Precautions to be taken while using biofertilizers

- Biofertilizers are not replacement of fertilizers but can supplement their requirement
- Biofertilizer are live product and require care in storage
- Store biofertilizer packets in cool and dry place away from direct sunlight and heat
- Use right combinations of biofertilizers
- Rhizobium is crop specific, so use in legume crop for which it is recommended
- Do not mix with chemicals unless compatible
- While purchasing ensure that each packet is provided with necessary information like name of the product, name of the crop in which it is to be used, name and address of manufacturer, date of expiry and date of manufacture, batch number and instruction for use
- Use the packet before expiry, only on the specified crop, by recommended method
- For the best results use both N and P biofertilizers
- Use of biofertilizers is being emphasized along with chemical fertilizers and organic manures

Availability of the technologies:

- ***Agrinnovate India Limited (www.agrinnovateindia.co.in)***
- ***ICAR-Directorate of Groundnut Research, Junagadh, Gujarat***

Citation:

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Microbial Technologies for Enhancing Profitability of Groundnut Production System

Technology Leaflet 02/2019

भाकृअनुप–मूँगफली अनुसंधान निदेशालय

इवनगर रोड, पोस्ट बॉक्स नं. 5, जूनागढ 362001, गुजरात, भारत

ICAR-Directorate of Groundnut Research

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NutBoost: A Wonder Formulation of PGPR for Groundnut

NutBoost

What for?

- Improving growth and yield of groundnut
- Improving solubilisation, mobilization and uptake of nutrients (N, P, K, Fe, Mn, Zn, etc.) from soil
- Improving soil health
- Managing fungal pathogens in soil

The composition of the consortium:

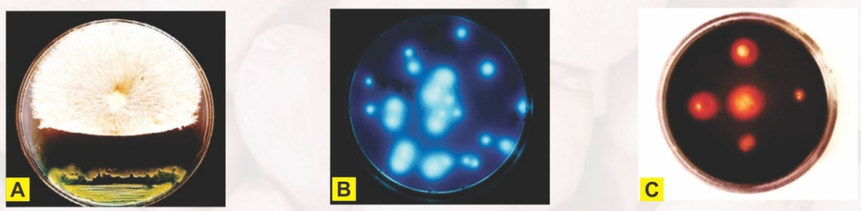
- *Pseudomonas gessardii* BHU1 (PGPR1)
- *Pseudomonas putida* S1(6) (PGPR2)
- *Pseudomonas fluorescens* BM6 (PGPR4)

What the consortium does?

- Produces ACC deaminase (an indicator of plant growth promotion)
- Solubilizes fixed forms of phosphates (Di/Tri-Ca-, Fe-, Al- and hydroxyapetites)
- Produces siderophore (mobilization of Fe)
- Produce antifungal metabolites (against stem and collar rot pathogens)
- Produces plant hormones like IAA, Gibberellins, etc.
- Transforms organic form of nitrogen into inorganic forms
- Solubilizes non-available forms of Zn, Mn, and K

What are the benefits?

- Nominal in cost (Rs.250-300/ha)
- Yield advantage upto 18%
- Improvement in soil health
- Improvement in nutrient mobilization and uptake like N,P,K,Fe,Zn, etc. (P, Zn, and K solubilizers) by 5-7%
- Minimizes incidence of soil-borne fungal pathogens (*S. rolfsii* and *A. niger*)
- Compatible with seed treating chemicals like Bavistin (Carbendazime)/Thiram
- Very fast growing and ease in large-scale multiplication
- Useful for both irrigated and rainfed conditions
- Formulated "NutBoost" (liquid/charcoal/talcum powder/FYM) has a shelf-life >1 yr at room temp.
- Can easily be be applied through irrigation water or through FYM or through drip beside seed treatment
- Easy to apply and eco-friendly and saves upto 30% cost of external inputs



Traits of PGPR of 'NutBoost' formulation:A=antifungal activity against *S. folfsii*; B=producation fluorescent pigments; C=production of siderophore

