Role of PGPR in sustainable agriculture: Global climate Change and Water sustainability

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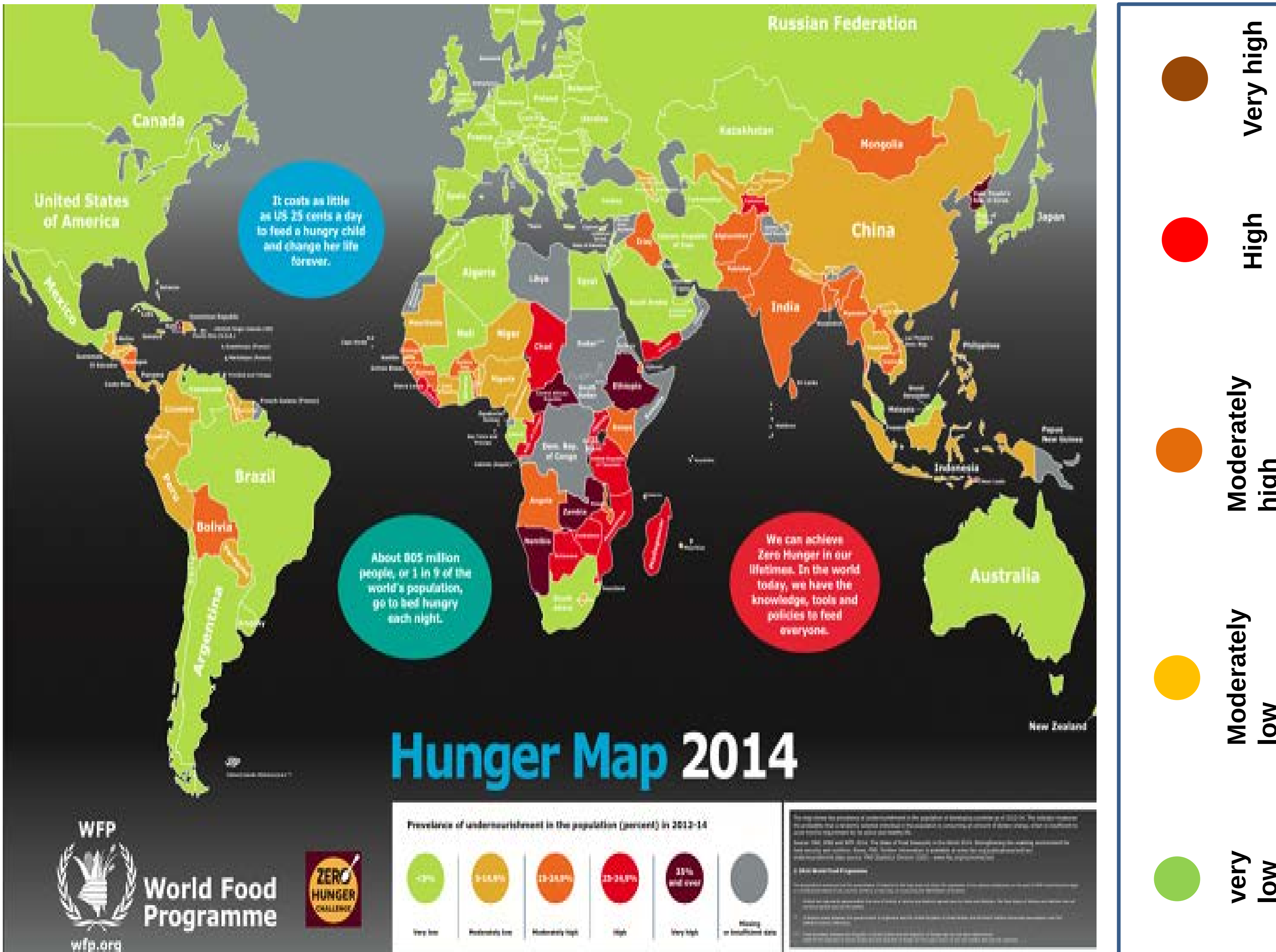
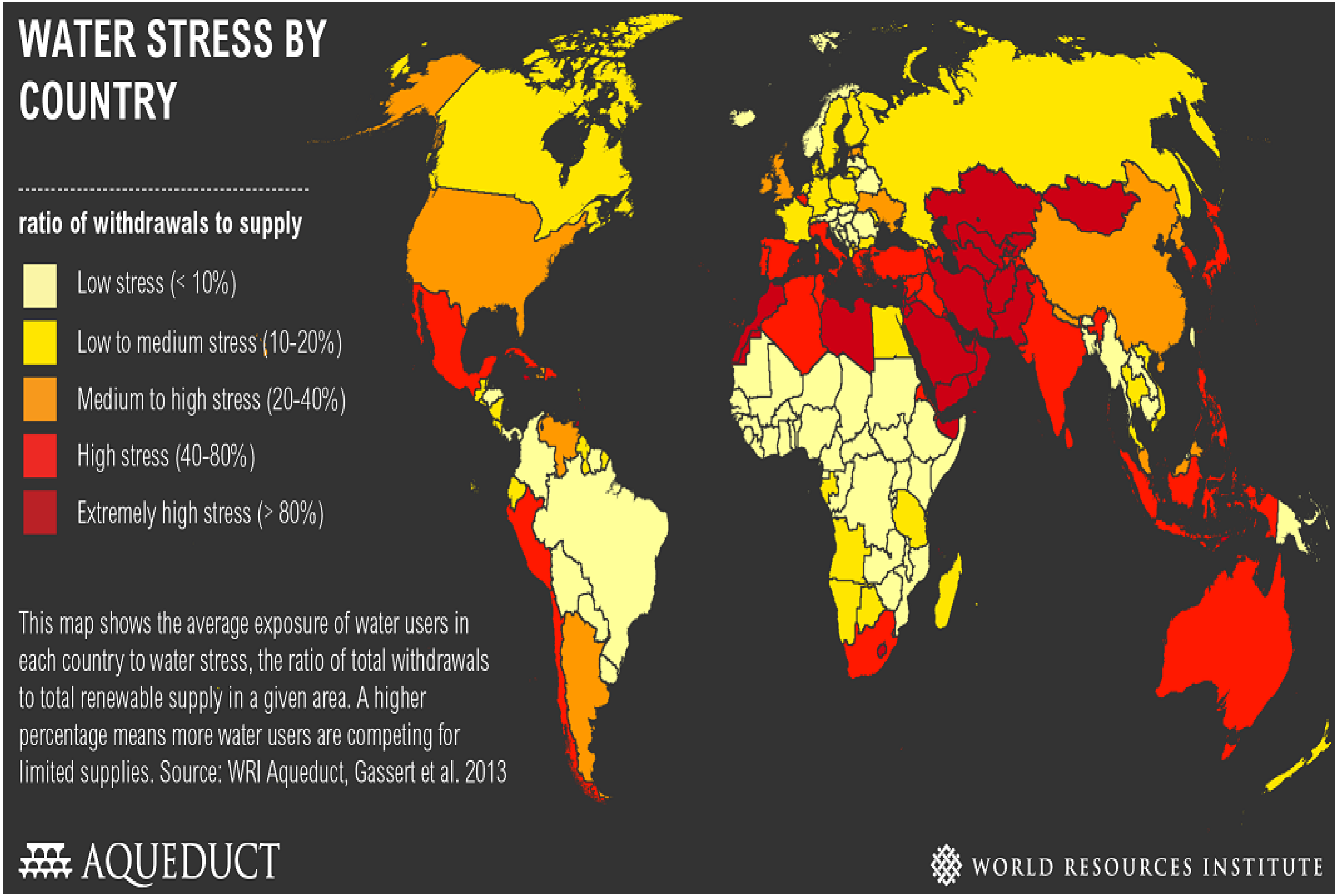
Climate Change and Global food security

Food security and Health

- Climate change could affect
  - Amount of food produced
  - Variety and nutritional value of food
  - Cost of food


Russian Federation
Canada
United States of America
Mexico
Brazil
Bolivia
Peru
Argentina
Algeria
Libya
Egypt
Mali
Niger
Chad
Ethiopia
Angola
Zambia
Namibia
Iraq
Kazakhstan
Mongolia
China
India
Japan
Philippines
Indonesia
Australia
New Zealand
It costs as little as US 25 cents a day to feed a hungry child and change her life forever.
About 805 million people, or 1 in 9 of the world's population, go to bed hungry each night.
We can achieve Zero Hunger in our lifetimes. In the world today, we have the knowledge, tools and policies to feed everyone.
Hunger Map 2014
WFP
World Food Programme
wfp.org
ZERO HUNGER
Prevalence of undernourishment in the population (percent) in 2012-14
Very high
High
Moderately high
Moderately low
very low

Global Water Shortage : the Key Challenge for Food Security



Framing the problem

- **In the next century, climate change and associated global warming will reduce staple crop yields in South Asia and Sub Saharan Africa while increasing it in temperate parts of the world**

- **Flooding, rise in sea level etc. might actually reduce the amount of cultivable land in South Asia**

- **At the same time, this region will experience enhanced demand for staples due to economic growth and population growth**

Impact of climate change on agriculture of Asia: Country specific findings

- **India:** Expected temperature rise and drought will impact on crop yield, **imply a decline of wheat yield of around 10-40 percent by 2050**

- **Pakistan:** Wheat yield which rose steadily till 2004 would **fall by around 6 percent by 2080**; the fall would be in all regions except the Northern mountainous region

- **Sri Lanka:** At the current rate of rise in temperature rice yield would **reduce by 5.9 percent every 30 years**

- **Bangladesh** : Approximately twenty drought events have been experienced from 1973 to 2011, **imparting negative effect on rice production**

