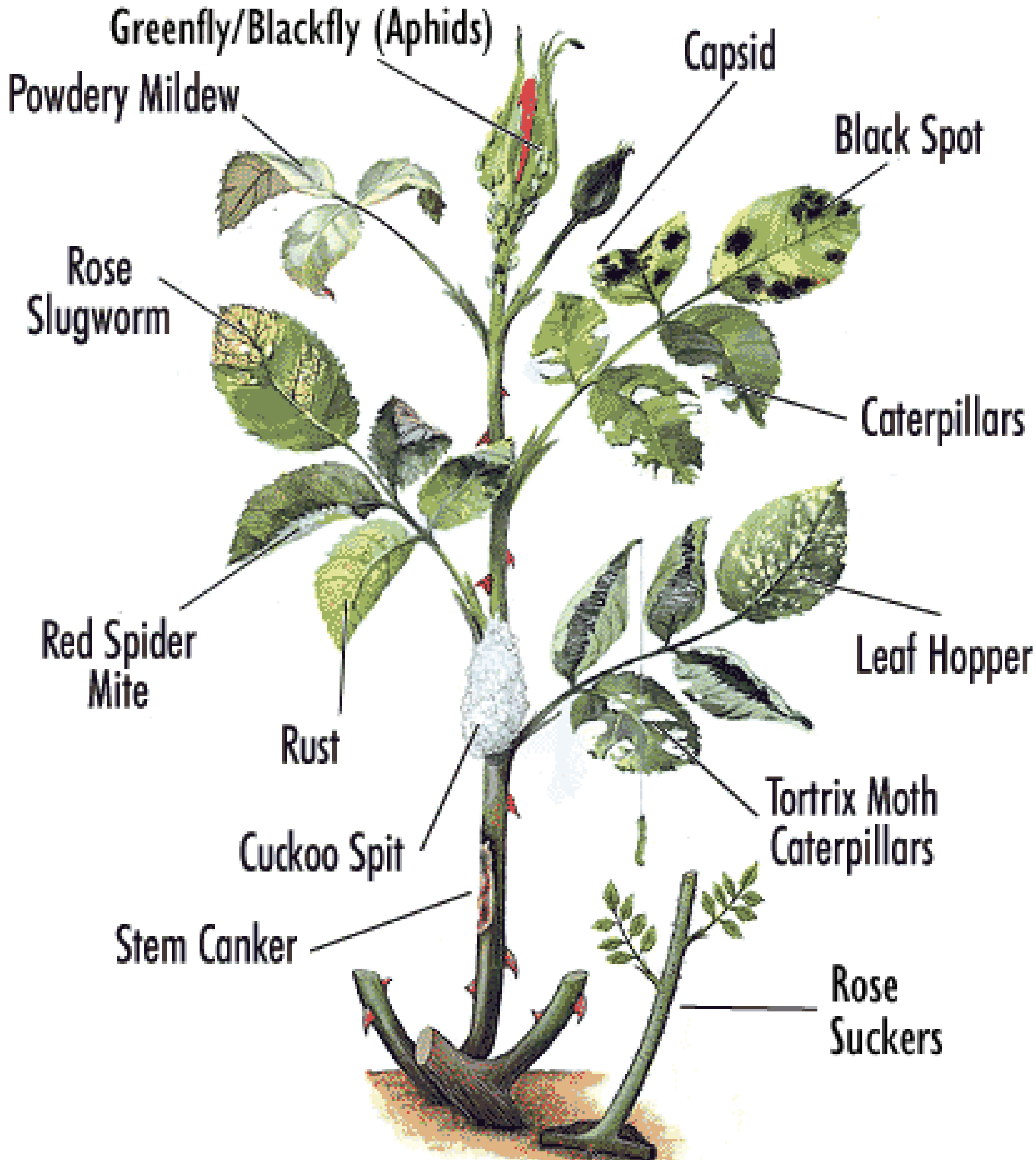
Universidad San Francisco de Quito

Research Stations USFQ

Universidad San Francisco de Quito

Pillars of Food Security

55 a 60% del costo del tallo es MO


Greenfly/Blackfly (Aphids)
Capsid
Powdery Mildew
Black Spot
Rose Slugworm
Caterpillars
Red Spider Mite
Rust
Leaf Hopper
Tortrix Moth Caterpillars
Cuckoo Spit
Stem Canker
Rose Suckers

Medidas para el control de enfermedades

Medidas a largo plazo

Laborares Culturales
Rotación de cultivo, mejoramiento de la calidad del suelo, seleccionar variedades resistentes, manejo del agua, monitoreo constante, barreras mecánicas, tratamiento postcosecha.

Manejo del ambiente
Ventilación dentro del invernadero, manejo de la humedad relativa, manejo de la temperatura.

Control Biológico
Introducción de organismos benéficos y antagónicos al patógeno.

Bio pesticidas o inductores de resistencia
Extractos de plantas, productos naturales, moléculas inductoras de resistencia.

Pesticidas Sintéticos
Myclobutanil , penconazole, hexaconazole,.....etc

Medidas a corto plazo


200 application per year
Boq

Impacto de pesticidas en los alimentos, organismos fitopatógenos y microorganismos benéficos en el Ecuador.

Sofía Curillo*[1], Susana Araujo[1], Gabriela Cueva[1], Antonio Leon-Reyes[1], Raúl de la Torre[1]*

[1] *Universidad San Francisco de Quito, Colegio de Ciencia e Ingeniería. Diego de Robles y Vía Interoceánica, Quito, Ecuador.*

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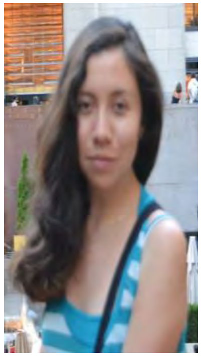
Resumen

El presente trabajo ilustra tres consecuencias derivadas del uso de plaguicidas para la protección de los cultivos en la agricultura convencional. El primer estudio sobre contaminantes peligrosos en los alimentos permite demostrar la presencia de residuos de insecticidas químicos: piretroides, carbamatos y organofosforados en alimentos de consumo diario (papa, tomate, frutilla). Se analizaron por separado pulpa y cáscara de cada alimento mediante el método ELISA de competencia y se encontró que todas las muestras analizadas contenían residuos de los pesticidas. En el segundo estudio se investigó el efecto de los fungicidas Carbedazin e Iprodione sobre el hongo fitopatógeno *Botrytis cinera* sometido a pruebas de sensibilidad a los dos fungicidas en diferentes dosis (0.1, 0.6, 0.01, 1 g/L); como resultado, la cepa de *Botrytis cinera* aislada exhibió pérdida de sensibilidad ante los fungicidas, evidenciando con ello el desarrollo de resistencia a los mismos. Finalmente, se evaluó el efecto de dos fungicidas de uso común, Carbedazin e Iprodione, en dosis de 1 ppm y 1000 ppm y de 100 ppm y 2000 ppm, respectivamente, sobre el organismo benéfico

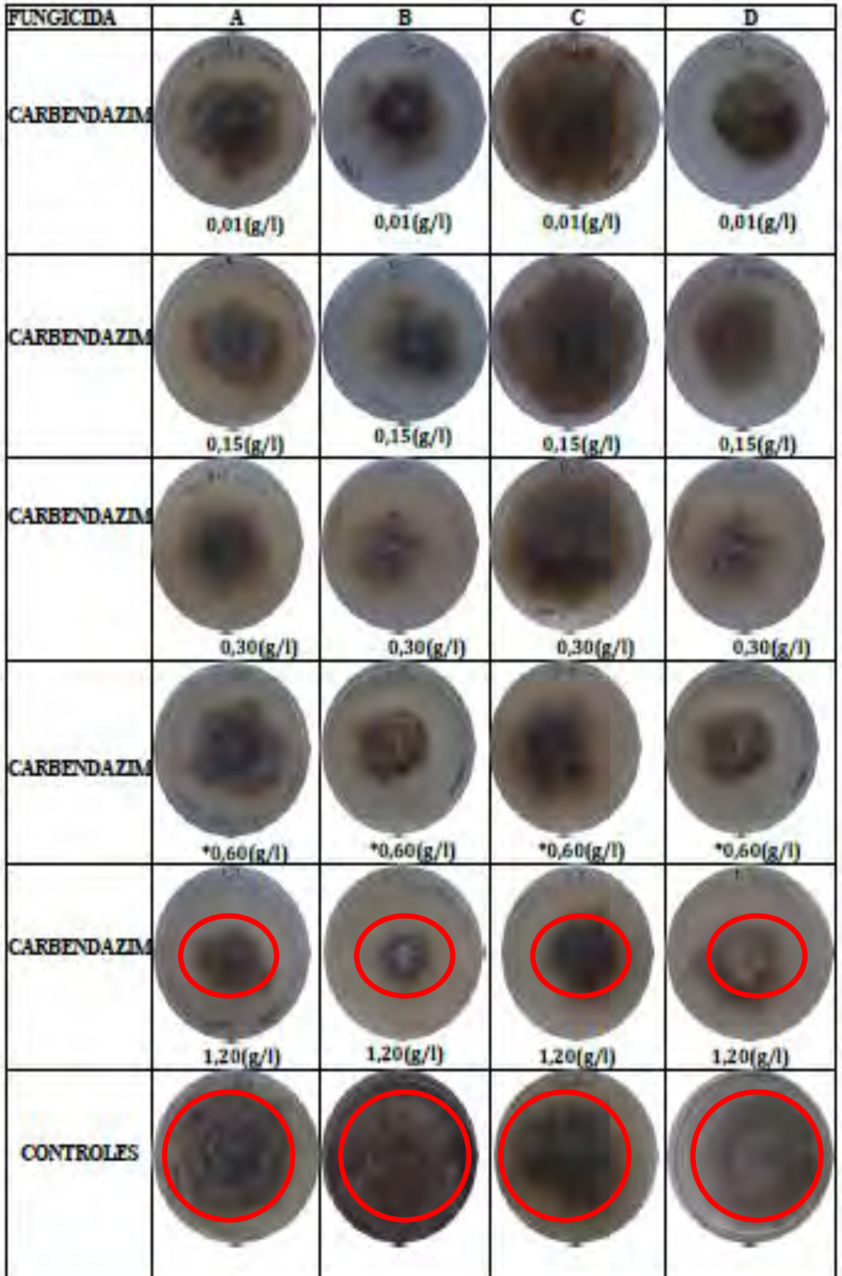
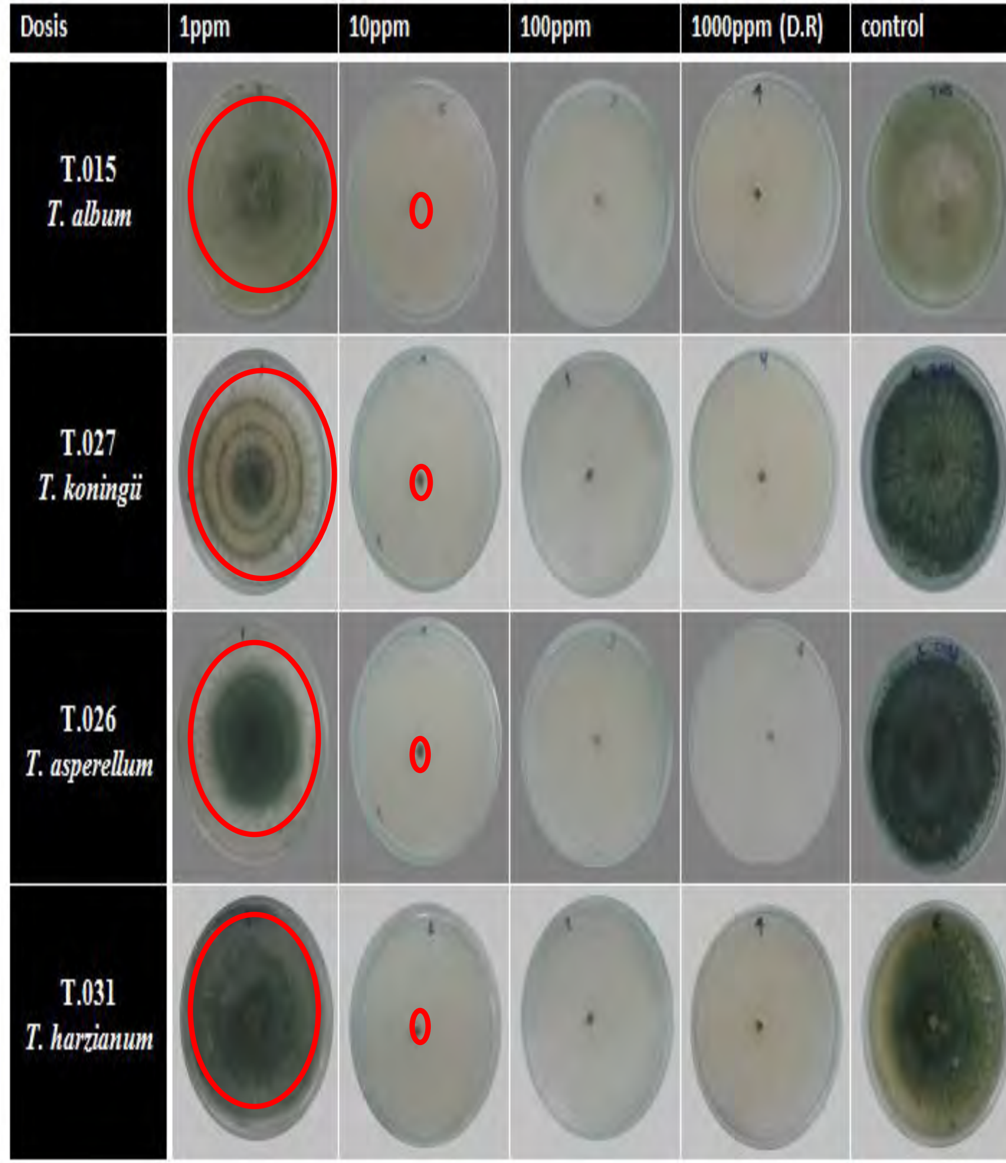



Figura 3.26. Cepas de *B. fuckeliana* expuestas a cinco dosis de Carbendazim (*Dosis recomendada) (Cueva, 2014).

Efecto de Carbendazim en *Botrytis* y *Trichoderma*



Only *Botrytis cinerea*?

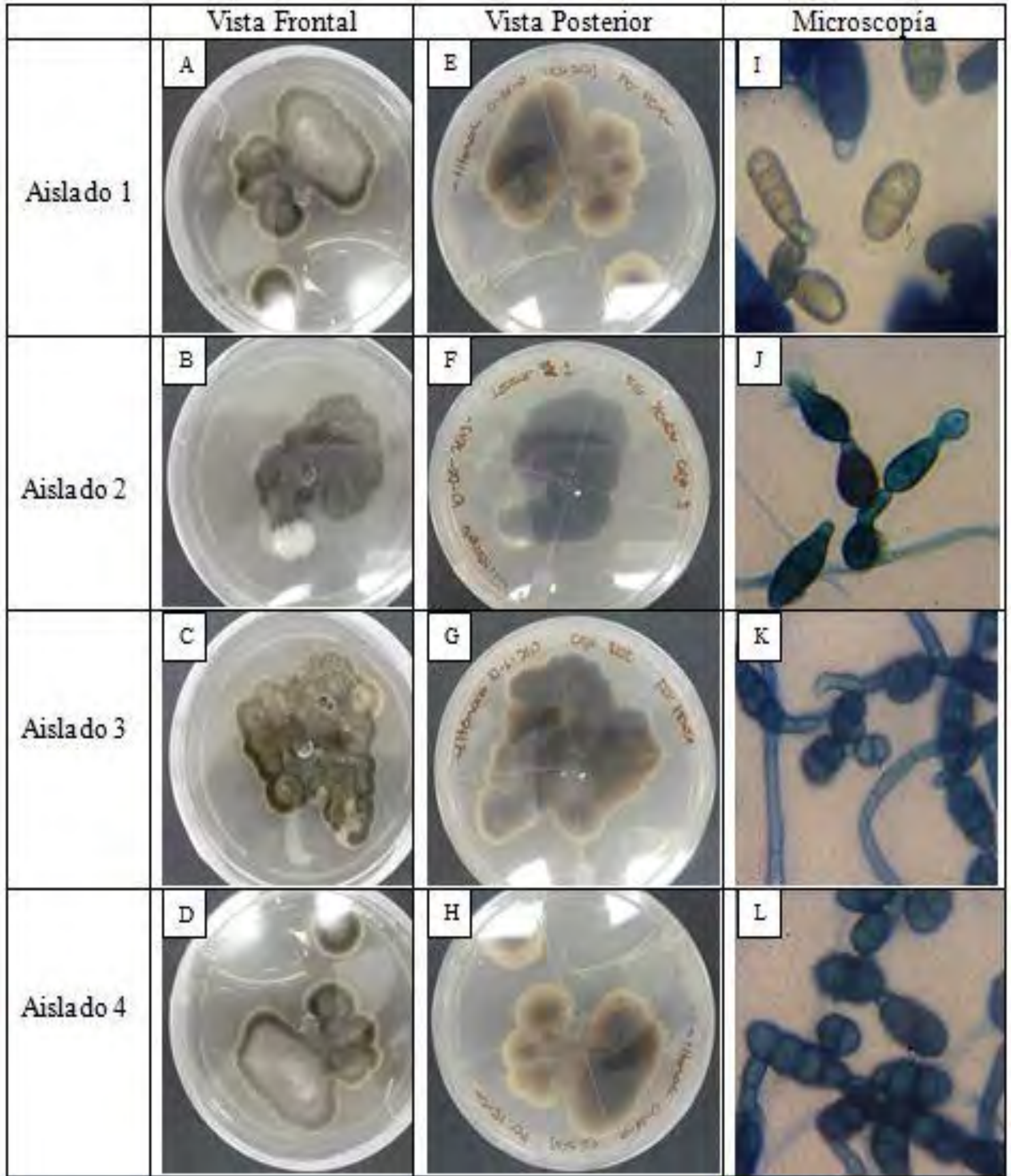


Figura 1: Cultivo de los 4 aislados de Alternaria spp en medio PDA y observación microscópica de las esporas

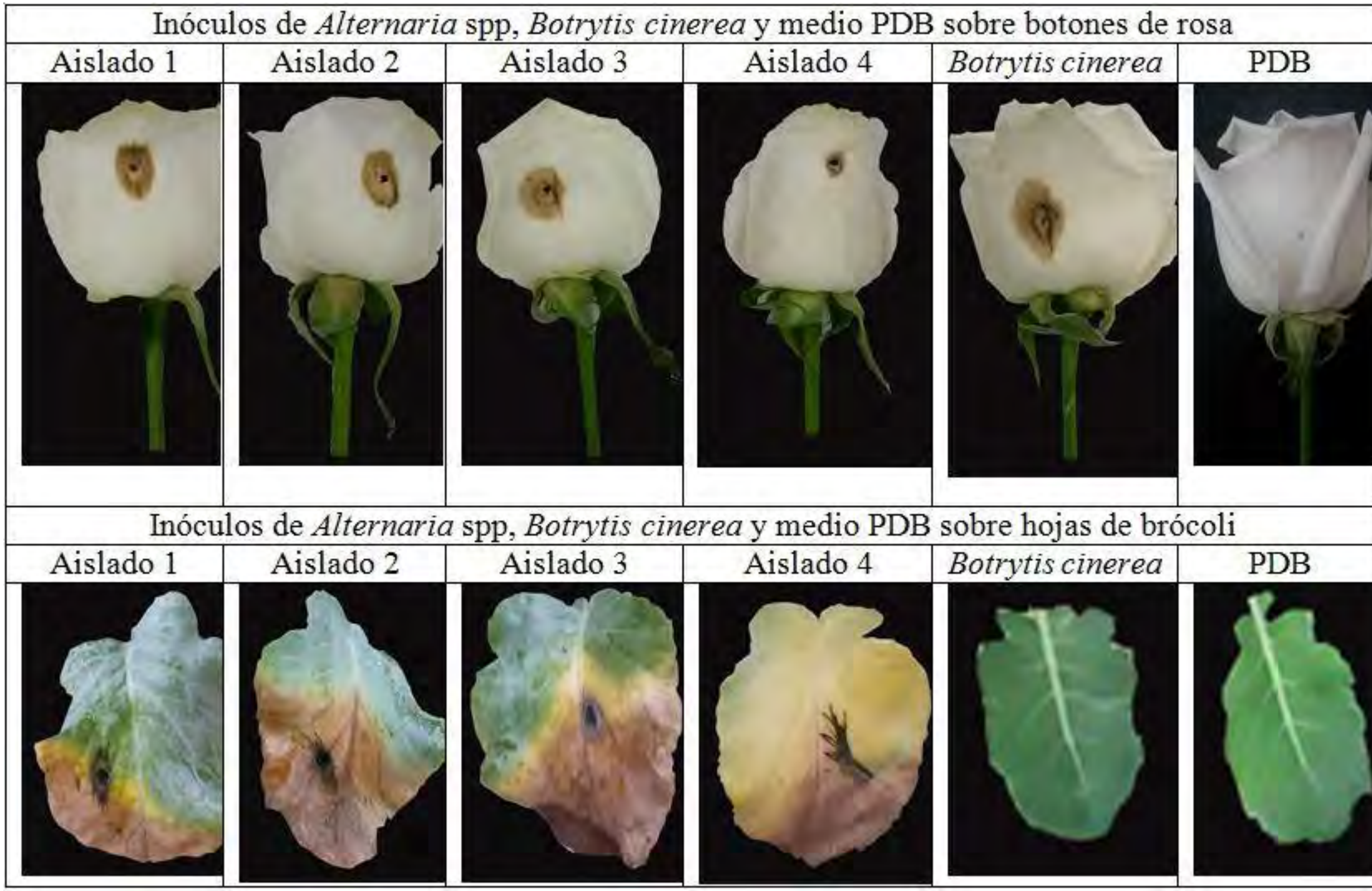
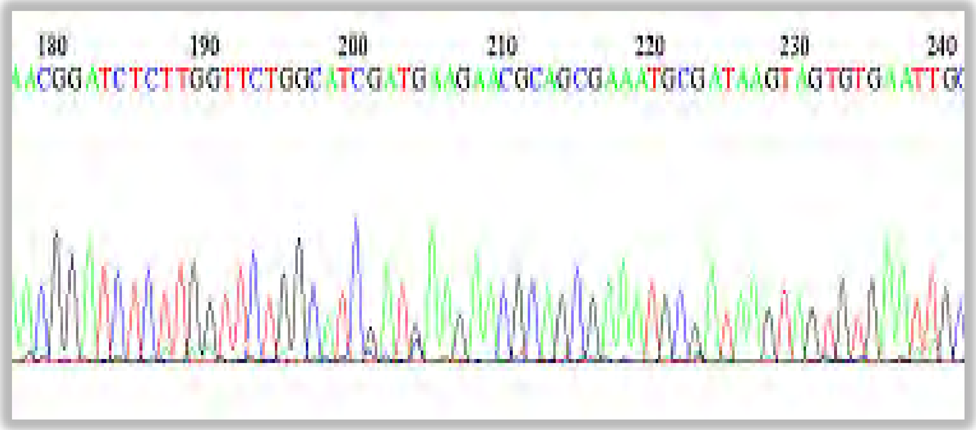
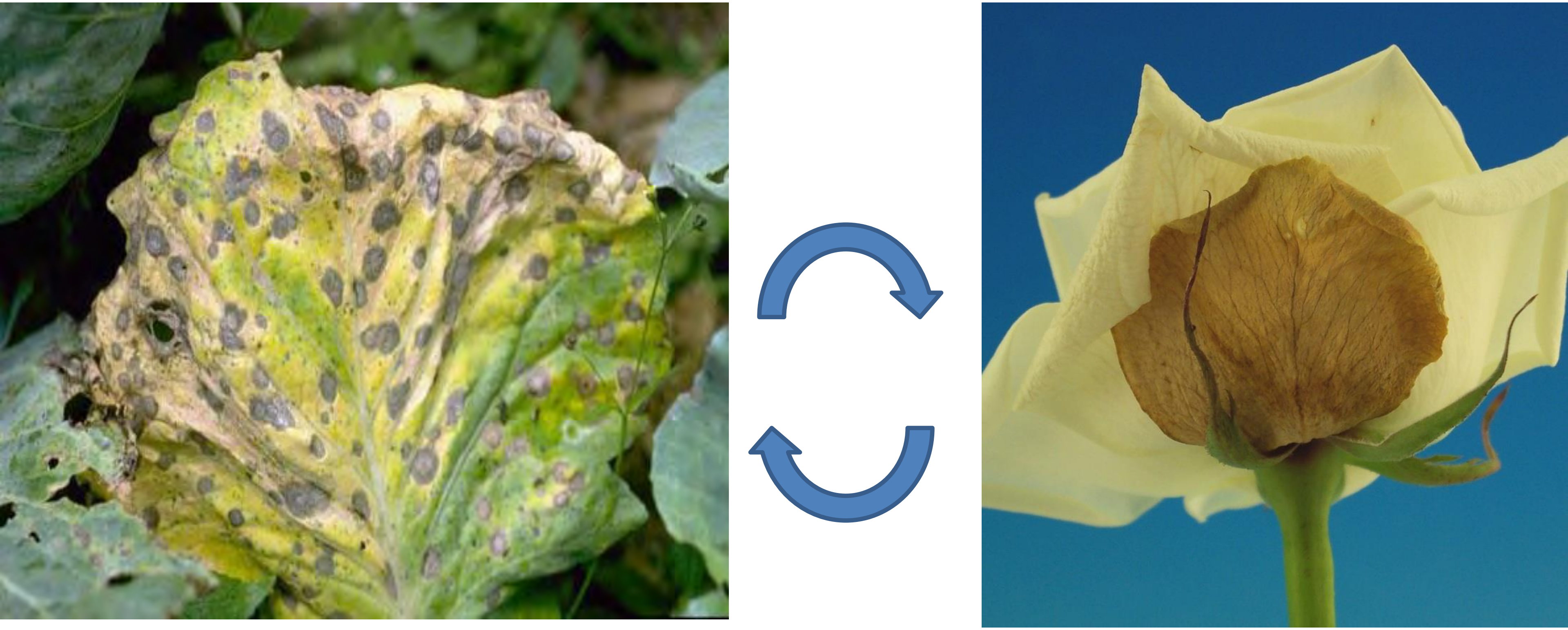


Figura 2: Comparación entre los bioensayos de patogenicidad *de Alternaria* spp. sobre botones de rosa y hojas de brócoli, además del control *Botrytis cinerea* y medio PDB

BLAST RESULTS



Aislado	Región Amplificada	Resultado del Secuenciamiento	Max SCORE	Total Score	Query Cover	E-value	Ident	Accesion
Aislado 1	Región ITS1 e ITS4	Alternaria japonica	623	623	100%	1,00E-174	98%	AY154703.1
Aislado 2	Región ITS1 e ITS4	Alternaria japonica	623	1014	98%	0.0	99%	AY154703.1
Aislado 3	Región ITS1 e ITS4	Alternaria alternata	584	682	97%	0.0	99%	KU645989.1
Aislado 4	Región ITS1 e ITS4	Alternaria alternata	623	623	94%	1,00E-174	99%	KU645989.1



Alternaria japonica, Alternaria alternata

P16 Análisis de residuos de plaguicidas químicos en alimentos de consumo humano con la metodología de laboratorio ELISA

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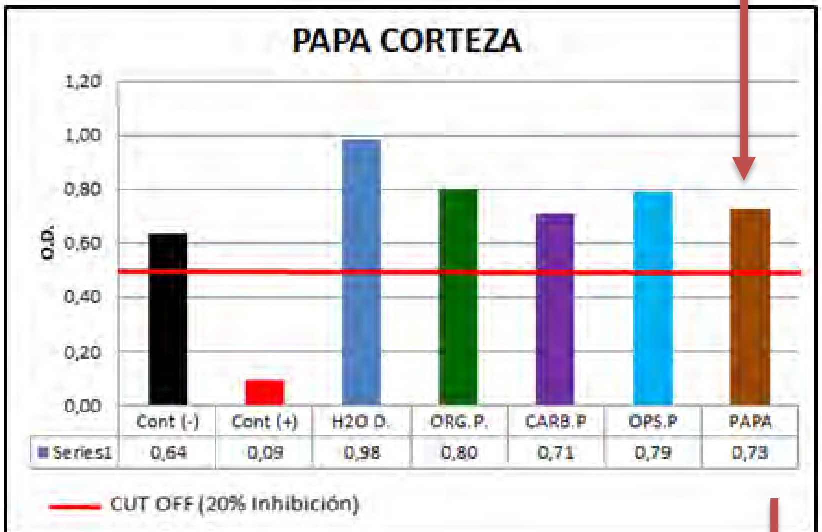
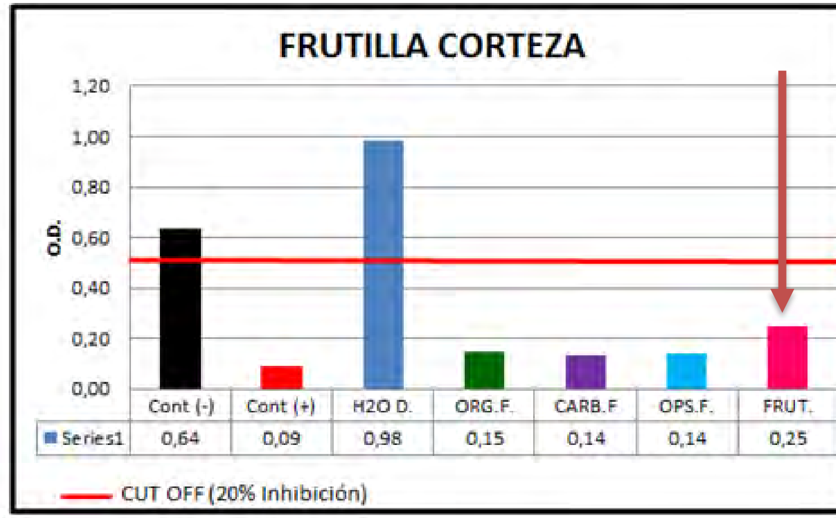
[1]*Universidad San Francisco de Quito, Ingeniería de Agroempresas. Diego de Robles y Vía Interoceánica, Quito, Ecuador.*

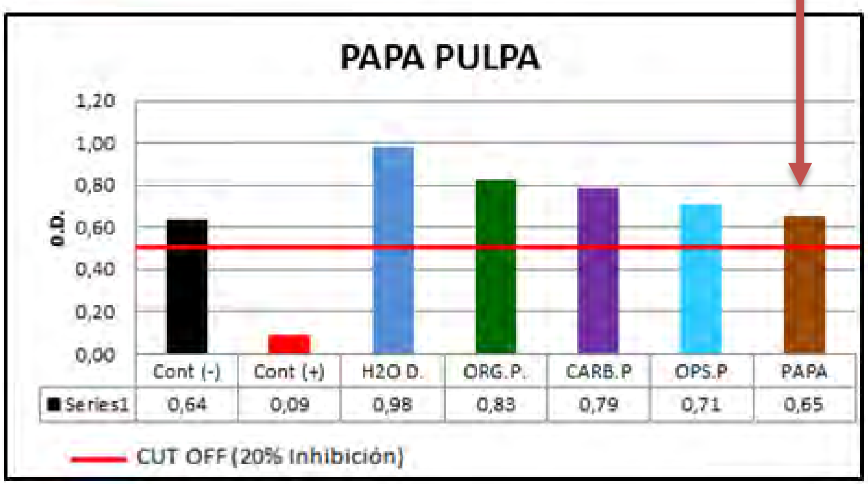
**Autor principal / Corresponding author, e-mail: sofiacurillo@gmail.com*

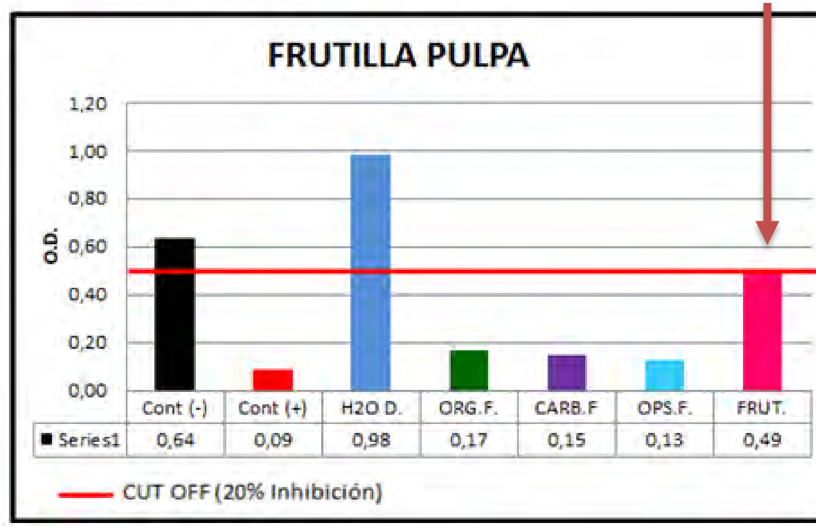
Determinación de Carbamatos y Organofosforados mediante ELISA de competencia

100% en muestras de supermercados









USDA

United States Department of Agriculture

Agricultural Marketing Service

Science and Technology Program

Pesticide Data Program

Annual Summary, Calendar Year 2015

Visit the program website at: www.ams.usda.gov/pdp

November 2016

Commodity / Pesticide	Pest. Type	% of Samples with Detections	Number of Samples Analyzed	Number of Samples with Detections	Range of Detections, ppm	Mean of Detections, ppm	EPA Tolerance, ppm
Strawberries (38 pesticides)							
Acequinocyl	A	16.7	532	89	0.010 - 3.7	0.337	0.50
Acetamiprid *	I	31.4	706	222	0.001 - 0.80	0.061	0.60
Azoxystrobin	F	10.8	706	76	0.001 - 0.57	0.058	10.0
Bifenazate	A	23.9	706	169	0.003 - 1.2	0.125	1.5
Bifenthrin *	I	28.6	706	202	0.003 - 0.30	0.06	3.0
Boscalid	F	48.3	706	341	0.003 - 0.99	0.096	4.5
Carbendazim (MBC) [1]	F	16.9	706	119	0.001 - 0.42	0.059	7.0
Chlorantraniliprole	I	13.2	706	93	0.006 - 0.16	0.033	1.0
Cyflufenamid	F	8.1	706	57	0.002 - 0.080	0.016	0.20
Cyflumetofen	A	6.9	706	49	0.006 - 0.39	0.078	0.60
Cyprodinil	F	49.6	706	350	0.003 - 1.7	0.157	5.0

¿Cual es el impacto de los agroquímicos en la defensa vegetal?

