Contribution of Microbial Biostimulants to Improving Agricultural Productivity in Benin

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WEBINAR

WEDNESDAY 5 FEBRUARY 2025
11:00 AM EST

PLAN

- 1. Agricultural context and challenges in Benin
- 2. Biostimulants : Importance and Mechanisms of action
- 3. Case studies in Benin : the success of biostimulants in sustainable agriculture
- 4. Conclusion

Agricultural context and challenges in Benin

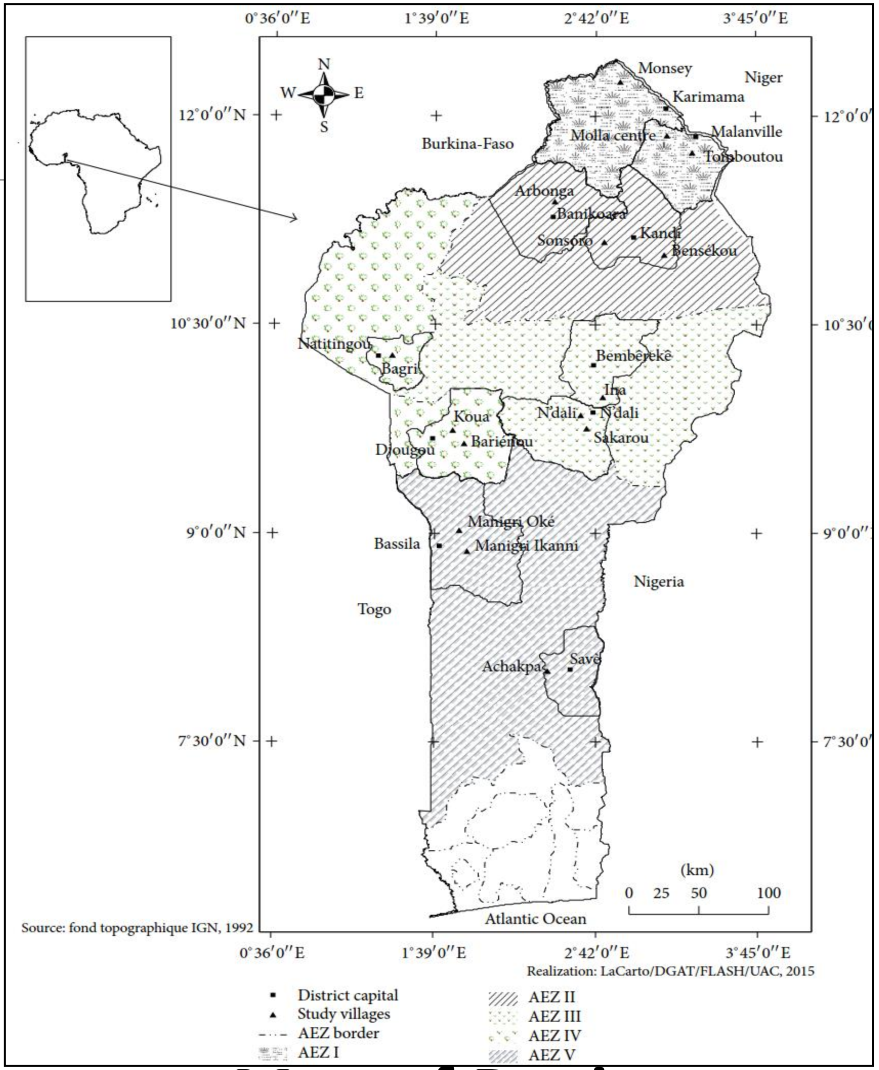
1. Agriculture Context in Benin

Agricultural context and challenges in Benin

- **Benin** is a West African country covering an area of 114,760 km2 and with a population of 13.7 million (INSAE, 2019)

- A country with a predominantly rural population

- **Agriculture** plays a crucial role in Benin's economy and society



Map of Benin

Agricultural context and challenges in Benin

Plays a central role in economic and social growth

Employs nearly 70% of the active population

Contributes nearly 75% of export earnings and 32% of GDP (Gross Interior Product) (INSAE, 2019)

A vital sector for guaranteeing food sovereignty and security

Agricultural context and challenges in Benin

Traditional agriculture

- The majority of farmers in Benin use traditional farming methods
- Agriculture is rain-fed

Economic importance

- Agriculture plays a crucial role in Benin's economy, both in terms of employment and food security.

Agricultural context and challenges in Benin

The main agricultural crops in Benin are:

Cotton

Cashew nuts

Pineapple

Oil palm

Food crops

- Maize
- Sorghum/millet
- Cowpea
- Peanut
- Yam
- Cassava

Despite its importance, agriculture in Benin faces a number of problems

Agricultural context and challenges in Benin

Environmental challenges

- Agricultural activities can face a number of environmental challenges: **Soil erosion, loss of biodiversity, Plant attack by pathogens, Crop contamination etc..**

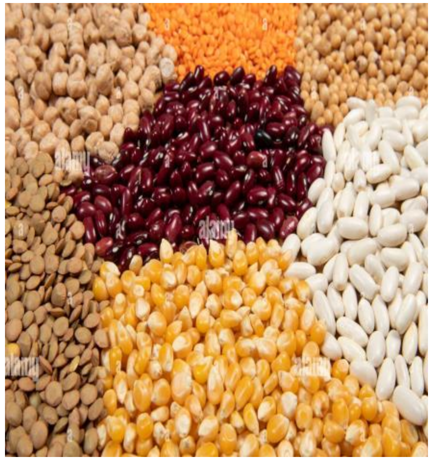
Agricultural context and challenges in Benin

To increase crop yields

Many farmers **use mineral fertilizers**, which are indeed considered the most effective weapon

