Development of biopolymeric materials for sustainable agricultural applications

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INTEMA

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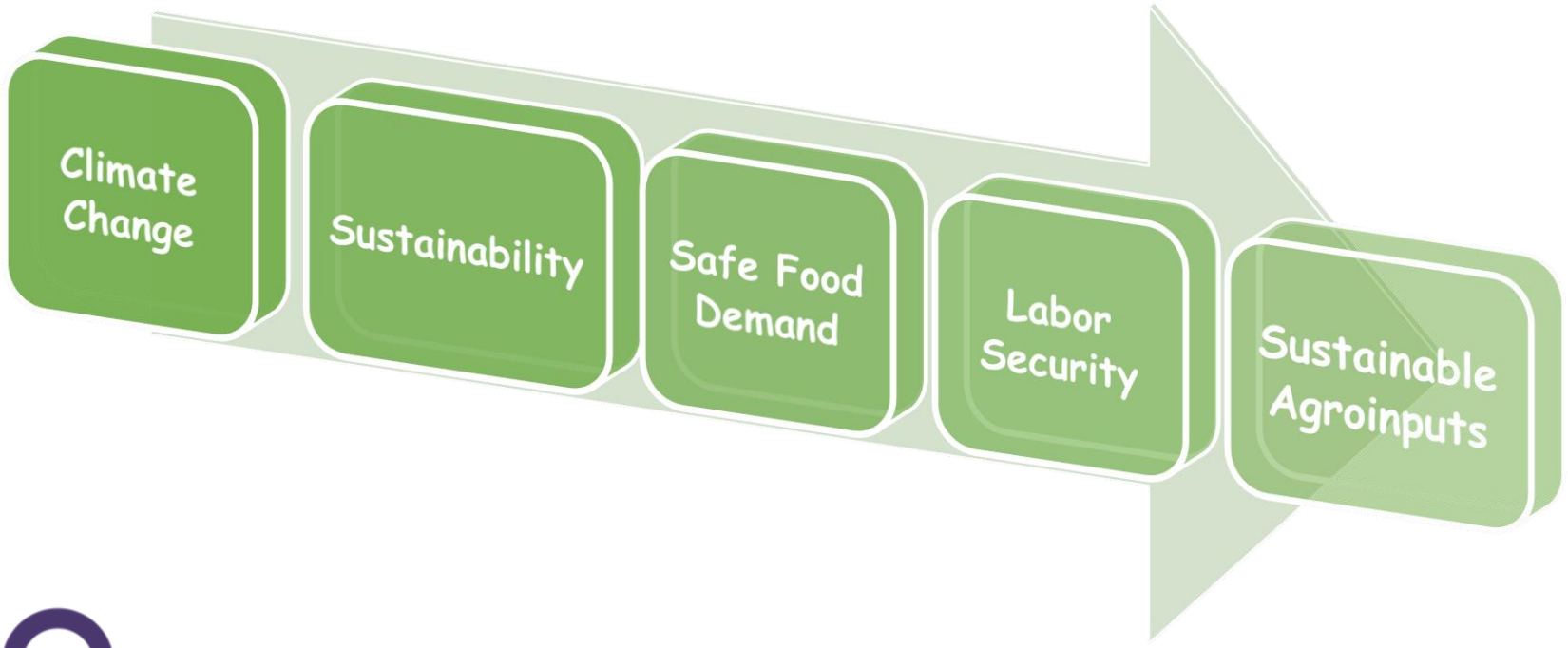
Horizon 2020
European Union Funding
for Research & Innovation

BBI JU

Bio-based Industries Consortium

What challenges does Agriculture face today?



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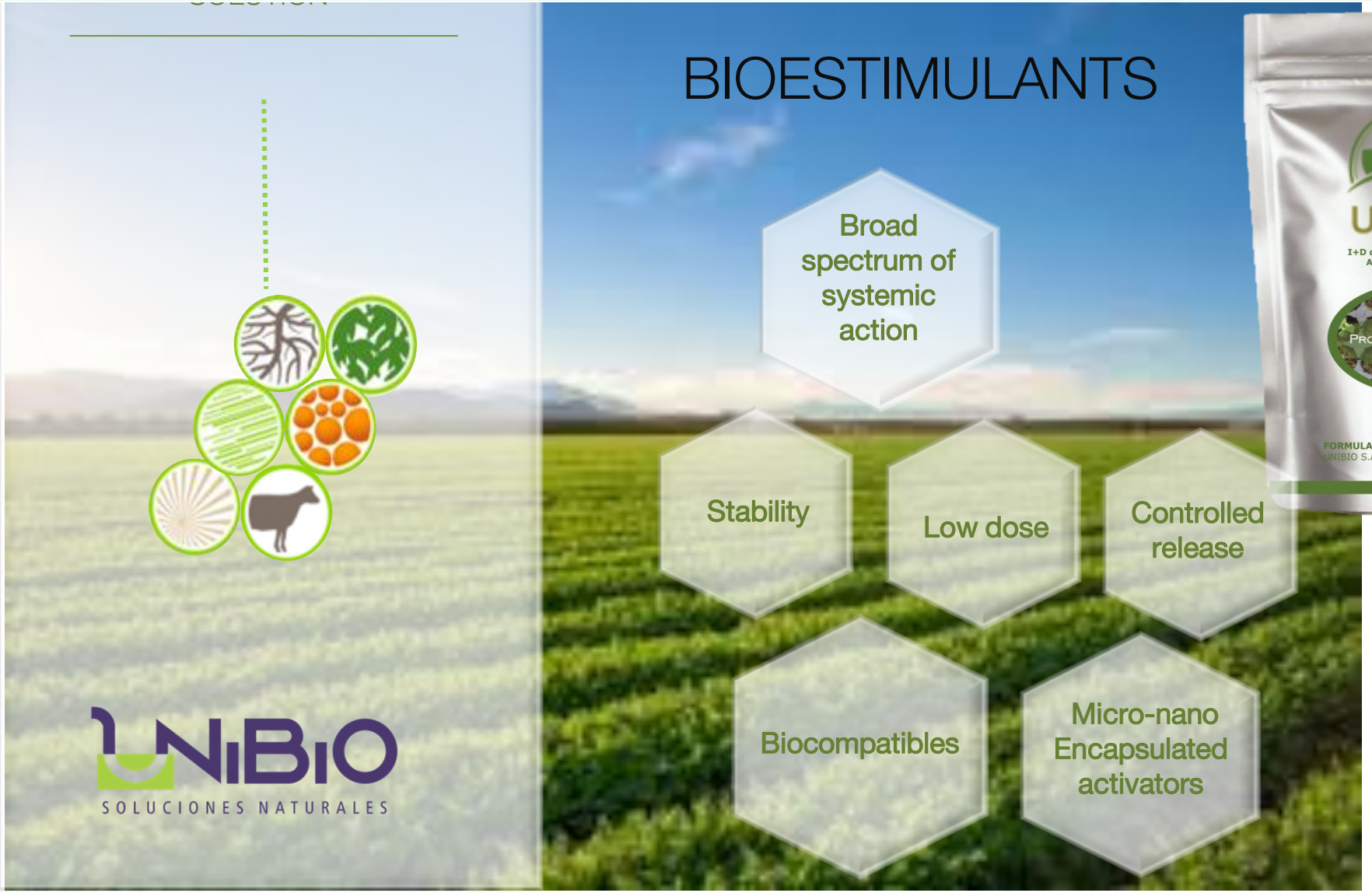
BIOESTIMULANTS
Broad spectrum of systemic action
Stability
Low dose
Controlled release
Biocompatibles
Micro-nano Encapsulated activators
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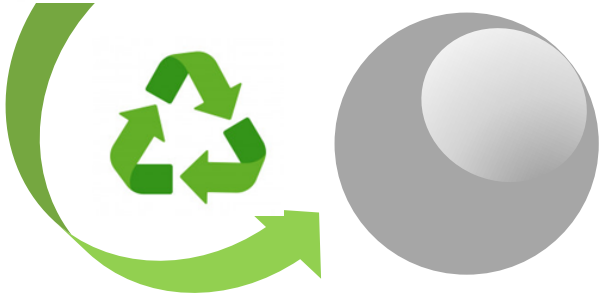
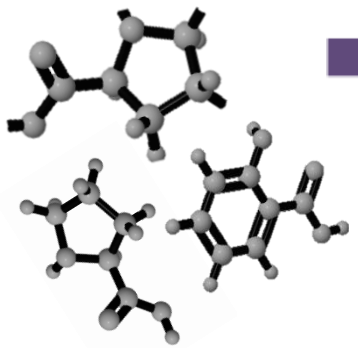
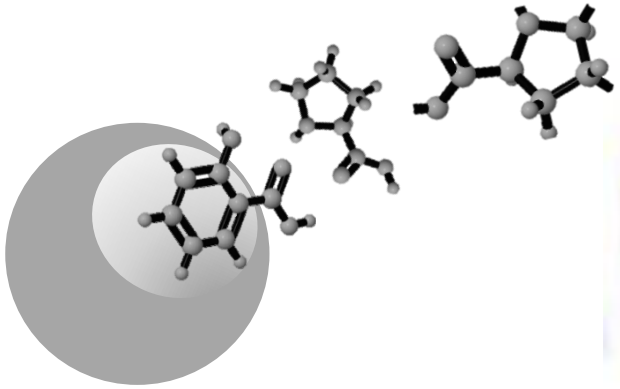
MICRO-NANO VEHICLES