The result would be

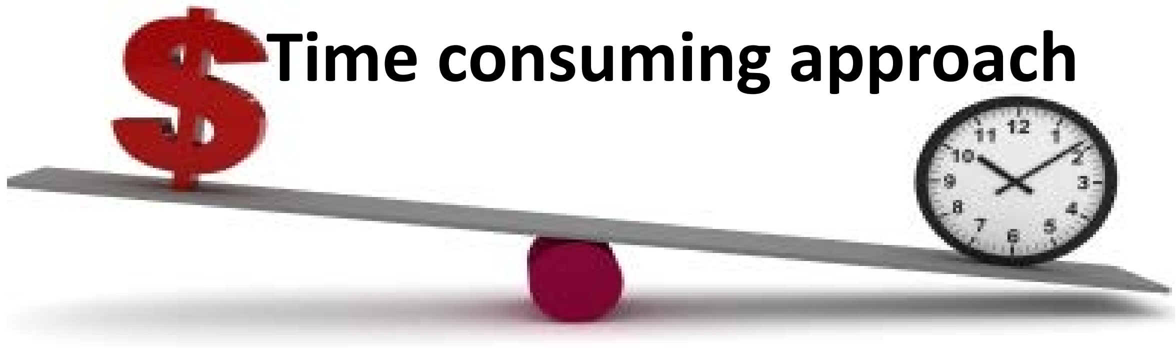
Food insecurity

So, what next

Biotechnological intervenes to combat with abiotic stresses

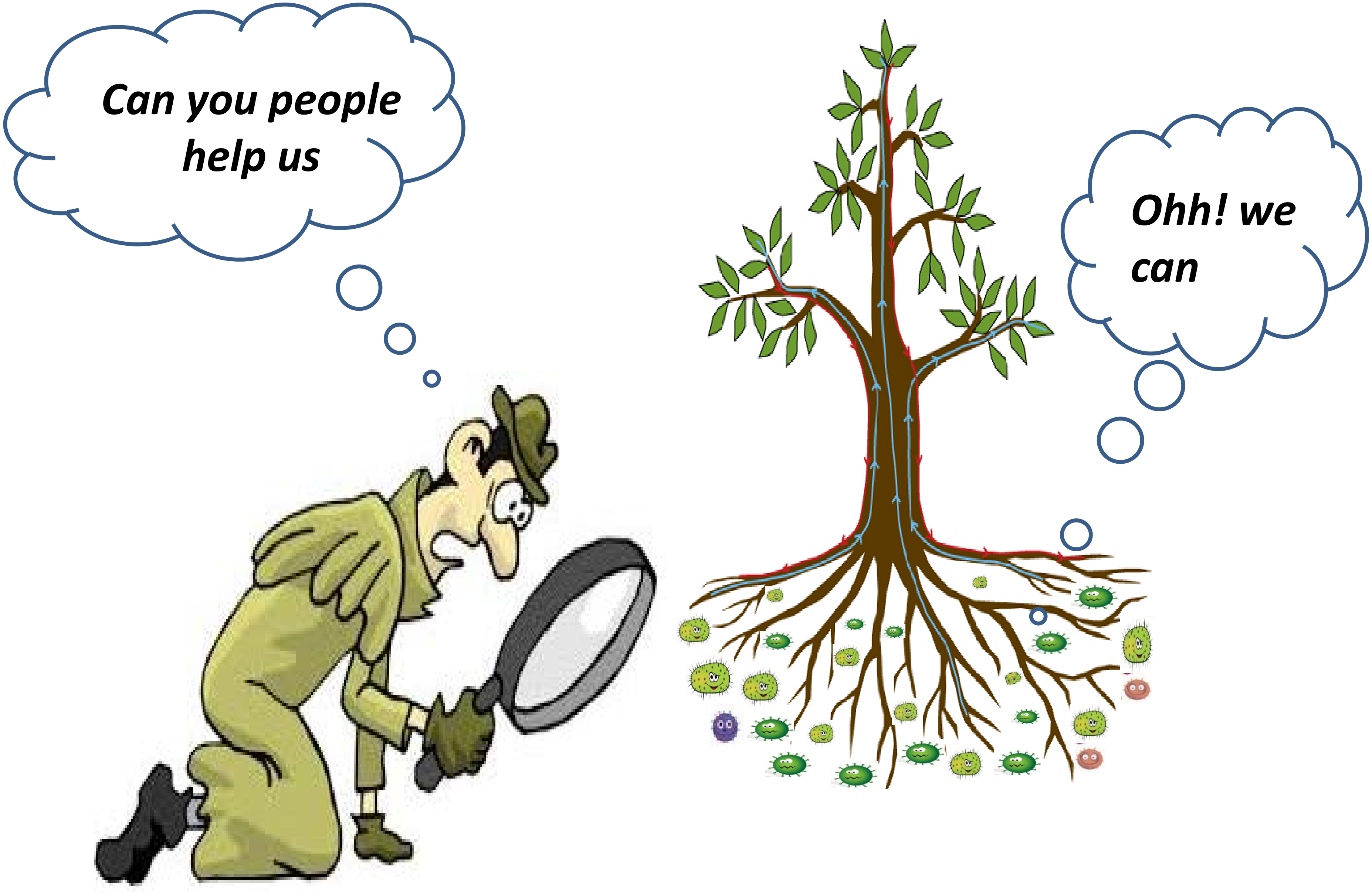
Marker-assisted breeding and quantitative trait loci (QTL) introgression

