



Plant Growth Promoting Rhizobacteria (PGPR) And Their Effects On Plants

Submitted by
Sarah Abbasi Rad

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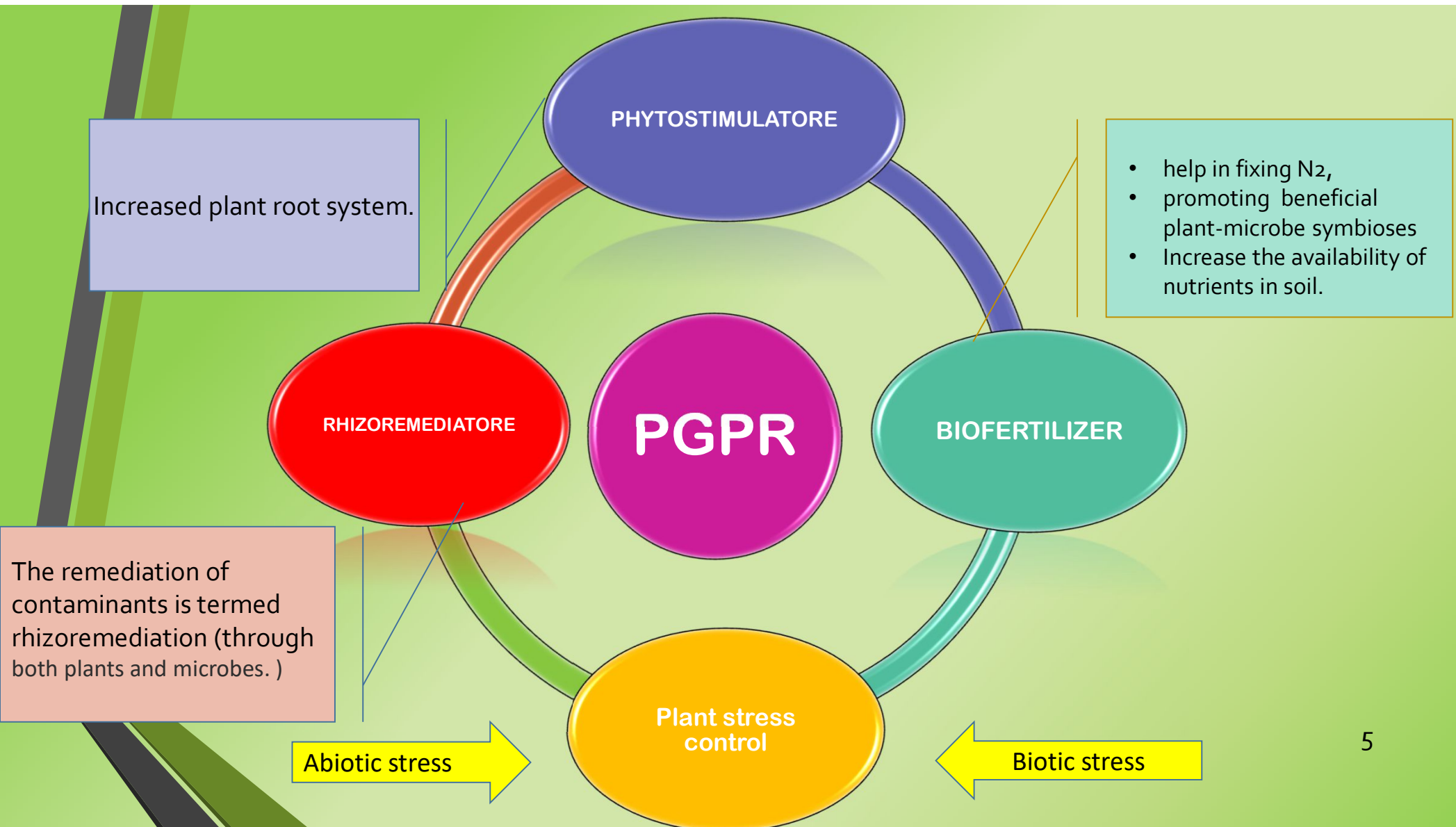
INTRUDUCTION

The term “plant growth promoting rhizobacteria (PGPR)” for beneficial microbe was introduced by Kloepper, JW (1981).

- ❖ Plant growth promoting rhizobacteria (PGPR) are the soil bacteria that colonized the roots of plants (rhizosphere) that enhance plant growth.
- ❖ Facilitate the plant growth.
- ❖ Decrease the global dependence on hazardous agriculture chemical .

CHARACTERISTIC OF PGPR

- Proficient to colonize the root surface.
- Surviving, multiply and compete with other micro biota.
- Promote plant growth.



TYPE OF PGPR:

A. Extracellular (e PGPR)

- Rhizosphere
- Rhizoplane
- the space between the cells of root cortex.

Agrobacterium, Azotobacter, Azospirillum, Bacillus, Pseudomonas, Arthrobacter and Seratia etc.