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Glyphosate effects on diseases of plants

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ABSTRACT

Glyphosate, N-(phosphonomethyl)glycine, is the most extensively used herbicide in the history of agriculture. Weed management programs in glyphosate resistant (GR) field crops have provided highly effective weed control, simplified management decisions, and given cleaner harvested products. However, this relatively simple, broad-spectrum, systemic herbicide can have extensive unintended effects on nutrient efficiency and disease severity, thereby threatening its agricultural sustainability. A significant increase in disease severity associated with the wide spread application of the glyphosate herbicide can be the result of direct glyphosate-induced weakening of plant defenses and increased pathogen population and virulence. Indirect effects of glyphosate on disease predisposition result from immobilization of specific micronutrients involved in disease resistance, reduced growth and vigor of the plant from accumulation of glyphosate in meristematic root, shoot, and reproductive tissues, altered physiological efficiency, or modification of the soil microflora affecting the availability of nutrients involved in physiological disease resistance. Strategies to ameliorate the predisposing effects of glyphosate on disease include judicious selection of herbicide application rates, micronutrient amendment, glyphosate detoxification in meristematic tissues and soil, changes in cultural practices to enhance micronutrient availability for plant uptake, and biological amendment with glyphosate-resistant microbes for nitrogen fixation and nutrient

Fig. 4. Fate of glyphosate-treated (10 μg plant^{-1}) bean plants grown in (A) vermiculite and (B) field soil 20 days after glyphosate treatment, and (C) non-glyphosate treated control plants. Glyphosate treated plants in field soil (B) collapsed 10 days after glyphosate treatment from *Pythium* infection.

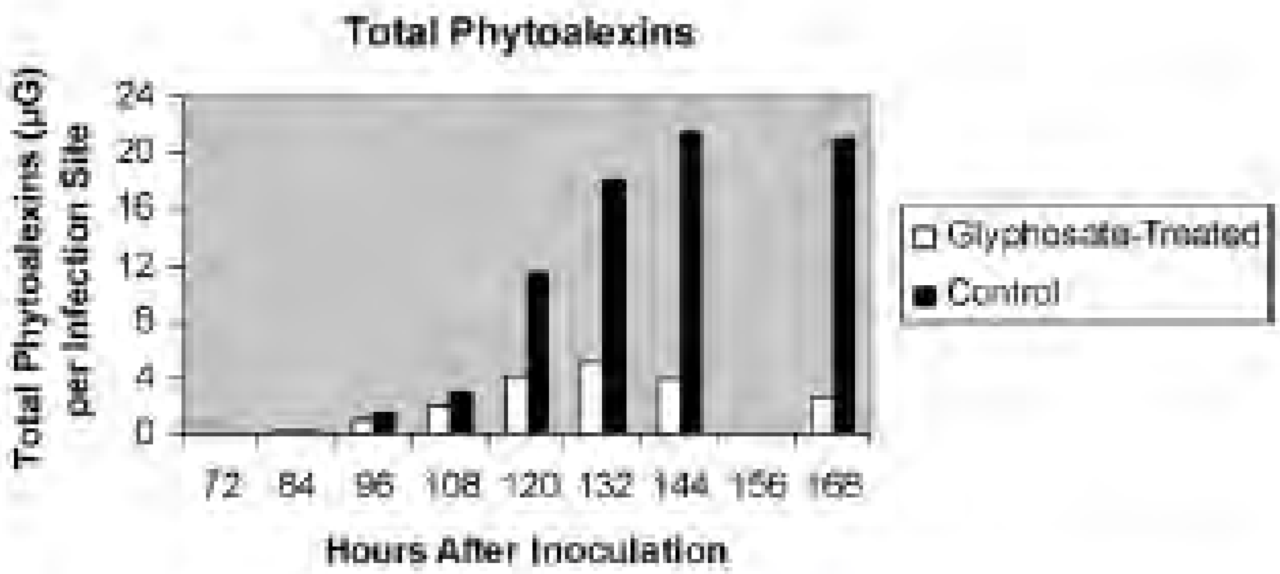
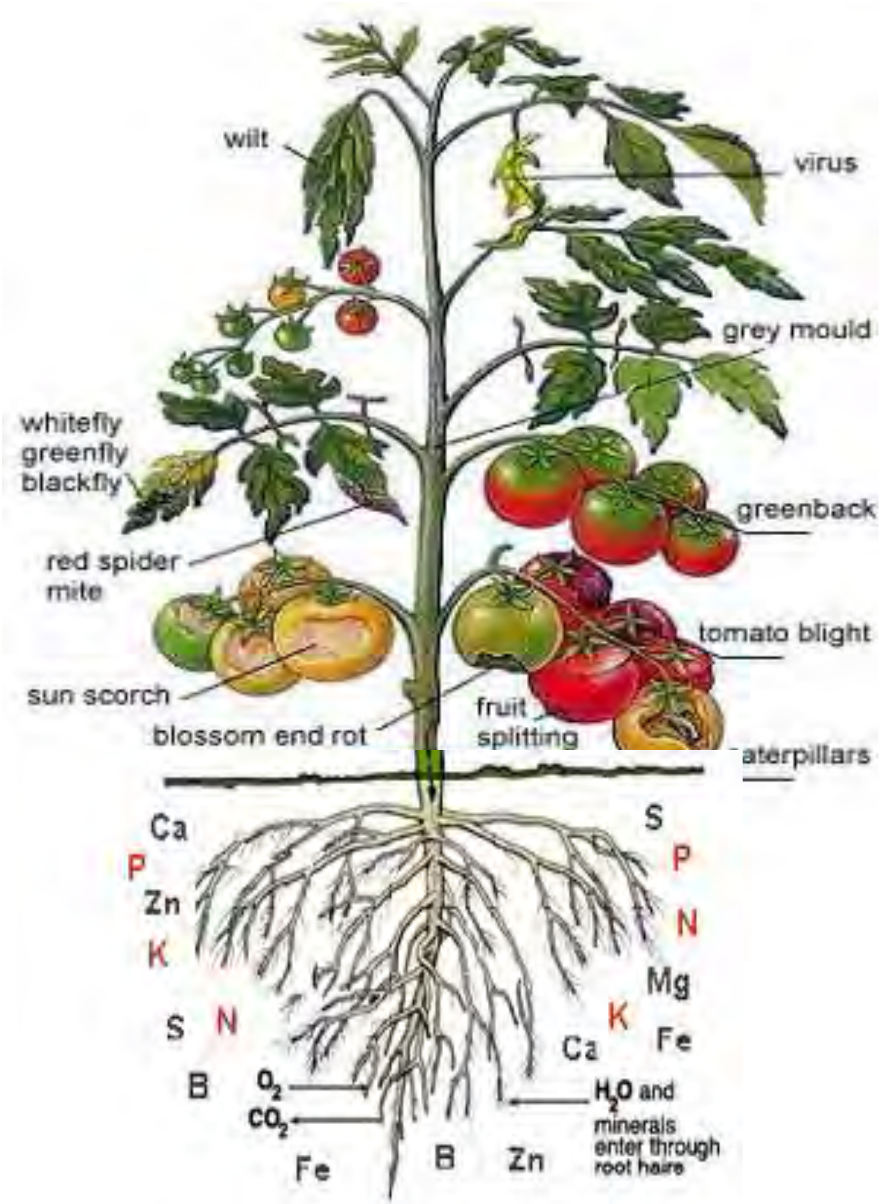


Fig. 7. Glyphosate suppression of phytoalexins in compatible bean anthracnose lesions by 10 µg glyphosate (after Johal and Rahe, 1990).

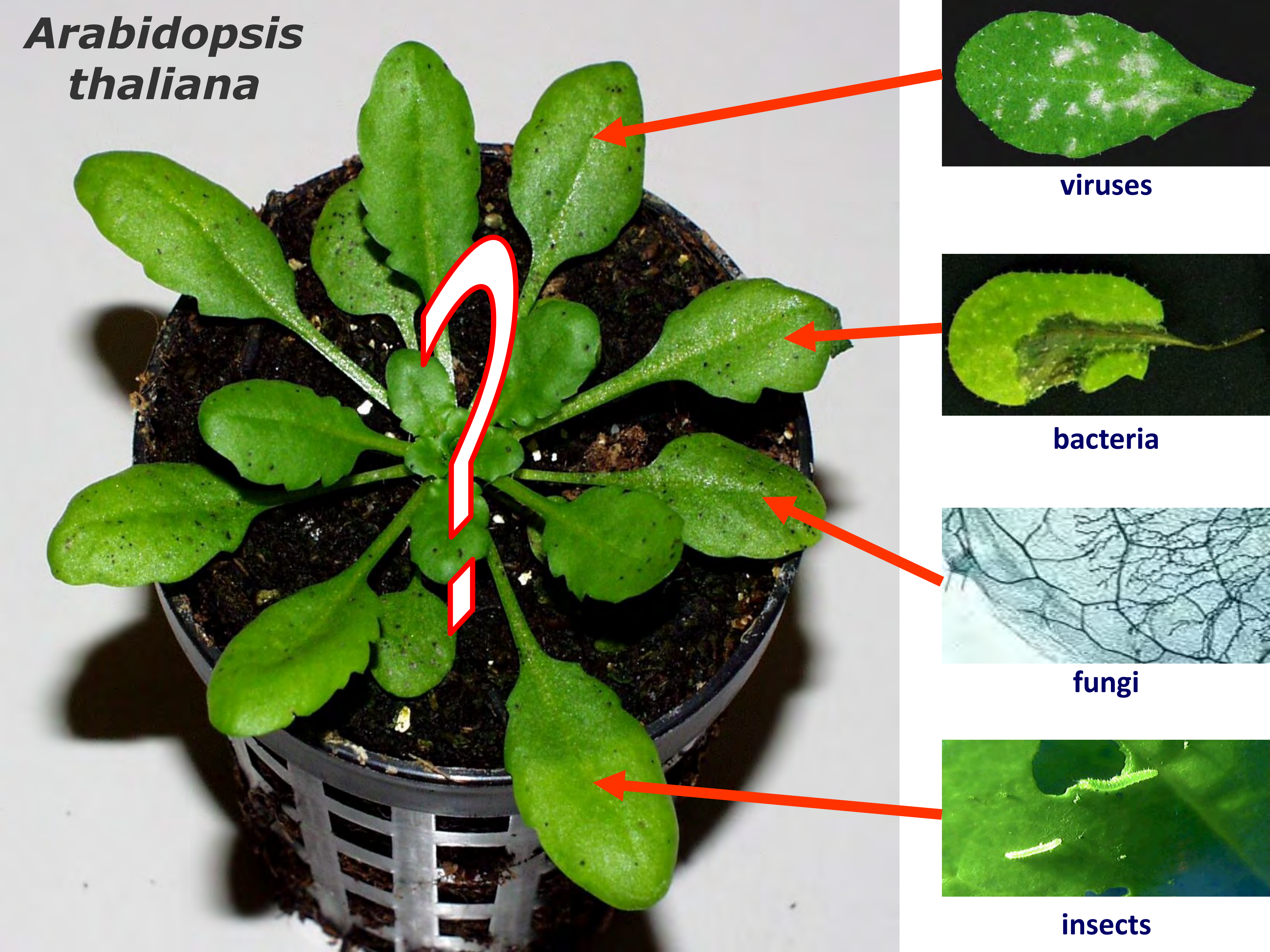
Is there a link between essential nutrients and induction of defense response?

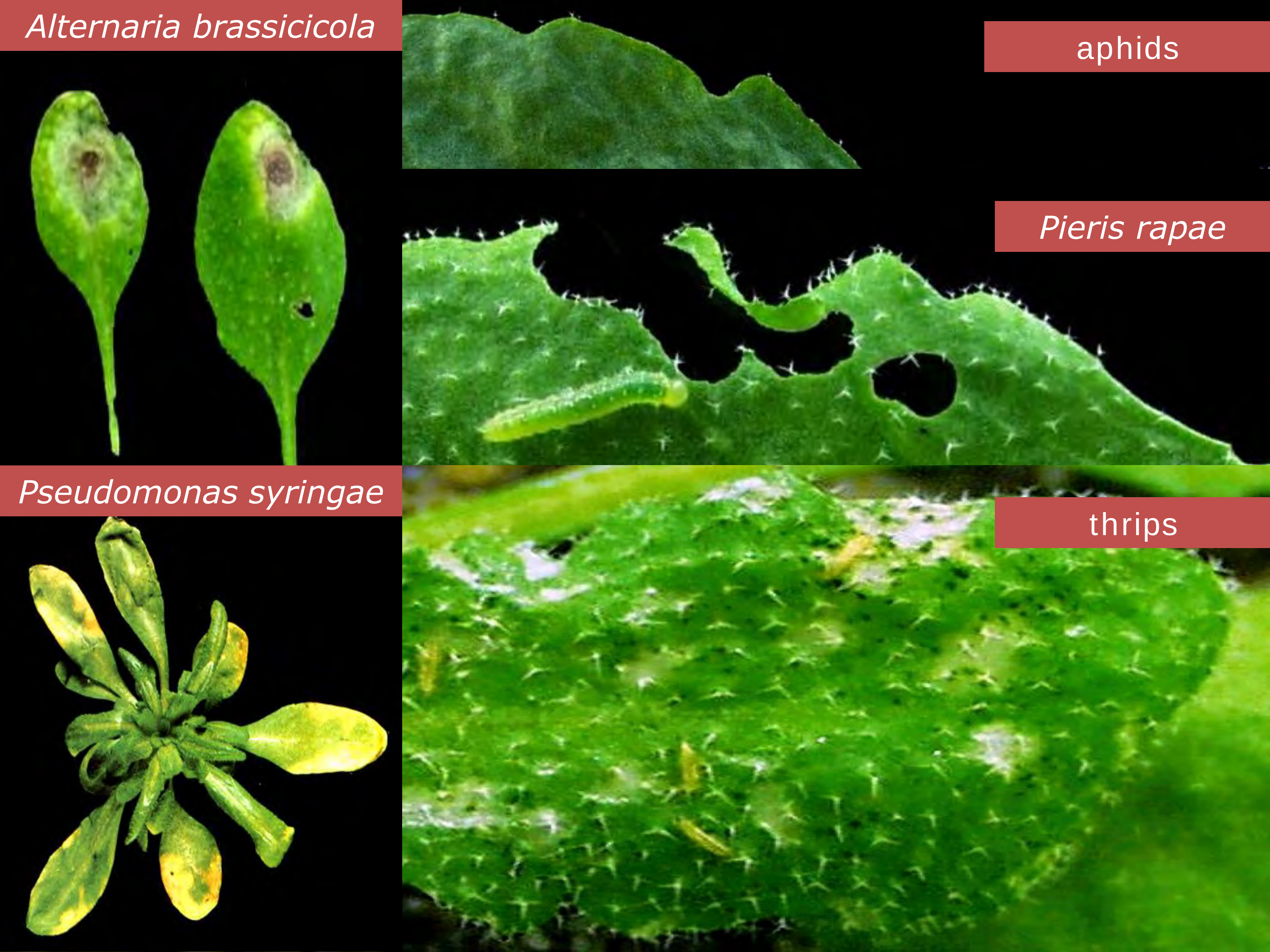


Podemos reducir las enfermedades con la nutrición?

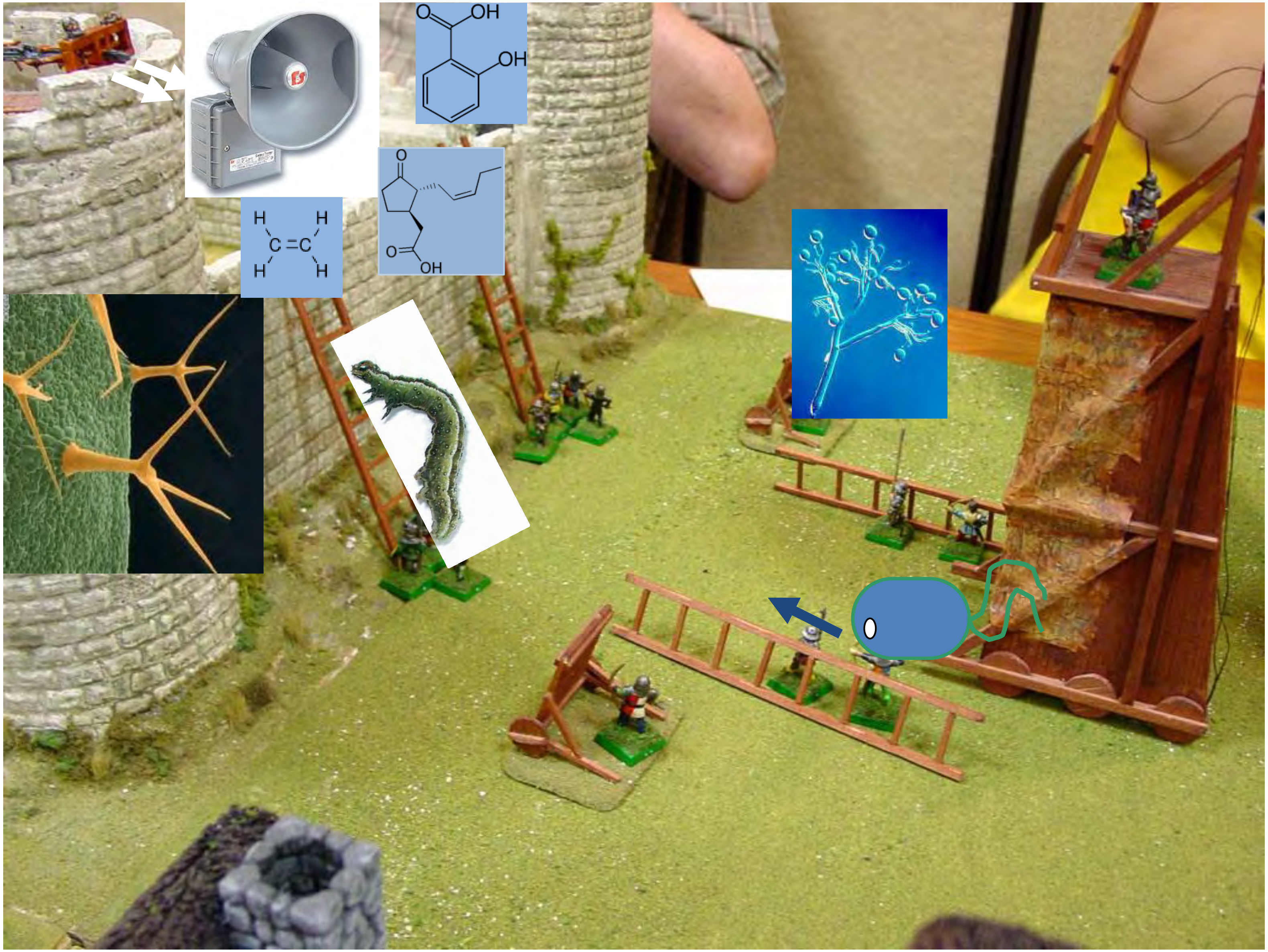
Que elementos son importantes para este efecto?

- Generations 6-8/year
- Mutant analysis
- Easy transfomation
- Fully sequenced genom
- Knock-out mutants
- Full-genome GeneChips


Arabidopsis thaliana
viruses
bacteria
fungi
insects


Alternaria brassicicola
aphids
Pieris rapae
Pseudomonas syringae
thrips

Constitutive and induced defenses



Vol 444|16 November 2006|doi:10.1038/nature05286 nature

REVIEWS

The plant immune system

Jonathan D. G. Jones[1] & Jeffery L. Dangl[2]

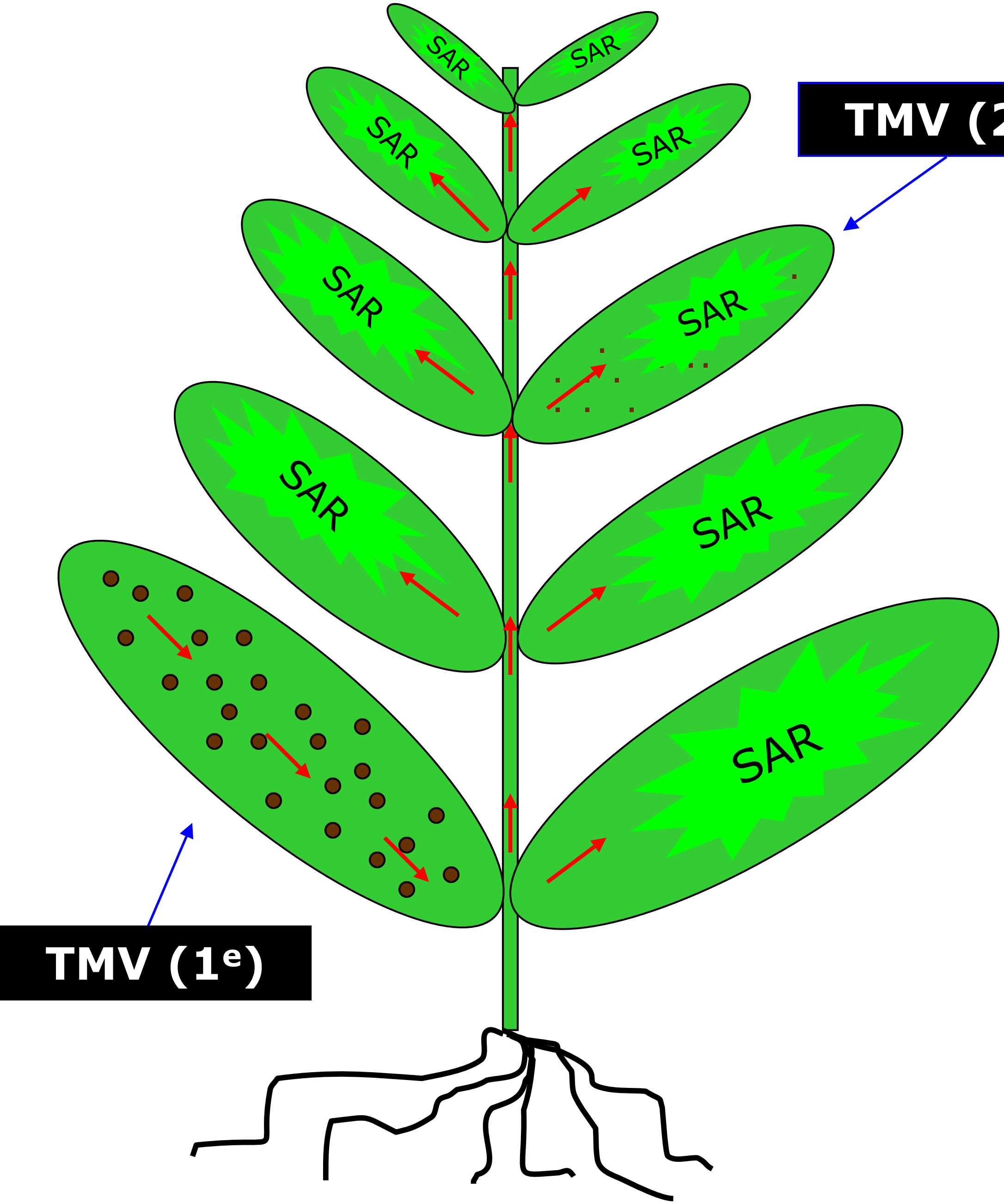
Many plant-associated microbes are pathogens that impair plant growth and reproduction. Plants respond to infection using a two-branched innate immune system. The first branch recognizes and responds to molecules common to many classes of microbes, including non-pathogens. The second responds to pathogen virulence factors, either directly or through their effects on host targets. These plant immune systems, and the pathogen molecules to which they respond, provide extraordinary insights into molecular recognition, cell biology and evolution across biological kingdoms. A detailed understanding of plant immune function will underpin crop improvement for food, fibre and biofuels production.

Introduction

Plant pathogens use diverse life strategies. Pathogenic bacteria proliferate in intercellular spaces (the apoplast) after entering through gas or water pores (stomata and hydathodes, respectively), or gain access via wounds. Nematodes and aphids feed by inserting a stylet

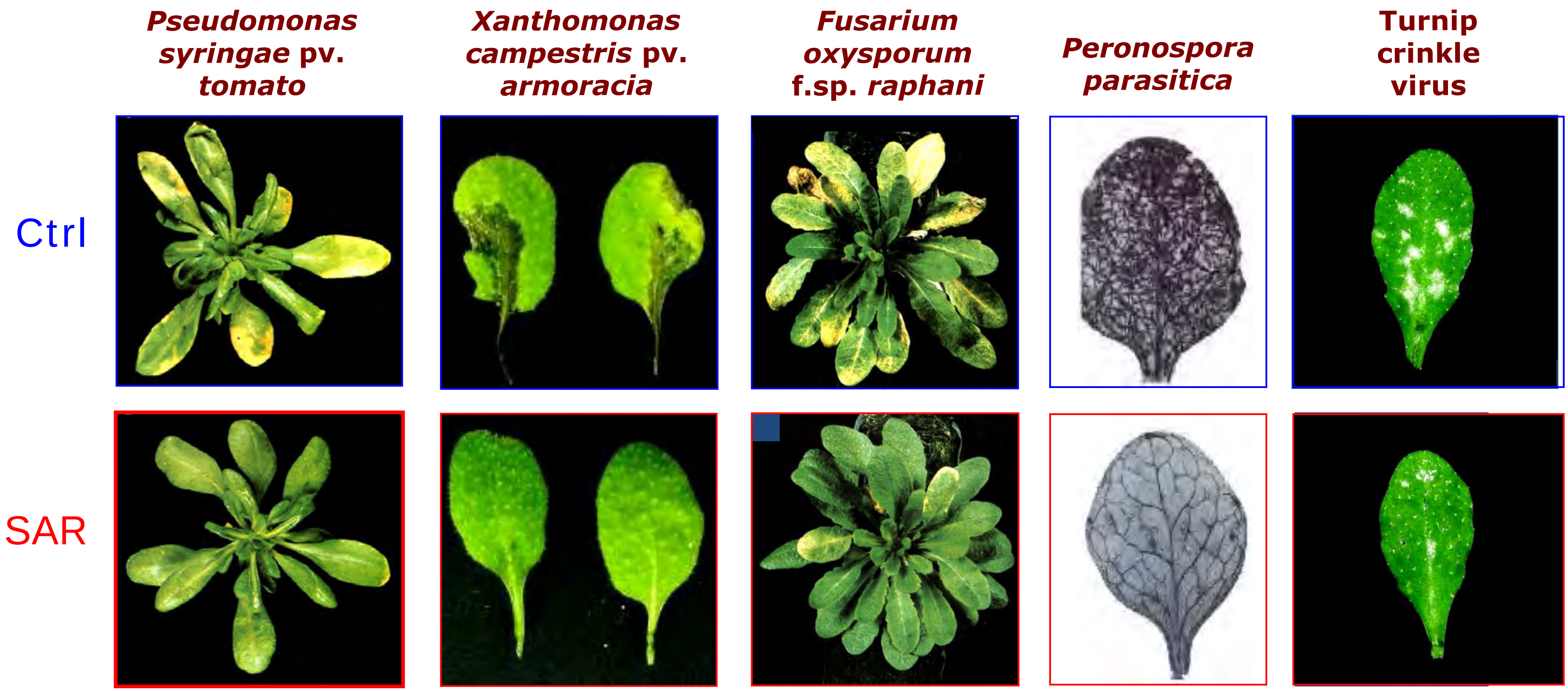
important abbreviations. In phase 1, PAMPs (or MAMPs) are recognized by PRRs, resulting in PAMP-triggered immunity (PTI) that can halt further colonization. In phase 2, successful pathogens deploy effectors that contribute to pathogen virulence. Effectors can interfere with PTI. This results in effector-triggered susceptibility (ETS).

Tabaco (*NN*) - TMV

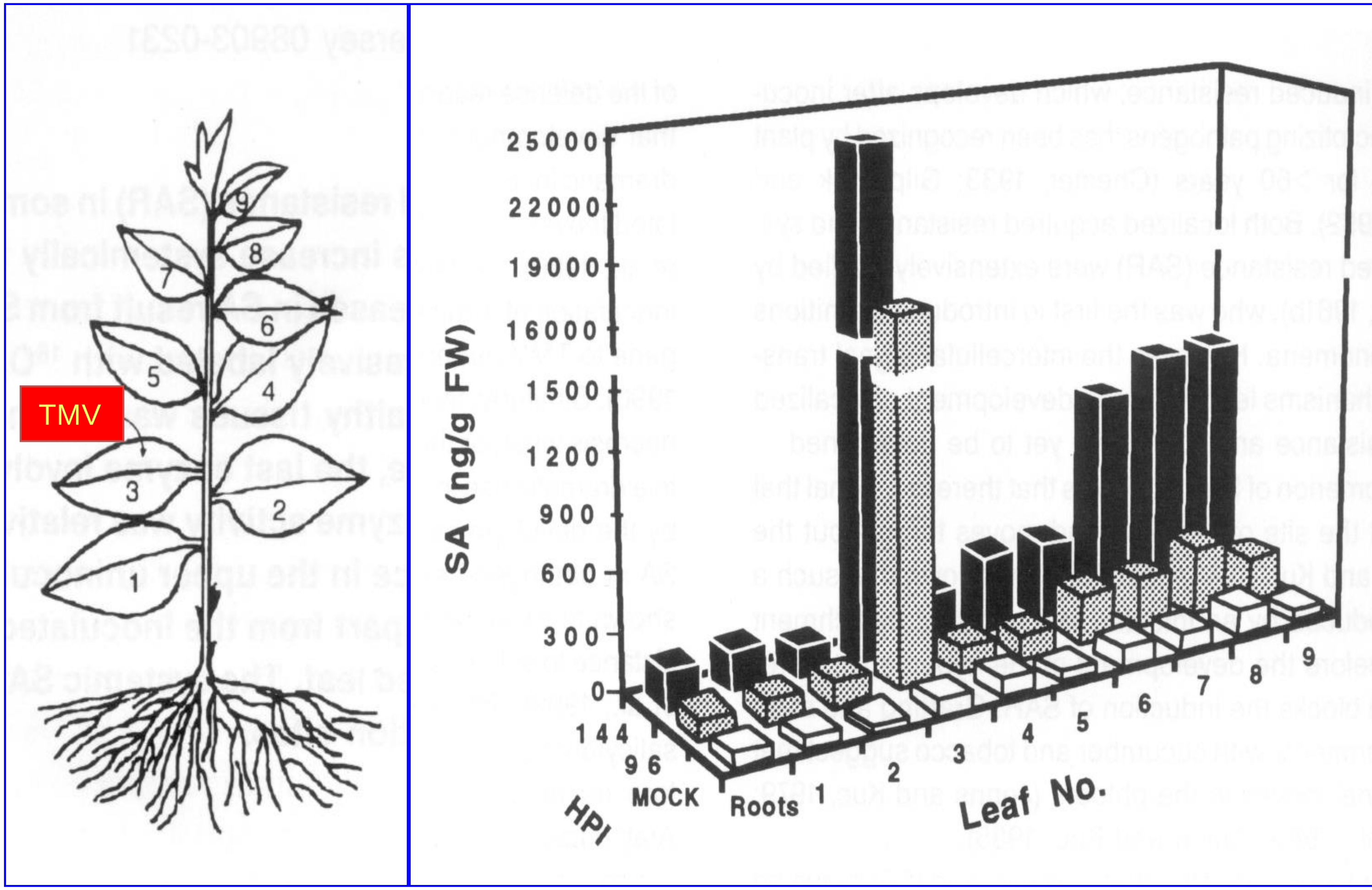


SAR: Systemic acquired resistance

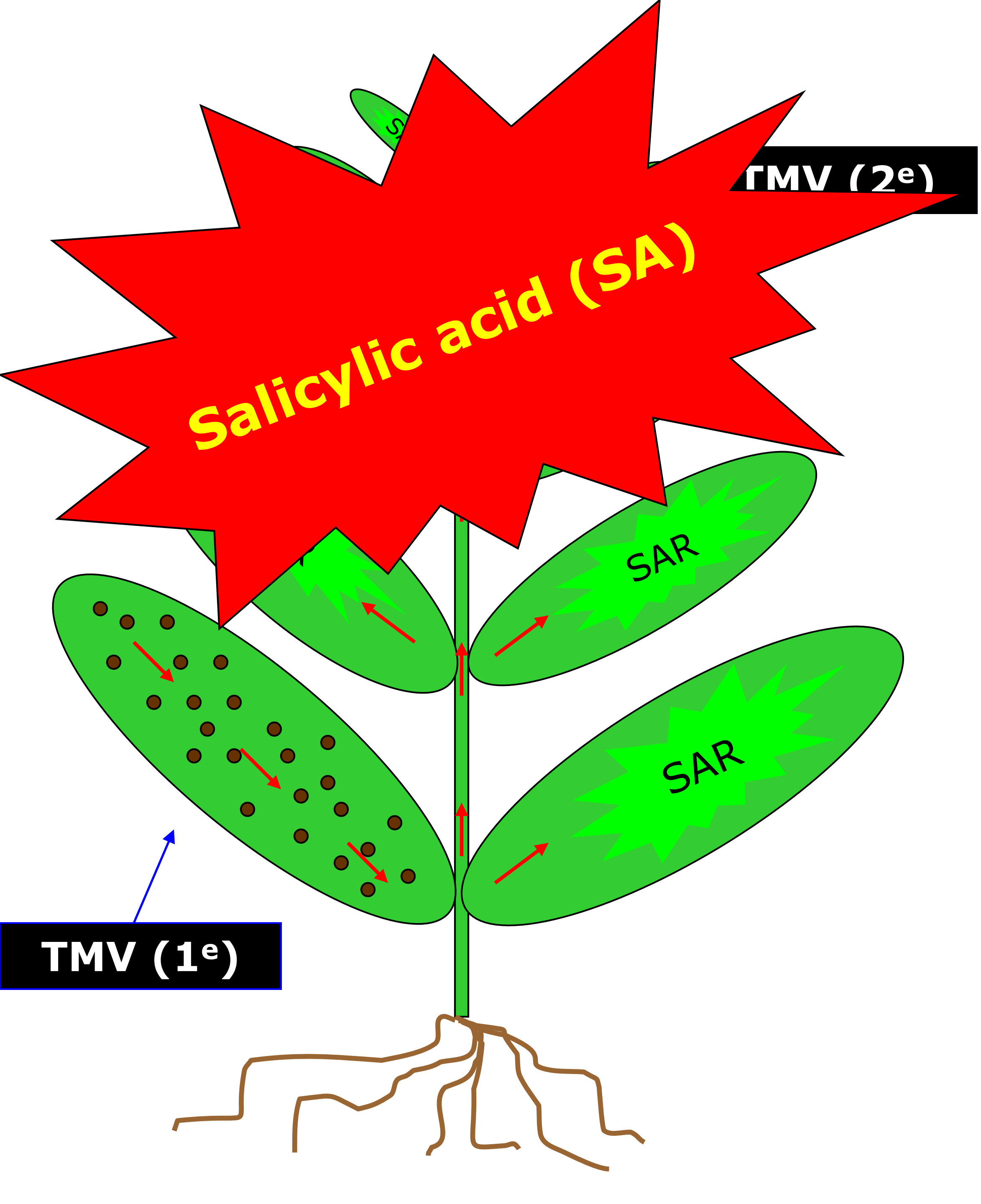
Effect of SAR

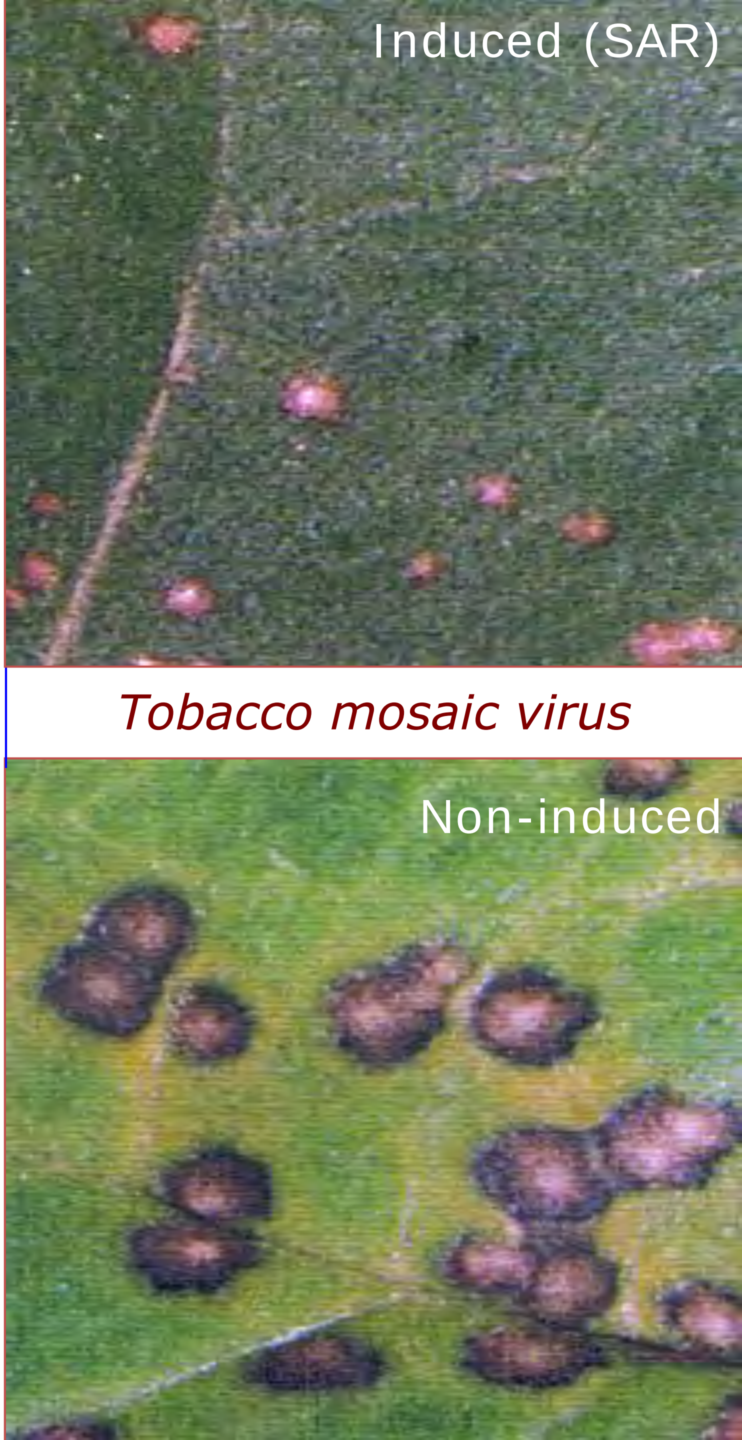


SAR: Salicylic acid (SA)

