Role of Bioinoculants and Organics in Sustainable Fertiliser Management

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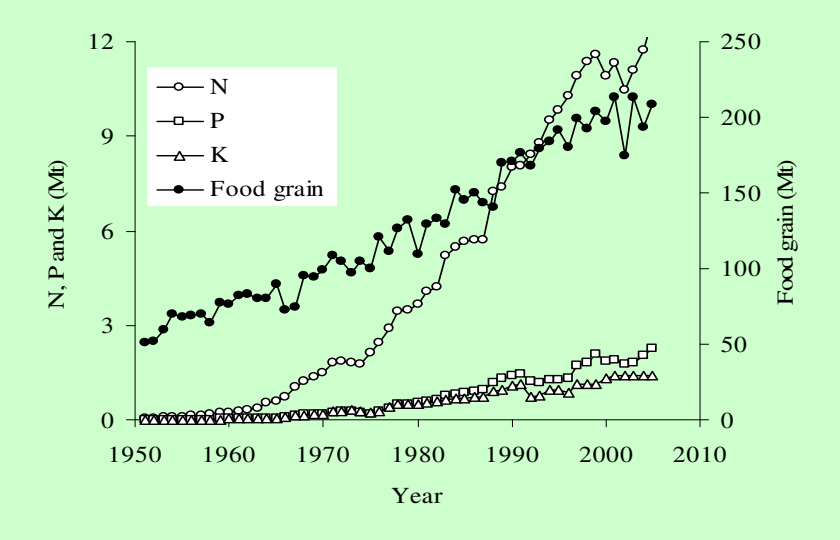
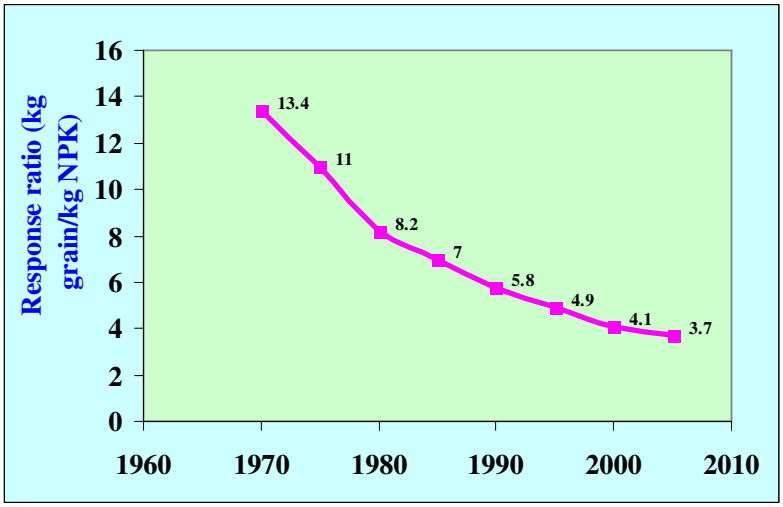
Food grain production and fertilizer use

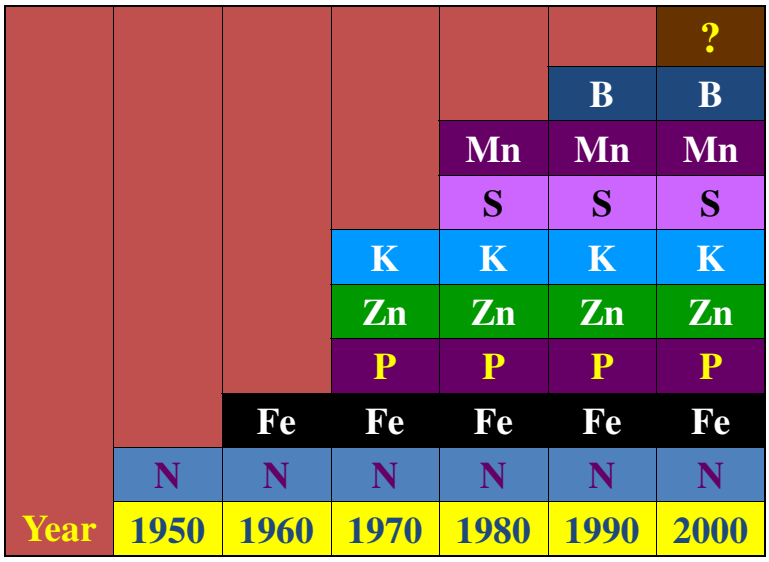


Fertilizers – An important input contributing 50% towards improvement in crop productivity

