# *Trends in biogenic metal nanoparticles: from the synthesis to agriculture applications*

Dr. Renata de Lima

University of Sorocaba

# *Outilines*

- METALLIC NANOPARTICLES AND AGRICULTURE
- ENVIRONMENT TOXICITY
- BIOGENIC METALLIC NANOPARTICLES
  - ADVANTAGE
  - SYNTHESIS
  - CHARACTERISTICS
  - TOXICITY
  - ACTIVITY
- DIFFERENT POSSIBILITIES

# Why use metallic nanoparticle in Agriculture?

Chemosphere 86 (2012) 491–499

Contents lists available at SciVerse ScienceDirect

Chemosphere

journal homepage: www.elsevier.com/locate/chemosphere

# Effect of silver nanoparticles in crop plants *Phaseolus radiatus* and *Sorghum bicolor*: Media effect on phytotoxicity

Woo-Mi Lee, Jin Il Kwak, Youn-Joo An *

Science of the Total Environment 649 (2019) 554–562

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Biochemical and physiological effects of copper compounds/ nanopar

ez [a],

Hindawi Publishing Corporation
The Scientific World Journal
Volume 2014, Article ID 925494, 8 pages
http://dx.doi.org/10.1155/2014/925494

frontiers in Plant Science

REVIEW
published: 25 April 2017
doi: 10.3389/fpls.2017.00697

# Titanium as a Beneficial Element for Crop Production

*Shiheng Lyu[1,2†], Xiangying Wei[1,2†], Jianjun Chen[1,2*], Cun Wang[2,3], Xiaoming Wang[4*] and Dongming Pan[1*]*

frontiers in Plant Science

REVIEW
published: 22 February 2016
doi: 10.3389/fpls.2016.00172

# Carbon Nanomaterials in Agriculture: A Critical Review

*Arnab Mukherjee[1], Sanghamitra Majumdar[1], Alia D. Servin[1], Luca Pagano[1,2,3], Om Parkash Dhankher[3] and Jason C. White[1]**

*Review Article*

# Zinc Oxide Nanoparticles for Revolutionizing Agriculture: Synthesis and Applications

**Sidra Sabir, Muhammad Arshad, and Sunbal Khalil Chaudhari**

Biotechnology Reports 15 (2017) 11–23

Contents lists available at ScienceDirect

Biotechnology Reports

journal homepage: www.elsevier.com/locate/btre

Review

# Nanotechnology: The new perspective in precision agriculture

Joginder Singh Duhan[a,*], Ravinder Kumar[a], Naresh Kumar[a], Pawan Kaur[a], Kiran Nehra[b], Surekha Duhan[c]

PLOS ONE

RESEARCH ARTICLE

# Effects of $TiO_2$ nanoparticles on wheat (*Triticum aestivum L.*) seedlings cultivated under super-elevated and normal $CO_2$ conditions

**Fuping Jiang[1], Yunze Shen[2], Chuanxin Ma[3,4], Xiaowen Zhang[1], Weidong Cao[5,6], Yukui Rui[1,3]***

Science of the Total Environment 625 (2018) 677–685

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

# Interaction mechanisms between $\alpha$-$Fe_2O_3$, $\gamma$-$Fe_2O_3$ and $Fe_3O_4$ nanoparticles and *Citrus maxima* seedlings

Junli Li [a,*], Jing Hu [a], Lian Xiao [a], Yunqiang Wang [b], Xilong Wang [c,*]

Ruttkay-Nedecky *et al. J Nanobiotechnol (2017) 15:33*
DOI 10.1186/s12951-017-0268-3

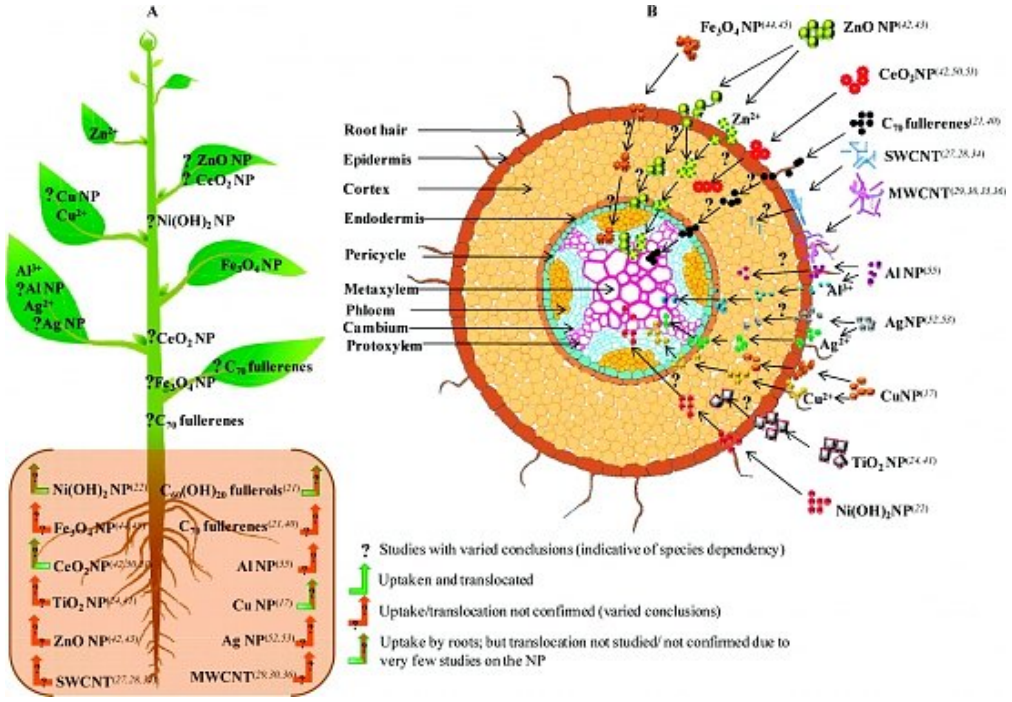
Journal of Nanobiotechnology

REVIEW Open Access

# Nanoparticles based on essential metals and their phytotoxicity

Branislav Ruttkay-Nedecky[1,2], Olga Krystofova[1,2], Lukas Nejdl[1,2] and Vojtech Adam[1,2*]

