जैवउर्वरक सूचना पत्र

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From Editors Desk

Dear Readers,

The benefits of Vesicular-Arbuscular Mycorrhizal (VAM) fungi in agricultural applications are widely practiced to tap its potentiality for increasing phosphorus uptake. Besides, the resulting crop responses due to VAM fungi are well documented. Further, tolerance of water stress, pathogens and adverse soil environments by VAM fungi are also well understood.

Root colonization and proliferation of external hyphae are complex and dynamic processes that interact with host and environments. VAM technology has shown spectacular success in horticultural and forestry crop but its application are limited due to constraints of its mass production technology. Hence, VAM fungi inoculums production is a very important area needs to be developed. This issue publishes an article on VAM inoculum production technology which could be easily adopted by farmers at negligible cost.

Besides this present issue has covered new areas of inoculant research news, seminar news and book reviews etc.

Hope, this issue will be appreciated by our esteemed readers.

R. N. Bisoyi
Editor

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On-Farm Production of Arbuscular Mycorrhizal Fungi

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सरांश

पिछले कुछ वर्षों में माइकोराइजा फफूँद जैव उर्वरक फसल उत्पादन प्रक्रिया के एक महत्वपूर्ण आदान के रूप में विकसित हुए हैं और कुछ इकाईयों द्वारा इनका वाणिज्यिक उत्पादन भीष्षुरू कर दिया है। माइकोराइजा के पूर्ण पराश्रयी सहजीवी होने के कारण इसकी उत्पादन प्रक्रिया होस्ट पौधे के विकास व बढ़वार पर निर्भर है। वाणिज्यिक उत्पादन प्रक्रिया अत्यंत खर्चीली होने के कारण छोटे किसानों की पहुँच से दूर है। किसानों के अपने खेतों पर ही इसका उत्पादन कर खर्च में कमीं की जा सकती है। इस उद्देष्य हेतु राष्ट्रीय सोयाबीन अनुसंधान संस्थान, इंदौर ने माइकोराइजा जैव उर्वरक उत्पादन की एक ऐसी कम खर्चीली प्रक्रिया विकसित की जिससे किसान अपने खेत पर इसका उत्पादन कर सकते हैं। इस प्रक्रिया में मक्का, गेंदा, ज्वार, सौंफ वरसीम इत्यादि पौधों पर माइकोराइजा फफूँद को उगाया जाता है। इस विधि से प्राप्त जैव उर्वरक के एक किलो मिश्रण में लगभग ३-४ लाख संक्रमण प्रोपेग्यूल होते हैं।

Introduction

Arbuscular mycorrhizal (AM) fungi are mutualistic symbiotic soil fungi that colonize the roots of most crop plants. Due to their proven potential in plant growth promotion, AM fungi are fast coming up as biofertilizers. The mycorrhizal response is mainly attributed to increased efficiency of mineral uptake especially of poorly mobile ions like phosphorus, improved water relations and disease resistance (Smith and Read, 1997). There are voluminous reports dealing with the nutritional benefits that plants derive from mycorrhizal associations (Douds and Reider, 2003; Sharma and Adholeya, 2000, 2004). The reports on significant yield enhancement and mineral uptake through field application of AM fungal inoculum in cereals, fruits, ornamentals and timber plants have been recorded and published in the literature. AM fungi can also be applied in stress environments like eroded soils, salt stress or in soils with heavy metal toxicity for bioremediation of such stressed sites. Although AM fungi are indigenous to most of the soils, the niche-based and adapted fungi and its subsequent adaptation and inoculation have improved the growth and yield of many field crops.

Since, arbuscular mycorrhizal fungi are obligate symbionts, they require host plants to sporulate and colonize roots to complete their life cycles. Currently AM fungi are being produced in various ways like monoxenic/*in vitro*, pot culturing/greenhouse, aeroponic system and nutrient film technique (Fortin et al., 2002; Adholeya, 2003). Inocula produced by these techniques are commercially available. The pot culture or conventional method is still widely used (Saito and Marumoto, 2002). There are many steps like isolation of AM fungi, use of substrate/potting mixture and subsequent maintenance and transportation, which involve huge costs and thereby limit its commercialization.

On-farm multiplication of indigenous and resident AM fungi removes many steps, reduce the cost and enhance the acceptability to the farmers (Gaur, 1997; Douds et al., 2006). The on-farm technology is more appropriate since it uses the indigenous AM fungi already adapted to that site and environment. Apart from this, the technology can also be used for producing introduced AM fungi (applied as starter culture in beds) using one or a succession of trap plants (Sieverding, 1991; Gaur, 1997). The aim of present study was to develop an on-farm production technique involving indigenous and resident AM fungi and trap plants with minimum inputs suitable for marginal farmers and growers of India.

On-farm AM production technique:-

The philosophy in developing such on-farm production technique was to ensure high quality AM inocula in large quantities at farmers field with very little cost. A nursery area of about 75 m^2 (5 m $\times$ 15 m) is selected and split into 3 beds of equal sizes (0.8 m $\times$ 15 m). The procedure for on-farm inoculum production basically incorporates (a) Development of mycorrhizal starter culture prepared by either isolating resident AM fungi or by procuring commercial starter culture and (b) multiplying the culture on trap plant roots at farmers' fields. National Research Centre for Soybean (NRCS-ICAR), Indore is one such source from where such inocula of indigenous AM fungi can be sourced. Starter inoculum isolated from various localities/sites is being multiplied at NRCS. In general, the procedure for inoculum production involves four steps-

(i) Selection of site: The site should be water logging free, leveled, low in available phosphorous and well protected. The site is prepared by ploughing and hoeing to make elevated/raised beds (80 cm wide, 20 cm high and 15 m in length) with a spacing of 0.6-0.8 m between rows. The soil in these beds needs to be amended with well decomposed compost/ vermi-compost @ 4 kg m^{-1} or fine powdered FYM @ 8kg m^{-1}.

(ii) AM fungal inoculation: AM fungal inoculum (@ 8,000 infective propagules m^{-2}) is placed 2-3 cm deep in furrows just below the seed at the time of seed sowing. Direct-seeded crops like methi; maize; marigold; barseem etc., can be used as trap plants. Transplanted crops like tomato, brinjal, onion etc., can also be used as trap plants in between routine multiplication cycles.

(iii) Multiplication: The multiplication of AM fungi generally coincides with the host cycle comprising of kharif, rabi and jaid cropping seasons. Initially one complete year with these three cropping seasons can produce sufficient inoculum for one hectare. Regular hoeing, weeding, watering, and protection from animals should be done during the multiplication cycles. There should not be any water logging in the nursery beds especially during rainy season.

(iv) Harvesting of inoculum: At the end of each cycle, the shoot of the trap plants are removed from the soil surface without disturbing the roots, the roots need to be retained in the beds but the soil should be hoed or loosened during second cycle of multiplication and so on. After 5

multiplication cycles the plants are uprooted gently to get maximum root biomass. The roots with adhering soil are then chopped finely and thoroughly mixed. This mixture is tested for percent root length mycorrhizal colonization and analyzed for number of infectious propagules (IP) per gm inoculum using standard protocols (Philips and Hayman, 1970; Gaur et al, 1998; Gerdemann and Nicolson, 1963.

At NRCS a comparison was made in terms of AM multiplication carried out in pots and in on-farm raised beds during the 5 growth cycles. It was found that all AMF parameters like spore density, mycorrhizal root colonization and infectious propagules density linearly increased with growing of trap plants both in pots and in raised beds (Table 1). In general higher quantity of AMF propagules were produced in raised bed system. Infective propagules were found to be higher in root based inoculums compared to soil based inoculum devoid of infected roots. Final product is prepared by mixing 800 gm of vermicompost with 200 gm of root based AM inocula to ensure 3-4 lakh infectious propagules, assuming a density of 1500-2000 infective propagules/g inoculum roots. The AM-vermi mix can be applied either as seed encapsulation through seed drill or in furrows or in holes at the time of sowing or planting. The seedlings can also be inoculated before transplantation by bare root dip treatment through dipping in a solution containing mycorrhizal inoculum. The inoculum in transplanted crops can also be applied in furrows of mother beds. In mother beds inoculum is applied @ 4000 propagules/m^2 in furrows just below the seeds.

