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From Editors Desk

Dear Readers,

You are aware that current day agriculture has witnessed the increased research in microbial technology associated with commercial interest so as to market the microbial product particularly the biofertilizers, to meet the consumer demand to suit various crops. Fortunately detailed biofertilizer production data of All India 2006-07 are available which reveal 16,145 tonnes were produced during the year but the min demand based biofertilizers like Azotobacter, Azospirillum, Acetobacter, Rhizobium and Phosphate Solubilizing Bacteria produced were 7386 meteric tones. Moreover the biofertilizer production data indicated that phosphate solubilizing bacteria contributed 41.9%, Rhizobium 36.4%, Azospirillum 11.9% and Azotobacter 9% of biofertilizer production. These biofertilizers have been produced in order to give the desired benefits to the farming community. Although the production of Acetobacter diazotrophicus which is now renamed as Gluconacetobacter diazotrophicus stoof 55.92 tonnes in India which are mainly utilized in sugarcane crop for increased productivity but recent research findings in this issue has assessed its new potentiality in rice as well. This experimental finding also gives new insight to the growing biofertilizer industry. Further the state wise biofertilizer production data reveals that Andhra Pradesh has produced 27.8% followed by Maharashtra 15%, Pondicherry 11.3%, Tamilnadu 10.9%, west Bengal 8.7% respectively out of 16,145 tonnes of biofertilizers in India. Regarding production of other inoculants, Karnataka tops the list of production.

Presen issue has mainly focused on biofertilizer production information in India as well as their State-wise distribution for the general idea of farming community besides knowledge of entrepreneurs. Moreover the present issue has splendidly dealt outstanding research findings in form of a research article, Research Notes/ News, Seminar and Symposium News, Book Reviews so as to cater the needs of our beloved readers.

Dr. R.N. Bisoyi
Editor

Sugarcane endophyte *Gluconacetobacter diazotrophicus* expanding its host range to paddy

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Introduction

Endophytic nitrogen fixing bacteria are believed to contribute substantial amounts of N_2 to certain graminaceous crops. The extension of nitrogen fixing symbioses to important crop plants such as cereals has been a long standing goal in the field of biological nitrogen fixation. One of the approaches that had been used to achieve this goal involves the testing for the possibility of colonization of monocots other than sugarcane by *Gluconacetobacter diazotrophicus.*

The discovery in 1988, of a nitrogen fixing bacterium, *G.diazotrophicus* inhabiting the interior of roots, stem and leaves of sugarcane plants opened a new avenue of research in nitrogen fixation and in plant / microbe interactions (Cavalcante and Dobereiner, 1988). The endophytic colonization of sugarcane by *G.diazotrophicus* represents a monocot / diazotroph association that is likely to be effective in terms of supplying significant amounts of bacterially fixed N_2 to benefit plant growth. It has been suggested that because of their endophytic nature these bacteria can fix N_2 more efficiently than those diazotrophs in rhizosphere or in rhizoplane (Patriquin *et al* 1983; Dobereiner *et al* 1995). Their efficiency may be due to the plant directly providing photosynthates for them and also a low O_2 environment created which is favourable for nitrogenase enzyme (James *et al* 2001).

Recently, it has been determined that *G.diazotrophicus* enhances plant growth, probably by providing both fixed-N and other growth factors for very young sugarcane plants (Sevilla *et al* 1998). This growth promoting factor is likely to be indole acetic acid (Fuentes-Ramirez *et al* 1993), which has been shown to be produced in significant amounts by *G.diazotrophicus*.

Since its first isolation from Brazilian sugarcane, it has also been isolated from other sugarcane varieties grown in many parts of the world and from other plants such as sweet potato (Paula *et al* 1991), Coffee (Jiminez-Salgado *et al* 1997), tea, banana (Matiru and Thomson, 1988) and ragi (Loganathan *et al* 1999). If one grass can arrange to harbour an endophyte, it is possible that others also can. So it may be meaningful to think of other cereals like corn, wheat, baby corn and rice being encouraged to leak sucrose into the intercellular spaces so that they might act as hosts to *G.diazotrophicus*.

Materials and methods

The studies were carried out to study the colonization of *G. diazotrophicus* in paddy by growing the seedlings in a specially constructed beaker to maintain

aseptic condition throughout the study. For the enhancement of colonization different growth promoters *viz*., IAA (Indole Acetic Acid), NAA (Naphthalene Acetic Acid) and 2,4-D (2,4-Dichloro Acetic Acid) and VAM (Vesicular Arbuscular Mycorrhizae) in different combinations were added in the growth solution. As a preliminary study, the effect of growth promoters on the growth of *G. diazotrophicus* cultures was tested at different concentrations and the optimum concentration was decided. Following treatment combinations were studied:

T1- *G.diazotrophicus* alone
T2- IAA 5ppm + *G. diazotrophicus* (Gd)
T3- IAA 5ppm+ (Gd)+VAM
T4- 2,4-D 5ppm+ (Gd)
T5- 2,4-D 5ppm + (Gd) +VAM
T6- NAA 5ppm + (Gd)
T7- NAA 5ppm + (Gd) + VAM

A beaker with a capacity of 200ml was designed with special attachments for this study. About 5cm below the rim of the beaker, a glass plate was fixed with 4 holes (diameter of 0.5cm) to place the seeds. Below this glass plate, a side arm extending to the top of the beaker was fitted along with a glass stopper. The growth solution was added through the side arm and the level was maintained up to the glass plate with holes.

The seeds of paddy (CO-47) were serially surface sterilized with sodium hypochlorite solution for one minute, with 70 per cent alcohol for two min and rinsed with sterile distilled water for 2-3 times. Overnight soaking in sterile distilled water was done and the imbibed seeds were transferred to Petri plates layered with moist cotton and incubated for overnight in dark for germination. The well sprouted seeds were then transferred aseptically to the specially constructed beakers with Hoagland's solution (To this solution, sucrose was added at 10 per cent concentration). Sprouted seeds were placed @ 4 per hole. After 2 days of growth in the beaker, growth promoters *viz*., IAA; 2,4–D and NAA were added. The inoculum *G. diazotrophicus* CSR 3 was added @ 100 µl beaker $^{-1}$. The day of inoculation was taken as 0 day of observation. The entire set up was covered with black paper and safely kept in the green house.

The population load of *G.diazotrophicus* colonizing the root, shoot and growth solution was enumerated (Cavalcante and Dobereiner 1988) at 3 days intervals up to 15th day. The shoot and root samples of both control and treated plants of paddy were collected and washed with sterile distilled water. The samples were surface sterilized with 70% alcohol for 10 seconds followed by washing with sterile distilled water for 3 times with an interval of 2 minute to remove the excess of alcohol. The samples were macerated in a pestle and mortar separately and serially diluted from 10^{-1} to 10^{-5}. One ml of each dilution was plated using LGI agar with double antibiotic marker [rifampicim (5µg/ml) + streptomycin (50µg/ml)] which was already determined for *G.diazotrophicus* CSR 3 strain. The colonies from these antibiotic plates were further confirmed by performing indirect fluorescent antibody reaction, using the rabbit antiserum of *G.diazotrophicus* CSR 3 and FITC (Fluorescein Iso Thio Cyanate) conjugate of goat anti-rabbit globulin.

Indirect Fluorescent Antibody Technique

Indirect fluorescent antibody technique was used for the detection of the strain. A thin smear of *G.diazotrophicus* from the enumeration plates was made on the microscopic slide and heat fixed. The smear was covered with 1:10 diluted rabbit antiserum in 100 mM phosphate buffered saline with Tween 20 (PBST,

pH 7.2) and incubated for 60 min. The excess antiserum was washed with PBST four times for 60 sec each time. Then the smear was covered again with 1:5000 diluted fluorescein isothiocyanate (FITC) conjugate of goat anti-rabbit globulin (Bangalore, Genei Pvt.Ltd., India) and incubated for 45 min. The excess FITC conjugate was washed off and placed in phosphate buffered saline for 20min. The washing process was completed by placing the slide in distilled water for 10 min, shade dried and a very small drop of mounting fluid (Buffered glycerol; Phosphate buffered saline and Glycerine at 1:9 ratio, pH 9.3) was added, mounted with A1 cover slip and observed under fluorescent microscope (Olympus FLM model) fitted with a dark field condenser and an HB 200 mercury burner (OSRAM) light source. The filters used were FITC exciter filter and Y-50 barrier filter

The pH of the growth solution was observed with the help of a pH meter by withdrawing 10 ml from the beaker at 3 days interval up to 15 days.

Results and observation

In the colonization study, there was no trace of *G.diazotrophicus* in growth solution of uninoculated control and growth regulator alone treated beakers. This proved the highly aseptic condition provided by the specially designed beaker. The population load was estimated at 3 days interval up to 15 days. In the growth solution, when inoculated without growth regulators, the population of *G.diazotrophicus* was $6.15x10^3$ on 3rd day itself and it gradually increased up to the last observation (15th day). On 15th day it reached $1.15x10^5$ CFU/ml of the solution. When inoculated along with 5ppm IAA, there was not much difference on 3rd day but on 6th day could observe almost tenfold increase in the population (from $7.23x10^3$ to $5.36x10^4$). In the next stages IAA addition showed slight increase and on 15th day there was four fold increase ($4.26x10^5$). Though the co-inoculation of VAM recorded increase in *G.diazotrophicus* load in growth solution on 15th day it was not statistically significant. In general, though there were variations in the population load of *G.diazotrophicus* in growth solution for different treatments it was not statistically significant but the variations between different day intervals were statistically significant (Table1.).

Appreciable counts of *G.diazotrophicus* could be observed in the roots of paddy. In T1 treatment the *G.diazotrophicus* count increased from $9.10x10^2$ on 3rd day to $1.25x10^4$ on 15th day. In T2 there was still more increase due to IAA ($1.43x10^4$). From 3rd day onwards the co-inoculation of VAM enhanced the colonization in roots unlike in growth solution where the increase was only on the 15th day. The influence of VAM on enhancing the infection of *G.diazotrophicus* has already been proved (Paula *et al* 1991; Isopi *et al* 1995). In paddy significant increase was observed due to VAM inoculation. 2,4-D and NAA also increased the colonization ($9.87x10^3$ and $7.24x10^3$ respectively on 15th day) but not to the level of IAA. The treatment with IAA was highly preferable than NAA & 2,4-D. The research works of Dobereiner *et al* (1994) and Muthukumarasamy and Revathi (1999) have also confirmed that 2,4-D addition enables better infection of *G.diazotrophicus* (Table 2.).

When comparing the population load on 3rd and 6th day (Fig1.) it was seen that there was much difference between treatments on 6th day of inoculation. T2 and T3; T5 and T6; T1 and T7 treatments were on par. However, the T1 (*G.diazotrophicus* alone) treatment recorded the lowest level.