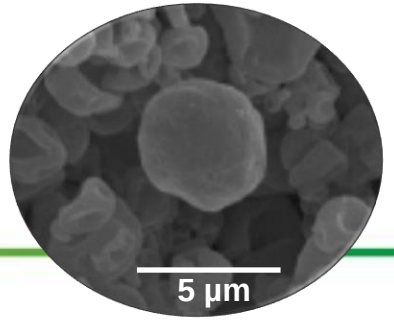




ACTIVE PRINCIPLES



MULTIFUNCTIONAL PARTICLES



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APDS:

Active principles delivery systems can be defined as devices capable of perform mechanisms to introduce active principles in a required places

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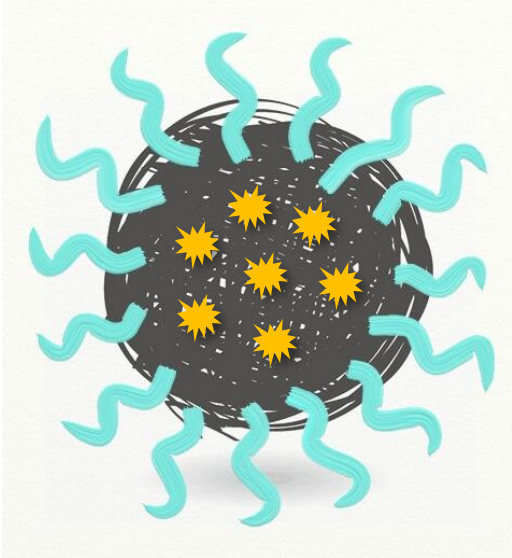
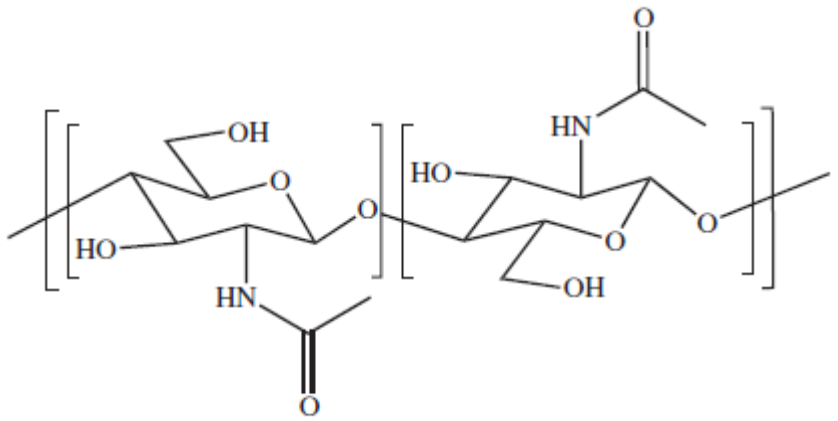
- Act as a vehicle for a wide variety of active principles.
- Protect active principle molecules from degradation in the real field.
- Modulate the release of the active principle to achieve the desired response
- Be biocompatible and be able to biodegrade.

Active principles can be encapsulated, covalently attached, or adsorbed onto such carriers

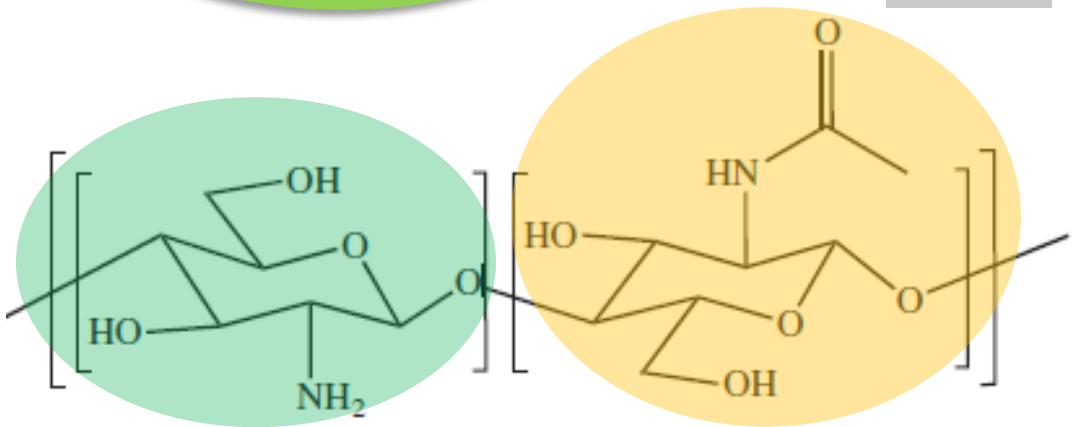


Polymeric Nanoparticles are submicron size entities made from a wide variety of polymers. These devices are being extensively used as active principles carriers and controlled release systems in different fields.



Chitosan

chitin



chitosan

- Linear polysaccharide
- Deacetylation of chitin
- 70-100% degree of desacetilation
- polycation

Chitosan

Properties

- Biocompatible and biodegradable
- Antibacterial
- Fungicide and fungistatic
- Low immunogenicity
- Stimulates cell proliferation
- Allows the transport of active ingredients

- Photography
- Cosmetics
- Water treatment
- Food industry
- (preservative, packaging ...)

- Drug-delivery systems (fibers, hydrogels, scaffolds, micro and nanoparticles ...)
- Tissue engineering
- Pesticides

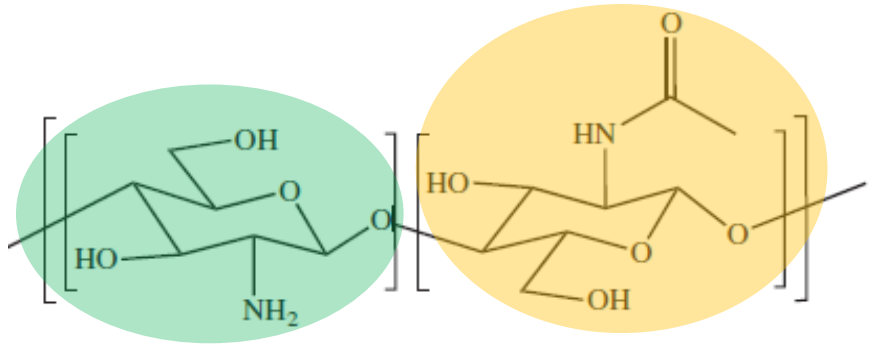
Synthesis of Chitosan

Exoskeleton from Pleoticus muelleri
from fish industry waste in Argentinean Patagonia