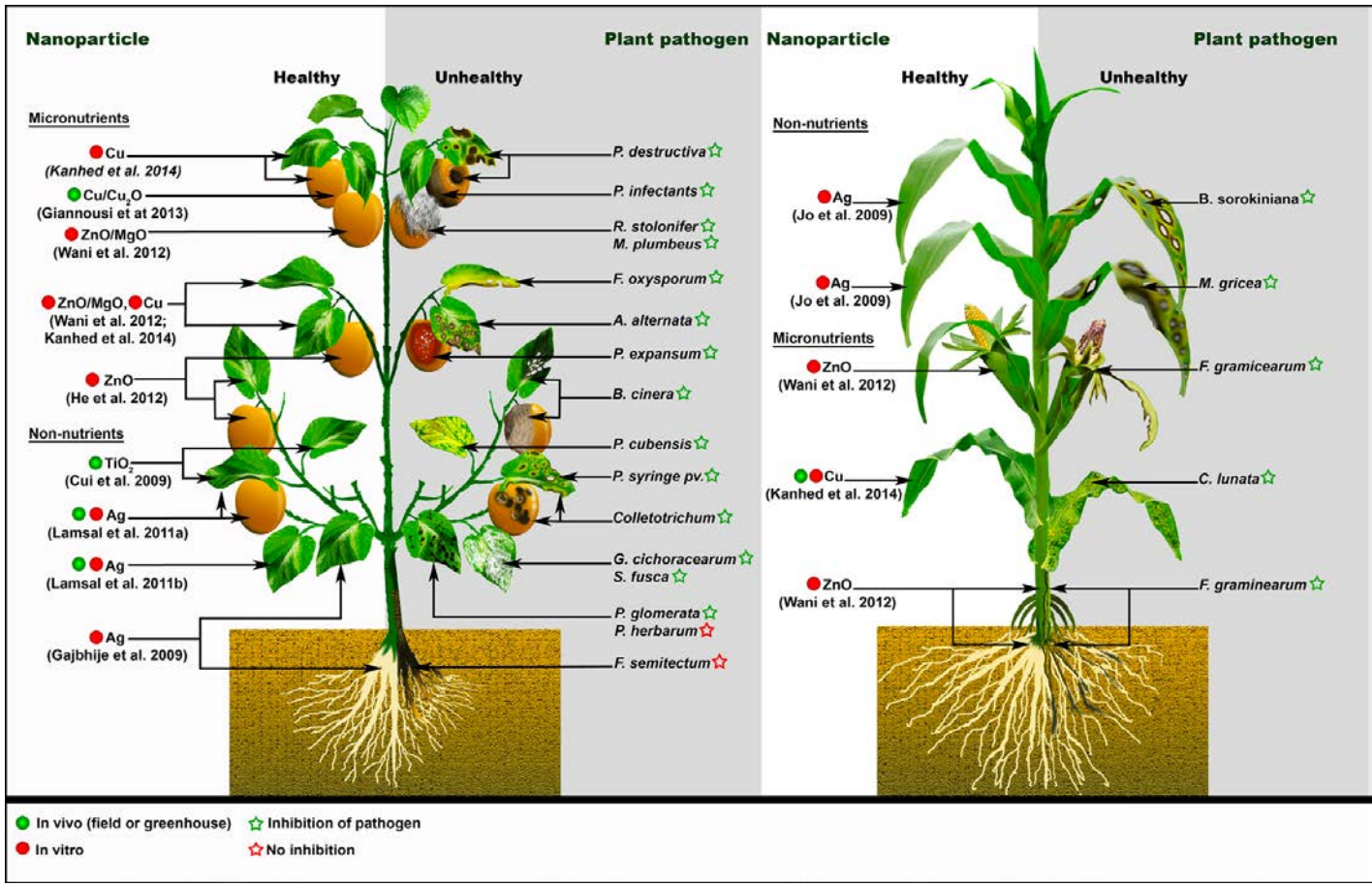
# *2 possibilities*




J. Agric. Food Chem. 2011, 59, 3485–3498

- **PROMOTE THE GROWTH OF CULTURES**

- **THE BACTERICIDE AND FUNGICIDE ACTIVITY**

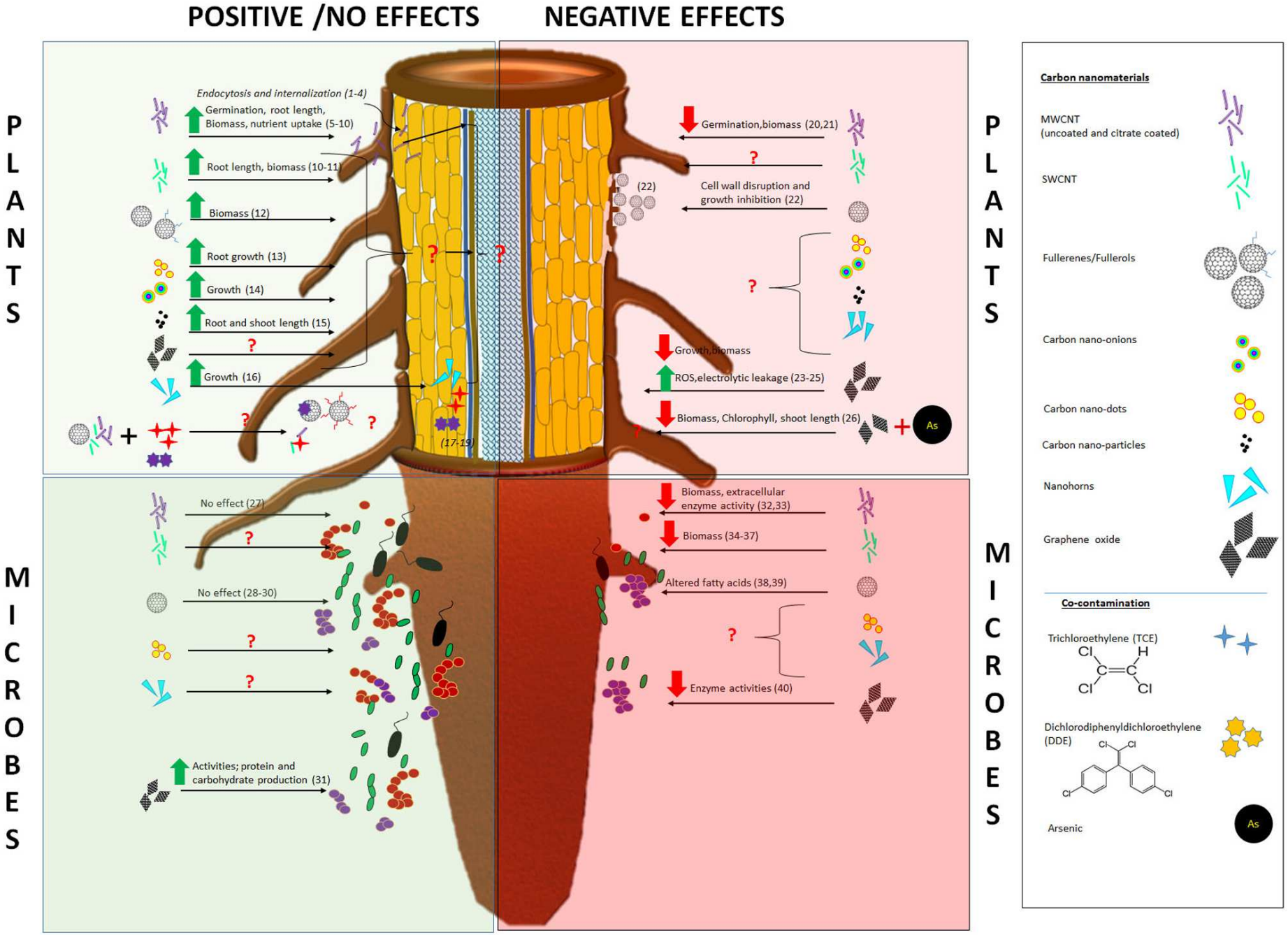



J Nanopart Res (2015) 17:92

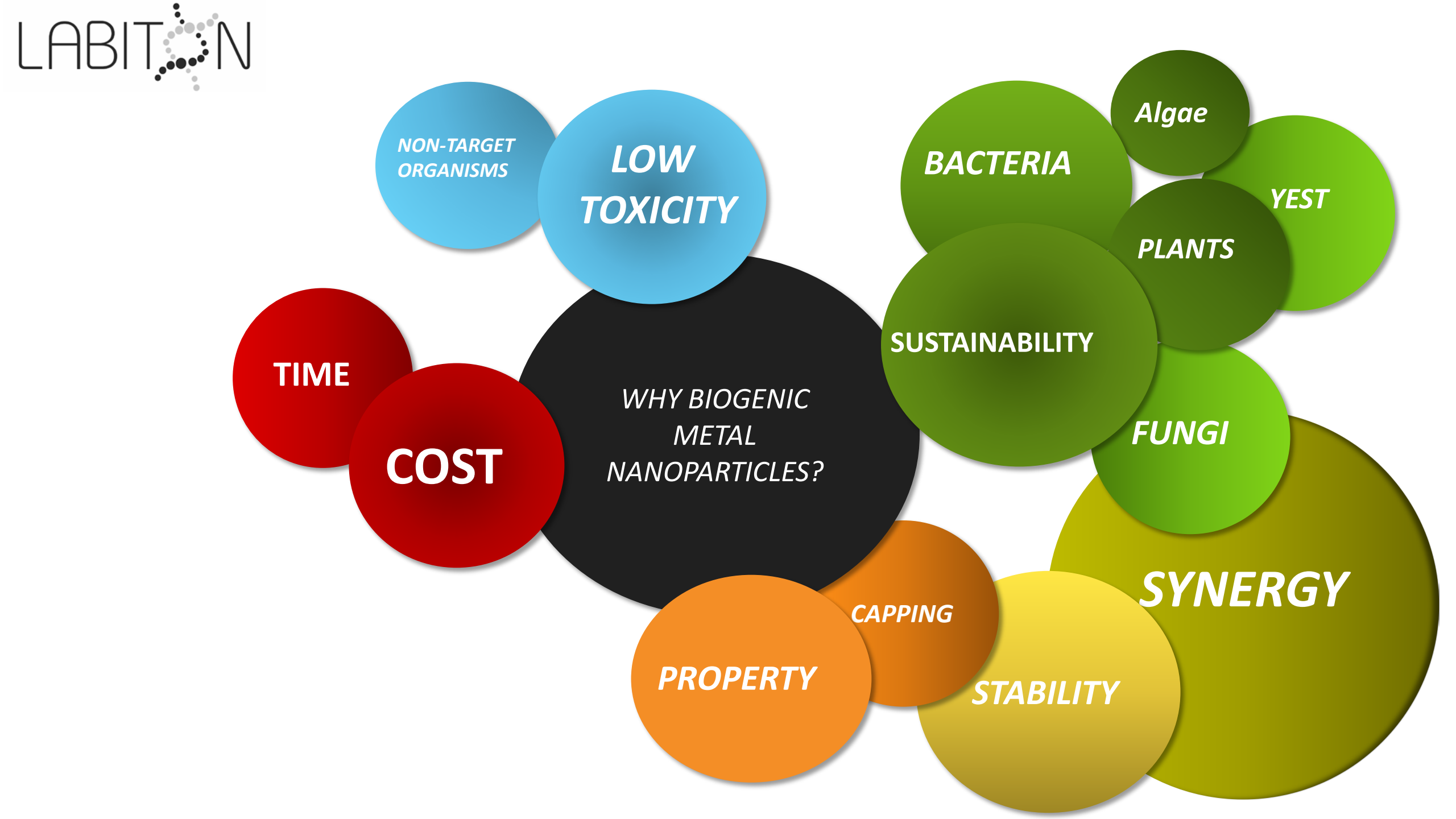
# Environmental toxicity

# *Roots*

- MORE STUDIES
- MANY POSSIBILITIES AND PARAMETERS NEED TO BE CONSIDERED




Frontiers in Plant Science Vol. 7 (172) M*ukherjee et al. (2016).*

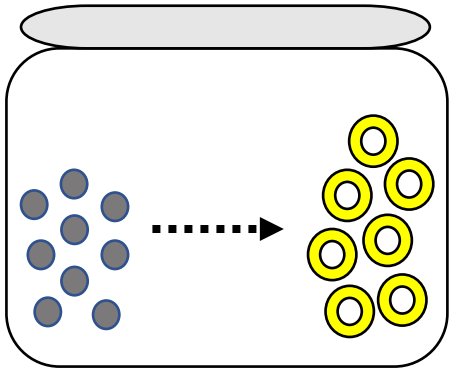

LABITON
NON-TARGET ORGANISMS
LOW TOXICITY
BACTERIA
Algae
YEST
PLANTS
SUSTAINABILITY
TIME
COST
WHY BIOGENIC METAL NANOPARTICLES?
FUNGI
SYNERGY
CAPPING
PROPERTY
STABILITY

**BASIC IDEA**

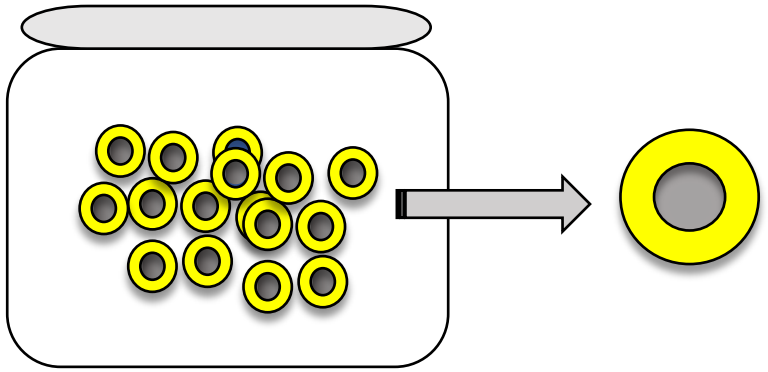
Biological synthesis

Metal salt concentration

Organism metabolites



**TIME optimization**



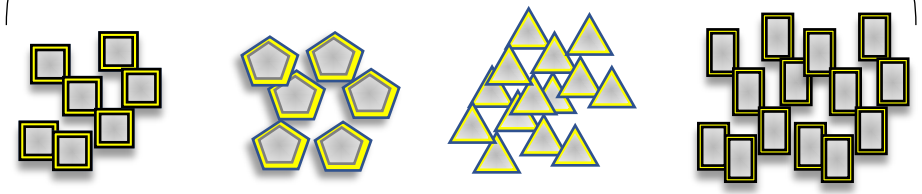
Biogenic nanoparticles

**PRINCIPAL CHARACTREISTIC**

Stable production of homogeneous and capped NPs with high yield

***Modify processing parameters***

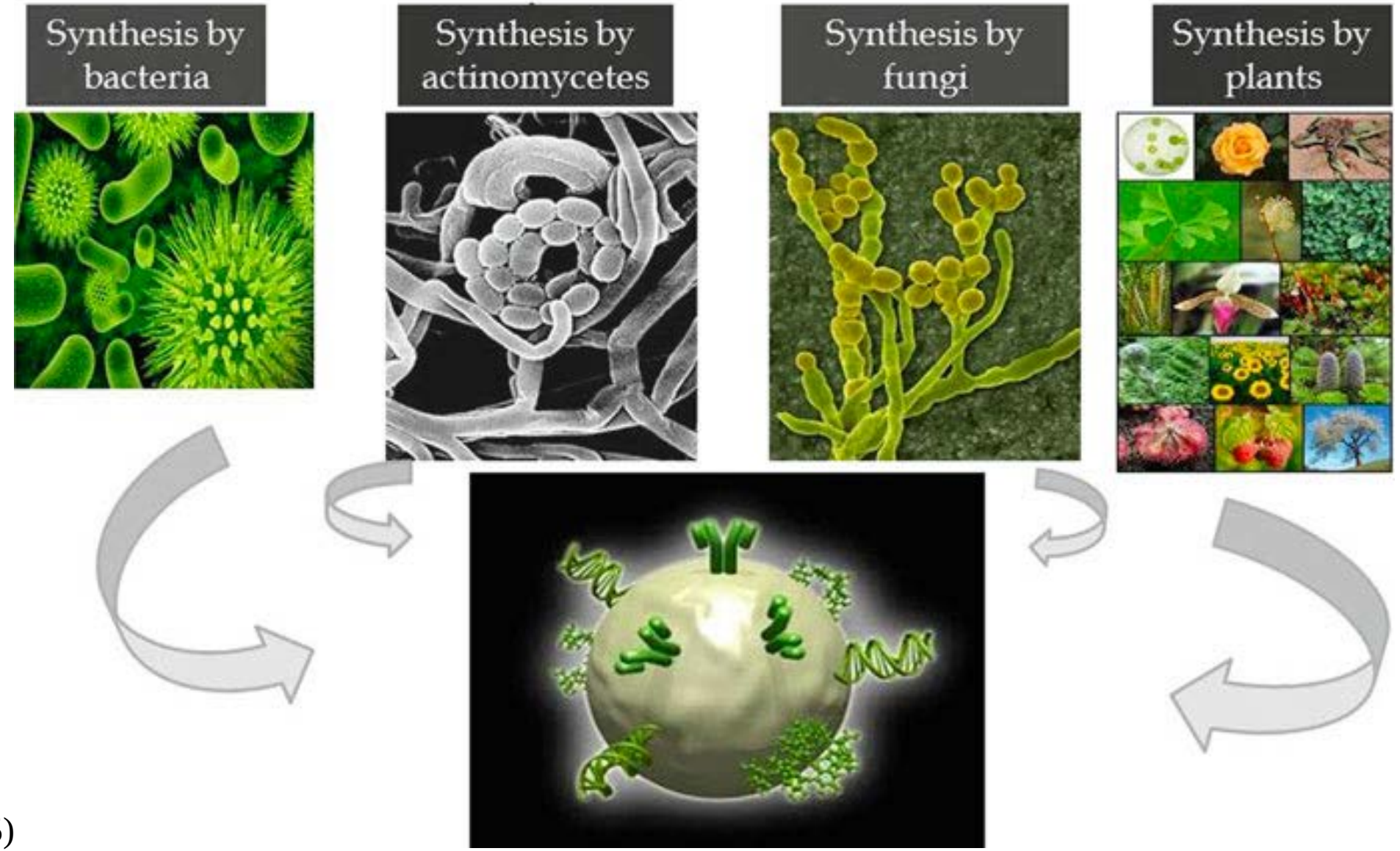
Controlled shape and morphology of NPs



**POSSIBILITY**

*Based: Trends in Biotechnology, July 2016, Vol. 34, No. 7*

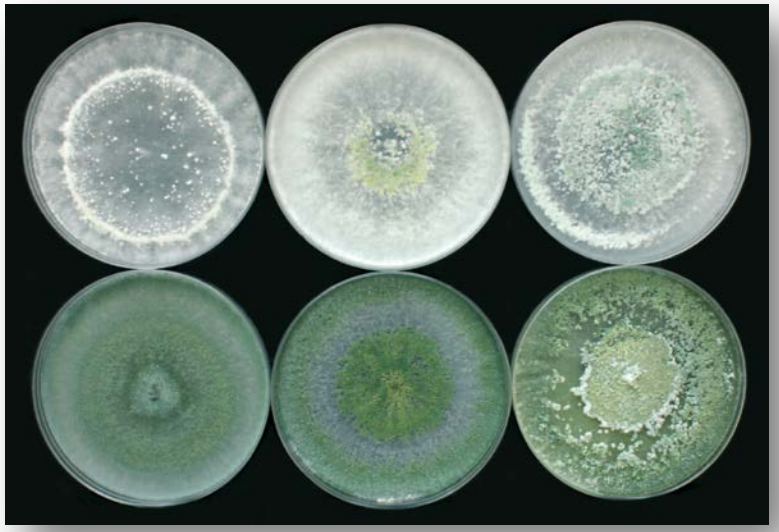
# Bio-inspired Green Nanomaterial synthesis