Table 1. Microbial load of *G.diazotrophicus* and influence of growth regulators on the multiplication in growth solution of paddy (under hydroponic condition)

Treatments	Population (CFU / ml of growth solution)				
	3rd day	6th day	9th day	12th day	15th day
T1-*G.diazotrophicus* alone	$6.15x10^3$ (3.788)	$7.23x10^3$ (3.859)	$1.02x10^5$ (5.008)	$1.13x10^5$ (5.053)	$1.15x10^5$ (5.060)
T2- IAA 5ppm + Gd	$5.31x10^3$ (3.725)	$5.36x10^4$ (4.729)	$3.83x10^5$ (5.583)	$4.2 x10^5$ (5.623)	$4.26x10^5$ (5.629)
T3- IAA 5ppm + Gd +VAM	$5.23x10^3$ (3.718)	$5.25x10^4$ (4.720)	$3.81x10^5$ (5.580)	$4.13x10^5$ (5.615)	$4.31x10^5$ (5.634)
T4- 2,4-D 5ppm + Gd	$4.07x10^3$ (3.609)	$3.48x10^4$ (4.541)	$2.63x10^5$ (5.419)	$3.21 x10^5$ (5.506)	$3.21x10^5$ (5.506)
T5- 2,4-D 5ppm + Gd +VAM	$4.72x10^3$ (3.673)	$3.94x10^4$ (4.595)	$2.50x10^5$ (5.397)	$3.30x10^5$ (5.518)	$3.34x10^5$ (5.523)
T6- NAA 5ppm + Gd	$3.27x10^3$ (3.514)	$2.89x10^4$ (4.460)	$1.06x10^5$ (5.025)	$1.13x10^5$ (5.053)	$1.74x10^5$ (5.240)
T7- NAA 5ppm + Gd +VAM	$2.89x10^3$ (3.461)	$2.72x10^4$ (4.434)	$1.08x10^5$ (5.033)	$1.12x10^5$ (5.049)	$1.81x10^5$ (5.257)
	Sed		CD(0.05)		
Treatments	0.211		0.422		
Days	0.178		0.356		
Treatments X Days	0.473		0.944		

*Transformed Log10 values in parentheses

Table 2. Microbial load of *G.diazotrophicus* in the roots of paddy and influence of growth regulators on the colonisation (under hydroponic condition)

Treatments	Population (CFU / g dry weight of root)				
	3rd day	6th day	9th day	12th day	15th day
T1-*G.diazotrophicus* alone	$9.10x10^2$ (2.959)	$1.82x10^3$ (3.260)	$1.01x10^4$ (4.004)	$1.20x10^4$ (4.079)	$1.25x10^4$ (4.096)
T2- IAA 5ppm + Gd	$5.20x10^2$ (2.716)	$9.14x10^3$ (3.960)	$1.25x10^4$ (4.096)	$1.32 x10^4$ (4.120)	$1.43x10^4$ (4.155)
T3- IAA 5ppm + Gd +VAM	$7.10x10^2$ (2.851)	$1.10x10^4$ (4.041)	$1.34x10^4$ (4.127)	$1.38x10^4$ (4.139)	$1.46x10^4$ (4.164)
T4- 2,4-D 5ppm + Gd	$5.32x10^2$ (2.725)	$7.10x10^2$ (2.851)	$9.57x10^3$ (3.980)	$9.64x10^3$ (3.984)	$9.87x10^3$ (3.994)
T5- 2,4-D 5ppm + Gd +VAM	$8.50x10^2$ (2.929)	$4.92x10^3$ (3.691)	$8.61x10^3$ (3.935)	$9.53x10^3$ (3.979)	$9.71x10^3$ (3.987)
T6- NAA 5ppm + Gd	$1.00x10^2$ (2.000)	$2.86x10^3$ (3.456)	$6.93x10^3$ (3.840)	$7.18x10^3$ (3.856)	$7.24x10^3$ (3.859)
T7- NAA 5ppm + Gd +VAM	$1.10x10^2$ (2.041)	$1.67x10^3$ (3.222)	$6.31x10^3$ (3.800)	$7.20x10^3$ (3.857)	$7.20x10^3$ (3.857)
	SEd		CD (0.05)		
Treatments	0.051		0.102		
Days	0.043		0.086		
Treatments X Days	0.115		0.229		

*Transformed Log10 values in parentheses

Fig. 1. Microbial load of *G.diazotrophicus* on roots of paddy on 3rd and 6th day of inoculation

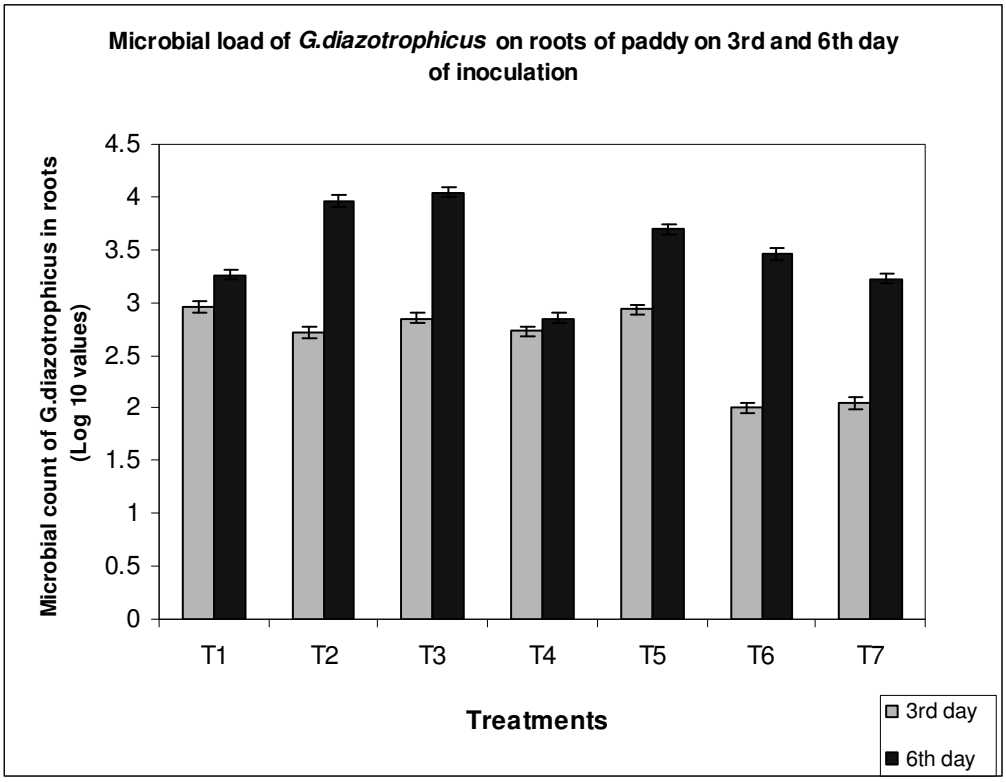


Fig. 2. Microbial load of *G.diazotrophicus* on roots of paddy on 3rd and 15th day of inoculation

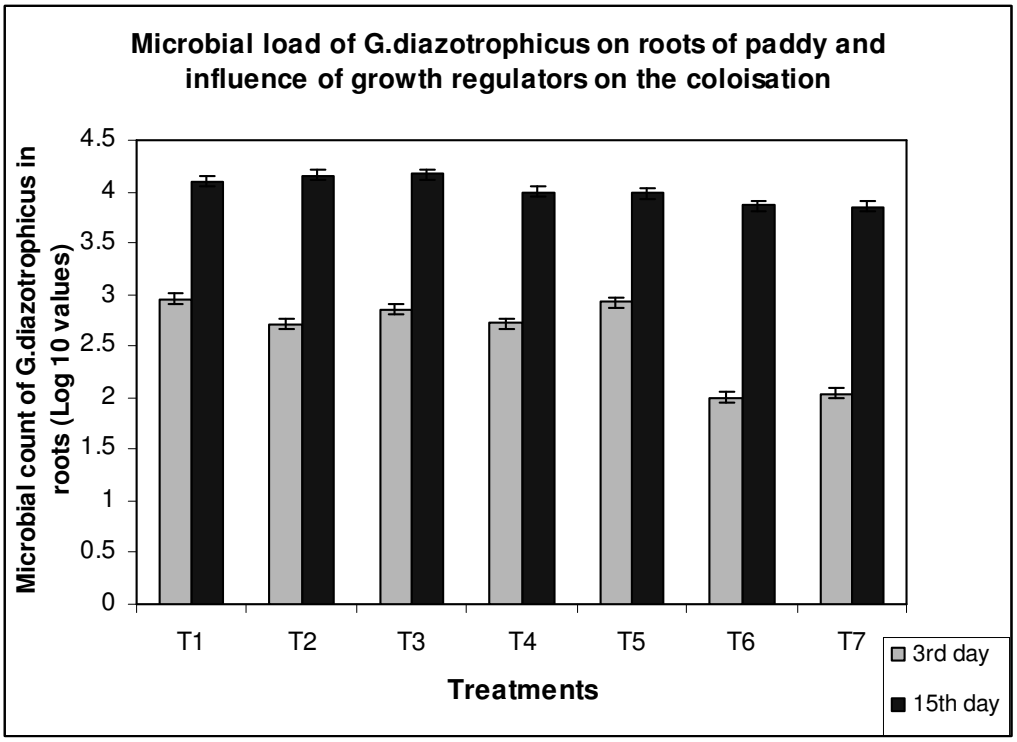
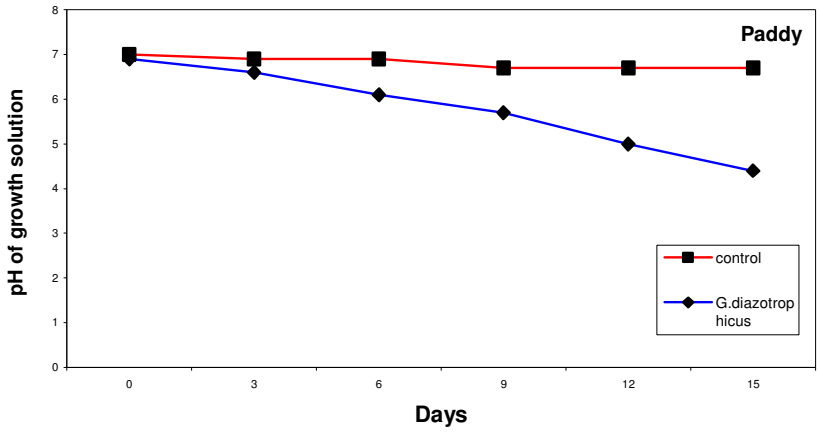


Fig.3. Fluctuations in the pH of growth solution of *G.diazotrophicus* inoculated and uninoculated paddy seedlings



But if 3rd day and 15th day population are compared (Fig2.) T1,T2 and T3 were on par with maximum level of population on 15th day. Hence it was obvious that paddy roots inoculated with *G.diazotrophicus* alone could perform equivalent to roots receiving *G.diazotrophicus* along with IAA or IAA+ VAM. Since *G.diazotrophicus* alone could colonize the roots of paddy there is no need for such growth promoters. If we want to enhance the process we can go for inoculating the culture along with IAA or 2,4-D.

The fluorescent antibody preparations of *G.diazotrophicus* CSR 3 showed brilliant yellow green fluorescence with its corresponding antiserum under fluorescent microscope. It confirmed that the colonies in the enumeration plates were the introduced *G.diazotrophicus* CSR 3 strain.