But are not without

Adverse **health and environmental consequences.**

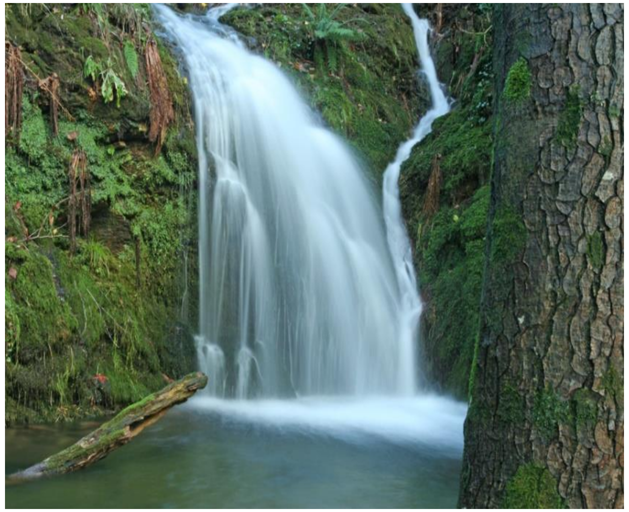





Agricultural context and challenges in Benin

What's more, excessive use of these fertilizers and pesticides has negative repercussions on human and animal health, as well as on the environment:

Contamination of agricultural products



Groundwater contamination

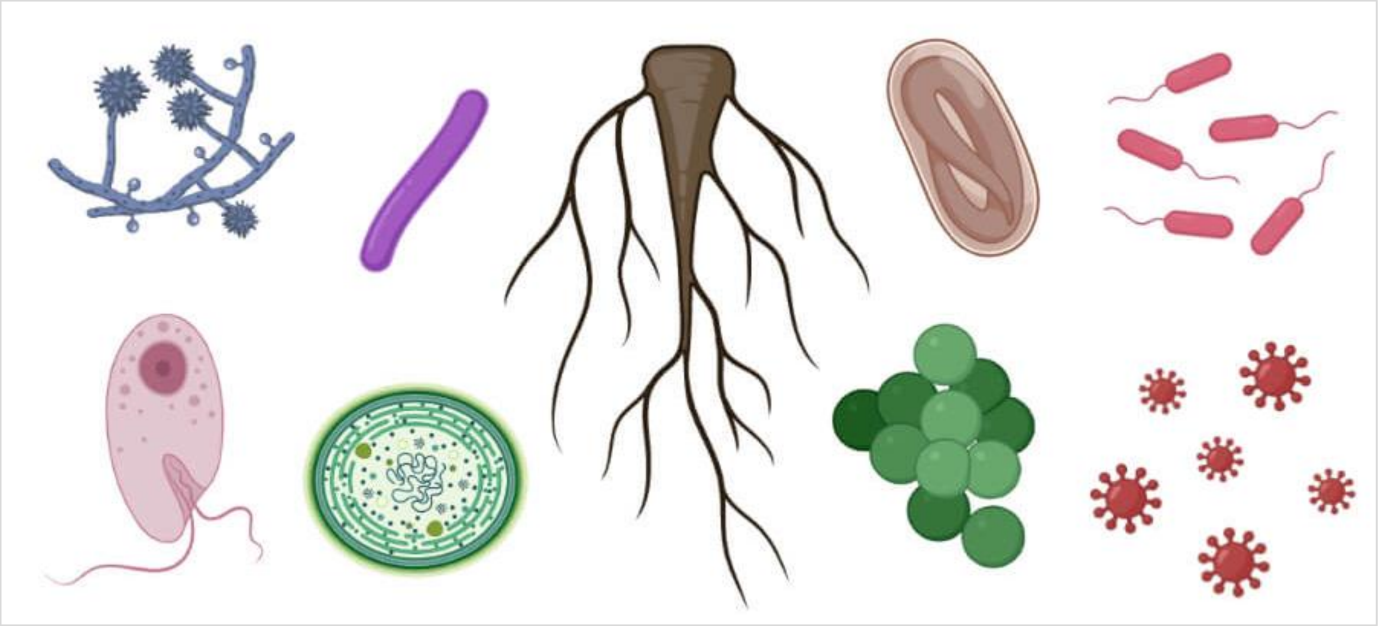
Reduction in soil fertility

Crop contamination

Agricultural context and challenges in Benin

Soils

Dynamic systems containing a diversity of microorganisms



Bacteria, Fungi, Parasites, Viruses and Algae

Maintenance of the diversity of microorganisms

Soil sustainability

Agricultural context and challenges in Benin

It is therefore imperative to move towards sustainable agriculture that reduces the use of chemical inputs.

One solution is the use of Biostimulants based on soil microorganisms and others bioproducts.

Indispensable

Sustainabe agriculture

2. Biostimulants : Importance and Mechanisms of action

Biostimulants : Importance and Mechanisms of action

Biostimulants...?

1

Substances or microorganisms applied to plants or soil or as seed coatings

2

Stimulate plants' natural processes, improving their ability to absorb nutrients

3

Improve crop productivity and resist environmental stress

Biostimulants : Importance and Mechanisms of action

Biostimulants...?

1 Integration into sustainable agricultural practices

Biostimulants can be integrated into sustainable cropping systems, reducing the need for chemical fertilizers and other inputs.

2 Development of new formulations

3 Farmer awareness and adoption

Raising farmers' awareness of the benefits of biostimulants is essential to encourage their adoption and improve the sustainability of agriculture.

Biostimulants : Importance and Mechanisms of action

Biostimulants

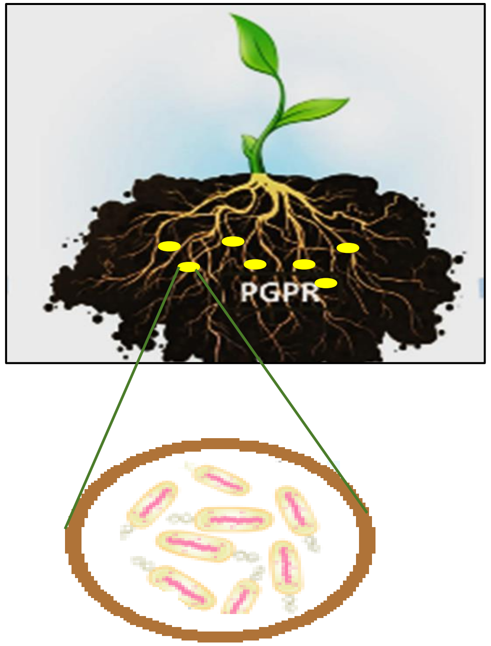
PGPRs ?

Mechanisms of action of PGPRs?

Plant Growth Promoting Rhizobacteria (PGPR)

Rhizobacteria promote plant growth

Bacteria capable of colonizing plant roots, stimulating growth and increasing yields.