M. Razavi et al. (2015)

# *GROUP PROPOSAL*

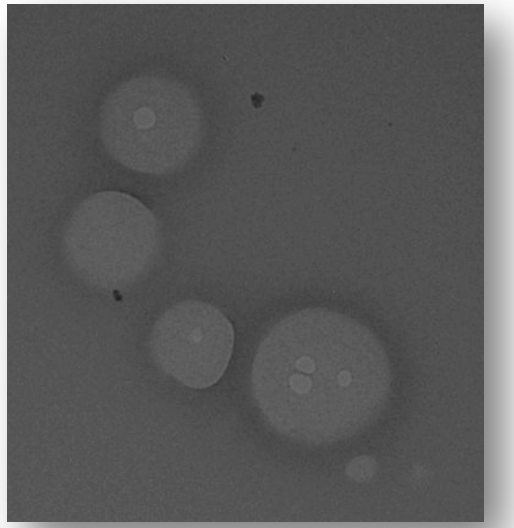
Trichoderma



Journal of Plant Protection Research 54 (4), 2014

Synthesis

**Nanoparticle**

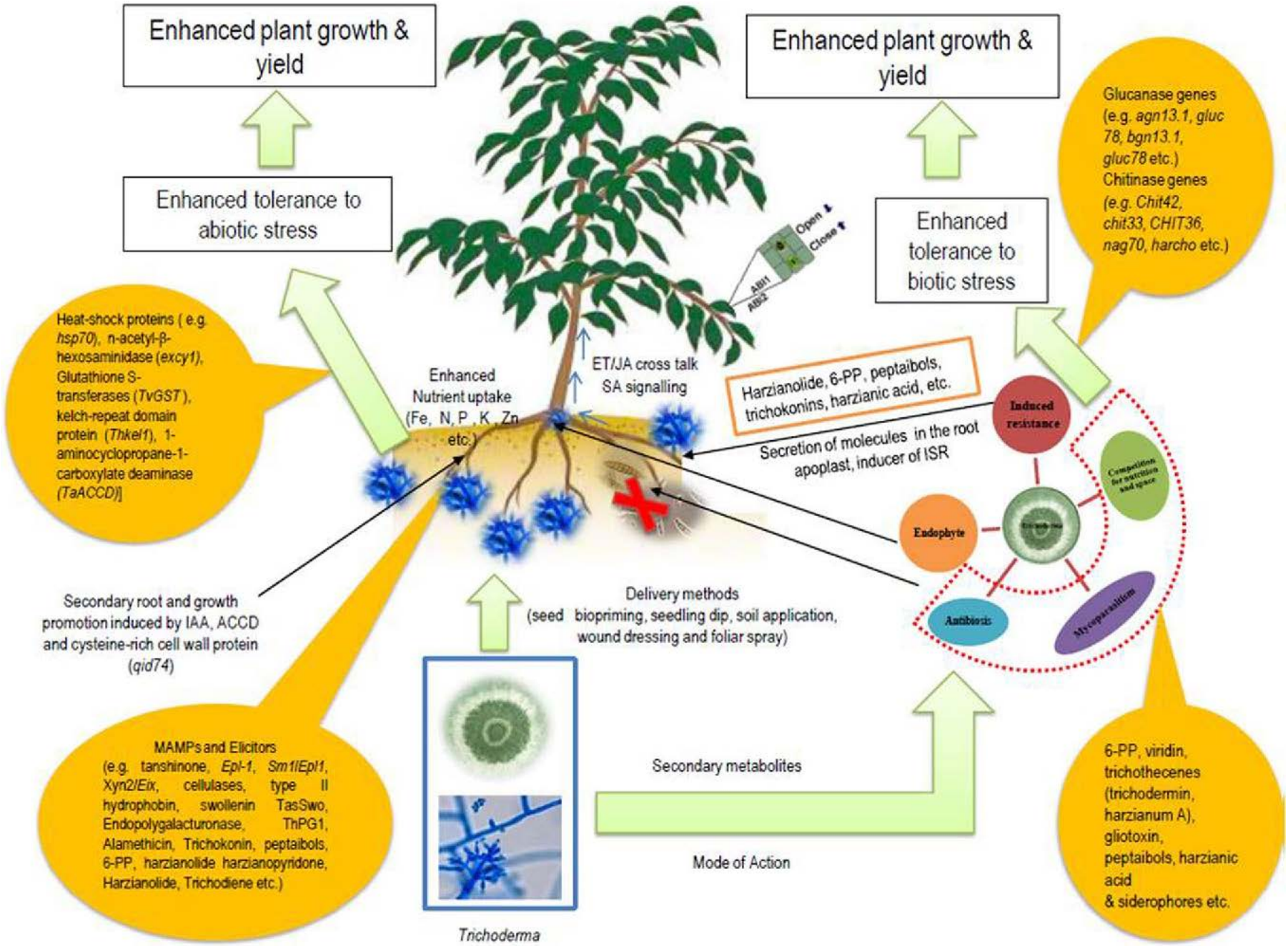


FOCUS

White mold - *Sclerotinia sclerotiorum*

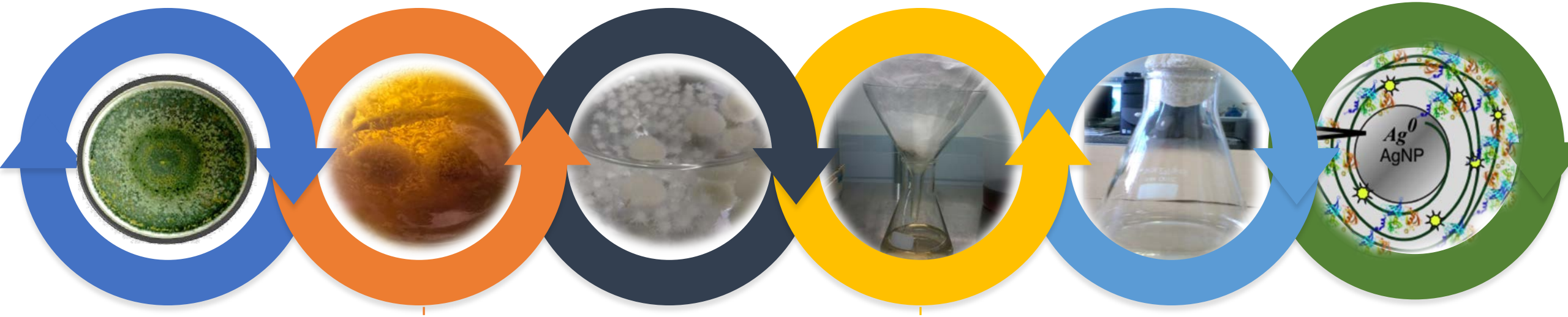
# Trichoderma

*PROTECT AND IMPROVE CROP*
*PROMOVE PLANT RESISTENCE*




World J Microbiol Biotechnol (2017) 33:155

# Synthesis Process




**Fungi Growth**

**Fungus in the broth medium**

**Fungus in water**

**filtrate**

**Use the filtrate to Synthesis nanoparticles**

**Nanoparticles**

*Biogenic Nanoparticles*

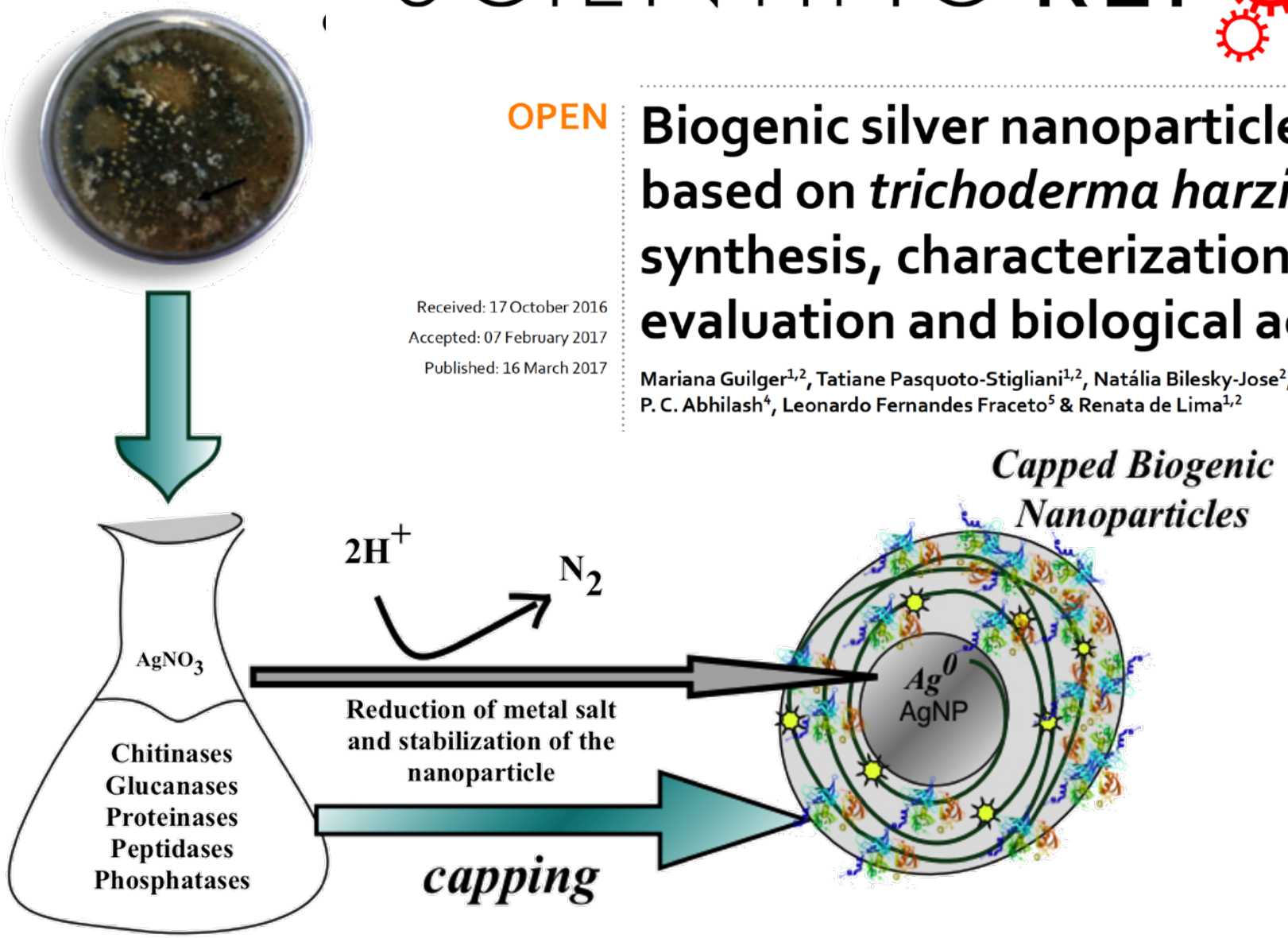
SCIENTIFIC REPORTS

OPEN

Received: 17 October 2016
Accepted: 07 February 2017
Published: 16 March 2017

# Biogenic silver nanoparticles based on *trichoderma harzianum*: synthesis, characterization, toxicity evaluation and biological activity

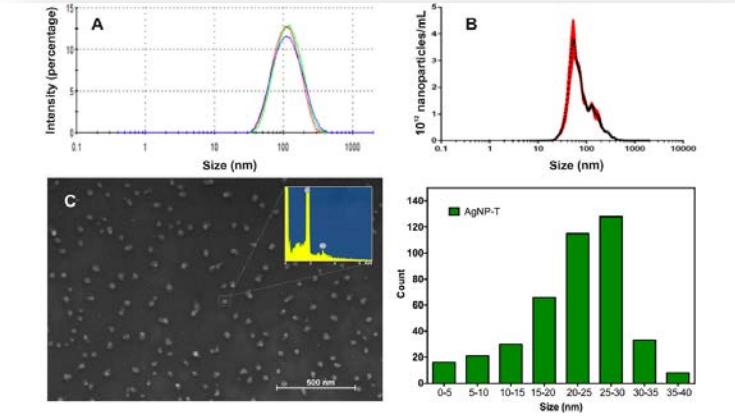
Mariana Guilger[1,2], Tatiane Pasquoto-Stigliani[1,2], Natália Bilesky-Jose[2], Renato Grillo[3], P. C. Abhilash[4], Leonardo Fernandes Fraceto[5] & Renata de Lima[1,2]



# RESULTS

SCIENTIFIC REPORTS

PRESENTED ACTIVITY AGAINST WHITE MOLD



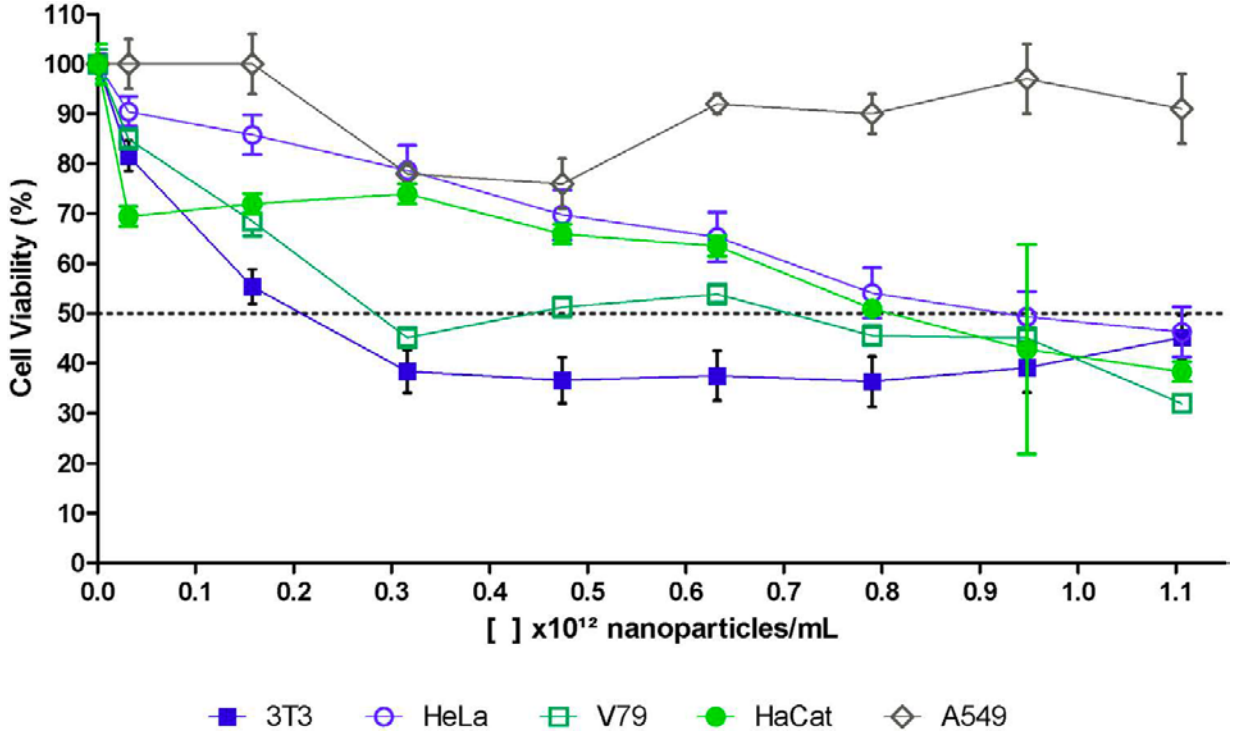

[redacted]

NO TRICHODERMA TOXICITY

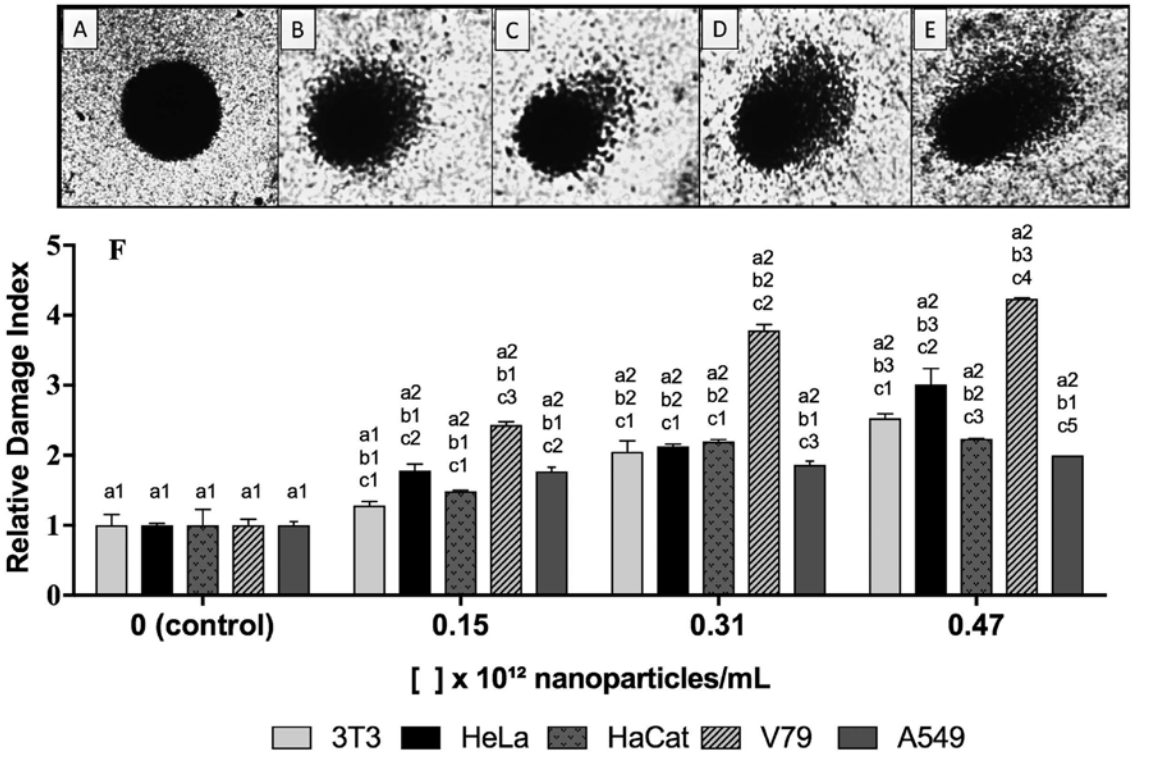
[redacted]