Effect of inoculation of PGPR of "NutBoost" formulation: D= in pots; E&F= in field condition

DroughtGuard: a formulation of endophyte for groundnut in drought-prone areas

DroughtGuard

With the changing climatic scenario, it is predicted that there will be increase in frequency and intensity of stresses, particularly drought, affecting productivity. As a result, vast stretches of arable land are likely to be further added to the already existing 40% of global land under arid and semi-arid areas. As groundnut is predominantly a rainfed crop grown in semi-arid tropics, and susceptible to drought, productivity of groundnut may reduce drastically because of inadequate and uneven distribution of rainfall in different parts of country. As endophytic microorganisms are believed to have co-evolved with plants and helped them in acclimatizing and circumventing the extremities of terrestrial ecosystem during their transition from aquatic life, this group of organisms can be exploited to alleviate drought and prevent reduction in yield.

Fig. 1: Impact of endophyte on pod yield of groundnut without any supplementary irrigation

Application ofendophytic bacteria like *Bacillus firmus* J22 identified in groundnut prevented the loss of yield of groundnut by 25% as compared to uninoculated control, with the application of a single irrigation at the time of sowing, and no irrigation thereafter with cultivar TG37A during successive summer seasons (Figure 1).With single supplementary irrigation at 55 DAE, the application of these endophytes were able to prevent yield loss to the tune of 17-25% over uninoculated control.

Economic/soil/other reliable impact

- **Water saving**: Summer groundnut is raised with the application of 10-12 irrigations depending upon soil type. But with the application of drought-stress alleviating endophytic bacteria, it was found that at least 3-4 irrigations can be saved without drastic reduction in pod yield.
- **Horizontal expansion in area**: the saved water can be utilized for horizontal expansion of irrigated area and thus total production can be improved substantially.
- **Economic benefit**: As application of three protective irrigations after emergence with endophytes like *Bacillus firmus* J22 gave 2260-2309 kg/ha of pod yield equivalent to that obtained with 10 irrigations after emergence (2233-2483 kg/ha), doubling the area with same available water can double the production and income.
- **Impact in farmers' field**: Demonstration in the farmer' field at Anantapur District of Andhra Pradesh with cultivar Kadiri 9 and 180 mm rainfall and two protective irrigations gave 32% yield improvement with *Bacillus firmus* J22 over untreated control.

Endophytes are saviour for groundnut in drought-prone areas like Anantapur, the largest groundnut growing district in the country with occurrence of drought frequently.

SalGuard: A formulation of endophyte is a saviour of cultivation of groundnut in salt affected areas

SalGuard

With the changing climatic scenario, it is predicted that the sea level is likely to rise and sea water ingression in coastal areas will render a vast area unfit for cultivation. Repeated use of ground water will also increase the level of salinity. In Gujarat around 1.5 lakh ha of groundnut area is affected by salinity in Kutch, Porbandar, and Mangrol areas. It is also predicted that around 50000 ha of land will add to salinity-affected areas in India. It is also known that salinity badly affected yield of groundnut. Thus, to make groundnut cultivation profitable in salinity affected areas in India, *Bacillus firmus* J22, an endophytic bacterium which has been reported repeatedly to alleviate salinity stress, has been demonstrated as FLD in the farmers field.

Fig. 1: Demonstration of endophytes in farmers field at Bhuj, Kutch, Gujarat

Application ofendophytic bacteria like *Bacillus firmus* J22 identified in groundnut prevented the loss of yield 15-20% as compared to uninoculated control in soil with EC level of 5-6 at Bhuj in experimental plots with susceptible cultivar TG37A.In summer 2017, 16 FLDs and in Kharif 2017, 30 FLDs were conducted in farmers field to demonstrate the beneficial effects of this endophyte.