There was no trace of *G.diazotrophicus* in shoots of paddy in any of the treatments. The same results have been reported in micro-propagated maize and rice seedlings (Sevilla and Kennedy, 2000). The pH of the growth solution of *G.diazotrophicus* inoculated treatments was reduced even up to 4.4 on 15th day (Fig.3).

The reduction of pH may be due to the accumulation of gluconate during the lag and early exponential phase of *G.diazotrophicus* as it oxidises the sucrose (Goodwin and Anthony, 2000). These acids are sources of biotically generated H^+ ions. In the uninoculated control also a pH reduction up to 6.5 on 15th day was observed. The acids in the root exudates of the monocots might have been responsible for this pH reduction.

The colonization of *Gluconacetobacter diazotrophicus*, an endophytic diazotroph in the monocots other than sugarcane, has been clearly evidenced by this study. The population load in roots touched 10^4 cells/g of root on 15th day of inoculation. The inoculation of *G.diazotrophicus* along with growth promoters enhanced colonization, however this isolate alone could record population load almost equal to that of combined treatments. In the growth solution, addition of growth promoters has increased the population of *G.diazotrophicus.* No colonies were observed in shoots of this monocot. The pH of growth solution showed a decline even up to 4.4 in those treatments receiving *G.diazotrophicus*. The colonization of introduced strain in the

monocots was confirmed by performing indirect fluorescent antibody reaction.

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Status of Biofertilizer Industry in India 2006-07

The biofertilizer, carrier based or liquid microbial inoculants are proven essential components in enriching and sustaining the fertility of soil. Biofertilizers have come a long way in India, the journey which was started with Rhizobium has now been diversified and various microbial inoculants/ formulations are being prepared for use in agriculture. These biofertilizers have been incorporated under FCO. Total production and consumption have also shown a phenomenal growth. Also a lot of new formulations have been introduced. State wise and production unit wise break up of different biofertilizers is presented here for year 2006-07. The information presented here is based on the documented information provided by the production units. Although, installed production capacity and actual production could be much more than reported here because out of 139 biofertilizer units in the country details could be collected for 99 units. Compiled information indicates that by the end of March 2007, the country was having total installed production capacity of about 43,495 MT with actual production at 16145 mt. With the increasing awareness about organic farming praxctices and increased demand for biological inputs, biopesticide industry is growing very fast. Almost all biofertilizer production units have also started production of biopesticides. The idle production capacity with biofertilizer industry is being effectively used for biopesticide production. This has resulted into effective utilization of total installed capacity. Over production details of different biofertilizers and other inoculants are presented in Table 1. State wise details of number of production units, total installed capacity, total production of biofertilizers and total production of other inoculants including biopesticides are given in Table 2. Share of different biofertilizers in total production is depicted in Fig. 1. State-wise and commodity wise production details are given in Table 3. State-wise and production units wise details are presented in Table 4.

Table 1. Production of different Biofertilisers and other Microbial formulations during the year 2006-07

Sr.No	Name of Biofertiliser/ inoculant	Production (in tones)
1.	*Azotobacter*	665.66
2.	*Azospirillum*	880.35
3.	*Acetobacter*	55.92
4.	*Rhizobium*	2691.80
5.	Phosphate solubilising Microorganism	3091.89
	Total biofertilizers	**16145.26**
6.	Other inoculants*	20071.30
	Grand Total	**36208.53**

*Others include compost enrichers , PGPRs, and biopesticides

Table 2: State Wise Number of Biofertilizer Production Units, Installed Capacity and Production (MT) in 2006-07

S. No.	States	No. of Units	Installed production Capacity	Total Production (MT)		
				Biofertilizer	Other inoculants	Total
1	Andhra Pradesh	11	5675	4500.6	0	4500.6
2	Assam	5	75	8.4	0	8.4
3	Bihar	1	150	36.9	0	36.9
4	Delhi	1	NA	-	-	-
5	Gujarat	5	1700	1250.6	0	1250.6
6	Goa	1	150	3.5	0	3.5
7	Haryana	1	75	30.2	0.9	31.1
8	Himachal Pradesh	1	75	0.0	0	0
9	Jharkhand	2	220	205.6	0	205.6
10	Karnataka	13	17850	341.6	16255.5	16597.2
11	Kerala	7	1535	261.7	1031.4	1293.1
12	Madhya Pradesh	7	1700	1204.7	0	1204.7
13	Maharashtra	34	3695	2425.9	0	2425.96
14	Mizoram	1	25	1.6	0	1.6
15	Nagaland	1	50	10.6	0	10.6
16	Orissa	3	475	280.5	0	280.5
17	Punjab	2	10	2.0	0	2.0
18	Pondicherry	3	2225	1827.7	12.5	1840.3
19	Rajasthan	3	550	339.7	49.5	389.2
20	Tamil nadu	24	5285	1770.2	2713.2	4483.5
21	Tripura	1	50	23.2	0	23.2
22	Uttar Pradesh	4	250	212.7	0	212.7
23	West Bengal	8	1675	1406.4	0	1406.4
	Total	**139**	**43495**	**16145.2**	**20071.3**	**36208.5**

Fig. 1 Share of different biofertilizers to total production

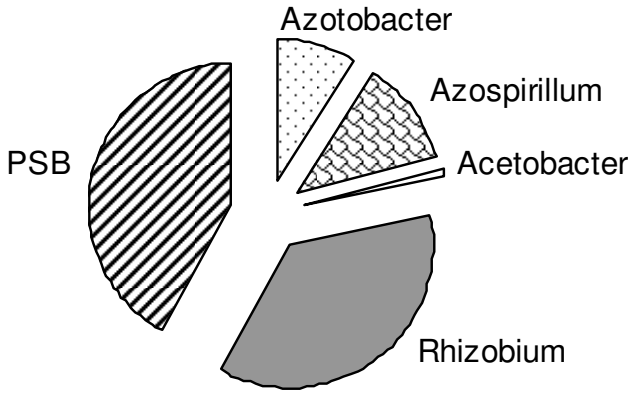

Table 3: State wise status of Biofertiliser Production (tones)

Name of State	**'Biofertiliser Production during the Year 2006-07**							
	Azotobacter	*Azospirillum*	*Acetobacter*	*Rhizobium*	PSB	Total BF	Others	Grand Total
Andhra Pradesh	0	0	0	0	0	4500.619	0	4500.619
Assam	3.9152	0.6034	0	0.388	3.5586	8.465	0	8.4652
Bihar	0	0	0	0	0	36.90	0	36.90
Goa	0	0	0	0	0	3.50	0	3.50
Gujarat	320.748	118.601	46.195	83.339	681.748	1250.63	0	1250.631
Haryana	7.276	0	0	6.556	16.384	30.22	0.948	31.164
Himachal Pradesh	0	0	0	0	0	0	0	0
Jharkhand	0	0	0	0	0	205.62	0	205.62
Karnataka	11.798	49.217	0	12.175	268.445	341.64	16255.583	16597.218
Kerala	26.64	39.362	0	32.45	163.30	261.75	1031.426	1293.178
Madhya Pradesh	127.419	0.50	0	297.63	779.21	1204.76	0	1204.757
Mizoram	0.316	0.252	0	0.444	0.67	1.68	0	1.682
Maharastra	0	0	0	0	0	2425.959	0	2425.96
Nagaland	2.3612	1.5964	0	1.9252	4.77	10.65	0	10.65
Orissa	0	0	0	0	0	280.54	0	280.54
Punjab	0	0	0	2	0	2	0	2
Rajasthan	18.95	0	0	100.49	220.31	339.75	49.50	389.25
Pondicherry	0	64.125	0	1686.66	76.994	1827.78	12.586	1840.365
Tamilnadu	40.79	602.7332	0	365.6302	761.132	1770.29	2713.259	4483.5444
Tripura	14.20	3	0	1.78	4.266	23.25	0	23.25
Uttar Pradesh	91.2502	0.3602	9.732	0.3368	111.1042	212.78	8	212.78
West Bengal	0	0	0	0	0	1406.48	0	1406.48
Total	**665.6636**	**880.3502**	**55.927**	**2591.8042**	**3091.89**	**16145.263**	**20071.302**	**36208.5536**

Table-4: PRODUCTION OF BIOFERTILISER/ORGANIC INPUTS IN INDIA BY VARIOUS UNITS 2006-2007

State	Organization Name	Capacity	GOI Funded	AZOTO.	AZOSP.	ACETO.	RHIZ.	PSB	Total BF	Others	Total
Andhra Pradesh	Mr. Krishan Rao, Krishna Agro Bioproducts Vrikshamitra 9/1/A-1 Road No. 16 IDA Nacharam, Hyderabad	3000	Private						2405.000	0	2405
Andhra Pradesh	Radar Biotech Vijay wara	150	Private						44.250	0	44.25
Andhra Pradesh	Rovar Biotech Vijaywara	150	Private						14.430	0	14.43
Andhra Pradesh	Prathista Industries Ltd. S. Lingotam (V) ,Chotuppal (M) Nalgonda (D) (A.P.)	2000	Private						1805.000	0	1805
Andhra Pradesh	Sri Sai Agro Bio Lab. Cheerumpally, Vijaynagaram (A.P.)	200	GOI funded						171.900	0	171.9
Andhra Pradesh	Varsha Biosciences and Technology 17-1 -382/SN/1/2 ,MNR Colony,Balaji Nagar, Hyderabad (A.P.)	75	Private						11.619	0	11.619
Andhra Pradesh	RSTL, Hyderabad	100							48.420	0	48.42
Andhra Pradesh Total		**5675**							**4500.619**	**0**	**4500.619**
Assam	N.E.Green Tech P.Ltd, Anuradha Complex, Baraum Maidan, Guwahati, Assam	25		0	0	0	0	0	0.000	0	0
Assam	BVFC, Namrup, Dibruganj, Assam	25		3.4152	0.1034	0	0.188	3.3586	7.065	0	7.0652
Assam	Orgaman R & D Division Nehru Park, T.R. Phukan Road, Jorhat	25		0.5	0.5	0	0.2	0.2	1.400	0	1.4
Assam Total		**75**		**3.9152**	**0.6034**	**0**	**0.388**	**3.5586**	**8.465**	0	**8.4652**
Bihar	Association for social Economic Transforamtion, Baurani, Bihar	150							**36.900**	0	36.9
Bihar Total		**150**							**36.90**	0	**36.9**
Goa	Cosme Biotech, Panaji,Goa	150	GOI funded						3.50	0	3.5
Goa Total		**150**							**3.5**	**0**	**3.5**
Gujarat	Gujarat State Cooperative Marketing Fed. Ltd., Ahemdabad	250	GOI funded	0	88.061	0.01	29.317	115.173	232.561	0	232.561
Gujarat	Gujarat State Fertilizers & Chemicals Ltd., Vadodara	600	GOI funded	86.538	23.3	11.615	22.542	133.275	277.270	0	277.27
Gujarat	KRIBHCO- Hazira, Surat	600	GOI funded	167.4	3.95	25.71	21.85	340.4	559.310	0	559.31
Gujarat	CORDET Kalol, Gandhi Nagar	250		66.81	3.29	8.86	9.63	92.9	181.49	0	181.49
Gujarat Total		**1700**		**320.748**	**118.601**	**46.195**	**83.339**	**681.748**	**1250.63**	**0**	**1250.63**