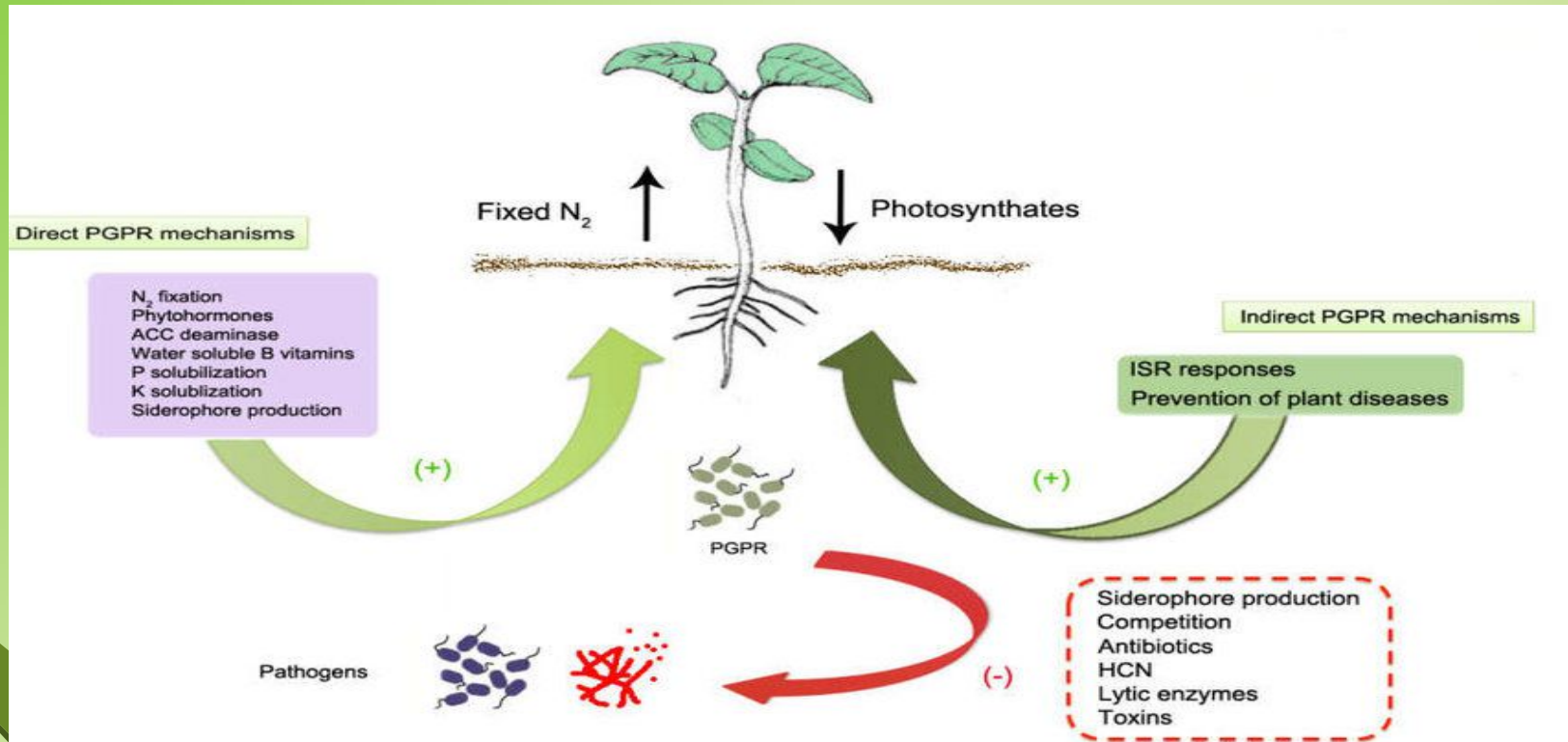
B. Intracellular (i PGPR)

- Inside root cell
- In specialized nodular structures of root cells.

Azorhizobium, Bradyrhizobium, Mesorhizobium and Rhizobium of the family of Rhizobiaceae

ROLE AND IMPORTANCE OF PGPR

- ❖ Plant growth promoting rhizobacteria promote plant growth directly and indirectly.



Mechanism of action of PGPR

Direct plant growth promotion
(Biofertilizer activity)