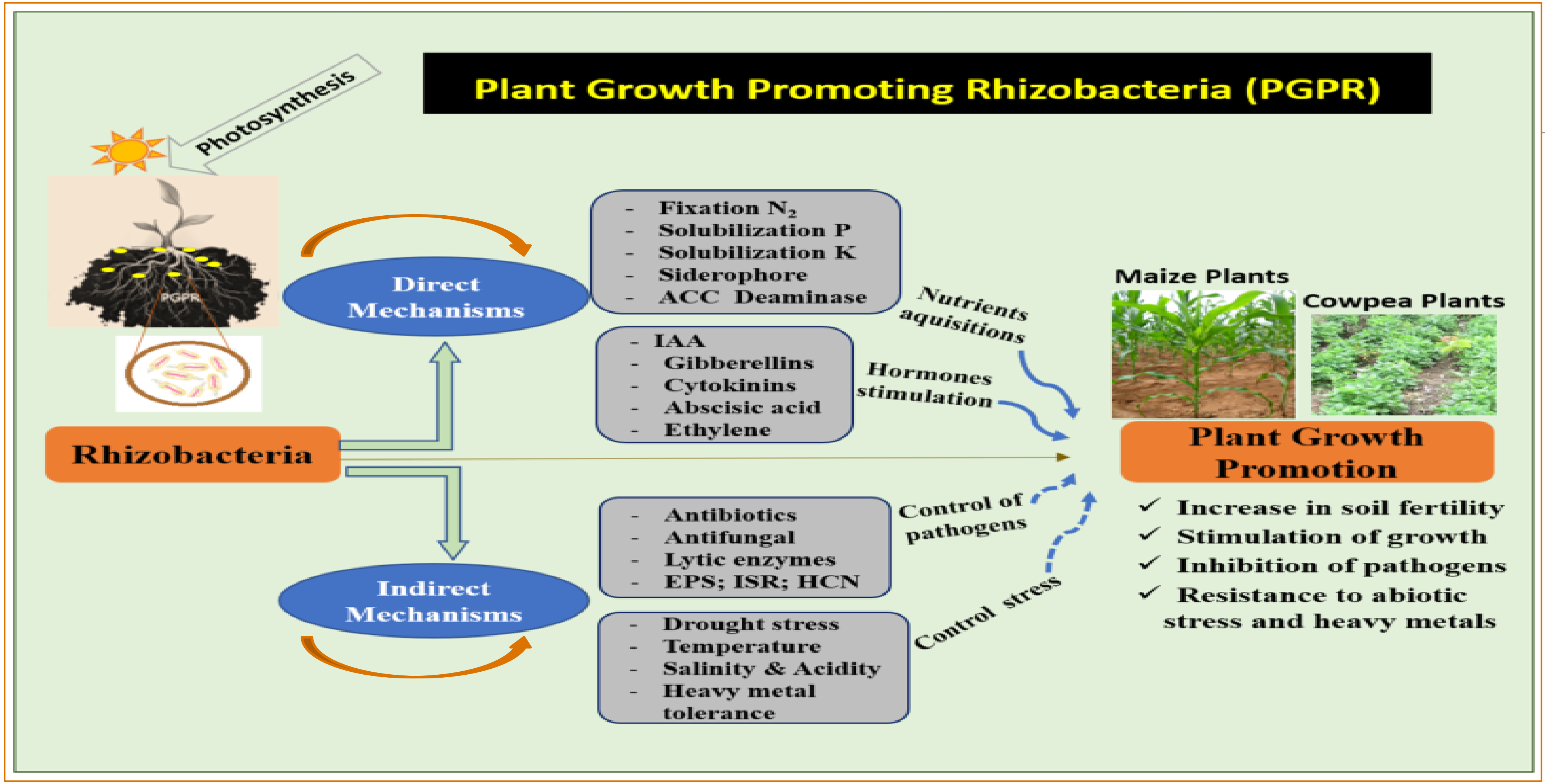


PGPR

PGPR mechanisms of action fall into 02 categories :

- ✓ **Direct Mechanisms**
- ✓ **Indirect Mechanisms**

Mechanisms of action of PGPRs?



Mechanisms of action of PGPRs (Agbodjato et al., 2024)

Mechanisms of action of AMFs ?

Biostimulants

AMFs ?

Mechanisms of action of AMF

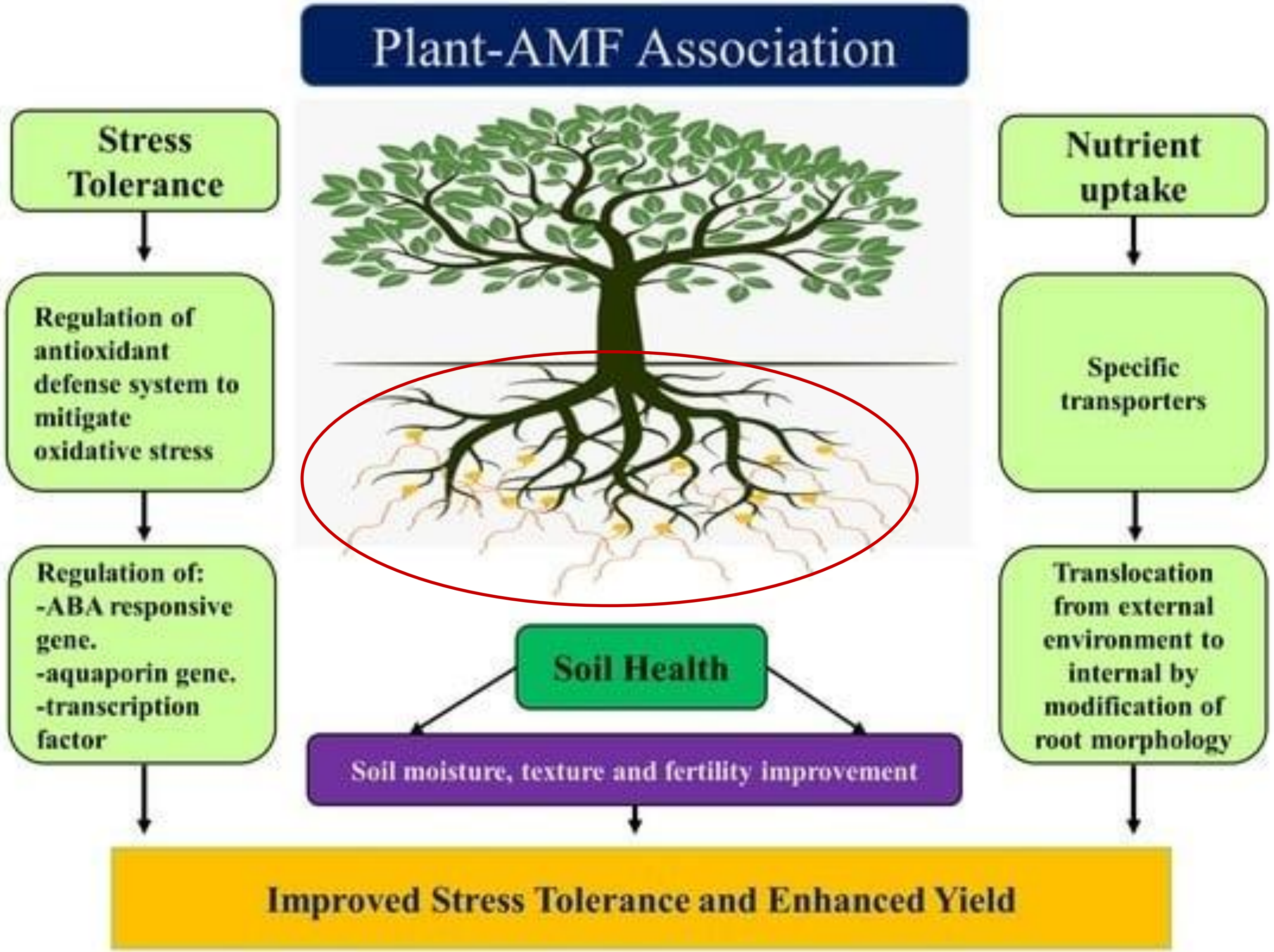
- **AMF ⇨ Arbuscular Mycorrhizal Fungi**