Table 1: Production profile of AM fungi under microcosms (pots) and field (on raised beds) conditions in 5 cycles of multiplication in vertisols of central Indian conditions

Trap plant/cycle	Multiplication in pots*			Multiplication in beds (On-farm)*		
	Spore density (g/soil)	Root colonization (%)	Infectious propagules (IP number/ g soil)	Spore density (g/soil)	Root colonization (%)	Infectious propagules (IP number/ g soil)
Marigold	1.61	34.66	2.14	2.33	20.66	0.82
Maize	3.82	28.33	3.82	3.61	26.33	2.98
Fenugreek	6.88	44.33	6.20	5.12	38.43	5.40
Sorghum	8.14	66.99	12.84	8.78	58.66	10.02
Barseem	10.12	78.33	16.83	9.20	72.66	12.10

The spore density at zero time was 0.62 spores/g soil; 1.02 IP/g soil.

Table 2: Cost of AM fungi production under on-farm conditions in three cycles on 75m^2 area (suitable for 5-7 hectare agronomic area) under central India conditions

Activities	Amount in Rupees in three cropping seasons			
	1st cycle (Nov-February)	2nd cycle (March-June)	3rd cycle (July Oct)	Total
1. Land preparation (clearing, ploughing, planking/leveling etc.,)*	FC	FC	FC	--
2. Preparation of raised beds, hoeing and firming up	FC	FC	FC	--
3. Cost of manuring (vermicompost in beds (@ 4kg/m^2)	400	-	100	500
4. Cost of starter culture**	400	--	-	400
5. Cost of seeds	70	50	50	170
6. Seed sowing and AM fungal Inoculation	FC	FC	FC	--
7. Maintenance of beds (regular Hoeing, weeding, watering and protection)	400	400	400	1200
8. Harvesting (uprooting, drying, chopping, Storing in jute bags until use)	200	200	200	600
9. Costs towards procuring indigenous items	600	500	500	1600
Total cost of producing inocula sufficient for 5-6 hectare	2070	1150	1250	4470
Cost of production for use in one hectare (Rs)	414	230	250	298

*FC, farmers contribution; ** cost of commercial/indigenous AMF starter culture

Economics of AMF Production

In this on-farm production technique, the left over rhizospheric soil (after harvesting of roots) contains fairly good number of infectious propagules (more than 10 IP/g soil) and can be used to continue subsequent production cycles, to produce 10 lakhs propagules of AM fungi during every cropping season. As described in the Table 2, the average cost of production is Rs. 300.00 during each production cycle for producing sufficient inoculum for application in one hectare.

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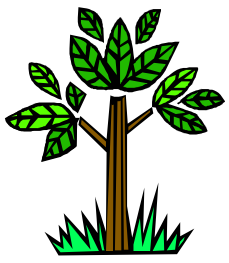

Vesicular Arbuscular Mycorrhizae- *Do not ignore me.*
Plant- *Ok, what benefits you can provide me?*
Vesicular arbuscular Mycorhizae-
I have a great potential to protect you. I promise to ensure mobilization of nutrients, uptake of water, phosphate, survivability in stress and draught conditions, strong root system--- and what not?
Plant- *Ok, fine then go on networking in my cortical cells.*
You are really a natures boon. Now I am not worried for food throughout my life. You are really a friend in need.

Research Notes and New Reports

Nitrogen-fixing and cellulose-producing *Gluconacetobacter kombuchae* sp. nov., isolated from Kombucha tea - A few members of the family *Acetobacteraceae* are cellulose-producers, while only six members fix nitrogen. Bacterial strain RG3^T, isolated from Kombucha tea, displays both of these characteristics. A high bootstrap value in the 16S rRNA gene sequence-based phylogenetic analysis supported the position of this strain within the genus *Gluconacetobacter*, with *Gluconacetobacter hansenii* LMG 1527^T as its nearest neighbour (99.1 % sequence similarity). It could utilize ethanol, fructose, arabinose, glycerol, sorbitol and mannitol, but not galactose or xylose, as sole sources of carbon. Single amino acids such as L-alanine, L-cysteine and L-threonine served as carbon and nitrogen sources for growth of strain RG3^T. Strain RG3^T produced cellulose in both nitrogen-
free broth and enriched medium. The ubiquinone present was Q-10 and the DNA base composition was 55.8 mol% G+C. It exhibited low values of 5.2–27.77 % DNA–DNA relatedness to the type strains of related gluconacetobacters, which placed it within a separate taxon, for which the name *Gluconacetobacter kombuchae* sp. nov. is proposed, with the type strain RG3^T (=LMG 23726^T=MTCC 6913^T). (Source – Dutta and Gachhui Int J Syst Evol Microbiol 57 (2007), 353-357)

***Azospirillum canadense* sp. nov., a nitrogen-fixing bacterium isolated from corn rhizosphere** - A free-living diazotrophic strain, DS2^T, was isolated from corn rhizosphere. Polyphasic taxonomy was performed including morphological characterization, Biolog analysis, and 16S rRNA, *cpn60* and *nifH* gene sequence analyses. 16S rRNA gene sequence analysis indicated that strain DS2^T was closely related to the genus *Azospirillum* (96 % similarity). Chemotaxonomic characteristics (DNA G+C content 67.9 mol%; Q-10 quinone system; major fatty acid 18 : 1ω7*c*) were also similar to those of the genus *Azospirillum*. In all the analyses, including phenotypic characterization using Biolog analysis and comparison of cellular fatty acids, this isolate was found to be different from the closely related species *Azospirillum lipoferum*, *Azospirillum oryzae* and *Azospirillum brasilense*. On the basis of these results, a novel species is proposed for this nitrogen-fixing strain. The name *Azospirillum canadense* sp. nov. is suggested with the type strain DS2^T (=NCCB 100108^T=LMG 23617^T). (Source – Mehnaz et al Int J Syst Evol Microbiol 57 (2007), 620-624)

***Ochrobactrum cytisi* sp. nov., isolated from nodules of *Cytisus scoparius* in Spain** - Two strains named ESC1^T and ESC5 were isolated from nodules of *Cytisus scoparius* growing in a Spanish soil. Phylogenetic analysis of the 16S rRNA gene showed that these strains belong to the genus *Ochrobactrum*, their closest relatives being *Ochrobactrum anthropi* and *Ochrobactrum lupini*, with 100 and 99.9 % similarity to the respective type strains. Despite this high similarity, the results of DNA–DNA hybridization, phenotypic tests and fatty acid analyses showed that these strains represent a novel species of genus *Ochrobactrum*. The DNA–DNA hybridization values were respectively 70, 66 and 55 % with respect to *O. lupini* LUP21^T, *O. anthropi* DSM 6882^T and

Ochrobactrum tritici DSM 13340^T. The predominant fatty acids were $C_{18:1}$ *7c* and $C_{18:1}$ 2-OH. Strains ESC1^T and ESC5 were strictly aerobic and were able to reduce nitrate and to hydrolyse aesculin. They produced β-galactosidase and β-glucosidase and did not produce urease after 48 h incubation. The G+C content of strain ESC1^T was 56.4 mol%. Both strains ESC1^T and ESC5 contained *nodD* and *nifH* genes on megaplasmids that were related phylogenetically to those of rhizobial strains nodulating *Phaseolus*, *Leucaena*, *Trifolium* and *Lupinus*. From the results of this work, we propose that the strains isolated in this study be included in a novel species named *Ochrobactrum cytisi* sp. nov. (Source – Piñeiro et al Int J Syst Evol Microbiol 57 (2007), 784-788)

Burkholderia nodosa* sp. nov., isolated from root nodules of the woody Brazilian legumes *Mimosa bimucronata* and *Mimosa scabrella – Three strains, Br3437^T, Br3461 and Br3470, were isolated from nitrogen-fixing nodules on the roots of *Mimosa scabrella* (Br3437^T) and *Mimosa bimucronata* (Br3461, Br3470), both of which are woody legumes native to Brazil. On the basis of 16S rRNA gene sequence similarities, all the strains were shown previously to belong to the genus *Burkholderia*. A polyphasic approach, including DNA–DNA hybridizations, PFGE of whole-genome DNA profiles, whole-cell protein analyses, fatty acid methyl ester analysis and extensive biochemical characterization, was used to clarify the taxonomic position of these strains further; the strains are here classified within a novel species, for which the name *Burkholderia nodosa* sp. nov. is proposed. (Source – Chen et al Int J Syst Evol Microbiol 57 (2007), 1055-1059)