State	Organization Name	Capacity	GOI Funded	AZOTO.	AZOSP.	ACETO.	RHIZ.	PSB	Total BF	Others	Total
Haryana	CCS Haryana Agriculture University, Hisar	75	GOI funded	7.276	0	0	6.556	16.384	30.22	0.948	31.16
Haryana Total		**75**		**7.276**	**0**	**0**	**6.556**	**16.384**	**30.22**	**0.948**	**31.16**
Himchal Pradesh	Sr. Analytical Chemist Laboratory, Shimla	75	GOI funded	0	0	0	0	0	0.00	0	0
Himchal Pradesh Total		**75**		**0**	**0**	**0**	**0**	**0**	**0.00**	**0**	**0**
Karnataka	University of Agril. Sciences, Department of Agril. Microbiology, College of Agriculture, Dharwad- 580 005	50	No	0.623	2.417	0.00	0.685	3.18	6.91	4.814	11.72
Karnataka	West Coast Herbo Chem Ltd., 105/B, Industrial Suburb II Stage, III Cross, Goraguntepalya, Tmukur Road, Bangalore- 560 022	50	No	0	0	0.00	2.68	22.95	25.63	0	25.63
Karnataka	Rhizobium Production Lab., Kotnur, Gulbarga	50	No	2.5	2.5	0.00	4.72	10	19.72	0	19.72
Karnataka	K.C.D.C. Haralakunte, Madiwala Post, Bangalore- 68	16000	No	0	0	0.00	0	0	0.00	15053.00	15053.00
Karnataka	Vital Plant Products, Gowrishankar Estate, Harihalli- 573 129, Via K. Hoskote, Alur TK, Hassan DT	1000	No	0	0	0.00	0	0	0.00	956.294	956.294
Karnataka	Rhizobium Prodn. Lab, Dharwad	25	No	0	0	0.00	0	0	0.00	8	8.00
Karnataka	Rhizobium Lab, Hebbal, Bangalore	75	GOI funded	1.3	0	0	2.59	7.14	11.03	0	11.03
Karnataka	Multiplex Biotech Pvt. Ltd., # 420-A, Peenya Indl. Area, Peenya Ist Stage, Bangalore- 58	400	GOI funded	7.375	44.3	0	1.5	55.175	108.35	211.475	319.825
karnataka	Chaitra Fertilizers & Chemicals (P) Ltd., No. E-1, Sri Krishna Complex, D. Banumaiah Circle, Mysore	200	GOI funded	0	0	0	0	170	170.00	22	192
Karnataka Total		**17850**		**11.798**	**49.217**	**0**	**12.175**	**268.445**	**341.64**	**16255.583**	**16597.218**
Kerala	M/s Agro Biotech Research Centre Ltd., Indl. Area, Poovanthuruthu P.O. Kottayam- 686 012, Kerala	500		21.44	13.5	0.00	32.45	155.3	222.69	200.37	423.06

State	Organization Name	Capacity	GOI Funded	AZOTO.	AZOSP.	ACETO.	RHIZ.	PSB	Total BF	Others	Total
Kerala	Chief Sales Manager Biofertilizer Prodn. Unit, The Fertilizer & Chemicals Travancore, Eloor, Udgyogamandal- 683 501, Kerala	10		0	0	0.00	0	0	0.00	3.91	3.91
Kerala	Plantrich Chemicals & Fertilizers Ltd., Industrial Estate, Manarcad P.O. Kottayam- 686 019, Kerala	25		5.2	5.7	0.00	0	8	18.90	0	18.9
Kerala	The Managing Director Poabs Environtech (P) Ltd., Vilapisala (PO), Peyad, Trivendrum- 695 573, Kerala	500		0	10.081	0.00	0	0	10.08	413.573	423.654
Kerala	Travancore Organic Fertilizer Company, Kangazha (PO), Kottayam- 686 541, Kerala	500	GOI funded	0	10.081	0	0	0	10.081	413.573	423.654
Kerala Total		**1535**		**26.64**	**39.362**	**0**	**32.45**	**163.3**	**261.75**	**1031.426**	**1293.178**
Madhya Pradesh	Nafed Biofertilizer , Indore	500	GOI funded	20.71	0	0	124.67	256.02	401.40	0	401.4
Madhya Pradesh	NFL-Vijaypur, Guna	150	No	32.757	0	0	17.772	73.671	124.20	0	124.20
Madhya Pradesh	Agri Business & Dev. Coop. Bhopal	50		4.9	0	0	10.22	21	36.12	0	36.12
Madhya Pradesh	The M.P. State Agro Ind. Dev. Corpn., Bhopal	500	GOI funded	40.112	0	0	112.825	290.12	443.06	0	443.057
Madhya Pradesh	JNKVV Jabalpur	100		13.73	0	0	18.64	49.9	82.27	0	82.27
Madhya Pradesh	MP Oil Seed Fed. Ltd. Dhar	150		10.91	0	0	12.7	82.6	106.21	0	106.21
Madhya Pradesh	Indore Biotech Input & Res. (P.) Ltd. Indore	250		4.3	0.5	0	0.8	5.9	11.50	0	11.5
Madhya Pradesh Total		**1700**		**127.419**	**0.5**	**0**	**297.627**	**779.211**	**1204.76**	**0**	**1204.757**
Mizoram	State Biofertilizer Production Unit, Nelhbawi, Mizoram	25		0.316	0.252	0	0.444	0.67	1.68	0	1.682
Mizoram Total		**25**		**0.316**	**0.252**	**0**	**0.444**	**0.67**	**1.68**	**0**	**1.682**
Maharashtra	M/s Niku Bio Research Station 613, Nanapeth, Pune (M.S.)	150	GOI funded	0	0	0	0	0	35.05	0	35.05
Maharashtra	Microplex India 36 Mohata Market, Main Road, Wardha	150	Private	0	0	0	0	0	44.18	0	44.18
Maharashtra	Kumar Krishi Mitra Bio Products(I) P Ltd., 917/17, 12 Ganeshwadi, Fergusan Road, , Pune (M.S.)	500	Private	0	0	0	0	0	459.5	0	459.5

State	Organization Name	Capacity	GOI Funded	AZOTO.	AZOSP.	ACETO.	RHIZ.	PSB	Total BF	Others	Total
Maharashtra	Bacterial Section, Agricultural College, Pune (M.S.) Phone (M.S.)	50	Private	0	0	0	0	0	34.94	0	34.939
Maharashtra	Choudhury Agrotech, Sri Devi Complex, Agyaram Devi Chowk, Subhas Road, Nagpur (M.S.)	50	Private	0	0	0	0	0	43.00	0	43.00
Maharashtra	Vaibhav Laxmi Biocontrol Lab, Wardha (M.S.)	75	Private						51.00	0	51.00
Maharashtra	Arun Biofertilisers Near MSEB, Power House Kurundwad, Tal-Shirol, Kolhapur	150	GOI funded	0	0	0	0	0	145.00	0	145.00
Maharashtra	Nomain Agribioproducts,6 Gandharav Apartment, S. No. 38, Erandvana, Near Mehendali Garage Opp Hotel Abhishek, Pune	20	Private	0	0	0	0	0	2.49	0	2.49
Maharashtra	Nilayam Bio-fertilizer Prod. Unit Plot No. 46/40, Mahad Colony Near ITI, Wardha	150	GOI funded	0	0	0	0	0	34.60	0	34.60
Maharashtra	Kisan Agto Chem., Bhartiya Complex, Behind Mundada Hospital, N/o Gujrathi High School, Nanded (M.S.)	50	Private	0	0	0	0	0	1.25	0	1.25
Maharashtra	ELLORA Biotech, 20, Udyogmitra Industrial Estate, Chitegaon, Paithan, Aurangabad (M.S.)	175	Private	0	0	0	0	0	161.50	0	161.50
Maharashtra	K-Fert Lab, 25 First Floor Gurunank Market, Nanded	150	GOI funded	0	0	0	0	0	88.00	0	88.00
Maharashtra	Institute of Natural Organic Agriculture (INORA) , 11 B, Kulkarani Bungalow, Shikshak Nagar, Paud Road, Pune	500	GOI funded	0	0	0	0	0	444.1	0	444.1
Maharashtra	Vasant Dada Sugar Industreis, Manjari (BK), Pune (M.S.)	300	GOI funded	0	0	0	0	0	200.11	0	200.11
Maharashtra	Maharashtra Research and Development Center, 396, Sainik, Santosh Nagar, Bale, Solapur (M.S.)	150	GOI funded	0	0	0	0	0	118.33	0	118.33
Maharashtra	BAIF Development Res. Foundation, Bhartiya Agro Industries Foundation, Central Res. Station, Urulikanchan, Pune (M.S.)	150	GOI funded	0	0	0	0	0	2.00	0	2.00

State	Organization Name	Capacity	GOI Funded	AZOTO.	AZOSP.	ACETO.	RHIZ.	PSB	Total BF	Others	Total
Maharashtra	Envrionmental Protection Research Foundation, ' Arundhati' Vishrambag, Sangali (M.S.)	150	GOI funded	0	0	0	0	0	76.5	0	76.5
Maharashtra	Bioira Technologies, B-15 Corporation Building, First Floor, Link Road, Nagpur (M.S)	75		0	0	0	0	0	50.50	0	50.50
Maharashtra	Govinda Agro Tech Pvt. Ltd., Opposite Agyaram Devi Mandir, Bus Stand Road, Nagpur (M.S.)	150	GOI funded	0	0	0	0	0	139.40	0	139.40
Maharashtra	OM.Agro Org, A-76 MIDC, Yavatamal	250	Private	0	0	0	0	0	165.00	0	165.00
Maharashtra	Deenee Chemicals Pvt. Ltd., 37/9, MIDC Road, Padoli, Chandrapur (M.S.)	150	GOI funded	0	0	0	0	0	3.25	0	3.25
Maharashtra	Sahakar Maharishi Shankarrao Mohite Patil,Sahakari Sakhar Karkhane Ltd. Shankarnagar, Akluj (M.S.)	150	GOI funded	0	0	0	0	0	126.26	0	126.26
Maharashtra Total		**3695.00**		**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**2425.959**	**0.00**	**2425.96**
Nagaland	Biofert Lab, Medziphema	50	GOI funded	2.3612	1.5964	0	1.9252	4.77	10.65	0	10.65
Nagaland Total		**50**		**2.3612**	**1.5964**	**0**	**1.9252**	**4.77**	**10.65**	**0**	**10.65**
Orissa	Orissa A.I.C.Ltd., BBSR.	75	Private	0	0	0	0	0	15.57	0	15.57
Orissa	Deputy Director of Agril., BBSR	150	GOI funded	0	0	0	0	0	29.97	0	29.97
Orissa	Maa Kanak Biofertilizer, BBSR	250	Private	0	0	0	0	0	235.00	0	235.00
Orissa Total		**475**		**0**	**0**	**0**	**0**	**0**	**280.54**	**0**	**280.54**
West Bengal	Deptt. of Agril. West Bengal	75		0	0	0	0	0	3.58	0	3.58
West Bengal	B.C.K.V.,LakeHall Campus,Kalyani	150		0	0	0	0	0	146.45	0	146.45
West Bengal	B.C.K.V.,Mohanpur	75	GOI funded	0	0	0	0	0	27.43	0	27.43
West Bengal	Nitrofix Laboratories, Kolkatta	150	Private	0	0	0	0	0	76.00	0	76.00
West Bengal	Vivekand Instt. of Biotechnology, 24-Pargansa, Kolkatta	75	GOI funded	0	0	0	0	0	73.86	0	73.86
West Bengal	Excel Biotech Pvt. Ltd., 24-Paragansa, Kolkotta	1000	Private	0	0	0	0	0	766.00	0	766.00
West Bengal	Lila Agrotech	375	Private	0	0	0	0	0	313.16	0	313.16
West Bengal Total		**1900**		**0**	**0**	**0**	**0**	**0**	**1406.48**	**0.00**	**1406.48**