Demineralization

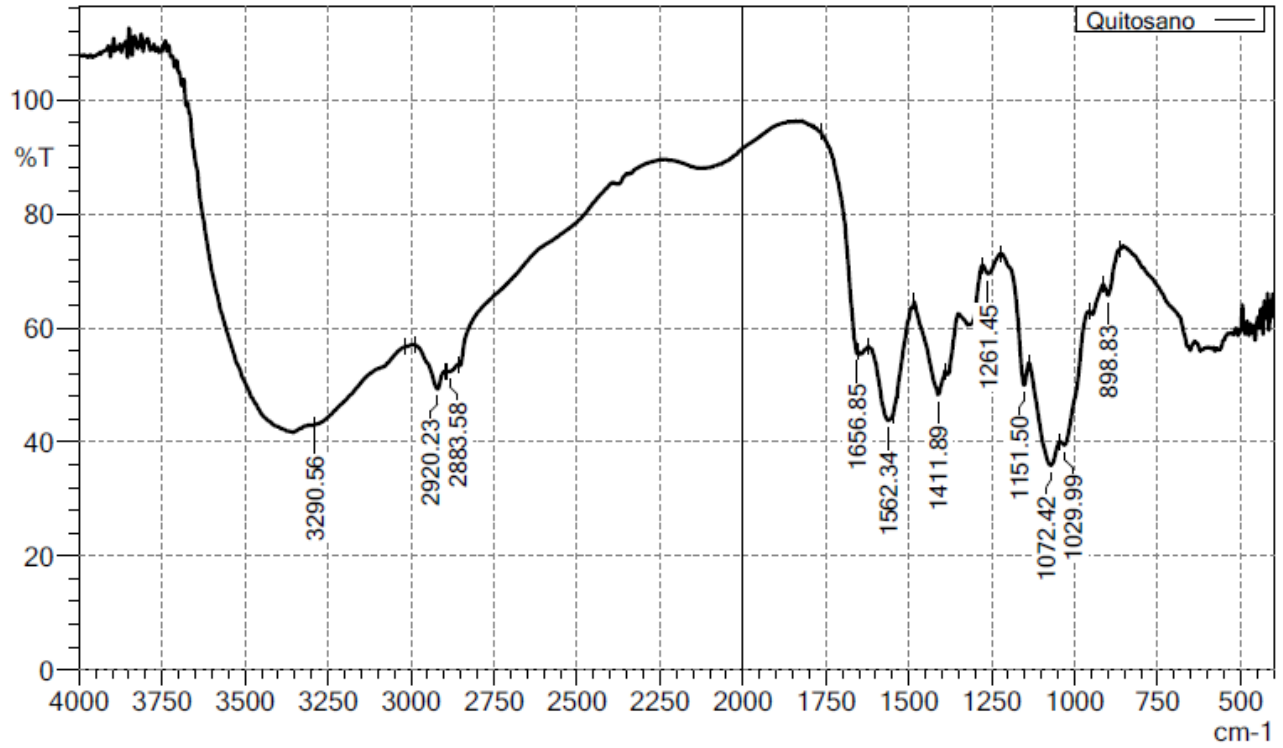
Deproteinization

Deacetylation



chitosan

Degree of deacetylation of the polymer FTIR



Grupo funcional	ν referencia [5] (cm^{-1})
Grupo -OH	3450
Grupo N-H	3292
Grupo C-H	2919 y 2862
Amida I	1655
Doblaje del grupo $-NH_2$	1580
Amida III	1313
Tensión asimétrica del C-O-C	1154
Vibraciones de su estructura piranósica	1082 y 1032
Tensión C-H de grupos anoméricos	896

DD =87-98 %

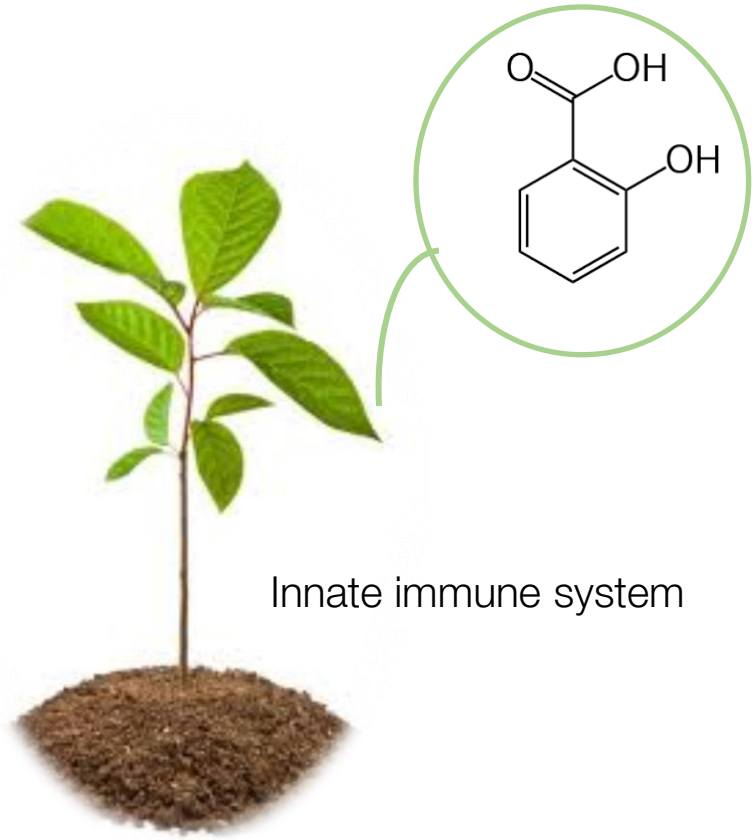
$$N - acetilación\ (\%) = 31.92x\left(\frac{A_{1318}}{A_{1380}}\right) - 12.20$$

Potentiometric titration
NMR
Elemental analysis

Mw = 1531 ± 372 kDa; Mn = 559 ± 95 kDa, PI = 1,95 ± 0,32 by SEC

SALICYLIC ACID IS A PLANT STRESS HORMONE

SA induces plant defense innate response against virus, fungus, bacteria
Local and systemic responses



Innate immune system

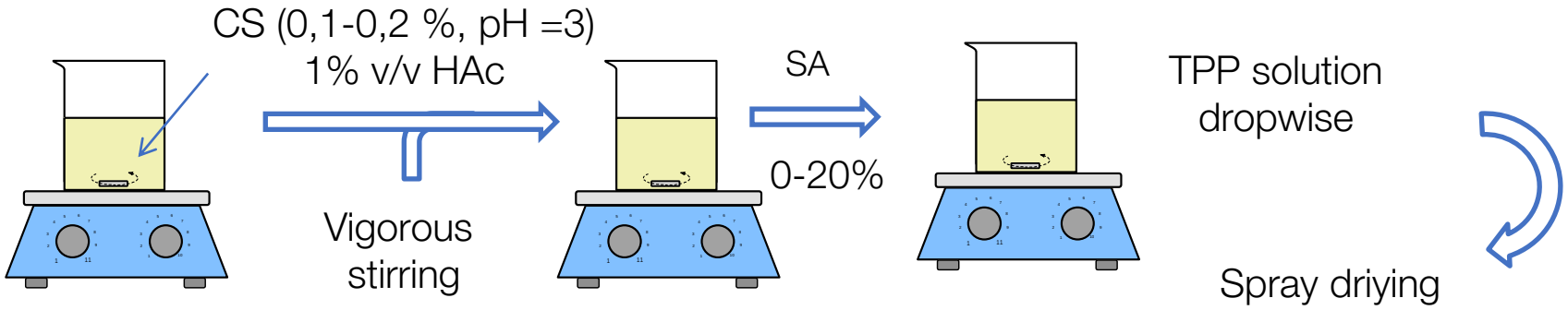
Local and Systemic acquired resistance (SAR)

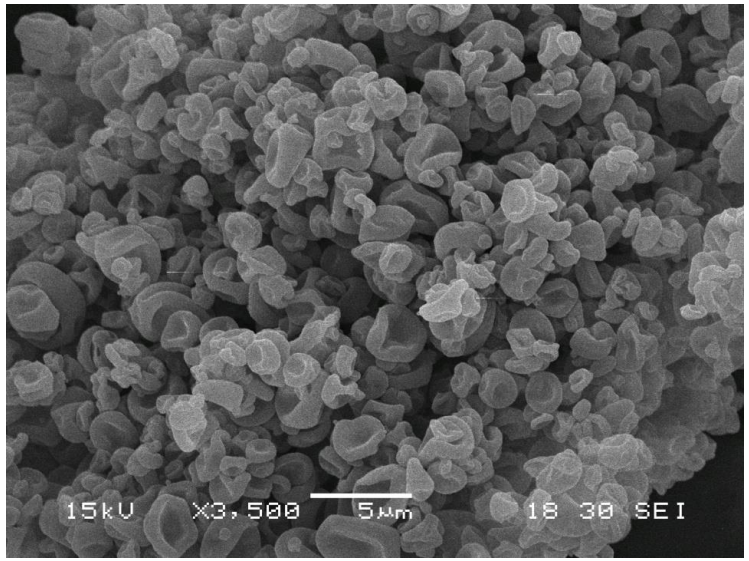
Antimicrobial activity

Microorganism	SA concentration	Reference
Escherichia coli Aerobacter aerogenes Leuconostoc mesenteroides Staphylococcus aureus Streptococcus feccalis	1 mM	Gershon & Parmegiani, 1962
Escherichia coli Staphylococcus aureus	0.23 mM 0.11 mM	Monte et al, 2014
Bacillus polymyxa Erwinia carotovora Pseudomonas solanacearum	> 10 mM	El-Mougy et al, 2002
Penicillium expansum	2.5 mM	Da Rocha Neto et al, 2015
Aspergillus flavus	1 mM	Panahirad et al, 2013
Rhizopus stolonifer	5 mM	Panahirad et al, 2013
Entypa lata	1 mM	Amborabé et al, 2002
Fusarium spp Rhizoctonia solani Sclerotium rolfsii Macrophomina phaseolinae Pythium spp Phytophthora spp	2.5 mM	El-Mohamed et al, 2013