Economic/soil/other reliable impact

Yield enhancement in salinity affected areas of Kutch: Demonstration was laid in 16 farmers field with plot area of 0.1 ha with soil salinity of 4.5 to 6.2 EC witj cultivar GG2. The pod yield in control plot ranged from 1000 to 3800 kg/ha with a mean of 2058 kg/ha whereas in treated plot, it ranged from 1250 to 4400 kg/ha with a mean value of 2427 kg/ha. The average increase in pod yield due to seed treatment with *Bacillus firmus* J22 over the control was 17.9%. The haulm yield increased by 5.6% due to seed treatment over the control.

Economic benefit in kharif groundnut: The bacterial seed treatment was economically beneficial as a net return of Rs 79,320/ha along with BCR of 2.37 was recorded under treated plot as against Rs 63,895/ha with BCR of 2.15 in control.

Demonstration Summer 2017 in salinity affected areas in Kutch: The pod yield in control plot ranged from1634 to 3064 kg/ha with a mean of 2246 kg/ha whereas in treated plot, it ranged from 2010 to 3403 kg/ha with a mean value of 2685 kg/ha. The average increase in pod yield due to seed treatment with bacteria over the control was 19.5%. The haulm yield increased by 5.9% due to seed treatment over the control. The pod yield increase was mainly due to increased number and weight of pods per plant under the treated plot as compared to the control.

Economic benefit in summer groundnut: The bacterial seed treatment was economically beneficial as a net return of Rs 63, 306/ha along with BCR of 2.28 was recorded under treated plot as against Rs 49,281/ha with BCR of 2.05 in control.

Availability of formulation: ICAR-DGR, Junagadh for commercialization.

Shelf-life: Bacilli are endospore-forming and has indefinite shelf-life in formulation and are compatible with seed treating chemicals of groundnut.

Possibility of expansion in groundnut area: Application of endophytes become saviour of groundnut cultivation in salinity affected areas and more salinity affected areas can be brought under cultivation with the help of endophytes in future.

'NutMagic': A Bacterial Formulation for Augmenting Groundnut Yield

NutMagic

What for?

- Improving growth and yield of groundnut
- Improving soil health
- Managing fungal pathogens in soil
- Improving solubilisation, mobilization and uptake of nutrients (N, P, K, Fe, Mn, Zn, etc.) from soil

The composition of the consortium:

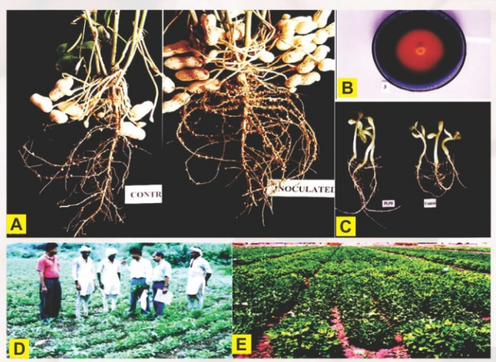
- PGPR: *Pseudomonas gessardii* BHU1, *Pseudomonas putida* S1(6)
- PSB: *Enterobacter cloacae* BM8*; Bacillus polymyxa*
- Rhizobia: *Sinorhizobium americanum* NRCG4, *Rhizobium* sp. NRCG9

What the consortium does?

- PGPR produce ACC deaminase (an indicator of plant growth promotion)
- PSB solubilizes fixed forms of phosphates (Di/Tri-Ca, Fe-, Al- and hydroxyapetite)
- All produce siderophore (mobilization of Fe)
- PGPR produces antifungal metabolites (against stem and collar rot pathogens)
- PGPR produces plant hormones like IAA, Gibberellins, etc.
- Transforms organic form of nitrogen into inorganic forms
- PGPR solubilizes non-available forms of Zn, Mn, and K
- Rhizobia fix atmospheric nitrogen biologically upto 200 kg/ha/yr

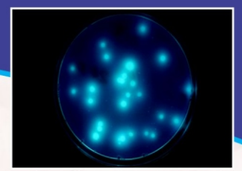
What are the benefits?