Declining Fertilizer Response



Emerging Multi-Nutrient Deficiencies in Soils



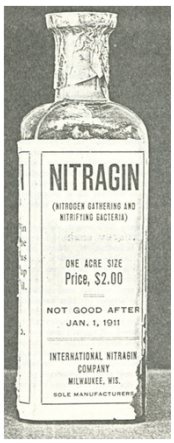
Biofertilizers

- Biofetilizers are the products containing living cells of different types of microorganisms that enrich the nutrient quality of soil.
- The main sources of biofertilizers are bacteria, fungi and cyanobacteria (blue green algae).
- Most biofertilizers belong to one of the following categories: nitrogen fixing, phosphate solubilizing and mobilizing, and plant growth promoting rhizobacteria.

Major biofertilisers and target crops

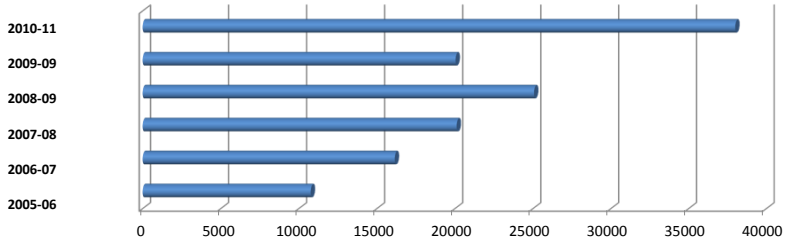
Biofertiliser	Target crops
Rhizobium	Leguminous crops
Azotobacter	Wheat, maize, cotton, mustard and vegetables (Potato, onion, tomato, brinjal)
Azospirillum	Cereal crops like wheat, maize, millets,
Gluconobacter diazotrophicus	Sugarcane
Blue green algae (BGA) & Azolla	Rice
P solubilizing bacteria	All
AM fungi	Nursery raised crops and orchard trees

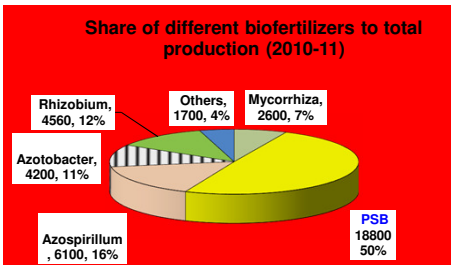
First Biofertilizer Nitragin

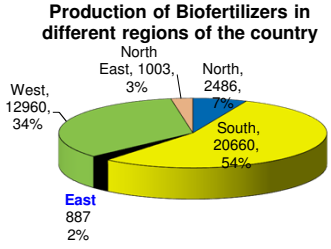


Nitragin: US Patent, 1896

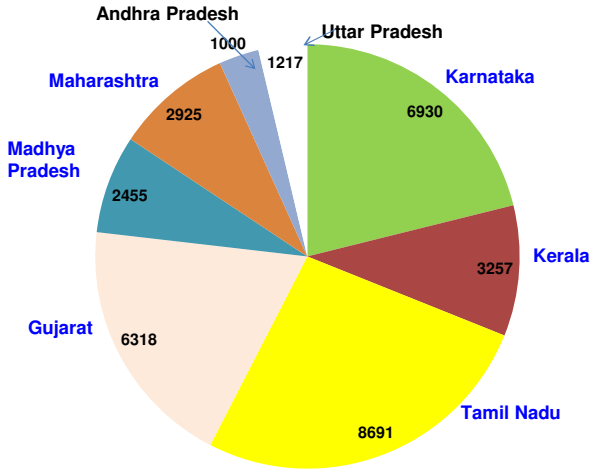
Biofertilizer Production Scenario in India







Important Biofertilizer Producing States



Six states account for 86% of total Biofertilizer production in

Why should we use Biofertilizers?