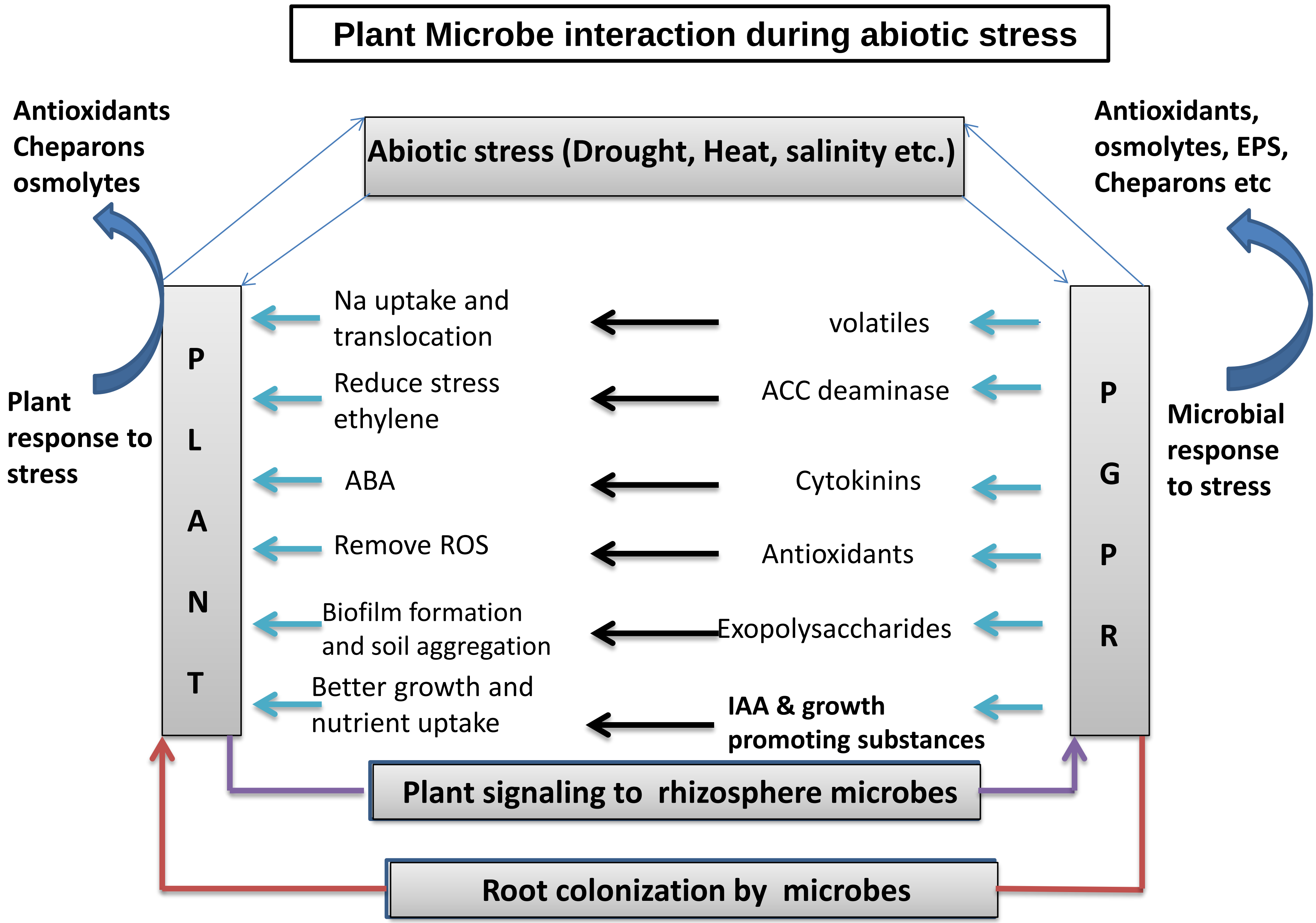
Time consuming approach



Development of *in vitro* regeneration techniques and transgenics

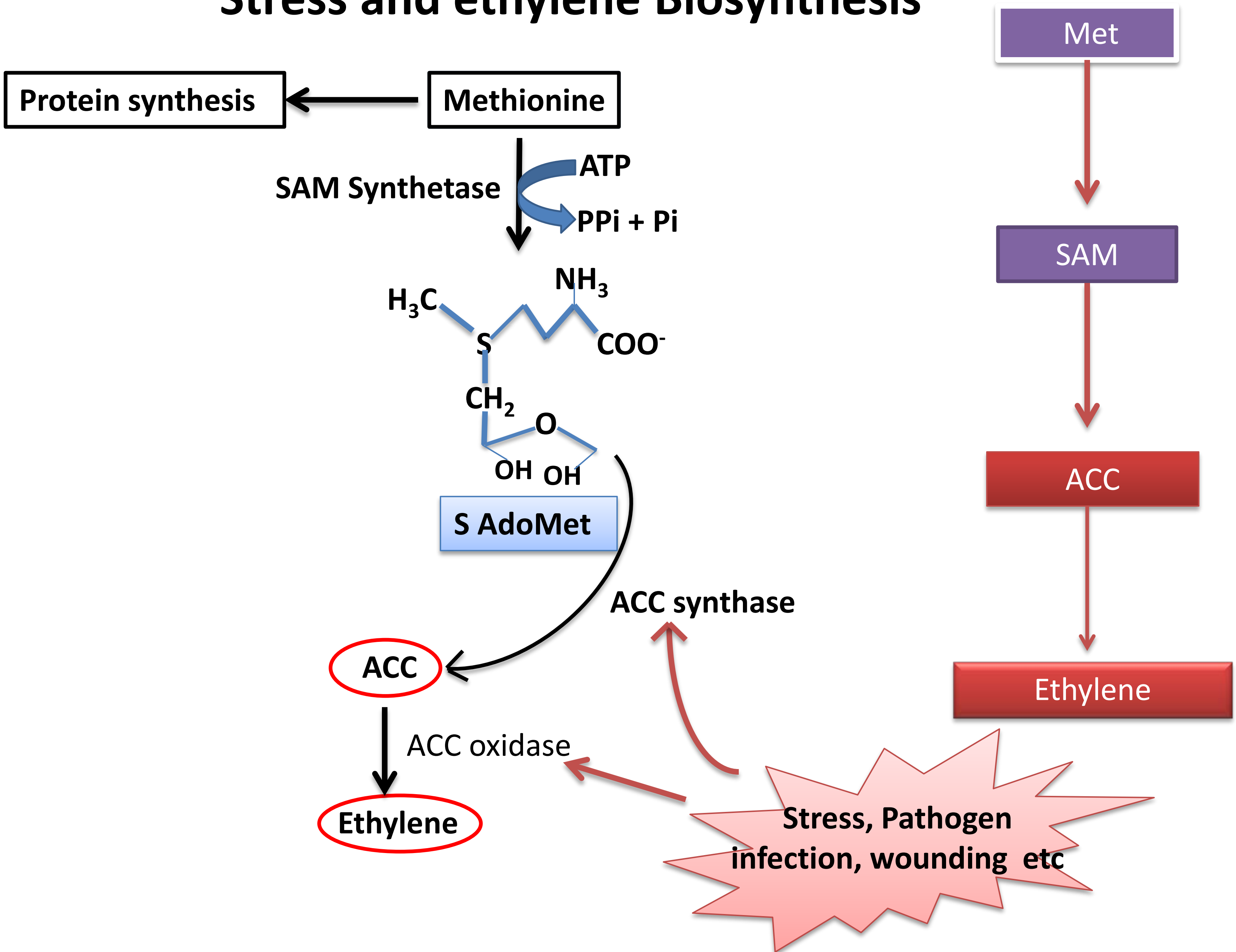
Debate between Scientific communities


Can you people help us
Ohh! we can

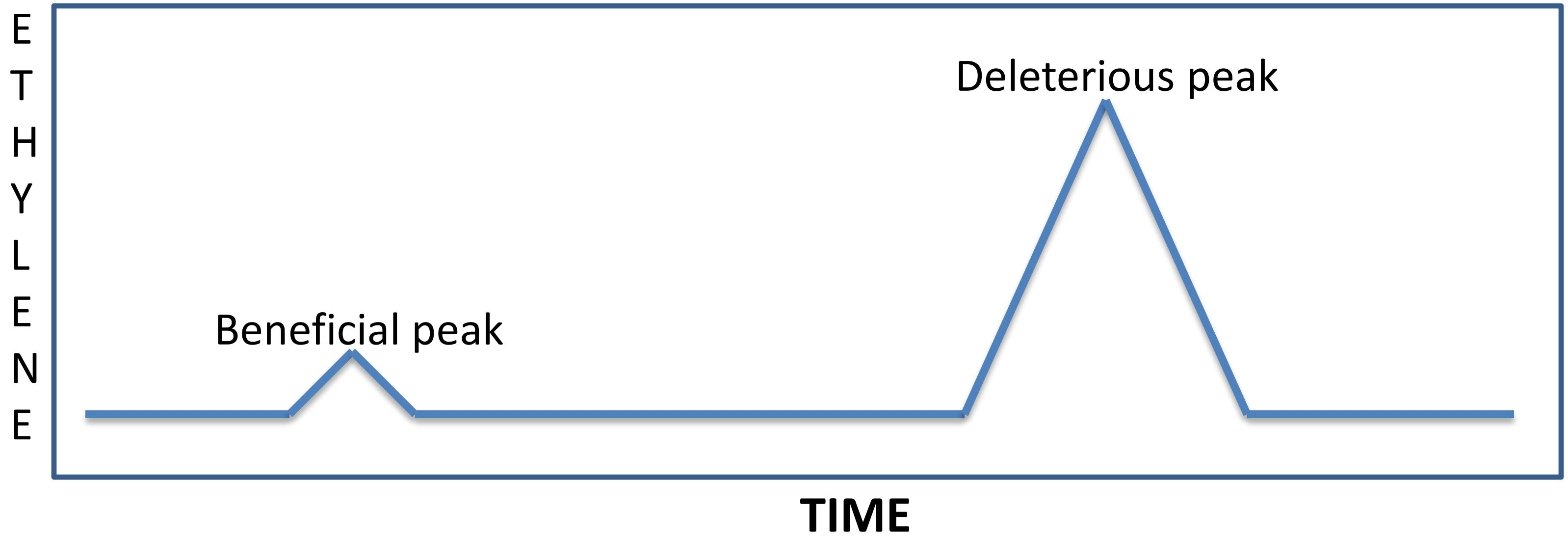


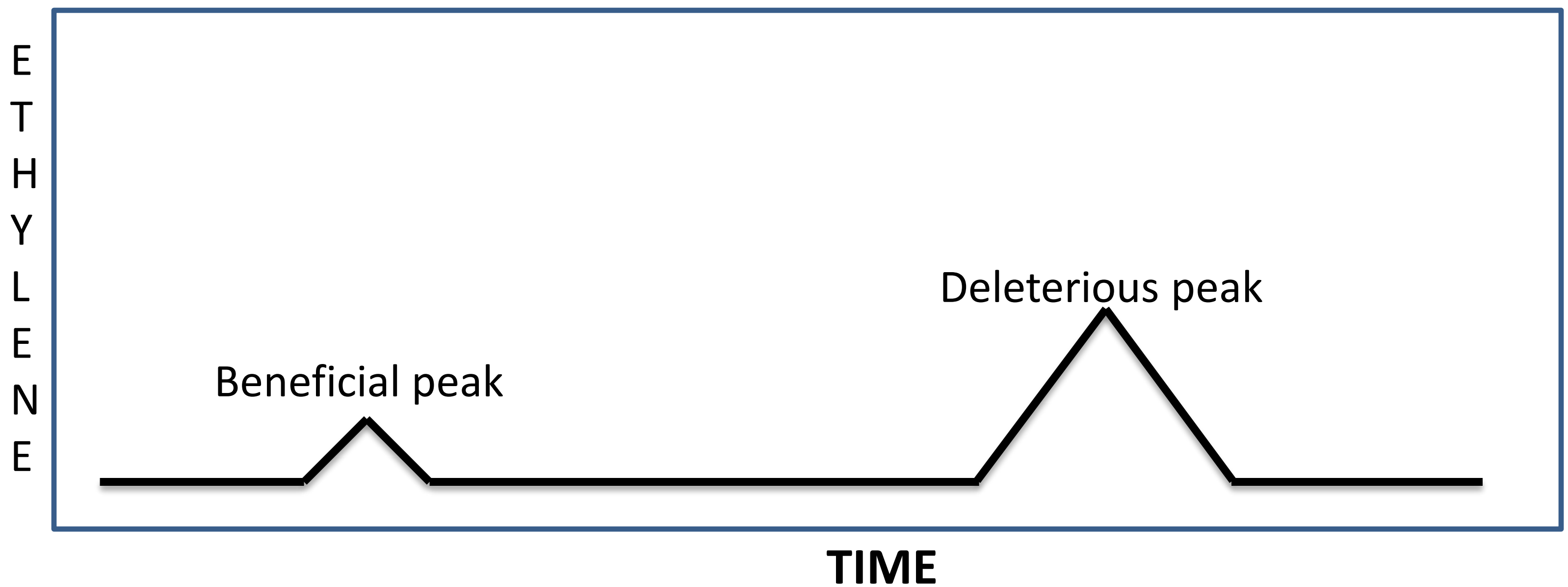
Plant Microbe interaction during abiotic stress
Abiotic stress (Drought, Heat, salinity etc.)
Antioxidants
Cheparons
osmolytes
Plant response to stress
Antioxidants, osmolytes, EPS, Cheparons etc
Microbial response to stress
P L A N T
P G P R
Na uptake and translocation
Reduce stress ethylene
ABA
Remove ROS
Biofilm formation and soil aggregation
Better growth and nutrient uptake
volatiles
ACC deaminase
Cytokinins
Antioxidants
Exopolysaccharides
IAA & growth promoting substances
Plant signaling to rhizosphere microbes
Root colonization by microbes

Stress and ethylene Biosynthesis



Plant ethylene production as a function of time following an environmental stress



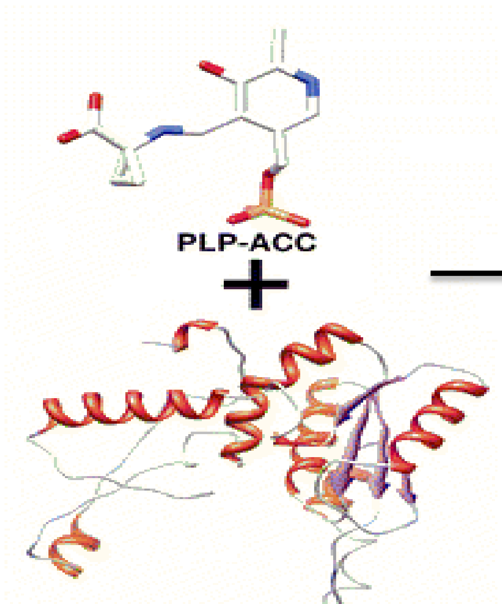


Bacterial ACC deaminase – An enzyme for abiotic stress tolerance

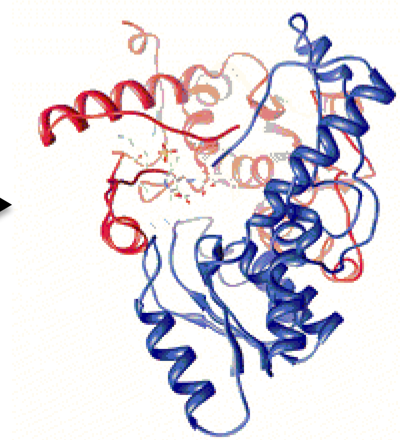
Biochemistry

✓ ACC deaminase is a multimeric enzyme (homodimeric or homotrimeric) with a subunit molecular mass of approximately 35-42 kDa.

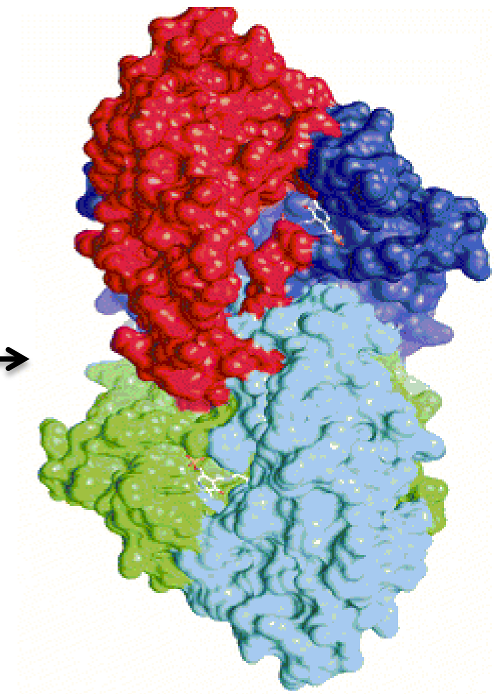
✓ It is a sulfhydryl enzyme in which one molecule of the essential co-factor pyridoxal phosphate (PLP)