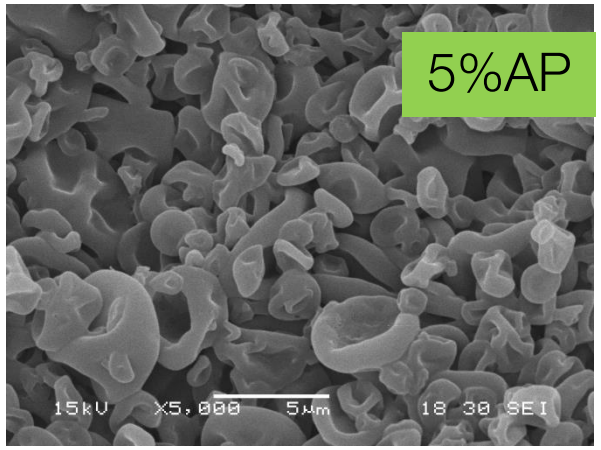
Da Rocha et al, 2015

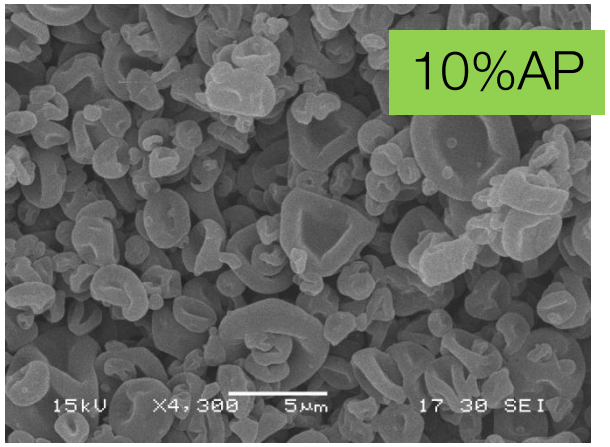
Preparation of MP-SEM

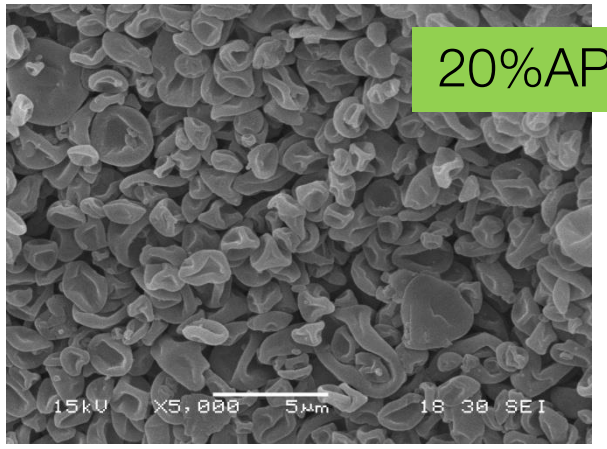


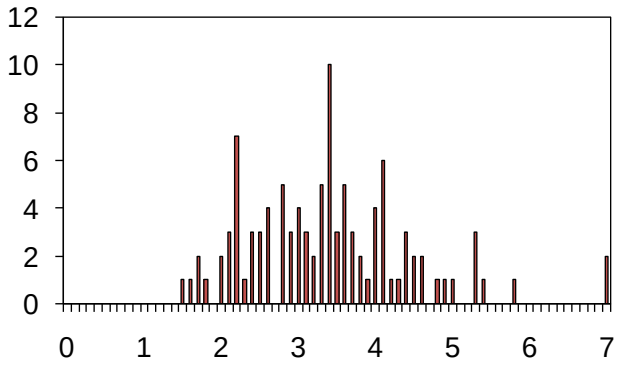


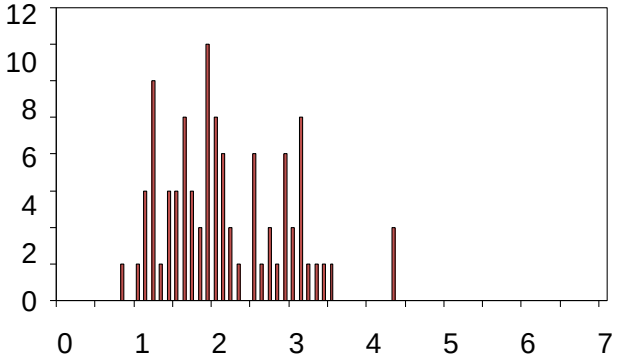
Characterization of MP – AP – average size