- **Complex communications between plants, fungi and soil**

- **AMFs form vesicles, arbuscules and hyphae both in roots and in the rhizosphere** (Begum et al., 2019).

Mechanisms of action of AMF

The formation of a hyphal network between AMFs and roots increases the latter's access to a large volume of soil for crop growth.



Mechanisms of action of AMF (Khaliq et al., 2022)

Mechanisms of action of Chitosan

Biostimulants

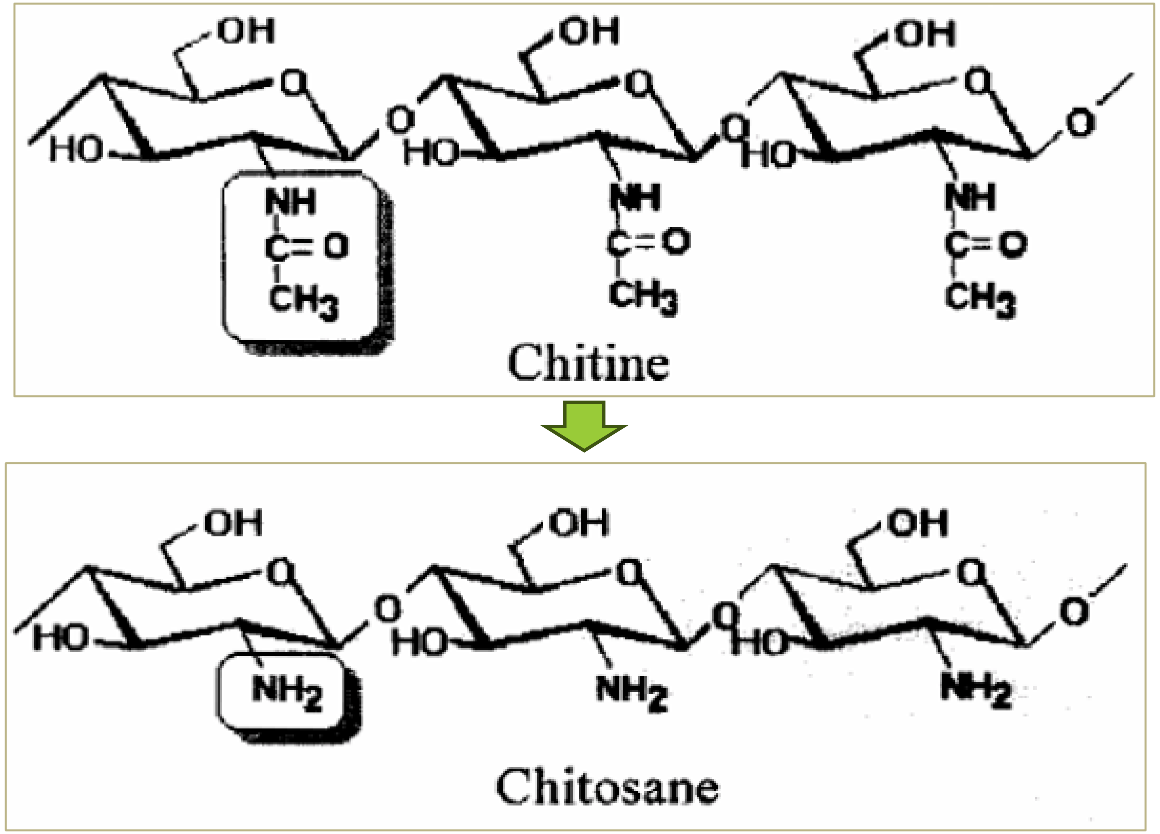
Chitosan ?

Mechanisms of action of Chitosan

Chitosan

Natural polymer derived from chitin, extracted from crustacean exoskeletons. Chitosan is obtained by N-deacetylation of chitin.

Crustacean exoskeletons



Chitosan

Mechanisms of action of Chitosan

Chitosan

- No-toxic, biocompatible and biodegradable polysaccharide
- Stimulate plants' innate ability to defend themselves against pathogens
- As a biostimulator, improves germination, growth and yield.