# RESULTS

## MTT




## COMET ASSAY

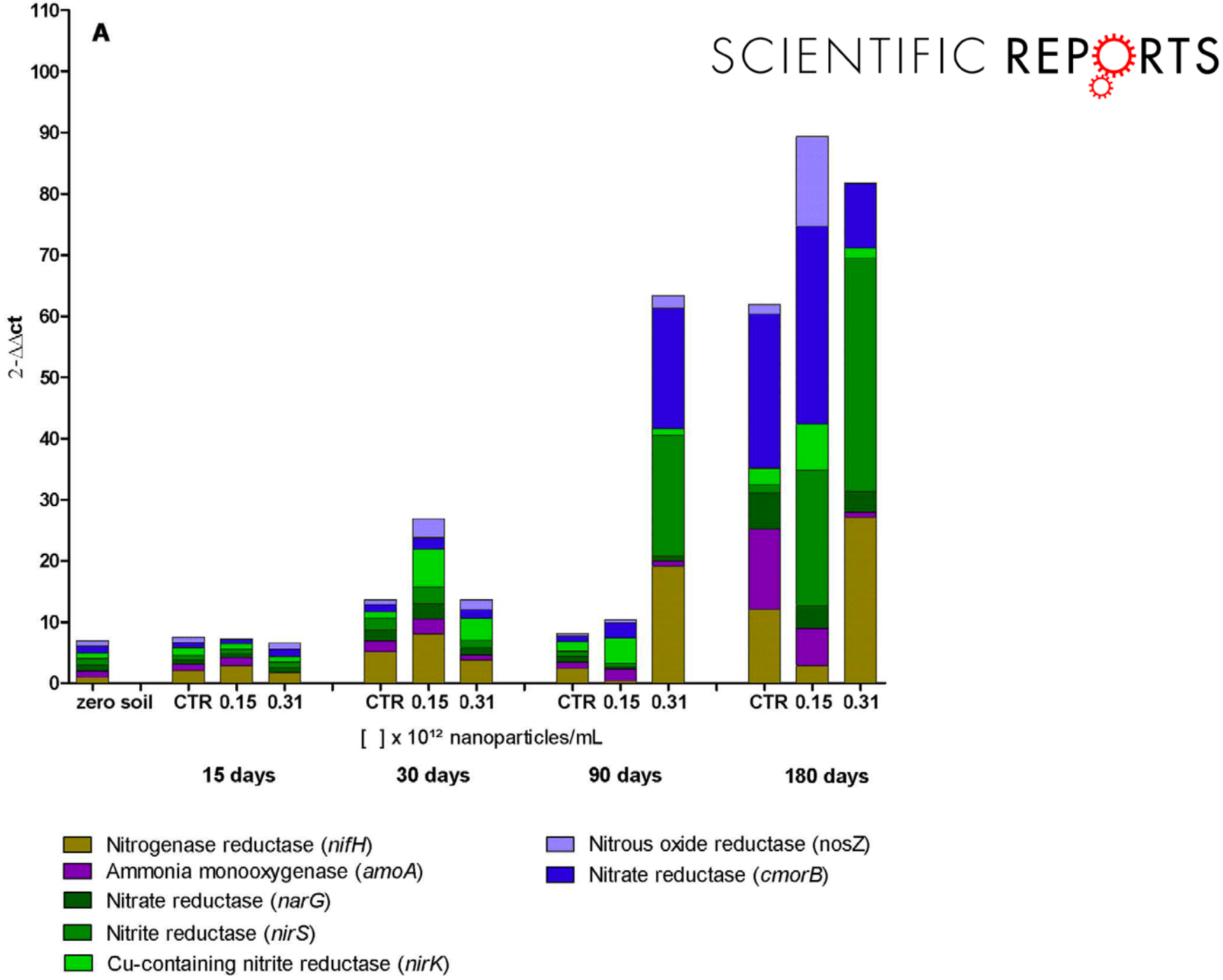



**a** (control x treatment); **b** (0.15 x 0.31 x 0.47); **c** (3T3 x HeLa x HaCat x V79 x A549)

LABITON

SCIENTIFIC REPORTS

# RESULTS



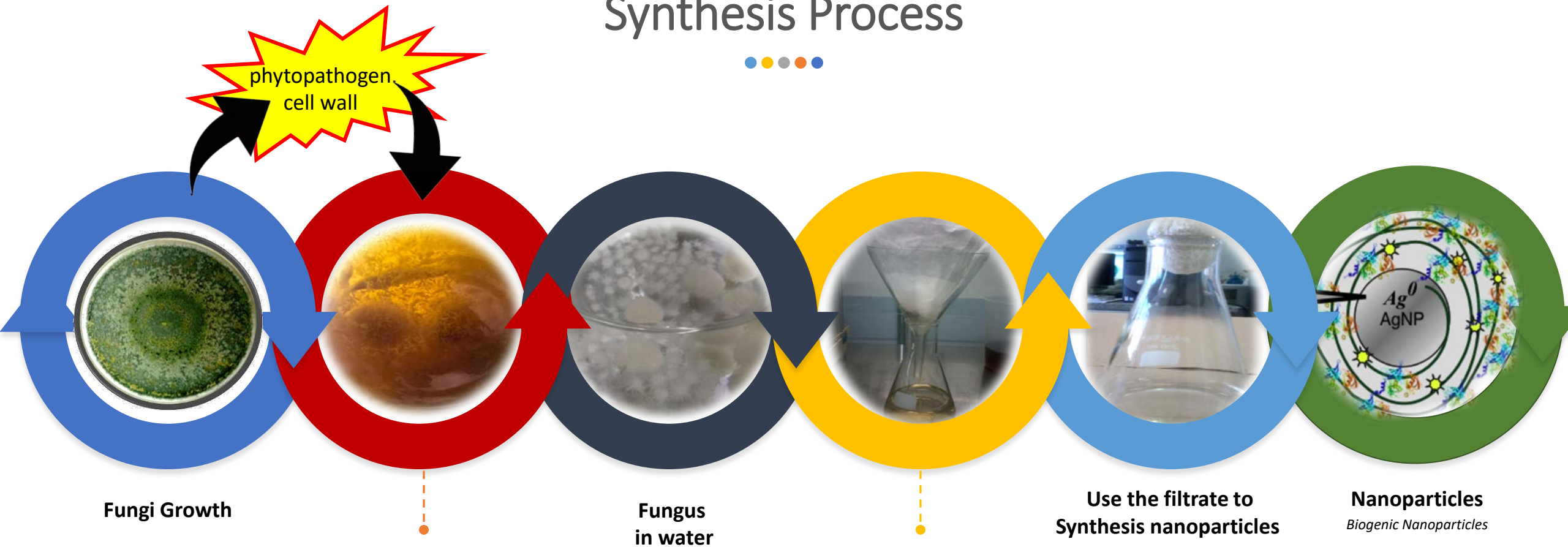
# Possibilities

# New studies

# Synthesis of biogenic silver nanoparticles using the filtrate of the fungus *Trichoderma harzianum +* phytopathogen cell wall (white mold)

# *Trichoderma stimulated - AgNP*

## Synthesis Process




**Fungi Growth**

**Fungus in the broth medium + phytopathogen cell wall**

**Fungus in water**

**filtrate**

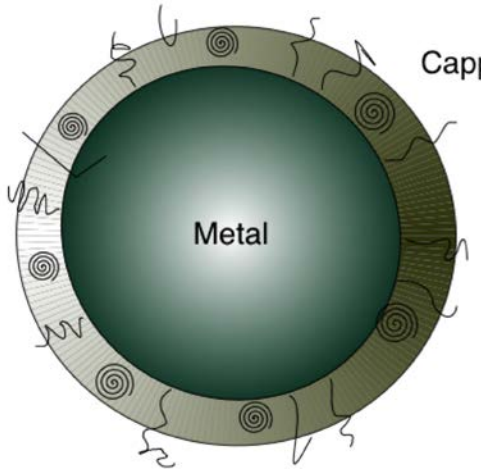
**Use the filtrate to Synthesis nanoparticles**

**Nanoparticles**

*Biogenic Nanoparticles*

# RESULTS

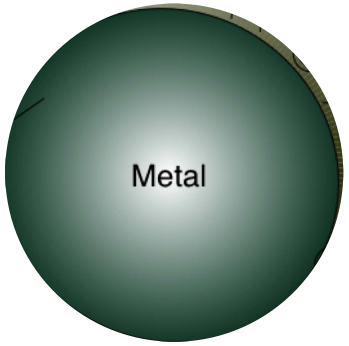
## *Trichoderma stimulate - AgNP*



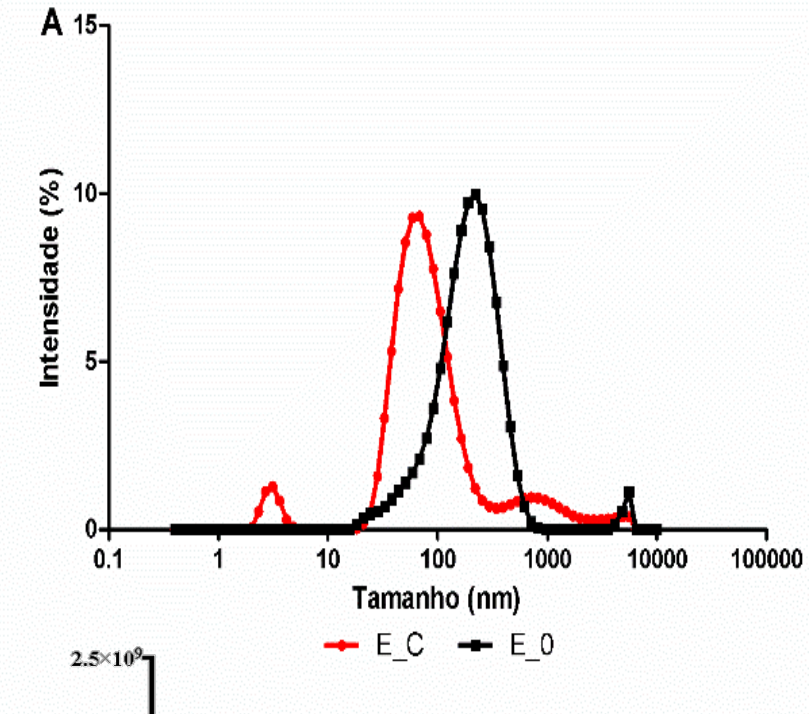

E_C

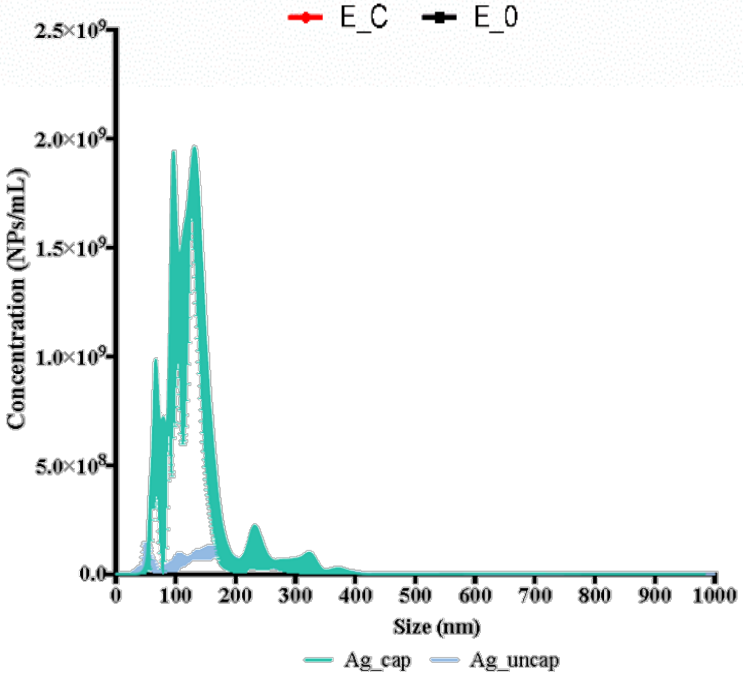
*Remove capping*

(SDS and Tris)