***Mesorhizobium albiziae* sp. nov., a novel bacterium that nodulates *Albizia kalkora* in a subtropical region of China** – A novel *Mesorhizobium* group associated with *Albizia kalkora* [Wang *et al.* (2006), *Syst Appl Microbiol* 29, 502–517] was further characterized. The seven strains in this group showed similar protein patterns and were different from defined *Mesorhizobium* species in SDS-PAGE of whole-cell proteins. The representative strain CCBAU 61158^T formed a novel *Mesorhizobium* lineage in phylogenetic analyses of 16S rRNA, *atpD*, *glnII* and *nifH* genes. However, its *nodC* gene sequence was more similar to that of *Rhizobium gallicum* R602sp^T than to those of *Mesorhizobium* species. DNA–DNA relatedness between CCBAU 61158^T and reference strains of defined *Mesorhizobium* species was lower than 34.1 %. These results indicated that this *Mesorhizobium* group was a unique genomic species. The subtropical distribution, host origin, PCR-RFLP patterns of 16S rRNA genes, fatty acid profile and a series of phenotypic characteristics could be used as distinctive features of this group. This group is therefore proposed as a novel species, *Mesorhizobium albiziae* sp. nov., with CCBAU 61158^T (=LMG 23507^T=USDA 4964^T) as the type strain. Strain CCBAU 61158^T could form effective nodules on *Albizia julibrissin*, *Glycine max*, *Leucaena leucocephala* and *Phaseolus vulgaris*. (Source – Wang et al Int J Syst Evol Microbiol 57 (2007), 1192-1199)

***Burkholderia silvatlantica* sp. nov., a diazotrophic bacterium associated with sugar cane and maize** - In a previous study, nitrogen-fixing isolates were recovered from the rhizosphere of maize and from surface-sterilized leaves of sugar cane cultivated in Rio de Janeiro, Brazil. On the basis of 16S

rRNA gene sequence similarities, these isolates were identified as belonging to the genus *Burkholderia*, and whole-cell-protein profiles demonstrated that they are closely related to each other. In the present study, novel isolates were recovered from the roots of different sugar-cane varieties cultivated in diverse geographical regions of Brazil. Twenty-one nitrogen-fixing isolates were analysed using polyphasic taxonomy criteria, including DNA–DNA relatedness, 16S rRNA gene sequence similarities, fatty acid profiles, whole-cell-protein patterns and multilocus enzyme electrophoresis profiles, as well as morphological, physiological and biochemical characterization. The analysis confirmed that these isolates belong to a novel species within the genus *Burkholderia*, for which the name *Burkholderia silvatlantica* sp. nov. is proposed. (Source – Perin et al Int J Syst Evol Microbiol 56 (2006), 1931-1937)

Azospirillum zeae* sp. nov., a diazotrophic bacterium isolated from rhizosphere soil of *Zea mays - Two free-living nitrogen-fixing bacterial strains, N6 and N7^T, were isolated from corn rhizosphere. A polyphasic taxonomic approach, including morphological characterization, Biolog analysis, DNA–DNA hybridization, and 16S rRNA, *cpn60* and *nifH* gene sequence analysis, was taken to analyse the two strains. 16S rRNA gene sequence analysis indicated that strains N6 and N7^T both belonged to the genus *Azospirillum* and were closely related to *Azospirillum oryzae* (98.7 and 98.8 % similarity, respectively) and *Azospirillum lipoferum* (97.5 and 97.6 % similarity, respectively). DNA–DNA hybridization of strains N6 and N7^T showed reassociation values of 48 and 37 %, respectively, with *A. oryzae* and 43 % with *A. lipoferum*. Sequences of the *nifH* and *cpn60* genes of both strains showed 99 and ~95 % similarity, respectively, with those of *A. oryzae*. Chemotaxonomic characteristics (Q-10 as quinone system, 18 : 1ω7*c* as major fatty acid) and G+C content of the DNA (67.6 mol%) were also similar to those of members of the genus *Azospirillum*. Gene sequences and Biolog and fatty acid analysis showed that strains N6 and N7^T differed from the closely related species *A. lipoferum* and *A. oryzae*. On the basis of these results, it is proposed that these nitrogen-fixing strains represent a novel species. The name *Azospirillum zeae* sp. nov. is suggested, with N7^T (=NCCB 100147^T=LMG 23989^T) as the type strain. (Source – Mehnaz et al Int J Syst Evol Microbiol 57 (2007), 2805-2809)

Nodulation of *Lupinus albus* by Strains of *Ochrobactrum lupini* sp. nov. - The nodulation of legumes has for more than a century been considered an exclusive capacity of a group of microorganisms commonly known as rhizobia and belonging to the α-*Proteobacteria*. However, in the last 3 years four nonrhizobial species, belonging to α and β subclasses of the *Proteobacteria*, have been described as legume-nodulating bacteria. In the present study, two fast-growing strains, LUP21 and LUP23, were isolated from nodules of *Lupinus honoratus.* The phylogenetic analysis based on the 16S and 23S rRNA gene sequences showed that the isolates belong to the genus *Ochrobactrum*. The strains were able to reinfect *Lupinus* plants. A plasmid profile analysis showed the presence of three plasmids. The *nodD* and *nifH* genes were located on these plasmids, and their sequences were obtained. These sequences showed a close resemblance to the *nodD* and *nifH* genes of rhizobial species, suggesting that the *nodD* and *nifH* genes carried by strain LUP21^T

were acquired by horizontal gene transfer. A polyphasic study including phenotypic, chemotaxonomic, and molecular features of the strains isolated in this study showed that they belong to a new species of the genus *Ochrobactrum* for which we propose the name *Ochrobactrum lupini* sp. nov. Strain LUP21^T (LMG 20667^T) is the type strain. (Source – Trujillo et al Appl Environ Microbiol. 2005 March; 71(3): 1318–1327)

Standardization of dosage of liquid and cyst formulations of *Azospirillum* for different application methods - *Azospirillum* bioinoculant is well known for its high nitrogen-fixing and plant growth-promoting characters. Carrier-based bioinoculants generally suffer from shorter shelf-life, poor quality, high contamination and low field performance. As an alternative, the liquid and cyst formulations of *Azospirillum* inoculants can play a significant role. Liquid and cyst formulations of *Azospirillum* were developed by adding amendments to the NFb broth and to MSM medium, respectively, which have longer shelf-life and tolerance to adverse conditions such as temperature and desiccation. The dosage of liquid and cyst-based formulations of *Azospirillum* for various inoculation methods such as seed treatment, seedling root dipping and soil application was standardized and their survival was studied. Inoculum levels of 10 ml/kg seeds, 150 ml/quantity of seedlings required for 1 ha and 300 ml/ha were found to be the optimum doses for seed treatment, seedling root dipping and soil application methods, respectively. The liquid and cyst formulations of *Azospirillum* have exhibited better adherence and survival on seeds, seedling roots and in the rhizosphere than the carrier-based form. These results indicated that there is substantial room to improve the liquid and cyst formulations of *Azospirillum* inoculant to obtain the desired benefits. (Source - Vedan and Thangaraju Acta Agronomica Hungarica Volume 55,Number 4/December 2007)

Development and standardization of cyst based liquid formulation of *Azospirillum* bioinoculant – Looking to the constraints in application methods, contamination problems, shorter shelf life, poor quality and low field performance, it is necessary to develop alternative new formulation of inoculants where cyst based inoculants can play significant role. The cyst based liquid formulation was developed by inoculating *Azospirillum* into the cyst inducing minimal salts medium (MSM). One hundred per cent conversion of vegetative cells into cyst cells was noticed in 96 h. The survival of cyst cells in the MSM was observed up to one year and two months and interestingly, the population level of 10^8 was maintained till the final observation. The cyst cells of *Azospirillum* accumulated poly- *β*-hydroxybutyrate (PHB) granules and exhibited desiccation tolerance up to 20 days and temperature tolerance up to 40 Â°C. Thus the cyst based liquid formulation has twin advantage of longer shelf life and tolerance to harmful environmental conditions. Regeneration of cyst cells into vegetative cells in different media viz., tap water, sterile water, rice gruel and nutrient broth was studied. The changes started within 3 h and complete return of vegetative cells was observed at 24 h. Although all the media tested favoured regeneration, comparatively quicker regeneration was observed in nutrient broth and followed by rice gruel. Thus, cyst based liquid formulation of *Azospirillum* has all the survival advantages and can be used as a potential bioinoculant. (Source – Vendan and Thangaraju Volume 54,