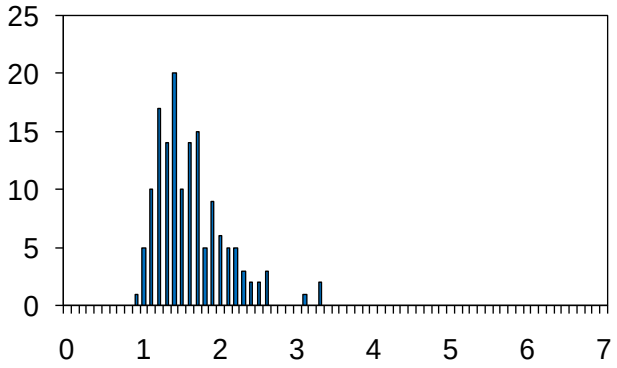










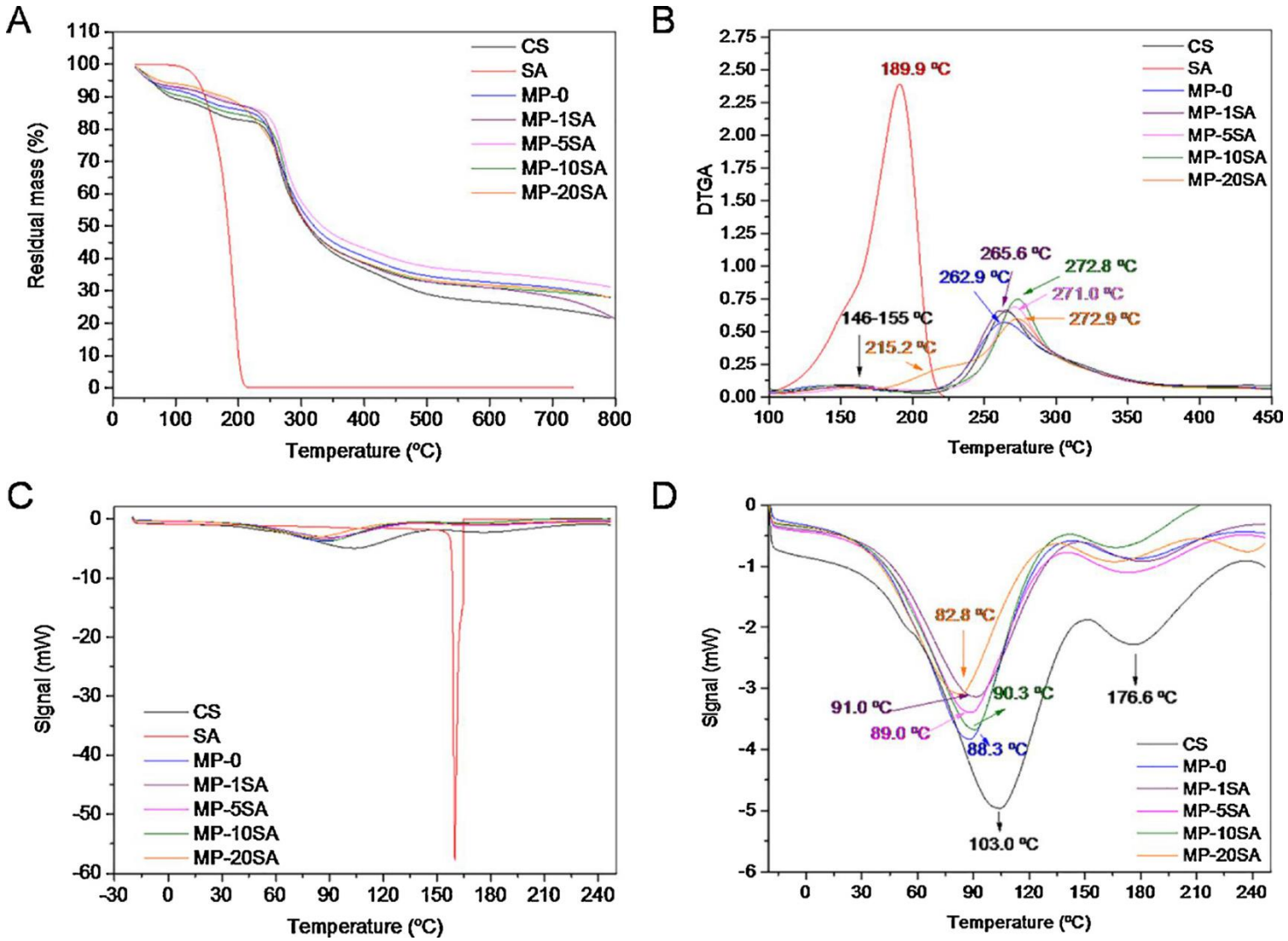


3.30 ± 1.10

2.05 ± 0.97

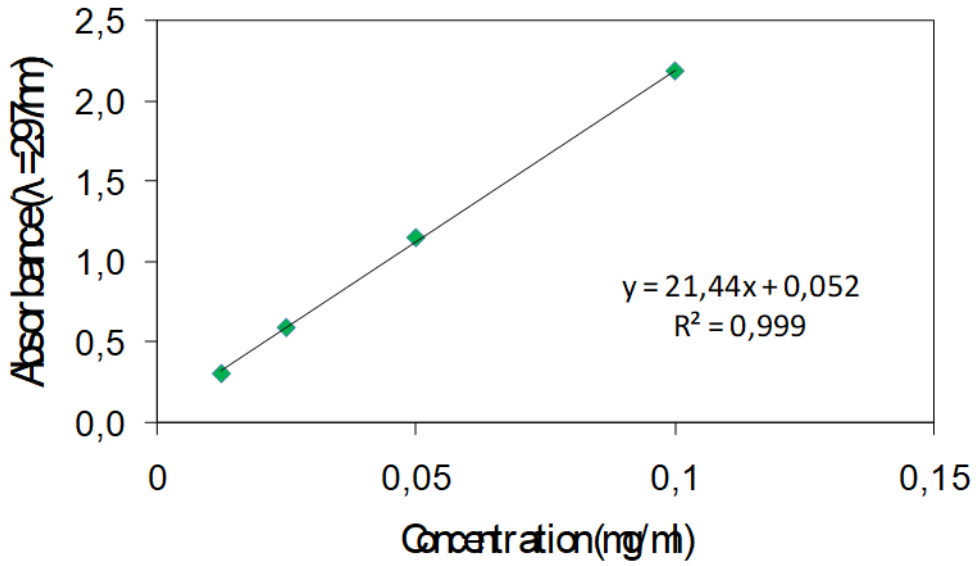
1.56 ± 0.45

Thermal characterization of MPQS

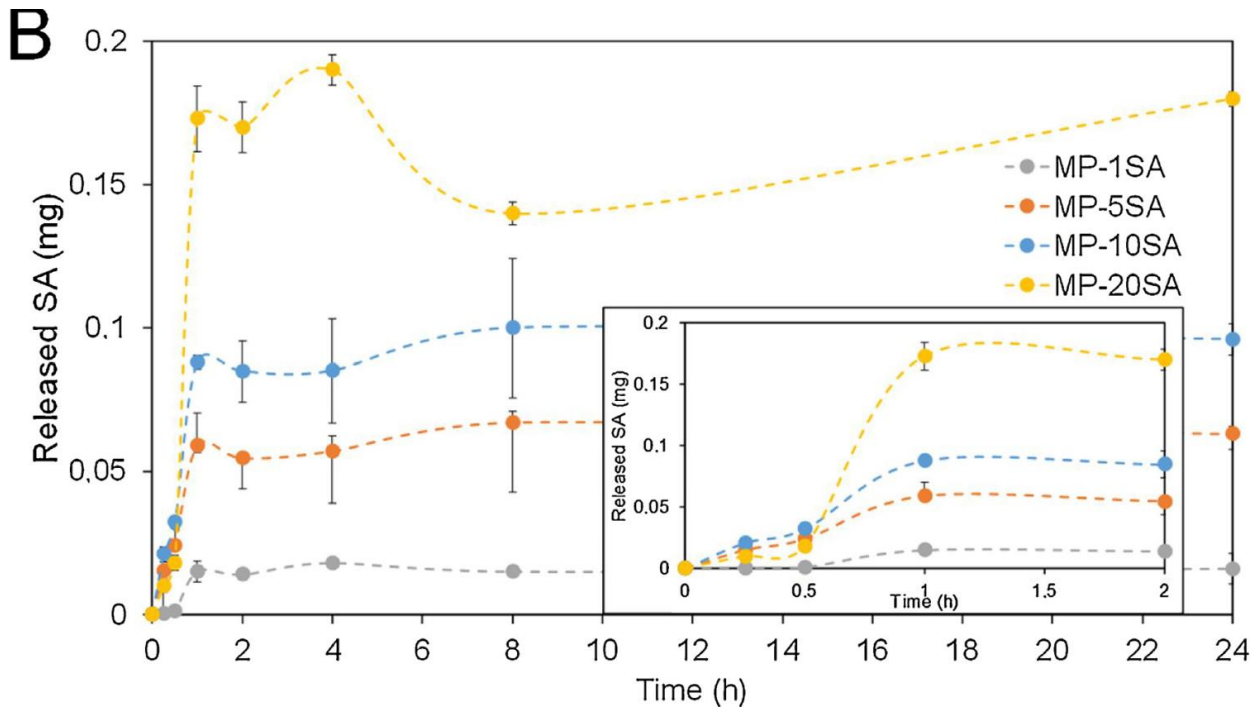


Characterization of MPQS

ID	% (w/w)	EE%
MP	-	-
MP 5% AP	5	98
MP 10% AP	10	69
MP 20% AP	20	59



SA release from MP

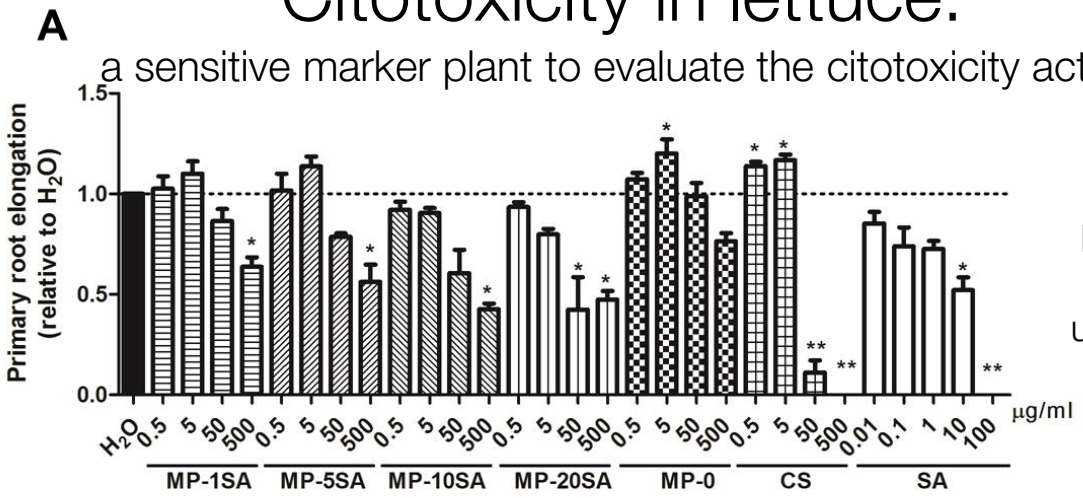


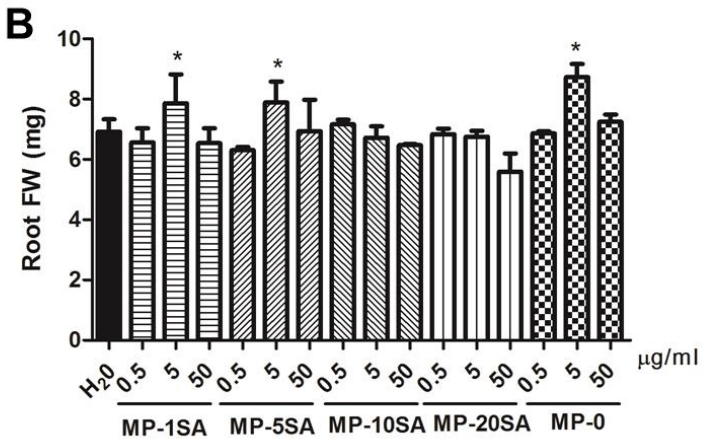
SA was release from MP in a sustained way