- Nominal in cost (Rs.250-300/ha); Improvement in soil health
- Improvement in nutrient mobilization and uptake like N, P, K, Fe, Mn, Zn, etc. (P, K, Mn and Zn solubilizers)
- Enhancement in biological nitrogen fixation
- Produces plant growth promoting substances like IAA, Gibberellins, etc.
- Compatible with seed treating chemicals like Bavistin (Carbendazime)/ Thiram
- Dependence on nitrogenous, potassic and phosphatic fertilizer can be reduced by 25-30%
- Yield advantage can be upto 20%
- Easy to apply and eco-friendly
- Can also be applied through irrigation water or through FYM or through drip besides seed treatment
- Shelf-life of liquid formulation/carrier based inoculum >1 yr at room temperature



Traits and effects of constituents of "NutMagic" tormulation: A=enhancement in nodulation by compotitive strains of rhizobia; B=production of siderophore; C=enhamcement in root growth unpon inoculation; D=demonstration of the effect of rhizobia of the consortium in farmers field; E=in station field trial

'NutGrow': Insurance Against Soil-borne Diseases of Groundnut



NutGrow

What is it?

Formulation of diacetyl-fluoroglucinol producing and multiple plant growth promoting fluorescent pseudomonads capable of developing suppressive-soil upon repeated use in the same field which will help the soil to become naturally suppressive to soil-borne fungal pathogens

What for?

- Improving growth and yield of groundnut
- Improving solubilisation, mobilization and uptake of nutrients (P, K, Fe, Mn and Zn) from soil
- Improving soil health by suppressing soil-borne fungal pathogens and nematodes
- Suppressing major soil-borne fungal pathogens of groundnut like *S. rolfsii* & *A. niger*

Who are these DAPG-producers?

Strains	Identified as	Traits
DAPG 2	*P. putida* DAPG2	Afu, IAA, Ammo, Phos., Sid, HCN, etc.
DAPG 4	*P. putida* DAPG4	Afu, ACC, IAA, Ammo, Phos., Sid, etc.
FP98	*P. fluorescens* FP98	Afu, ACC, IAA, Ammo, Phos., Sid, Gibb., etc.
FP86	*P. putida* FP86	Afu, ACC, IAA, Phos., Sid, etc.

What 'NutGrow' does?

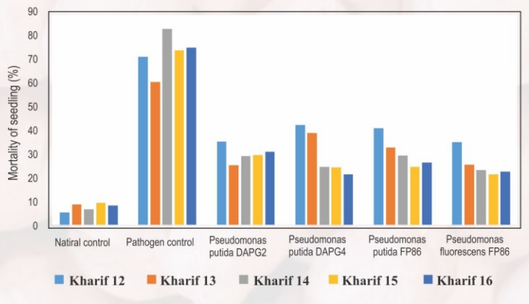
- Produces DAPG-a broad spectrum antibiotics for suppression of soil-borne fungal
- pathogens like *S. rolfsii*, *A. niger*, *A. flavus*, etc.
- Produces IAA, gibberellins, siderophores, volatiles, HCN, etc.
- Solubilizes fixed form of phosphates, K, Mn, Zn, etc. and make them available
- Produce ACC which improves seedling vigour and thus better plant stand

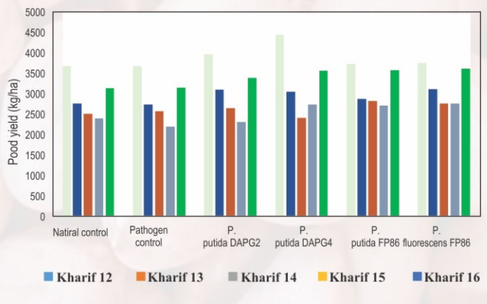
What benefits NutGrow provide?