E_0

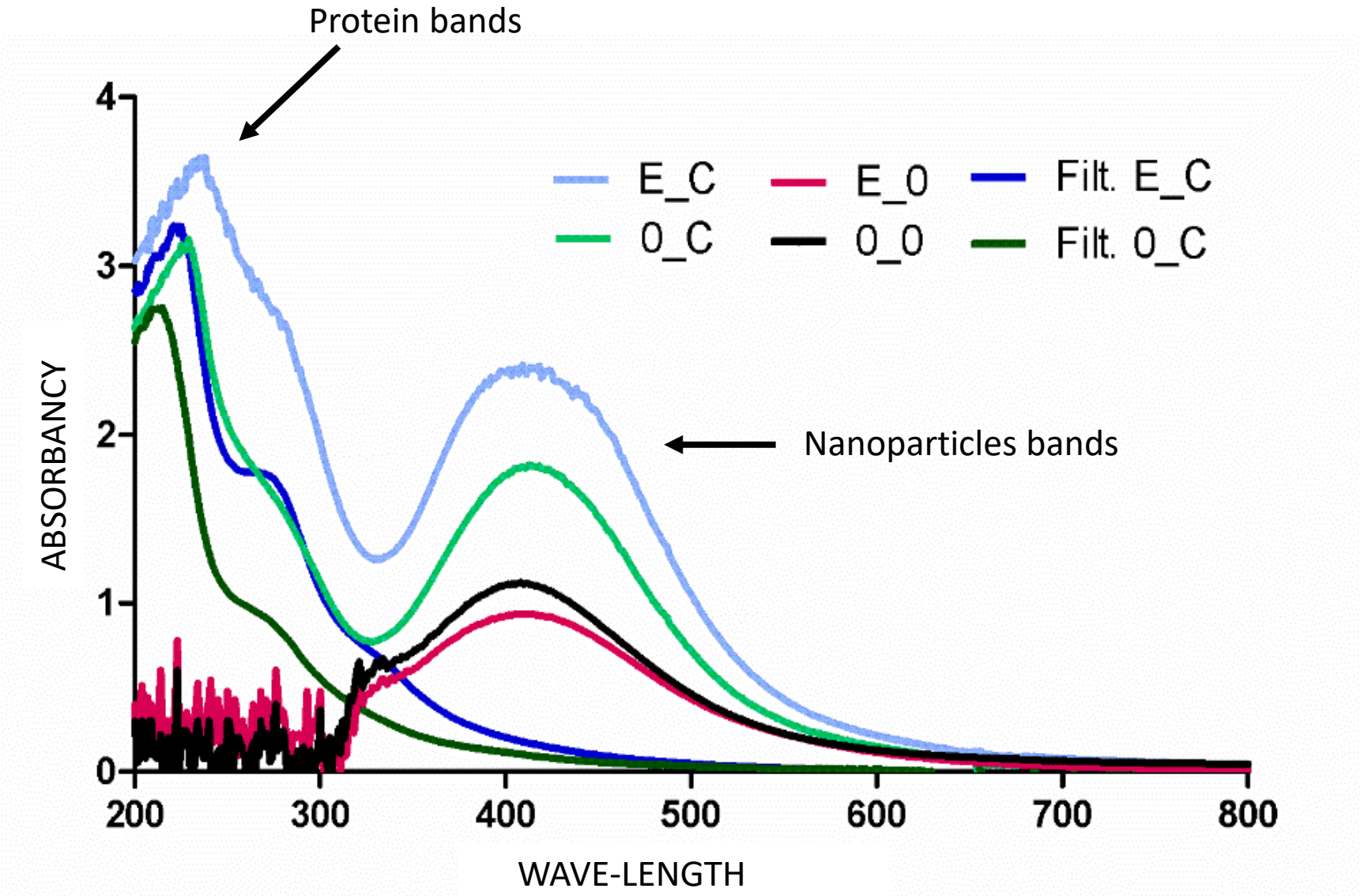


LABITON

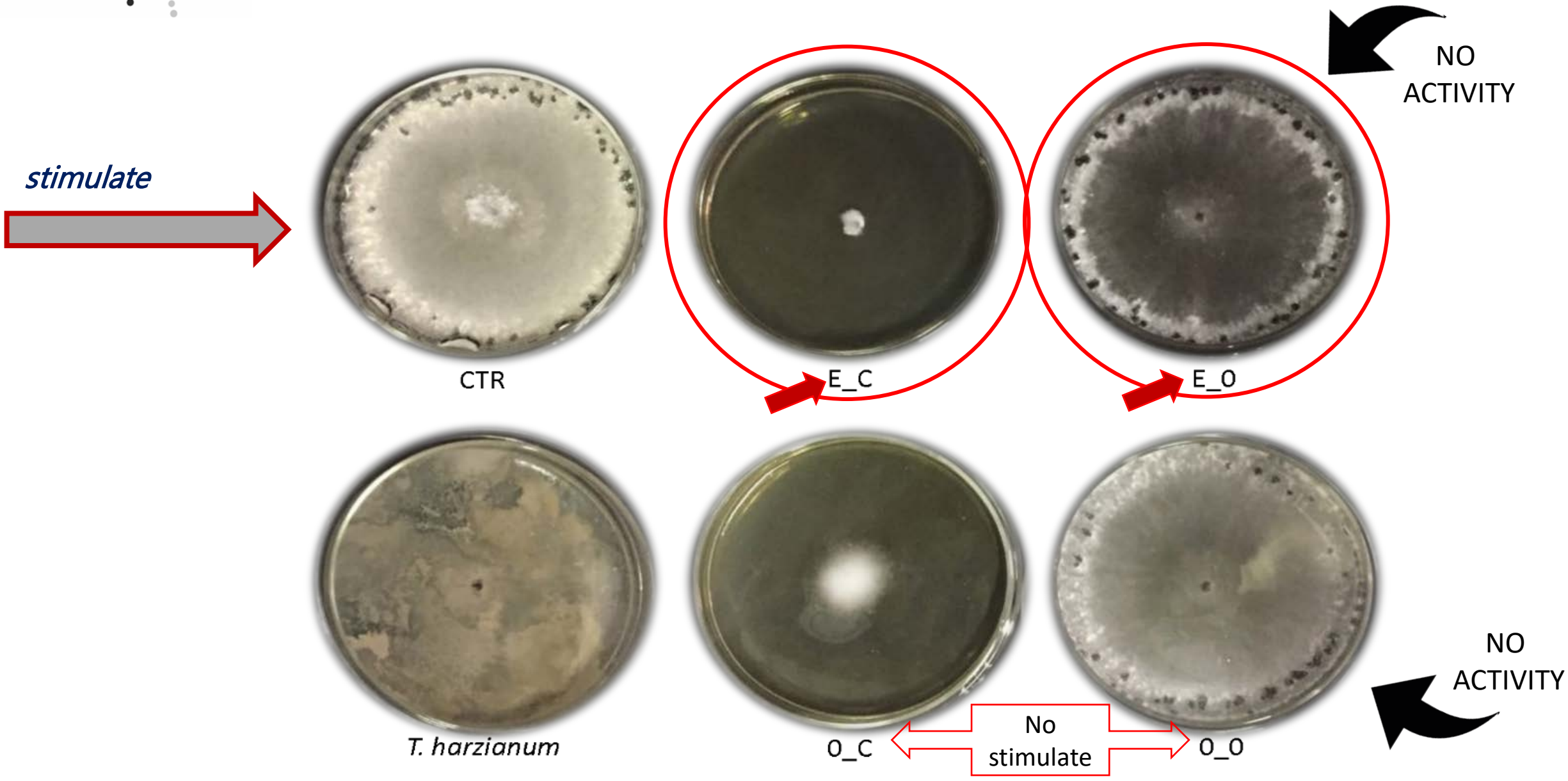
# RESULTS

## *UV visible* to confirm capping remove



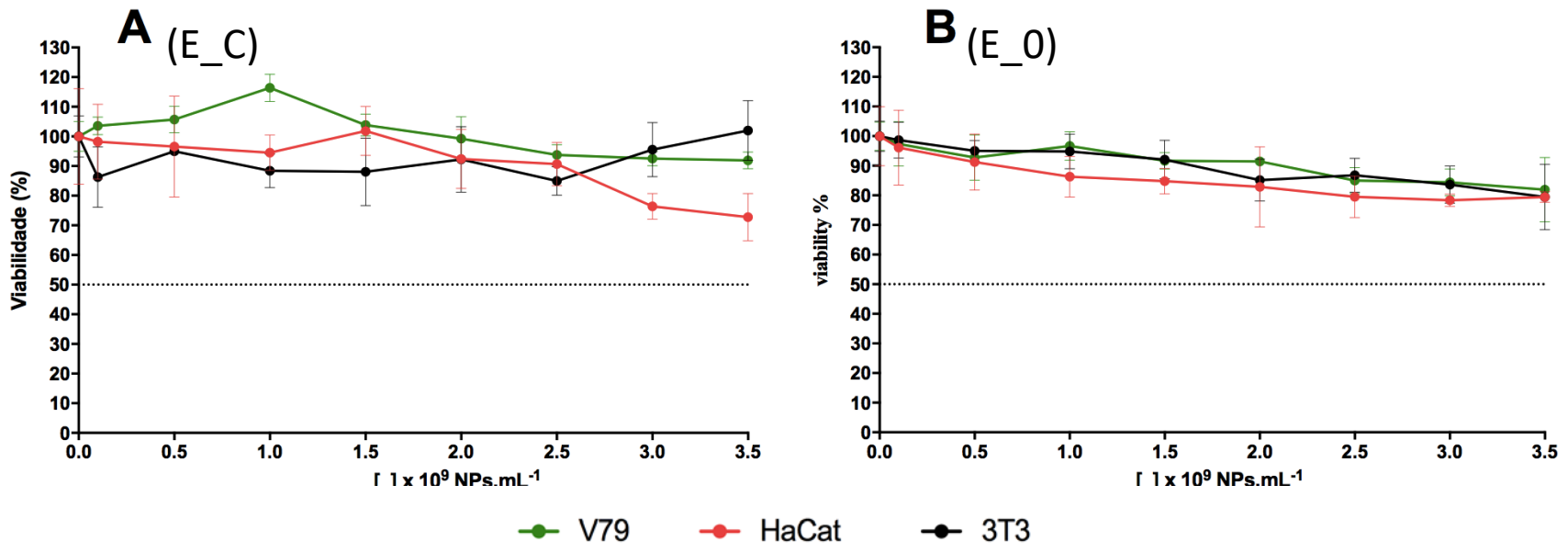
# RESULTS

## *Trichoderma stimulate - AgNP*

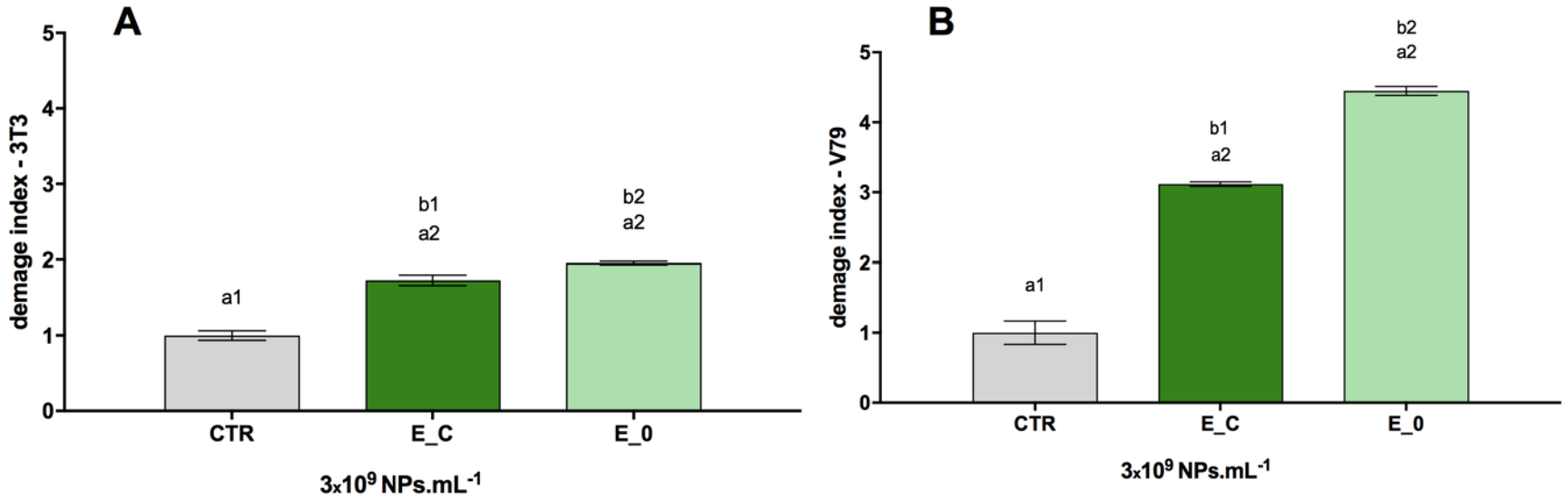


# RESULTS

**MTT**




***Alium cepa***



# Synthesis of biogenic iron nanoparticles using the filtrate of the fungus *Trichoderma harzianum*

# *Trichoderma- Iron - NP*

## ACTIVITY

White mold

NANOPARTICLES

**NANO 1**

**$FeCl_3$ (0.07)**
**FeCl2 (0.02)**

**NANO 2**

**FeCl3 FeSO4**

**NANO 3**
***$FeCl_3NP$***

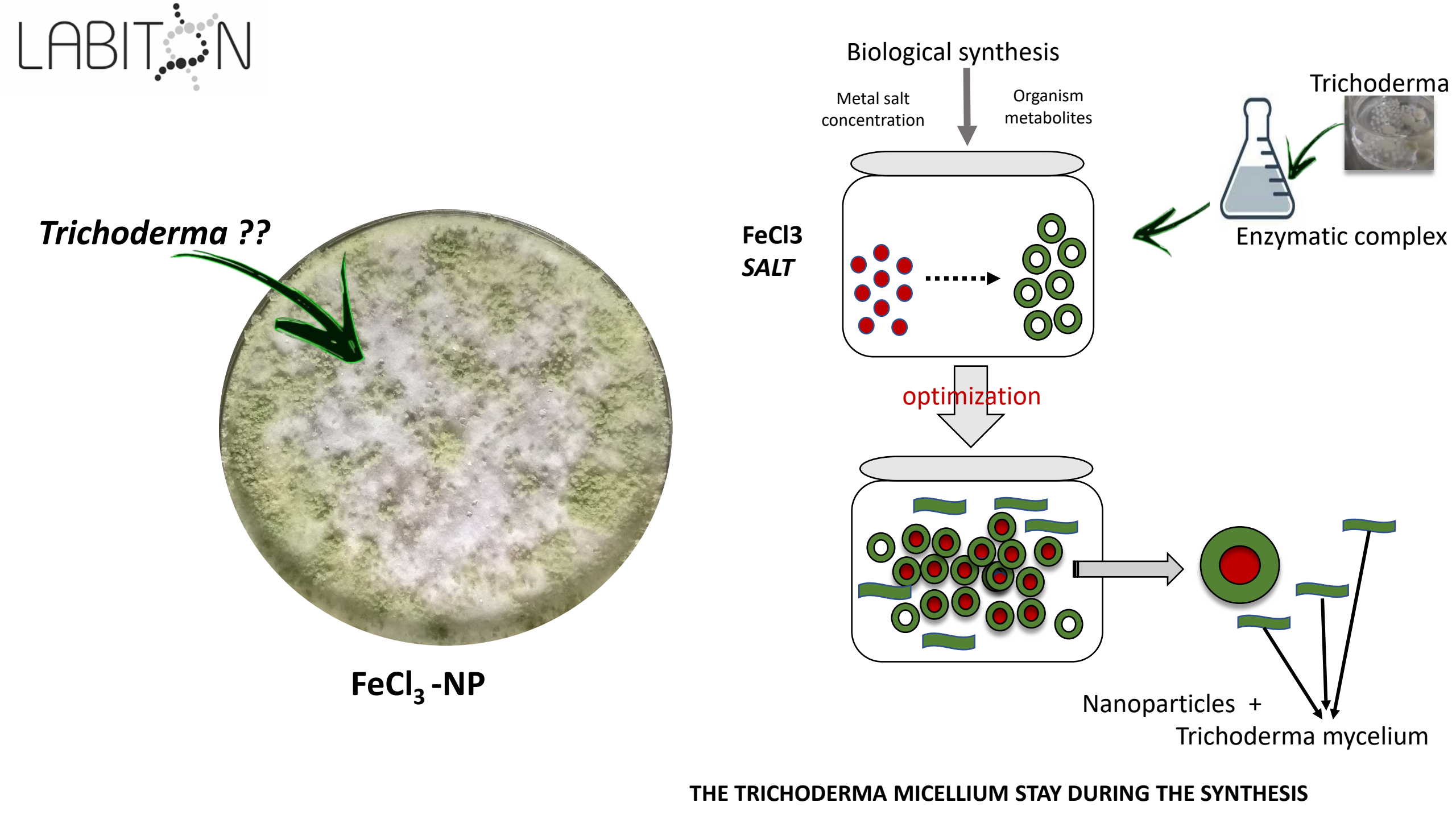
**FeCl3 (0.001)**

**NANO 4**

**FeCl3 1:1**

**NANO 5**


**FeCl2 (0.2)**
**FeCl3 (0.1)**

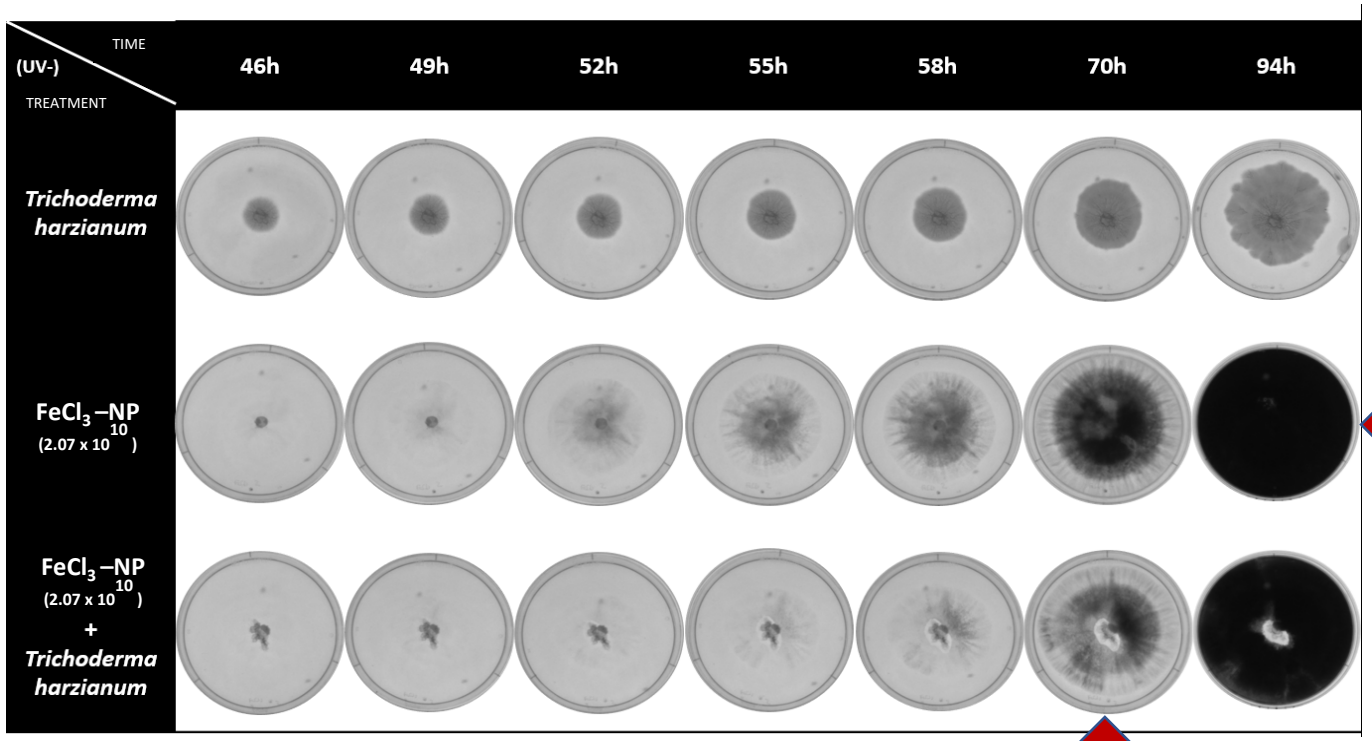

Trichoderma ??
FeCl3 -NP
Biological synthesis
Metal salt concentration
Organism metabolites
Trichoderma
Enzymatic complex
FeCl3
SALT
optimization
Nanoparticles +
Trichoderma mycelium
THE TRICHODERMA MICELLIUM STAY DURING THE SYNTHESIS