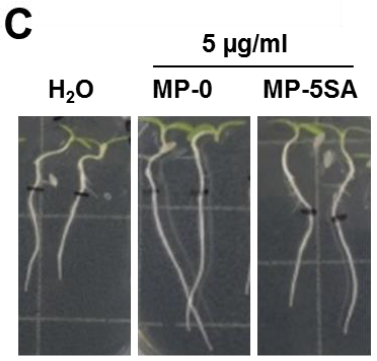
Biological tests

Citotoxicity in lettuce:

a sensitive marker plant to evaluate the citotoxicity action





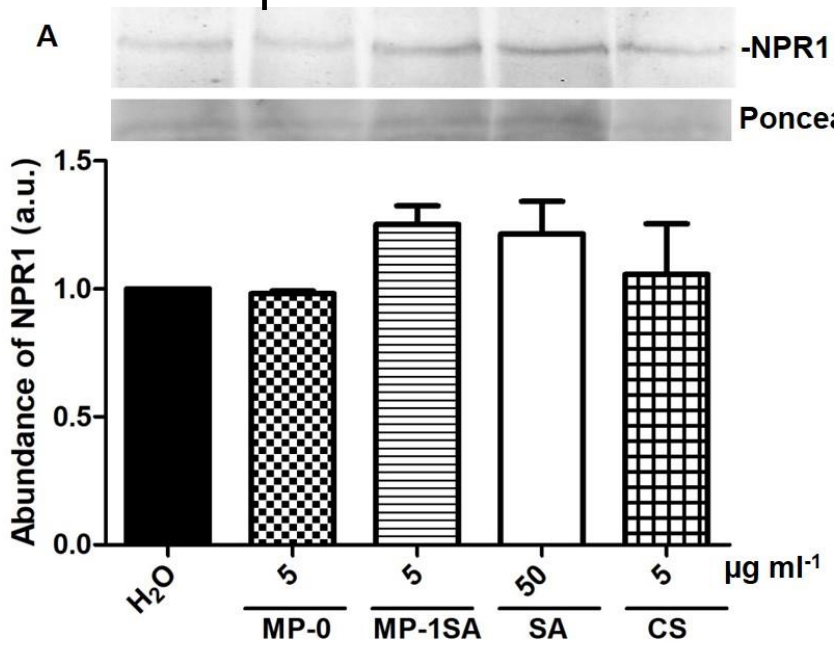


Particles do not exert citotoxicity in lettuce

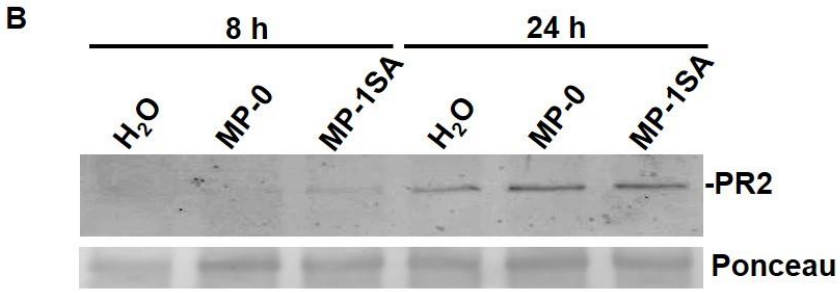
MP-CS positively modulates root growth in lettuce seedlings

NPR1 and PR2 protein levels

NPR1 and PR2 protein levels become increased upon treatments with particles



NPR1:master regulator of the SA-mediated induction of defense genes



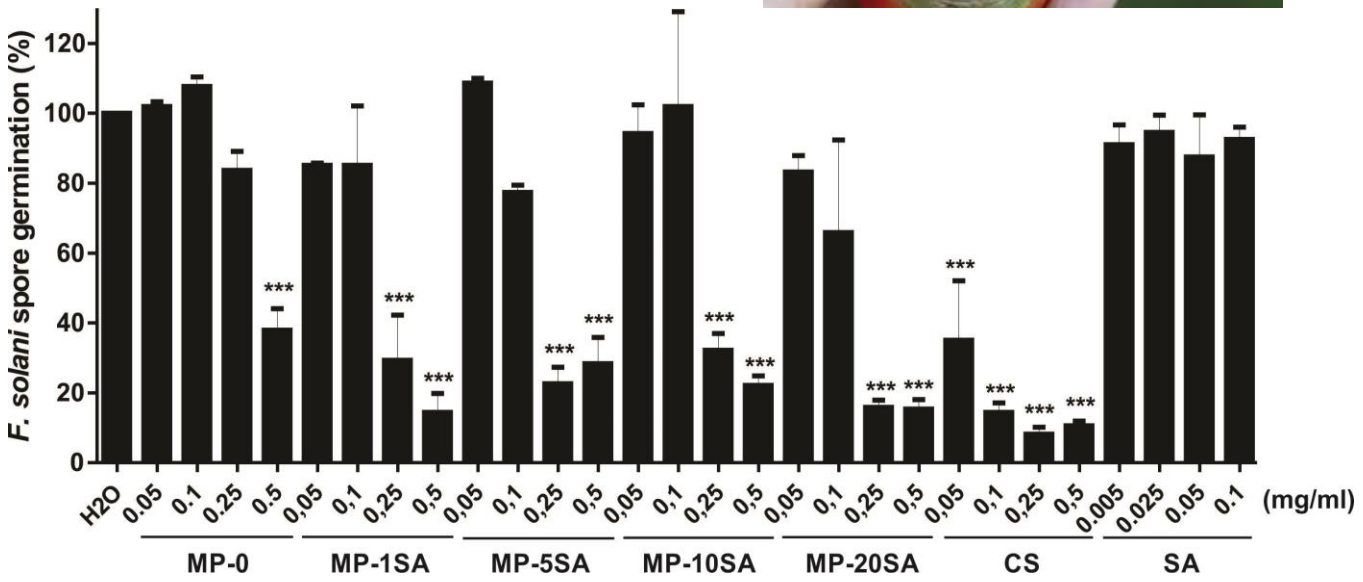
PR2: defense marker protein induced by SA

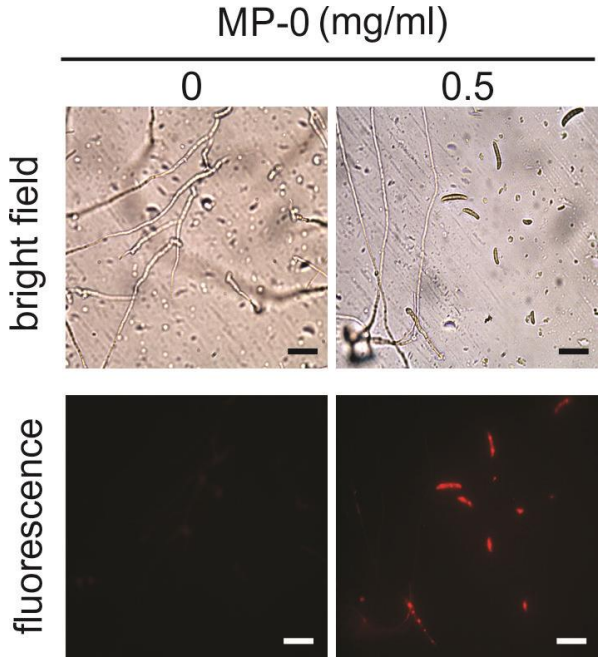
Positive effect on root growth

Dose-dependent action on the regulation of root growth

Biological tests

Antimicrobial activity and citotoxicity in F. solani spores





Fusarium solani is a phytopathogen of different plant species including tomato plants

CS-based systems exert antimicrobial activity and induce citotoxicity in F. solani spores