Phytophthora sojae ACC deaminase



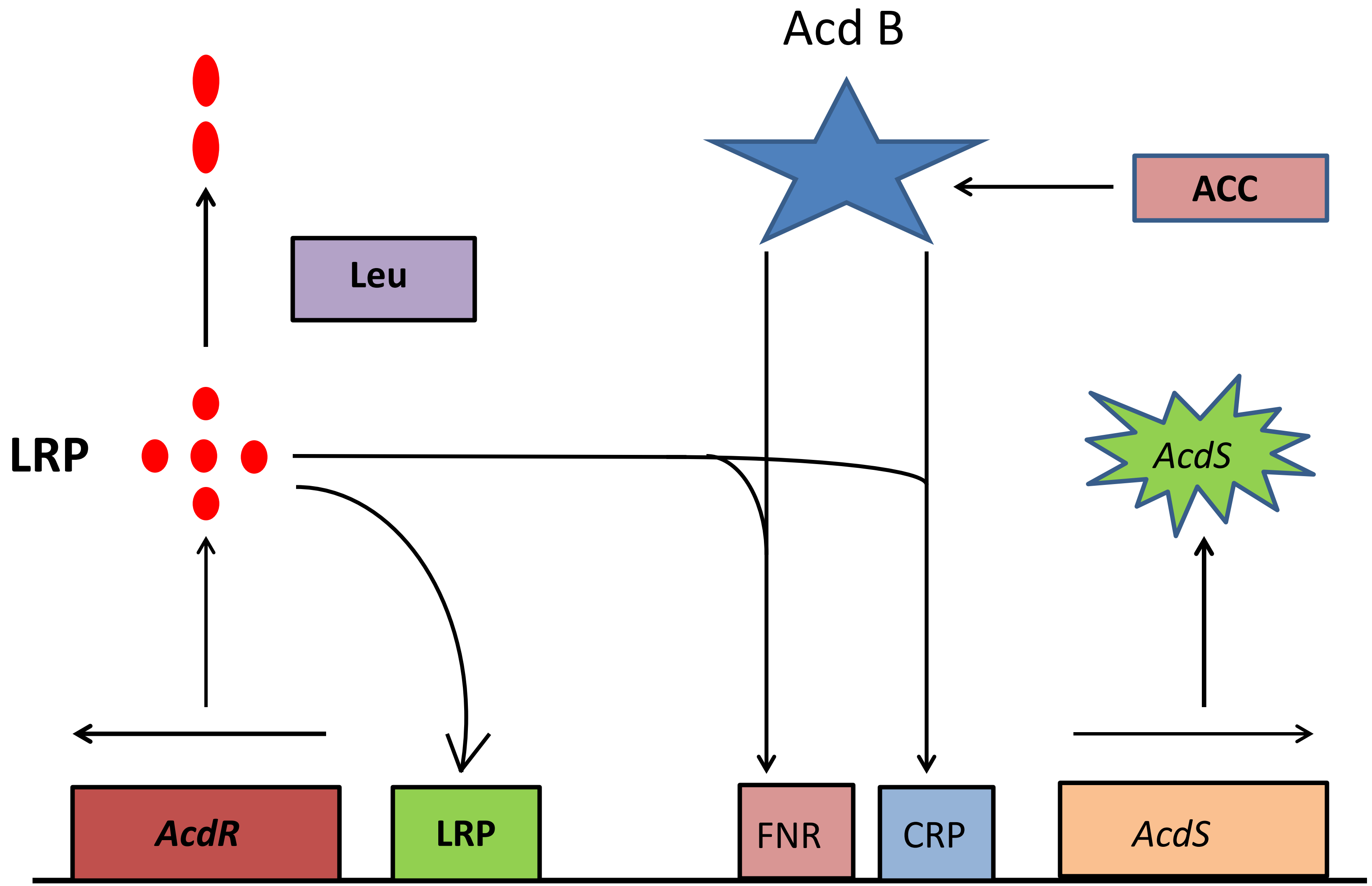
ACC deaminase dimer with substrate



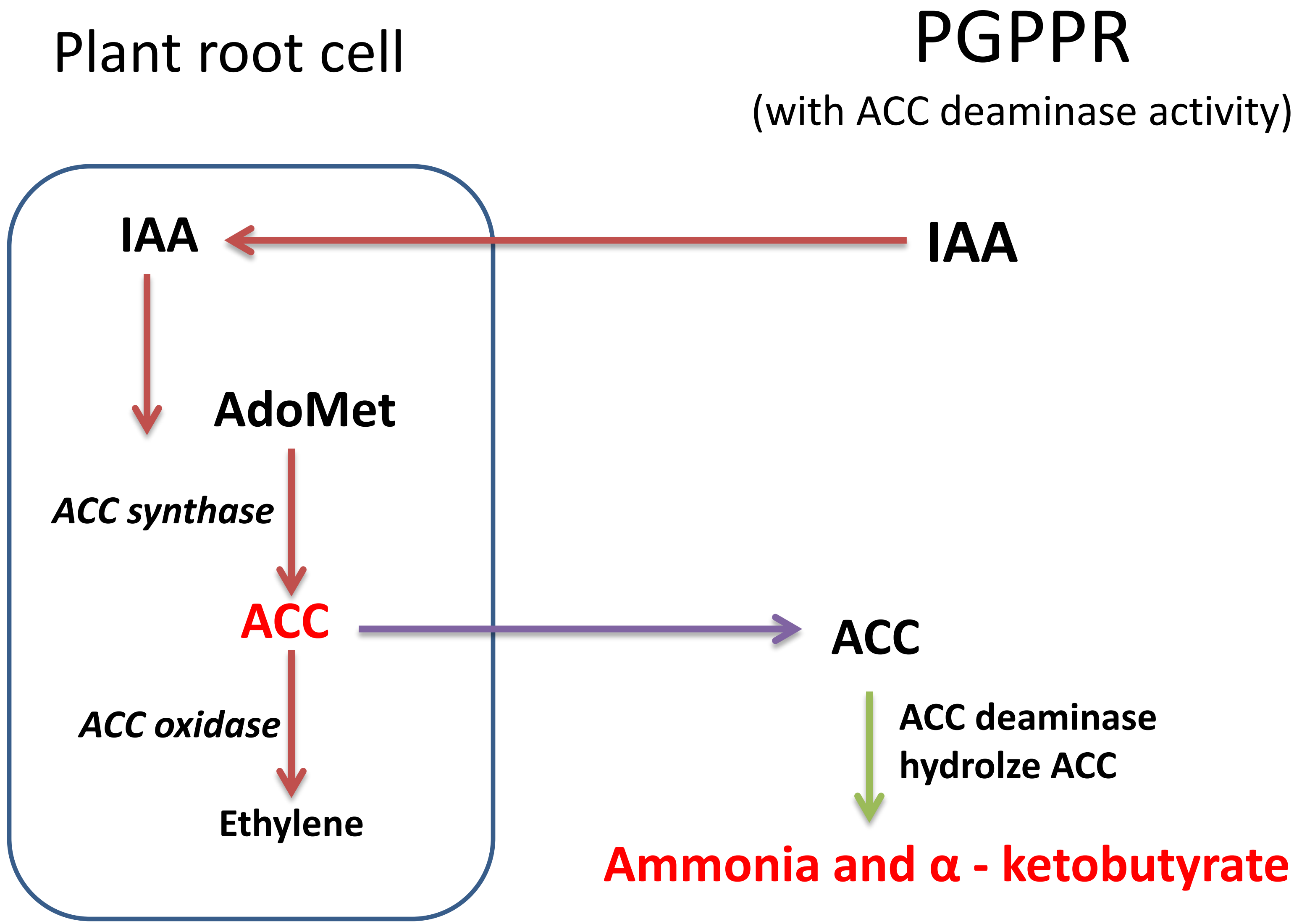
ACC deaminase tetramer

Singh and Kashyap, 2012

REGULATION OF ACC DEAMINASE ACTIVITY



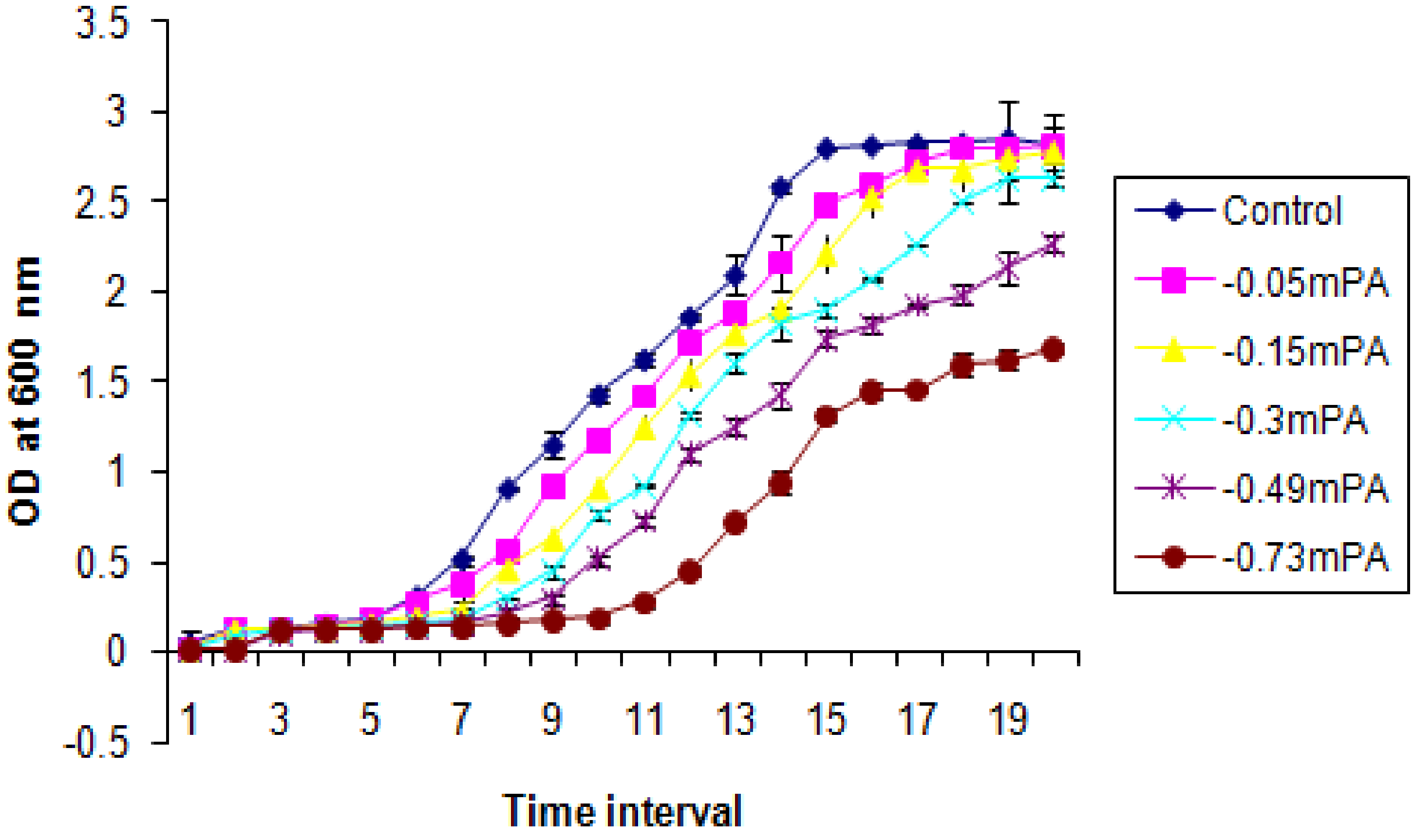
Mechanism of ACC deaminase Action



Glick et al., 2010

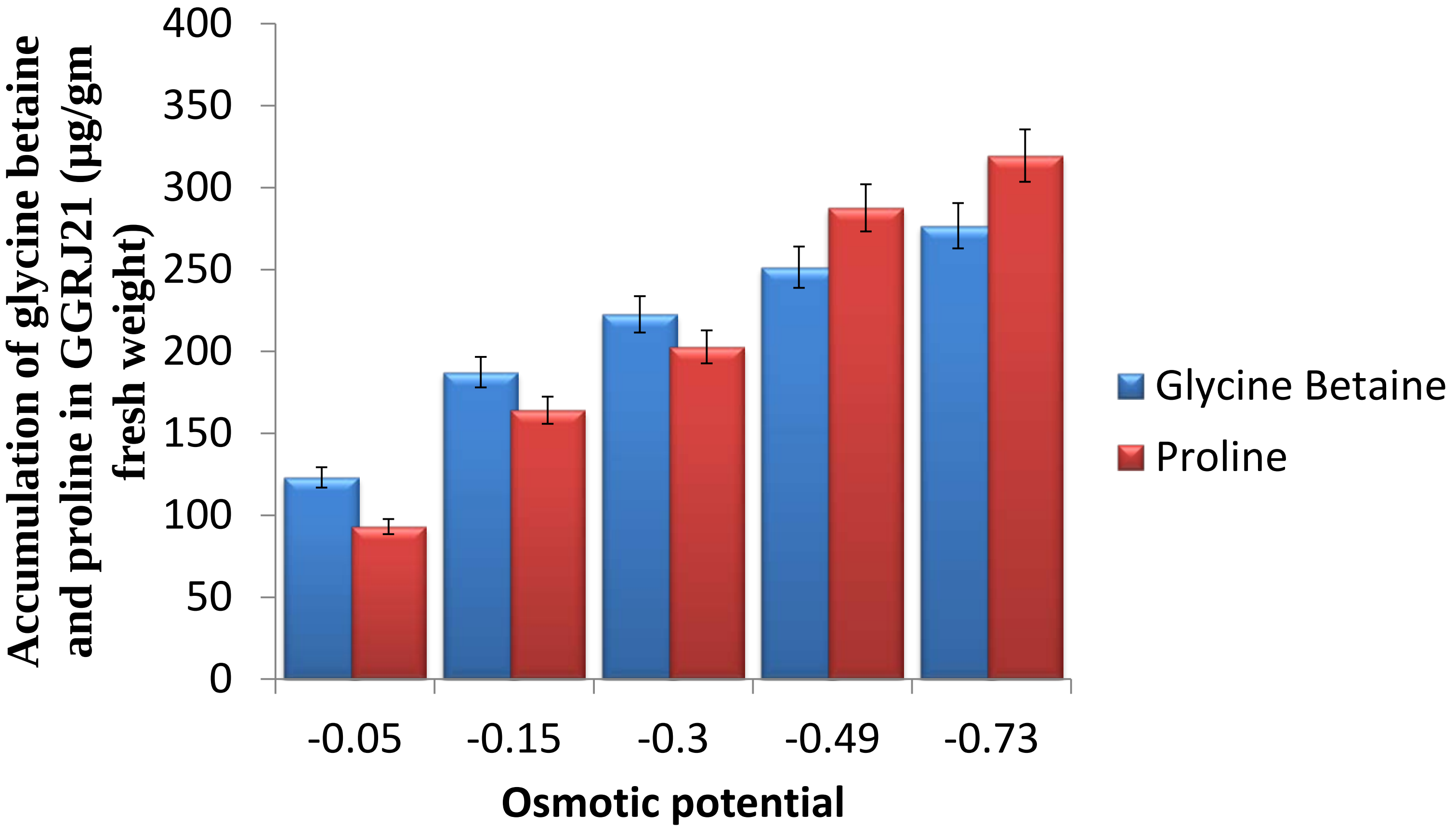
My findings regarding plant microbes interaction and water stress assessment

Osmotic Stress resistant *Pseudomonas strains* was isolated from green gram rhizosphere.



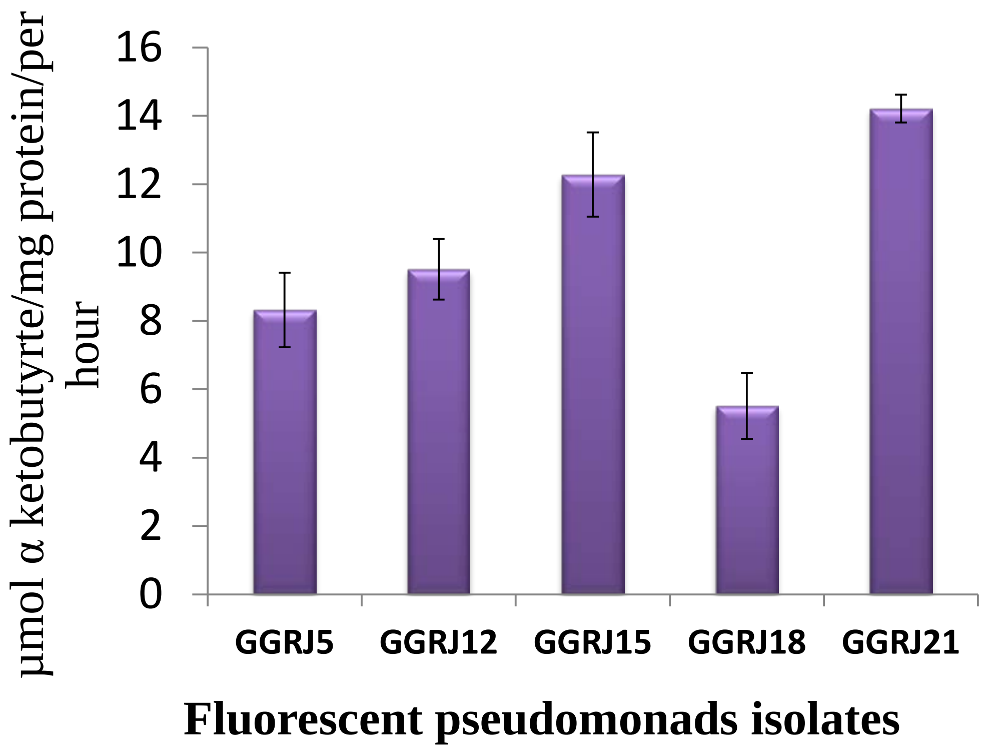
Bacterial Growth kinetics in different osmotic stress

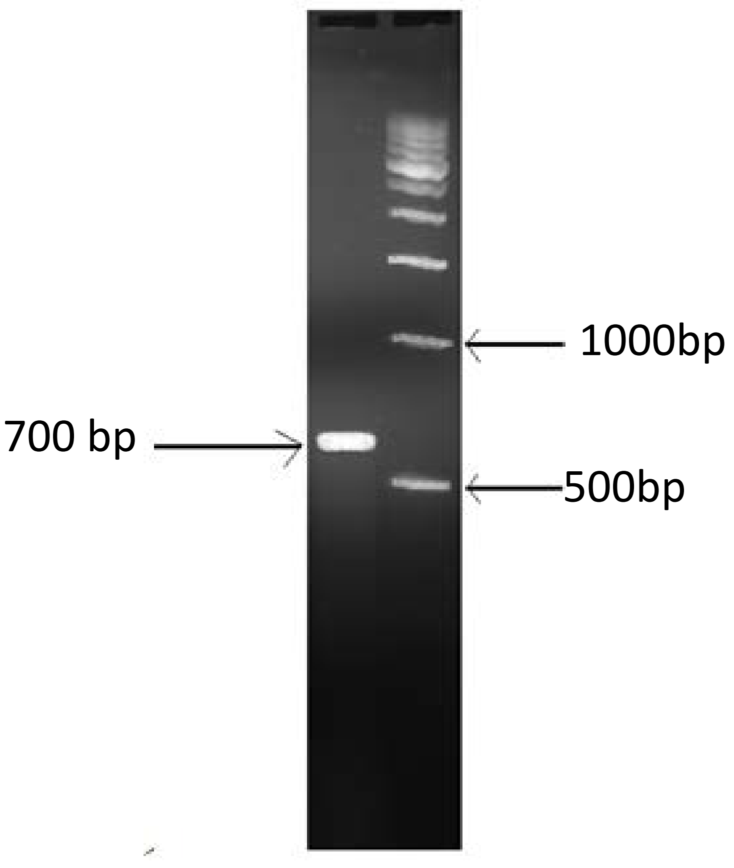
Quantification of endogenous osmolytes (µg 100 ml^{-1} culture) of Pseudomonas isolate in luria broth (LB), growing under different osmotic stress condition