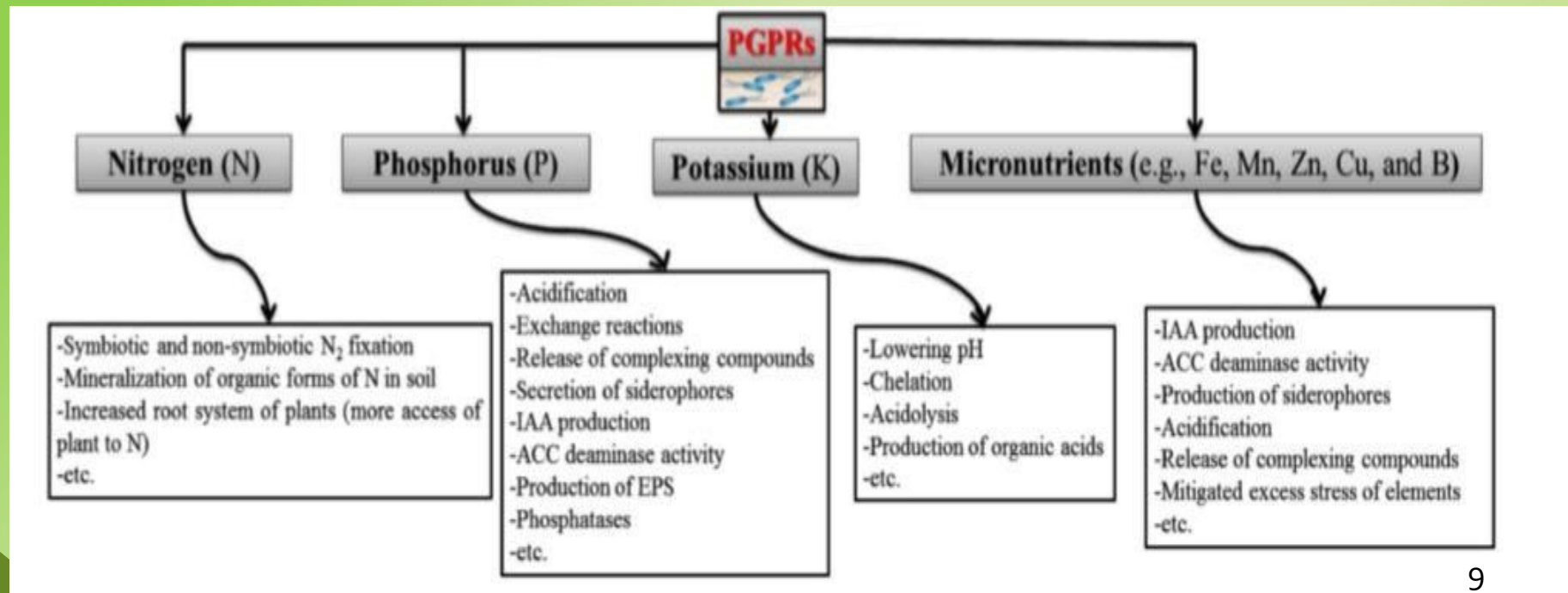
- Nitrogen fixation
- Phosphate solubilization
- Potassium solubilization
- Siderophore production
- Phytohormone production

Indirect plant growth promotion
(Biocontrol Activity)

- Antibiotic production
- Cell wall degradation enzyme (lytic enzymes)
- Induced systemic resistance (ISR)
- Extracellular polymeric production
- Volatile (VOCs)

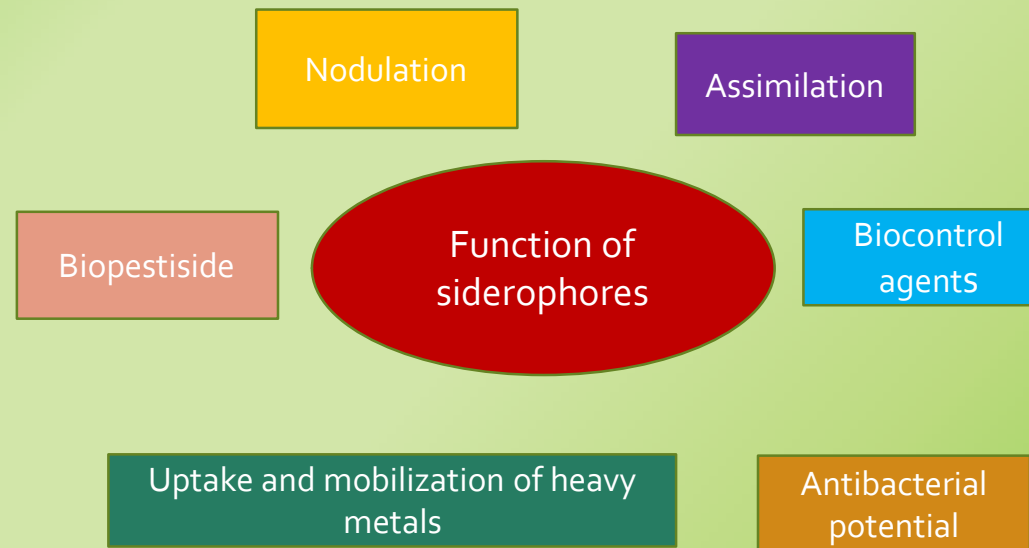
DIRECT MACHANISMS

It facilitate uptake or increase nutrient availability.



SIDEROPHORE PRODUCTION

- Siderophores is a iron-chelating compound help in assimilation of iron.
- Deficiency in iron inhibits the growth of pathogens by blocking key processes such as, nucleic acid synthesis and sporulation.
- *Pseudomonas fluorescens* produce two major types of Siderophore-Pseudobactins
 - ✓ the fluorescent pigmented pyoverdins (Lemanceau et al., 1993)
 - ✓ the pyochelins (nonfluorescent **siderophore**) (Leeman et al., 1996).