Biological tests

MP-CS as a bioestimulant

Positive action on root growth parameter

Aerial Biomass

Leaf growth
Leaf area
Chlorophyll content

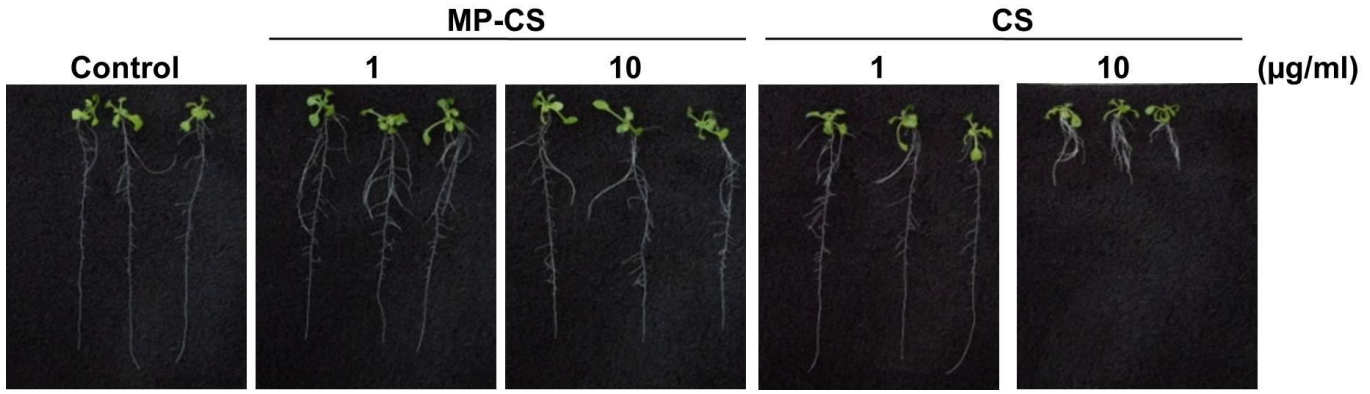
Performance and nutritional characteristics in fruit

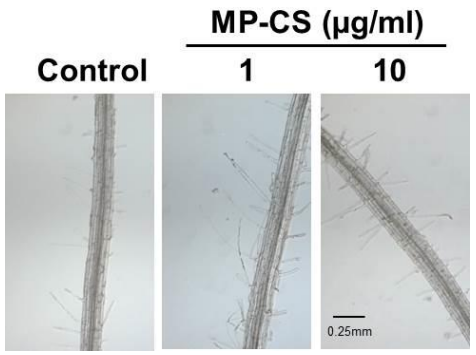
Root System

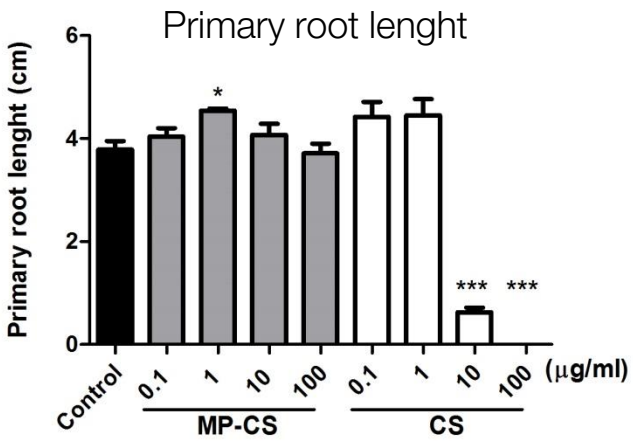
Length of the primary root
Number and growth of lateral roots
Fresh and dry weights

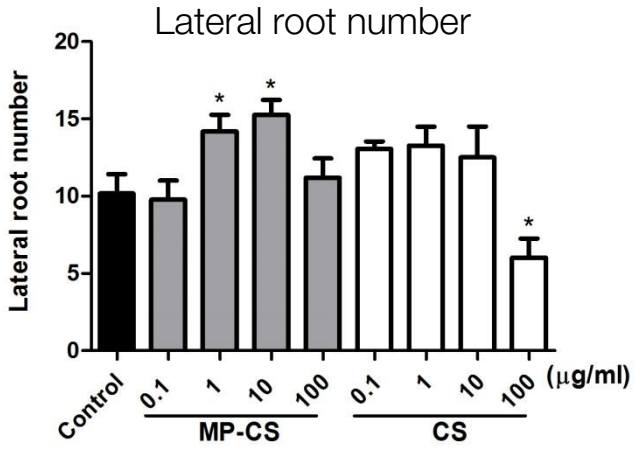
Study of the mechanistic action as a bioactive growth promoter

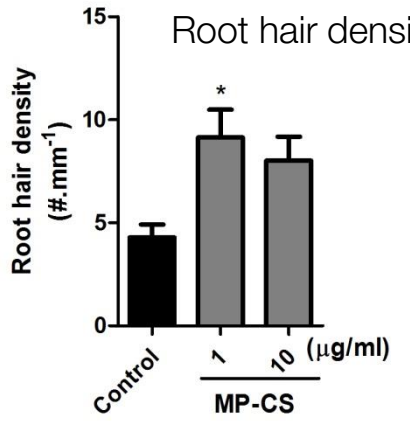
Biological tests







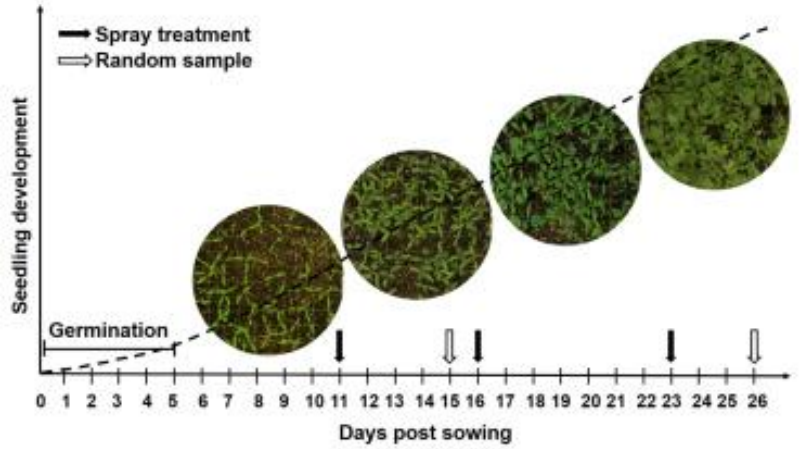


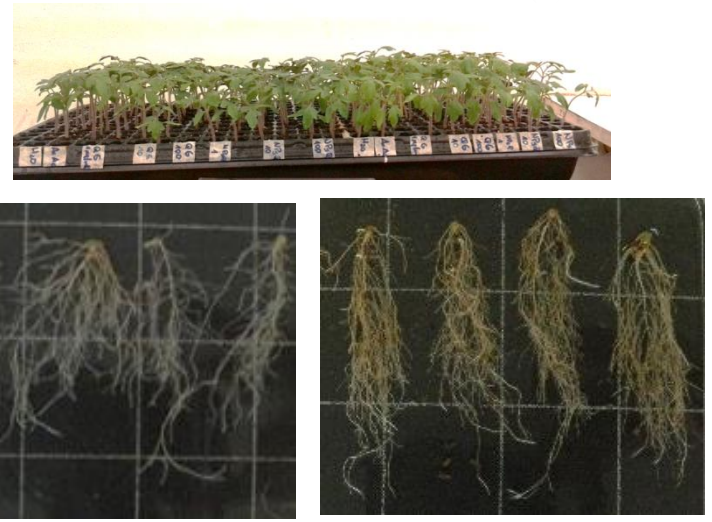


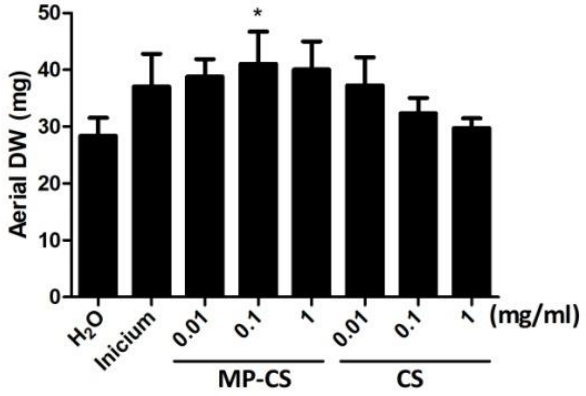
- Action on multiple root traits: Primary root, lateral root and hair root
- Improved performance compared to CS
- No citotoxicity in a wide range of concentrations

Biological tests

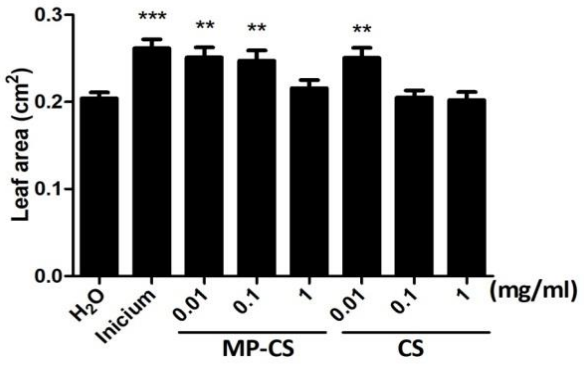
MP-CS improve rooting and aerial biomasses in tomato plants