Number 2, June 2007 Acta Microbiologica et Immunologica Hungarica)

Shelf life and on seed stabilization of liquid bacterium inoculants – A US Patent 20060150488 eloborates an invention which describes a method for producing a liquid inoculant containing a desiccant. As per the methodology, once the substantially stationary phase is attained (i.e., after the bacteria has been allowed to grow at an exponential rate rate), a desiccant treatment containing a desiccant is introduced into the liquid inoculant to create a partially desiccated inoculant product. The term "desiccant treatment" means a mixture of a desiccant and a diluting substance, generally water. The term "desiccant" means a substance that, when added to water, reduces water activity (which is defined as the partial pressure of water vapour at the surface of the substance divided by saturation pressure). Reduction of water activity to a level less than 0.995 is contemplated to be effective in enhancing in pack survival of the bacteria in the partially desiccated inoculant product. Reduction of water activity to a level less than 0.990, preferably less than about 0.980, is contemplated to be effective in enhancing on seed survival of the bacteria in the partially desiccated inoculant product. As used herein, "desiccants" can include any compound or mixture of compounds that can be classified as a desiccant regardless of whether the compound or compounds are used in such concentrations that they in fact have a desiccating effect on the liquid inoculant. Examples of suitable desiccants include one or more of trehalose, sucrose, glycerol, and triethylene glycol. Other suitable desiccants include, but are not limited to, non reducing sugars and sugar alcohols (e.g., mannitol). The amount of desiccant introduced into the liquid inoculant generally is in a concentration from about 5% to about 50% by weight/volume of the partially desiccated inoculant product. When the desiccant is trehalose, the desiccant is preferably in a concentration from about 10% to about 40% by weight/volume of the partially desiccated inoculant product. More preferably, the trehalose is in a concentration from about 20% to about 30% by weight/volume of the partially desiccated inoculant product. The desiccant treatment can include a mixture of more than one desiccant. In fact, the mixtures can be any combination of two or more desiccants, as desiccant is defined herein. For example, the desiccant treatment can include a mixture of trehalose and glycerol, a mixture of trehalose and sucrose, or a mixture of sucrose and triethylene glycol. A mixture of trehalose and glycerol can include trehalose in concentrations from about 5% to about 40% by weight/volume of the partially desiccated inoculant product and glycerol in concentrations from about 1% to about 10% by weight/volume of the partially desiccated inoculant product. More particularly, the concentrations of the trehalose and the glycerol in the mixture can be about 20% and about 5% by weight/volume of the partially desiccated inoculant product, respectively. The desiccant can be added to the liquid inoculant while the liquid inoculant is still in the vessel used during incubation (e.g., fermentation reactor or shaking incubator). Alternatively, the desiccant can be added to the liquid inoculant during packaging. In one embodiment, sufficient desiccant is present to at least partially desiccate the bacteria in the partially desiccated inoculant product, thereby: (1) improving the stability and survival of the bacteria in subsequent steps such as packaging and storing, (2) and improving

the stability and survival of the bacteria in subsequent steps such as on-seed application of the partially desiccated inoculant product. The partially desiccated inoculant product can then be packaged and stored. The packaging can be any standard packaging known in the industry. For example, the partially desiccated inoculant product can be packaged in polyethylene bladders.

Plant growth promotion and induction of resistance in *Camellia sinensis* by *Bacillus megaterium* - *Bacillus megaterium* de Bary TRS-4 was isolated from tea rhizosphere and tested for its ability to promote growth and cause disease reduction in tea plants. *In vivo* studies revealed the ability of this bacterium to promote growth of tea plants very significantly. Brown root rot disease, caused by *Fomes lamaoensis* was markedly reduced by application of the bacterium to the soil. Population of *F. lamaoensis* in soil before and after application of *B. megaterium,* as determined by ELISA and dot-blot using PAb raised against the pathogen, was shown to be greatly reduced in presence of the bacterium. Biochemical changes induced in tea plants were also examined. Root colonization by *B. megaterium* and subsequent inoculation with *F. lamaoensis* also led to an increase in polyphenolics, as well as in defense related enzymes-peroxidase, chitinase, β-1,3-glucanase and phenyl alanine ammonia lyase. Determination of mechanism of action of this bacterium revealed it to be able to solubilize phosphate, produce IAA, siderophore and antifungal metabolite. The plant growth promotion and reduction of disease intensity have been shown to be due to a combination of several mechanisms. (Source – Chakraborti et al 2006, Journal of Basic Microbiology Volume 46, Issue 3 , Pages 186 – 195)

A Halophilic and Osmotolerant *Azospirillum brasilense* Strain from Algerian Soil Restores Wheat Growth under Saline Conditions - A new bacterial isolate (NH) from salt-affected soil was identified as *Azospirillum brasilense* using phenotypic analyses and 16S rDNA-based phylogeny. This isolate showed resistance towards 3,4-dehydroproline and optimal growth at 200 mmol/L NaCl, tolerating salt stress of 300 mmol/L NaCl in the absence of osmoprotectants and up to 600 mmol/L NaCl in the presence of glycine betaine and *Ulva lactuca* extracts. This effect was enhanced with extracts of the marine algae *Ulva lactuca. A. brasilense* strain NH can produce auxin indole acetic acid under saline conditions. The hypothesis was tested that the inoculation of this osmotolerant rhizosphere strain could improve the growth of wheat under saline stress conditions. Normal wheat growth was restored in the presence of both 150 mmol/L and 200 mmol/L NaCl after inoculation with *A. brasilense* NH. Under saline conditions, its effect of promoting plant growth of wheat was significantly superior to that of *A. brasilense* Sp7, the non-halotolerant type strain. *A. brasilense* NH restored wheat growth at elevated salt concentrations in pot and field experiments even better in the presence of osmoprotective *Ulva lactuca* extracts. (Source – Nabti et al 2007, Engineering in Life Sciences Volume 7, Issue 4 , Pages 354 – 360).

Performance and gene effects for root characters and micronutrient uptake in wheat inoculated with arbuscular mycorrhizal fungi and *Azotobacter chroococcum* – The present investigation was conducted to investigate the impact of bio-inoculants on the magnitude and direction of gene effects and mean performance for root length density, root biomass per plant,

AMF colonization in roots and micronutrient uptake (Cu, Fe, Mn, Zn) in wheat under low input field conditions. The material for study comprised three wheat cultivars, WH 147 (low mineral input), WH 533 (drought-tolerant), Raj 3077 (high mineral input) and six generations (P_1, P_2, F_1, F_2, BC_1 and BC_2) of three crosses, namely WH 147 Ã— WH 533, WH 533 Ã— Raj 3077 and WH 147 Ã— Raj 3077. The experiment was conducted in a randomized block design with three replications having three treatments, i.e. (i) control; (ii) inoculation with arbuscular mycorrhizal fungi (AMF, *Glomus fasciculatum*); (iii) dual inoculation with AMF and *Azotobacter chroococcum* (*Azc*). The fertilizer doses in all three treatments were 80 kg N + 40 kg P + 18 kg $ZnSO_4$ $ha^{â^`1}$. Root length density, root biomass per plant, AMF colonization in roots and Zn and Mn content were found to be maximum after dual inoculation with AMF+ *Azc* in all three crosses. Joint scaling tests revealed that additive-dominance gene effects were mainly operative in governing the expression of root biomass, Cu and Zn content in all three crosses for all three treatments (i.e. control, AMF and AMF + *Azc*). Pedigree selection in crosses WH 147 Ã— WH 533 and WH 147 Ã— Raj 3077 could be effective for breeding pure lines of wheat for sustainable agriculture (low input genotypes responsive to biofertilizers such as AMF and *Azotobacter*). (Source – Singh et al 2007, Acta Agronomica Hungarica 55 (3) 325-330)