Quantitative estimation of ACC deaminase in stress tolerant fluorescent pseudomonads

Plant growth promoting traits of *Pseudomonas aeruginosa* strain GGRJ21 under normal growth and osmotic stress condition at 0.73MPa.





Amplification of acdS gene of GGRJ21

Effect of Pseudomonas consortium on growth attributes of Green gram (*var k851*)

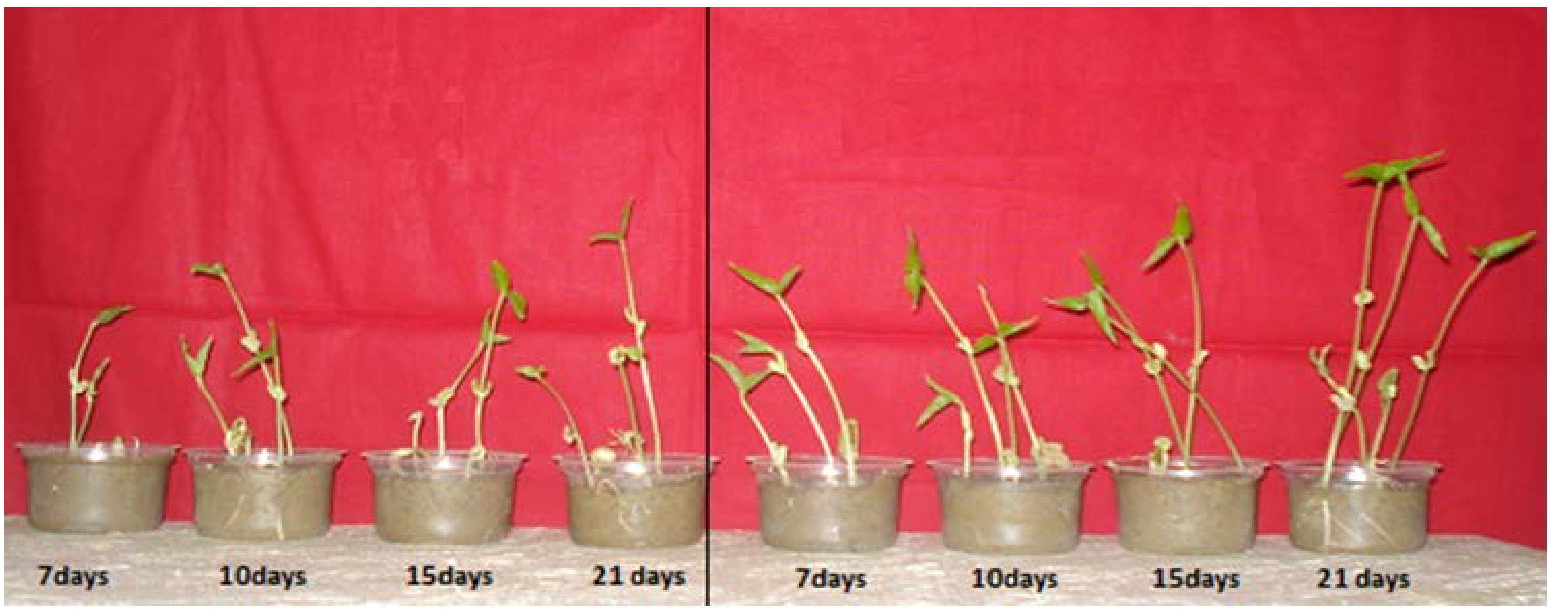
Treatments	Shoot length (m)	Root length (m)	Fresh weight (kg)	Dry weight (kg)	Relative water content (%)
Uninoculated Watered plant as control	0.2166±2[a]	0.0366±0.57[a]	0.42766±4[a]	0.17833±7[a]	78[a]
Plants inoculated with bacteria and sufficient water supply	0.3066±3[b]	0.0866±1.52[b]	0.53033±6[a]	0.262±5.68[b]	72[a]
Bacteria inoculated plants under drought stress	0.19±2[a]	0.12±2.64[c]	0.31866±7[b]	0.132±5.2[c]	63[b]
Uninoculated Plants under drought stress	0.10±2[c]	0.04±1[a]	0.208±4[c]	0.107±4.9[c]	40[c]