State	Organization Name	Capacity	GOI Funded	AZOTO.	AZOSP.	ACETO.	RHIZ.	PSB	Total BF	Others	Total
Jharkhand	Birsa Agril, University, Ranchi	20	Private	0	0	0	0	0	5.62	0	5.62
Jharkhand	Swarnarekha Enterprises, Ranchi	200	Private	0	0	0	0	0	200.00	0	200.00
Jharkhand Total		**220**		**0**	**0**	**0**	**0**	**0**	**205.62**	**0**	**205.62**
Punjab	Punjab Agriculture University, Ludhiana	10	No	0	0	0	2	0	2.00	0	2.00
Punjab Total		**10**		**0**	**0**	**0**	**2**	**0**	**2.00**	**0**	**2**
Rajasthan	Rhizobium Production Lab., Durgapura, Jaipur	50	No	4.95	0	0	4.49	9.31	18.75	0	18.75
Rajasthan	Nafed Biofertilizer SPL-80 RIICO Industrial Area Bharatpur (Rajasthan)	500	GOI funded	14	0	0	96	211	321.00	49.5	370.5
Rajasthan Total		**550**		**18.95**	**0**	**0**	**100.49**	**220.31**	**339.75**	**49.5**	**389.25**
Tamil Nadu	Monarch Biofertilizers & Res. Centre, No. 12, SIDCO Indl. Area, Thiramazhisai Chennai- 602 107	10		1.74	0	0	0	1.465	3.21	0.69	3.895
Tamil Nadu	M/s Elbitec Innovations Ltd, 46 & 48, 2nd Floor, Masilamani Road, Balajinagar, Chennai- 600 014	100	No	0	20.4	0	0	45.2	65.60	30.4	96
Tamil Nadu	The Chief Manager-Bio Products, Madras Fertilizers Ltd., Manali, Chennai- 600 068	300	GOI funded	0	0	0	0	0	0.00	228.2	228.2
Tamil Nadu	The Agricultural Chemist Biofertilizer Produ. Unit, Jamal Mohd. College Post Khajamalai Trichy- 620 020, Tamil nadu	300	GOI funded	0	104.22	0	43.848	78.4074	226.48	0	226.4754
Tamil Nadu	The Agricultural Chemist Biofertilizer Prodn. Unit Seelanaickenpatty Salem- 636 201, Tamilnadu	400	GOI funded	0	142.26	0	59.33	113.992	315.58	0	315.582
Tamil Nadu	The Agril. Chemist Biofertilizer Prodn. Unit Kudumianmalai- 622 104, Pudukottai Dist. (Tamilnadu)	300	No	0	0	0	0	0	0.00	252.166	252.166
Tamil Nadu	The SIMA Cotton Dev & Res. Assn. "Shanmukha Manram", P.B.No. 3871, Race Course, Coimbutore- 641 018	100	No	0	3.98	0	7.85	42.78	54.61	0	54.61
Tamil Nadu	M/s T. Stanes & Co. Ltd. 8/23-24, Race Course Rd, Coimbatore- 641 018	500	No	30	0	0	200	160	390.00	110	500.00

State	Organization Name	Capacity	GOI Funded	AZOTO.	AZOSP.	ACETO.	RHIZ.	PSB	Total BF	Others	Total
Tamil Nadu	Agril. Chemist Biofertilizers Prodn. Unit, Ramanathapuram R.T.O. Office Road, Collectorate Post, Ramanathapuram- 623 503	400		0	168.696	0	25.094	116.485	310.28	0	310.275
Tamil Nadu	M/s Jeypee Biotechs 25, Chinniah School Street, Virudhunagar- 626 001, Tamilnadu	75		8.6	21.8	0	3.36	24.6	58.36	0	58.36
Tamil Nadu	Agriculture Chemist Biofertilizer Prodn. Unit, Dept. of Agriculture, Govt. of TamilNadu, Gundusalai Road, Sommandalam, Cuddalore- 607 001	300		0	0	0	0	0	0.00	274.503	274.503
Tamil Nadu	Agriculture Chemist Biofertilizer Prodn. Unit, Dept. of Agriculture, Govt. of TamilNadu, Sakkottai, Thanjavur- 612 401	300		0	135.3772	0	25.8482	95.7026	256.93	0	256.928
Tamil Nadu	Tamil Nadu Cooperative Sugar Federation Ltd., 474, Anna Salai, Periyar EVR Bldg., 5th Floor Nandanam, Chennai- 600 035	400		0	0	0	0	76	76.00	228	304
Tamil Nadu	OMEGA Ecotech Products India Pvt. Ltd. No.- 63-A, Bharathi Nagar Main Road, Bharathi Nagar, Ganapathy, Coimbatore- 641 006	500		0.45	6	0	0.3	6.5	13.25	412.3	425.55
Tamil Nadu	Innova Agrotech (P) Ltd., 2/527-1, East Street, Kulloorchanadai, Virudhunagar- 626 001	600		0	0	0	0	0	0.00	508	508
Tamil Nadu	R. Sundar, 25, ChinniahSchool Street, Virudhunagar- 626 001	700	GOI funded	0	0	0	0	0	0.00	669	669.00
Tamil Nadu Total		**5285**		**40.79**	**602.7332**	**0**	**365.63**	**761.132**	**1770.29**	**2713.259**	**4483.5444**
Tripura	Regional Biofertilizer Production Centre, Tripura	50		14.2	3	0	1.78	4.266	23.25	0	23.246
Tripura Total		**50**		**14.2**	**3**	**0**	**1.78**	**4.266**	**23.25**	**0**	**23.25**
Uttar Pradesh	Motil Lal Nehru Farmers Training Institute, Phulpur, Allahabad	250	GOI funded	91.2502	0.3602	9.732	0.3368	111.1042	212.78	0	212.78
Uttar PradeshTotal		**250**		**91.2502**	**0.3602**	**9.732**	**0.3368**	**111.1042**	**212.78**	**0**	**212.78**

State	Organization Name	Capacity	GOI Funded	AZOTO.	AZOSP.	ACETO.	RHIZ.	PSB	Total BF	Others	Total
Pondicherry	ROM Vijay Biotech No. 5, Cuddalore Main Road, Kanniakoil Pondicherry	150		0	63.75	0	6.25	76	146.00	0	146.00
Pondicherry	M/s. Golulam Enterprises, No. 36, Sri Ram Nagar, Cuddalore Pondy Main Road, Kaniakoil Puducherry-607 402	2000		0	0.375	0	1680.41	0.994	1681.78	0	1681.78
Pondicherry	M/s PASIC, BF Prodn. Centre Agro House Agriculture Complex, Thattanchavady, Puducherry- 605 009	75		0	0	0	0	0	0.00	12.586	12.586
Pondicherry Total		**2225**		**0**	**64.125**	**0**	**1686.66**	**76.994**	**1827.78**	**12.586**	**1840.365**
Grand Total	**Total 99 Nos**	**43720.00**		**665.66**	**880.35**	**55.93**	**2591.80**	**3091.89**	**16145.25**	**20063.30**	**36208.552**

Research Notes / News

Inheritance of promiscuous nodulation in soybean - Soybean symbiotically associates with rhizobia to form root nodules that fix nitrogen thereby dispensing with the need for application of nitrogenous fertilizers. Two types of rhizobial inoculants, namely B. japonicum and Bradyrhizobium spp. (cowpea-type), are capable of establishing this symbiotic relationship. Genetic variation for the response to cowpea-type rhizobia has been reported with two responses observed: (i) promiscuous, which forms functional nodules capable of nitrogen fixation after cowpea-type rhizobial inoculation and has green leaves without nitrogen fertilization; and (ii) nonpromiscuous, which forms nonfunctional or no nodules after cowpea-type rhizobial inoculation and has yellow leaves without nitrogen fertilization. Information on the inheritance of the promiscuous trait is very limited. The trait was initially observed in the cultivar Hernon 147 (Corby, 1967) that had been released in 1942 for commercial fodder production in Zimbabwe (Gwata and Nziramasanga, 2001). This observation suggested that Hernon 147 was segregating for the promiscuous trait. In a study conducted in uninoculated sandy soils in the field, segregation was observed in a cross between promiscuous and nonpromiscuous genotypes with no genetic analysis reported (Kueneman et al., 1984). Inheritance studies using ureide accumulation (Kueneman et al., 1984) and acetylene reduction (Chowdhury and Doto, 1981) screening techniques for promiscuous nodulation also obtained inconclusive results. Based partly on these observations, it was concluded that promiscuous nodulation in soybean was probably regulated by a few major genes (Kueneman et al., 1984). The objective of this study was to determine the inheritance of promiscuous nodulation using leaf color as a measure of [N.sub.2] fixation effectiveness.
(Source-: Gwata, et al 2005, Crop Science)

Studies on VA-Mycorrhizal Fungi (VAM) as a Potential Biofertilizer in an Acid Alfisol of Northwestern Himalayas - Experiments aimed at the development of soil test based and yield target oriented fertilizer recommendations for rainfed maize-wheat and soybean-wheat cropping systems, consisting of combined application of fertilizer NPK, FYM and VAM, were carried out under both controlled as well as field conditions. At first instance, VAM resource survey aimed at screening out efficient local VAM strains was carried out through mycorrhizal analysis of 600 soil samples collected from various crop rhizospheres in wet temperate zone of Himachal Pradesh (India), located in North-Western Himalayas. The crops covered were maize, wheat, oats, berseem, soybean, Frenchbean, onion, potato, garlic, chilies, citrus, apple, pear, peach etc. Maximum spore count (110-185 spores/250 g soil) was recorded under vegetable field soils. In VAM root infectivity studies conducted in green house with selected soils as VAM inoculants, highest infectivity in maize (38%) and soybean (40%) was noticed with use of VAM inoculant from vegetable fields. It is concluded from above that vegetable field soil may be the best inoculant for mycorrhizal biofertilizer. In most soils/crops, *Glomus* spp. of VAM was found to be

predominant. Field experiments (2001-2004) aimed at evolution of VAM biotechnology, comprised of 12 treatments (laid out in RBD with 3 replications) viz. combinations of 3 VAM cultures (TERI,IARI & local) with 2 levels of phosphorus (50 & 75 % of recommended), each culture alone,100 % recommended P_2O_5 as SSP, farmers' practice and control. Relevant soil test crop response based fertilizer models were used to calculate nutrient (NPK) doses for targets of 25 q in soybean and 30 q each in case of maize and wheat per hectare. In above experiments, integrated use of 3 VAM culture(s) and 75% of soil test crop response (STCR) concept/yield target concept recommended P_2O_5 dose as single super phosphate (SSP) was almost equal to 100% P_2O_5 dose as SSP in respect of grain/seed yield and various other supporting parameters. It can be inferred from above that the use of VAM or mycorrhizal biofertilizer can economize soil test based fertilizer phosphorus dose by 25 per cent under the above situation. In above experiments, soil available NPK status and soil organic carbon levels were also at par with that under 100% P_2O_5 dose as SSP. It is inferred from above study that VAM has the potential to improve crop productivity and soil fertility in P-deficient acid soils.
(source – Suri et al, 2006, Presses scintifiques du CNRC, July 9-15, 2006,)