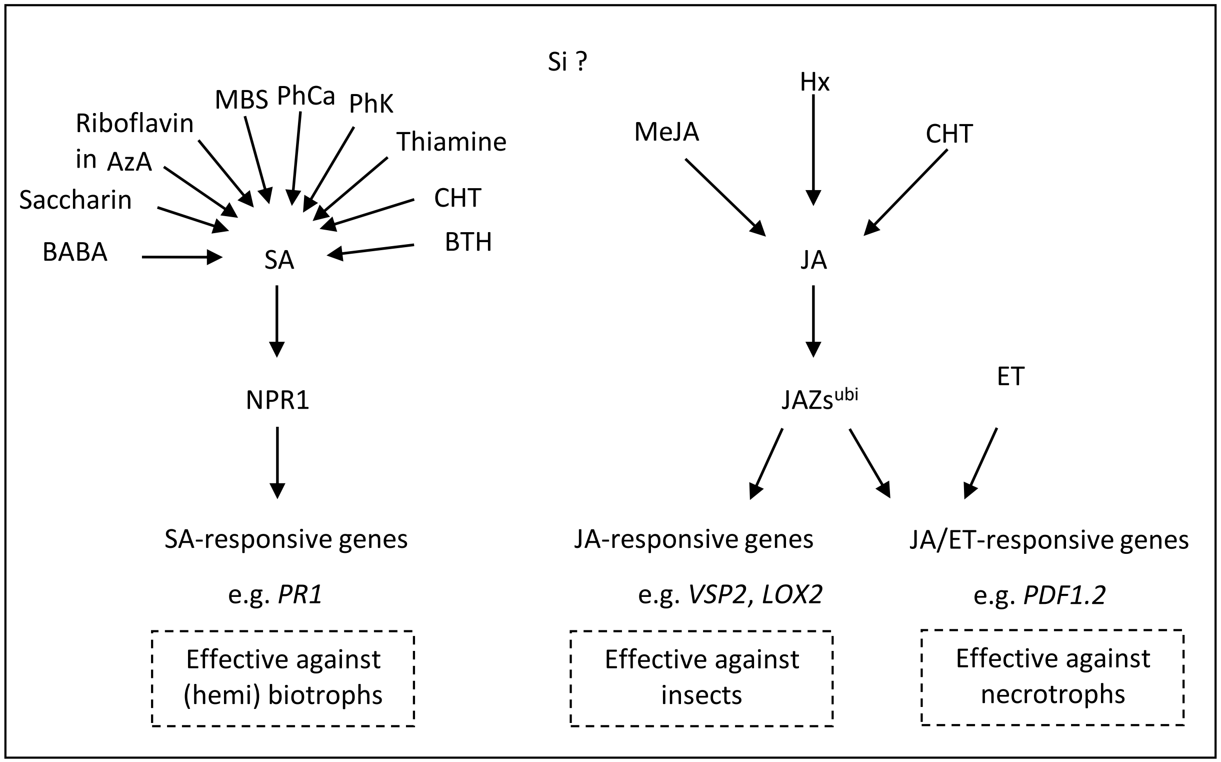


Shulaev *et al.* (1995); Plant Cell 7: 1691-1701


TMV (2e)
Salicylic acid (SA)
SAR
SAR
TMV (1e)


Induced (SAR)
Tobacco mosaic virus
Non-induced

Elicitors and induced resistance to biotic and abiotic stress



Jhon Jairo Venegas


16 elicitors with
3 concentrations,
biotic and abiotic
(5)


Control


ELICITOR

Control

ELICITOR

Control

ELICITOR

Control

ELICITOR

Control

ELICITOR

Control

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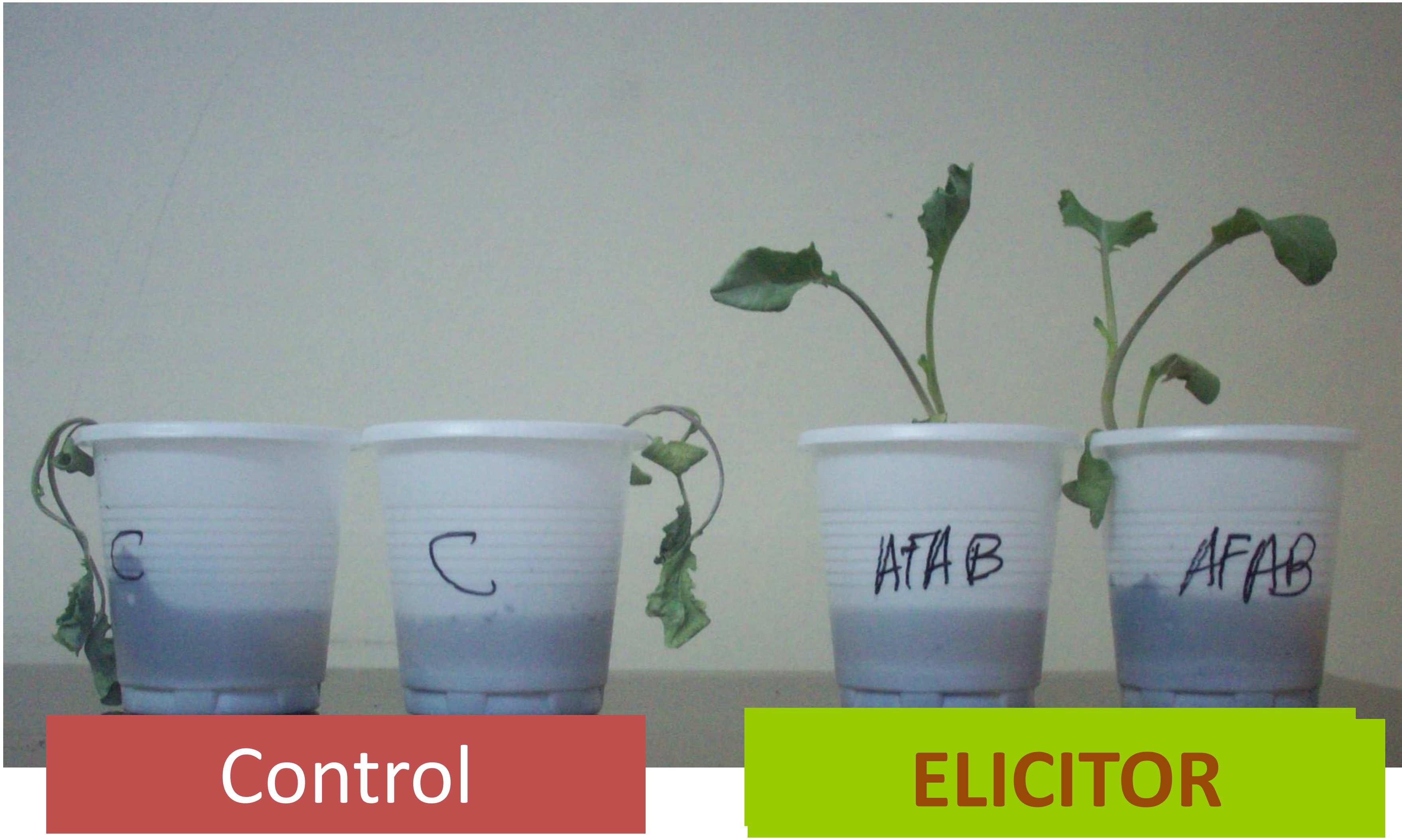
C
C
AFA B
AFAB
Control
ELICITOR

Control

ELICITOR

Control

ELICITOR

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ELICITOR

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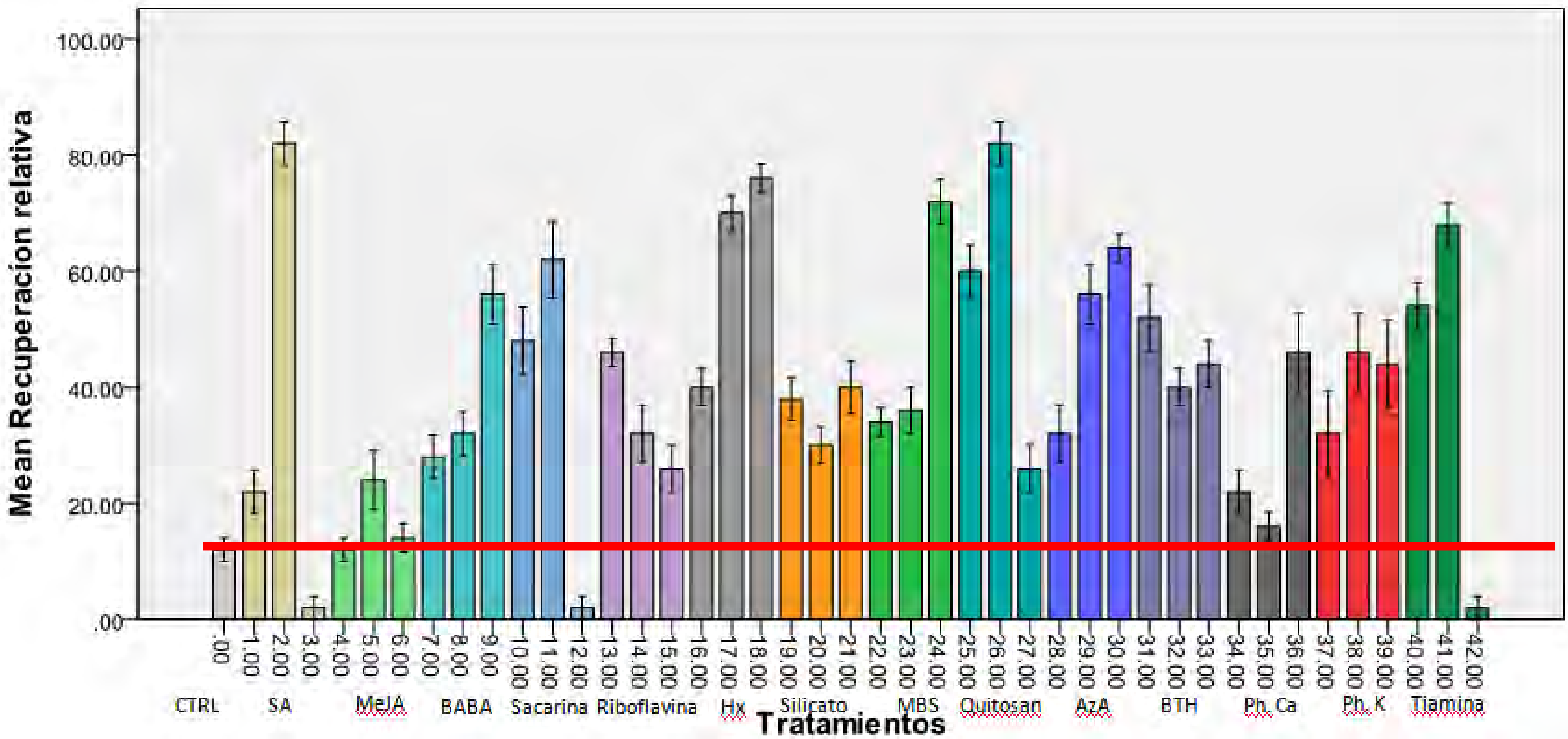
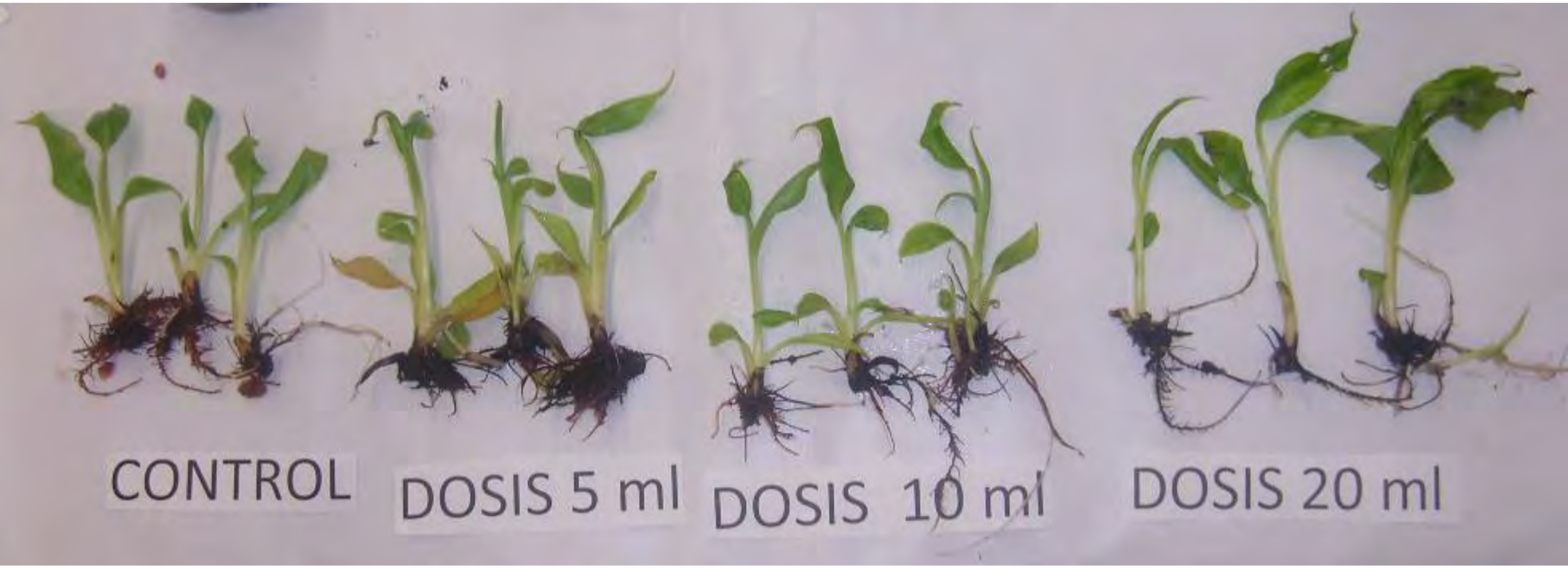
ELICITOR

Elicitors effect on drought tolerance in broccoli



Concentration matters


Control
5 ml
10 ml
20 ml


CONTROL
DOSIS 5 ml
DOSIS 10 ml
DOSIS 20 ml

Elicitor X: Defense Plus ®

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ELSEVIER

Journal of Plant Physiology

Volume 168, Issue 8, 15 May 2011, Pages 807–815

Salicylic acid alleviates decreases in photosynthesis under salt stress by enhancing nitrogen and sulfur assimilation and antioxidant metabolism differentially in two mungbean cultivars

Rahat Nazar, Noushina Iqbal, Shabina Syeed, Nafees A. Khan

Show more

Abstract

Salicylic acid (SA) is known to affect photosynthesis under normal conditions and induces tolerance in plants to biotic and abiotic stresses through influencing physiological processes. In this study, physiological processes were compared in salt-tolerant (Pusa Vishal) and salt-sensitive (T44) cultivars of mungbean and examined how much these processes were induced by SA treatment to alleviate decrease in photosynthesis under salt stress. Cultivar T44 accumulated higher leaf Na^+ and Cl^- content and exhibited greater oxidative stress than Pusa Vishal. Activity of antioxidant enzymes, ascorbate peroxidase (APX) and glutathione reductase (GR) was greater in Pusa Vishal than T44. Contrarily, activity of superoxide dismutase (SOD) was greater in T44. The greater accumulation of leaf nitrogen and sulfur through higher activity of their assimilating enzymes, nitrate reductase (NR) and ATP-sulfurylase (ATPS) increased reduced glutathione (GSH) content more conspicuously in Pusa Vishal than T44. Application of 0.5 mM SA increased nitrogen and sulfur assimilation, GSH content and activity of APX and GR. This resulted in the increase in photosynthesis under non-saline condition and alleviated the decrease in photosynthesis under salt stress. It also helped in restricting Na^+ and Cl^- content in leaf, and maintaining higher efficiency of PSII, photosynthetic N-use efficiency (NUE) and water relations in Pusa Vishal. However, application of 1.0 mM SA resulted in inhibitory effects. The effect of SA was more pronounced in Pusa Vishal than T44. These results indicate that SA application alleviates the salt-induced decrease in photosynthesis mainly through inducing the activity of NR and ATPS, and increasing antioxidant metabolism to a greater extent in Pusa Vishal than T44.

Nitrógeno y Azufre

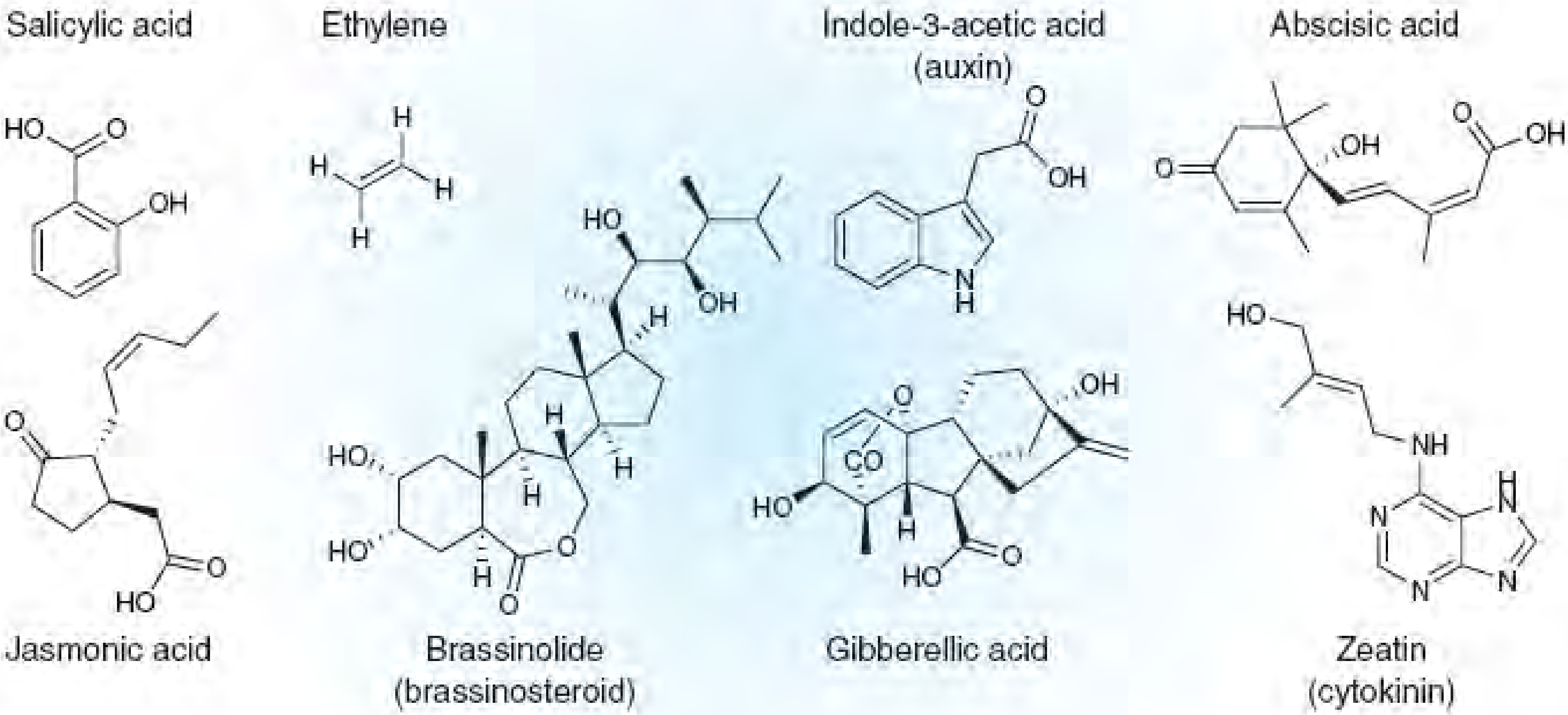


Figure 1 Phytohormones implicated in the plant immunity signaling network.

REVIEW

nature chemical biology (2009)

Networking by small-molecule hormones in plant immunity

Corné M J Pieterse, Antonio Leon-Reyes, Sjoerd Van der Ent & Saskia C M Van Wees

Plants live in complex environments in which they intimately interact with a broad range of microbial pathogens with different lifestyles and infection strategies. The evolutionary arms race between plants and their attackers provided plants with a highly sophisticated defense system that, like the animal innate immune system, recognizes pathogen molecules and responds by activating specific defenses that are directed against the invader. Recent advances in plant immunity research have provided exciting new insights into the underlying defense signaling network. Diverse small-molecule hormones play pivotal roles in the regulation of this network. Their signaling pathways cross-communicate in an antagonistic or synergistic manner, providing the plant with a powerful capacity to finely regulate its immune response. Pathogens, on the other hand, can manipulate the plant's defense signaling network for their own benefit by affecting phytohormone homeostasis to antagonize the host immune response.

ET

SA

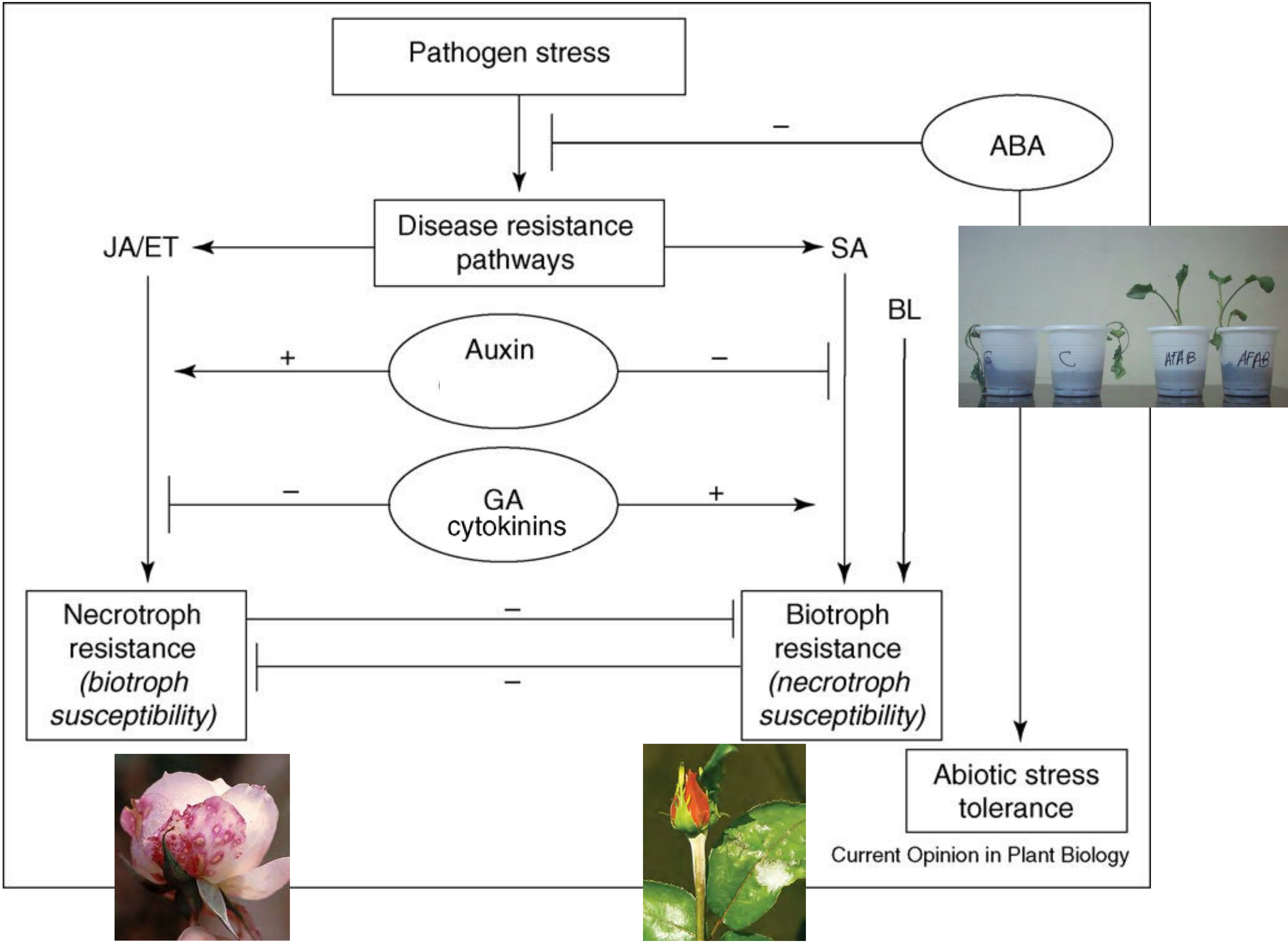
JA

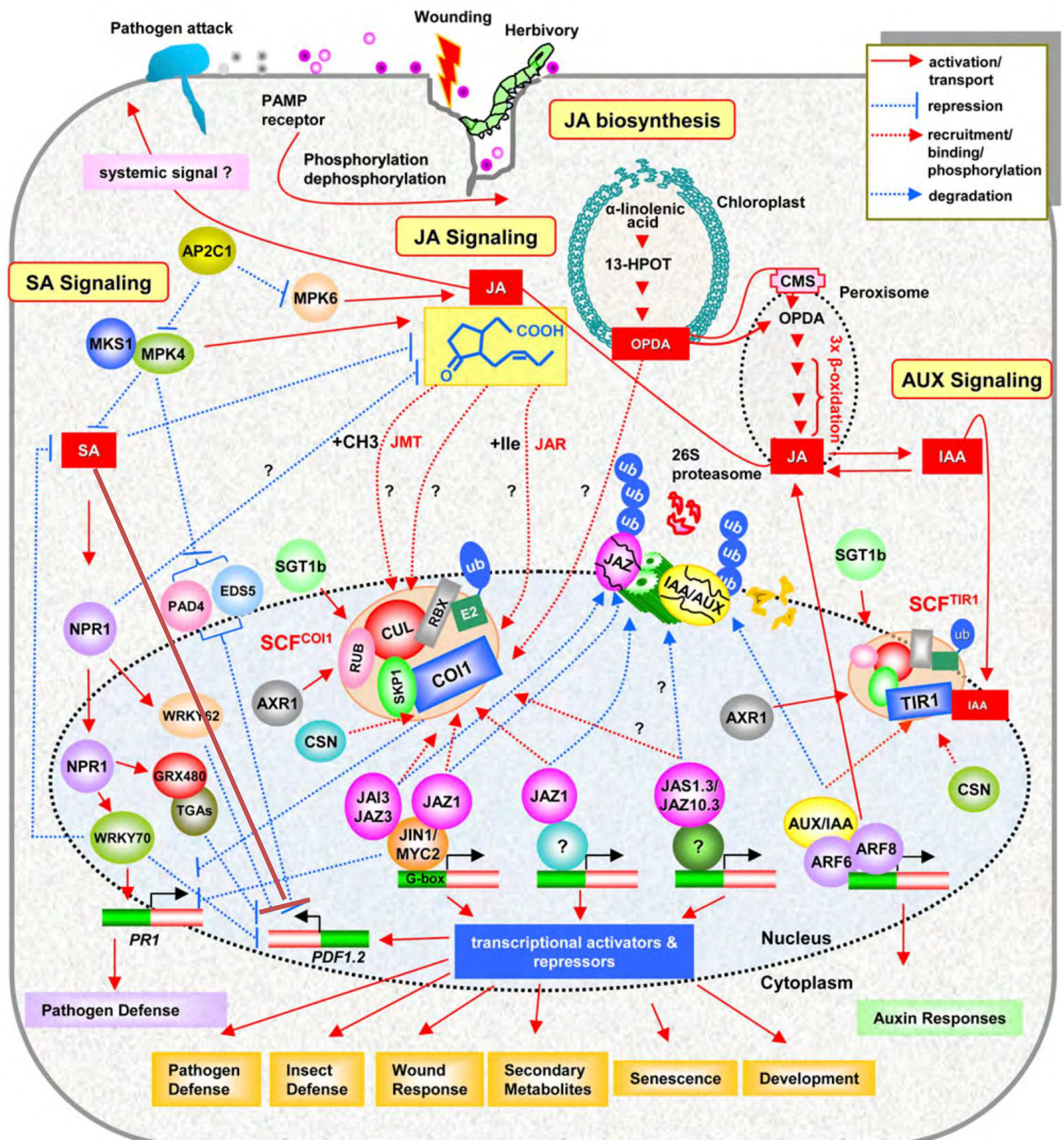
Koornneef, Leon-Reyes, *et al.* (2008) Plant physiology.