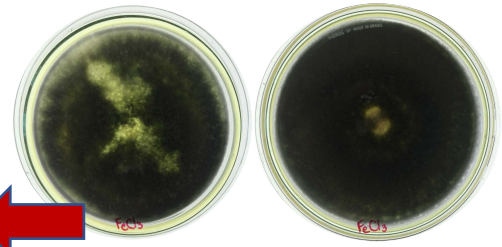
LABITON

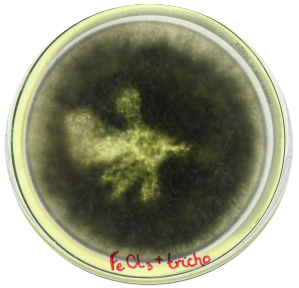
# RESULTS

# Growth Kinetics

## $FeCl_3NP$ Biogenic Trichoderma nanoparticles





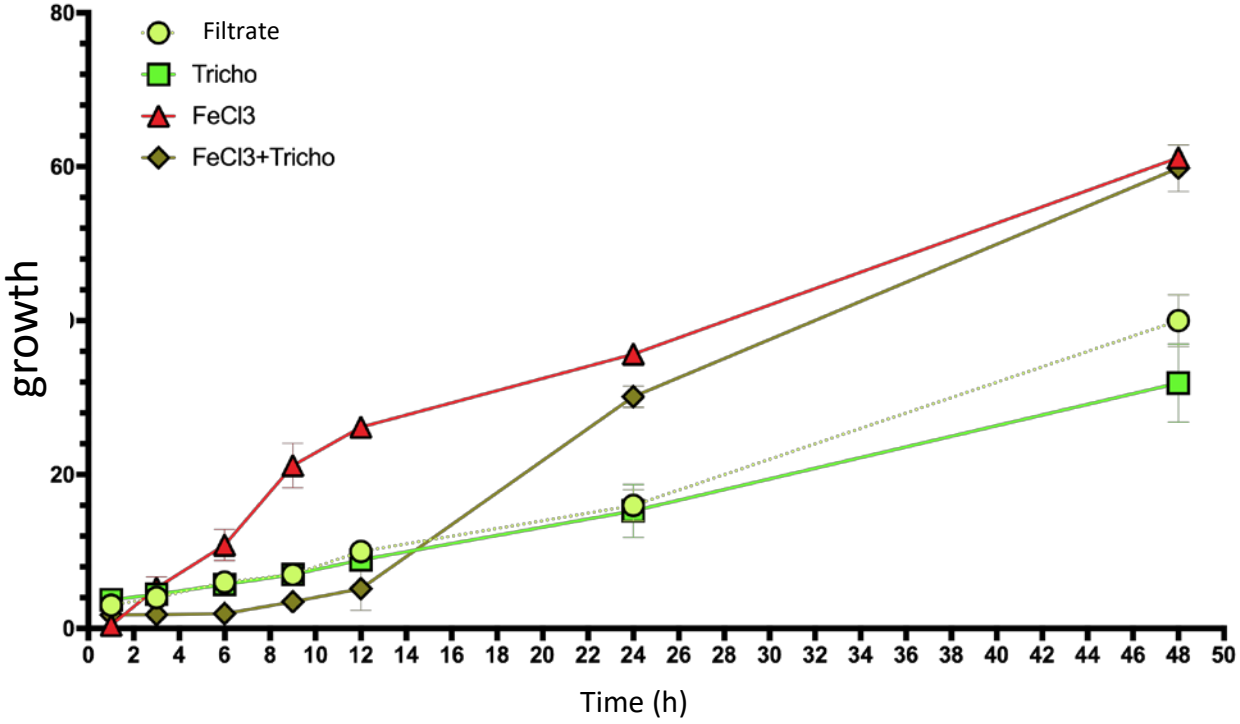
LABITON

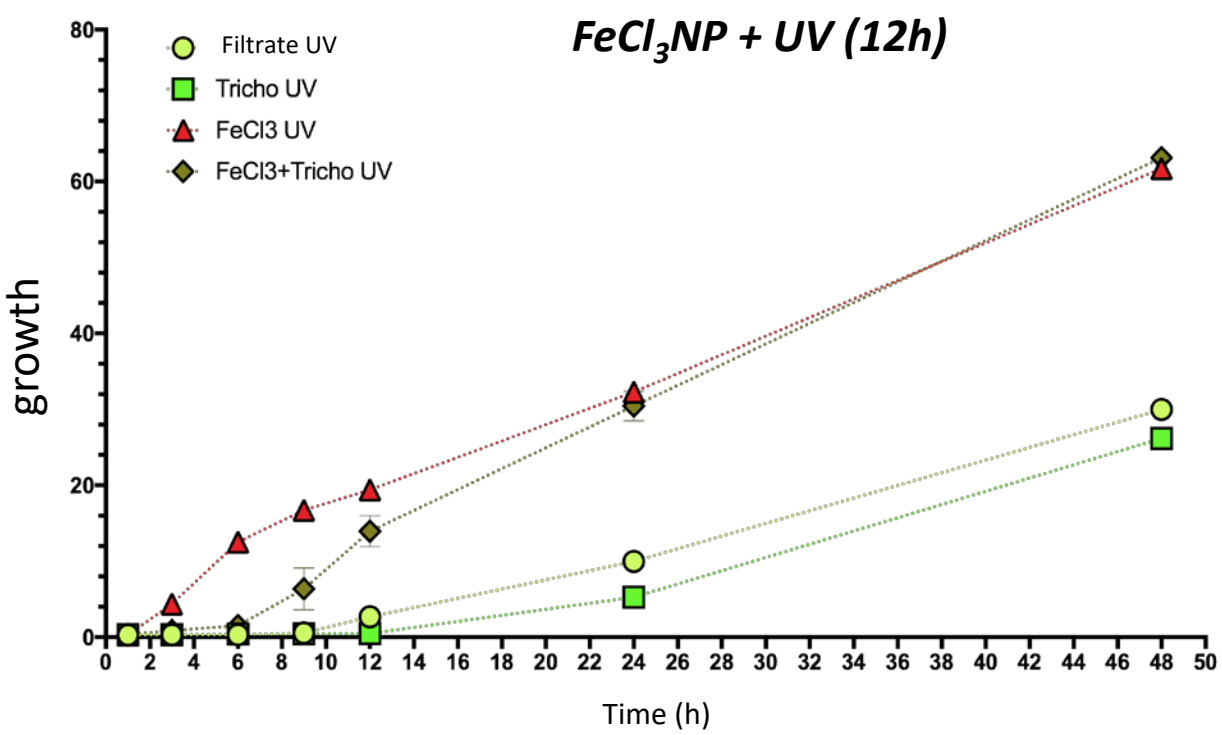
RESULTS

# $FeCl_3NP$

## Biogenic Trichoderma nanoparticles

## *Growth Kinetics*



LABITON

# RESULTS

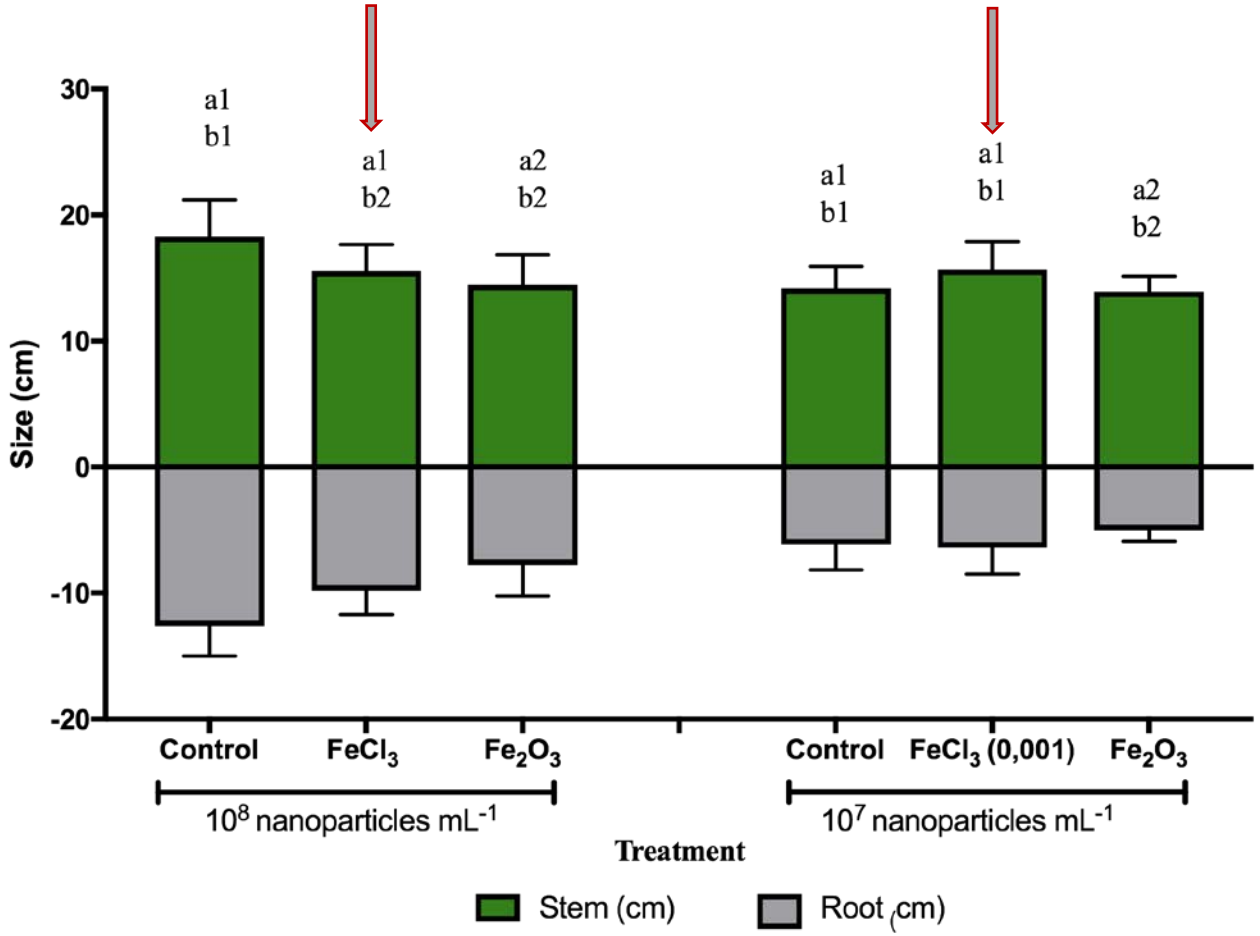
# $FeCl_3NP$

## Biogenic Trichoderma nanoparticles

### *HYDROPONY*

Control

***$FeCl_3NP$***



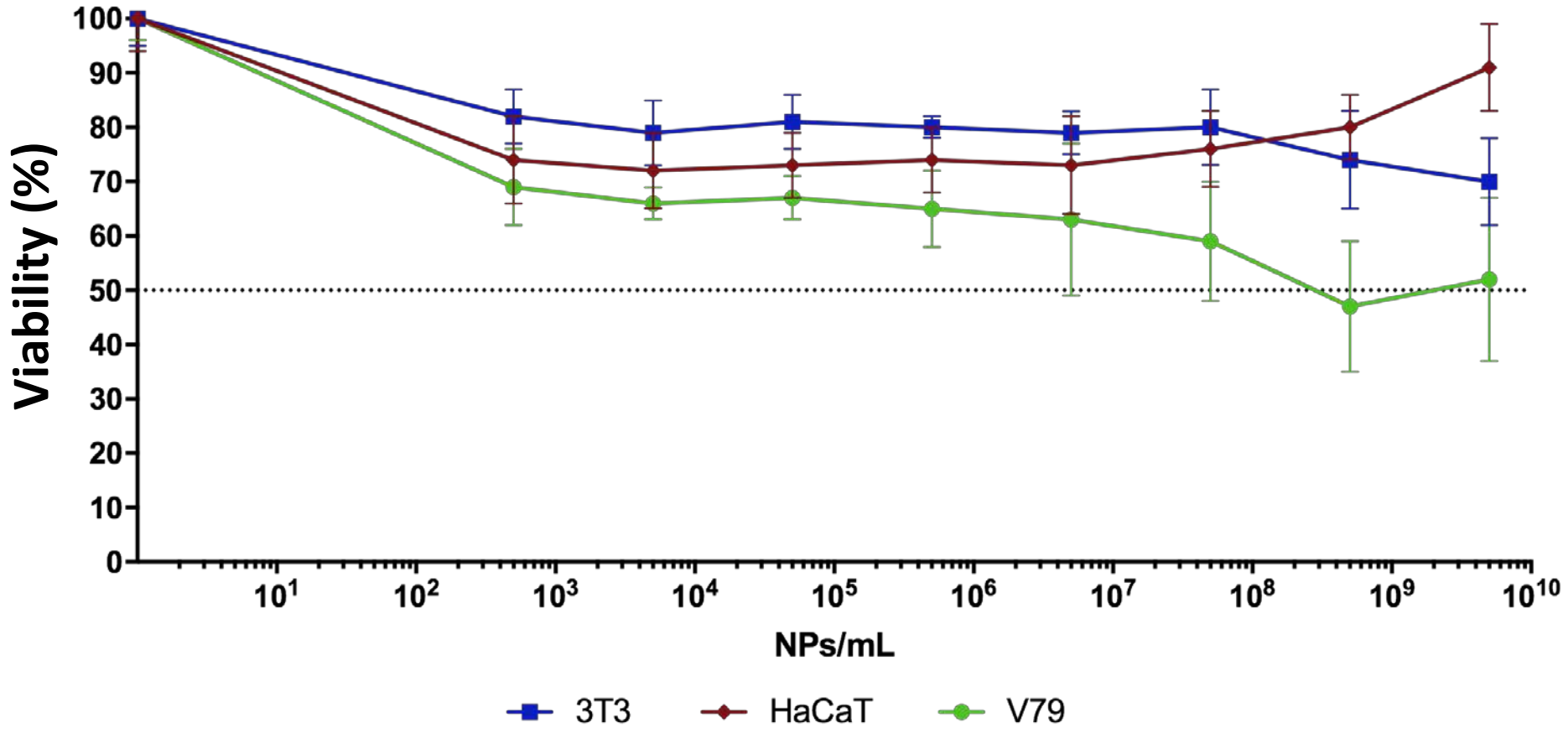
LABITON

# RESULTS

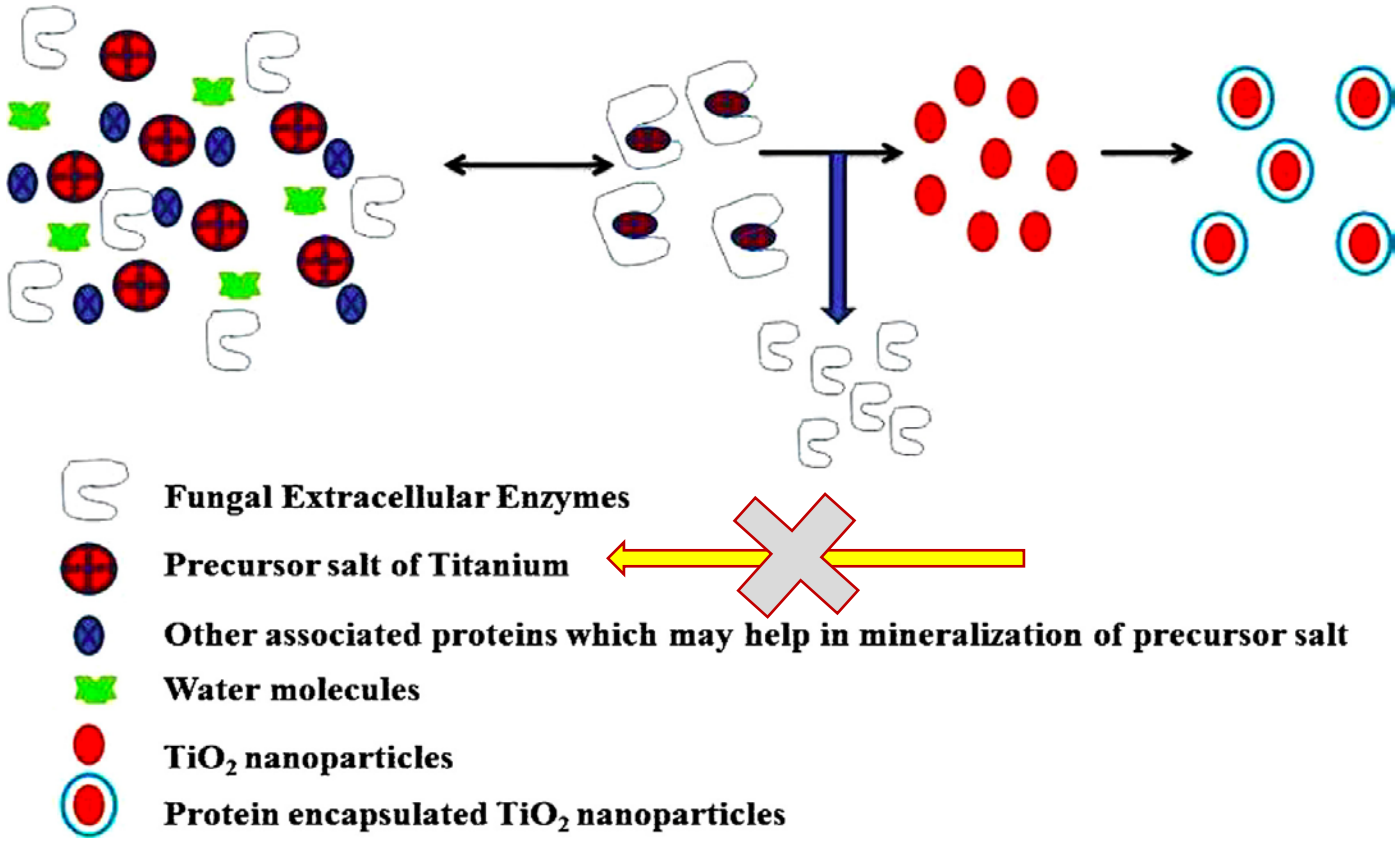
## $FeCl_3NP$

## Biogenic Trichoderma nanoparticles

***Toxicity (MTT)***



# Synthesis of biogenic Titanium nanoparticles using the filtrate of the fungus *Trichoderma harzianum*



LABITON

Biological synthesis

Organism metabolites

Trichoderma

**Titanium (II) Oxide**
**Titanium (IV) Oxide Anatase**
**Titanium (IV) Oxide Rutile**

**Powder**

Disperse

Enzymatic complex

optimization

Filtrate

0.2 um

Colloid

Tichoderma mycelium

# *Trichoderma- TiO-NP*

*Trichoderma harzianum*
*CONTROL*

***Trichoderma***

NPTiO II-SE

**Titanium (II) Oxide**

NPTiOI VA-SE

**Titanium (IV) Oxide Anatase**

NPTiOI VR-SE

**Titanium (IV) Oxide Rutile**

LABITON

*RESULTS*

# *Trichoderma- TiO-NP*

| NANOPARTICLE | DLS | | NTA | | pH |
|---|---|---|---|---|---|
| | POLIDISPERSIVITY | ZETA P. (mV) | SIZE (nm) | (NPs/mL) | |
| **NPTiO II-SE** | 0.524 | -19.7 | 286 ± 48 | $6.02.10^{9}$ | 6.41 |
| **NPTiO IV-A-SE** | 0.207 | -17.3 | 374 ± 185 | $4.19.10^{10}$ | 7.31 |
| **NPTiO IV-R-SE** | 0.755 | -23.4 | 295 ± 22 | $6.80.10^{9}$ | 7.41 |