Effects of inoculation with *Azospirillum brasilense* on chickpeas (*Cicer arietinum*) and faba beans (*Vicia faba*) under different growth conditions - The effects of the inoculation of chickpeas (*Cicer arietinum* L.) and faba beans (*Vicia faba* L.) with *Azospirillum brasilense* strain Cd were studied under different growth conditions. In greenhouse experiments with both legumes, inoculation with *A. brasilense* significantly enhanced nodulation by native rhizobia and improved root and shoot development, when compared with non-inoculated controls. Moreover, the bacterial treatment was shown to significantly reduce the negative effects on plant growth caused by irrigation with saline water. In field experiments, inoculation of chickpeas with *A. brasilense* peat-based inoculants also resulted in a significant increase in nodulation, root and shoot growth, and crop yield as compared with non-inoculated controls.
(Source - Hamaoui et al 2001 INRA, EDP Sciences 2001)

Initiation of root growth stimulation by *Azospirillum lipoferum* CRT1 during maize seed germination - In the present study, an experiment was carried out to study the effect of density of *Azospirillium* inoculum and period of contact with seed (maize) on growth of root surface area. Maize seeds were inoculated with a commercial inoculants containing 1.3×10^7 *Azospirillium lipoferum* CRT1 cells. After 24 or 48 hrs, bacterium was washed from the seed surface. Washed and unwashed seeds were planted in pots containing perlite and grown for 28 days under greenhouse conditions. Irrespective of the density of *Azospirillum* at planting, the number of these bacteria at the end of the experiment were similar ($1.9\text{-}8.0 \times 10^7$ bacteria·plant^{-1}). However, comparison of root surface area of the plants were different depending on the period of contact between seeds and the density of the inoculum. Twenty-four hours of contact was not sufficient to increase root growth surface areas. Contact for 48 h resulted into increase in root surface area comparable with those measured after a continuous contact. These results showed that in order to promote maize root surface area, an optimal density of *Azospirillum* is not required during the whole cultural cycle.

This optimal density is indispensable only up to the emergence of the radicle.
(Source:- Jacoud et al, 1999, Can.J.Microbiol,45(4) : 339-342)

Short term effects of *Glomus claroideum* and *Azospirillum brasilense* on growth and root acid phosphatase activity of *Carica papaya* L. under phosphorus stress - Experiment was carried out to determine the effect of *Glomus claroideum* (Gc), and plant growth promoting rhizobacterium *Azospirillum brasilense* strain VS7 [Ab]) on root phosphatase activity and seedling growth of *Carica papaya* L. cv. Red Maradol under low P conditions. There were four treatments colonization with (1) Gc, (2) Ab, (3) Gc+Ab, and (4) non-inoculated seedlings. Plants were planted in a coarse-sand : sandy-loam substrate under P-limitation (11mg P ml^{-1}), supplied with a modified Long Ashton Nutrient Solution. Treatment Gc+Ab inoculation showed greater total dry matter and leaf area than non-colonized plants. Gc-inoculated plants had greater leaf area than non-colonized plants. GC inoculated plants had greater leaf area than non colonized plants. There was a non-significant effect on stem relative growth rate with Gc and Gc+Ab plants. Mycorrhizal colonization enhanced the bacterial population 3.4-fold in the Gc+Ab treatment compared with the population quantified in Ab treatment. Soluble and extractable root acid phosphatase activity (RAPA) was higher in Gc inoculated plants.
(Source:- Rev Latinoam Microbiol 2002; 44 (1): 31-37)

Effect of VAM fungi and bacterial biofertilizers on mulberry leaf quality and silkworm cocoon characters under semiarid conditions - The influence of VAM fungi and bacterial biofertilizer (BBF) with 50% reduction in the recommended dose of (N and P) chemical fertilizers on leaf quality traits of mulberry variety (S-13) and its impact on silkworm (PM-NB4D2) growth and cocoon characters were studied under semi-arid conditions. Four different treatments were imposed i.e., T1: Control (only 100% NPK); T2: VAM (50% cut in P); T3: BBF (50% cut in N) and T4: BBF and VAM (50% cut in N and P). The results revealed that reduction (50%) in the dose of chemical fertilizers in T2, T3 and T4 did not affected the leaf quality traits or cocoon parameters, this may be due to the effect of microbial inoculants in these treatments, which had efficiently regulated the normal growth, metabolism and physiological activity in plants. Among the three biofertilizer treatments, leaf quality, silkworm growth and cocoon parameters were found improved in T4 and was on par with T1 control. The dual inoculation (T4) proved economical and beneficial with regard to saving of 50 % cost of chemical fertilizers and improvement in soil fertility, leaf quality and cocoon parameters, thus this technology can be recommended to sericulture farmers of semi-arid conditions.
(Source:- Ram Rao et al Caspian, 2007, J. Env. Sci., Vol. 5 No.2 pp. 111-117)

Effect of urea, blue green algae and *Azolla* on nitrogen fixation and chlorophyll accumulation in soil under rice - Nitrogen fixing potential in terms of acetylene reducing activity (ARA) and biomass accumulation (in terms of chlorophyll) were investigated using surface and below-surface soil cores, collected from rice fields 45 and 90 days after transplanting (DAT). Treatments included different levels of urea (30, 60, 90 and 120 kg N ha^{-1}) in combination with inoculation using blue green algae (BGA) and *Azolla* biofertilizers. Application of biofertilizers brought about a significant enhancement in chlorophyll accumulation and

nitrogenase activity, when measured 45 DAT. Positive effects in below-surface soil cores, on both these parameters as a result of application of biofertilizers further emphasized their contribution to the N economy of rice fields. Plots treated with 30 and 60 kg N ha^{-1} along with biofertilizers exhibited the highest percentage increase in terms of algal biomass and ARA, both in surface and below-surface soil cores at 45 DAT. A definite need to examine critically the nature and metabolic activities of below-surface microflora is highlighted through our investigation (Nayak et al 2004, Biology and Fertility of Soils 40 (1) : 67-72)

Comparative Performance of Three Carrier Based Blue Green Algal Biofertilizers for Sustainable Rice Cultivation – Nitrogen fixing cyanobacteria or blue green algae are ecologically significant inputs in rice cultivation in the tropics. Field experiments were conducted to compare the efficiency of two newly developed carrier based blue green algal (BGA) biofertilizers (wheat straw and multani mitti), with the traditional soil based BGA biofertilizer, on the grain yield of rice for a period of three years. Treatments included five levels of nitrogenous fertilizer urea and their interaction with the three types of BGA biofertilizers, on the grain yield of rice variety 'PNR 381'. Highest grain yields were obtained with the application of multani mitti based biofertilizer along with 90 kg N/ha, although maximum percent increase in yield over control (37.97%), when applied along with 60 kg N/ha. The straw based and soil based biofertilizer treatments showed highest yields when supplemented with 90 and 120 kg N/ha, respectively. This investigation clearly emphasizes the need for supplementing chemical fertilizerswith the newly developed BGA biofertilizers in rice cultivation for maximizing crop productivity, reducing inputs of chemical fertilizers and sustaining soil fertility (Source - Journal of Sustainable Agriculture, Volume 30, (2), 2007 , pp. 41-50).

An Improved Technique for measurement of nitrogen fixation by Blue Green Algae and Azolla using moist soil cores from rice - A modified technique for measurement of nitrogen fixation by blue green algae and *Azolla* sp. using intact, moist soil cores was developed for use in field studies in which chemical fertilizers, blue green algae and *Azolla* biofertilizers had been used in association with a rice crop. This method involves collection of fresh and moist soil cores (0–30 mm) using a soil auger, incubation with 10% acetylene in airtight glass vials under field conditions for three hours, and measurement of the ethylene produced using a gas chromatograph. Experiments carried out over a period of three consecutive years revealed that the estimates of nitrogen fixation were comparable with data of other researchers obtained through the use of soil water columns, sophisticated chambers and automated sampling devices. This simplified technique, therefore, can provide rapid and reliable measurements of nitrogen fixation in field experiments. (Source – Prasanna et al Experimental Agriculture (2003), 39: 145-150)

Growth, Nutritional, and Yield Parameters of Wetland Rice as Influenced by Microbial Consortia Under Controlled Conditions - A pot culture experiment was undertaken to investigate the interactive effect of microbial inoculants—blue-green algae (BGA), Azospirillum , phosphate-solubilizing bacterium (PSB) Pseudomonas striata , vesicular-arbuscular mycorrhizal fungus (VAMF), and Azolla , individually and in combination with chemical fertilizers

and/rock phosphate on the wetland rice (Oryza sativa L.) cultivar `PNR 381'. The microbial inoculants positively interacted with one another, resulting in significant improvement in yield and nutritional parameters. Application of biofertilizers also substantially improved soil (peat) fertility status by increasing the nitrogen (N), phosphorous (P), and organic carbon content. The biofertilizer combination BGA + PSB + VAMF + Azospirillum was best for improved growth and yield traits, nutritional status of rice, and sustained soil (peat) fertility. Azolla , which is a highly competitive organism, suppressed the growth of the other four inoculants. The inclusion of VAMF and PSB was observed to significantly improve the zinc nutrition of the paddy and the P utilization of the applied rock phosphate. A basal dose of nitrogenous fertilizer was essential for deriving maximum benefits from applied inoculants, thereby underlying the supplementary/ complementary role of biofertilizers in efficient nutrient management in agriculture.
(Source – Muthukumaravel et al Journal of Plant Nutrition, Volume 29, Number 5, 2006 , pp. 857-871)

Use of bio-fertilizer (*Azospirillum*) in onion - A field experiment was conducted in Jaipur, Rajasthan, India, during the rabi seasons of 1999-2000, 2000-01 and 2001-02 to find out the effects of nitrogen and *Azospirillum brasilense* on the yield of onion cv. RO-1 bulbs. Treatment consisted of four levels of nitrogen (no nitrogen, 50%, 75% and 100% of recommended rate of nitrogen (i.e. 100 kg/ha)) and two levels of biofertilizer (with and without *Azospirillum brasilense*). Application of nitrogen fertilizer and biofertilizer had significant independent effects on yield of onion bulbs. Significant and highest yield (336.5 q/ha) was recorded with 100 kg N/ha, which was at par with 75 kg N/ha (328.4 q/ha). The improvement in bulb yield was 14.1 and 11.4%, respectively, over the control treatment (without nitrogen application). *Azospirillum* inoculation recorded a higher bulb yield of onion (323.7 q/ha) over the control (310.9 q/ha). A slight increase in available nitrogen content in soil was observed with increasing nitrogen rate in all the samplings. With the application of *Azospirillum*, an increasing trend of available nitrogen content of soil for all the samplings was found and a significant difference was noticed in the 2nd sampling of third year and 3rd sampling of first year only, and the increase in available nitrogen was 10.97 and 11.14 kg/ha, respectively. Treatment with 100 kg N/ha + *Azospirillum brasilense* inoculation recorded the highest net profit per hectare (Rs. 32 791.95) which was at par with 75 kg N/ha + *Azospirillum brasilense*
(Source – Yadav et al , 2004 Haryana Journal of Horticultural Sciences, Vol. (3/4) 281-283)