Leon-Reyes, A., et al (2009) Plant Physiology

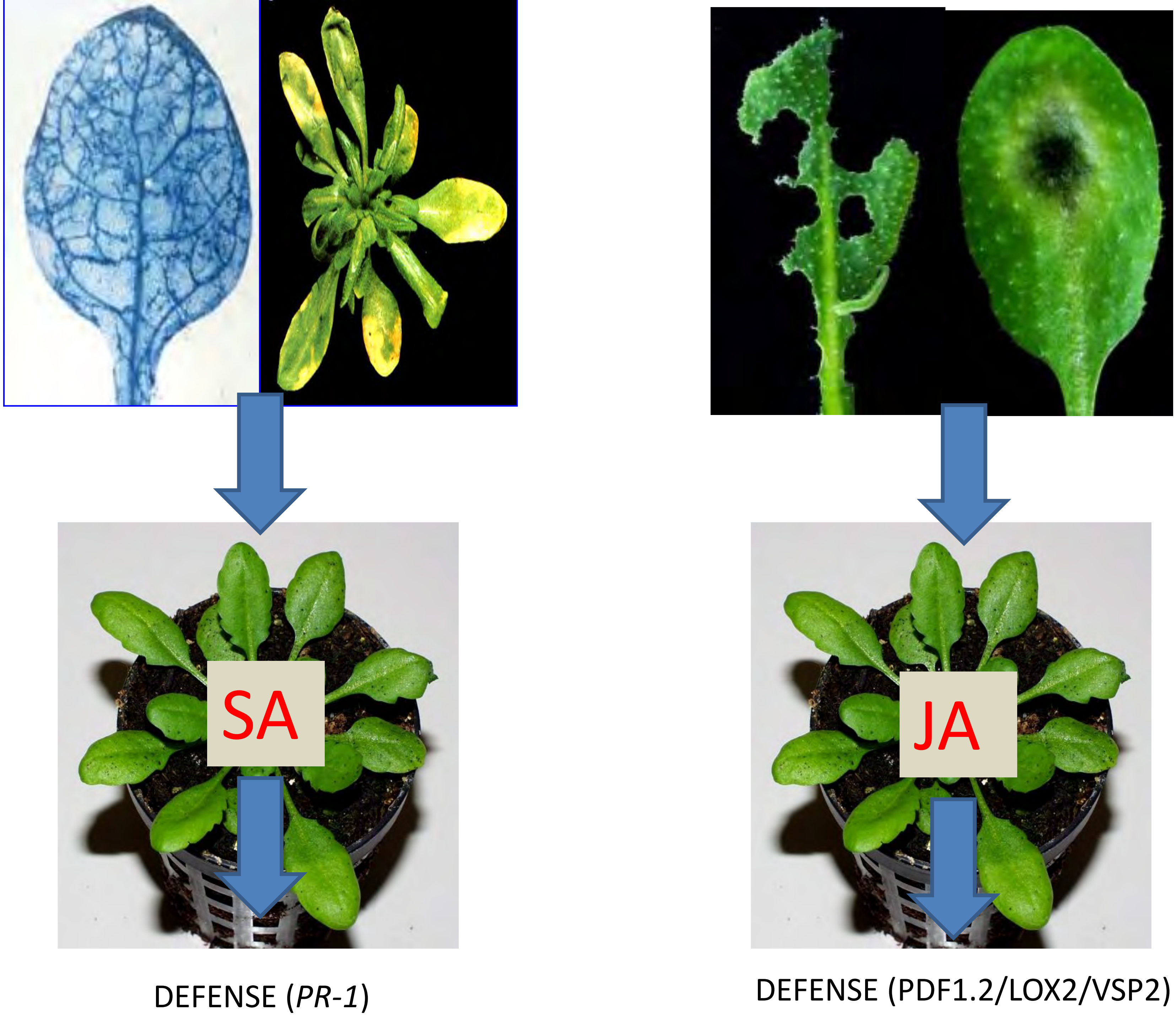
Leon-Reyes, A., et al (2010) MPMI

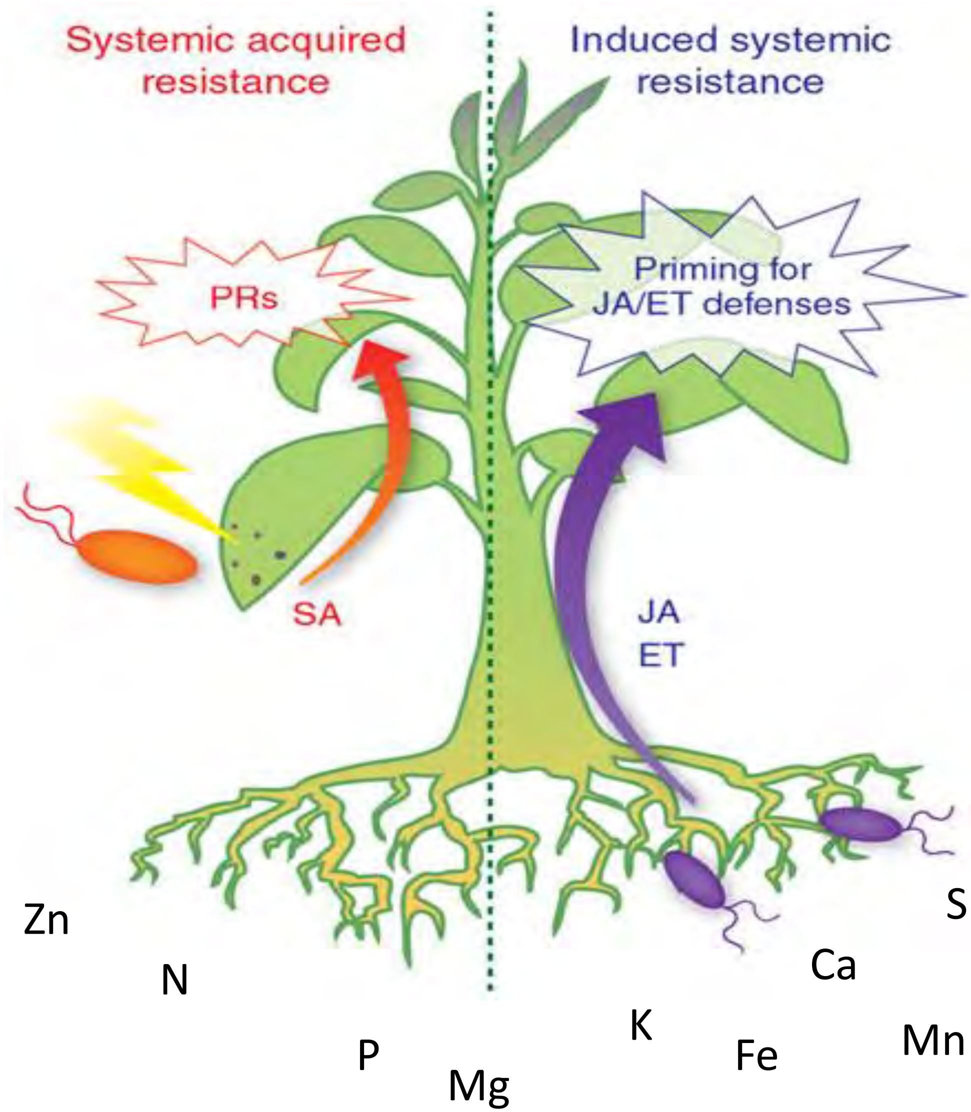
Van der Does, D., Leon-Reyes, A., et al (2013), Plant Cell


Pathogen stress
ABA
–
Disease resistance pathways
JA/ET
SA
BL
Auxin
+
–
GA
cytokinins
–
+
Necrotroph resistance (biotroph susceptibility)
Biotroph resistance (necrotroph susceptibility)
–
–
Abiotic stress tolerance
Current Opinion in Plant Biology



Pathogen attack
Wounding
Herbivory
activation/ transport
repression
recruitment/ binding/ phosphorylation
degradation
PAMP receptor
JA biosynthesis
systemic signal ?
Phosphorylation dephosphorylation
α-linolenic acid
13-HPOT
Chloroplast
JA Signaling
AP2C1
SA Signaling
MPK6
JA
CMS
Peroxisome
OPDA
COOH
MKS1
MPK4
3x β-oxidation
AUX Signaling
SA
+CH3
JMT
+Ile
JAR
26S proteasome
IAA
ub
JAZ
IAA/AUX
SGT1b
PAD4
EDS5
NPR1
SCF^COI1
CUL
RBX
E2
RUB
SKP1
COI1
SCF^TIR1
TIR1
AXR1
WRKY62
CSN
GRX480
TGAs
WRKY70
JAI3 JAZ3
JAZ1
JIN1/ MYC2
JAS1.3/ JAZ10.3
AUX/IAA
ARF6
ARF8
G-box
PR1
PDF1.2
transcriptional activators & repressors
Nucleus
Cytoplasm
Pathogen Defense
Auxin Responses
Pathogen Defense
Insect Defense
Wound Response
Secondary Metabolites
Senescence
Development


SA
JA
DEFENSE (*PR-1*)
DEFENSE (PDF1.2/LOX2/VSP2)



Pieterse C., Leon-Reyes, A., et al 2009. Nature Chemical Biology

essential element

noun

1. (**biochem**) any chemical element required by an organism for healthy growth. It may be required in large amounts (macronutrient) or in very small amounts (trace element) *See also* macronutrient, trace element

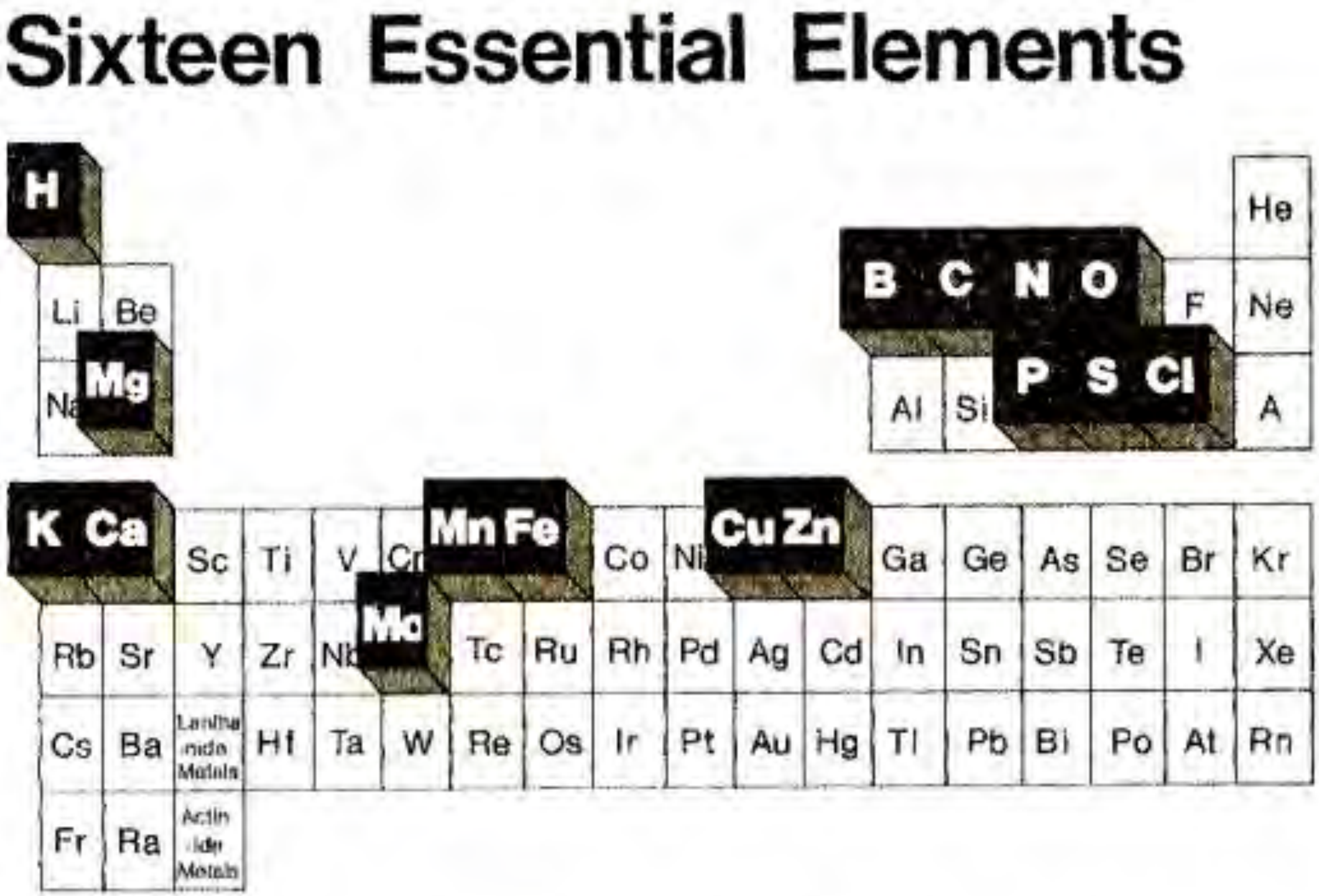


Fig. 4-1. Periodic table of elements highlighting the 16 essential plant nutrients.

Essential Elements for Plant Growth	
Macronutrients	**Micronutrients**
Carbon (C)	Iron (Fe)
Hydrogen (H)	Manganese (Mn)
Oxygen (O)	Boron (B)
Nitrogen (N)	Molybdenum (Mo)
Phosphorus (P)	Copper (Cu)
Potassium (K)	Zinc (Zn)
Calcium (Ca)	Chlorine (Cl)
Magnesium (Mg)	Nickel (Ni)
Sulfur (S)	Cobalt (Co)
	Sodium (S)
	Silicon (Si)

Element	Amount in Whole Plant %
Oxygen	45
Carbon	44
Hydrogen	6
Nitrogen	2
Phosphorus	0.5
Potassium	1.0
Calcium	0.6
Sulfur	0.4
Magnesium	0.3
Boron	0.005
Chlorine	0.015
Copper	0.001
Iron	0.020
Manganese	0.050
Molybdenum	0.0001
Zinc	0.0100
Total	99.9011

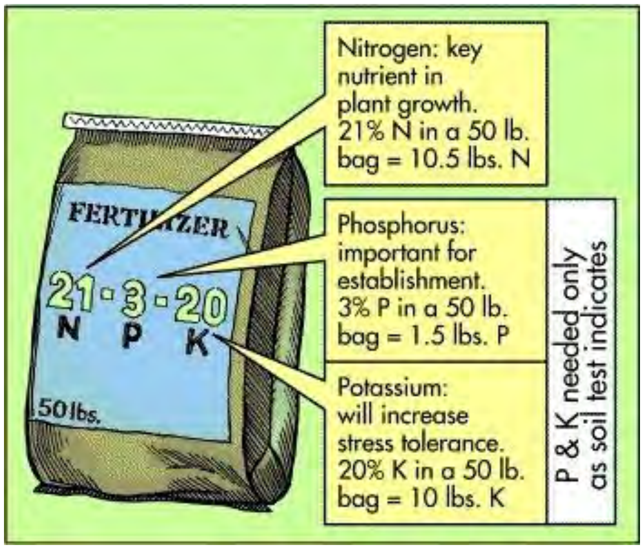
Role of essential nutrients in plants

Nutrient	Function
Carbon	It is the basic molecular component of carbohydrates, proteins, lipids and nucleic acids.
Oxygen	It occurs in all the organic compounds of living organisms.
Hydrogen	This element plays a central role in plant metabolism. It is very important in ionic balance, as the main reducing agent, and plays a key role in energy relations of cells.
Nitrogen	It plays a significant role in the synthesis of important organic compounds, amino acids, proteins, nucleic acids (RNA, DNA), enzymes etc.
Phosphorus	It is an important component of proteins and enzymes, nucleic acids (DNA and RNA) and phytin. Phosphorus is also involved in various energy transfer reactions of adenosine triphosphate and diphosphate (ATP and ADP).
Potassium	It helps in osmotic and ionic regulation. Potassium is a cofactor or activator for many enzymes of carbohydrate and protein metabolism.
Calcium	It is involved in cell division and plays a major role in the maintenance of membrane integrity.
Magnesium	It is a component of chlorophyll and a cofactor for many enzymatic reactions.
Sulfur	Somewhat like phosphorus, it is involved in plant cell energetics. It plays an important role in plant lipid synthesis.

Element	Chemical symbol	Principal form(s) taken up by roots	Described as essential Year	Author
Macronutrients				
Carbon	C	CO_2	1882	Sachs, J.
Hydrogen	H	H_2O	1882	Sachs, J.
Oxygen	O	H_2O, O_2	1804	De Saussure, T.
Nitrogen	N	NH_4^+, NO_3^-	1872	Rutherford, G.K.
Phosphorus	P	H_2PO_4-, HPO_4^{2-}	1860	Ville
Potassium	K	K^+	1860	Sachs, J., Knop
Calcium	Ca	Ca_2^+	1856	Salm-Horstmar, F.
Magnesium	Mg	Mg_2^+	1906	Willstatter
Sulfur	S	SO_4^{2-}	1865	Sachs, J. , Knop
Micronutrients				
Iron	Fe	Fe_2^+, Fe_3^+	1860	Sachs, J., Knop
Zinc	Zn	Zn_2^+, $Zn(OH)_2$	1926	Sommer and Lipman
Manganese	Mn	Mn_2^+	1922	McHargue
Copper	Cu	Cu_2^+	1931	Lipman and MacKinney
Boron	B	$B(OH)_3^0$	1923	Warington
Molybdenum	Mo	MoO_4^{2-}	1938	Arnon and Stout
Silicon* *	Si	$Si(OH)_4^0$	1980's	
Sodium*	Na	Na+	1980's	
Chlorine*	Cl	Cl-	1954	Broyer, Stout
Nickel	Ni	Ni_2^+	1983	Brown, Welsh &Cary
Cobalt	Co	Co_2^+	1980's	
Vanadium	V	V+	1987	

* Macronutrients for several crops

* * "Quasi-Essential Element"



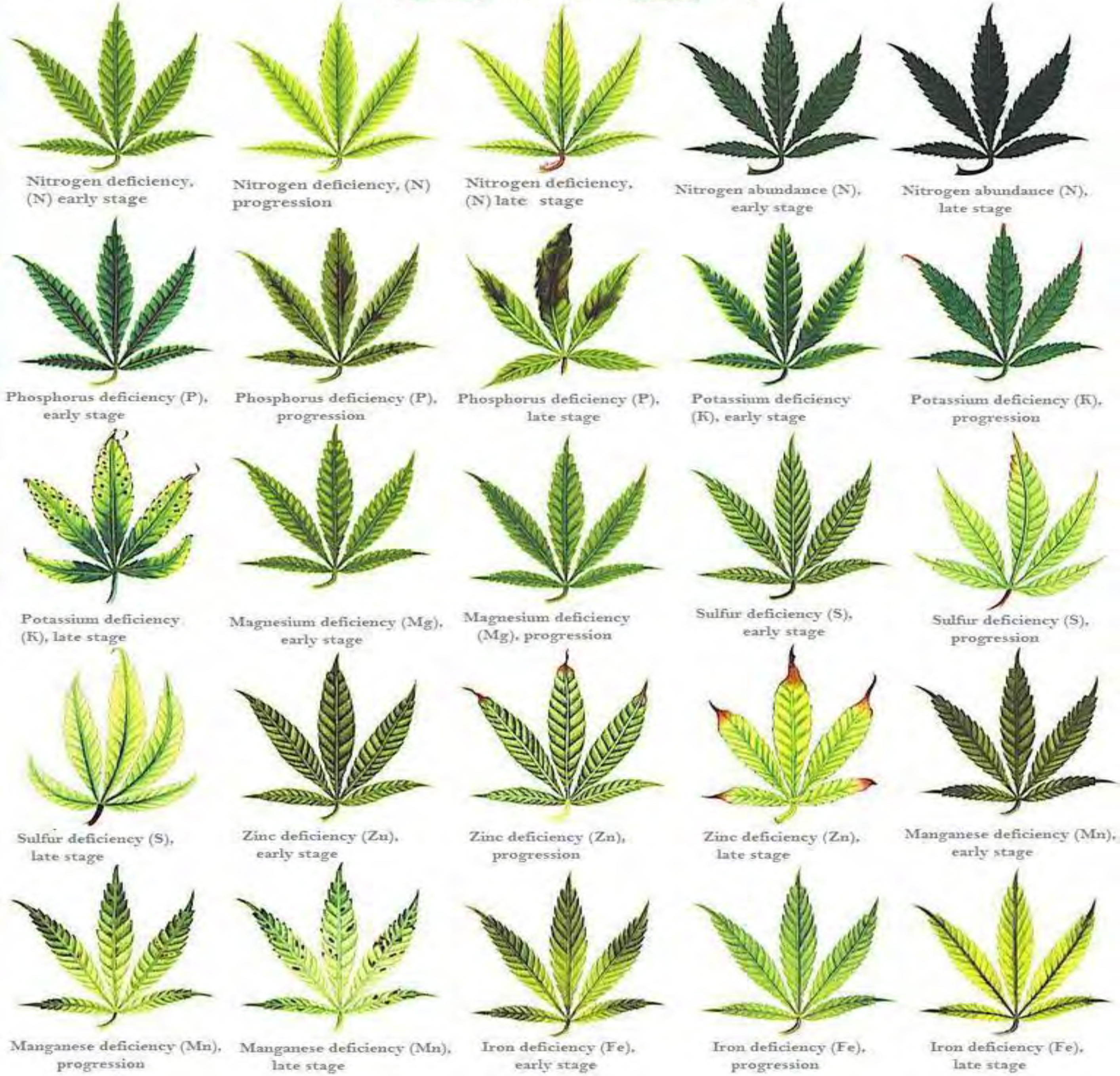
Element	Species required for plant uptake	Some commonly used ingredients
Macronutrients		
Nitrogen (N)	Nitrate (NO_3^-)	Potassium nitrate, calcium nitrate, magnesium nitrate, ammonium nitrate
Phosphorus (P)	Phosphate ($H_2PO_4^-$)	Mono-potassium phosphate, mono-ammonium phosphate
Potassium (K)	Potassium (K^+)	Potassium nitrate, potassium sulfate
Calcium (Ca)	Calcium (Ca^{2+})	Calcium nitrate
Magnesium (Mg)	Magnesium (Mg^{2+})	Magnesium sulfate, magnesium nitrate
Sulfur (S)	Sulfate (SO_4^{2-})	Potassium sulfate, magnesium sulfate
Trace elements		
Iron (Fe)	Iron (Fe^{3+})	Iron EDTA, iron EDDHA
Copper (Cu)	Copper (Cu^{2+})	Copper EDTA
Manganese (Mn)	Manganese (Mn^{2+})	Manganese EDTA
Zinc (Zn)	Zinc (Zn^{2+})	Zinc EDTA
Molybdenum (Mo)	Molybdate (MoO_4^{2-})	Sodium molybdate
Boron (B)	Borate ($H_2BO_3^-$)	Borax


Cultilène MaXXima

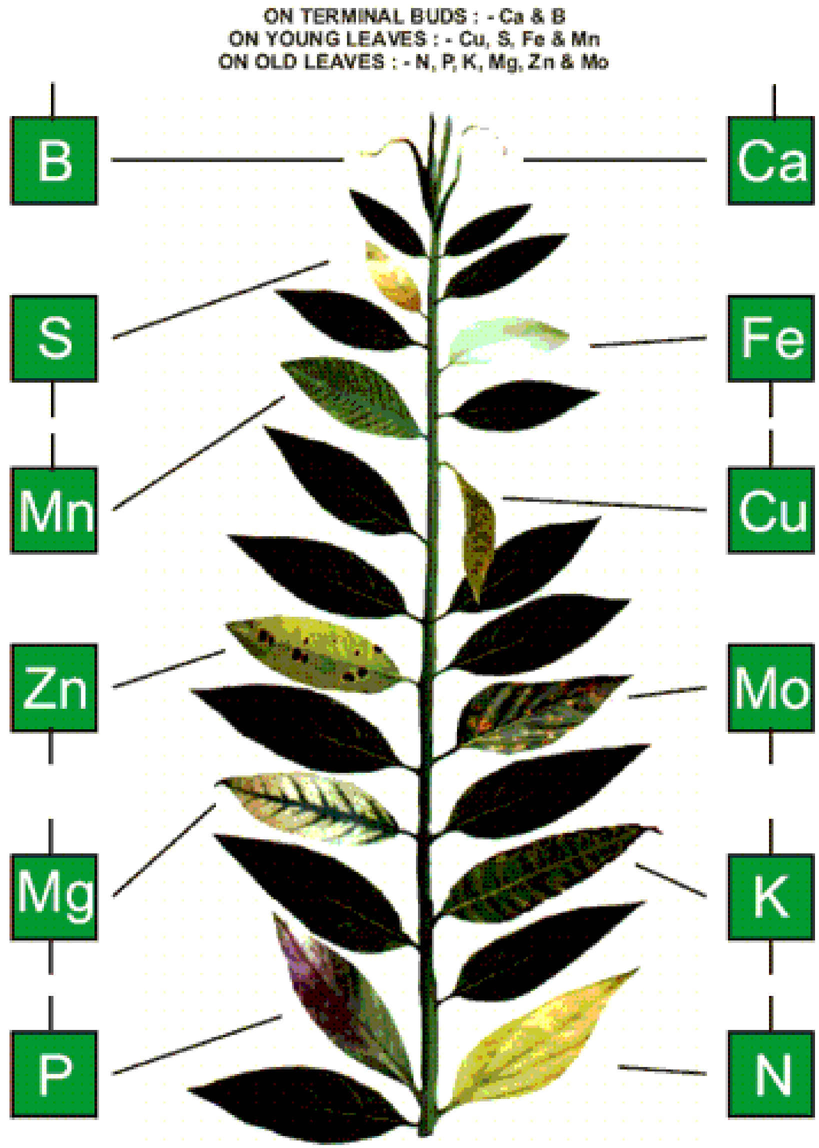
Nutrient imbalance!

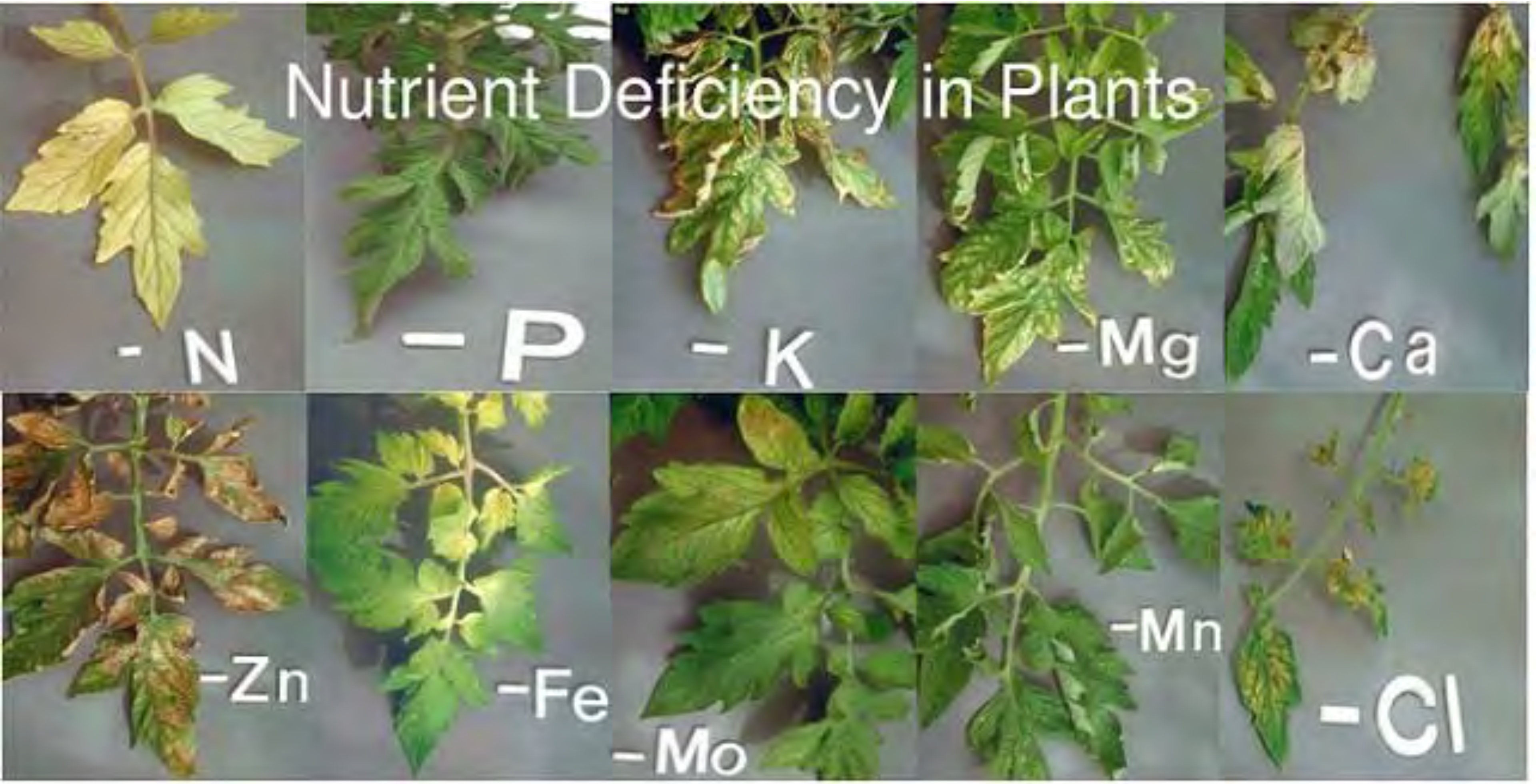
DEFICIENCY AND ABUNDANCE OF FERTILIZATION ELEMENTS

(pictures by Хохе Сервантеса, edited by SRV)



Deficiencies and phenotypes

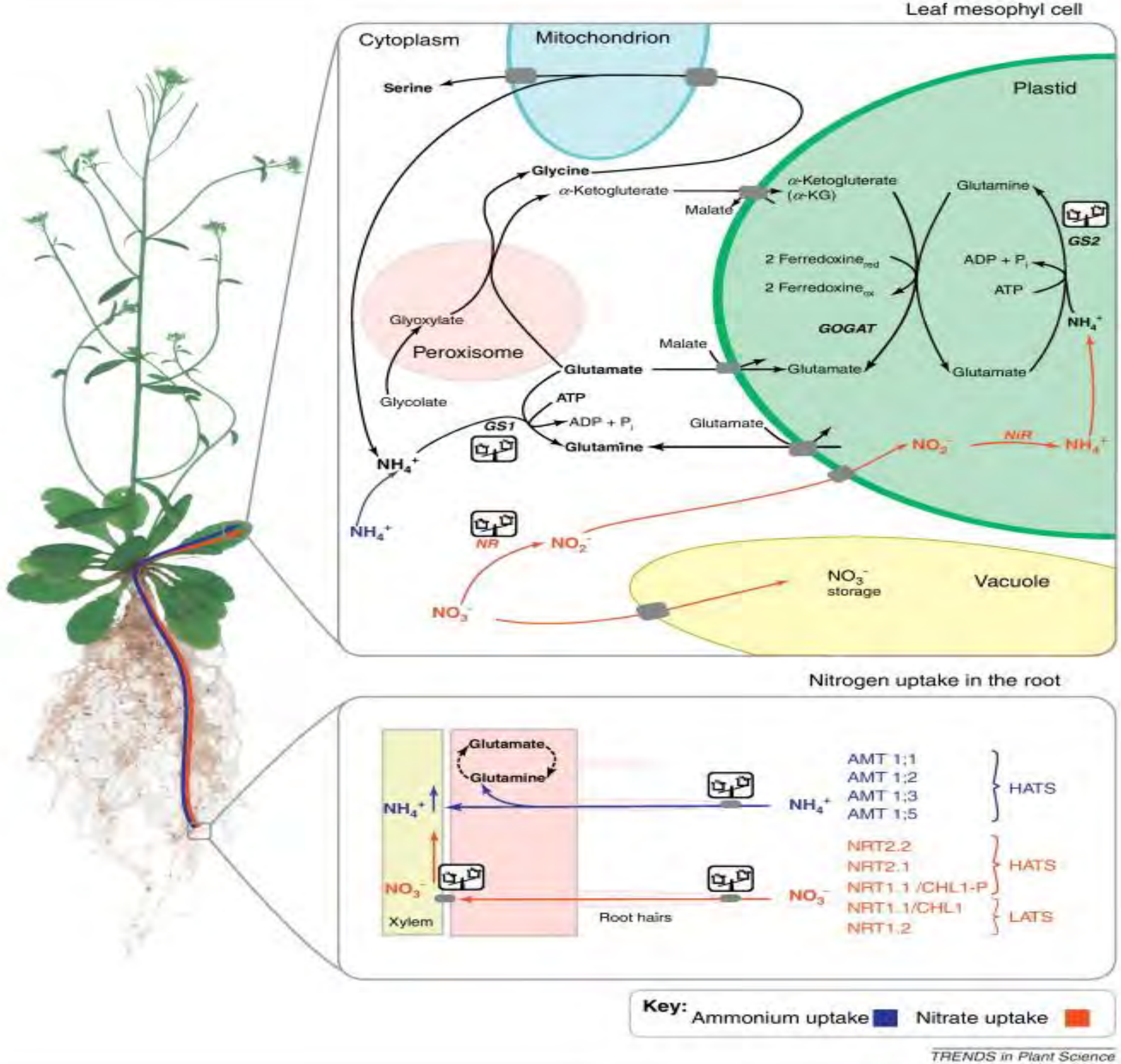



Nutrient Deficiency in Plants
- N
- P
- K
-Mg
-Ca
-Zn
-Fe
-Mo
-Mn
-Cl

Too much of nitrogen

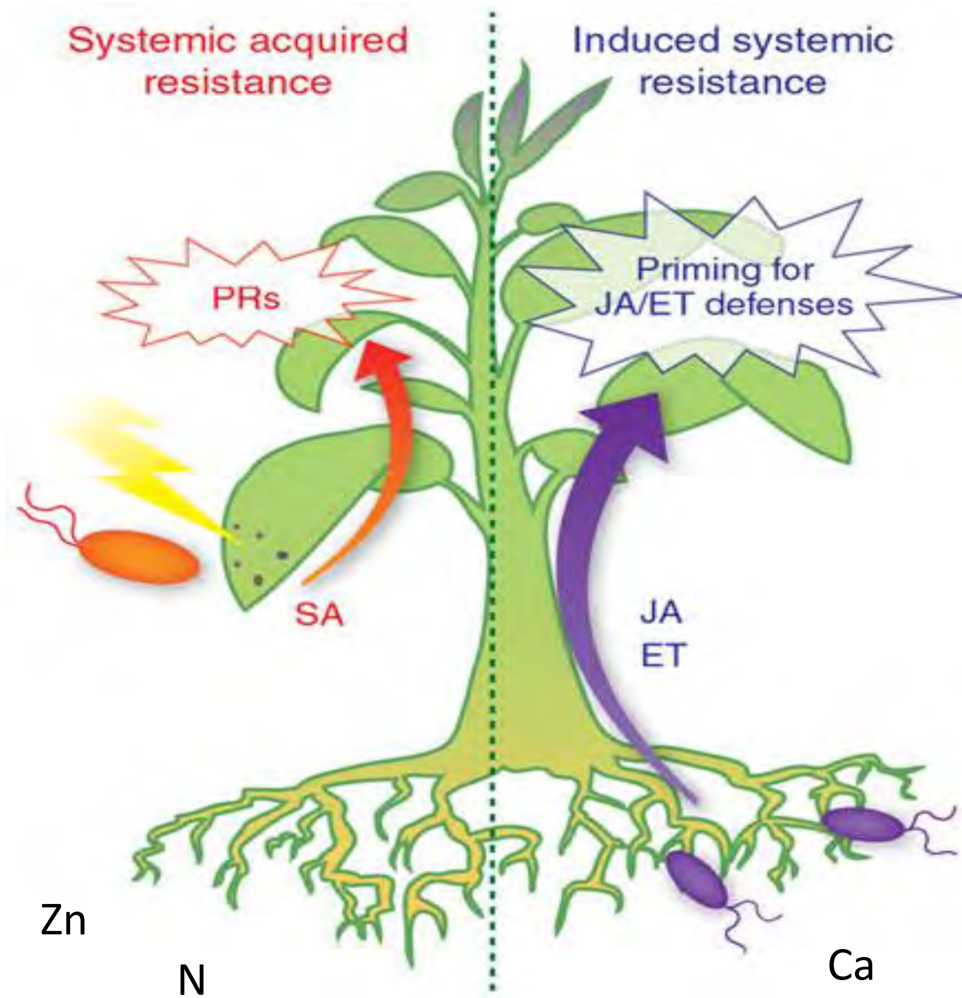
Uptake mechanisms in plants

Nutrient	Form absorbed	Method of uptake
N	NO_3^-, NH_4^+, N_2	Active, electro-chemical gradient
P	$H_2PO_4^-$, HPO_4^{2-}	Active
K	K^+	Active, electro-chemical gradient
Ca	Ca^{2+}	Active & diffusion
Mg	Mg^{2+}	Active, NH_4^+, H^+ dependant
S	SO_4^{2-}, SO_2	Active, electro-chemical gradient
Na	Na^+	Active, electro-chemical gradient
Cl	Cl^-	Active, metabolically controlled
Fe	Fe^{2+}, Fe Chelates	Active, metabolically controlled
Mn	Mn^{2+}, Mn Chelates	Active, metabolically controlled
Zn	Zn^{2+}, Chelates	Active, metabolically controlled
Cu	Cu^{2+}, Cu Chelates	Active, metabolically controlled
Mo	Molybdate	Active
B	Boric acid	Passive non-metabolic process