- Modern agriculture is dependent upon the supply of chemical fertilizers, which are becoming scarcer and more costly.
- These are major agents for water and air pollution also.
- This situation has led to development of eco friendly inputs like biofertilizers in crop cultivation, which not only helps in saving chemical fertilizers but also safeguards soil health and quality of crop products.

Carrier based Biofertilizer Technology

- **IARI pioneered the development and commercialization of biofertilizers (*Rhizobium*, *Azotobacter*, *Azospirillum*, phosphate solubilizers, AM fungi and BGA) that provided the input for practicing organic agriculture in India.**











Rhizobium

- Symbiotic nitrogen fixing bacteria Specific for leguminous crops
- Fixes 50- 100 kg N/ha
- Yield increase - 10-70 %



Response of soybean to inoculation with *Bradyrhizobium japonicum*

Increase in yield of pulse crops due to *Rhizobium* inoculation

Crop	% yield increase
Arhar	32
Mungbean	33
Gram	41
Groundnut	49
Lentil	30
Soybean	51

Saving of N fertilizer: 20-25 kg ha^{-1}

Azotobacter

- Free living nitrogen fixer
- Useful for non-leguminous crops– Wheat, Paddy, Maize, Barley, Tomato, Potato and Mustard
- Fixes 15-20 Kg N/ha
- Secretes growth promoters
- Suppresses growth of pathogenic microorganisms
- Increases grain yield- 15-30 %

Effect of *Azotobacter* on crop yield

Increase in yield over yields obtained with chemical fertilizers (%)

Food grains		Others	
Wheat	8-15	Potato	13
Rice	5	Carrot	16
Maize	15-20	Cauliflower	40
Sorghum	15-20	Tomato	2-24
		Cotton	7-27
		Sugarcane	9-24

Azospirillum : Potentials and Prospects

- In semi arid regions - soils are nutritionally deficient, temperatures are as high as 42-45^{o}C.
- In such areas, supply of nitrogen is largely dependent on biological nitrogen fixation.
- *Azospirillum*, a non symbiotic microaerophilic nitrogen fixer in association with the roots of grasses is a suitable option for supplementing N.

Potential contribution of *Azospirillum*

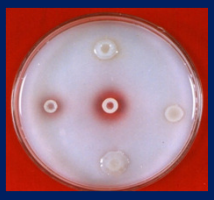
- Nitrogen fixation
- Growth promoting substances
  - Phytohormones production
    - IAA
    - Gibberellins
    - Cytokinins
  - Vitamins
- Siderophore production
- Production of antifungal metabolites

Gluconoacetobacter diazotrophicus

- An endophytic bacteria that associates and colonizes within all parts of sugarcane (root, cane, leaves)
- Fixes atmospheric nitrogen and enhances the availability of N to sugarcane and produces growth hormone (IAA)
- Results visible after 5-6 weeks of its application
- Increases size and length of internodes
- Improves yield (5-20 t/ha) and sugar content (5-15%)

Phosphate Solublizing Biofertilizer (PSB)

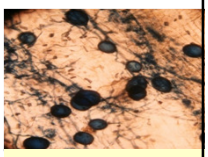
- A product with single or consortium of *Bacillus, Pseudomonas* and *Aspergillus awamori*



- Multiply rapidly around the root zone, acts on inorganic bound soil phosphate and makes phosphorous available to the plant
- Contributes 20-25 kg P/ha
- Improves plant vigor and yield up to 15%.