Control

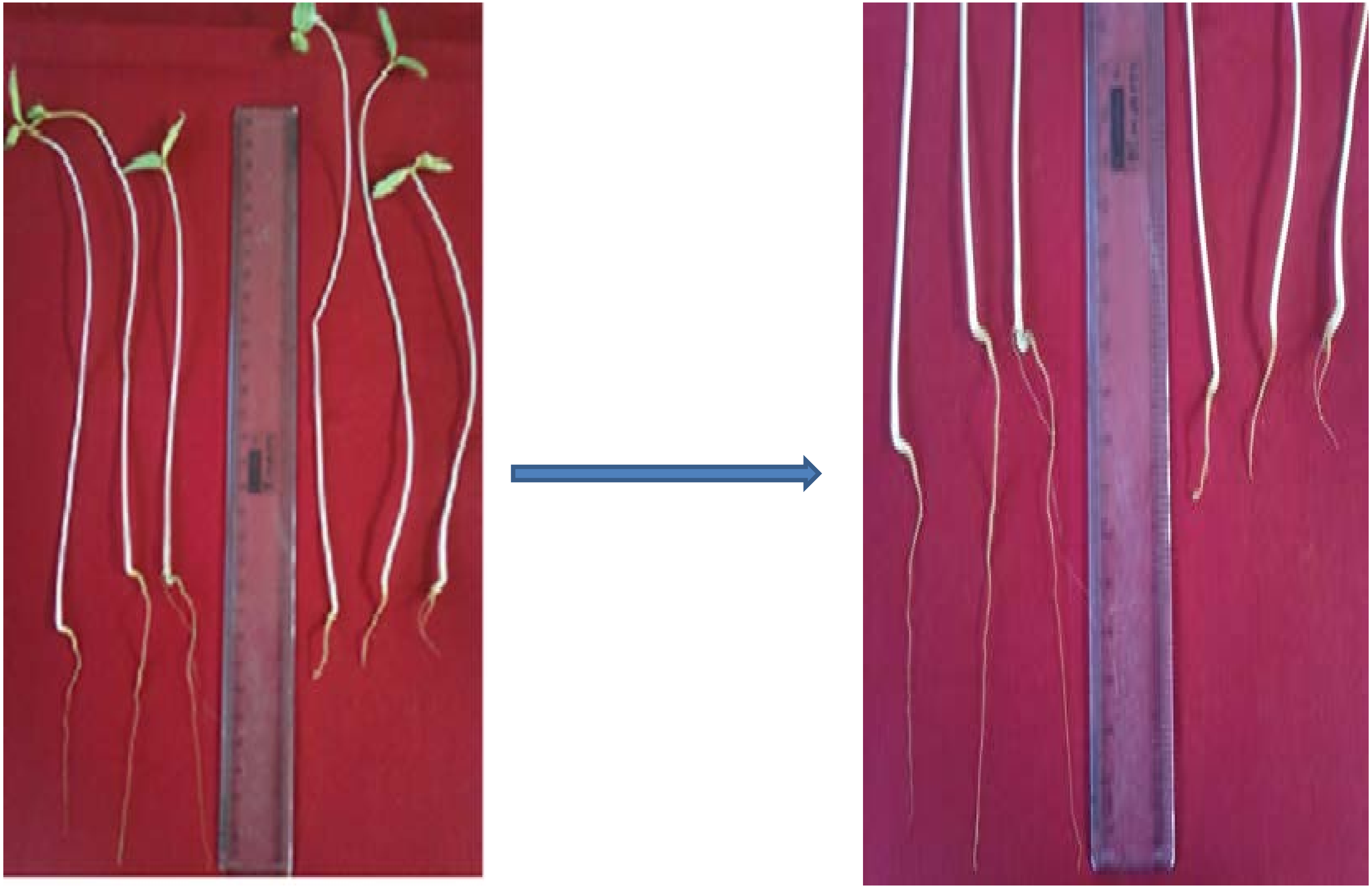
Treated with bacteria

Treated Control

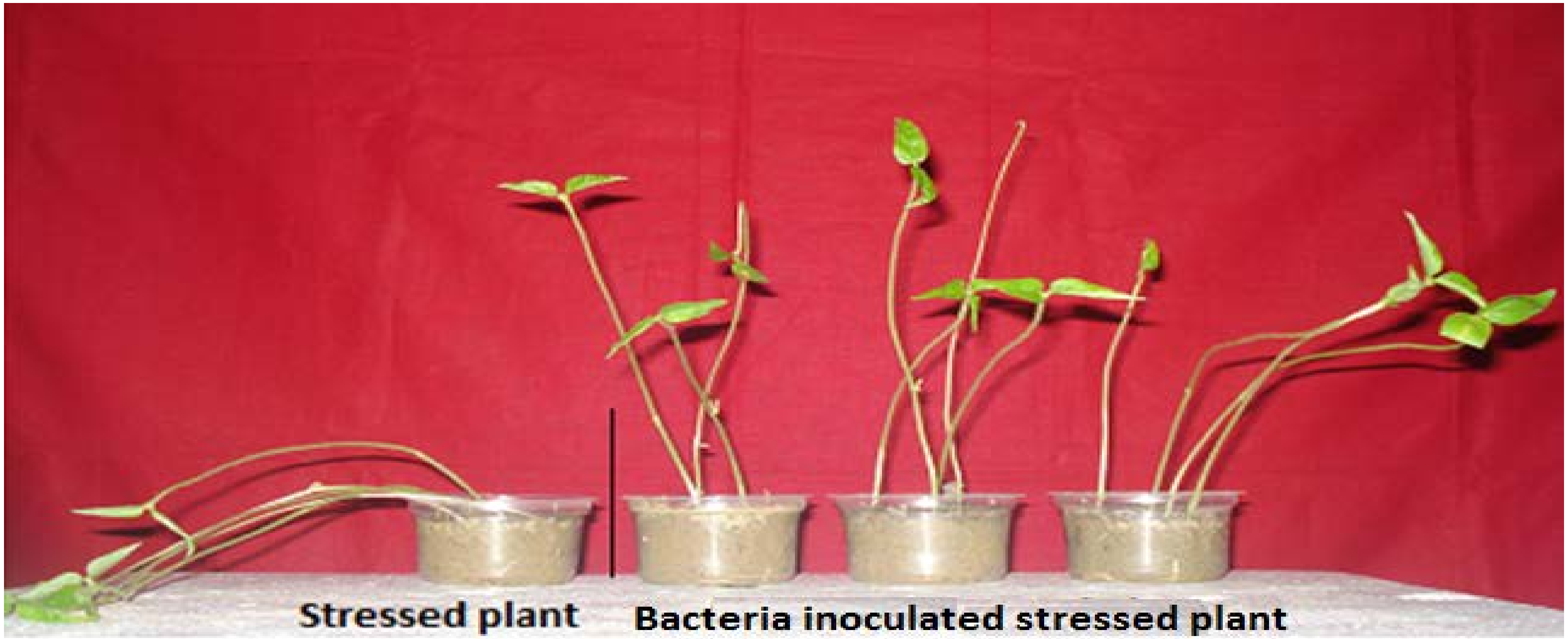
Control Treated with the consortium



Plant growth promotion under normal irrigated condition



Treated **Control**



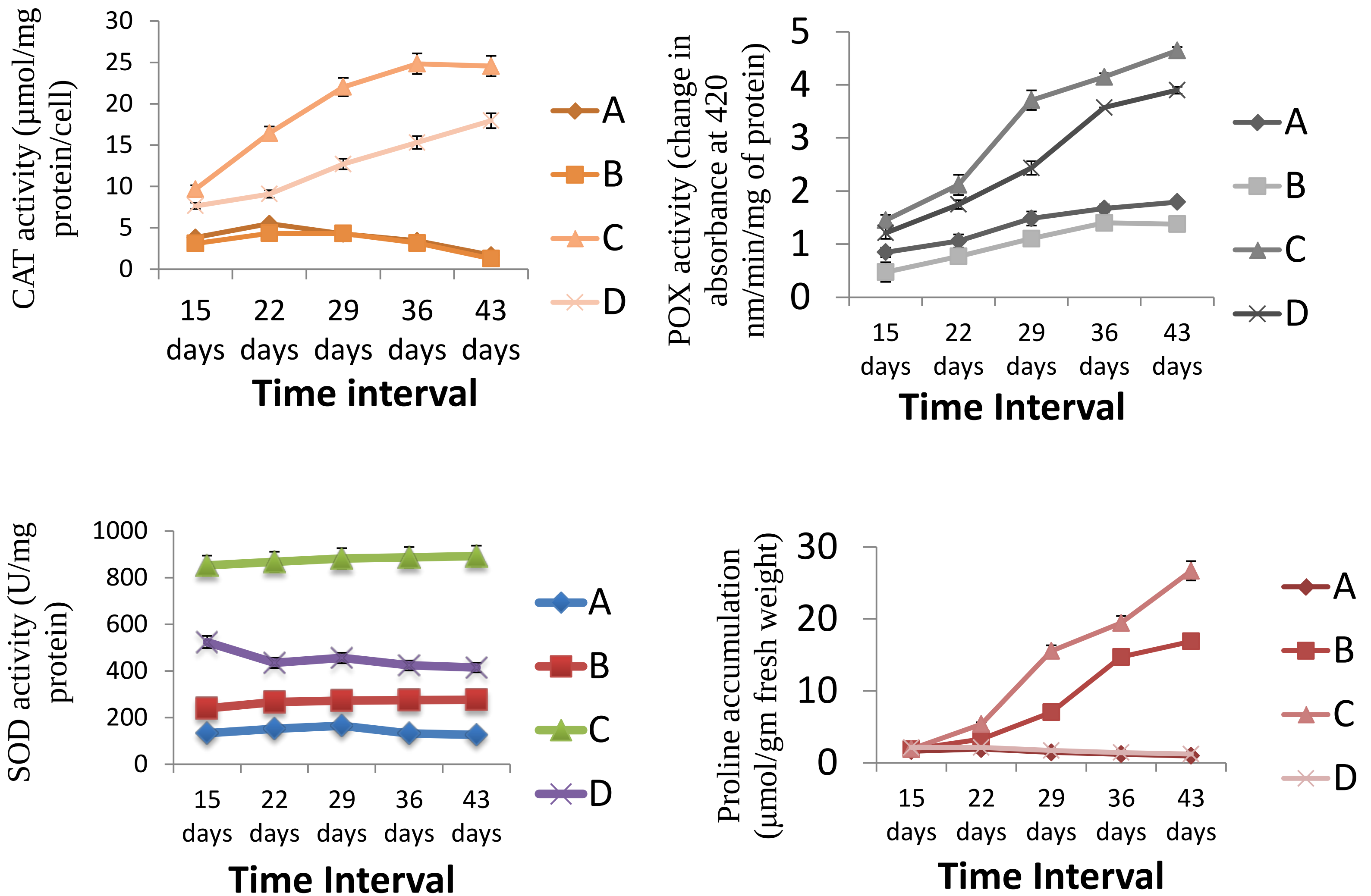
10 days 20 days 30 days 40 days

Drought Stressed plant

10 days 20 days 30 days 40 days

Treated plant in drought stressed condition

Estimation of ROS scavenging enzymes and osmolytes in green gram plants under different treatment condition