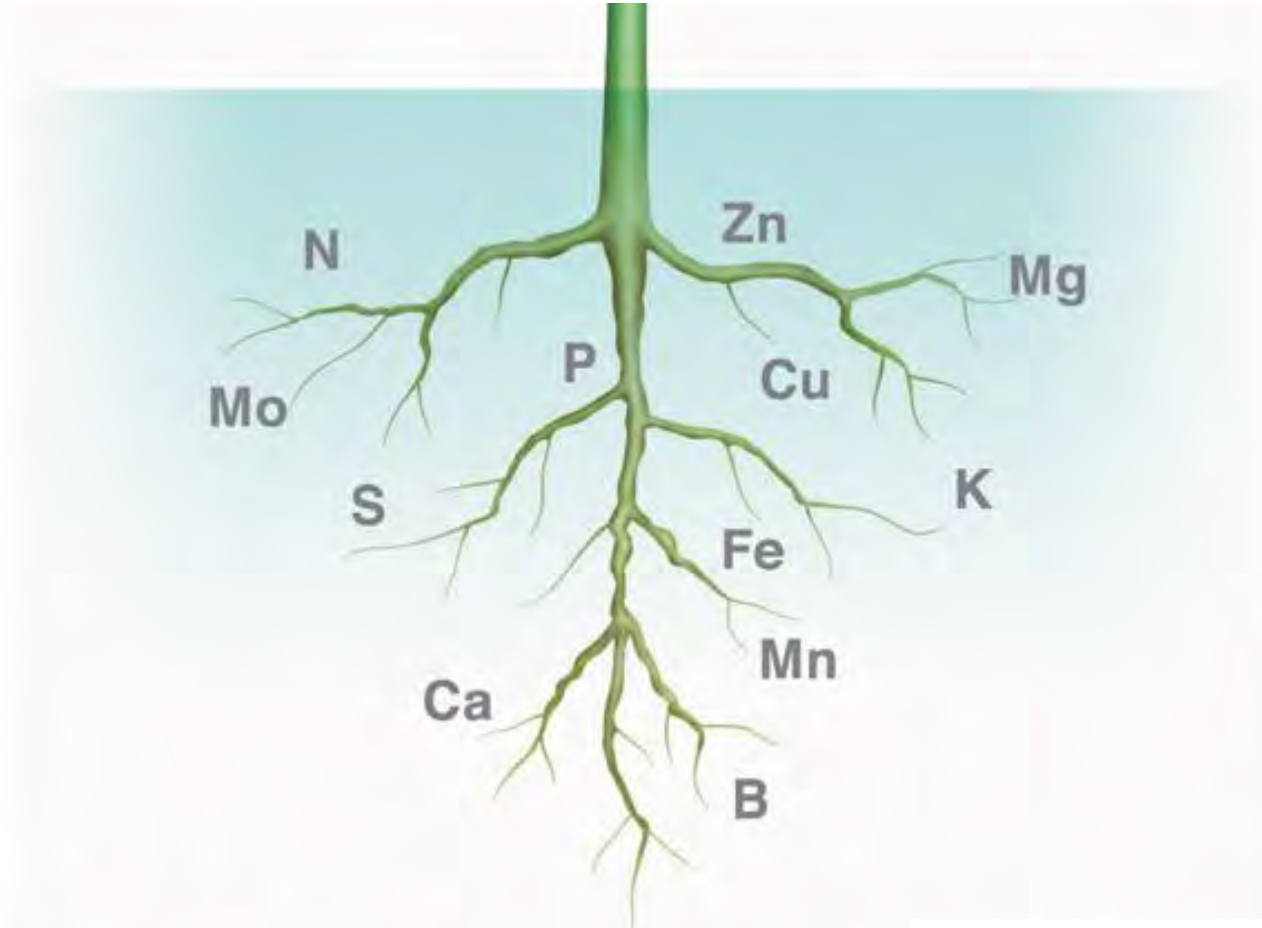
Leaf mesophyl cell
Cytoplasm
Mitochondrion
Plastid
Serine
Glycine
α-Ketogluterate
Malate
α-Ketogluterate (α-KG)
Glutamine
GS2
2 Ferredoxine$_{red}$
2 Ferredoxine$_{ox}$
ADP + P_i
ATP
GOGAT
NH_4^+
Glyoxylate
Peroxisome
Malate
Glutamate
Glutamate
Glutamate
Glycolate
ATP
GS1
ADP + P_i
Glutamate
Glutamine
NH_4^+
NO_2^-
NiR
NH_4^+
NH_4^+
NR
NO_2^-
NO_3^- storage
Vacuole
NO_3^-
Nitrogen uptake in the root
Glutamate
Glutamine
NH_4^+
NH_4^+
AMT 1;1
AMT 1;2
AMT 1;3
AMT 1;5
HATS
NRT2.2
NRT2.1
NRT1.1 /CHL1-P
HATS
NO_3^-
NO_3^-
NRT1.1/CHL1
NRT1.2
LATS
Xylem
Root hairs
Key: Ammonium uptake Nitrate uptake
TRENDS in Plant Science

Is there a link between a specific nutrient and a defense hormone?

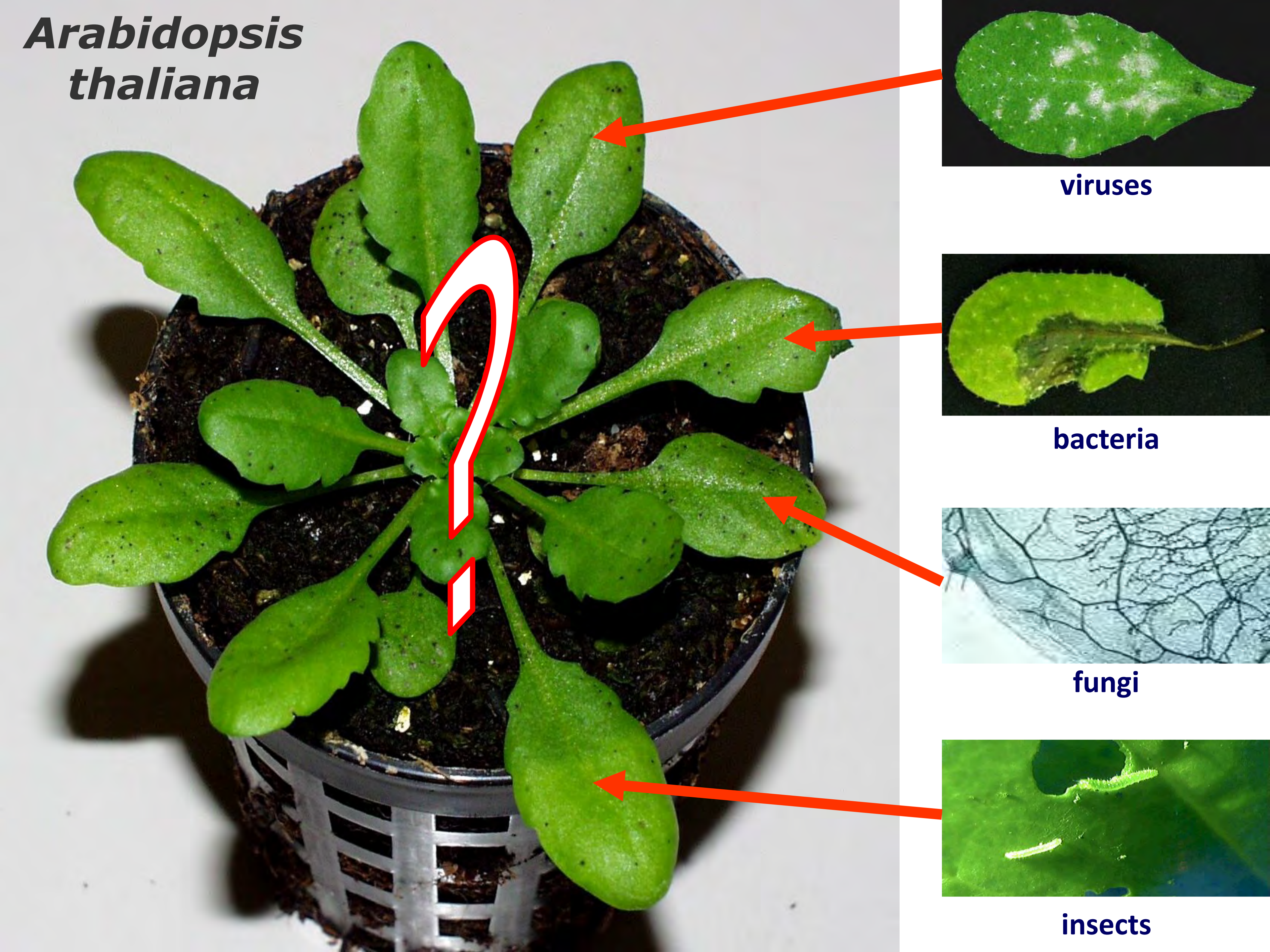


Zn N P Mg K Fe Ca S Mn

Sofia Moya



Macro Elements	**Secondary Elements**
N - Nitrogen	**Ca -** Calcium
P - Phosphorous	**Mg -** Magnesium
K - Potassium	**S -** Sulphur


Arabidopsis thaliana
?
viruses
bacteria
fungi
insects

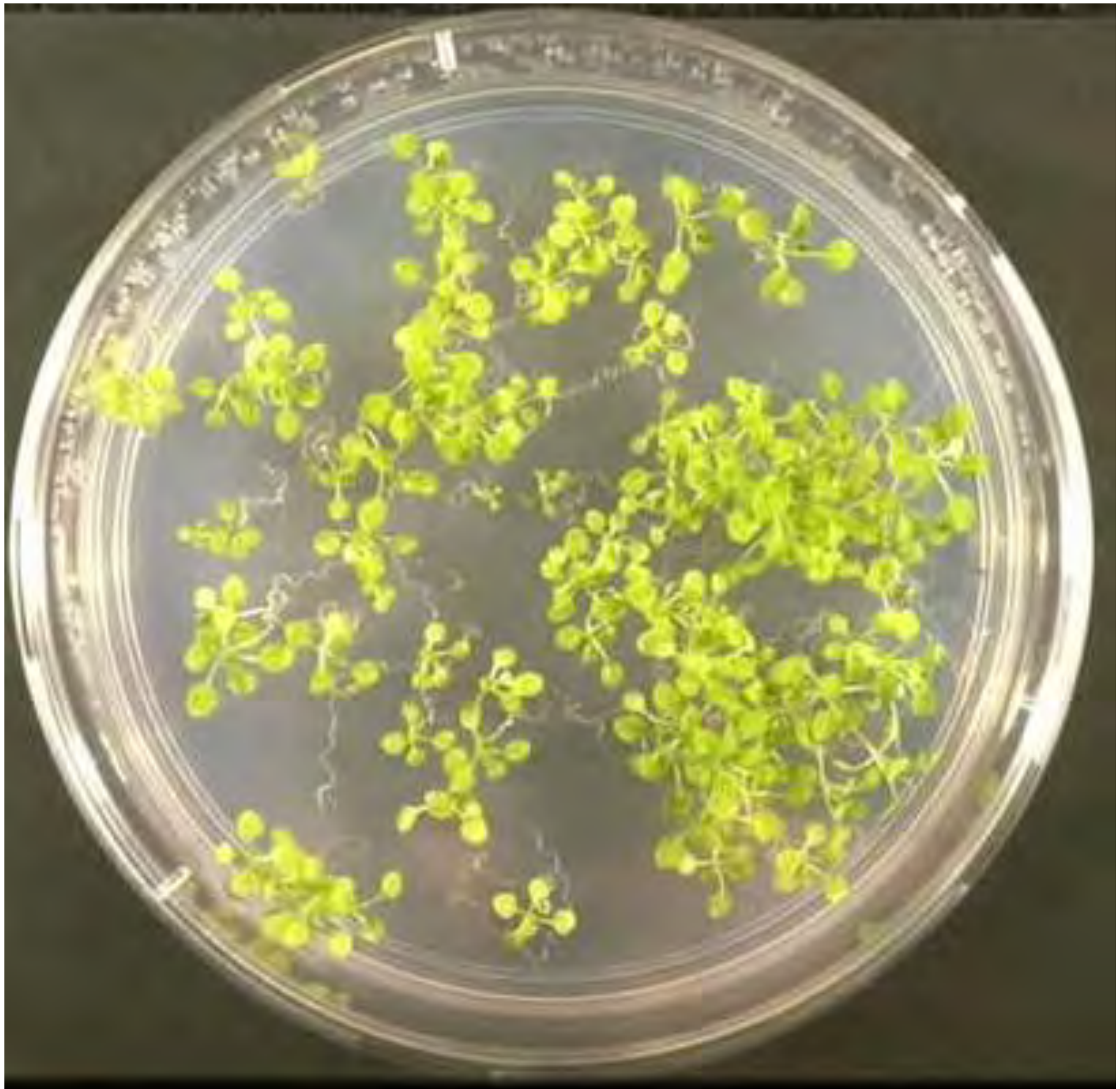
Deficiency diets based on MS medium (mmol)

Elemento	Óptimo	-N	-P	-K	-S	-Ca	-Mg
N	60	-	60	60	60	60	60
P	1,5	1,3	-	1,5	1,3	1,3	1,3
K	21,5	21,5	20	-	21,5	25	22
S	1,7	1,7	1,7	1,7	-	1,7	1,6
Ca	3	3	3	3	3	-	3
Mg	1,5	1,5	1,5	1,5	1,5	1,5	-
Fe	0,1	0,1	0,1	0,1	0,2	0,1	0,1
Cu	0,0001	0,0001	0,0001	0,0001	0,0001	0,0001	0,0001
Mo	0,001	0,001	0,001	0,001	0,001	0,001	0,001
Zn	0,03	0,03	0,03	0,03	0,03	0,03	0,03
B	0,1	0,1	0,1	0,1	0,1	0,1	0,1
Mn	0,1	0,1	0,1	0,1	0,1	0,1	0,1
I	0,003	0,003	0,003	0,003	0,003	0,003	0,003
Co	0,0001	0,0001	0,0001	0,0001	0,0001	0,0001	0,0001
Cl	6	26	6	6	7,5	6	6
Na	0,02	0,02	0,02	0,02	0,02	0,02	0,02

Excess diets based on MS medium (mmol)

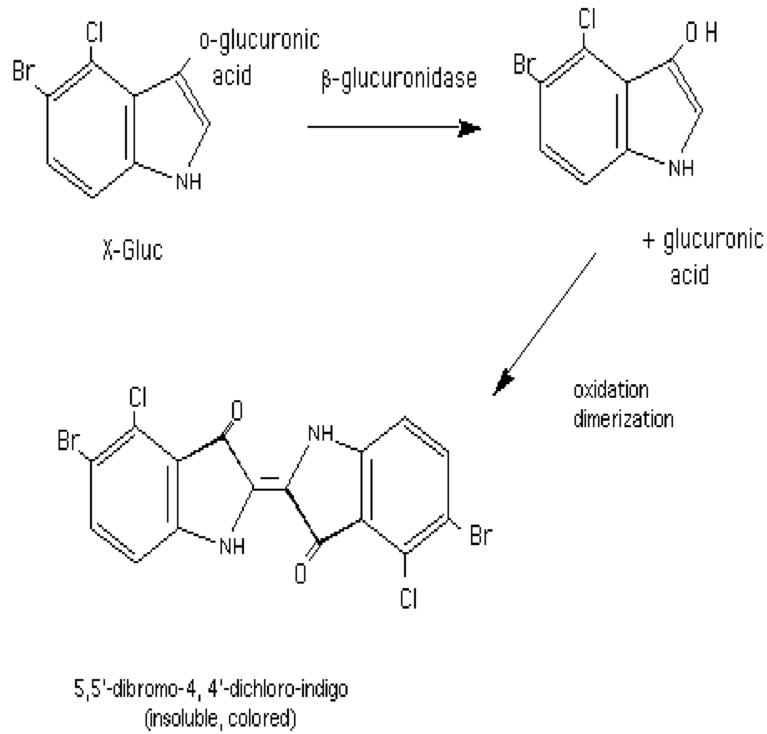
+N	+P	+K	+S	+Ca	+Mg
120	60	60	60	60	60
1,5	5	1,5	1,5	1,5	1,5
21,5	21,7	86	21,5	21,5	21,5
1,7	1,7	1,7	6,8	1,7	1,7
3	3	3	3	15	3
1,5	1,5	1,5	1,5	1,5	6
0,1	0,1	0,1	0,1	0,1	0,1
0,0001	0,0001	0,0001	0,0001	0,0001	0,0001
0,001	0,001	0,001	0,001	0,001	0,001
0,03	0,03	0,03	0,03	0,03	0,03
0,1	0,1	0,1	0,1	0,1	0,1
0,1	0,1	0,1	0,1	0,1	0,1
0,003	0,003	20	0,003	0,003	0,003
0,0001	0,0001	0,0001	0,0001	0,0001	0,0001
6	6	30	6	6	15
0,02	0,02	0,02	0,02	0,02	0,02

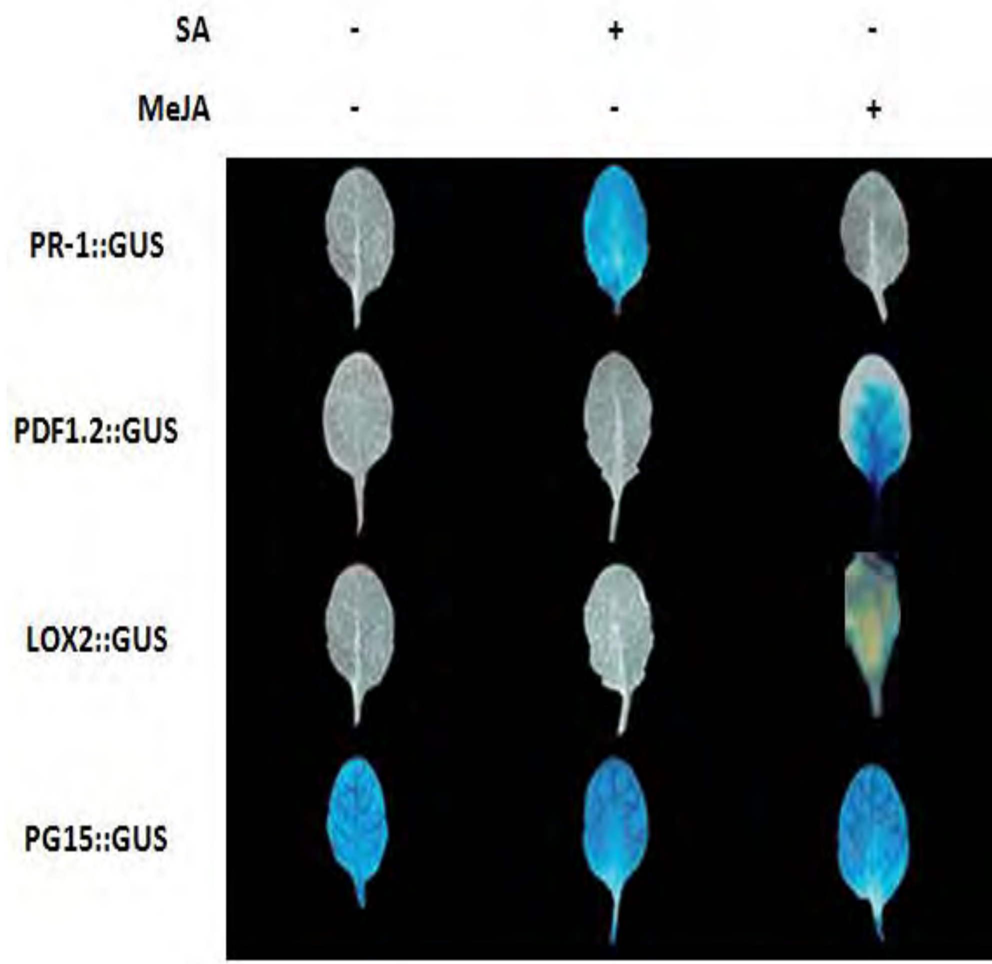
Invitro assay



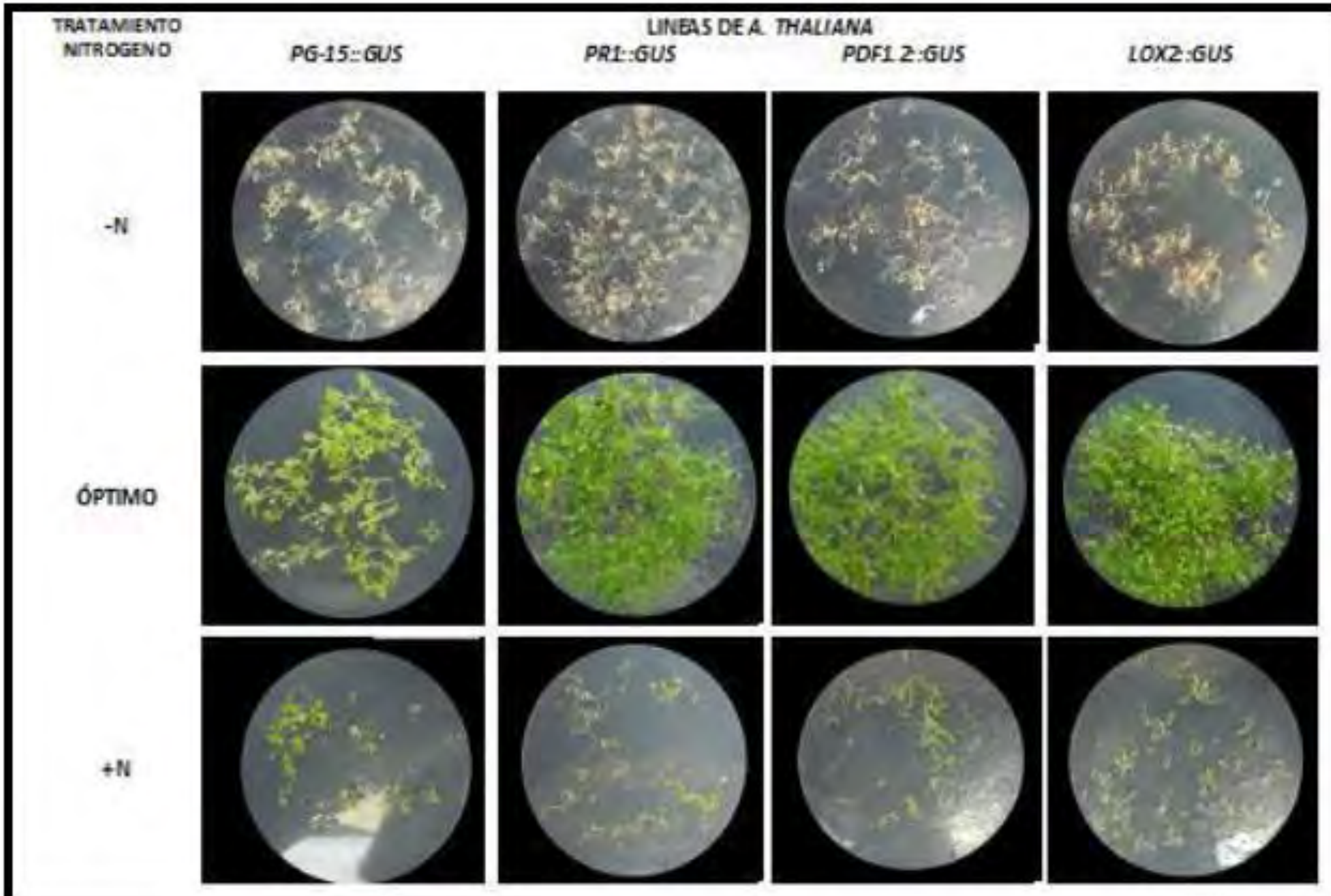
Invivo assay

HISTOCHEMICAL ASSAY GUS

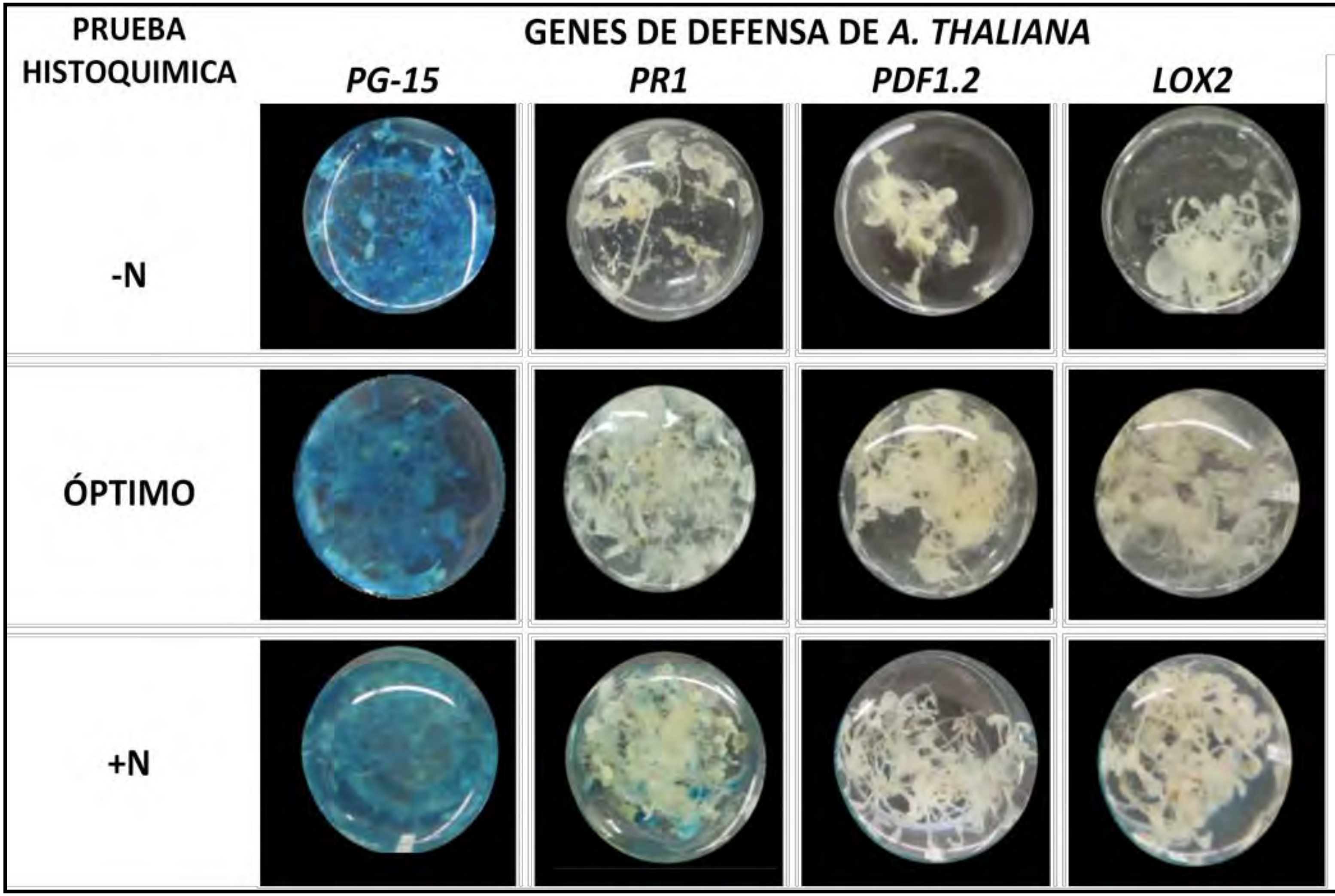




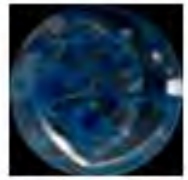
N and defense



NITROGEN

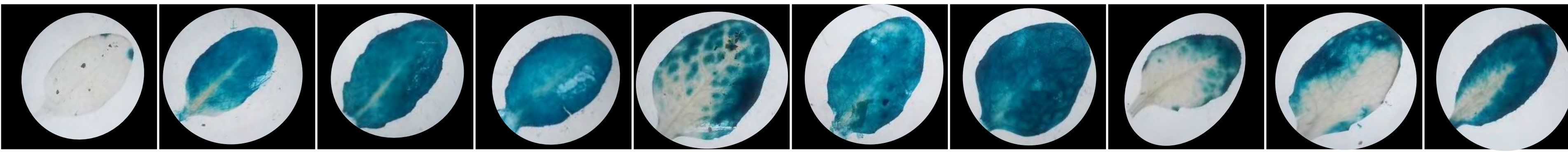

PRUEBA HISTOQUIMICA
GENES DE DEFENSA DE A. THALIANA
PG-15
PR1
PDF1.2
LOX2
-N
ÓPTIMO
+N

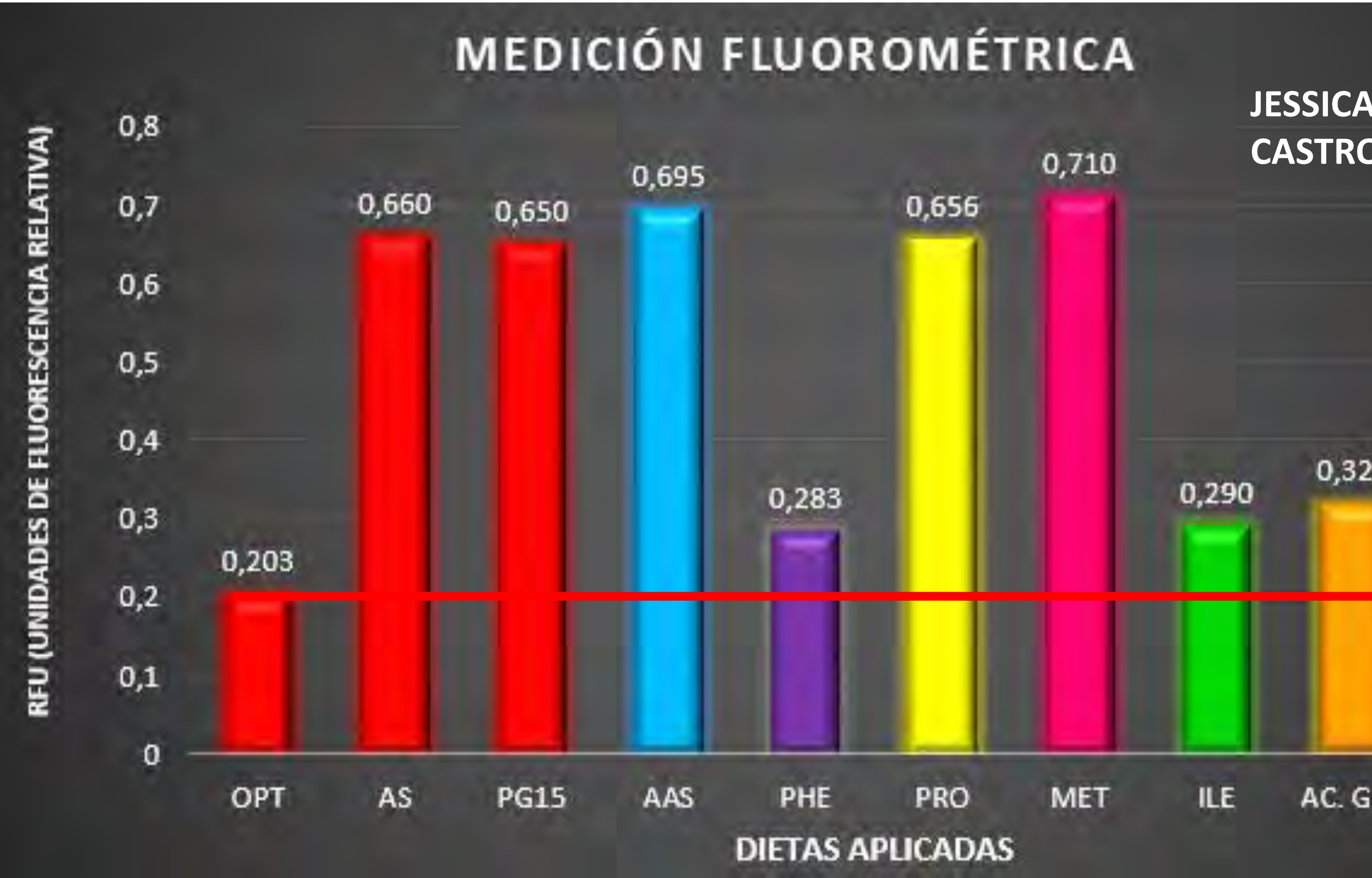
FORMS OF NITROGEN: NO3 & NH4

Tratamiento/Línea	PG-15	PR-1	PDF1.2	LOX2
T0 Control				
T1 100 NH_4^+ /0 NO_3^-				
T2 75 NH_4^+ / 25 NO_3^-				
T3 50 NH_4^+ / 50 NO_3^-				
T4 25 NH_4^+ / 75 NO_3^-				
T5 0 NH_4^+ / 100 NO_3^-				

DIETAS A BASE DE AMINOÁCIDOS

OPT	AS	PG15	AAS	PHE	PRO	MET	ILE	AC.GLU	GLI





JESSICA
CASTRO

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Journal of Experimental Botany
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RESEARCH PAPER

The form of nitrogen nutrition affects resistance against *Pseudomonas syringae* pv. *phaseolicola* in tobacco

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Abstract

Different forms of nitrogen (N) fertilizer affect disease development; however, this study investigated the effects of N forms on the hypersensitivity response (HR)—a pathogen-elicited cell death linked to resistance. HR-eliciting *Pseudomonas syringae* pv. *phaseolicola* was infiltrated into leaves of tobacco fed with either NO_3^- or NH_4^+. The speed of cell death was faster in NO_3^--fed compared with NH_4^+-fed plants, which correlated, respectively, with increased and decreased resistance. Nitric oxide (NO) can be generated by nitrate reductase (NR) to influence the formation of the HR. NO generation was reduced in NH_4^+-fed plants where N assimilation bypassed the NR step. This was similar to that elicited by the disease-forming *P. syringae* pv. *tabaci* strain, further suggesting that resistance was compromised with NH_4^+ feeding. *PR1a* is a biomarker for the defence signal salicylic acid (SA), and expression was reduced in NH_4^+-fed compared with NO_3^- fed plants at 24 h after inoculation. This pattern correlated with actual SA measurements. Conversely, total amino acid, cytosolic and apoplastic glucose/fructose and sucrose were elevated in NH -treated plants. Gas chromatography/mass spectroscopy was used to characterize metabolic events following different N treatments. Following NO_3^- nutrition, polyamine biosynthesis was predominant, whilst after NH_4^+ nutrition, flux appeared to be shifted towards the production of 4-aminobutyric acid. The mechanisms whereby NO_3^- feeding enhances SA, NO, and polyamine-mediated HR-linked defence whilst these are compromised with NH_4^+, which also increases the availability of nutrients to pathogens, are discussed.