Arbuscular Mycorrhizae fungi

- Developed Arbuscular Mycorrhizal inoculum for all crops specially horticultural crops and nursery grown vegetables and commercialized under the trade name 'Nutrilink'.
- It mobilize phosphorus and trace elements like zinc, iron, copper, cobalt, magnesium, molybdenum.
- Also reduces salt stress, checks soil erosion, degradation and reduces losses caused by nematodes.
- Increases grain yield by 15-50 %.



Root colonization by arbuscular mycorrhizal fungi

Inoculation effect of AM fungi on *Oxalis*

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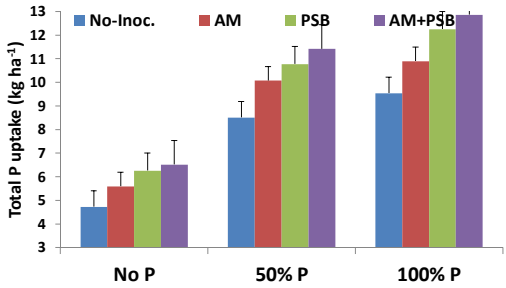
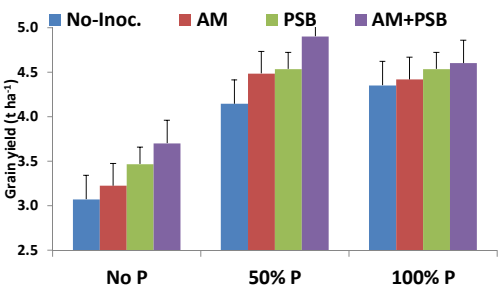
Enhancing P-use efficiency

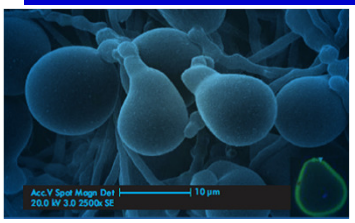




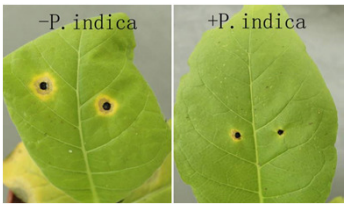
Bar represents Tukey's HSD at 5% for the fertilizer and microbial inoculants interaction

- In Maize-Wheat system, inoculation of PSB + AM fungi significantly improved the P uptake and grain yield indicating possibility of curtailing fertilizer P demands.

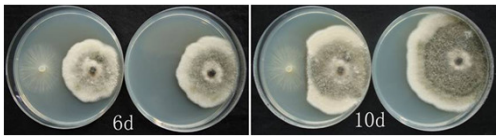
Piriformospora indica

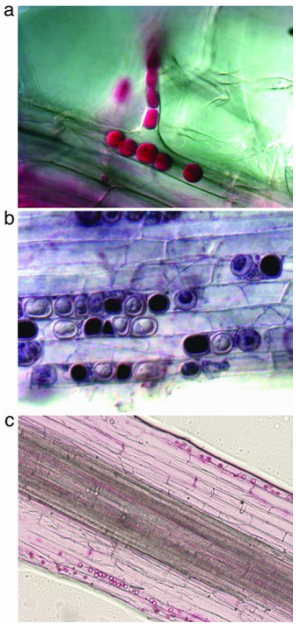


- The endophytic fungi *Piriformospora indic*a is a newly discovered AM-like fungi that are found in close association with various plant species.
- Helps the plant to take up P and other micronutrients



Suppresses *Alternaria longipes* infection in tobacco





Suppresses powdery mildew disease

Liquid bioincoulants with extended shelf life of 30 months

These formulations are available for

1. ***Rhizobium*** **: provide 20-30 kg N/ha**
2. ***Azotobacter*** **: provide 15-20 kg N/ha to soil**
3. ***Azospirillum*** **: provide 5-10 kg N/ha**
4. **Phosphorus solubilizing bacteria: 15-20 kg P_2O_5 /ha**
5. **Potash solubilizing bacteria: provide 5-10 kg K/ha to crop**
6. **Zinc solubilizing bacteria: improves Zn nutrition**
7. **NPK (Nitrogen, Phosphorus and Potash) providing formulation : 15-20 kg N, 15-20 kg P_2O_5 and 5-10 kg K ha^{-1}.**