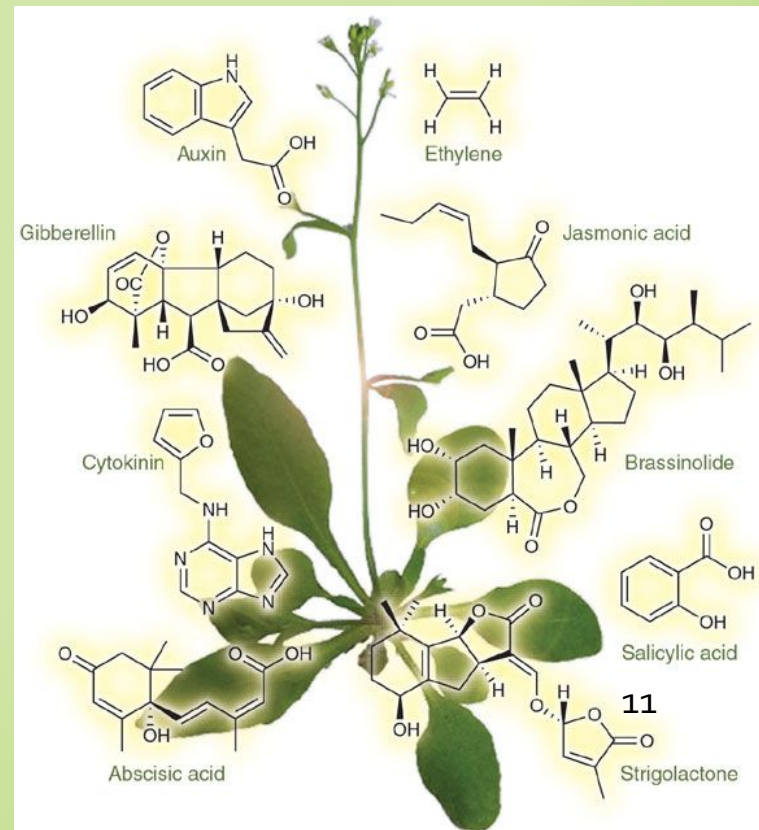


Phytohormone production

PGPR is associated with changes in plant metabolism, signaling, and hormone homeostasis.

Phytohormones regulate germination, growth, metabolism, or other physiological activity.

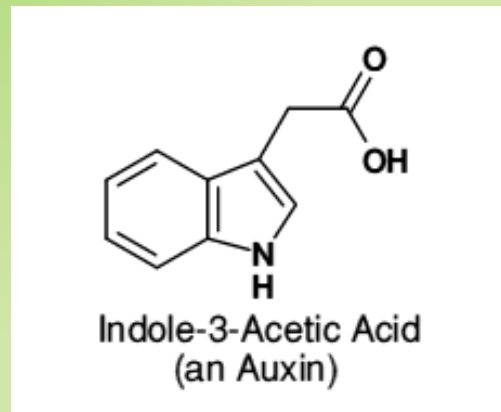
Phytohormones regulate various cellular processes in plants, including abiotic stress responses and plant - pathogen interaction.



Exogenous **auxin** suppresses the resistance of the plant to salicylic acid and activates the resistance associated with jasmonic acid.

Pseudomonas
Acinotobacter

(L-tryptophan)



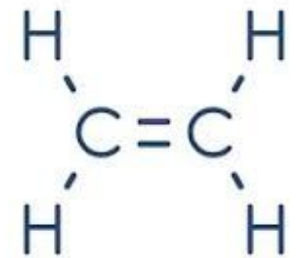
Help in plant cell division and differentiation

Stimulate seed and tuber germination.

Biosynthesis of various metabolites, and resistance to stressful condition

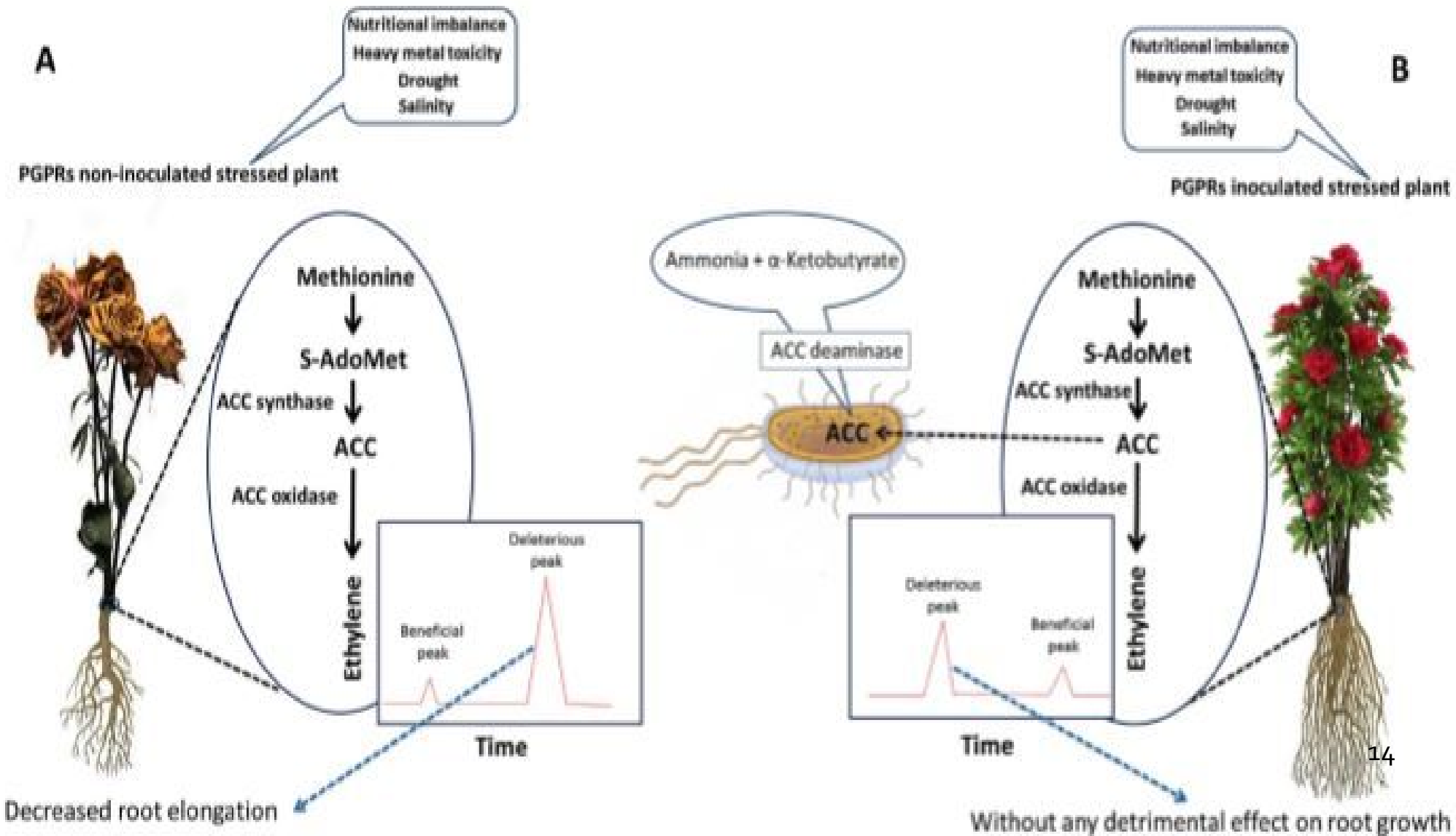
Bacterial IAA-induced alterations in root structure could lead to an increase root surface area, consequently improve nutrient and water uptake, which might have positive effects on plant growth.