Effect of biofertilizer on physico-chemical characteristics of guava (*Psidium guajava*) fruit. - A field experiment was conducted to study the effect of 2 free-living N fixers (*Azotobacter* and *Azospirillum*) and 3 phosphate-solubilizers [vesicular-arbuscular mycorrhiza (*Glomus mosseae*), microphos and phosphobactrin], on fruit physico-chemical characteristics of 'L 49' guava (*Psidium guajava*). Biofertilizers were applied at 200 g/tree/year charged with 20 kg farmyard manure in a randomized block design with 4 replications and 2 plants/unit. Application of P solubilizers significantly influenced fruit weight of guava over the control (128.5 g). Highest fruit weight (154.5 g), fruit length (4.27 cm), and fruit diameter (4.68 cm) were obtained with the application of phosphobactrin. Application of vesicular-arbuscular mycorrhiza gave highest total

soluble solid (10.1 °Brix) and total soluble solid:acid ratio (15.78). Application of P-solubilizers significantly influenced vitamin C content of guava over the control (140.0 mg/100 g). Highest vitamin C (ascorbic acid) content (151.8 mg/100 g) was recorded with vesicular-arbuscular mycorrhiza, which was, however, on a par with the application of phosphobactrin (149.3 mg/100 g) and microphos (147.5 mg/100 g). When grouped together, P solubilizers were found to have more beneficial effect on physico-chemical parameters of guava than that of N fixers under acid soil condition of Chotanagpur region. (Source – Dey et al 2005, Indian Journal of Agricultural Sciences, 2005, 75 (2) : 95-96).

Nodule induction in non-legumes by rhizobia - Although nitrogenous fertilizers benefit plants, they also cause pollution as reduced nitrogen may lead to acidification through nitrification, if significant leaching of nitrates occurs. Hence, systems capable of fixing nitrogen will exploit the environment less and may even contribute positively. Such systems appear to be symbiosis or loose associations of the host plants with various diazotrophs. Approximately 170 million tonnes nitrogen is contributed annually through biological nitrogen fixation by many bacteria and some actinomycetes in association with legumes and non-legumes. Extending legume-*Rhizobium* symbiosis to non-legumes will significantly increase the amount of available nitrogen and thereby biomass of several cereal and other non-legume crops. Both the genetic and non-genetic approaches could be used to express *hac* genes in monocots like rice, maize, wheat and sorghum. The latter techniques involve use of specific rhizobia that show loose association with roots of non-legume or enzymatic removal of cell wall of root-cells that facilitates rhizobial infection into the root cortex or treatment of seedling-roots with phytohormones as 2,4-D, NAA, IBA or cytokinins along with inoculation by *Azorhizobium caulinodans* or treatment with the signal compounds (flavonoids), that are involved in nodule development and colonization by rhizobia. Rhizobia may invade the roots of non-legumes by specialized crack entry at the ruptured corners of the roots that occur due to emerging lateral roots. The nitrogen fixation is attributed to presence of *nod*, *nif* and *fix* genes that code for nitrogenase complex and other accessory proteins needed for proper functioning of the nitrogenase complex. A feeble nitrogen fixation was observed in paranodules of non-legumes since they lack the important O_2 scavenger, leghaemoglobin. Therefore, other possible sites of colonization as xylem vessels should be studied and possible techniques of transfer and expression of this gene in non-legumes should be pursued. Though induced nodulation in non-legumes holds possibility of extending rhizobial symbiosis and biological nitrogen fixation to cereals, this area remains to be sheathed by numerous similar cascades of reactions, present in legumes, to be deciphered in non-legumes.
(Source - Kalia and Gupta 2002 Indian Journal of Microbiology, 42(3) : 183-193)

Non-rhizobial nodulation in legumes - Legume - Rhizobium associations are undoubtedly form the most important N_2-fixing symbiosis and play a subtle role in contributing nitrogen and maintaining/improving soil fertility. A great diversity in the rhizobial species nodulating legumes has been recog-nized, which belongs to a subgroup of proteobacteria covering the genera, *Rhizobium, Sinorhizobium* (renamed as *Ensifer*), *Mesorhizobium, Bradyrhizobium* and *Azorhizobium*. Recently, several non-rhizobial species,

belonging to a and b subgroup of Proteobacteria such as *Methylobacterium, Blastobacter, Devosia, Phyllobac-terium, Ochro-bactrum, Agrobacterium, Cupriavidus, Herbaspirillum, Burkholde-ria* and some g-Proteobacteria have been reported to form nodules and fix nitrogen in legume roots. The phylogenetic relationship of these non-rhizobial species with the recognized rhizobial species and the diversity of their hosts are discussed in this review.
(Source - Balachander et al 2007, Biotechnology and Molecular Biology Reviews Vol. 2 (2), pp. 049-057)

Tracing non-legume orthologs of legume genes required for nodulation and arbuscular mycorrhizal symbioses – Most land plants can form a root symbiosis with arbuscular mycorrhizal (AM) fungi for assimilation of inorganic phosphate from the soil. In contrast, the nitrogen-fixing root nodule symbiosis is almost completely restricted to the legumes. The finding that the two symbioses share common signaling components in legumes suggests that the evolutionarily younger nitrogen-fixing symbiosis has recruited functions from the more ancient AM symbiosis. The recent advances in cloning of the genes required for nodulation and AM symbioses from the two model legumes, Medicago truncatula and Lotus japonicus, provide a unique opportunity to address biological questions pertaining to the evolution of root symbioses in plants. Here, we report that nearly all cloned legume genes required for nodulation and AM symbioses have their putative orthologs in non-legumes. The orthologous relationship can be clearly defined based on both sequence similarity and microsyntenic relationship. The results presented here will serve as a prelude to the comparative analysis of orthologous gene function between legumes and non-legumes, and will facilitate our understanding of how gene functions and signaling pathways have evolved to generate species- or family-specific phenotypes.
(Source – Zhu et al 2006, J. Genetics)

Production of rhizobia biofertilizers using baker's yeast effluent and their application to Leucaena leucocephala - Industrial baker's yeast effluent (BYE) was experimented on as a culture medium for growth and biomass production of six fast-growing rhizobia strains. Diluting the effluent with distilled water was necessary to maximize bacterial biomass production. The addition of phosphate buffer, ammonium chloride or trace-elements did not improve the final biomass yield of tested micro-organisms. Rhizobial growth and biomass on the effluent were comparable to traditional yeast extract mannitol medium (YEM). The Rhizobium spp. biomass, produced using either YEM or BYE, was evaluated as inoculum for Leucaena leucocephala (Lam.) de Wit in a pot experiment. No significant differences were reported in respect of legume nodule and growth parameters. Simultaneous inoculation with rhizobia and a group of associative diazotrophs supported better nodulation and nitrogenase activity. (Source – Sayeda et al 2005, Archives of Agronomy and Soil Science, 51, (6) :. 605-617)

Ascending Migration of Endophytic Rhizobia, from Roots to Leaves, inside Rice Plants and Assessment of Benefits to Rice Growth Physiology - Rhizobia, the root-nodule endosymbionts of leguminous plants, also form natural endophytic associations with roots of important cereal plants. Despite its widespread occurrence, much remains unknown about colonization of cereals by rhizobia. We examined the infection, dissemination, and colonization of healthy rice plant tissues by four species of *gfp*-tagged rhizobia and their influence

on the growth physiology of rice. The results indicated a dynamic infection process beginning with surface colonization of the rhizoplane (especially at lateral root emergence), followed by endophytic colonization within roots, and then ascending endophytic migration into the stem base, leaf sheath, and leaves where they developed high populations. In situ CMEIAS image analysis indicated local endophytic population densities reaching as high as 9×10^{10} rhizobia per cm^3 of infected host tissues, whereas plating experiments indicated rapid, transient or persistent growth depending on the rhizobial strain and rice tissue examined. Rice plants inoculated with certain test strains of *gfp*-tagged rhizobia produced significantly higher root and shoot biomass; increased their photosynthetic rate, stomatal conductance, transpiration velocity, water utilization efficiency, and flag leaf area (considered to possess the highest photosynthetic activity); and accumulated higher levels of indoleacetic acid and gibberellin growth-regulating phytohormones. Considered collectively, the results indicate that this endophytic plant-bacterium association is far more inclusive, invasive, and dynamic than previously thought, including dissemination in both below-ground and above-ground tissues and enhancement of growth physiology by several rhizobial species, therefore heightening its interest and potential value as a biofertilizer strategy for sustainable agriculture to produce the world's most important cereal crops. (Source – Chi et al 2005 Applied and Environmental Microbiology, 71(11) : 7271-7278)

Phylogenetic assignment and mechanism of action of a crop growth promoting *Rhizobium radiobacter* strain used as a biofertiliser on graminaceous crops in Russia - The taxonomic position of "*Agrobacterium radiobacter* strain 204," used in Russia as a cereal crop growth promoting inoculant, was derived by a polyphasic approach. The phenotypic analyses gave very similar biochemical profiles for strain 204, *Rhizobium radiobacter* NCIMB 9042 (formerly the *A. radiobacter* type strain) and *R. radiobacter* NCIMB 13307 (formerly the *Agrobacterium tumefaciens* type strain). High percentage similarities, above the species separation level, were observed between the 16S rRNA, *fusA* and *rpoB* housekeeping gene sequences of these three strains, and the genomic DNA–DNA hybridisation of strain 204 against the type strain of *R. radiobacter* NCIMB 9042 was over 70%. Strain 204 is not phytopathogenic and it does not fix atmospheric N_2 or form a physical association with the roots of barley. Strain 204 culture and culture supernatant stimulated the rate of mobilisation of seed reserves of barley in darkness and promoted its shoot growth in the light. Gibberellic acid (GA) concentration was 1.3 µM but indole acetic acid was undetectable (<50 nM) in cultures of strain 204. It is concluded that strain 204 is phenotypically and genotypically very similar to the current *R. radiobacter* type strain and that the mechanism of its effect on growth of cereals is via the production of plant growth promoting substances. GA is likely to play an important role in the strain 204 stimulation of early growth of barley. (Source – Humphry et al 2007 Antonie van Leeuwenhoek 91(2) : 105-113)

Seminar/ Conference and Symposium News

20th North American Symbiotic N_2 Fixation Conference - The 20th North American Symbiotic N_2 fixation conference was organized during 10-14th July 2007 in the Marquette University Alumni Memorial Union and the adjoining Weasler Auditorium, Milwaukee, Wisconsin. The important topics of discussion and presentations during the conference were nodule development and physiology evolution of symbiosis, bacterial endophytes, agriculture applications, field findings, Physiology and genetics of bacteria, Physiology and genetics of plant host, Genomic approaches to understand symbiosis. Every planning session was followed by poster sessions on the same topics. Detailed proceedings are awaited.