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Advantages of Liquid Bioinoculant

- ❖ It can be stored at elevated temperature upto 45^{0}C.
- ❖ It has a shelf life of more than 2 years as compared to 6 months of carrier based formulation.
- ❖ No loss in plant growth promoting activities in formulation even on long storage.
- ❖ It has a very high microbial load of more than 10^{10} cells /ml.
- ❖ Bacterial protectants added to the formulation improve the shelf life, survival of the culture on seed and also help the culture regain active growth under favourable conditions.

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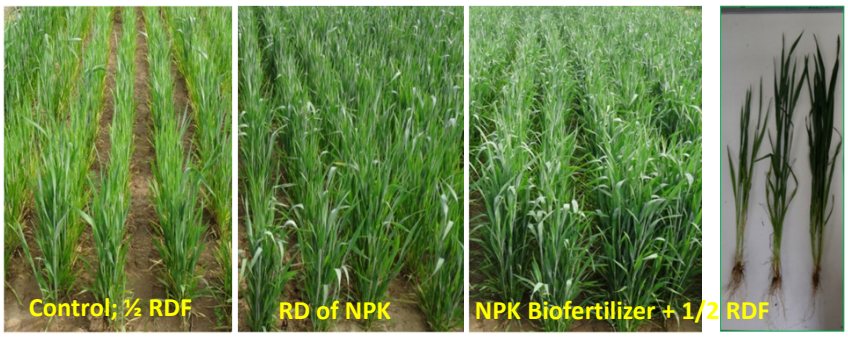
Influence of NPK formulation on growth and yield of wheat



	Treatments	Shoot Length (cm)	Root Length (cm)	Shoot FW (g)	Root FW (g)	Tiller/ plant	Chlorophyll	Yield (t ha^{-1})
1	Control (1/2 RDF)	59.77	22.94	56.19	8.59	3	38.61	4.35
2	RD NPK	74.25	22.52	125.82	13.84	5	46.20	4.72
3	NPK Biofertilizer + ½ RDF	68.83	16.68	100.14	13.71	4	47.70	4.62
	CD (0.05)			8.28	2.24		5.22	0.18

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Effect of Zinc solubilizing PGPR on Zn uptake and seed yield of soybean

Treatments	Seed Yield (t/ha)	Seed Zn uptake (g/ha)
Control	1.54	60.78
2.5 kg Zn/ha	1.73	70.70
5 kg Zn/ha	1.88	90.75
Bacillus sp.* + 2.5 kg Zn/ha	1.73	85.81
*Bacillus endophyticus** + 2.5 kg Zn/ha	1.72	81.54
Bacillus-Providencia-Brevundimonas consortium* + 2.5 kg Zn/ha	1.89	90.52
SEm±	0.04	3.72
CD at 5%	0.13	10.62

* Seed treatment; Zn source- ZnSO4

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Microbial formulations for biofortification of rice and wheat

- Two formulations, each containing a consortium of three plant growth promoting rhizobacteria were developed
  - ✓ *Bacillus pumilus* PW1 + *Providencia* sp. PW5 + *Brevundimonas diminuta* PW7 for wheat
  - ✓ *Providencia* sp. PR3 + *B. diminuta* PR7 + *O. anthropi* PR10) for rice.
- 13 - 20% increase in Fe, Zn and Mn concentrations in rice and wheat grains
- Enhanced plant growth and nutrient uptake
- 10-15% increase in yields
- 20-30 kg N savings/ha

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Use of organic manures

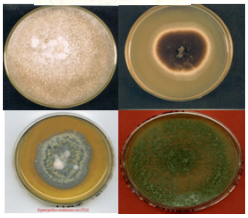
Compost

Vermicompost

School of NRM, Indian Agricultural Research Institute, New Delhi

Development of consortium of fungi for rapid decomposition of various agroresidues