Key words: ammonium, hypersensitive response, nitrate, nitric oxide, Pseudomonas, tobacco.

Formas de nitrógeno y su efecto en la defensa

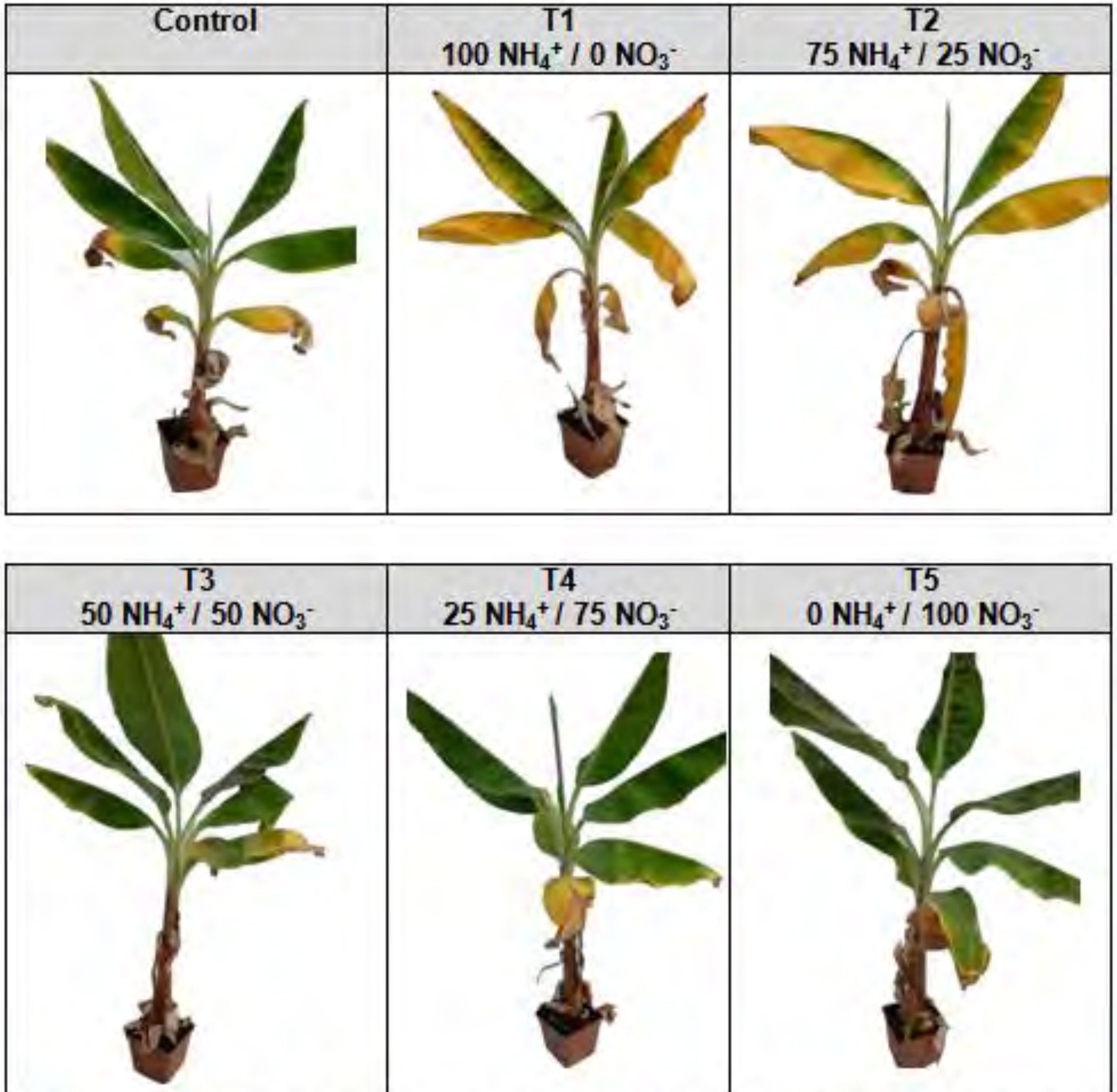
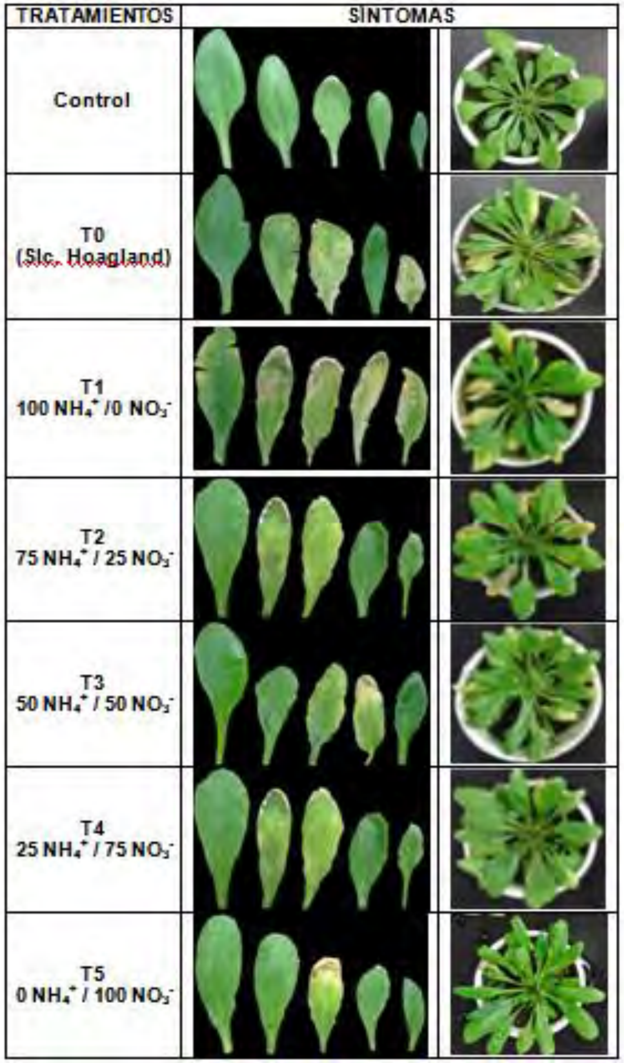
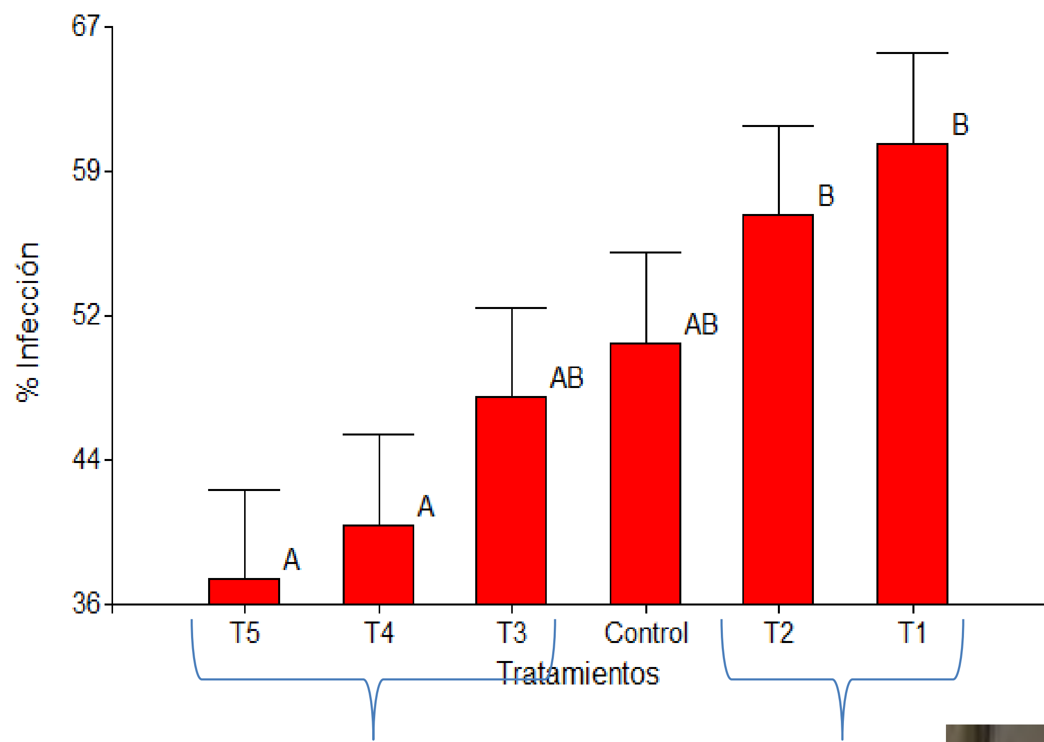


Figura 3.1 Plantas de banano (*Musa paradisiaca*) bajo la influencia de los tratamientos con diferentes proporciones de NH_4^+ y NO_3^-.

Forms of Nitrogen againts *Pst*



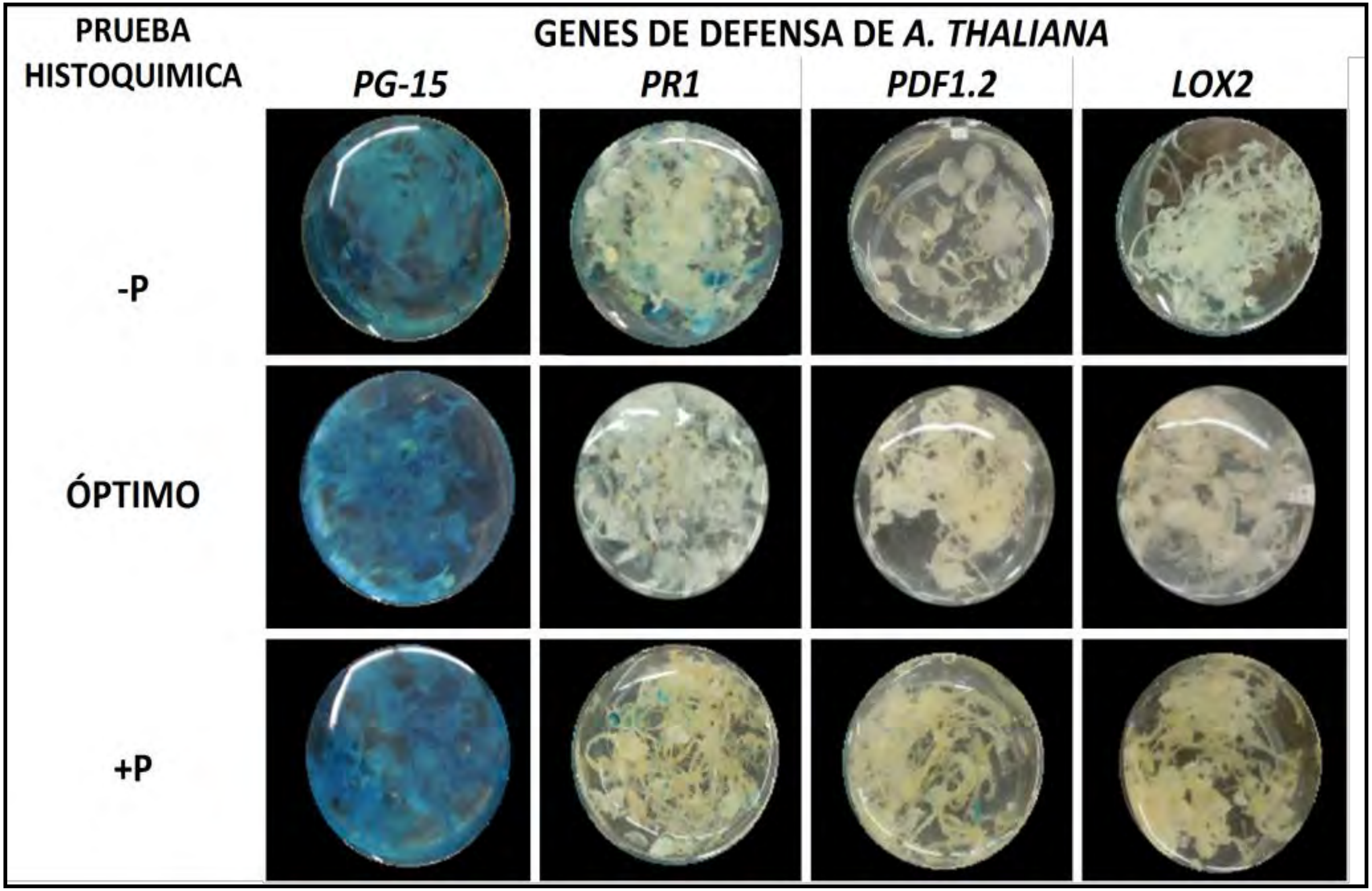


More NO3

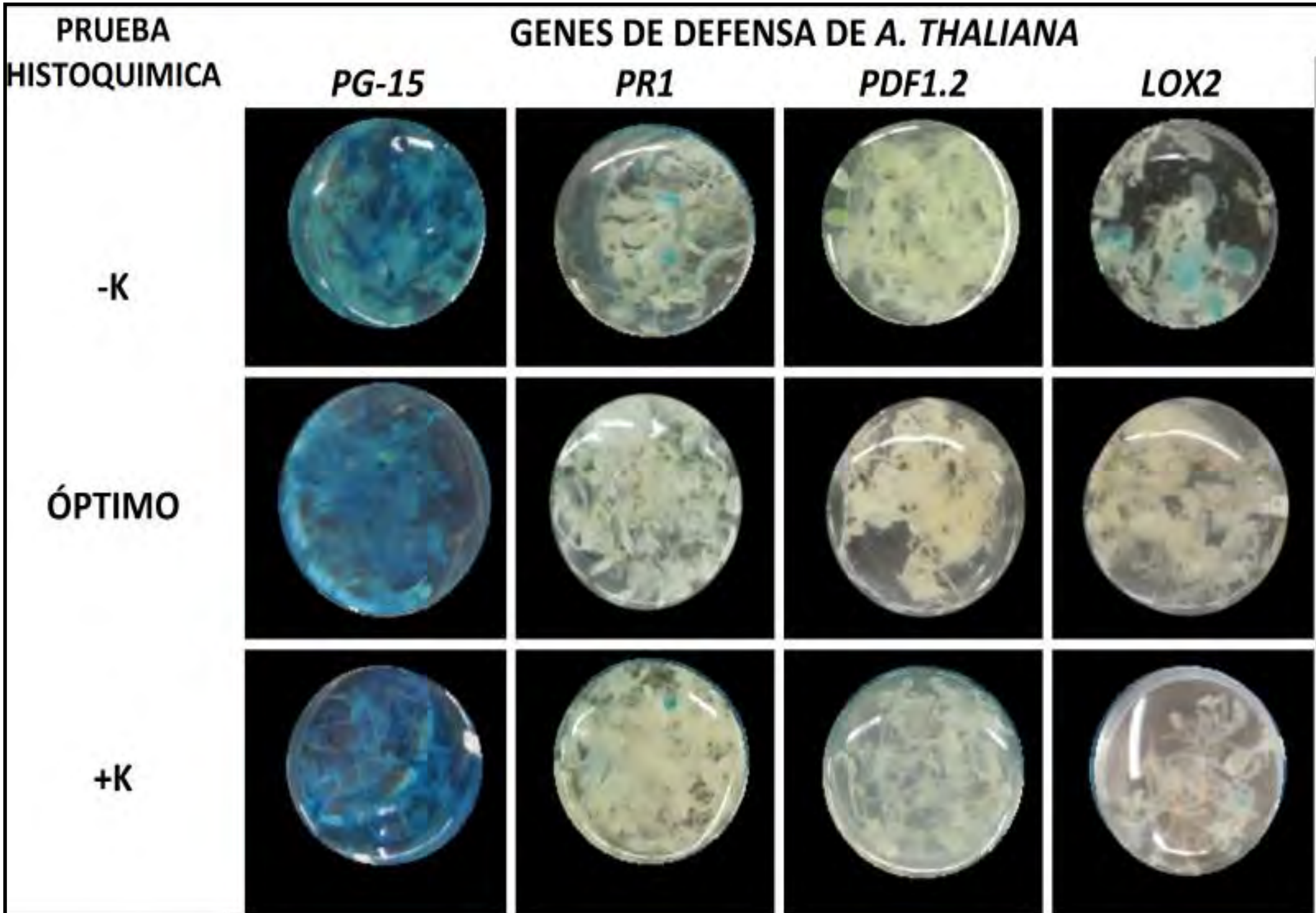
More NH4

Ivan Astudillo

Phosphorus and defense



Potasium and defense



Troufflard et al. BMC Plant Biology 2010, 10:172
http://www.biomedcentral.com/1471-2229/10/172

BMC Plant Biology

RESEARCH ARTICLE Open Access

Potassium deficiency induces the biosynthesis of oxylipins and glucosinolates in *Arabidopsis thaliana*

Stephanie Troufflard[1], William Mullen[1], Tony R Larson[2], Ian A Graham[2], Alan Crozier[1], Anna Amtmann[1*], Patrick Armengaud[1,3]

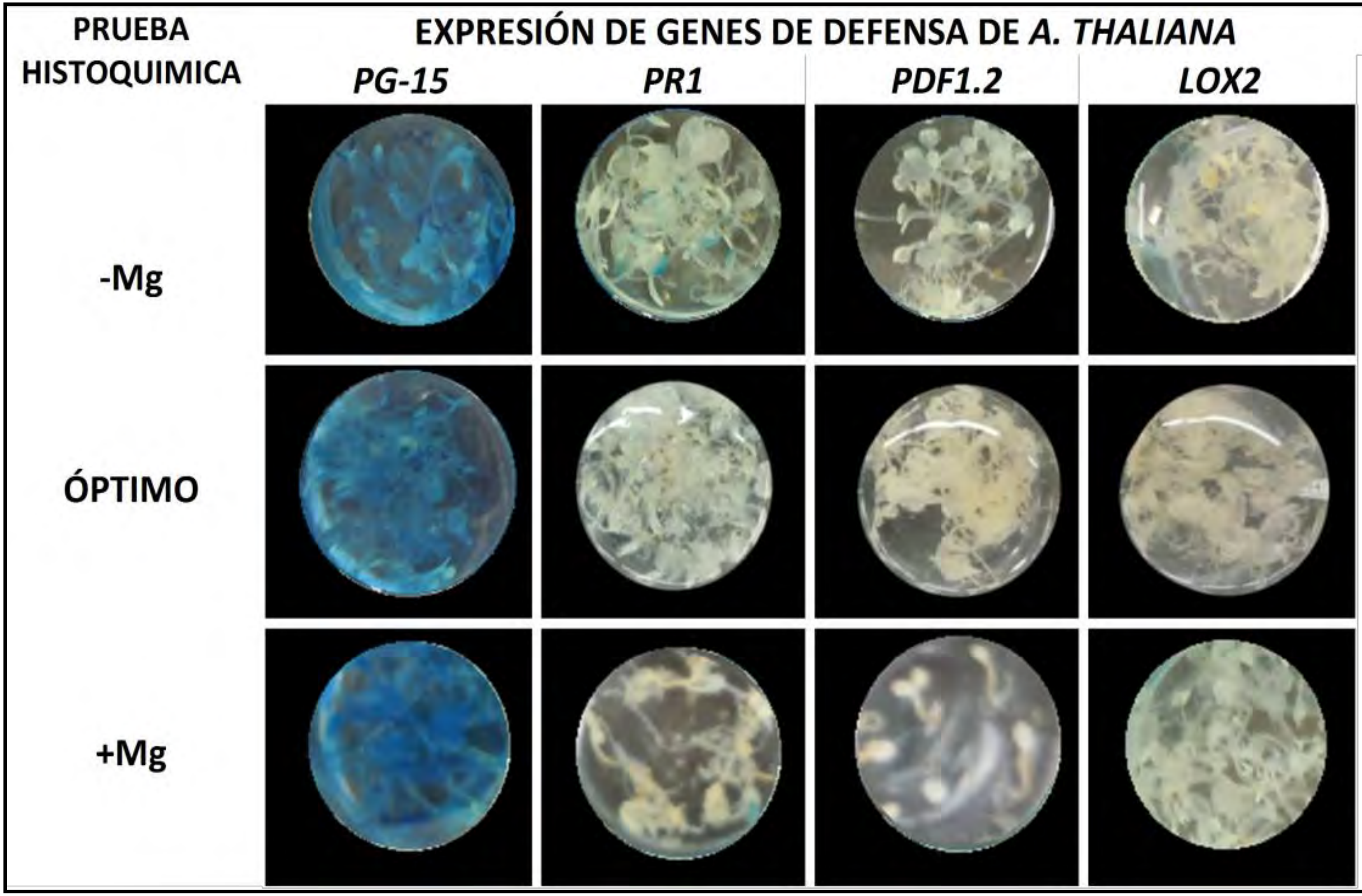
Abstract

Background: Mineral fertilization and pest control are essential and costly requirements for modern crop production. The two measures go hand in hand because plant mineral status affects plant susceptibility to pests and *vice versa*. Nutrient deficiency triggers specific responses in plants that optimize nutrient acquisition and reprogram metabolism. K-deficient plants illustrate these strategies by inducing high-affinity K-uptake and adjusting primary metabolism. Whether and how K deficient plants also alter their secondary metabolism for nutrient management and defense is not known.

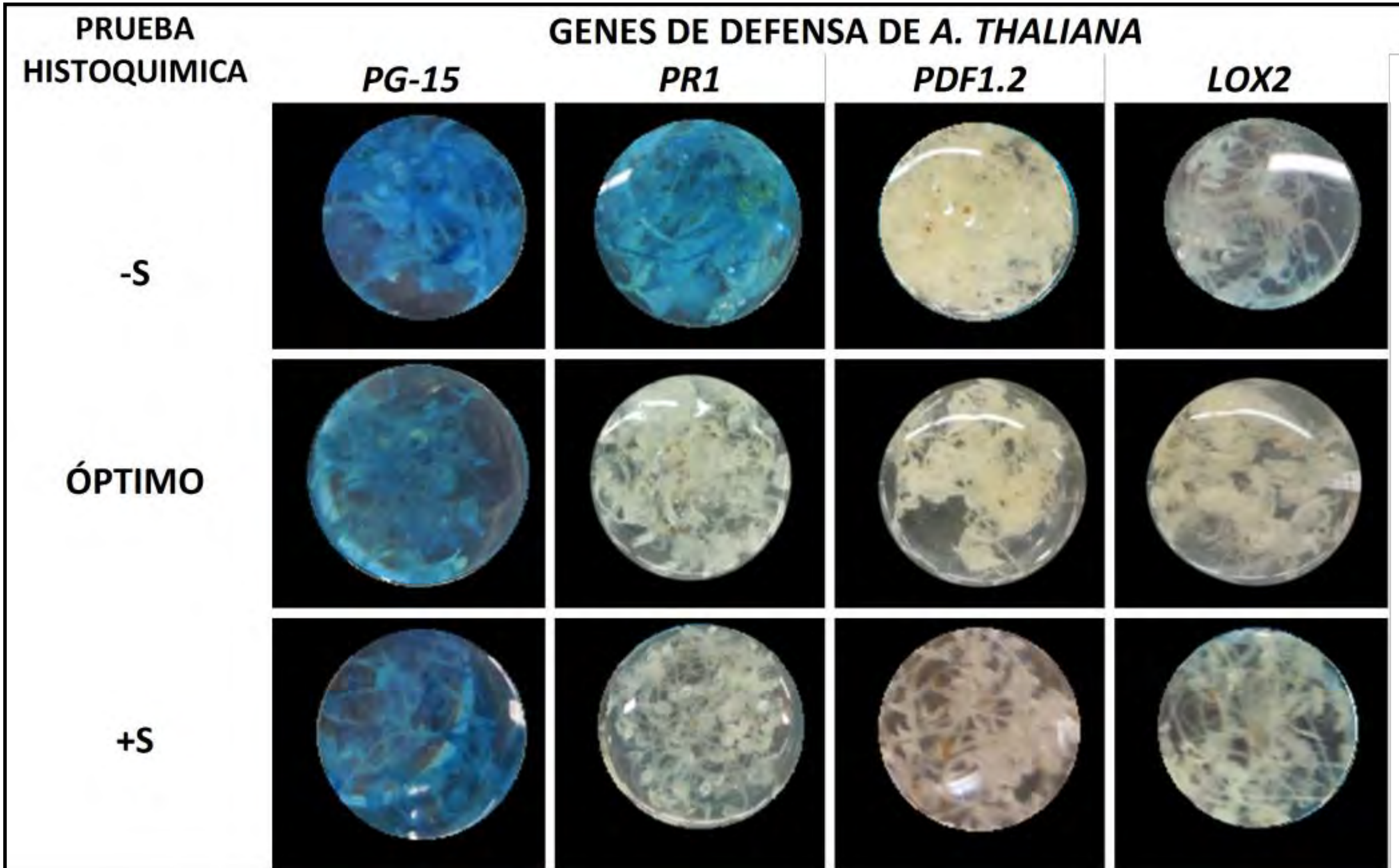
Results: Here we show that K-deficient plants contain higher levels of the phytohormone jasmonic acid (JA), hydroxy-12-oxo-octadecadienoic acids (HODs) and 12-oxo-phytodienoic acid (OPDA) than K-sufficient plants. Up-regulation of the 13-LOX pathway in response to low K was evident in increased transcript levels of several biosynthetic enzymes. Indole and aliphatic glucosinolates accumulated in response to K-deficiency in a manner that was respectively dependent or independent on signaling through Coronatine-Insensitive 1 (COI1). Transcript and glucosinolate profiles of K-deficient plants resembled those of herbivore attacked plants.

Conclusions: Based on our results we propose that under K-deficiency plants produce oxylipins and glucosinolates to enhance their defense potential against herbivorous insects and create reversible storage for excess S and N.