Co-inoculation of nitrogen-fixing and phosphate-solubilizing bacteria to promote growth, yield and nutrient uptake in chickpea - A total of 32 bacterial isolates including *Mesorhizobium* (N=10), *Azotobacter* (N=12) and phosphate-solubilizing bacteria (N=10) were isolated and tested for siderophore, HCN, ammonia, indole acetic acid production and phosphate solubilization *in vitro* . The bacterial cultures were positive for siderophore, HCN and ammonia. Among the isolates, *M. ciceri* RC3 and *A. chrococcum* A4 displayed 35 and 14 Î¼g ml $^{â^`1}$ of IAA, respectively, whereas *Bacillus* produced 19 ( *Bacillus* PSB1) and 17 Î¼g ml $^{â^`1}$ (*Bacillus* PSB10) of IAA in Luria Bertani broth. The diameter of the P solubilization zone varied between 4 (*Bacillus* PSB1) and 5 mm (*Bacillus* PSB10) and a considerable amount of tricalcium phosphate (7 and 8 Î¼g ml $^{â^`1}$ by *Bacillus* PSB1 and *Bacillus* PSB10, respectively) was released in liquid medium, with a concomitant drop in pH. The effects of N_2 -fixing and PS bacteria on the growth, chlorophyll content, seed yield, grain protein and N uptake of chickpea plants in field trials varied considerably between the treatments. Nodule number and biomass were significantly greater at 90 days after sowing (DAS), decreasing by 145 DAS. Seed yield increased by 250% due to inoculation with *M. ciceri* RC3 + *A. chroococcum* A4 + *Bacillus* PSB10, relative to the control treatment. Grain protein content ranged from 180 (*Bacillus* PSB1) to 309 ng $g^{â^`1}$ (*M. ciceri* RC3 + *A. chroococcum* A4 + *Bacillus* PSB10) in inoculated chickpea. The N contents in roots and shoots differed considerably among the treatments. (Source – Wani et al 2007, Acta Agronomica Hungarica 55 (30) 315-323).

Root and plant characters in wheat under low input field conditions with dual inoculation of mycorrhiza and *Azotobacter chroococcum* : Gene effects - Field experiments were conducted over two years under low input conditions to know the influence of bio-inoculants, namely arbuscular mycorrhiza fungi (AMF, *Glomus fasciculatum*) and *Azotobacter*

chroococcum (Azc) on the performance and gene effects for important root and plant characters in three crosses of wheat (WH147Ã—WH157, WH147Ã—PBW175 and WH147Ã—WH542). Six generations representing P_1, P_2, F_1, F_2, BC_1 and BC_2 populations of each cross were grown in randomized block design with three replications. The estimate of means (m) indicated that bio-inoculants enhanced the mean performance of most of the characters and root length density and grain yield in some crosses only. Crop season also showed considerable effect on impact of bio-inoculants. The joint scaling test revealed adequacy of additive-dominance model of gene effects for root biomass, root length density, flag leaf area, tillers/plant, grain weight and grain yield in all the crosses and bio-inoculants treatments in both years. The AMF treatment brought about changes in the magnitude and significance of additive component for root biomass, plant height, flag leaf area in all the three crosses. Both additive (d) and dominance (h) components were affected with respect to grain yield in WH147Ã—WH157 and WH147Ã—WH542. The dominant component was important for tillers/plant, grain yield, root length in control, as well as bio-inoculants treated populations of WH147Ã—PBW175 but treatment of AMF and AMF+ *Azc* reduced the magnitude of h and increased the magnitude of d. Digenic interactions were prominent for grains/spike in WH147Ã—WH157. Magnitude of digenic interactions was higher under bio-inoculation. Simple pedigree and bulk pedigree methods are suggested to capitalize on adequate additive gene effects for developing bio-inoculants responsive wheat genotypes. (Source – Sharma et al 2007, Cereal Research Communications 35 (4) 1573-1582)

Genetic tagging of *Azotobacter chroococcum* for colonization on wheat (*Triticum aestivum*) and cotton (*Gossypium sp.*) roots - A*zotobacter chroococcum* strains E12, HT57 were genetically tagged with *lac Z, gfp* to study the colonization behaviour on wheat (*Triticum aestivum*) and cotton (*Gossypium sp.*) in soil under controlled conditions. 10^3 - 10^4 cfu g^{-1} soil of HT57 *lac Z* were found to colonize roots of both cotton and wheat crops whereas 1.7×10^4 - 7.2×10^4 cfu g^{-1} soil of E12 *gfp* was colonizing wheat roots and 1.6×10^4 - 9.3×10^4 cfu g^{-1} soil of E12 *gfp* colonized cotton roots respectively. Tagged strains colonized mostly on root tips compared to basal roots in both the crops. (Source – Kumar et al Archives of Agronomy and Soil Science, Volume 52, Issue 3 June 2006 , pages 359 – 364)

Development of multiple co-inoculants of different biofertilizers and their interaction with plants - The present investigation was undertaken to assess the feasibility and compatibility of different biofertilizers like *Rhizobium*, *Azotobacter*, *Azospirillum*, *Pseudomonas* and *Bacillus* as co-cultured multiple inoculant. The microbe-microbe interaction under cultural conditions, in charcoal-based carrier and with pigeonpea and mungbean plants was determined. Under cultural conditions, co-inoculation of *Azotobacter*, *Bacillus*, *Pseudomonas* and *Rhizobium* resulted in reduced growth of *Rhizobium*. A co-culture multiple inoculant in sterilized fine wood charcoal powder (200 g) of *Azotobacter*, *Azospirillum*, *Bacillus* and *Pseudomonas* containing more than 2×10^8 cells g^{-1} carrier was possible. However, the number of rhizobia reduced to less than 2×10^8 cells g^{-1} carrier, when co-cultured with *Rhizobium*. Inoculation of pigeonpea and mungbean seeds with multiple co-inoculant produced maximum

nodule biomass, plant biomass and total soil N in case of pigeonpea and mungbean hosts. However, no beneficial effect of co-cultured multiple inoculants on nodule occupancy of pigeonpea or mungbean was observed. (Source – Suneja et al Archives of Agronomy and Soil Science, Volume 53, Issue 2 April 2007 , pages 221 – 230)

Tolerance of *Bradyrhizobium japonicum* E109 to Osmotic Stress and the Stability of Liquid Inoculants Depend on Growth Phase - Salinity and drought induce osmotic stress in plants and nodulating bacteria. The introduction of soybean in areas with higher soil salt contents or periods of drought pose a challenge for the rhizobial inoculants used to improve nodulation and enhance nitrogen fixation. *Bradyrhizobium japonicum* is a slow-growing rhizobium used for soybean inoculation that was previously regarded as salt-sensitive. We tested the survival ability of cultures of *B. japonicum* E109 at the exponential and stationary phases of growth in liquid culture medium against different concentrations of NaCl. We found that stationary-phase cells could tolerate higher levels of salt than exponential-phase cells. This result suggested that the physiological manipulation of the cultures could improve the salt tolerance of this strain. Nonetheless, we also found that exponential-phase cells adapted significantly better to two key situations that a commercial product must face, survival in liquid formulations and survival in soil microcosms resembling conditions of drought. These results suggest that the use of actively growing cells could be an improvement in the production of inoculants. However, it is not cost-effective, because bacteria should be harvested at a time when cell density is lower than that of early stationary-phase cultures, which are normally used in the industry. To overcome this drawback it is proved that a fed-batch system can produce exponential-phase cultures with higher cell densities and able to produce liquid inoculants with acceptable survival rates. (Source – Soria et al 2006, World Journal of Microbiology and Biotechnology 22(11) : 1235-1241)

Biocontrol of *Meloidogyne javanica* by *Rhizobium* and plant growth-promoting rhizobacteria on lentil - Biocontrol of the root-knot nematode *Meloidogyne javanica* was studied on lentil using plant growth-promoting rhizobacteria (PGPR) namely *Pseudomonas putida, P. alcaligenes, Paenibacillus polymyxa* and *Bacillus pumilus* and root nodule bacterium *Rhizobium* sp. *Pseudomonas putida* caused greater inhibitory effect on the hatching and penetration of *M. javanica* followed by *P. alcaligenes*, *P. polymyxa* and *B. pumilus*. Inoculation of any PGPR species alone or together with *Rhizobium* increased plant growth both in *M. javanica*-inoculated and -uninoculated plants. Inoculation of *Rhizobum* caused greater increase in plant growth than caused by any species of plant growth-promoting rhizobacteria in nematode-inoculated plants. Among PGPR, *P. putida* caused greater increase in plant growth and higher reduction in galling and nematode multiplication followed by *P. alcaligenes*, *P. polymyxa* and *B. pumilus*. Combined use of *Rhizobium* with any species of PGPR caused higher reduction in galling and nematode multiplication than their individual inoculation. Use of *Rhizobium* plus *P. putida* caused maximum reduction in galling and nematode multiplication followed by *Rhizobium* plus *P. alcaligens*. *Pseudomonas putida* caused greater root colonization and siderophore production followed by *P. alcaligenes*, *P. polymyxa* and *B. pumilus*.