- Consortium of four hyper lignocellulolytic fungi – *Aspergillus awamori*, *A.nidulans*, *Phanerochaete chrysosporium* and *Trichoderma viride* recommended and commercialized for composting of lignocellulosic waste.
- Using consortium, N (1-1.5%) and P (0.3-0.5%) enriched compost can be prepared from diverse crop residues within 70-75 days.
- Technology licensed to Patanjali, Haridwar



Mature compost

School of NRM, Indian Agricultural Research Institute, New Delhi

Machines for composting

Shredder
Only for leaves, twigs & wood

Shredded material

Loader
for loading material

Compost Turner cum Mixer

Mixing of material

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Rapid composting technology of agro waste at low temperatures

- Consortium was developed using low temperature tolerant cultures isolated from Leh with ability to produce lignocellulolytic enzymes
  - Bacterial partners (*Bacillus atropheus* and *Bacillus* spp)
  - Fungal partners (*Eupenicillium crustaceum* and *Paecilomyces variotii*)
- Could decompose the biomass within 75 days at an average temperature of 10^0C.

33

(*Eisenia fetida*)

Vermicompost
Method and advantages

- ❖Can consume half it's weight of food per day
- ❖Requires 70% moisture to breath
- ❖Temperature – 20-25^0 C
- ❖ Acidity – pH 6 – pH 8
- ❖Aeration – Good ventilation and drainage
- ❖Bedding and Food
- ❖Surface area
- ❖Darkness

Vermicast

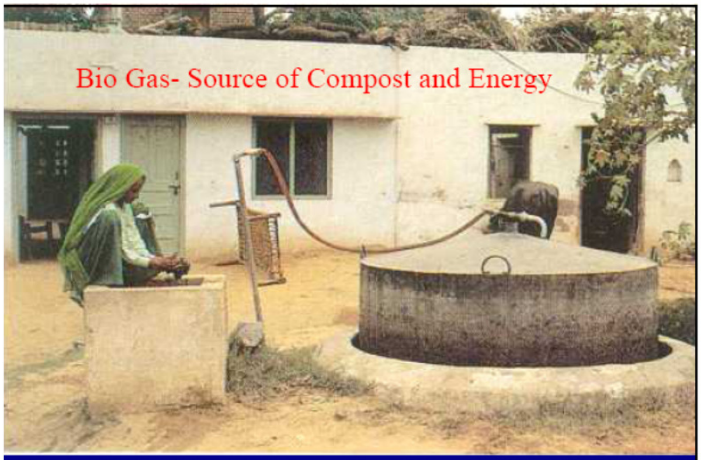
- ~ Rich in plant nutrients
- ~ Contain a high percentage of humus
- ~ Biologically active containing thousands of bacteria, and enzymes
- ~ 5 times the available nitrogen, 7 times the available potash, and 1 ½ times more calcium than found in good top soil

Average nutrient content of vermicompost and FYM (Dry wt. basis)

Sl. No.	Nutrient	Vermicompost	FYM
1.	N (%)	1.6-2.0	0.5-0.75
2.	P_2O_5	5.04	0.17
3.	K_2O	0.80	0.55
4.	Ca (%)	0.44	0.91
5.	Mg (%)	0.15	0.19
6.	Fe (ppm)	175.2	146.50
7.	Mn (ppm)	96.51	69.00
8.	Zn (ppm)	24.43	14.50
9.	Cu (ppm)	4.89	2.80
10.	C:N ratio	15.50	31.28

Biogas slurry

Biogas slurry is very good source of nutrients. Loss of N through Ammonia or nitrate is minimum in biogas slurry