3. Case studies: the success of biostimulants in sustainable agriculture

Activities carried out on PGPRs

Production of Biostimulant based on the best PGPR strains in Benin

Activities carried out on PGPRs

- **Isolation of rhizobacteria strains from Benin soils and characterization of their PGPR profiles**

Siderophore production

Phosphate solubilization

Antagonism between rhizobacteria and pathogenic fungi

Production of ExoPolySaccharides(EPS)

Hydrogen cyanide production(HCN)

Production of indole acetic Acid (IAA)

Protease production

Lipase production

Activities carried out PGPR

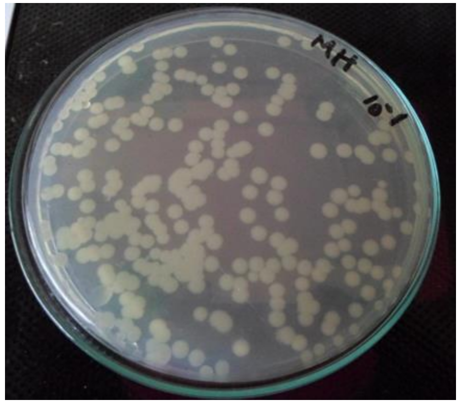
- **Production of PGPR-based biostimulants and evaluation of their effects on maize growth and yield in farming conditions**

Refreshing PGPR strains → **Preparation of bacterial inocula** → **Preparation of biostimulants** → **Drying biostimulants** → **Ready-to-use biostimulant** → **Soil preparation** → **Sowing maize seeds** → **Biostimulant application by the farmer**

Activities carried out on PGPRs

➢ 1. Extraction of DNA from PGPR strains

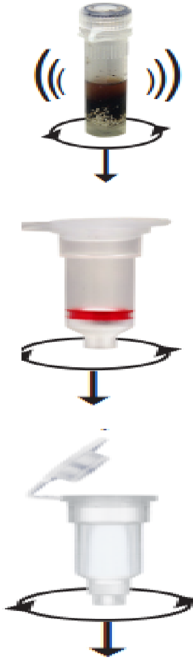
Bacterial DNAs of the strains were extracted at NWU University (South -Africa) from a 24H culture using a commercial Miniprep Quick-DNA™ kit following the manufacturer's instructions.



24H bacterial culture

kit commercial Miniprep Quick-DNA™

Microbiology Lab du NWU



Homogenize sample with ZR Lysis tube BashingBead™

Filter the lysate with Zymo-Spin™ III-F

Bind, wash and elute DNA with Zymo-Spin™ IIC

Obtaining ultra-pure DNA

Activities carried out…

➢ 2. Sequencing of DNA from PGPR strains

- **DNA libraries were generated using a NEBNext® Ultra™ IIDNA Library Prep Kit with commercial supplier NOVOGEN Company in Singapour.**

- **They were then sequenced with a NovaSeq PE150 sequencing strategy using the Illumina NovaSeq 6000 platform.**

- Sequences were analyzed on the **KBase platform.**
- Removal of sequence adapters and low-quality reads with **Trimmomatic v0.36**
- Reads were moderately assembled with **SPAdes** v3.13.0 (Nurk et al., 2013).

Activities carried out on CMAs

Production of Biostimulant based on the best AMF strains in Benin

Activities carried out on CMAs

- **Isolation of CMA spores and production of native CMA-based biostimulants for maize cultivation**

Mycorrhiza spores isolated from soils → *Propagation substrate (clay)* → *Multiplication of efficient spores* → *Unwrought biostimulant*

↓

Packaged mycorrhizae-based biostimulant → *Corn seed coating* → *Setting up tests at the Center* → *Collection of mycorrhization parameters*

Activities carried out on Chitosan

Production of Chitosan-based biostimulant in Benin

Activities carried out on Chitosan

- **Extraction of Chitosan from crab exoskeletons and production of Biostimulant for corn cultivation**

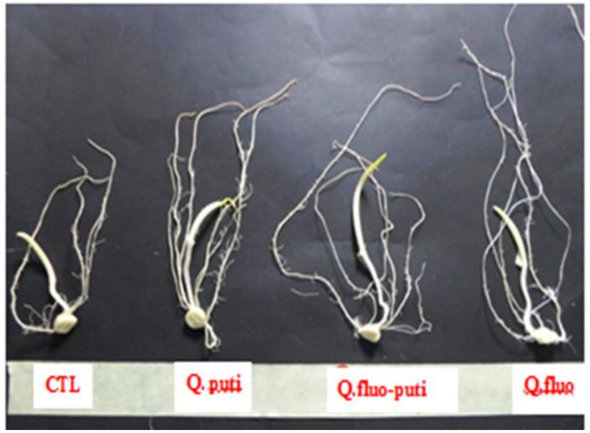
Drying Crabs exoskeletons → Grinding and Demineralization → Deproteination+ Bleaching=Chitin → Desacetylation= Chitosan

↓

Various extracted Chitosans → Coating preparation → Coated seed → Setting up tests at the Center → Sowing coated seeds

Results obtained ….

- Some photos of the effects of the biostimulants PGPR, AMF and Chitosan in a controlled environment and in a farming environment.



Control PGPR

Contol AMF

PGPR field

Hydroponic Test of PGPR

Control AMF

PGPR field + Chitosan

Control PGPR

Some Results obtained :PGPR ….

- **Isolation and identification of PGPR strains in rhizospheres of maize soils in Benin**