National Seminar on Technology Upgradation in Biofertilizers and Biopesticide Production – A one day National Seminar on technology upgradation in biofertilizers and biopesticide production was organized on 26th September 2007 at Amity Institute of Bio-Organic Research and Studies, Noida, U.P. The seminar addressed all importamnt issues related to technological development of biofertilizers and biopesticides through interaction of eminent scientists, researchers, representatives of industry, Institutes and policy makers. Efforts were directed to address various technological constratints related to shelf life, carrier selection, strain identification, packaging, storage, quality control etc and find out possible ways for technology upgradation. Major themes of the seminar were: (a) Current status of biofertilizer and biopesticide production in india, (b) Identification of technological constraints in production, storage, quality and application and (c) Technology development for superior biofertilizer and biopesticides. For further details and proceedings please contact Dr. P. Bhattacharyya, Director, Amity Institute of Bio-Organic Research and Studies, Block A, Amity University Campus, Sector 25, Noida, U.P., Email – pbhattacharya@amity.edu.

Training on Microbial Products and their Application in Food Processing – A 22 days long training is being organized at Coimbatore, Tamil Nadu, during 21st January to 10th February 2008. The course is sponsored by the Indian Council of Agricultural Research, New Delhi. Food Microbial technology includes a wide range of diverse technologies and they may be applied in different food and agricultural sectors. During fermentation processes, microbial growth and metabolism results in production of a diversity of metabolities. Many of these microbial metabolites viz, vitamins, antimicrobial compounds, texture forming agents, amino acids, organic acids and flavour compounds are produced at the industrial level. This course is designed to make the researchers, teachers of SAUs and ICAR institutions to sensitize the broad issues in research and development in food biotechnology, general biotechnology, biosafety, bioethics and their impact on the societ at large. The training is designed to provide both theoretical knowledge and practical skill. For further details please contact Dr. S.P. Sundaram, CAS Director and Head, Department of Agricultural Microbiology, Tamil Nadu Agricultural University, Coimbatore – 641 003. Phone 0422-6611294, Fax 0422-2431672.

BOOK REVIEW

The Complete Technology Book on Biofertilizer and Organic Farming Edited by National Institute of Industrial Research, 106-E, Kamla Nagar, New Delhi-110007, ISBN: 8186623841, Code: NI115, Pages: 620, Published 2007, Price: Rs. 1,100.00 US$ 125.00 - Bio-Fertilizers are natural fertilizers which are microbial inoculants of bacteria, algae; fungi alone or in combination and they augment the availability of nutrients to the plants. The use of bio-fertilizers, in preference to chemical fertilizers, offers economic and ecological benefits by way of soil health and fertility to farmers. In view of the immense potential of bio-fertilizer technology covers all major types of bacterial fertilizers, Nitrogen fixation, Nitrogen fixing microorganism- Symbiotic and asymbiotic, Phosphate solubilizing microorganisms: Fungi and bacteria, mycorrhizae. Application of biofertilizers and evaluation techniques, crop response to biofertilizers, fermenters, biogas from liquid biofertilizers derived from banana and coffee processing, pest and disease management system in agriculture, biopesticides, sustainable agriculture, production and quality control of biofertilizer and ,marketing and feature research planning have also been elucidated in this book . This book will be of use and interest to consultants, researchers, libraries, and entrepreneurs, Manufacturers of bio-fertilizer and for those who wants to venture in to this field.

PGPR: Biocontrol and Biofertilization - Edited by Siddiqui, Zaki A. Springer 2006 318 p., ISBN 1402040024 £65.00 - PGPR (Plant growth promoting rhizobacteria) have gained world wide importance and acceptance for agricultural benefits. These microorganisms are the potential tools for sustainable agriculture and the trend for the future. This book deals with the scientific researches involving multidisciplinary approaches to understand adaptation of PGPR to the rhizosphere, mechanisms of root colonization, effects on plant physiology and growth, biofertilization, induced systemic resistance, biocontrol of plant pathogens, production of determinants etc. Biodiversity of PGPR and mechanisms of action for the different groups: diazotrophs, bacilli, pseudomonads, and rhizobia are shown. Effects of physical, chemical and biological factors on root colonization and the proteomics perspective on biocontrol and plant defence mechanism are also discussed. Visualization of interactions of pathogens and biocontrol agents on plant roots using autofluorescent protein markers has provided more understanding of biocontrol process. Commercial formulations and field applications of PGPR are detailed.

Biology of the Nitrogen Cycle, Edited by Hermann Bothe, Stuart Ferguson and William E. Newton, Academic press 2006 , Pages 452, ISBN 9780444528575 Price £69.00 - All organisms require nitrogen to live and grow. The movement of nitrogen between the atmosphere, biosphere, and geosphere in different forms is described by the nitrogen cycle. This book is an activity of the COST 856 Action on Denitrification. It covers all aspects of the N-cycle: chemistry, biology (enzymology, molecular biology), physics, applied aspects (greenhouse effect, N-pollution problems, practices in farming, in waste-water treatment, and more). In this book, leading editors has offerred the latest research available on dentrification (reduction of nitrates or nitrites

commonly by bacteria- as in soil). The book specifically provides details on (i) denitrification and its general role in the environment (ii) latest research in N-Cycle and its reactions (iii) impacts on various environments: agriculture, wetlands, plants, waste-water treatment and more. The contents of the book are spread over 27 chapters written by internationally recognized experts in the field and covers all modern aspects, emphasizing molecular biology and ecology for nitrogen cycle.

Biofertilizers Technology for Rice Based Cropping System/ Edited by S. Kannaiyan, K. Kumar and K. Govindarajan. Jodhpur, Scientific, ISBN: 81-7233-359-5, Pages: 450, 2004, Price: US$ 66 - Rice based cropping system is the major cropping system practised in India which includes the rotation of crops involving rice, pulses, oil seeds, cotton, sugar cane, green manures etc. The rice based cropping system offers lot of scope for the effective utilization of a wide range of biofertilizers such as *Azolla,* BGA*, Azospirillum, Rhizobium Gluconacetobacter diazotrophicus* and other heterotrophic N_2 fixing bacteria which help to increase the yield by reducing the cost of cultivation. It thus has dual advantages of being sustainable without endangering the environment and being highly cost effective. This book is a comprehensive compilation of chapters based on different biofertilizer types contributed by different renowned authors. The book 'Biofertilizers Technology for Rice Based Cropping System' deals with the current developments in the basic and applied aspects of biofertilizers used in the rice based cropping including the novel endophytic diazotrophs *viz., Azorhizobium coulinodans, Gluconacetobacter diazotrophicus,* Pink Pigmented Facultative Methylotrophs (PPFM) etc. The role of P, Zn and Si solubilizers in the nutrient dynamics of the rice ecosystem has also been covered. The strategies for production and distribution of quality inoculants for rice based cropping system have been given due importance with a focus on the molecular approaches for rapid and reliable quality control of biofertilizers. This book can be considered as a monograph on the usage of biofertilizers in rice based cropping system. It will be very useful for the scientists, researchers, students and extension workers involved in the management of crops in rice based cropping system.

Bioinoculants: A Step Towards Sustainable Agriculture, by Shammi Kapoor R.P. Gupta Anu Kalia 2007 New India Publishing Agency, ISBN 8189422219 Price $105.93 - Developing countries as the nations of Indian subcontinent are experiencing big-bangs regarding their economic, agricultural and industrial development. The sole aim of present mechanized and advanced agricultural practices is to produce enhanced grain yield to satiate the hunger of burgeoning population. Thus the present scenario demands the use of chemical fertilizers and other agrochemicals. However the production cost of these chemical products is too high as it increases pressure on the fossil fuel reserves of the country. These fossil fuel reserves are finite or unsustainable in the long-term and give hazardous oxidized products posing threat to environmental and human health. Moreover the inorganic fertilizer application tremendously debilitates the soil's physical and chemical status as well as drastically alters microbial diversity including microbial flora and fauna vital to sustain the fertility of soil. Sustainable agriculture is configured on use of a variety of prophecies, phenomena and products stressing on land reclamation and awareness towards hazards of over-industrialization and

pollution on health of ecosystem. This concept urges the utilization of an array of techniques as organic farming, biofertilizers, biocontrol agents/ biopesticides, mixed/inter-cropping. Bioinoculants are the culture concoctions/live microbial isolates that are presently the most ecologically feasible and economically sound example of practical reproduction of lab experimentation for the help of modern day farmers. Broadly, bioinoculants include biofrrtilizers, biopesticides and organic decomposers. Biofertilizers are live cells of beneficial microbial isolates that provide necessary nutrients (nitrogen, phosphorous etc), excrete growth promoting compounds and provide resistance to a variety of diseases that culminates to enhanced yield and production. While biopesticides are live microbial isolates or their metabolic products that eradicate/kill known insects/pests of crops. Among commercialized biopesticides Bt cotton emerged as the first brand ambassador of modern day pesticides. The third component of bioinoculants are the organic decomposers that include certain fungal species, bacterial genera and actinomycetes that hasten decomposition of organic compounds and make available nutrients held as organic matter.

Handbook of Organic Farming and Bio-Fertilizers by M.K. Gupta Jaipur, ABD Pub., 2007, 220 p, ISBN 81-8376-110-9, Price $39. - Organic farming is an agricultural philosophy and a farm management system aiming at promotion of plant, animal and human health. Through the use of environment friendly bio-fertilizers it maintains and improves productivity of land as far as possible by encouraging natural biological processes in the soil. Eliminating high cost inputs like chemical fertilizers, pesticides etc. it also results in the reduction of cost of agricultural production. "Handbook of Organic Farming and Bio-Fertilizers" presents compilation of edited articles of eminent authorities on various concepts, aspects researches, developments, etc., concerning organic farming and use of bio-fertilizers. The book has been written in easy-to-understand manner comprising requisite data and figures. Aiming at increasing practice of organic farming and use of bio-fertilizers, the book is of tremendous use to students, teachers, scholars, farmers and general readers." (jacket)

Handbook Book of Biofertilizers & Vermiculture Publisher: Engineers India Research Institute 2006, ISBN: 8189765019, Price $ 39.60 - The book 'Hand Book of Biofertilizers & Vermiculture' covers various methods including the Living Soil, Organic Sources and Dynamics, vermiculture, Application of vermiculture Biotechnology, Composting of Agricultural and Industrial wastes, Biological fertilizers, Microbial inoculants for Nitrogen Fixation, Mechanism and Estimation of Nitrogen fixation, Biological Mobilization of Phosphorus, The Cyclic System of Nutrient Management, perspectives, list of Bio-fertizers Units in India and Abroad, Plant Economics of Agrofertilizer from Leaves, Plant economics of Biofertilizers from Chicken refuges, Oil cakes, Bone Mills, Plant economics of Biofertilizers from Cowdung & Other Wastage, Plant economics of Biofertilizers (Organic fertilizers) from Garbage (MSW), Plant economics of Organic Manure, Plant economics of sea weed Liquid fertilizer, Plant economics of vermin-Composting. The book has been written for the benefit and to prove an asset and a handy reference guide in the hands of new entrepreneurs and well established industrialists.