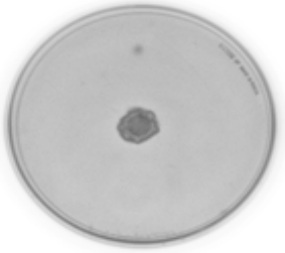
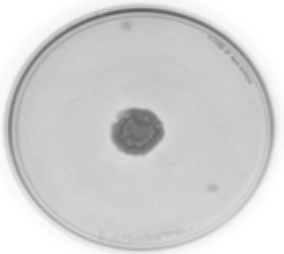
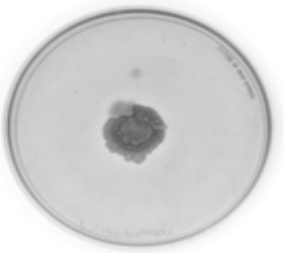
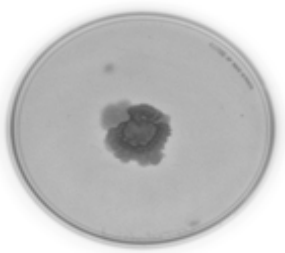
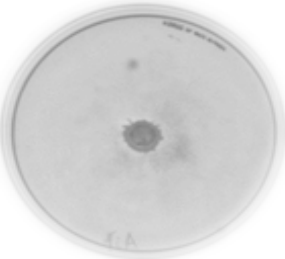
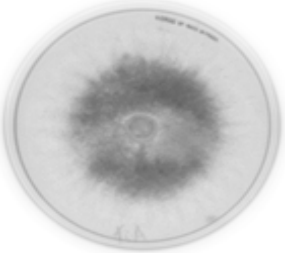
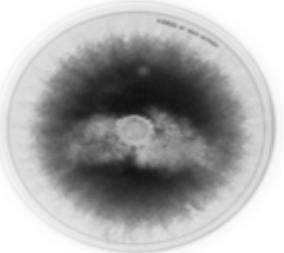
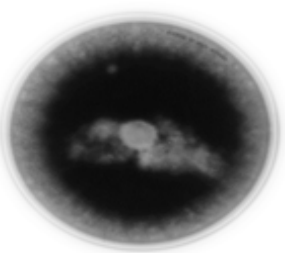
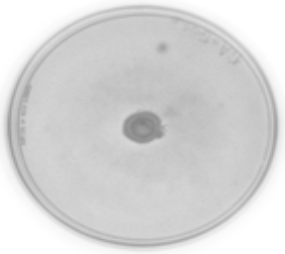
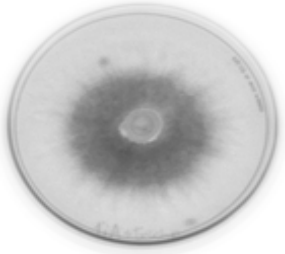
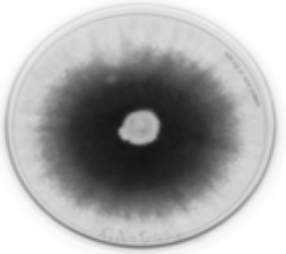
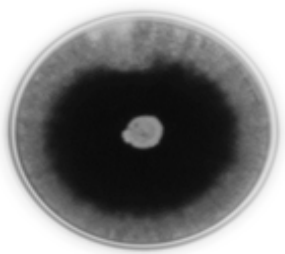
*Sclerotinia sclerotiorum* Activity


LABITON

# RESULTS

## TiO-NP (II)

## Biogenic Trichoderma nanoparticles

| Treatment \ Time | 40h | 50h | 60h | 70h |
|---|---|---|---|---|
| *Trichoderma harzianum* |  |  |  |  |
| ***TiO-NP (II)*** 6x10$^9$ NPs/mL |  |  |  |  |
| ***TiO-NP (II)*** 6x10$^9$ NPs/mL + *Trichoderma harzianum* |  |  |  |  |

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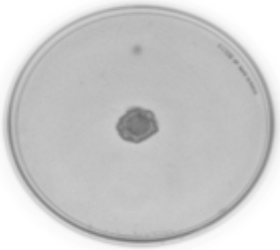
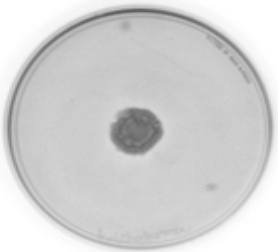
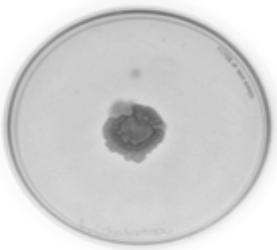
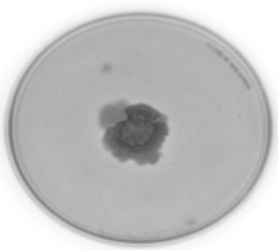
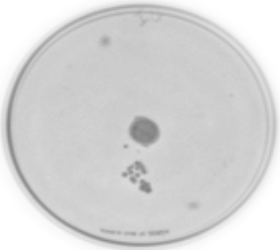
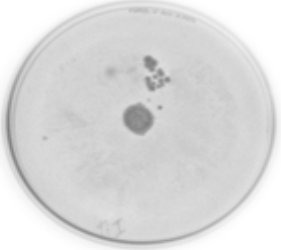
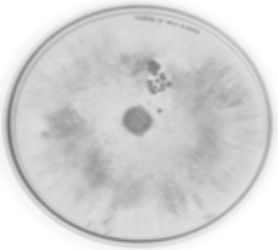
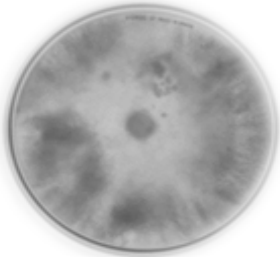
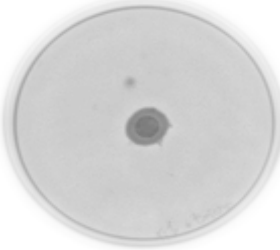
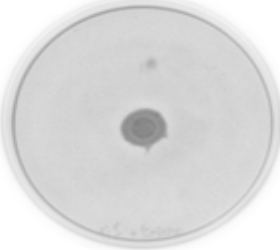
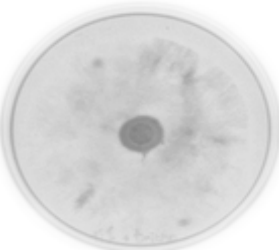
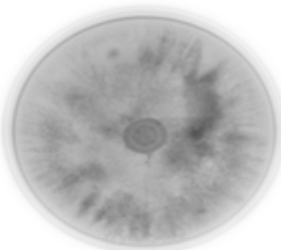
# RESULTS

## TiO-NP (IV)

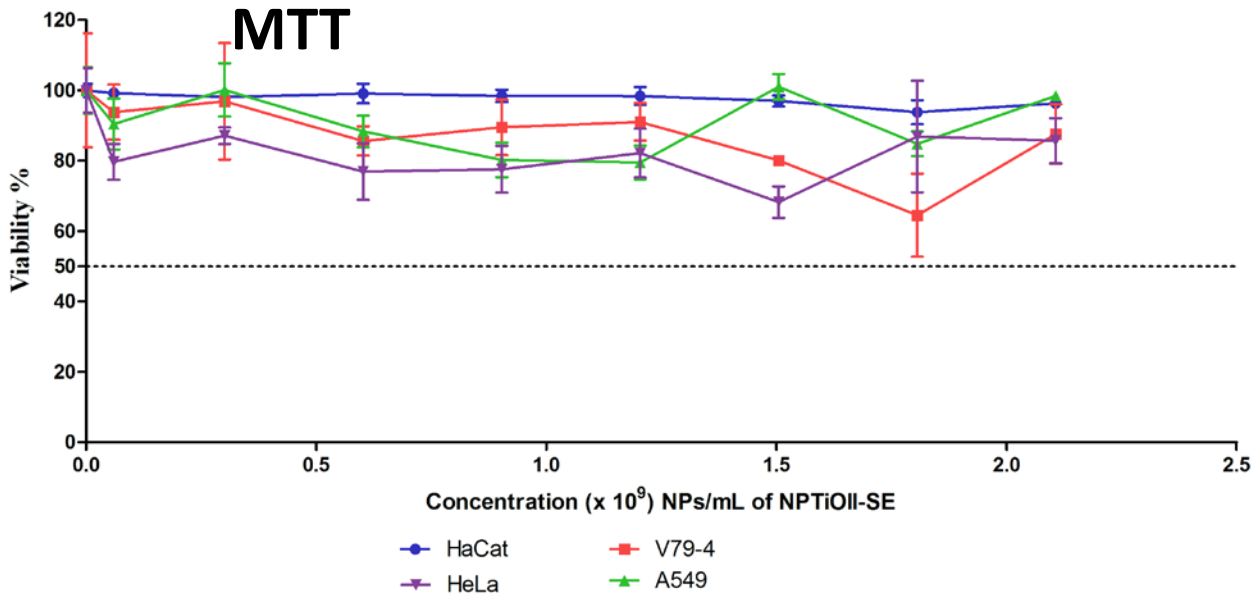
## Biogenic Trichoderma nanoparticles

| Treatment \ Time | 40h | 50h | 60h | 70h |
|---|---|---|---|---|
| *Trichoderma harzianum* |  |  |  |  |
| ***TiO-NP (IV)*** RUTILO $6x10^9$ NPs/mL |  |  |  |  |
| ***TiO-NP (IV)*** RUTILO $6x10^9$ NPs/mL + *Trichoderma harzianum* |  |  |  |  |

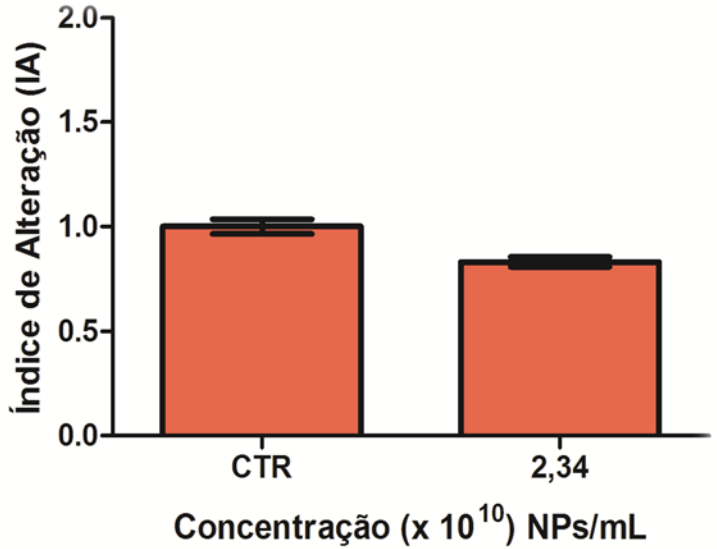
# RESULTS

# TiO-NP (II) ($10^{-1}$M)

## Toxicity




## *Allium cepa*



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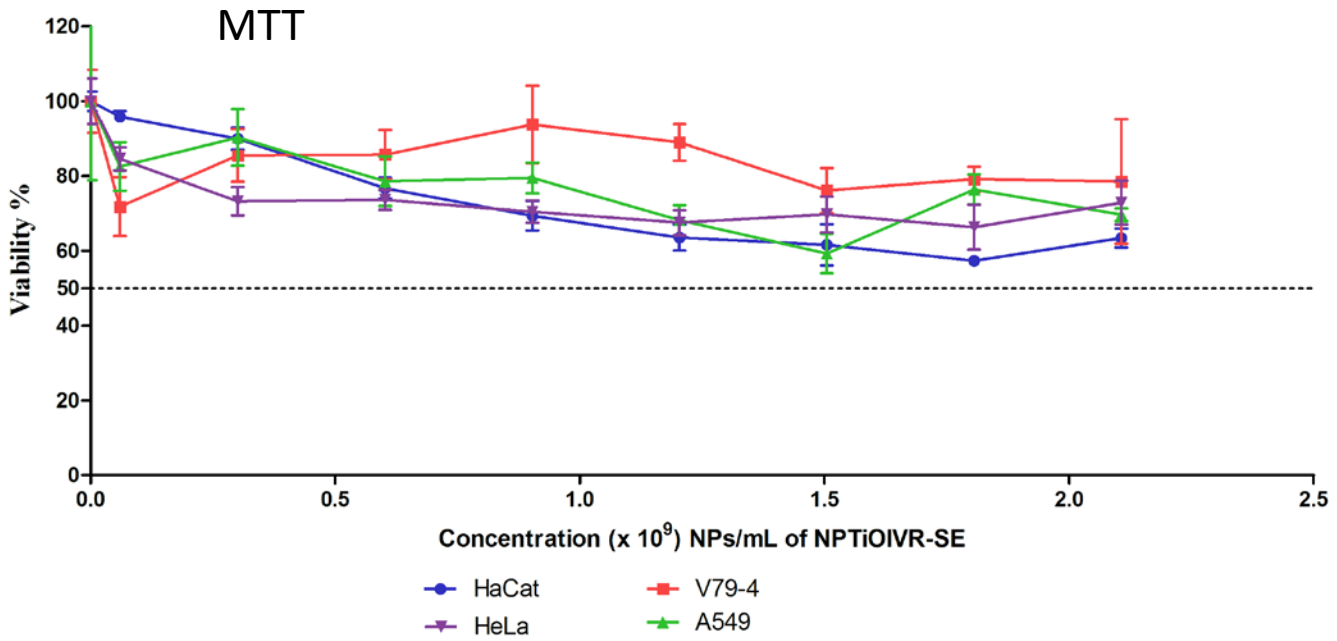
# RESULTS