- *Azospirillium lipoferum,*

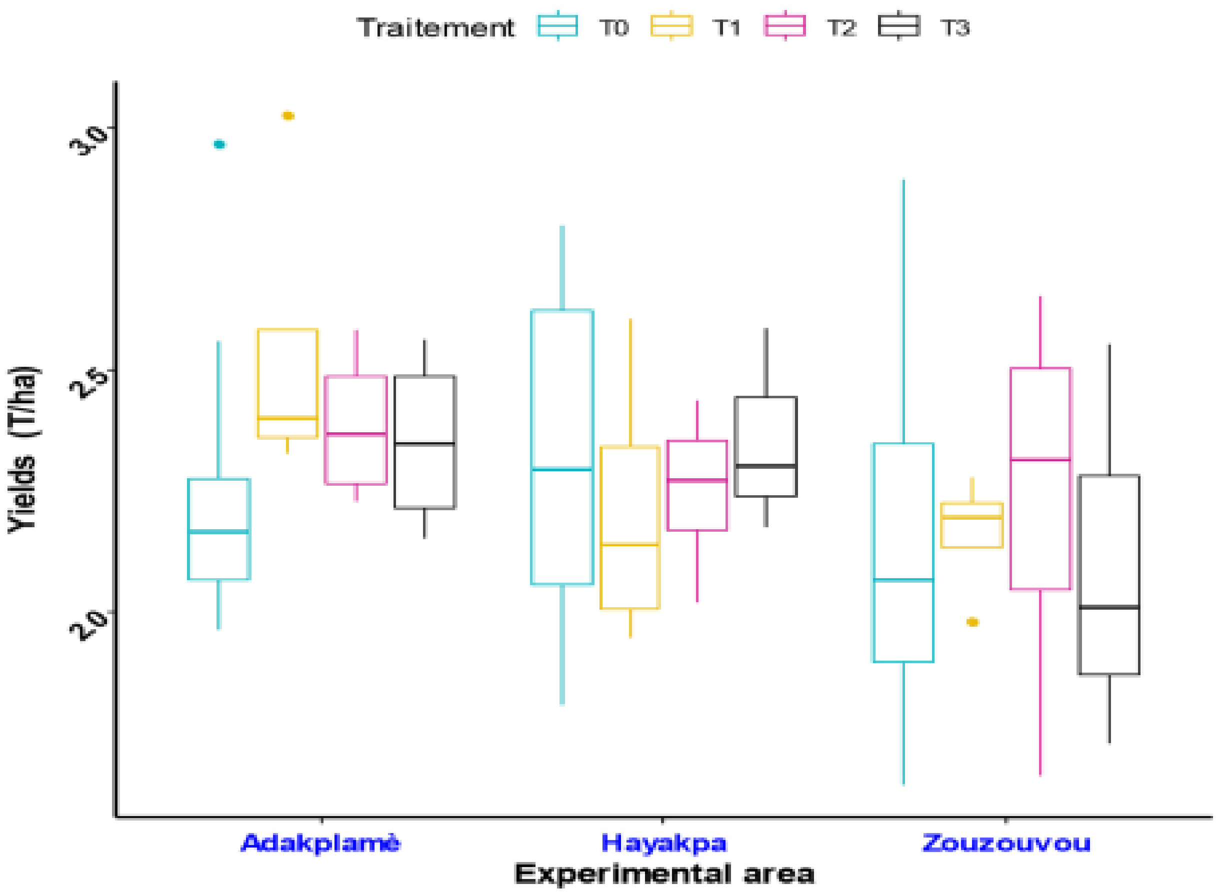
- *Pseudomonas fluorescens,*

- *Pseudomonas putida*

-*Bacillus polymyxa, B. panthothenicus, B. anthracis, B. thuringiensis , B. circulans.*
-*Pseudomonas cichorii, P. putida , P. syringae,*
-*Serratia marcescens*

Some Results obtained :PGPR ….

- **Effects of formulated biostimulants on maize growth and yield in farming conditions**

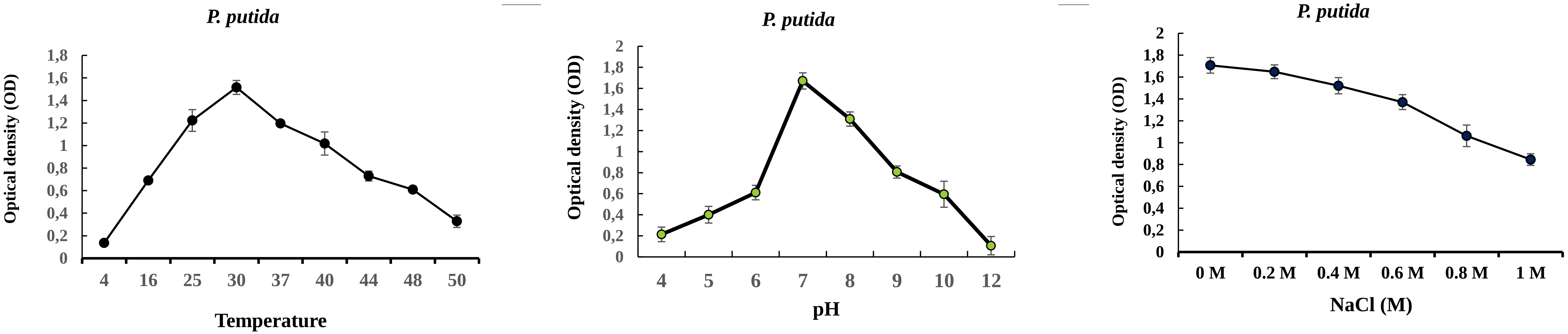


T0:100% NPK (agricultural practice) ;
T1: Clay + P. putida + 50% NPK ;
T2: Peat + P. putida 50% NPK ;
T3:Clay + Peat + P. putida + ½ NPK

Biostimulant *PGPR*+50%NPK (T1) induces the best yield, i.e. 15% compared to 100% NPK (T0) at Adakplamè (southern Benin).).

Some Results obtained :PGPR ….

In Vitro Effect of PGPR Tolerance to Different Environmental Stress Conditions



Effect of Temperature , pH and NaCl Variation on the Growth of P. putida

- *P. putida* reached its optimum growth at 30 °C but reduced from 40 °C. At extreme temperatures (4, 16, 48, 50 °C
- *P. putida* grew from pH 4 to pH 8
- *P. putida* was found to be salt tolerant at different concentrations (0.2 M to 1 M