Analysis of the protein bands of these four species by SDS-PAGE revealed that *P. putida* had a different protein band profile compared to the protein profiles of *P. alcaligenes, P. polymyx*a and *B. pumilus.* However, the protein profiles of *P. acaligenes*, *P. polymyxa* and *B. pumilus* were similar. (Source Siddiqui et al 2007, World Journal of Microbiology and Biotechnology Volume 23, Number 3 / March, 2007 pp 435-441)

Desiccation tolerance of rhizobia when protected by synthetic polymers - Survival of rhizobia applied to the surface of legume seeds is poor due to factors such as desiccation. Poor survival of rhizobia results in poor nodulation and yield of legumes. Selecting polymeric adhesives for inoculation of legume seed with rhizobia that provide protection during desiccation may improve survival and increase the potential for maximum legume yields. Vacuum-drying cells after suspension in selected polymers proved an effective method for screening the potential of polymers to improve the desiccation tolerance of rhizobia. The effect of different polymers on survival of desiccated rhizobia could be attributed to their different chemical and physical properties. The specific protective properties of polymers have been difficult to determine due to the variation in the chemical nature of polymers often compared. In this research polyvinyl alcohol (PVA) with varying degrees of hydrolysis provided a useful range of measurable physical properties against which bacterial survival could be measured. PVA with a percent hydrolysis in the range 86.5–89% was better able to protect desiccated cells of a range of rhizobial strains than polymers with higher (98.5%) or lower (78.5–82%) degrees of hydrolysis. The percent hydrolysis affected the moisture properties of PVA and survival of rhizobia was not maximised with high moisture sorption or low water activity by the polymer but rather when moisture properties were at an intermediate level. In comparison, survival was poorest in highly hygroscopic polymers methyl cellulose (MC) and polyvinyl pyrrolidone (PVP). The survival profile of desiccated rhizobia stored at different relative humidities was altered when cells were embedded in different polymers and is probably related to moisture sorption by those polymers. The percent hydrolysis also affects the extent to which PVA is able to stabilise colloids against the precipitating action of KCl. The colloid-stabilising property and survival was highest at 86.5–89% indicating that this property may be manipulated to achieve better survival. There is an indication that highly stabilising PVA may lead to more evenly dispersed cells providing more colony forming units rather than better survival. However, survival was not strongly correlated to the colloid-stabilising properties of the other polymers and was very poor after suspension in highly stabilising MC indicating a strong interaction between factors. Synthetic polymers designed to improve survival of rhizobia exposed to desiccation stress should include properties that combine high stabilisation and optimum moisture sorption properties. (Source – Deaker et al Soil Biology and Biochemistry Volume 39, Issue 2, February 2007, Pages 573-580)

The tripartite symbiosis between legumes, rhizobia and indigenous mycorrhizal fungi is more efficient in undisturbed soil - We investigated how the rate of colonization by indigenous arbuscular mycorrhizal fungi (AMF) affects the interaction between AMF, *Sinorrhizobium meliloti* and *Medicago truncatula* Gaertn. To generate a differential inoculum potential of indigenous AMF, five cycles of wheat,

each of 1 month, were grown in sieved or undisturbed soil before *M. truncatula* was sown. The early colonization of *M. truncatula* roots by indigenous AMF was faster in undisturbed soil compared with sieved soil, but by pod-fill the frequency of hyphae, arbuscules and vesicles was similar in both treatments. At this latter stage, *M. truncatula* grown in undisturbed soil had accumulated a greater biomass in aboveground tissues, had a greater P concentration and derived more N from the atmosphere than plants grown in disturbed soil, although soil compaction resulted in plants having a smaller root system than those from disturbed soil. The difference in plant P content could not be explained by modifications in hydrolytic soil enzymes related to the P cycle as the activity of acid phosphatase was greater in sieved than in undisturbed soil, and the activity of alkaline phosphatase was unaffected by the treatment. Thus, the results observed were a consequence of the different rates of AMF colonization caused by soil disturbance. Together with earlier results for soybean, this study confirms that soil disturbance modifies the interaction between indigenous AMF, rhizobia and legumes leading to a reduced efficacy of the bacterial symbiont. (Source Varennes and Goss 2007, Soil Biology and Biochemistry Volume 39, Issue 10, October 2007, Pages 2603-2607)

Arbuscular mycorrhizal fungi and organic farming - Symbiotic associations between arbuscular mycorrhizal fungi and plant roots are widespread in the natural environment and can provide a range of benefits to the host plant. These include improved nutrition, enhanced resistance to soil-borne pests and disease, improved resistance to drought, tolerance of heavy metals and better soil structure. Many agricultural crops are mycorrhizal and there is widespread if equivocal evidence that crop plants benefit from the arbuscular mycorrhizal (AM) association in the same way. However, many agricultural practices including use of fertilisers and biocides, tillage, monocultures and the growing of non-mycorrhizal crops are detrimental to arbuscular mycorrhizal fungi (AMF). As a result, agroecosystems are impoverished in AMF and may not provide the full range of benefits to the crop. Organic farming systems may be less detrimental to AMF because they exclude the use of water-soluble fertilisers and most biocides and generally have diverse rotations. The evidence available suggests that this leads to increased AMF inoculum in soils, greater crop colonisation and enhanced nutrient uptake. AMF might therefore be able to substitute for reduced fertiliser and biocide inputs in organic systems, though there is little evidence for increased yield resulting from high rates of AMF colonisation in organic systems. This review examines the benefits that the AM association can have for agroecosystems and how farm management practices influence the AM association. Management options that may be employed to increase the benefits that AMF can bring to this type of farming system, such as changes to the rotation and careful use of tillage, are discussed. (Source Gousling et al Agriculture, Ecosystems & Environment Volume 113, Issues 1-4, April 2006, Pages 17-35)

The effects of several factors on the growth of pure and mixed cultures of *Azotobacter chroococcum* and *Bacillus subtilis* – The authors studied the effect of a clay mineral, palygorskite, on the physiological activity of *Azotobacter chroococcum* and the phosphate-mobilizing bacterium *Bacillus subtilis*, as well as their mixed cultures,

under various oxygen supply conditions during the utilization of phosphorus from readily and poorly soluble compounds (K_2HPO_4 Â· $3H_2O$) and ($Ca_3(PO_4)_2$), respectively. During cultivation of the bacteria in a nutrient medium with $Ca_3(PO_4)_2$, the number of microorganisms was higher than that observed in a medium with K_2HPO_4. An increase in oxygen mass transfer in the nutrient medium was followed by a rise in the number of *Bacillus subtilis* cells and an inhibition of *Azotobacter chroococcum* growth. An addition of palygorskite (5 g/l) into the nutrient medium stimulated the growth of both bacteria and stopped the decreasing growth of *Azotobacter chroococcum* at high values of oxygen mass transfer. The number of *Bacillus* and, particularly, *Azotobacter* cells was two to five times lower in a mixed culture than in a monoculture. These differences were less significant during the cultivation of mixed cultures in medium with palygorskite. (Source – Kistena et al 2006, Applied Biochemistry and Microbiology Volume 42, Number 3 / May, 2006 278-283)