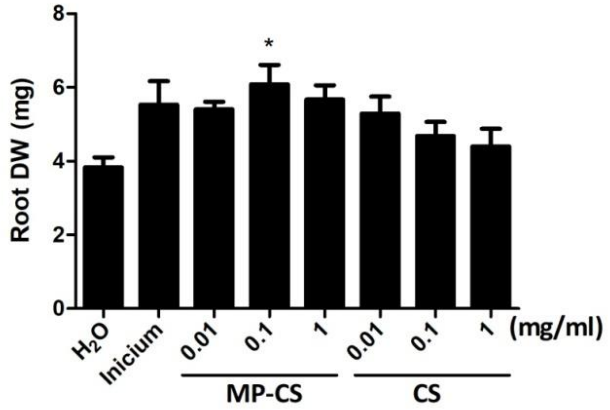




Aerial dry weigth

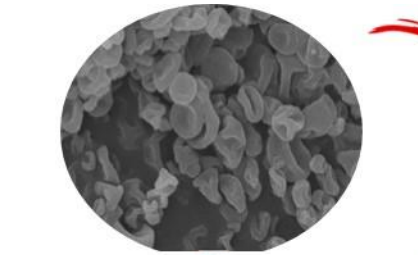


Leaf area



Root dry weight

PROMISORY ACTIONS OF CHITOSAN-MICROPARTICLES



Chitosan microparticles generation

Spray treatment

✓ Improves rooting and aerial biomasses

✓ Induces antioxidant capacity

✓ Enhances defense response

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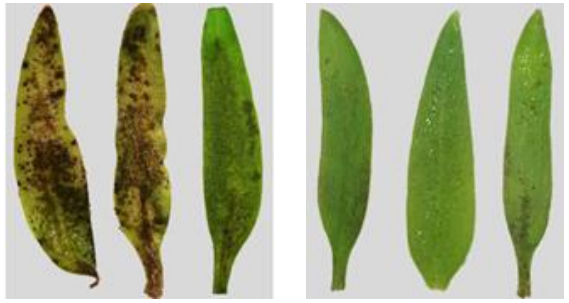
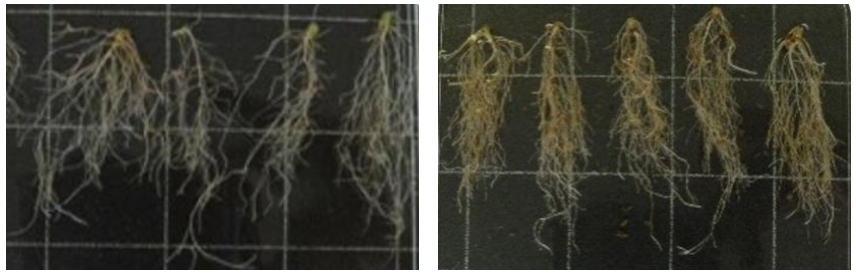
100% NATURAL

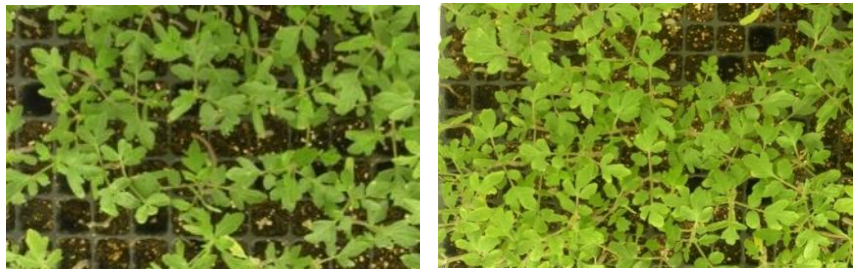
Nanotechnology applied to agriculture



Activation of vegetal inmunity



Plant growth promotion



Increased crop yield

CONCLUSIONS

- In plant assays using chitosan synthesized particles demonstrate that have high potential to be used in the development of innovative materials for modern agriculture.

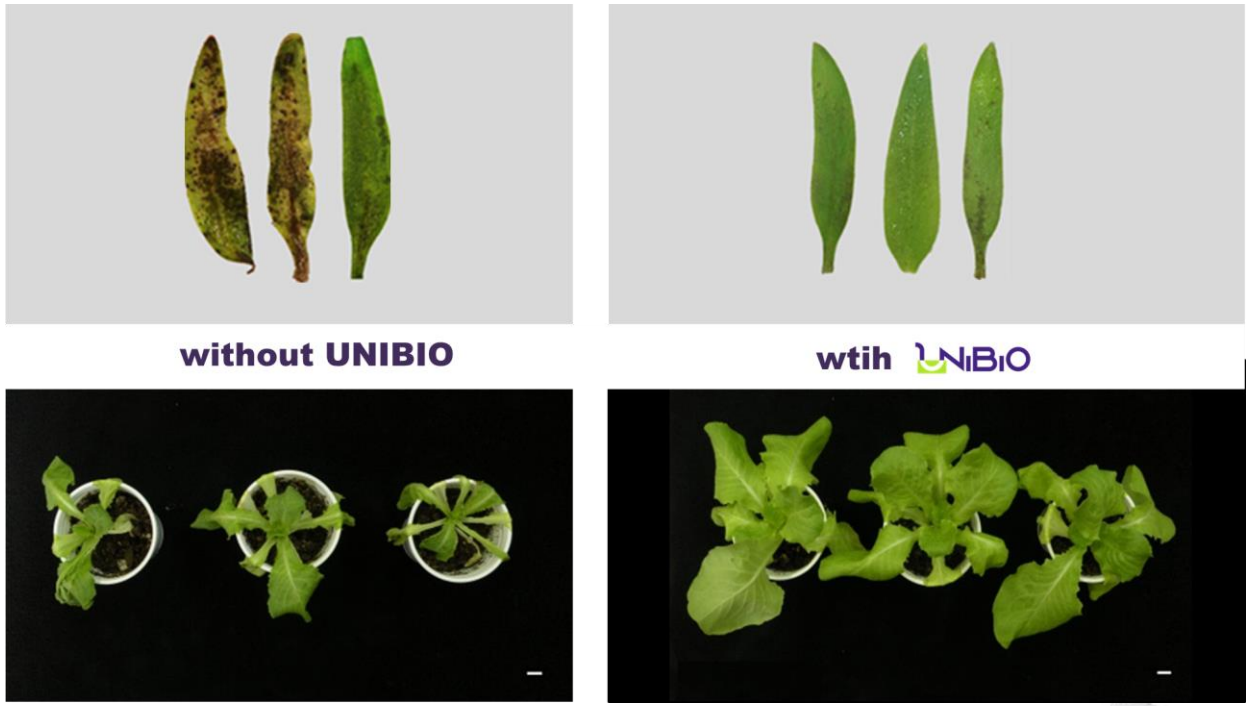
- However, we assume that it is essential to understand the mechanistic action of these materials in plants and also, to explore their action in the field.

- Field test are being carried out

- Several materials are being developed

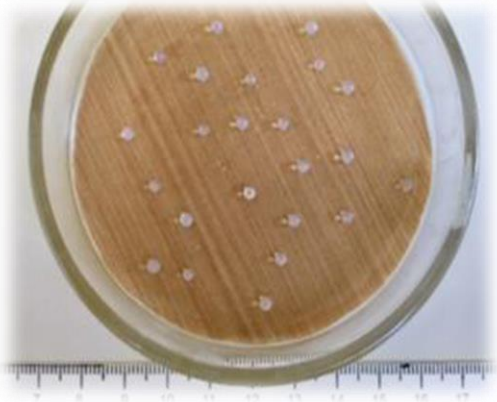
- Patents precede Papers in all cases

- Industries are involved in several cases



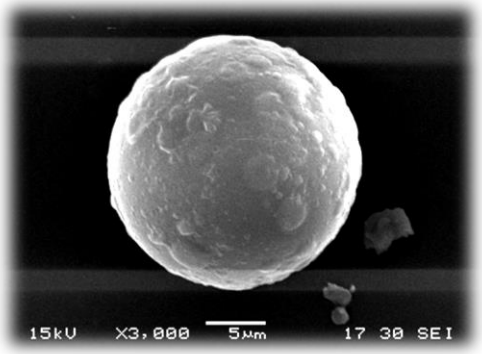
CONCLUSIONS AND FUTURE PERSPECTIVES

EXTRACT



HYDROGELS

ENCAPSULATED
Micro and nano



MULCH

Water remediation

Biomedicine

Textile Industry

Thank you!

Vera Alvarez
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