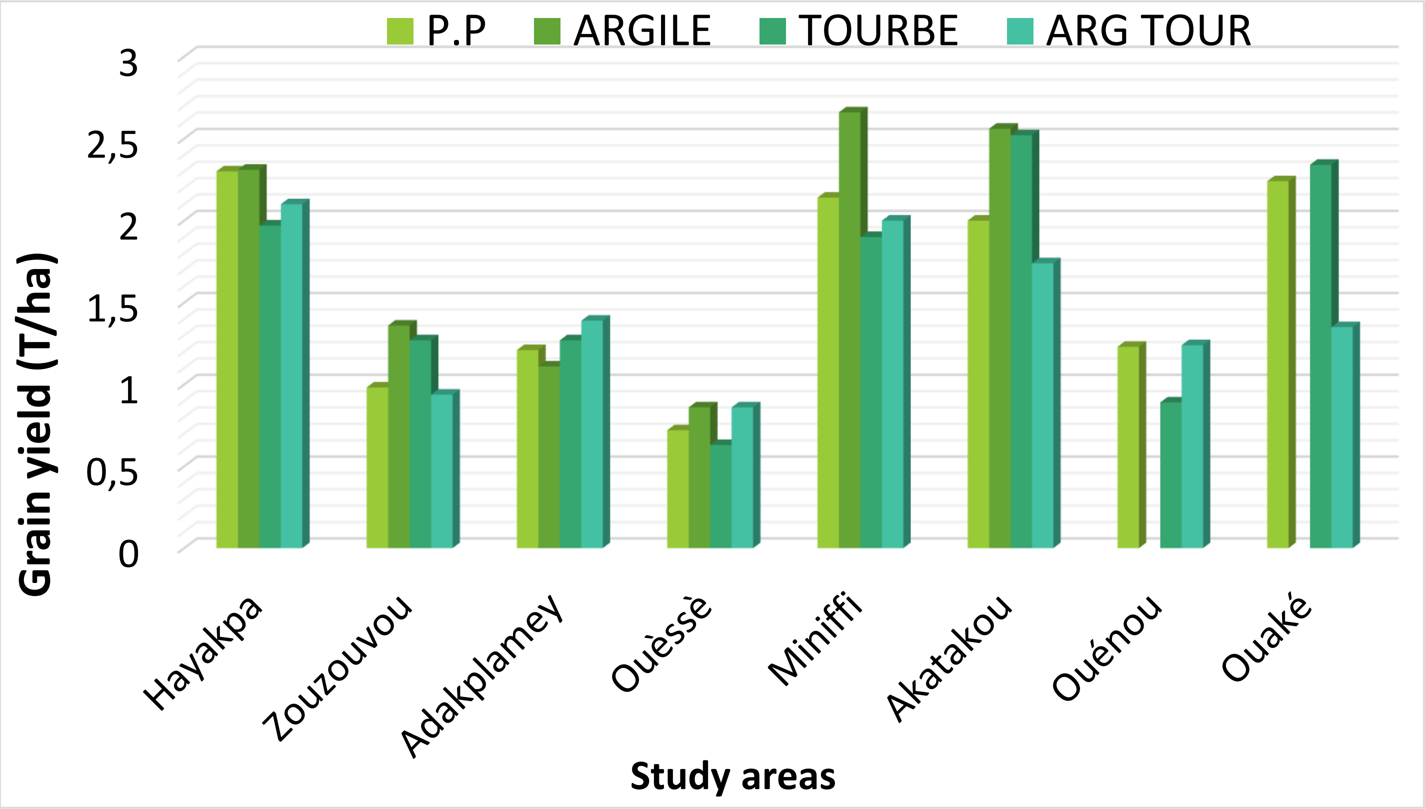
Some Results obtained :PGPR ….

Table 1: Whole Genome Sequencing characteristics of *B. cereus* ADO11, *S. maltophilia* NAA11, *A. pittii* LAM11 and *S. marcescens* NSA15 (Agbodjato et al., 2022)

Strains / Parameter	*Bacillus cereus* ADO11	*Stenotrophomonas maltophilia* NAA11	*Acinetobacter pittii* LAM11	*Serratia marcescens* NSA15
Genome Size (pb)	4,476,462	4,731,402	4,080,875	4,959,744
G+C (%)	35.4	66.42	38.8	59.8
Contigs	28	141	89	56
Genome Coverage	290.0x	198.0x	115.0x	135.0x
N_{50}	296,930	54,168	88,379	164,348
L_{50}	4	25	14	11
Gene (total)	4616	4420	3977	4731
Protein	4467	4300	3771	4629
rRNA	11	1	5	4
tRNA	37	67	58	55
Other RNA	5	4	4	12
Pseudo Gene	96	48	139	33
BioProject number	PRJNA750908	PRJNA751730	PRJNA751219	PRJNA754119
SRA accession number	SRX11612109	SRX11634702	SRX11616698	SRX11727062
GenBank accession number	JAIRCN000000000.1.	JAIUDP000000000.1.	JAMQVB000000000.1	JAMQIW000000000.1

Some Results obtained : AMF….