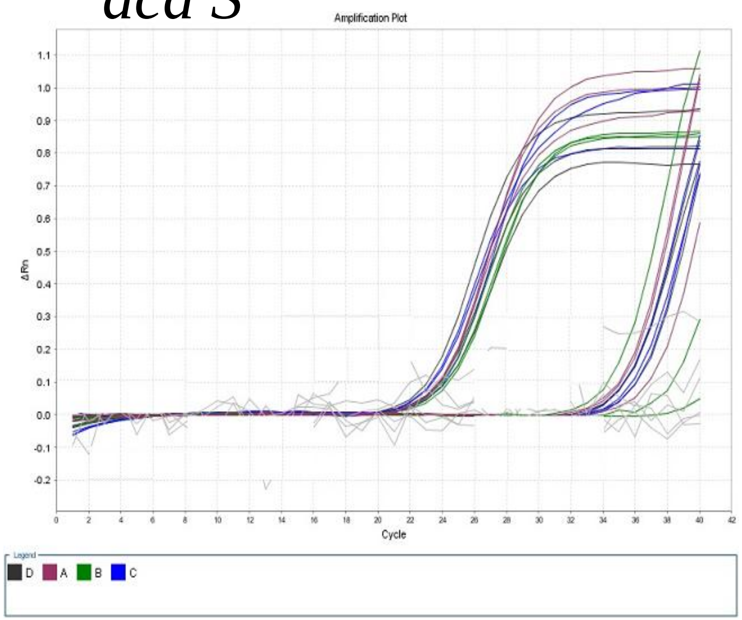


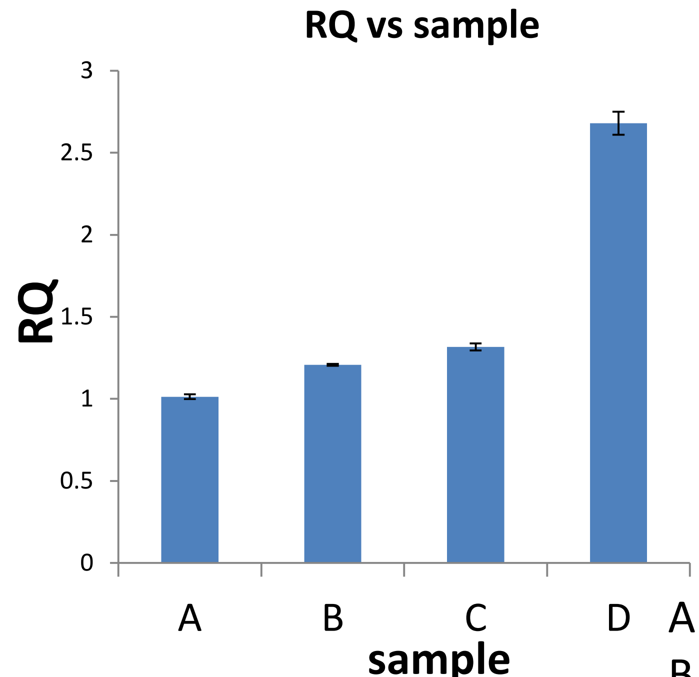
A-Uniniculated watered plant, B- Inoculated plants with sufficient water supply, C – Inoculated plants under stress, D-Uninoculated plants under stress

Expression analysis of stress responsive genes

Gene expression study in Bacteria

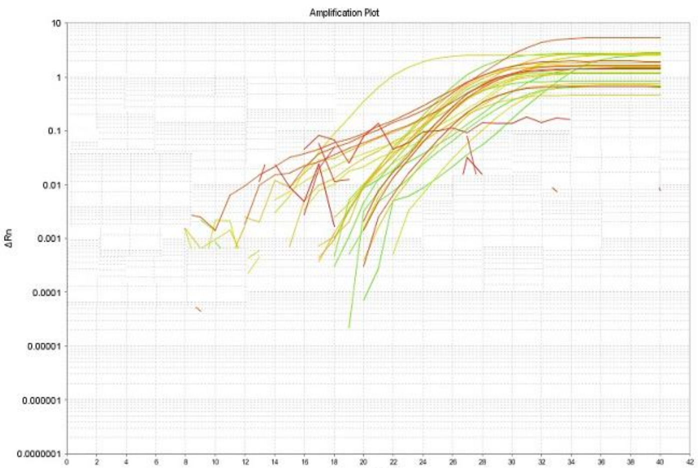
acd S

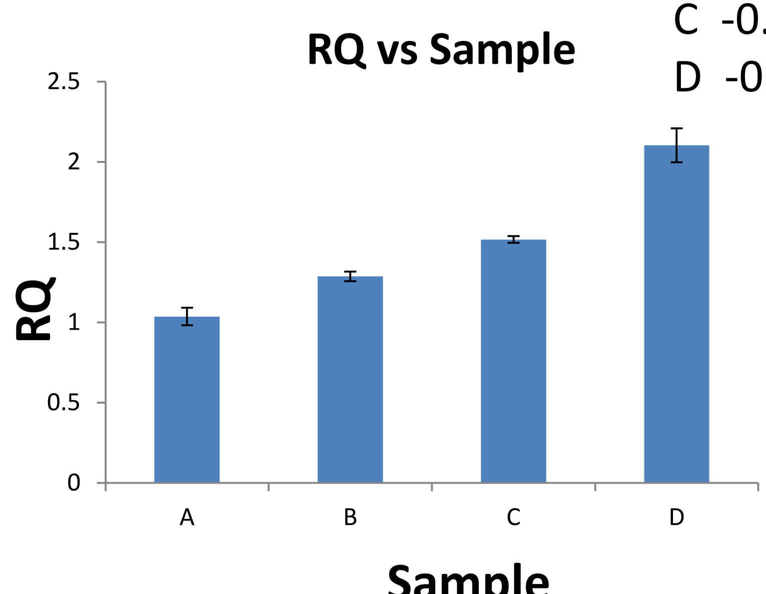




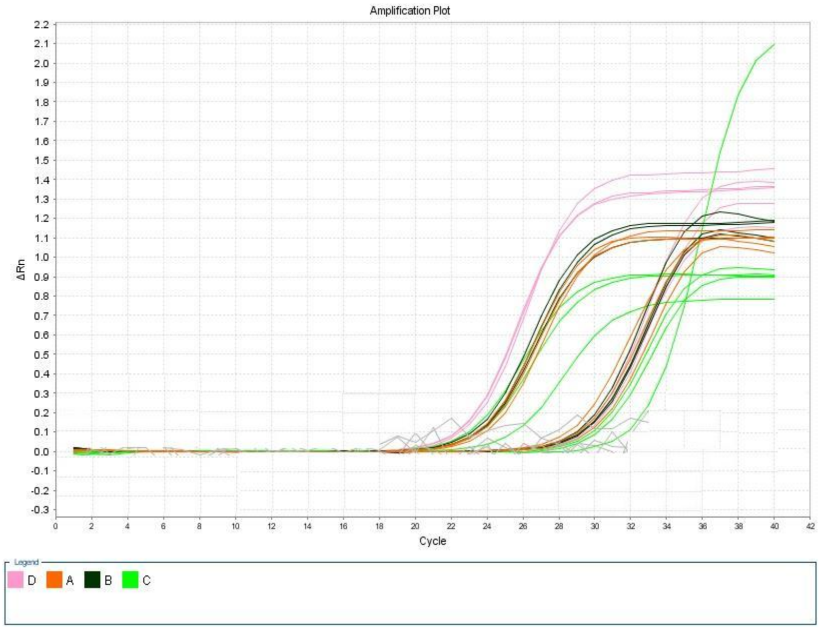
A control
B -0.3 mPA
C -0.49mPA
D -0.73mPA