- **Ethylene** is an essential hormone for plant growth and development.
 - At high concentrations including in conditions of stress cause a problem in plant growth.
 - Due to production of “**stress ethylene**”, root and shoots growth of all plants subjected to stressful conditions (e.g., stress of drought, salinity, heavy metal toxicity, nutritional imbalances, etc.) decrease.
 - ACC deaminase-possessing PGPRs can cleave ACC, the plant ethylene precursor, to ammonia and α -ketobutyrate.
- ✓ Decreased stress-induced ethylene production
 - ✓ Increased root growth



ethylene

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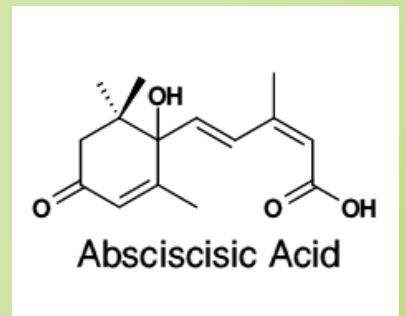
➤ PGPR can affect the level ABA in the plant, in this way influencing its growth and abiotic stress resistance (drought, cold, salt stress, soil pollution) .

- ✓ inhibits seed germination
- ✓ plant senescence
- ✓ abscission of leaves and fruits
- ✓ promotes stomatal closure
- ✓ affects the root system architecture.

Bacillus licheniformis Rt4M10 and
Pseudomonas fluorescens Rt6M10



synthesize both ABA and hormones that are ABA antagonists, such as gibberellins and cytokinins.