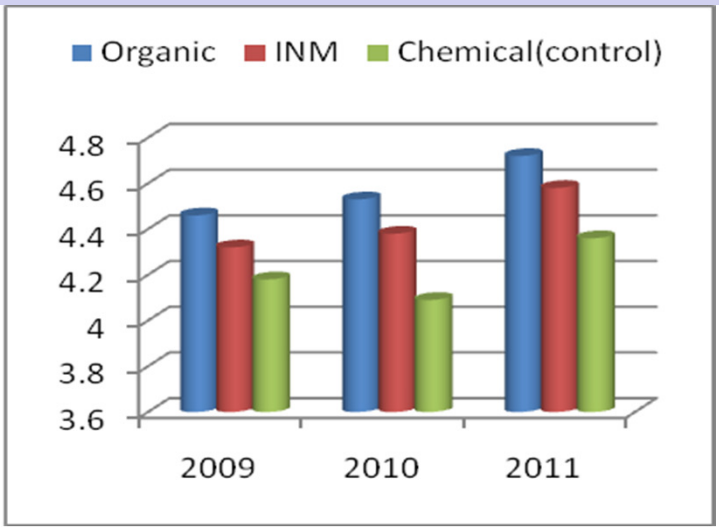
Bio Gas Slurry - a Good Manure

Green manuring

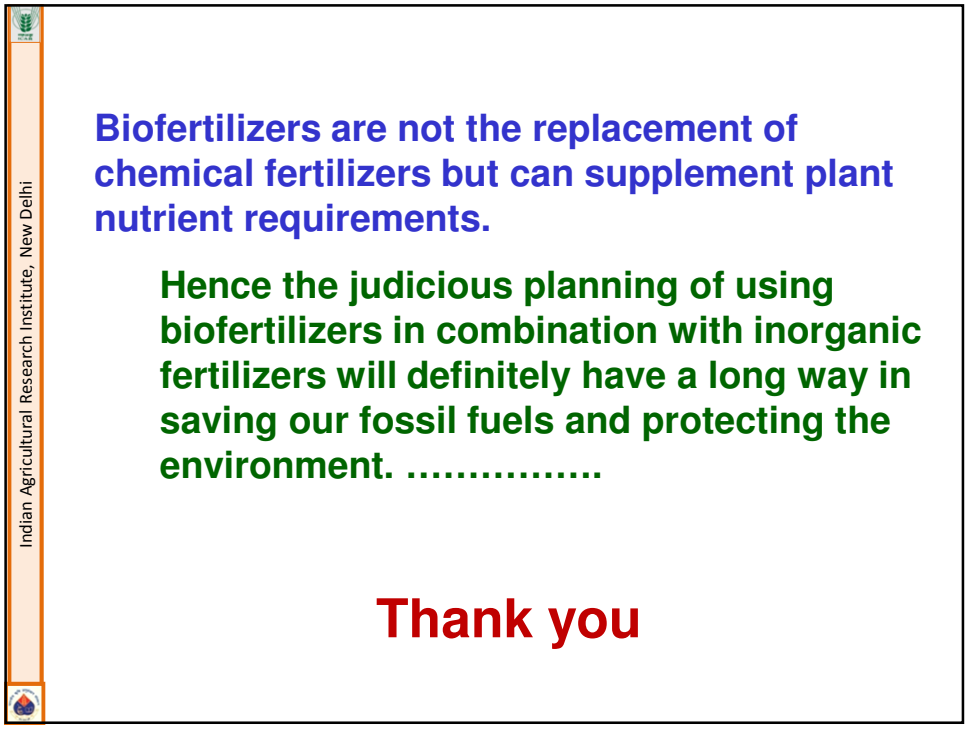
Sesbania **is an excellent green manuring crop which provide upto 320 kg N/ha**

Crotalaria

Effect of organic and inorganic nutrition of rice on grain yield (2009-11)



Organic: (BGA@ 2.0 Kg/ha + *Azolla* @ 1.0 t /ha + FYM@ 5.0t/ha+ Vermicompost@ 5.0 t/ha)
INM (FYM @ 5.0 t/ha + Chemical fertilizer @ N_{90} P_{60} K_{60})



Biofertilizers are not the replacement of chemical fertilizers but can supplement plant nutrient requirements.

Hence the judicious planning of using biofertilizers in combination with inorganic fertilizers will definitely have a long way in saving our fossil fuels and protecting the environment. ……..

Thank you