Effects of AMF biostimulants on maize grain yields

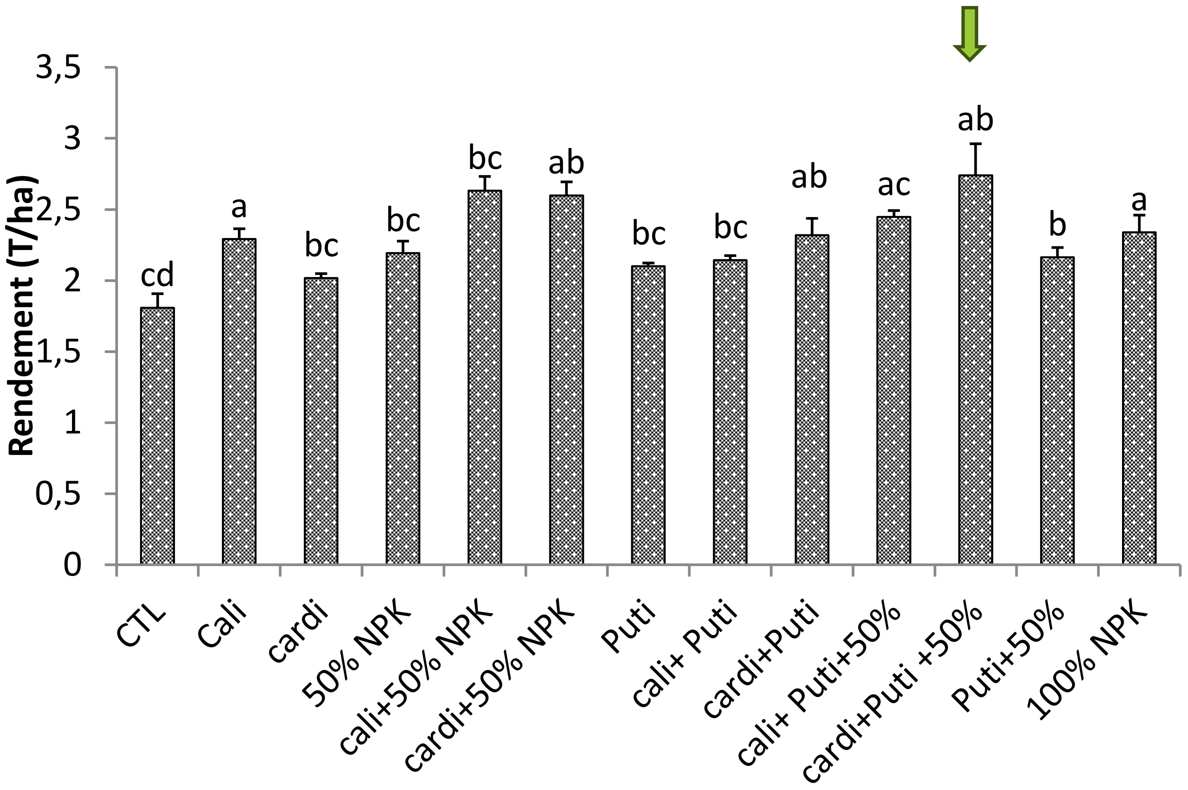


Effect of AMF biostimulants on maize grain yield per treatment

The best grain yields were obtained with the **AMF** formulated with clay in combination with 50% NPK.

Some Results obtained: Chitosan with PGPR

- **Effects of chitosans produced from *C. amnicola* and *C. armatum* in combination with *P. putida* on maize yield on station**



Variation in maize grain yield

- Good yield performance in all treatments compared to control.

- Plants treated with the combination of Chitosan extracted from *C. armatum* + *P. putida*+50% NPK gave the best maize grain yields with an increase of 51.68%.

VALORIZING PGPR RESULTS from 2011 to date

More than 40 scientific articles published and 02 technical data sheets

02 scientific articles and one technical data sheet in progress

Many Research Projects

More than 15 posters, 04 exhibitions, 1 prize (4th prize for scientific innovation at UAC)

11 PhD ➕ **6 Masters Courses**

Publications

List of some publications

Hindawi Publishing Corporation
Applied and Environmental Soil Science
Volume 2015, Article ID 901656, 9 pages
http://dx.doi.org/10.1155/2015/901656

Hindawi

Research Article

Characterization of Potential Plant Growth Promoting Rhizobacteria Isolated from Maize (*Zea mays* L.) in Central and Northern Benin (West Africa)

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African Journal of Microbiology Research

Full Length Research Paper

Biofertilising, plant-stimulating and biocontrol potentials of maize plant growth promoting rhizobacteria isolated in central and northern Benin

Nadège Adoukè Agbodjato[1], Olaréwadjou Amogou[1], Pacôme Agossou Noumavo[1,2], Gustave Dagbénonbakin[3], Hafiz Adio Salami[1], Rachidath Karimou[1], Abdel-Madjid Alladé[1], Oyedele Adedayo[4], Farid Baba-Moussa[2], Adolphe Adjanohoun[5] and Lamine Saïd Baba-Moussa[1*]

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frontiers in Sustainable Food Systems

ORIGINAL RESEARCH
published: 14 April 2021
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Check for updates

Efficacy of Biostimulants Formulated With *Pseudomonas putida* and Clay, Peat, Clay-Peat Binders on Maize Productivity in a Farming Environment in Southern Benin

Nadège Adoukè Agbodjato[1,2], Marcel Yévèdo Adoko[2], Olubukola Oluranti Babalola[1], Olaréwadjou Amogou[2], Farid T. Badé[2], Pacôme A. Noumavo[2,3], Adolphe Adjanohoun[4] and Lamine Baba-Moussa[2]*

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Publications

List of some publications

frontiers | Frontiers in Plant Science

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SPECIALTY SECTION
This article was submitted to Plant Symbiotic Interactions, a section of the journal Frontiers in Plant Science

Effect of the application or coating of PGPR-based biostimulant on the growth, yield and nutritional status of maize in Benin

Marcel Yévèdo Adoko[1], Agossou Damien Pacôme Noumavo[1,2], Nadège Adoukè Agbodjato[1], Olaréwadjou Amogou[1], Hafiz Adéwalé Salami[1], Ricardos Mèvognon Aguégué[1], Nestor Ahoyo Adjovi[3], Adolphe Adjanohoun[3] and Lamine Baba-Moussa[1*]

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GENOME SEQUENCES

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Draft Genome Sequences of Four Strains of Plant Growth-Promoting Bacteria Associated with Maize Rhizosphere

Olubukola Oluranti Babalola,[a] Nadège Adoukè Agbodjato,[a,b] Ayansina Segun Ayangbenro,[a] Adolphe Adjanohoun,[c] Lamine Baba-Moussa[b]

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ABSTRACT This study presents the draft genome sequences of four strains of rhizobacteria, namely, *Bacillus cereus* ADO11, *Stenotrophomonas maltophilia* NAA11, *Acinetobacter pittii* LAM11, and *Serratia marcescens* NSA15, which were isolated from maize soils and have the ability to stimulate plant growth. The genome assembly sizes for the strains were 4,476,462 bp, 4,731,402 bp, 4,080,875 bp and 4,959,744 bp, respectively.

agronomy | MDPI

Article

Use of Plant Growth Promoting Rhizobacteria in Combination with Chitosan on Maize Crop: Promising Prospects for Sustainable, Environmentally Friendly Agriculture and against Abiotic Stress

Nadège Adoukè Agbodjato [1,2], Toussaint Mikpon [2,3], Olubukola Oluranti Babalola [1,*], Durand Dah-Nouvlessounon [2], Olaréwadjou Amogou [2], Halfane Lehmane [2], Marcel Yévèdo Adoko [2], Adolphe Adjanohoun [3] and Lamine Baba-Moussa [2]

Conclusion

The use of biostimulants based on PGPR, AMF and Chitosan

→ An alternative for soil sustainability, reducing chemical fertilizers and improving crop productivity

We are open to collaborations aimed at promoting sustainable agriculture on the African continent.

Benin is also able to supply growers with biostimulants to promote sustainable agriculture...

Acknowledgements

LBTMM team
headed by **Prof. Lamine BABA-MOUSSA**
(University of Abomey-Calavi/Benin)

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Laboratory teams from South Africa and Italy

The End

THANKS FOR YOUR ATTENTION!

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