INDIRECT MECHANISM

INDUCED AND SYSTEMIC RESISTANCE

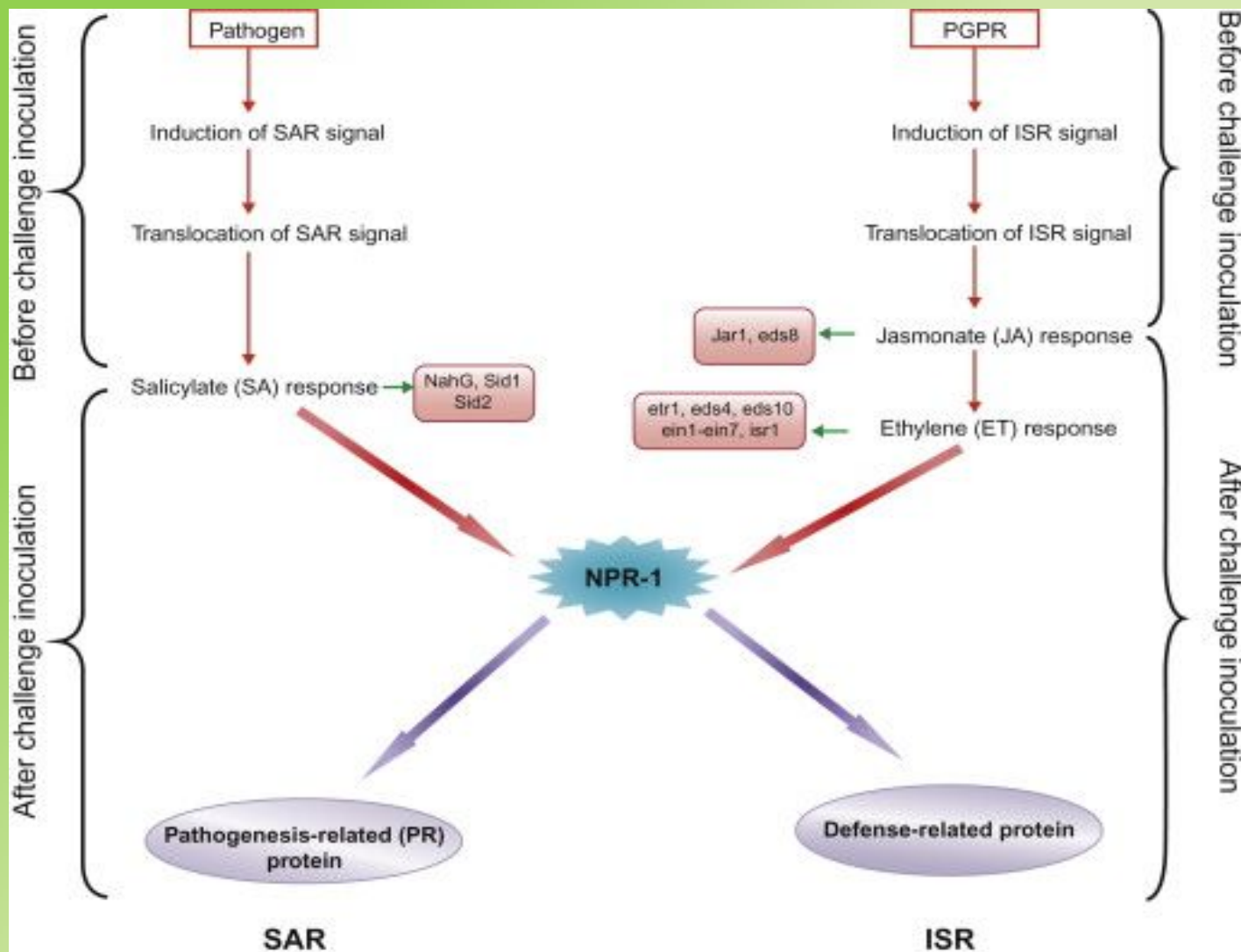
Plants have two types of resistance mechanisms depending on the amount of external stimuli:

✓ Systemic acquired resistance (SAR)

- **SAR** caused by fungi, bacteria, viruses, nematodes, parasitic plants, and even insect herbivores.
- The accumulation of **resistant proteins associated with pathogenesis (PR)** and **salicylic acid (SA)** is induced in SAR.

✓ Inductive systemic resistance (ISR)

- **ISR** is initiated by PGPR and does not include the accumulation of PR or SA.
- It also depends on the paths set by **Jasmonate (JA)** and **ethylene (ET)**.



Molecular studies on *Arabidopsis* have shown that SAR and ISR are linked through npr1 gene.

Gene activation processes during ISR

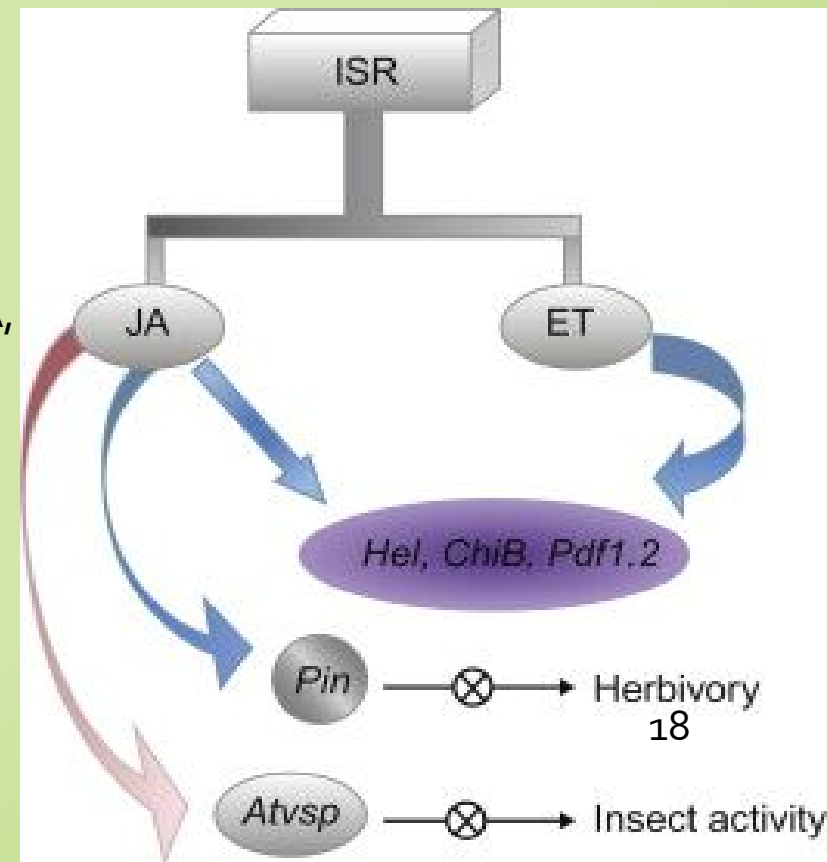
Hel gene (encoding a hevein-like protein)
ChiB gene (encoding a basic chitinase)
Pdf1.2 gene (encoding a plant defensin)

} Antifungal Activity

The **pal1** gene (encoding **phenylalanine ammonia-lyase (PAL)**) plays an important regulatory role in the synthesis of **lignin** and **SA**, induced by JA .