Synergistic effects of the inoculation with nitrogen-fixing and phosphate-solubilizing rhizobacteria on the performance of field-grown chickpea - The synergistic effects of nitrogen-fixing and phosphate-solubilizing rhizobacteria on plant growth, yield, grain protein, and nutrient uptake of chickpea plants were determined in a sandy clay-loam soil. Legume grain yield and concentration and uptake of nitrogen (N) and phosphorus (P) were significantly increased as a result of co-inoculation with *Mesorhizobium* and P-solubilizing *Pseudomonas* and *Bacillus spp.* The inoculation with *M. ciceri* RC4 + *A. chroococuum* A10 + *Bacillus* PSB9 tripled the seed yield and resulted in highest grain protein (295 mg g^{-1}) at 145 d after sowing (DAS). An 8% increase in P concentration above the uninoculated control was observed in case of a single inoculation with *Pseudomonas* PSB 5, while the P uptake was highest (2.14-fold above the uninoculated control) with a combined inoculation with [*M. ciceri* RC4 + *A. chroococcum* A10 + *Bacillus* PSB 9] at 145 DAS. The highest N concentration and N uptake at 145 DAS (81% and 16% above the uninoculated control, respectively) were observed with the triple inoculation of [*M. ciceri* RC4 + *A. chroococcum* A10 + *Pseudomonas* PSB 5). These findings show that multiple inoculations with rhizospheric microorganisms can promote plant growth and grain yield and increase concentrations and uptake of N and P by field-grown chickpea. (Source – Wani et al 2007, Journal of Plant Nutrition and Soil Science 170(2) 283-287)

Seminar Conferences/ Workshops

15th International Congress on Nitrogen Fixation & 12th International Conference of the African Association for Biological Nitrogen Fixation - The 15th International Congress on Nitrogen Fixation, hosted by the African Association for Biological Nitrogen Fixation, was held during 21–26 January 2007 at Cape Town, South Africa. It was planned to offer an exciting mix of presentations spanning from field application to genomics research. The theme of the Congress was Biological Nitrogen Fixation Applications for Poverty Alleviation. Nitrogen availability in agricultural soils is frequently the limiting factor for crop productivity. This problem will become more severe in the 21st century, as agricultural production must keep pace with Increased world population. Biological nitrogen fixation (BNF), through symbiotic, associative and free-living microbial systems, already contributes a major and sustainable input into agriculture. Enhancing these systems through research and development could provide an ecologically acceptable alternative to the increased application of nitrogen fertilizers, particularly in Africa and other developing countries. Important topics of deliberations were: Genomics of Nitrogen Fixers and Associated Plants; Legumes in Agriculture and Forestry; Fundamentals of Nitrogen Fixation; Chemistry and Biochemistry of Nitrogenases; Rhizosphere Associations and Nitrogen-Fixing Endophytes; Genetics and Regulation of Nitrogen Fixation; Sustainable Agriculture and Limitations to BNF; Frontiers of BNF Research; Phylogeny of Nitrogen Fixers and Evolution of Symbioses; Nodule Organogenesis and Function (Legumes and Actinorhizal plants); Phytosynthetic Nitrogen Fixers; BNF and food security; BNF and Poverty Reduction.

11th International Symposium on Nitrogen Fixation with Non-Legumes and 8th European Nitrogen Fixation Conference - The 11th International Symposium on Nitrogen Fixation with Non-Legumes is scheduled during August 30 to September 3, 2008 at the Aula Academica of the Ghent University in the heart of Ghent (Belgium).This Conference is the 8th in a series of biennial Conferences that were initiated in 1994 in Szeged (Hungary) with the aim of bringing together European researchers with a passion for the different aspects of biological nitrogen fixation. This process, carried out by prokaryotes, provides a sustainable input of nitrogen in the ecosystem of our planet and has an enormous potential for a future more and more oriented towards environmentally friendly agriculture. The goal of the meetings is to strengthen European collaborations in this field, to foster scientific and technological cooperation between Europe and the rest of the world, particularly with developing countries, and to offer a training ground for junior researchers. The sessions of the Conference will cover the various aspects of biological nitrogen fixation, including microbiology, plant-microbe interactions, plant cell biology, genomics and new high-throughput approaches. Placing this research in the context of global agriculture and environmental changes will highlight the general importance of biological nitrogen fixation. The Conference will last for four days and will include 12 plenary lectures, two poster sessions and three Workshops. The 11th International Symposium on Nitrogen

Fixation with Non-Legumes that is organised as a Satellite Meeting to the 8th European Nitrogen Fixation Conference, will start on Wednesday afternoon, September 3 and will continues on Thursday, September 4. For more information contact Celine Monbailliu Email celine.evident@skynet.be (mention '8ENFC' in your subject line) Phone +32 (0)9 225 72 90, Fax: +32 (0)9 225 30 34.

SAARC Workshop on Biofertiliser Production and Quality Control and Test methods

A two days SAARC workshop on biofertiliser production, quality control and test methods was held during 26-27th March 2008 at Aftab-Mehtab, Hotel Taj Mahal, Mansingh Road, New Delhi. The workshop was participated by 15 no. participants from different SAARC countries like Bangladesh (2no.), Srilanka (2no.), Pakistan (1no.) Bhutan (2no.), Maldives (2no.), Afghanistan (2no) and India (4no.). Inaugural session was initiated with the welcome address by Smt Madhulika Prakash, Deputy Director General (Project, planning & coordination), Bureau of Indian Standards and Programme Objectives by Shri Rakesh Verma, IAS, Add. Director General (Technical), Bureau of Indian Standards. The workshop was inaugurated by Shri Shyam Chatterjee, IAS, Director General, Bureau of Indian Standards. The workshop comprised of three technical sessions and one field visit. First technical session was chaired by Dr. A.K. Singh, DDG(NRM), Indian council of Agricultural Research and covered important topics in the field of biofertiliser technology like 'Biofertilisers and benefits" by Dr B. D. Kaushik, Professor of Eminence, Division of Microbiology, IARI, New Delhi. Quality control of biofertilisers and testing protocols was presented and discussed by Dr A.K. Yadav, Director, National Centre of Organic Farming, Ghaziabad. Details on Standardization of biofertilisers were presented by Smt Madhulika Prakash and Smt. Surya Kalyani, Scientist-B, Food and Agriculture, Bureau of Indian Standards. In post lunch session a field trip was arranged to visit International Panacea Ltd, Mohan Industrial Estate, Badarpur Border Area, New Delhi.

On second day of workshop the participants were busy in attending the second and third technical sessions. The second technical session was chaired by Dr A. K. Yadav, Director, National Centre of Organic Farming, Ghaziabad. In this technical session first presentation on "Current scenario and future challenges in Biofertiliser Technology" was presented by Dr K.K. Tripathi, Scientist G Department of Biotechnology, New Delhi. He also discussed the thrust areas in biofertilisers during XIth plan and elaborated importance of biofertiliser in INM, net work project on biofertilizers, biofertilizer based packages recommended for rice based cropping system, wheat-moong bean in sequence to rice, wheat moong bean sequence in agroforestry, sugarcane based cropping system etc, commercial production of rhizobium, BGA, mycorrhizae and their technology transfer. Second presentation on "Commercialisation of Biofertilisers – Experiences and Expectations" was discussed by Dr S.G.Balaji, International Panacea Ltd, New Delhi. All technical sessions were followed by detailed discussions on respective topics. Third technical session was chaired by Dr K.K. Tripathi, which comprised of the presentations from the participants. Valedictory session was chaired by Shri Rakesh Verma and co chaired by Shri Yogeshwar Sangwan, Director, SAARC, Ministry of External Affairs.

Book Reviews

Nitrogen-fixing Actinorhizal Symbioses By Katharina Pawlowski 2007, Published by Springer, Pages 312 - This book is the self-contained sixth volume of a comprehensive series on nitrogen fixation. It presents the state-of-the-art in regards to actinorhizal symbioses. Like legumes, actinorhizal plants form root nodules that host nitrogen-fixing soil bacteria. However, because the macrosymbionts are, with one exception, woody plants rather than crop plants, actinorhizal symbioses are less well-known than legume symbioses to which they are phylogenetically related. Actinorhizal plants come from eight different families. They can grow on marginal soils by virtue of these symbioses and are used extensively in reforestation, soil reclamation, and desert agroforestry. The diversity of the involved host plants poses a variety of challenges to the actinorhizal symbiosis and results in interesting strategies, for example, to cope with the O2 dilemma or nutrient exchange between plant and bacterium. The actinorhizal micro-symbionts are Gram-positive actinomycetes of the genus Frankia. The inability to culture several actinorhizal microsymbionts has led to the development of diverse molecular strategies for strain identification. This volume includes chapters that deal with all these aspects of the symbiosis and both symbionts plus their ecological role and use. Subsequent chapters deals with the global distribution of different actinorhizal plants and their microsymbionts and how this impacts the question of co-evolution of the micro- and macrosymbionts as well as comparing the actinorhizal and leguminous symbioses. This book intended to serve as an indispensable reference work for academic, governmental, and industrial scientists working in this area, to introduce students to the global importance of this association, and to provide science administrators with ready access to vital relevant information.