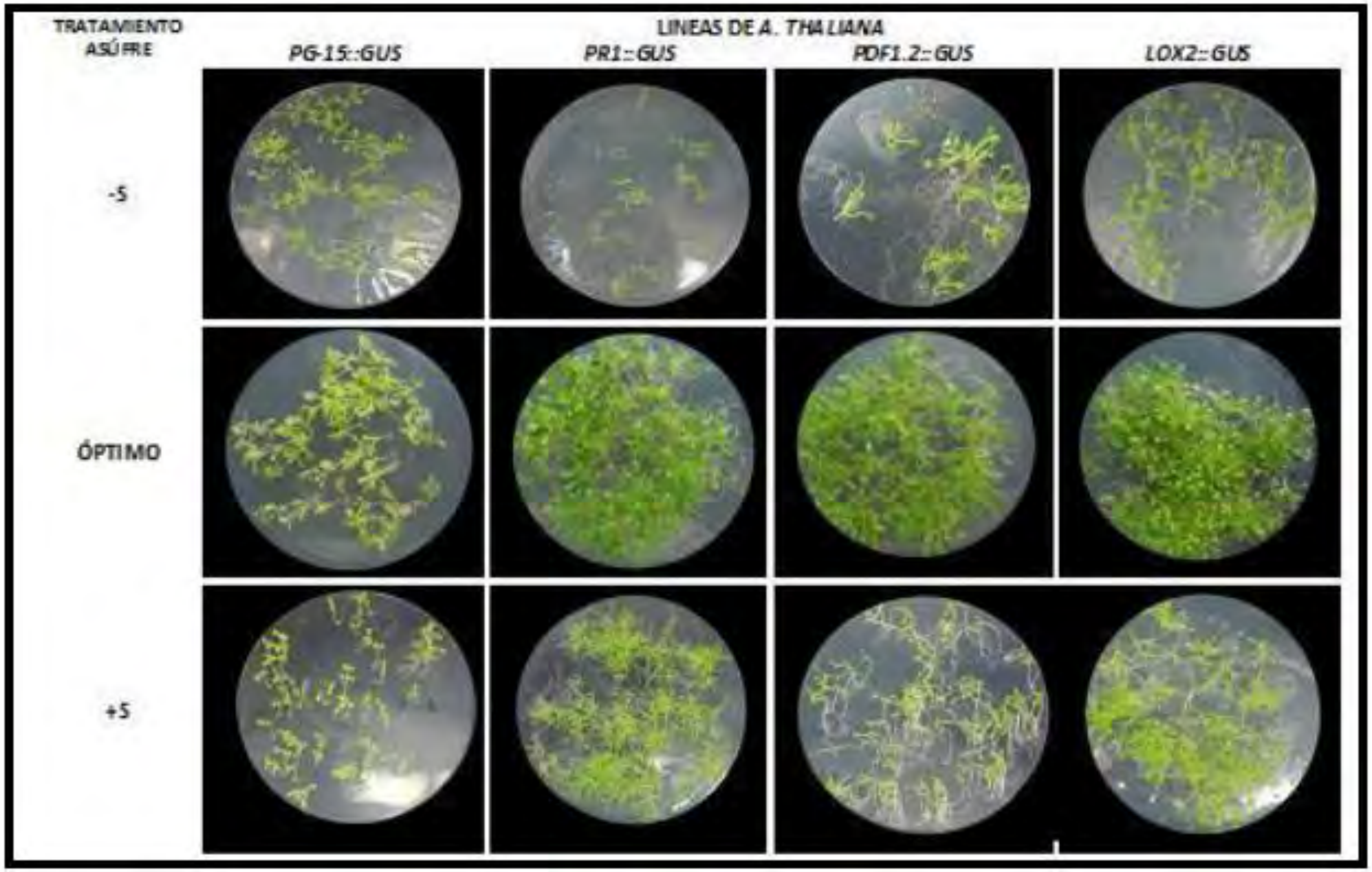
Magnesium and defense

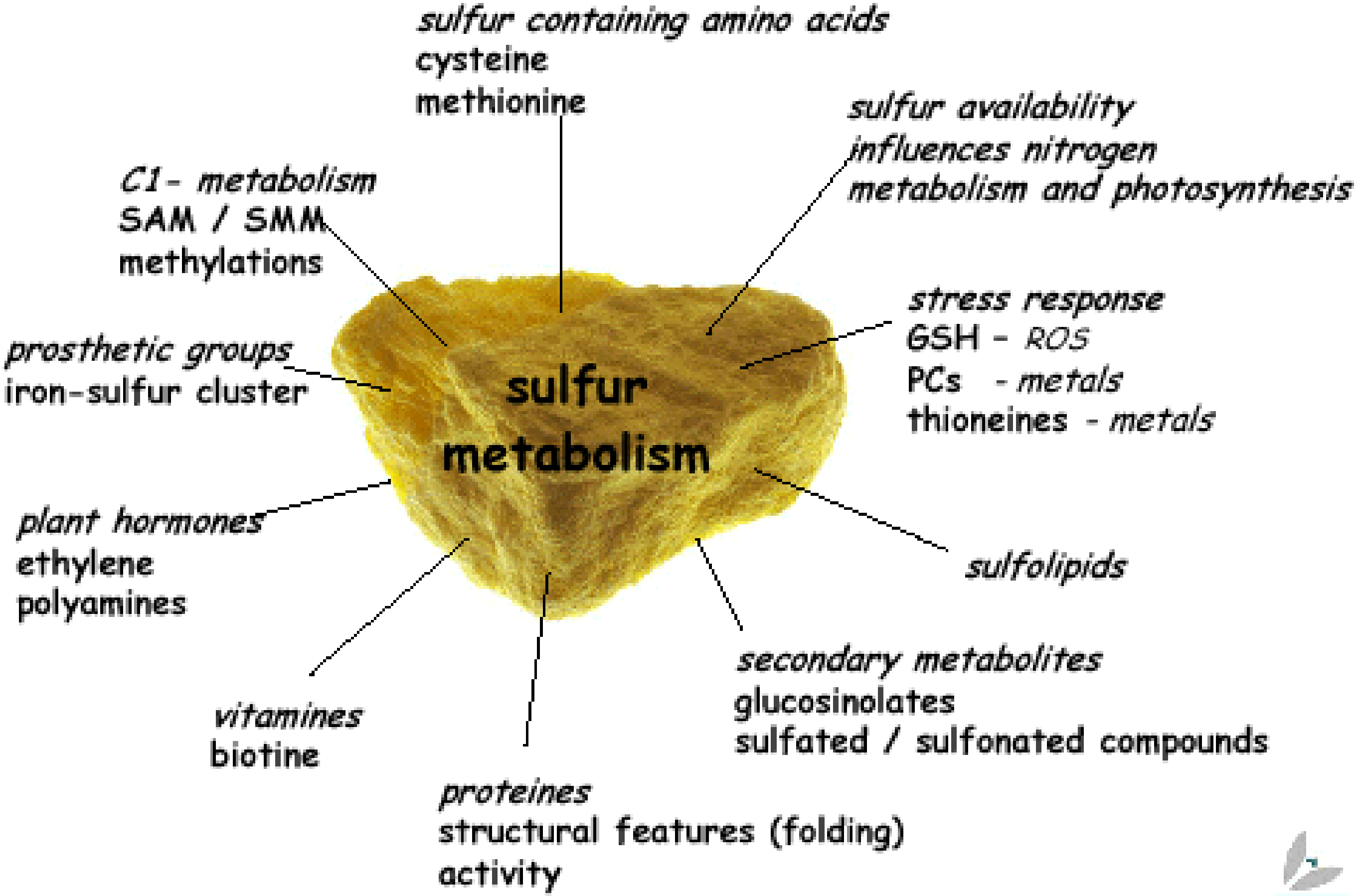


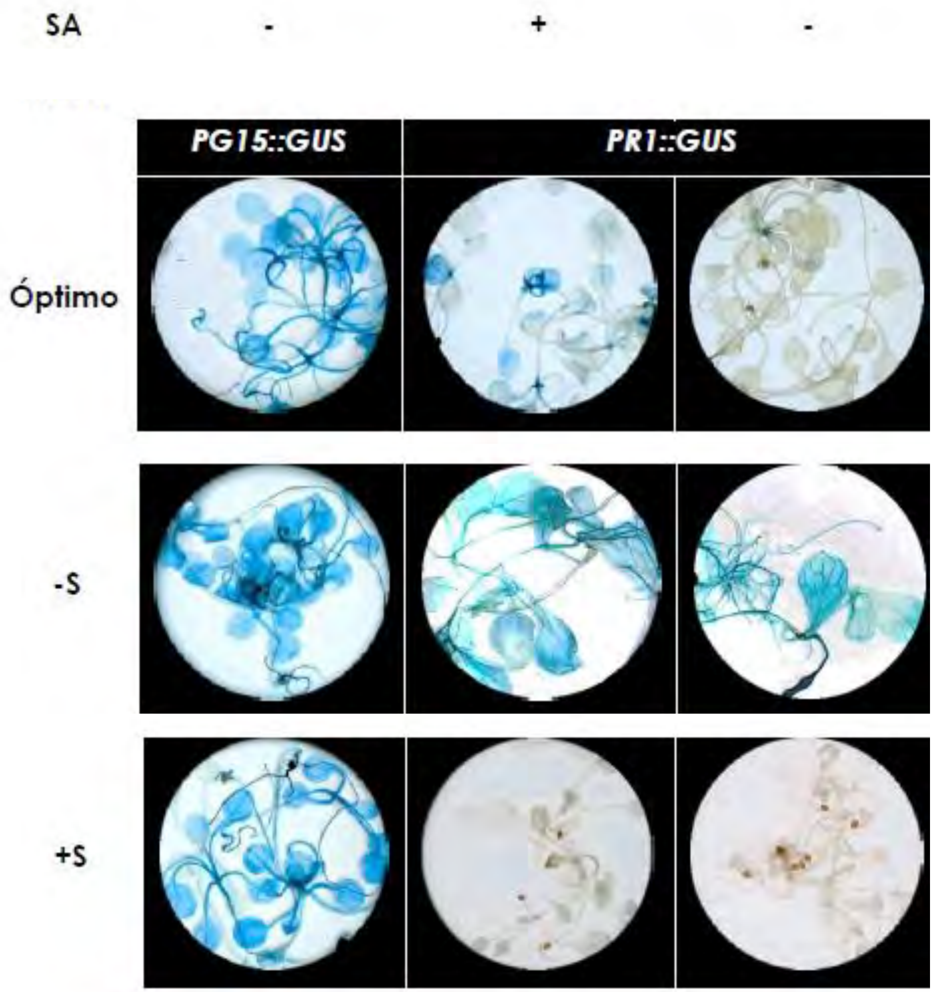
Sulphur and defense

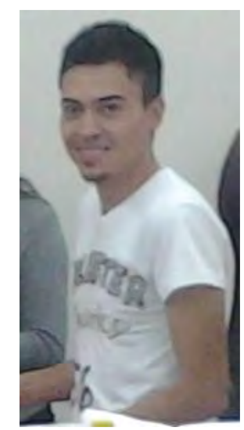


Sulphur and defense



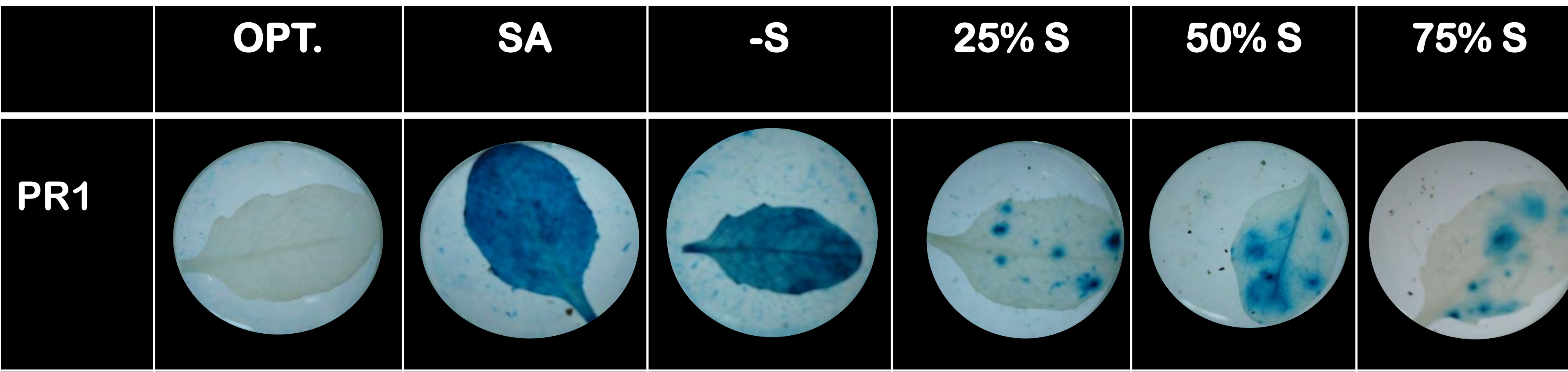

sulfur containing amino acids
cysteine
methionine
sulfur availability
influences nitrogen
metabolism and photosynthesis
C1- metabolism
SAM / SMM
methylations
stress response
GSH - ROS
PCs - metals
thioneines - metals
prosthetic groups
iron-sulfur cluster
sulfur
metabolism
plant hormones
ethylene
polyamines
sulfolipids
secondary metabolites
glucosinolates
sulfated / sulfonated compounds
vitamines
biotine
proteines
structural features (folding)
activity





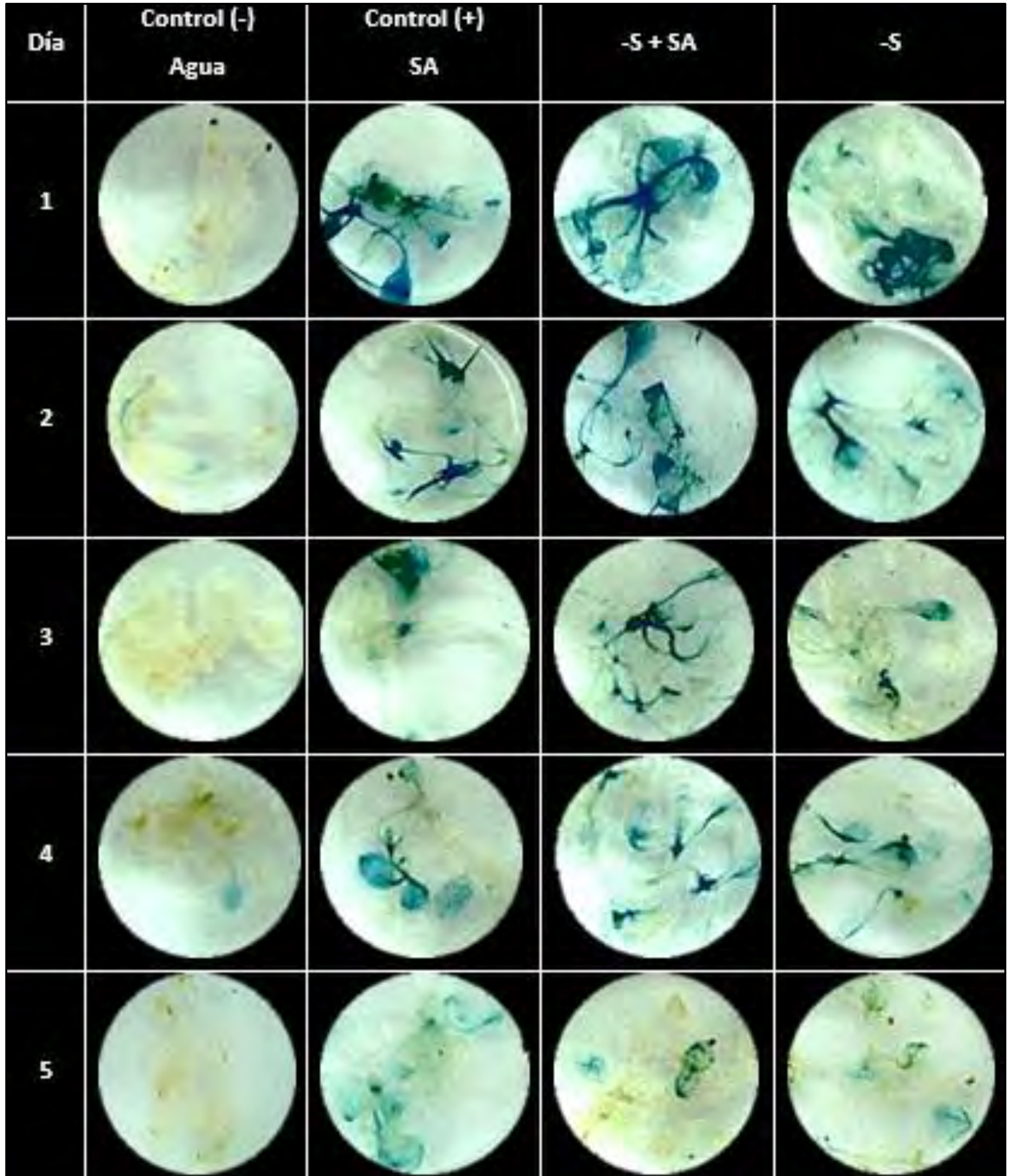
Steve Criollo

Expression of PR1 in sulphur diets

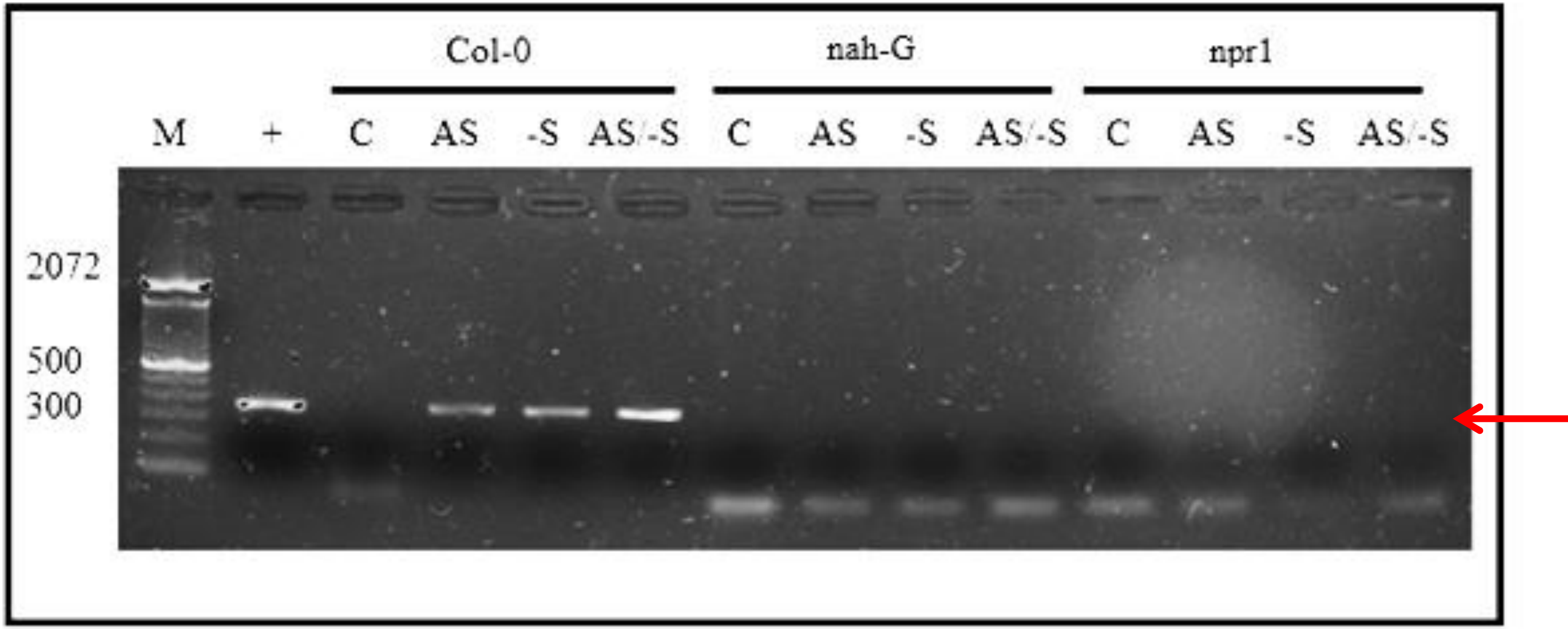


Victor Gonzalez

PR1 after 1 day to be transfered to –S diet

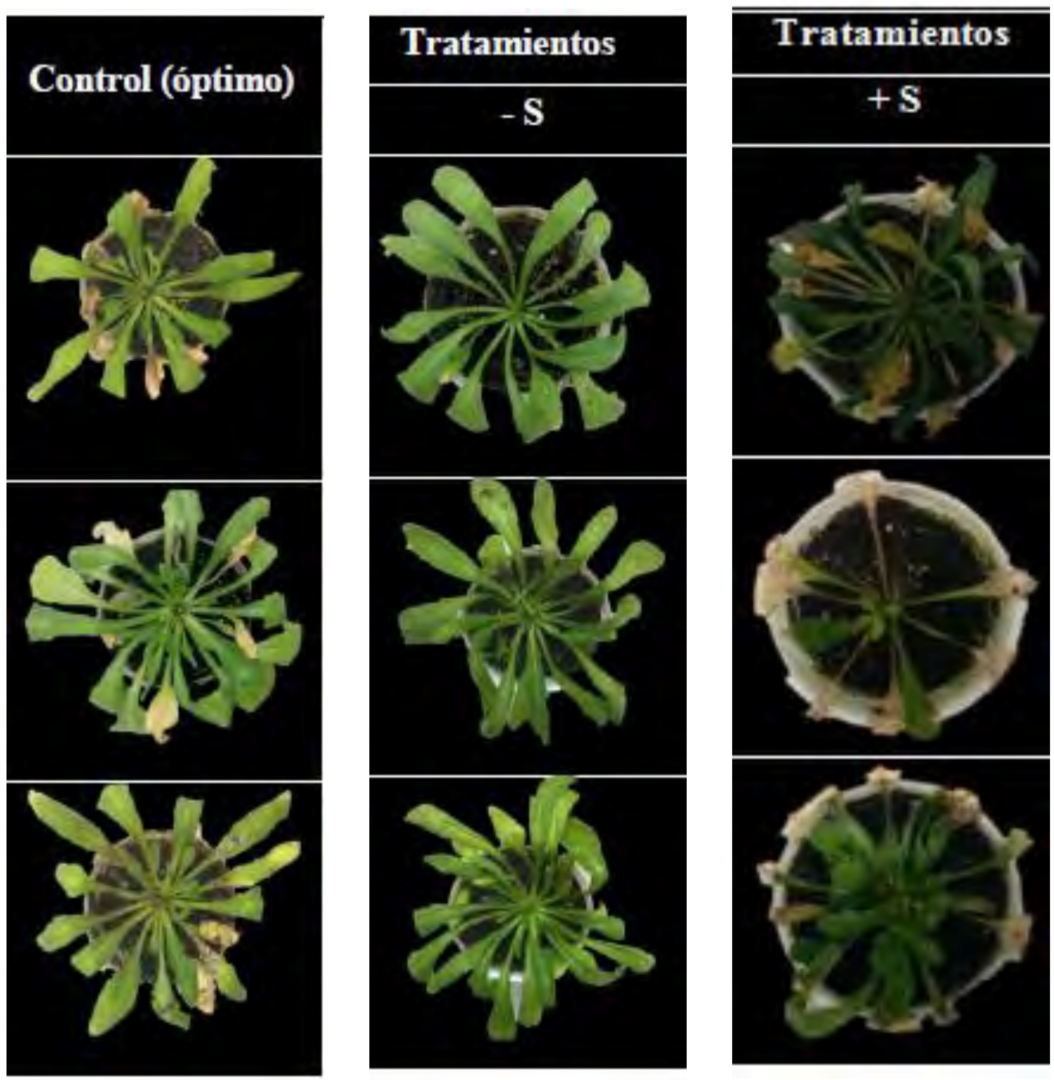


RT-PCR analysis with PR1 marker gene in plants deficient in SA



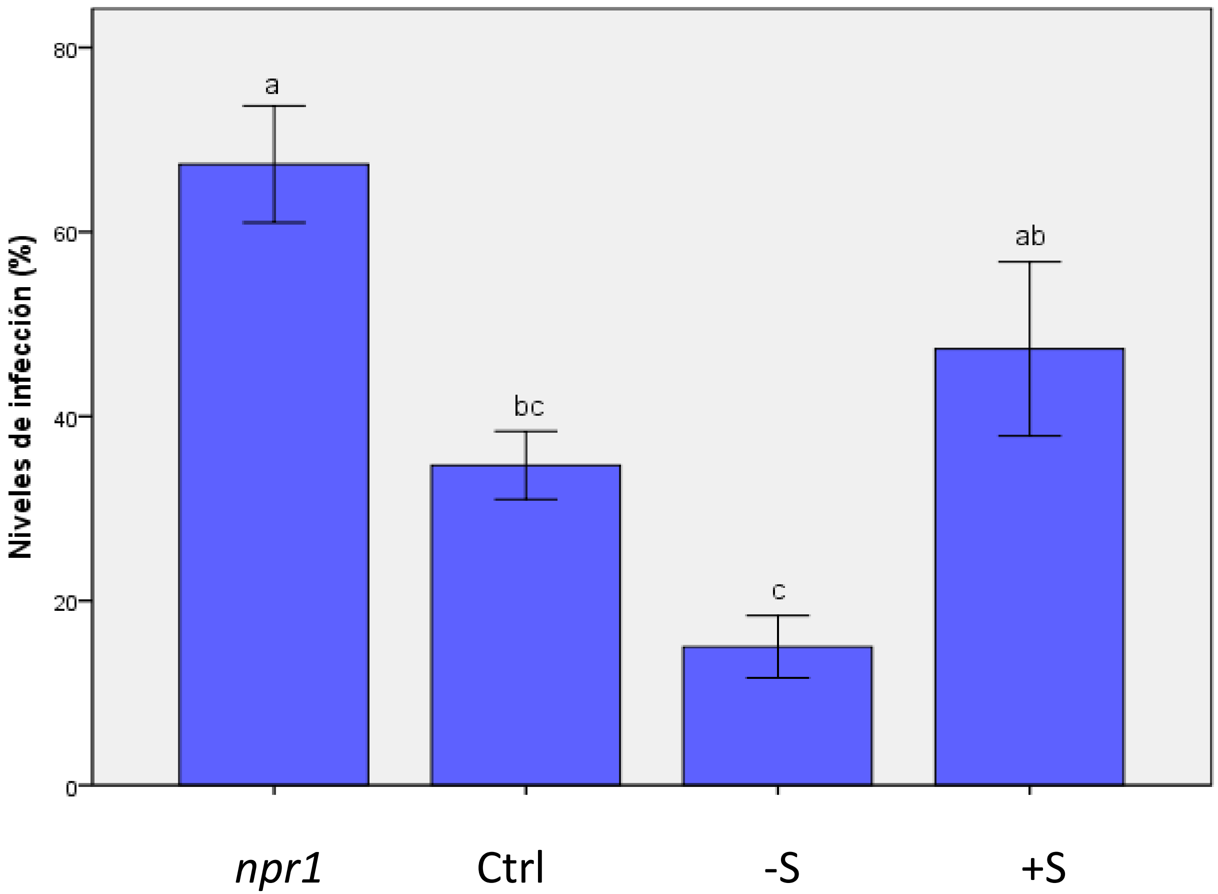
Martin Jiménez

Bioassay with *Pst* DC3000 in sulphur diets



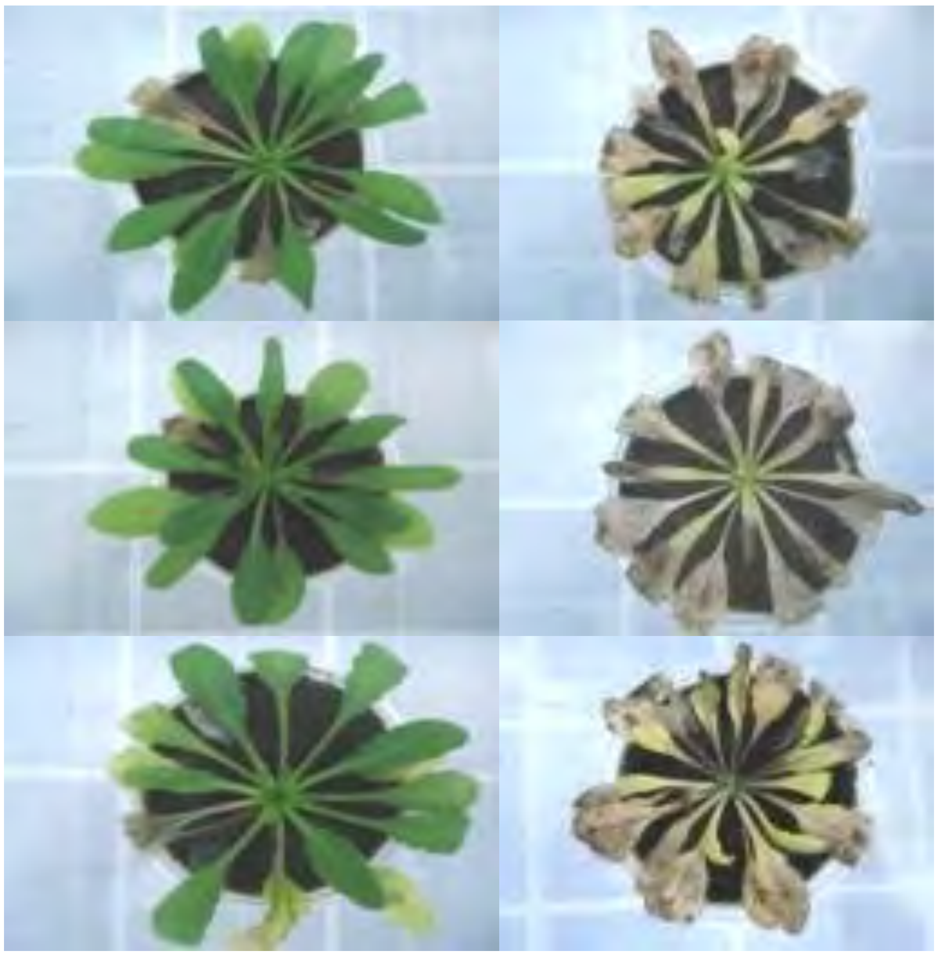
Steve Criollo

S and plant resistance against *Pst* DC3000

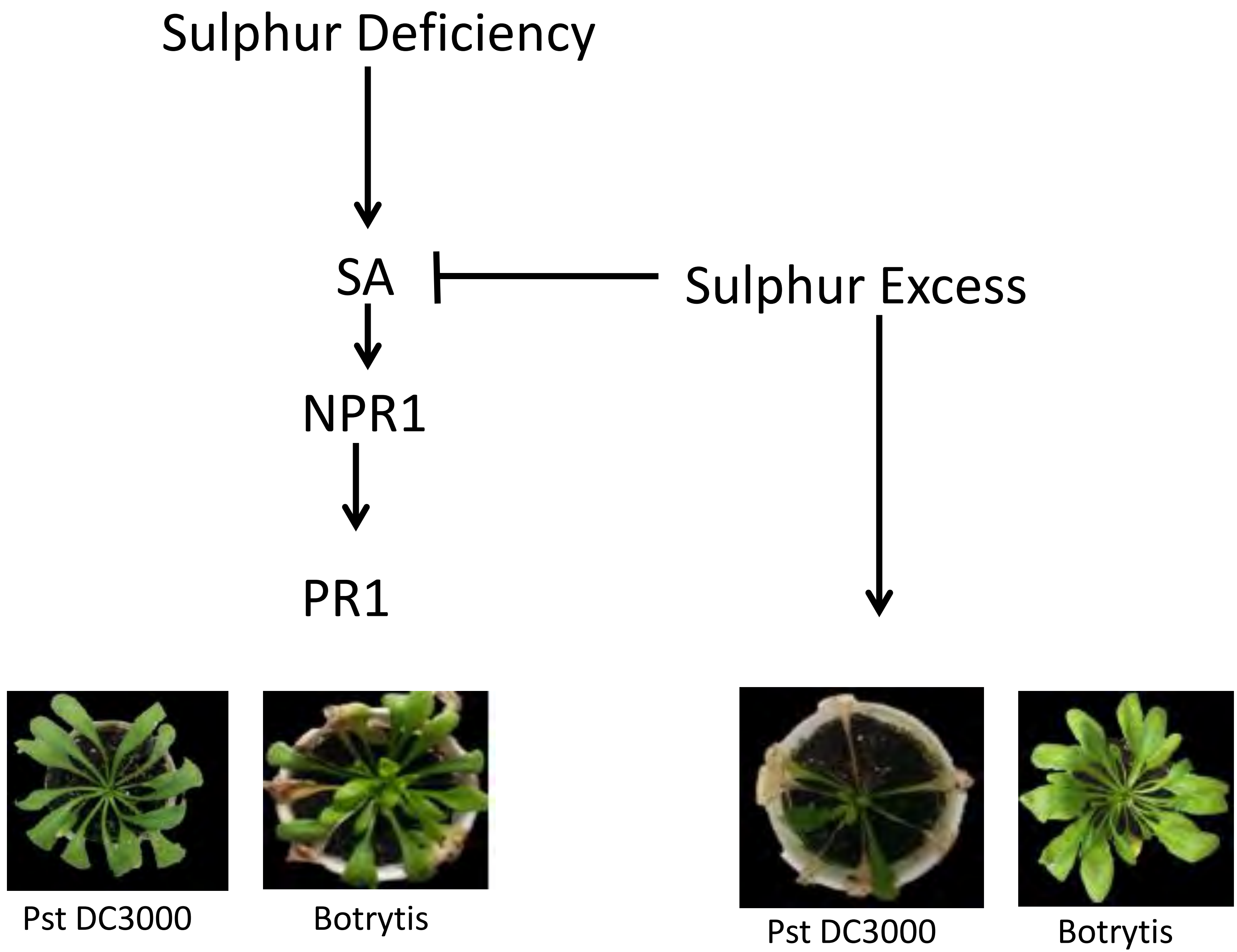


Sulphur and *Botrytis* resistance

CTRL -S

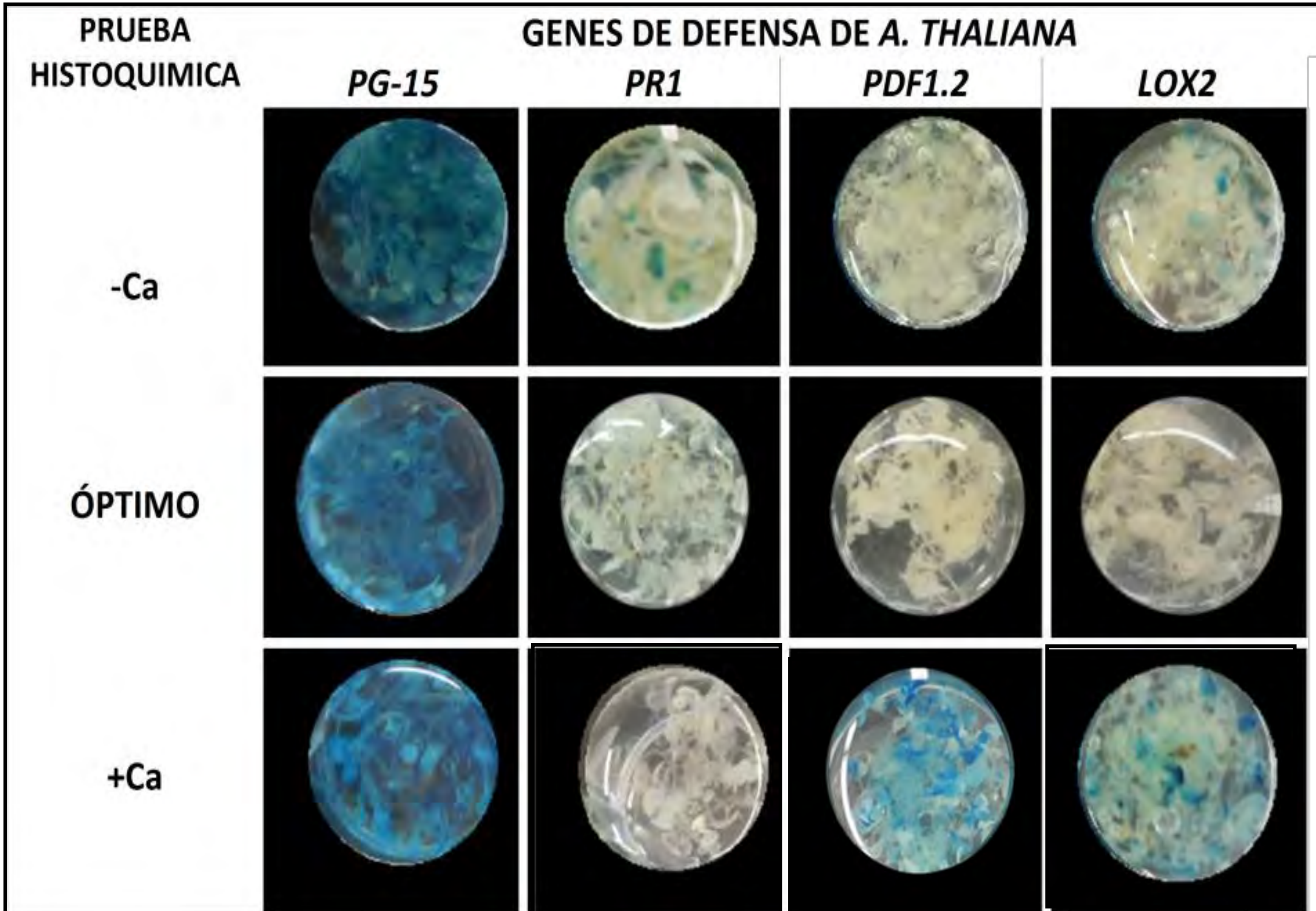


Victor Gonzalez

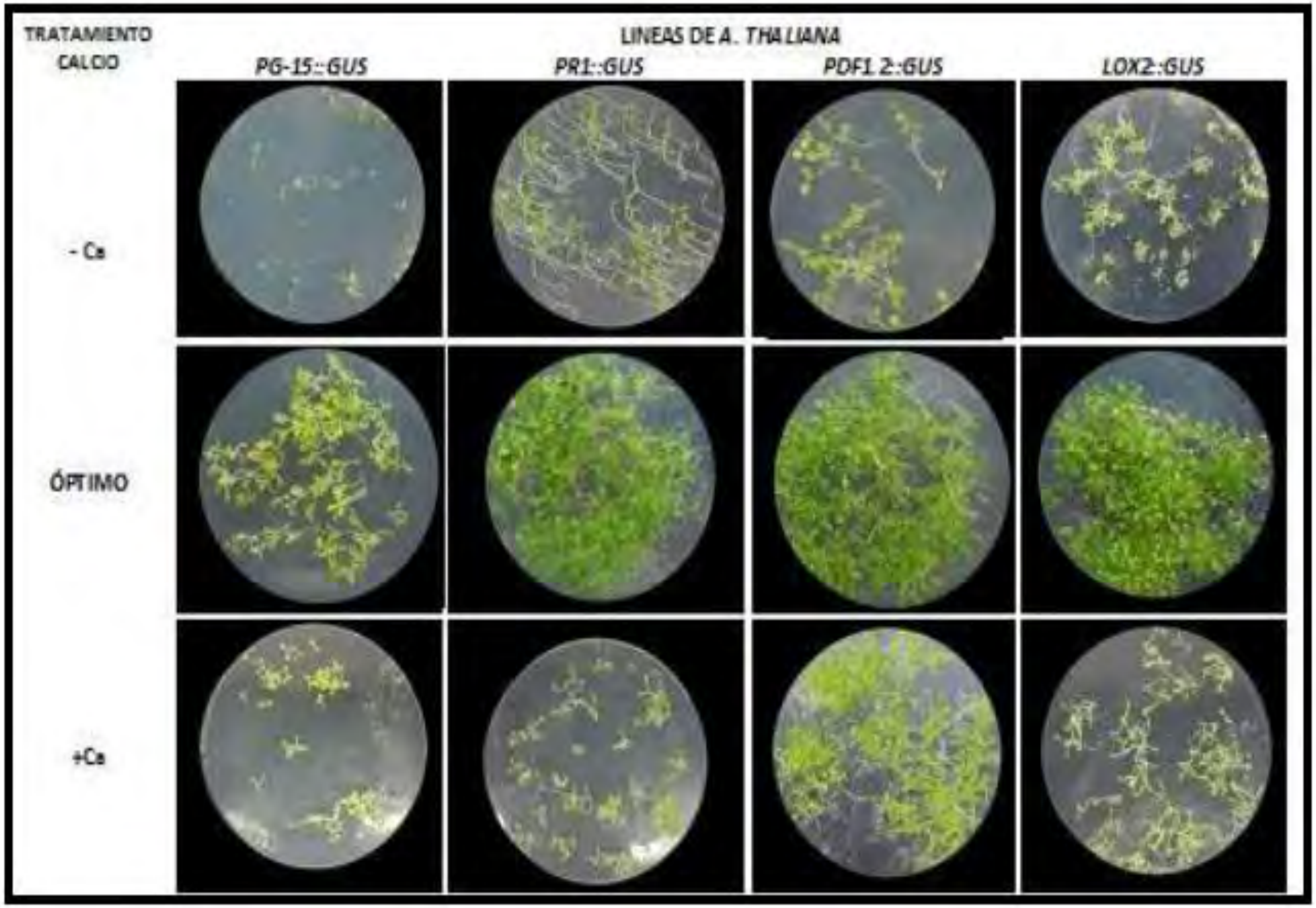


Sulphur Deficiency
SA
Sulphur Excess
NPR1
PR1
Pst DC3000
Botrytis
Pst DC3000
Botrytis

Calcium and defense



Calcium and defense



Roles of Calcium in Plants

Calcium is an essential plant nutrient. It has many roles:

Participates in metabolic processes of other nutrients uptake.