The **Pin** gene (encoding for the **proteinase inhibitor proteins**) protects the plant against herbivory.

The **Atvsp** gene (encoding the **vegetative storage protein (VSP)**) **VSP** possesses **acid phosphate activity**.

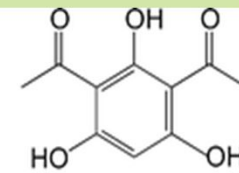


Antibiotics

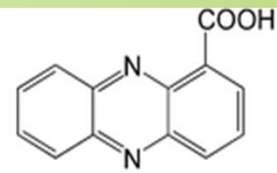
➤ Antibiotics production is biocontrol mechanisms of PGPR against phytopatogens.

Pseudomonads Fluorescent produce a wide range of antibiotics including

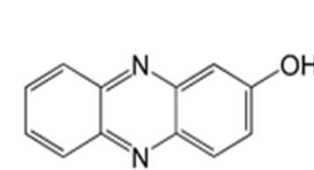
- **2,4-diacetylphloroglucinol (DAPG)**
- phenazine-1-carboxylic acid (PCA)
- 2-hydroxyphenazine (2OH-PHZ)
- phenazine-1-carboxamide (PCN)
- pyoluteorin (PLT)
- pyrrolnitrin (PRN)



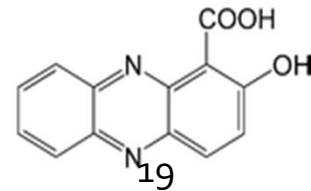
2,4-Diacetylphloroglucinol
(2,4-DAPG)



Phenazine-1-carboxylic
acid (PCA)



2-Hydroxyphenazine
(2OH-PHZ)



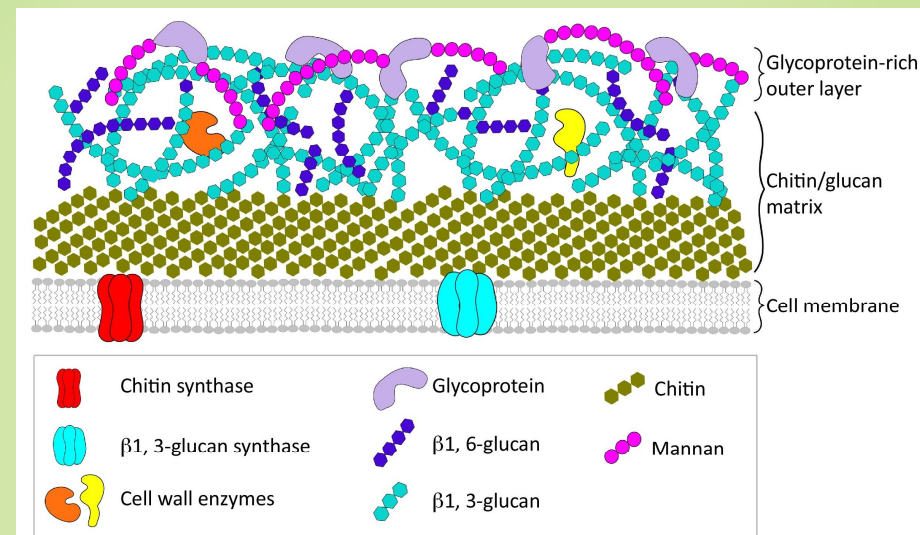
2-Hydroxyphenazine
-1-carboxylic acid
(2OH-PCA)

Cell wall degradation enzyme

➤ PGPR strains produce enzymes which exhibit hyperparasitic activity.

- **Chitinases**
- **β -1,3-gluconase**
- Dehydrogenases
- Lypases

➤ Protecting from biotic and abiotic stresses.



Trends in Microbiology

Glucosamine and chitine are the main constituents of the fungal cell wall pathogenesis.

Extracellular Polymeric Substance (EPS)

- **EXOPOLYSACCHARIDES** are long chain polysaccharides formed from sugar units such as **glucose, galactose** and **rhamnose** which are important in **biofilm formation and root colonization**.

Pseudomonas spp.

Acinetobacter spp.

- ❖ Enhanced the volume of soil macropores and rhizosphere soil aggregation
- ❖ Increased water and fertilizer availability to plant
- ❖ Decreased the content of Na⁺ available for plant uptake

- pyruvate ketals
- neutral sugars
- uronic acids
- amino sugars
- organic ester-linked substituents.

Drought & Salinity
Resistant PGPR

Volatile

Microbial VOCs are characterized as low molecular weight and with enough high vapor pressure under normal conditions that are produced through catabolic pathways, including glycolysis, proteolysis, and lipolysis.