- Improves yield by 20% and reduces incidence of collar and stem rot by 40-60% and nematodes by 30-40%
- Improves soil health by suppressing plant pathogens and nematodes
- Improves availability of macro- and micro-nutrients (P, K, Mn, Zn, etc.) by 20-25%
- Formulation in liquid, charcoal, talcum powder and peat has shelf-life of > 1 yr at room temperature
- Compatible with Bavistin/Thiram, eco-friendly and can be applied with FYM/irrigation water/drip/ soil drenching etc.
- Dependence on external inputs of P, K, Mn, Zn, and Fe can be reduced by 30%

Impat of inoculation of DAPG-producing fluoresent pseudomonads in reducing the mortality of seedlings of gronudnut caused by *S. rolfsii* in GG20

Pod yield of groundnut as influenced by incidence of *Sclerotium rolfsii* by inoculation of DAPG-producing fluorescent pseudomonads with GG20





Wealth from groundnut wastes: production of enzymes at industrial scale utilizing groundnut shell and de-oiled cakes as substrates

ICAR-Directorate of Groundnut Research, Junagadh has developed two economically viable fermentation technologies for production of enzymes, cellulases and proteases, from groundnut shell and de-oiled groundnut cakes, respectively by microbial fermentation. Both the technologies have already been transferred to M/s Paccar Biotech Pvt. Ltd., Ahmedabad on non-exclusive licensing basis. However, both the technologies are available for further licensing to other entrepreneurs and start-ups. The details of the technologies are given below:

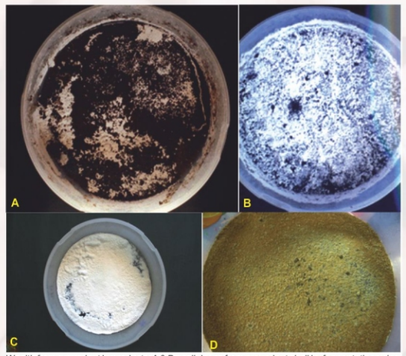
Targets for both the technologies: Start-ups, SSIs and MSEs

Cellulase from groundnut shell by microbial fermentation

A techno-economically viable process has been developed for production of enzyme cellulases from groundnut shell. The cellulase enzyme is used in industries engaged in bio-polishing fabrics/garments, bio-stone washing, animal feed, textile, food industry, enzymatic saccharification of agrowaste, etc. To meet the growing demand of the use of enzymes in different sectors, a fermentation technology has been developed for producing cellulase enzyme by utilizing groundnut shell as a substrate employing microbes like *Trichoderma* sp. and *Phanerochaete* sp. by fermentation (both solid substrate and liquid). By liquid fermentation, 150-200 IU of cellulase can be produced/g of groundnut shell. Considering the present market price, from processing of 100 kg of groundnut shell an amount of Rs. 20,000/ can be earned as income. It needs minimum facilities to produce crude cellulase which has wide application in textile, paper and pulp, and animal feed industries. As raw material is very cheap, the cost per unit would be very nominal.

Proteases from de-oiled groundnut cakes by microbial fermentation

A simple process has been developed for producing proteases from de-oiled groundnut cake by employing industrially useful microbes like *Aspergillus nidulans*, *Penicillium roqueforti* and *Bacillus subtilis* by solid substrate, liquid and slurry fermentation conducted at 28°C. By employing solid substrate fermentation with *Aspergillus nidulans* upto 18-25 IU of neutral proteases/g of cake can be obtained after 72 h of fermentation. This neutral protease produced by *Aspergillus nidulans* is tolerant to detergents available in the market. By employing *Bacillus* sp. P5, all the three proteases (80, 160 and 350 IU/mg protein for acid, neutral and alkaline proteases at 35°C) can be produced. Besides proteases tolerant to salinity; high temperature, detergent and heavy metals have also been produced from de-oiled groundnut cake employing *Bacillus* spp. in slurry and liquid fermentation. Considering the present market price, from processing of 100 kg of de-oiled groundnut cake an amount of Rs. 20,000-25,000/ can be earned as income.



Wealth from groundnut byproducts: A & B= cellulases from groundnut shell by fermentation using *Phanerochaete* sp.; C&D= proteases from de-oiled groundnut cake by fermentation using *Aspergillus nidulans*