Promotes proper plant cell elongation.

Strengthen cell wall structure - calcium is an essential part of plant cell wall. It forms calcium pectate compounds which give stability to cell walls and bind cells together.

Participates in enzymatic and hormonal processes.

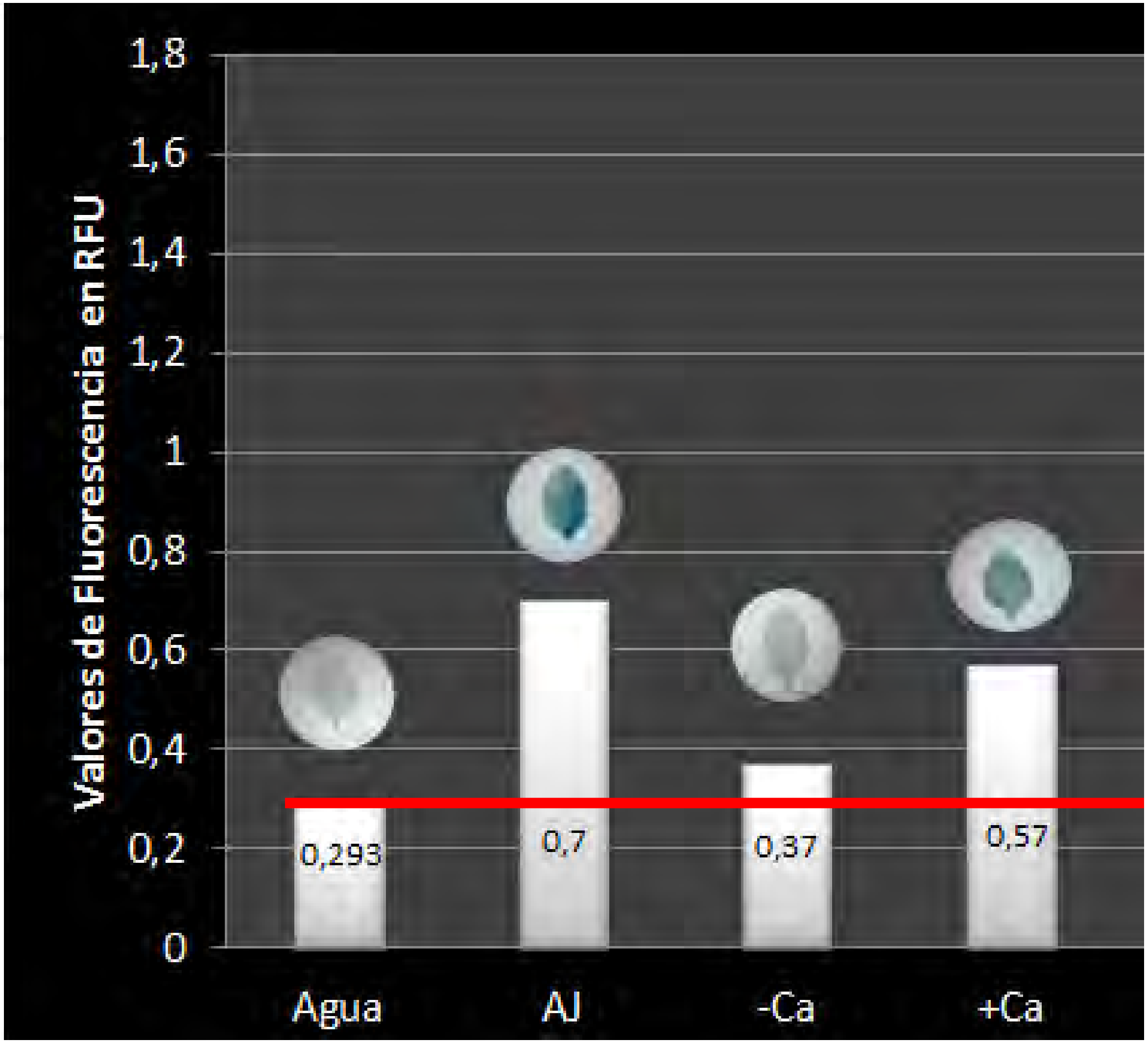
Helps in protecting the plant against heat stress - calcium improves stomata function and participates in induction of heat shock proteins.

Helps in protecting the plant against diseases - numerous fungi and bacteria secret enzymes which impair plant cell wall. Stronger Cell walls, induced by calcium, can avoid the invasion.

Affects fruit quality.

Has a role in the regulation of the stomata.

Gus activity with PDF1.2::GUS y con QPCR



Daniela G

Leidy Borja

POSTER #42

OVERVIEW OF TREATMENTS

Planting
Col-0 or *coi1-21*
(substrate: sand)

8 weeks

Per week: 2 times water and 1 time Hoagland

Nutrient rinse
mQ water used to remove nutrient residues.
(Flush EC <0,3 mS)

3 days

Application of diets
MS, HA or Ca

1 day

Harvesting
tissue for RNA extraction

6 day

Harvesting
tissue for RNA extraction

MS: Murashige and Skoog nutrient diet
HA: Hoagland nutrient diet
Ca: Diets with different concentration of calcium.

Control +++Ca

Ca and *Botrytis* resistance

(mutant pad3)

-Ca +Ca

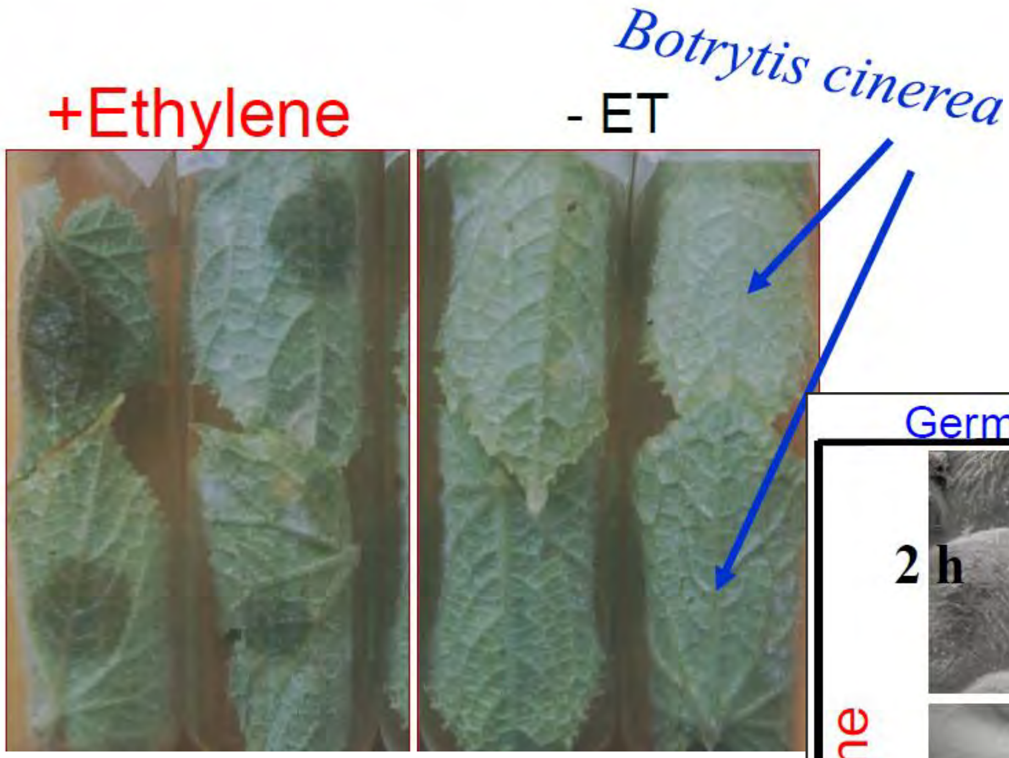
Ca and *Pst* DC 3000

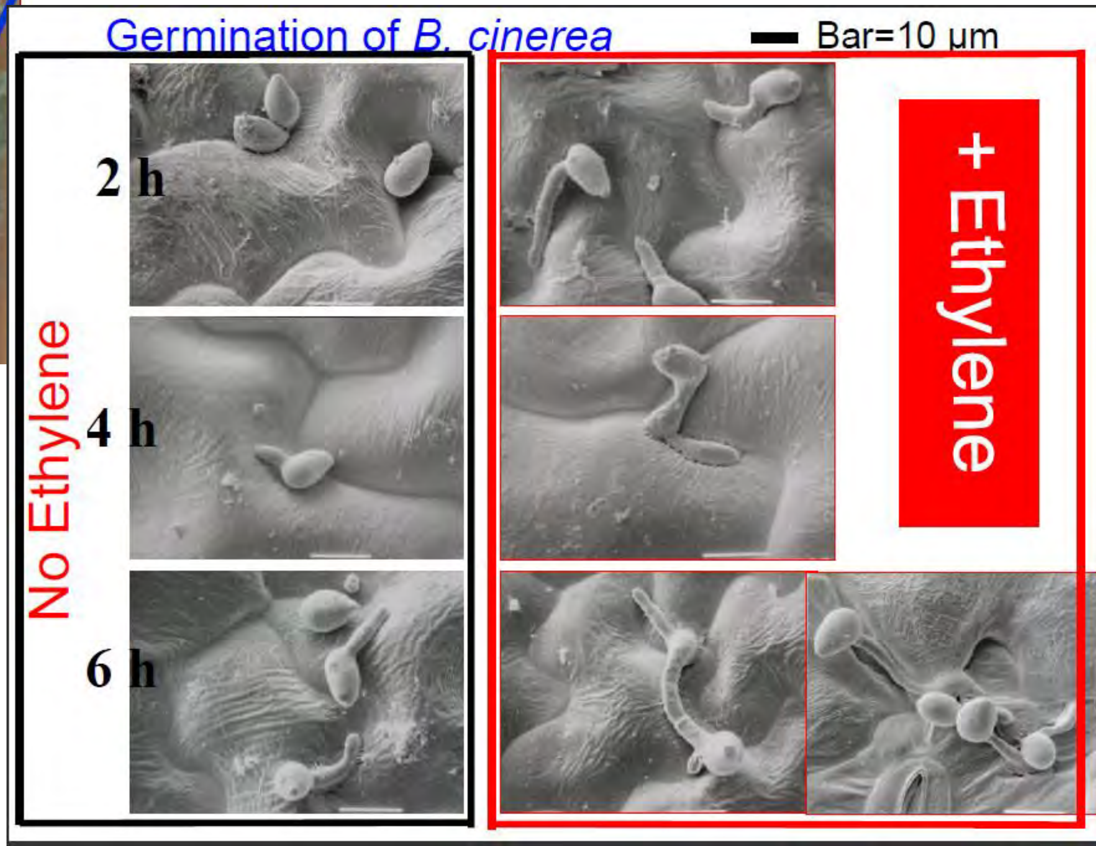
CONTROL

Ca+

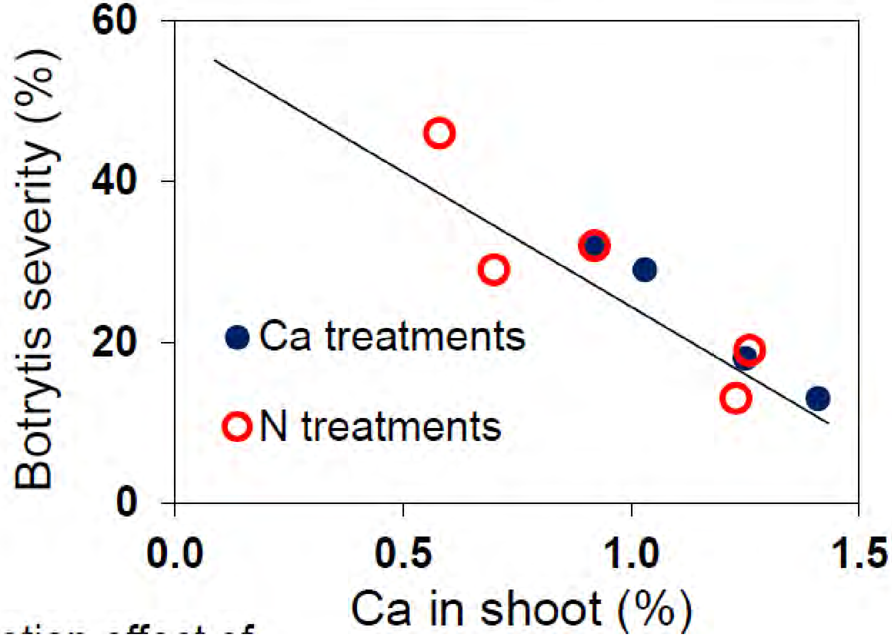
Ca several mechanisms

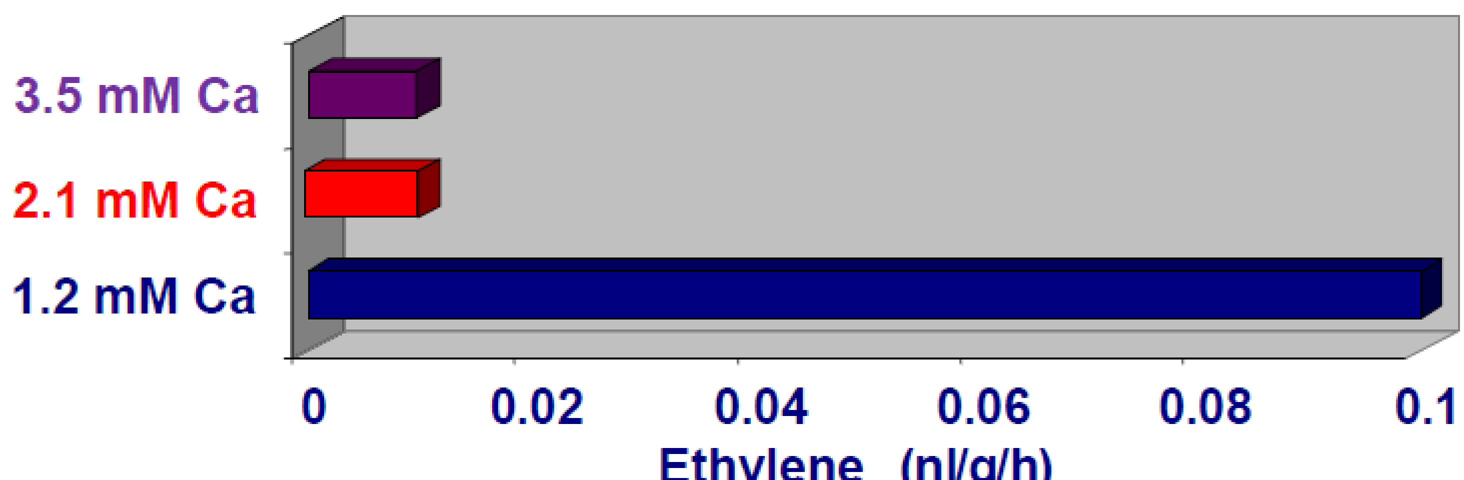
Increased ET concentration in leaves atmosphere



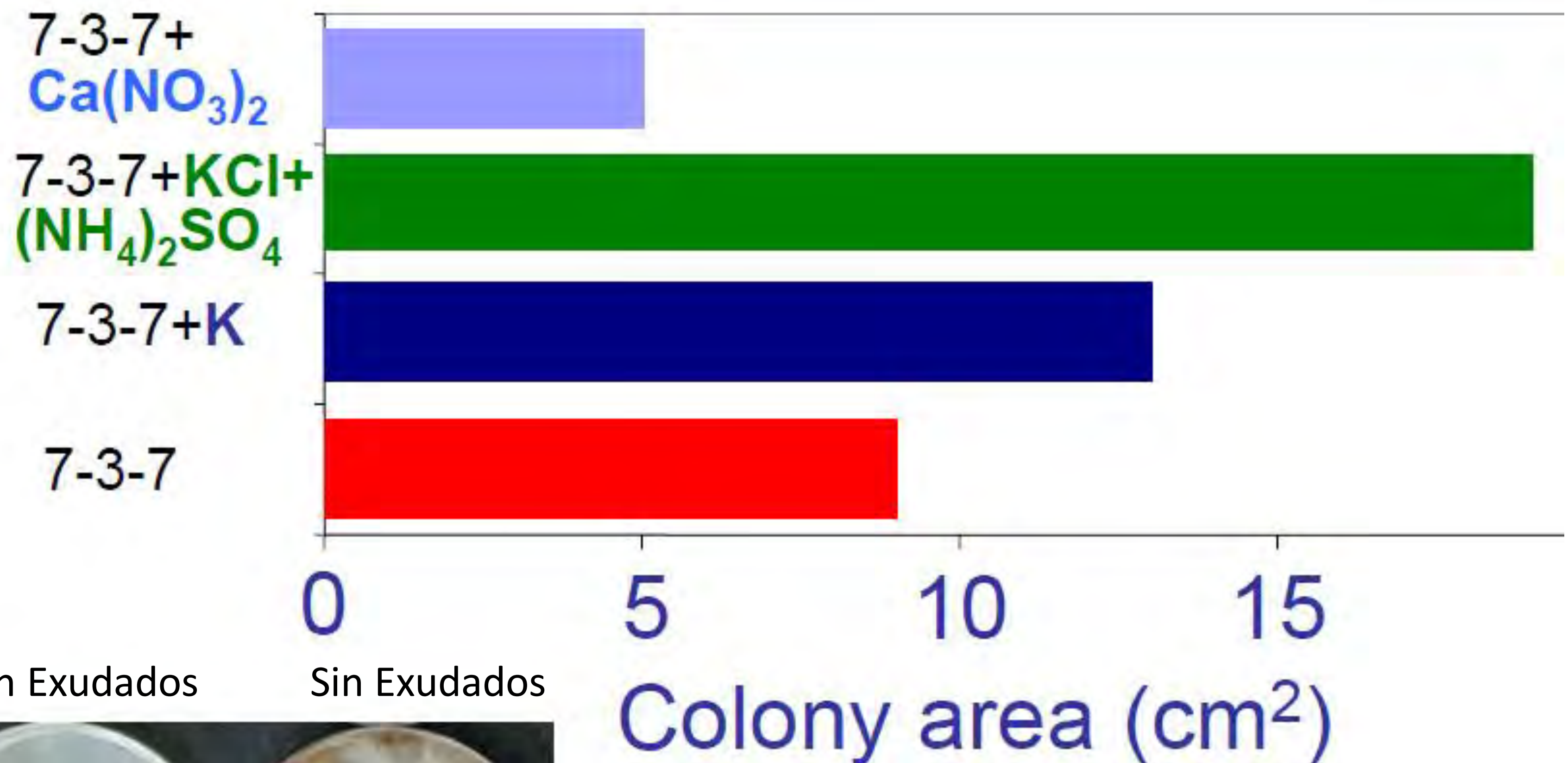


N and Ca effect

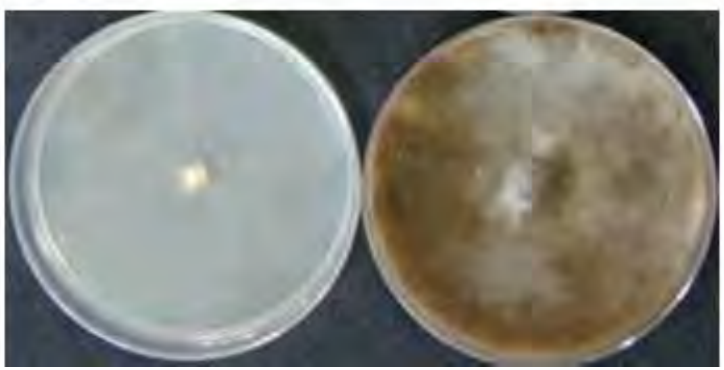




Growth of *B. cinerea* on washings from fertilized plants

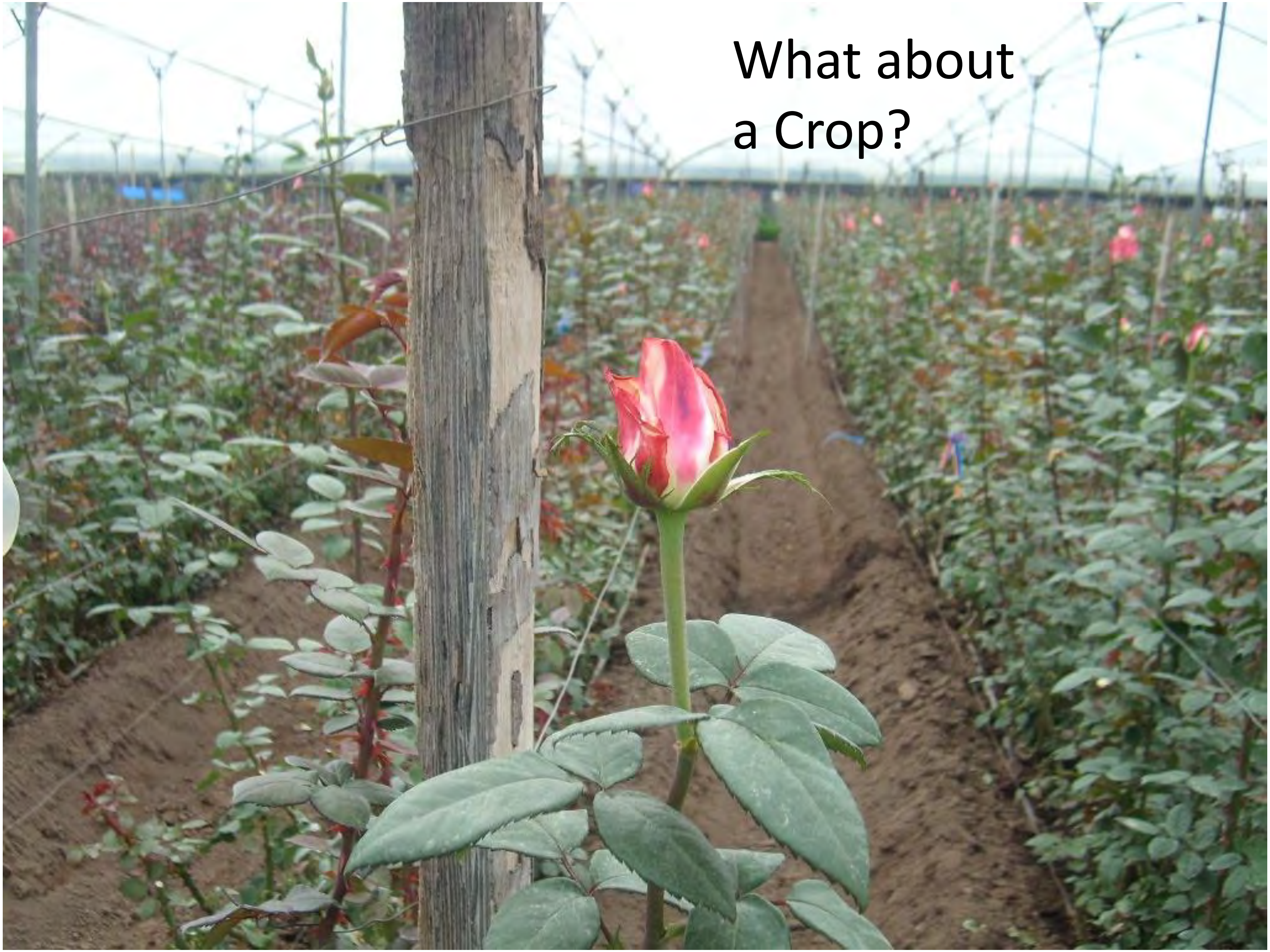


Con Exudados Sin Exudados



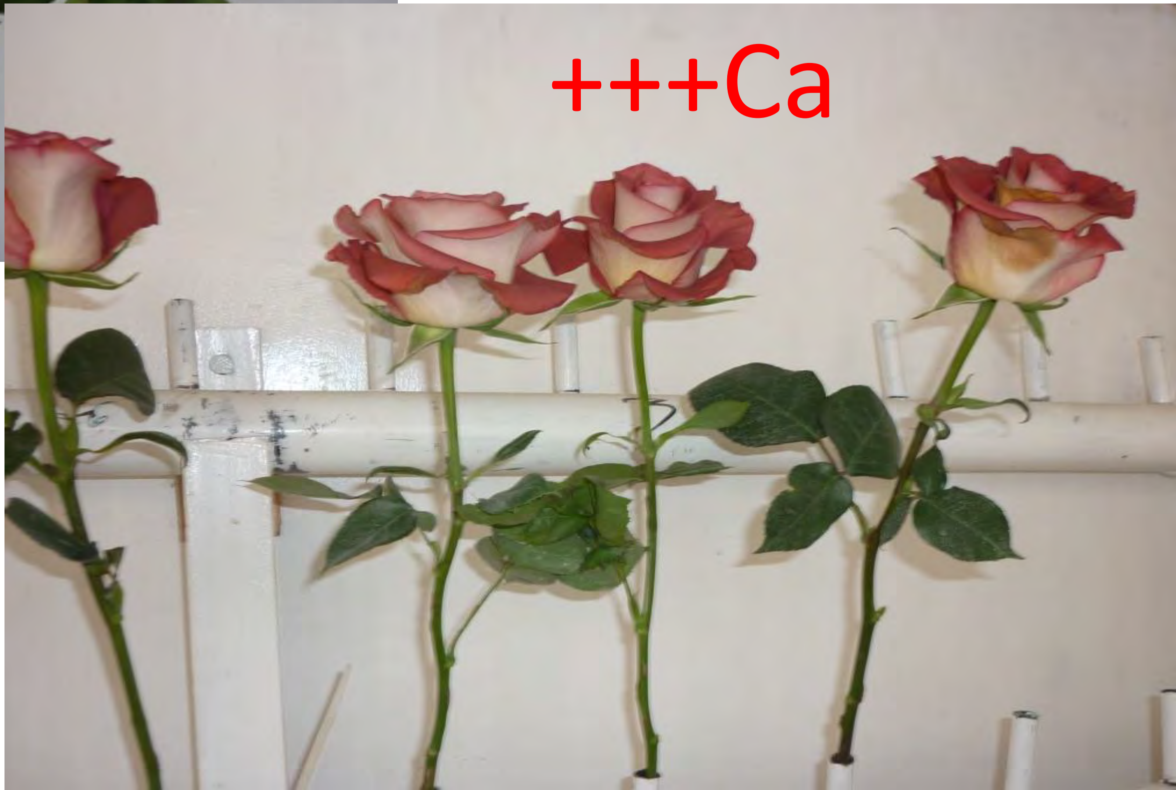
Mecanisms of Ca induced resistance…

- Mecanisms of protection by Calcium:
  a) +++ Ca more cell wall reinforcement
  b) +++ Ca less ethylene
  c) +++ Ca more antimicrobial compounds
  d) +++ Ca induced JA responses (New!)


What about
a Crop?

Ca and *Botrytis*(120 ppm Ca under drip irrigation, CaCl)


Control


+++Ca

CONCLUSIONES GENERALES

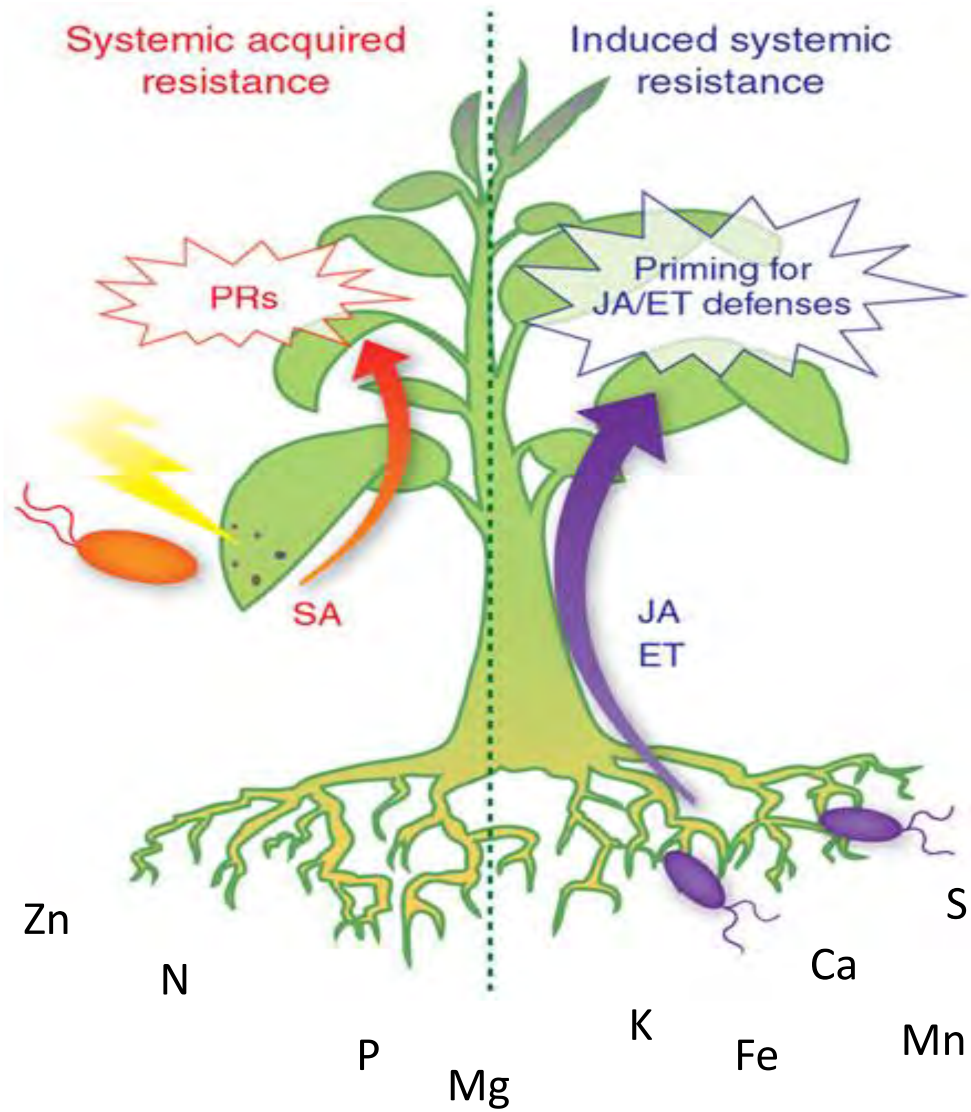
1) Quitar nutrientes y aumentar nuevamente aumenta las defensas generals de la planta

2) Exceso de Nitrato induce SA y exceso de Amonio reduce defensas en general e induce suceptibilidad a patogenos

3) Deficiencia de K induce JA

4) Deficiencia de S induce SA y Resistencia a biotroficos depende de NPR1

4) Exceso de Ca induce JA y promueve Resistencia a necrotroficos y es dependiente de COI


Systemic acquired resistance
Induced systemic resistance
PRs
Priming for JA/ET defenses
SA
JA
ET
Zn
N
P
Mg
K
Fe
Ca
S
Mn

Pillars of Food Security

Universidad San Francisco de Quito

Carlos Ruales

Universiteit Utrecht

ANCUPA
sirviendo al palmicultor

ESPE
UNIVERSIDAD DE LAS FUERZAS ARMADAS
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Saponin determination, expression analysis and functional characterization of saponin biosynthetic genes in *Chenopodium quinoa* leaves

J. Fiallos-Jurado et al. / Plant Science 250 (2016) 188–197

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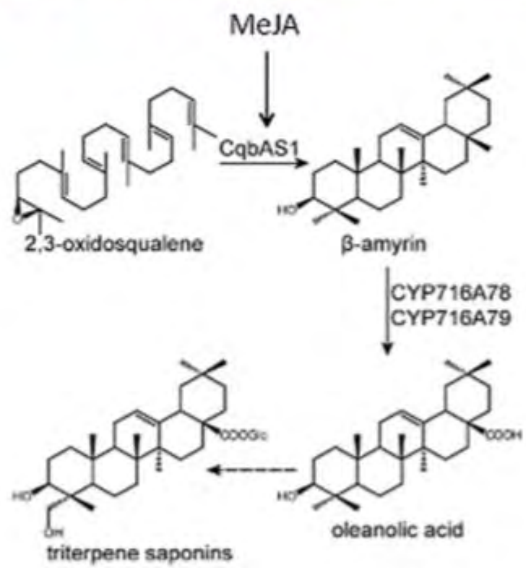

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