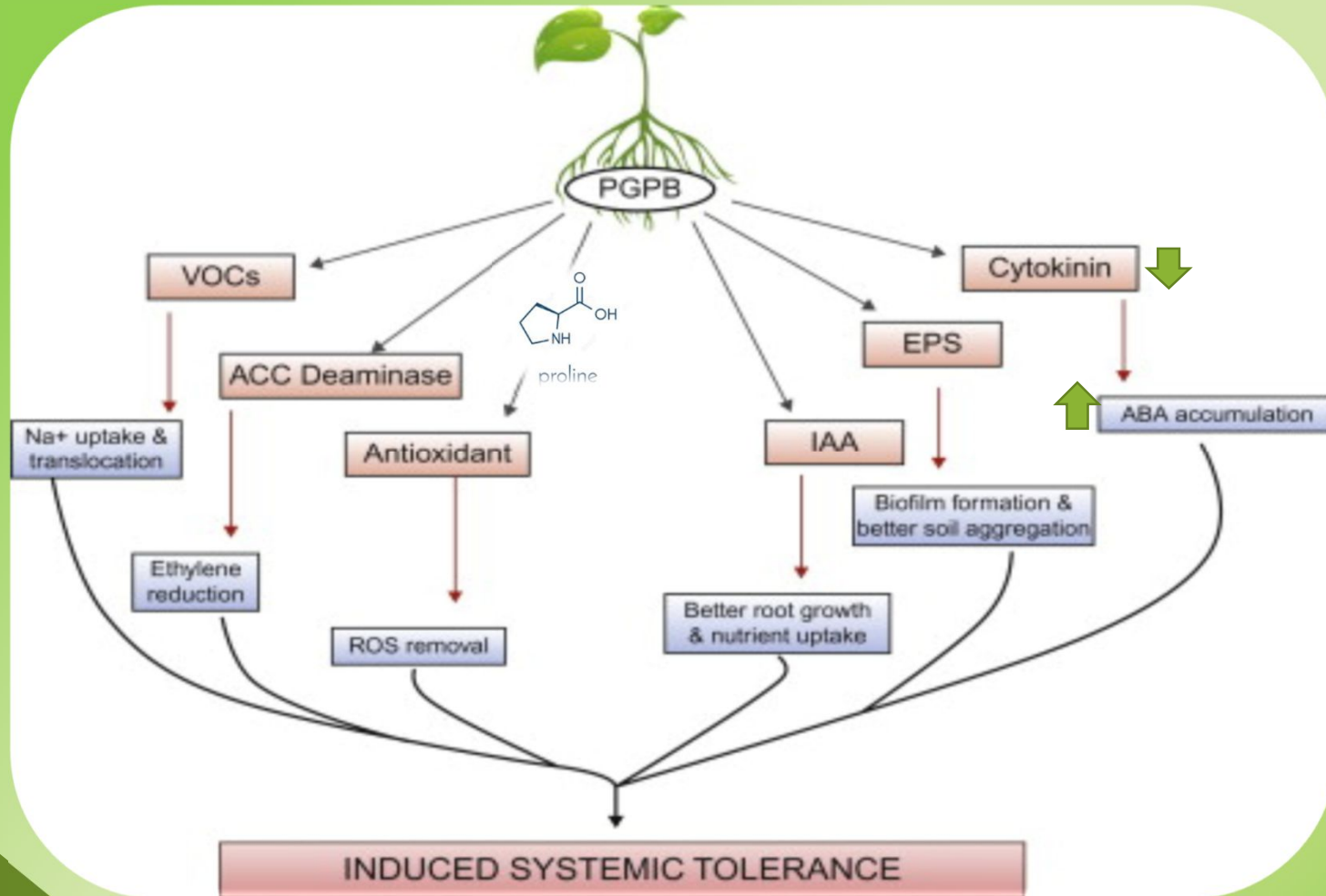
Methyl salicylate (**MeSA**), methyl jasmonate (**MeJA**) also works as a volatile signal.

- Modulated expression of genes involve in cell wall structure.
- Stimulated biosynthesis of **choline** and **glycine betaine**
- Regulated expression gene of high affinity K^+ transporter (HKT₁) in roots and shoots and maintain lower Na^+
- Closed stomata in plants
- Triggered stress defensive responses (ISR)

- Dodecane,
- 2-Undecanone
- 2-tridecanone
- 2-tridecanol
- **2, 3-butanediol**
- **3-hydroxy-2-butanone (acetone)**
- tetramethyl pyrazine

Drought & Salinity
Resistant PGPR

PGPBs play a crucial role against abiotic stress by enhancing plant tolerance. PGPB-induced tolerance has been proposed, including physical and chemical changes .



CONCLUSION

- PGPR are economically and environmentally beneficial for plant growth promotion.
- In future , they are expected to replace the chemical fertilizer, pesticides and artificial growth regulators which have numerous side-effects to sustainable agriculture.
- Generally, ACC deaminase and IAA-producing bacteria can be a good option for optimal crop production and production of bio-fertilizers in the future due to having multiple potentials in alleviating stresses of salinity, drought, nutrient imbalance, and heavy metals toxicity in plants.
- The use of PGPRs may lead to plant health improvements that play an important role in reducing the amount of chemicals to achieve sustainable agricultural productivity.

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Thank you for your attention!