Biological Nitrogen Fixation, Sustainable Agriculture and the Environment, By Yi-Ping Wang 2005, Published by Springer Pages 442, ISBN 1402035691 - This volume of book covers all aspects of fundamental and applied nitrogen-fixation research, extending from biochemistry and chemistry through genetics, regulation and physiology to agricultural practice and environmental impact. It describes recent progress on studies of potential catalysts for nitrogen fixation; how the N2-fixing process is regulated in living cells; the use and impact of genetics and genomics on our understanding of the biological process; the wide variety of associations of nitrogen-fixing microbes with plants, including the formalized Rhizobium-legume and actinorrhizal associations as well as the less formalized associative and endophytic interactions; and the impact of nitrogen fixation in agriculture and forestry, including its effect on the environment. This volume provides an up-to-date referenced source, which can be readily accessed by all practicing and otherwise interested proponents of nitrogen fixation research, including those with related interests in the areas of plant and microbial science, genomics, plant-microbe interactions, genetics and regulation, plant growth and biocontrol, agriculture, forestry, ecology, taxonomy and evolution.

Handbook of Biofertilizers and Microbial Pesticides by M.S. Vora, H.N. Shelat and R.V. Vyas. Delhi, Satish Serial Pub., 2008, Pages 252 Price $65. ISBN 81-89304-41-0- Through this book an effort has been made to provide knowledge of biofertilizers and microbial pesticides with microbiological techniques required for maintenance and use. Chemical fertilizers and pesticides have provided foot for First Green Revolution which is now switches to use of biofertilizers and microbial pesticides in current era of organic farming and eco-friendly management practices for which all information is complied in the book. The book is edited by related renowned scientists having wide field experiences with an exhaustive compilation. Book consist 24 chapters covering information on various beneficial microorganisms commonly used in agriculture, covering all aspects like isolation, identification, characterization, mass multiplication and product formation; quality testing, financial aspects and future prospect with basic information on various techniques. Book will be a good reference for young researchers, students and entrepreneurs and shall surely provide fundamental knowledge on microbial bioinoculants for safer and green approaches of modern agriculture." (jacket)

Advanced Techniques in Soil Microbiology By Ajit Varma and Ralf Oelmüller, 2007, Pub. Springer Pages 427, ISBN:3540708642 - "Advanced Techniques in Soil Microbiology" presents a wide range of biotechnological methods for application in soil microbiology analysis. These include all essential methods involving molecular biology, immunology, microbiology, and structural biology, such as transcriptome analysis, RNAi technology, molecular matchmaking, RAPD, T-RFLP and FT/MS. The techniques and procedures have been selected with the aim of offering practical guides for immediate use in the laboratory. The systems investigated range from individual molecules and cells to entire eukaryotic organisms, with a focus on bacteria, fungi, mycorrhiza, and higher plants. This volume of state-of-the-art, practice oriented methods will be of great use both to the first-timer and to the experienced scientist.

Molecular Approaches to Soil, Rhizosphere and Plant Microorganism Analysis: Edited by JE COOPER and J.R. Rao, CABI, 2006, Pages 297, Price - $ 150, ISBN -978-1-84593-062-2 - Soil harbours the highest abundance and diversity of microorganisms found on earth. The use of traditional cultivation based approaches to examine soil microbial dynamics has proven frustrating to researchers, as these methods retrieve only a small fraction of diversity. Recently developed molecular techniques allow previously unobtainable information to be gathered on the microflora of soils, plants and their rhizosphere. Many of these methods are somewhat related; most target nucleic acids and a high proportion are in some way dependent on the polymerase chain reaction. The vast profusion of new methods available to researchers through this book highlights the utility of this volume containing details on newly available techniques and discussing the applicability and limitations of each. This edited hardcover draws on the knowledge of a range of experts to cover the emergence of cutting edge molecular technologies from *in-vivo* expression technology to transcriptomics, while also providing strong reviews of standard methods.

List of Biofertilizer Production Units Funded under National Project on Organic Farming (April 2005 to March 2008)

Government Units funded directly by the Department of Agriculture and Cooperation, Govt of India.

1. Commisioner, Department of Agriculture, Andhra Pradesh, Hydrabad, A.P.
2. Director, Department of Agriculture, Chattisgarh, Raipur
3. Director, Department of Agriculture, Himachal Pradesh, Shimla
4. Director, Department of Agriculture, Jammu, Jammu and Jashmir
5. Director, Department of Agriculture, Jharkhand, Ranchi
6. Director, Department of Hortiiculture, Orissa, Bhubanshwar
7. Director, Department of Agriculture, Tailnadu, Chennai (for strengthening of six existing units)
8. Director Research, MP Krishi Vidyapeeth, Rahuri, Distt Ahmdnagar, Maharashtra
9. Director Research, Tamilnadu Agricultural University, Coimbatore
10. Director Research SVP University of Agriulture and technology, Meerut, Uttar Pradesh
11. Director, Department of Agriculture, Manipur, Imphal
12. Director, Department of Agriculture (Research and Education), Mizoram, Aizwal
13. Director, Department of Soil and Water Conservation, Nagaland, Kohima

Private units provided with 25% subsidy through NABARD under credit linked back ended subsidy scheme

1. M/S GMR Industries Ltd, Sankilli, Distt Srikakulam, Andhra Pradesh
2. M/S Sri Sai Agro Bio Labs (P) Ltd, Garividi, Vizianagaram, Andhra Pradesh
3. M/S Prahallada, Karimnagar, Andhra Pradesh
4. M/S K.N. Bioscience (India) Pvt Ltd., Plot No. 28, Ushodaya Enclave, Madinaguda, Miyapur, Hyderabad, A.P.
5. M/S Sri Bio-Tech, 5-35/319, SaiBaba Colony, Kukatapally, Hyderabad, A.P.
6. M/S Cosme Biotech Pvt Ltd, Vathadev, Sarwan, Bicholim, Goa.
7. M/S Agriland Biotech, Nr Shyamlaya Railway Crossing, Savli, Baroda, Gujrat.
8. M/S Shreenathji Biofertilizers, Gamdi, Dabhoi, Atmajyoti Ashram Road, baroda, Gujrat
9. M/S Multiplex Biotech Pvt Ltd, 180 1st Main Road, Mahalaxmi Layout Extn., Bangalore, Karnataka
10. M/S Travancore Organic Fertilizer Company Pvt Ltd, Kangazha, Kottayam, Kerala
11. M/S Govinda Agrotech Ltd., Post Kelod, Taluka Saoner, Distt Nagpur, Maharashtra
12. M/S Deeni Chemicals Pvt Ltd, 37/9 MIDC Road, Padoli, Chandrapur, Maharashtra
13. M/S Vanita Chemicals, Icthalkaranji, Kolhapur, Maharashtra
14. M/S Vishnudutt Minerals Pvt Ltd, MIDC, Hingna Industrial Estate Road, Nagpur, Maharashtra
15. M/S Ruchi Oyster Mushroom, At Kudwa, The. Gondia, Distt Gondia, Maharashtra
16. M/S Patkai herbs and Spices Pvt Ltd., 2nd Floor, Eureka Tower, Chandmari Flyover, U Turn, Guwahati, Assam
17. M/S Antecdent Pabulum Inc.m E-55 Growth Centre, Mansa Road, Bathinda, Punjab
18. M/S Rhizo Organic, B/242, RHB, Hanumangarh, Rajasthan
19. M/S R. Palaneeshwar, 25 Chnniah School St., Virudhunagar, Virudhunagar, Tamailnadu
20. M/S Rajshree Sugar and Chemicals Ltd, Avinashi Road, Peelamedu, Coimbatore, Tamilnadu
21. M/S A. Pantnagar Biolabs (Biofertilizer manufacturing Unit) Plot No. 20A, Sec. 2 IIE, Pantnagar, Distt US Nagar, Uttarakhand.
22. M/S Sankalpa Biotech, MOUZA Bahirsarbamangala, Hatudevan, katwa Road, Burdwan, West Bengal.