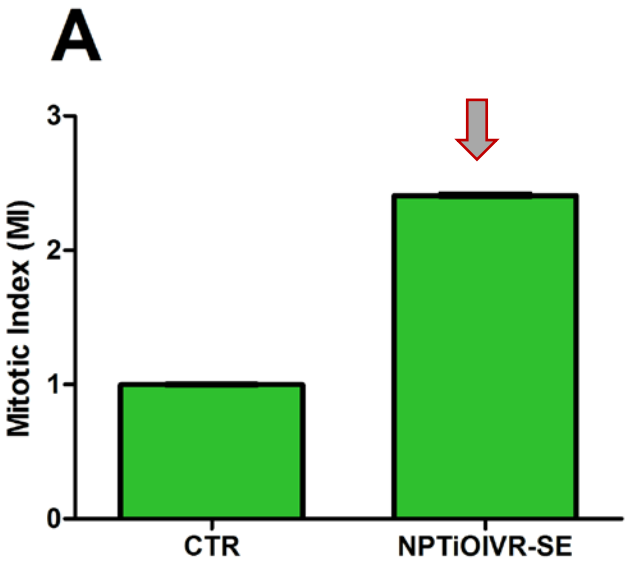
## *TiO-NP (IV)*

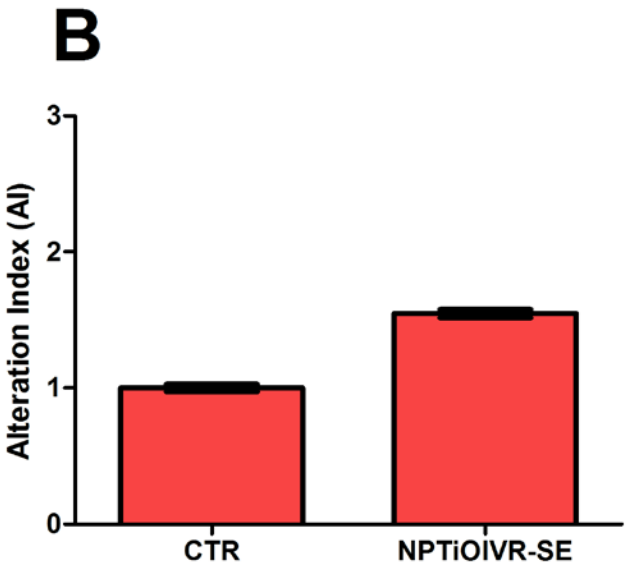
## Biogenic Trichoderma nanoparticles

### Toxicity




*Allium cepa*



**BUT THE QUESTION WAS….**

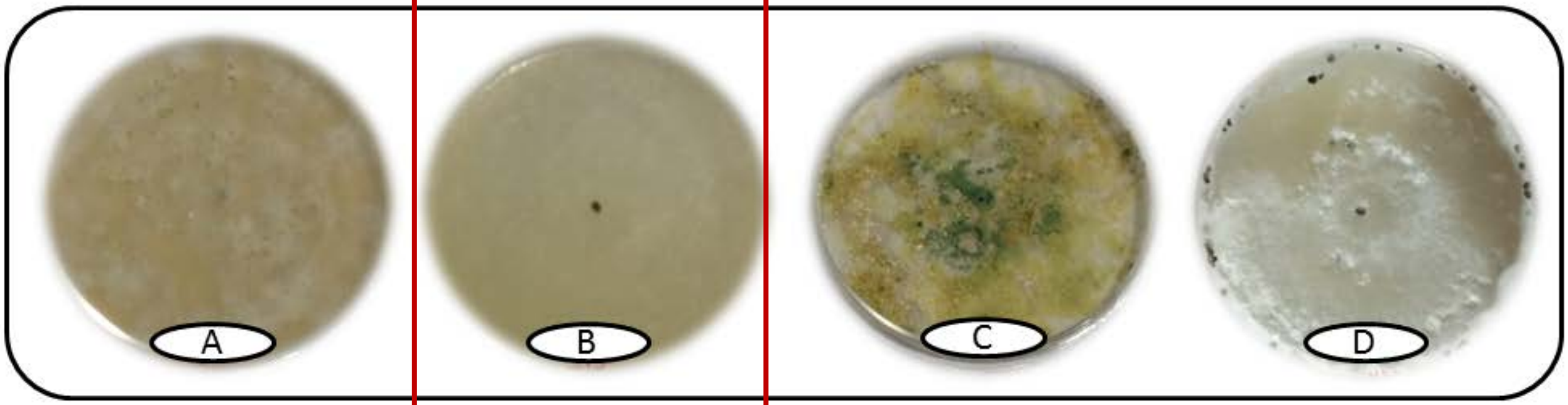
**IS THE ACTIVITY OBSERVED BECAUSE THE PRESENCE OF TICHODERMA?**

*Sclerotinia sclerotiorum* Activity


# TiO-NP (IV)

## Biogenic Trichoderma nanoparticles

## Activity - *S. sclerotiorum*




**A:** NP + *S. Sclerotiorum*

**B:** NP + *S. Sclerotiorum* FILTRATE

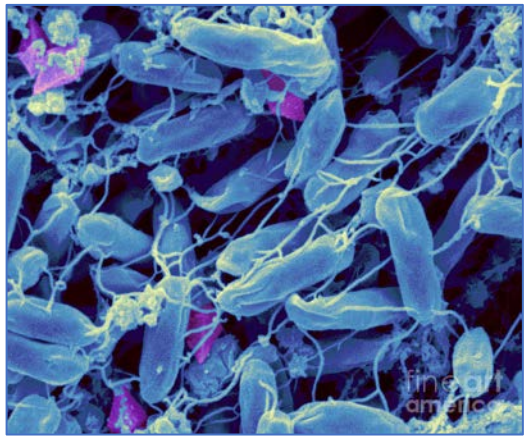
**C:** Trichoderma

**D:** *S. Sclerotiorum* (Control)

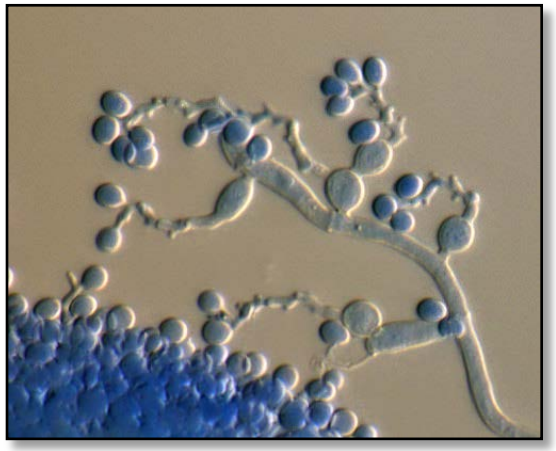

Possibilities
Possibility
Possibility
Possibility
Possibility
Possibility

# LABITON STUDIES

*Bacillus thuringiensis*



*Beauveria bassiana*



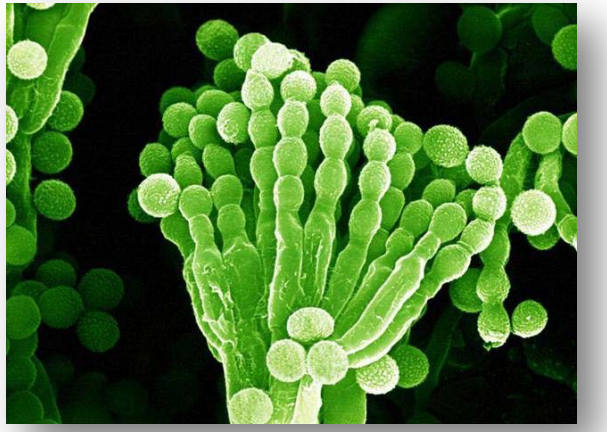
*Trichoderma harzianum*


***AGRICULTURE***

*Althaea officialis*

*Kalanchoe pinnata*

*Penicillium*



***HEALTH***

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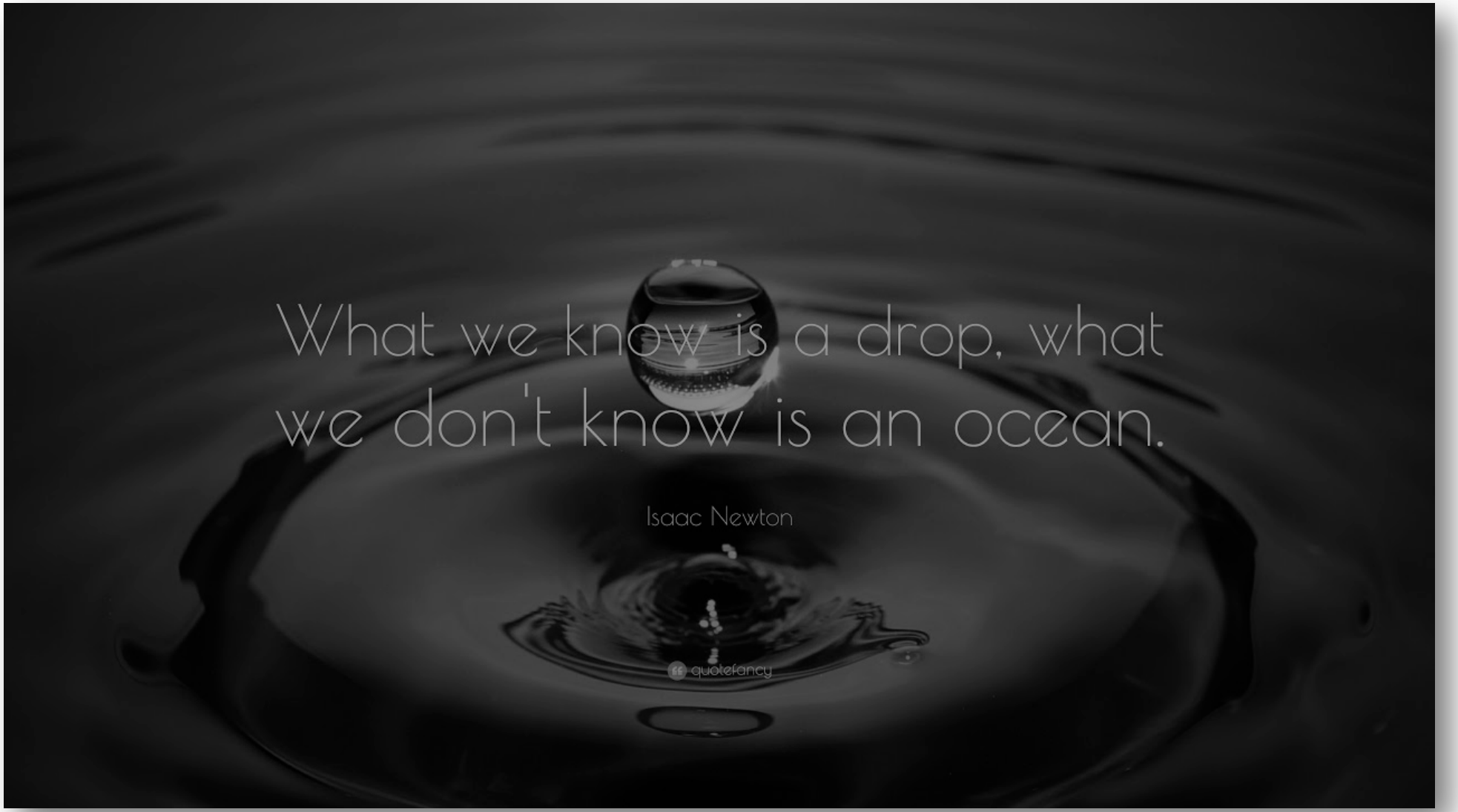
# *Conclusions*

- Is possible synthetize biogenic nanoparticles using fungi and others organisms
- The capping probably is responsible for the nanoparticle activity (synergy)
- The nanoparticles present low toxicity (probably because the capping)
- Possibility of targeted synthesis of nanoparticles




**WE HAVE MUCH STUDY AHEAD**

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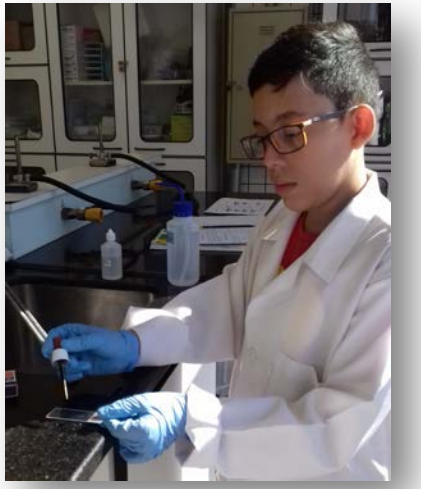
*I like to thanks*



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- **Collaborators**
  - Dr Leonardo F. Fraceto (UNESP/Sorocaba)
  - Dr. Halley Caixeta (UEL)
  - Dr. Gerson Araujo Medeiros (UNESP/Sorocaba)
  - Dr. Ricardo Antonio Polanczyk (Unesp/Jaboticabal)
  - Dr. Marco Vinicius Chaud (Uniso/Sorocaba)


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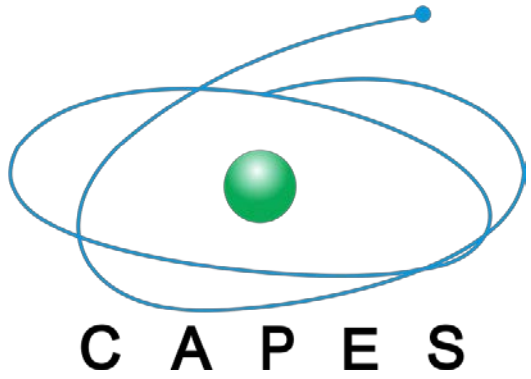
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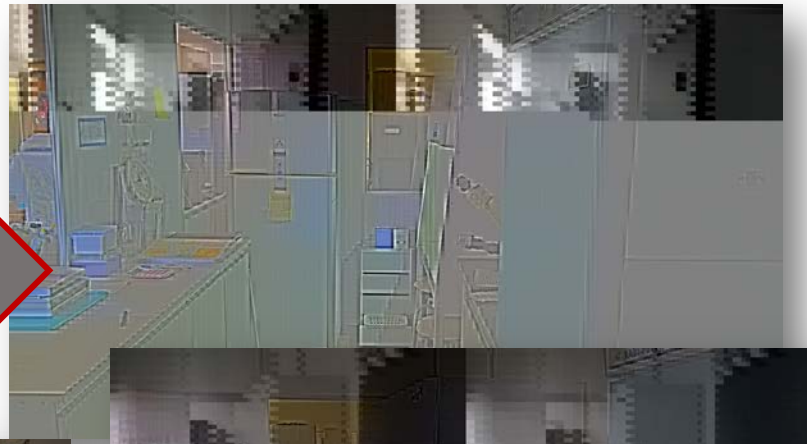

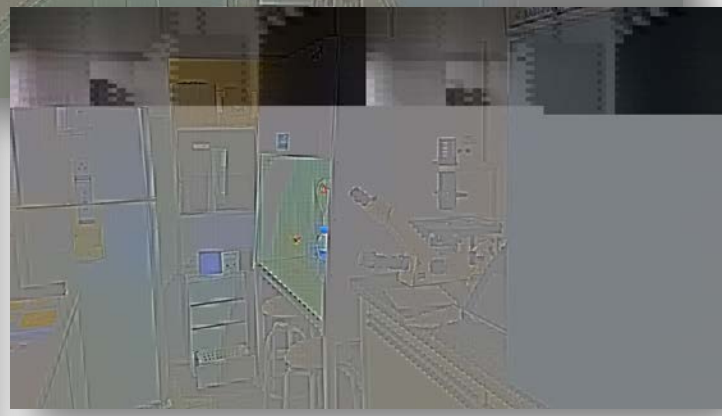

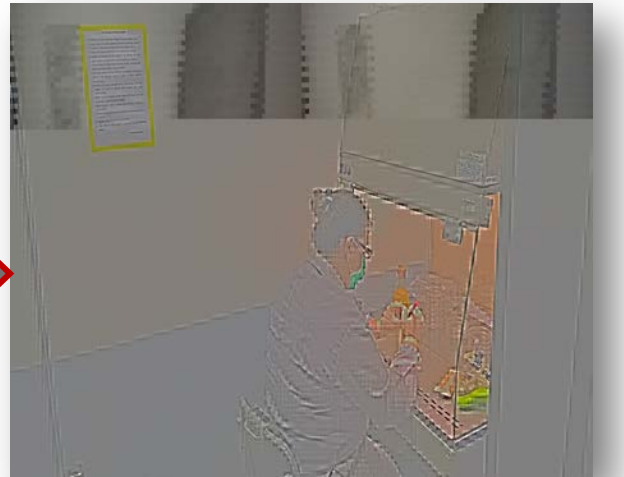

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Tank you for you attention


- Renata de Lima
- renata.lima.ppba@gmail.com
- renata.lima@prof.uniso.br