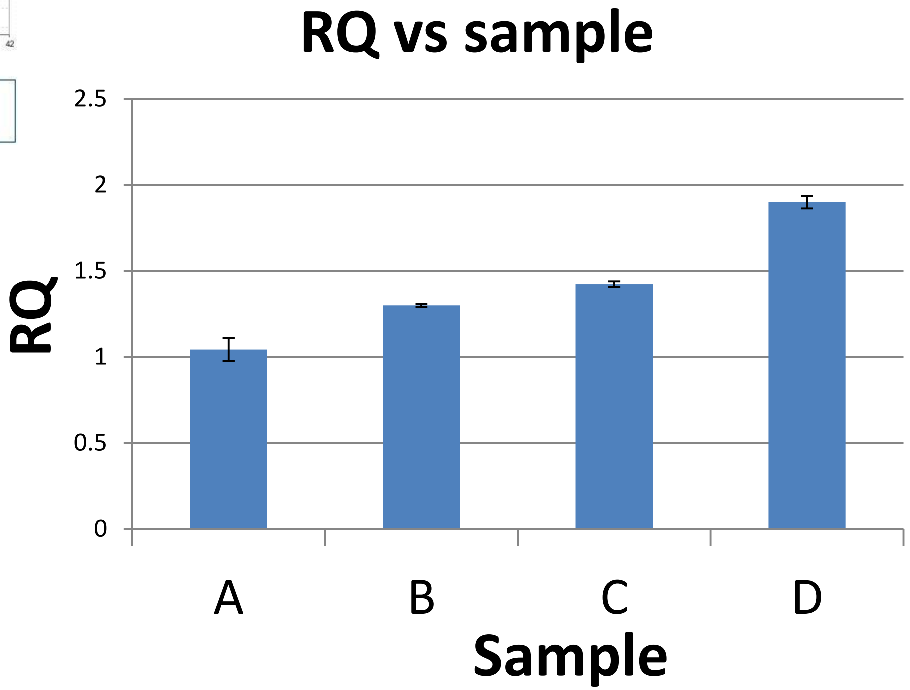
Kat A





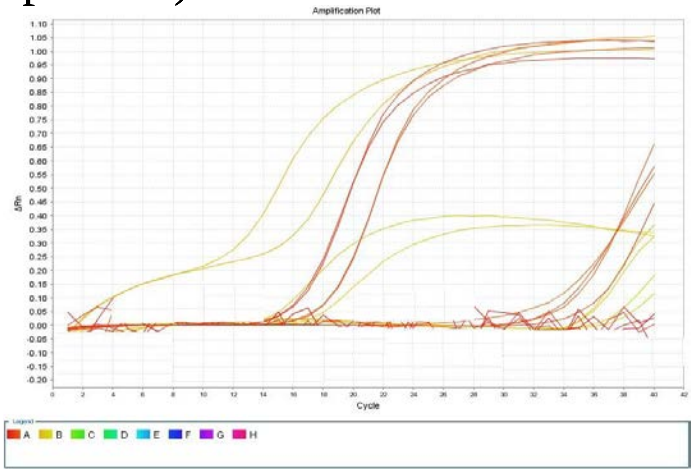
gbsA

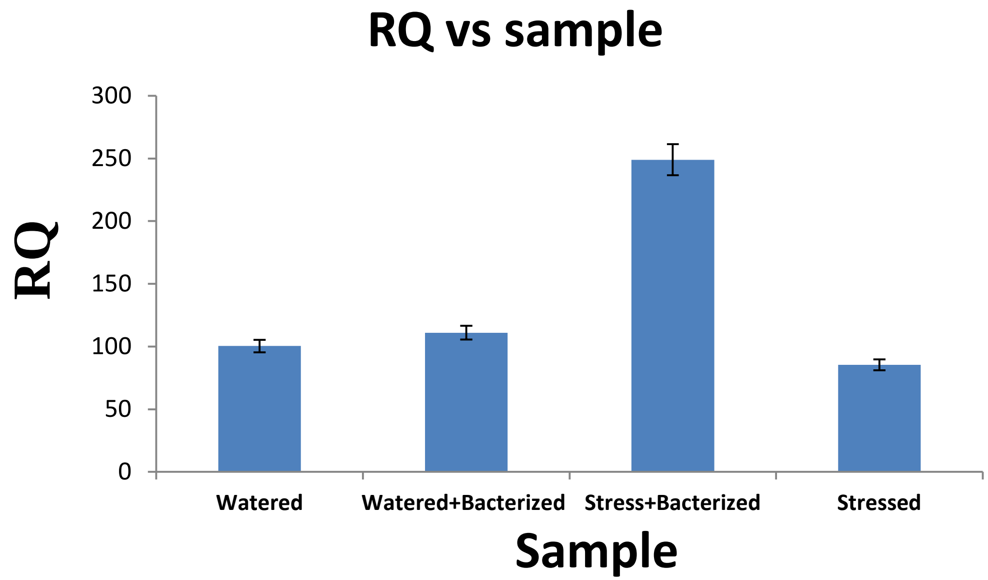

Amplification Plot
ΔRn
2.2
2.1
2.0
1.9
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42
Cycle
Legend
D
A
B
C


RQ vs sample
RQ
2.5
2
1.5
1
0.5
0
A
B
C
D
Sample

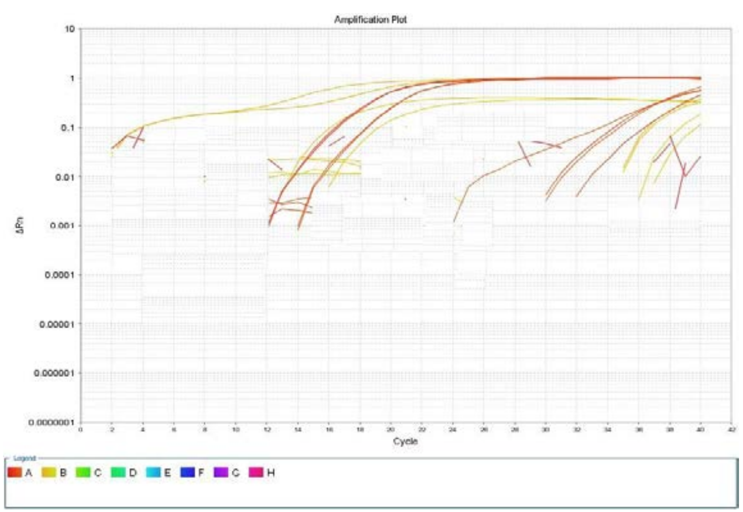
Gene expression study in plants

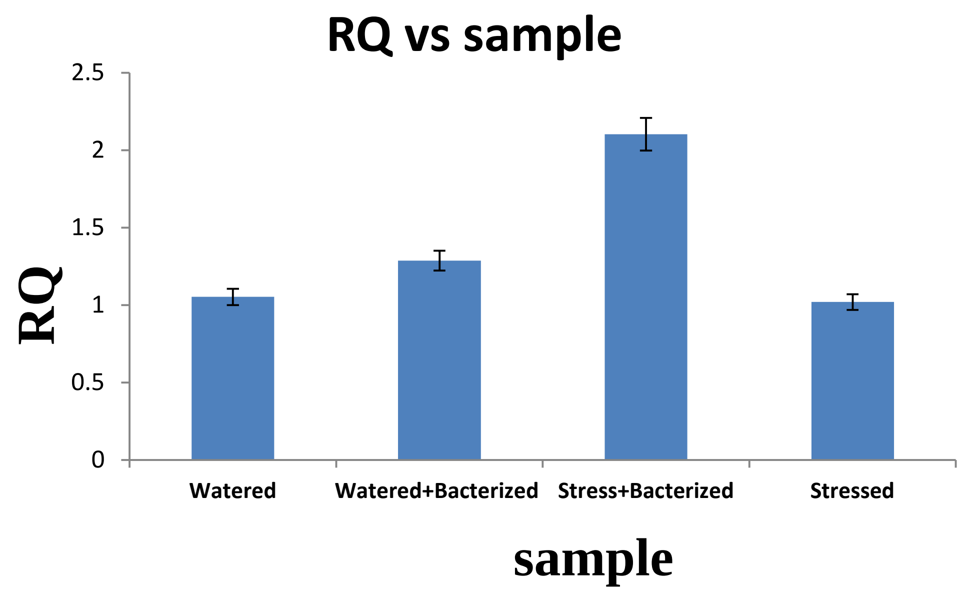
Dreb 2A (Dehydrogenase responsive element binding protein)



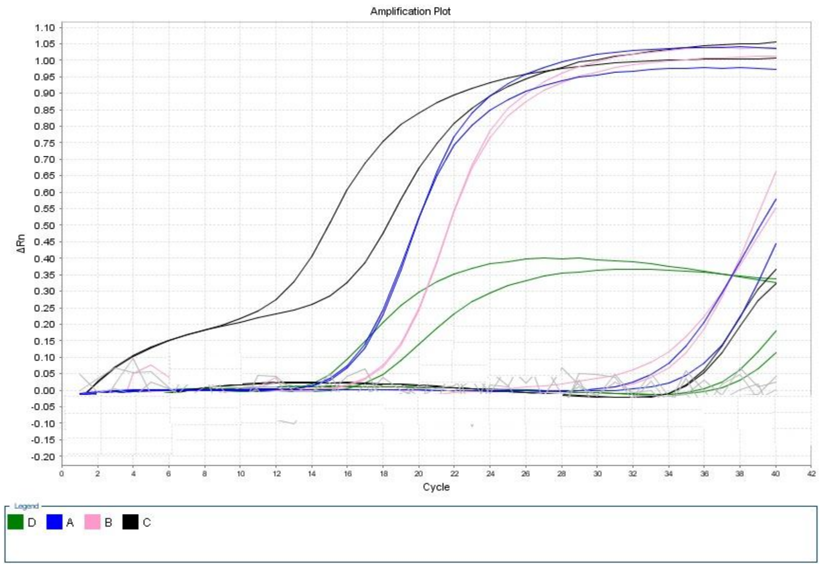


CAT1

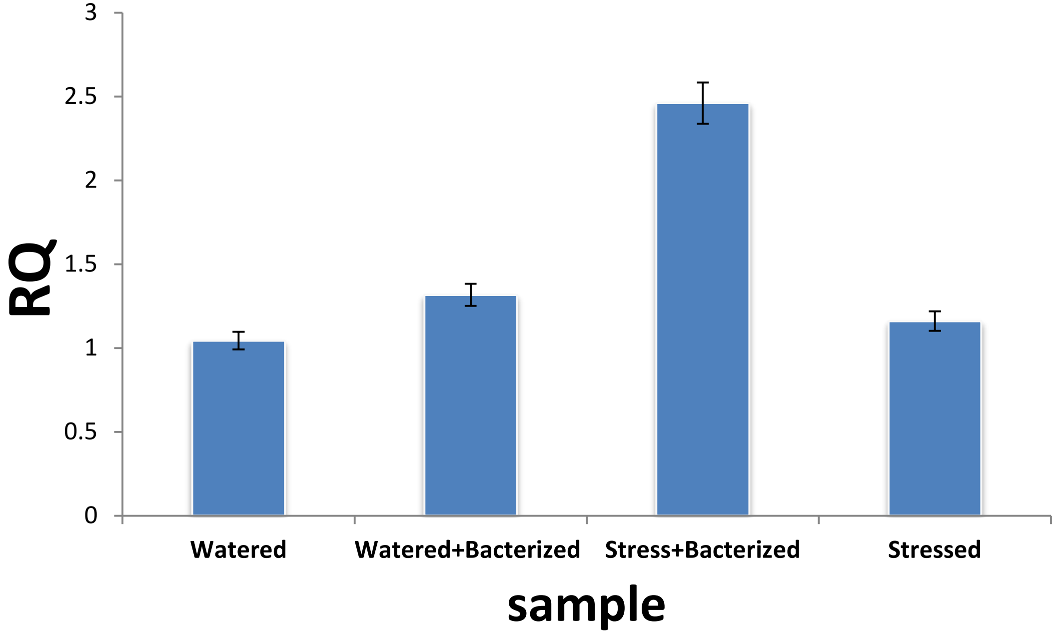




DHN



Amplification Plot
ΔRn
Cycle
Legend
D
A
B
C



RQ
Watered
Watered+Bacterized
Stress+Bacterized
Stressed
sample

Field Experiment

Experimental Condition	Pod number		Fresh weight (kg)		Dry weight (kg)	
	2012-2013	2014-2015	2012-2013	2014-15	2012-13	2014-15
Control Plants with proper irrigation	226±9.1[a]	273±16.6[a]	61±12.8[a]	57±9.6[a]	28±6.6[a]	29±4.1[a]
GGRJ21 inoculated plants under drought stress	171±9.4[b]	174±9.5[b]	52±10.5[a]	43±6.2[b]	21±3[a]	23±2.6[a]
Uninoculated plants under drought stress	61±14.2[c]	55±8.5[c]	29±4.5[b]	22±6.5[c]	10±3.6[b]	12±3[b]

Conclusion

1. The root-associated bacterium provides a greater benefit to the plant, most likely reflecting the fact that in addition to lowering ethylene levels, the bacteria may also provide a variety of other benefits to the plant.

2. It is far easier to modify a bacterium than complex higher organisms

3. several plant growth-promoting traits can be combined in a single organism

4. Instead of engineering crop by crop, a single, engineered inoculants can be used for several crops

5. It is better to use indigenous community rather than a foreign insert.

6. Eco-friendly approach for green agriculture.


Thanks for
Your kind Attention!