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From Editorial Desk…

Dear Readers,

The entire globe was watching the recent "Copenhagen conference" on climate change in Denmark which has stressed on conservation and efficient use of energy, a key factor in terms of both economic development and climate change. Integrated energy supply systems are devised for environmental management system. Biofertilizers, the microbial inoculants offers bright scope as an alternate source of bio-energy for increasing crop productivity. Since a century, use of biofertilizers as an agronomic practice have proved to assist in maintaining soil fertility and crop productivity. The microbial inoculants of Azotobacter, Azospirillum, Rhizobium *and P-solubilizing microorganisms have played important role in nurturing crop nutrition and soil health. A recent compilation by National Project on Organic Farming revealed that the current production of biofertilizers in India is 25417MT. Among the biofertilizers, PSB contributes about 55%,* Azotobacter *30%,* Azosprillum *6% and* Rhizobium *9%. The detailed biofertilizer production scenario of India is presented in this issue. It is noteworthy to observe that, current year, biofertilizer production in India has increased by 25 times as compared to 20 years back. No doubt such high production of biofertilizer is indeed a spectacular achievement but at the same time, quality assurance is most essential so as to ensure crop productivity. In order to protect the interest of millions of biofertilizer consumers so as to assure the quality of the biofertilizer, Govt. of India has amended the FCO,1985 vide extraordinary Gazette Notification, dted.1.11.2009. This newly amended FCO, 1985 has been precisely presented in this issue.*

Although biofertilizer usages in pulses were more in past years but recently biofertilizers are being largely used for vegetables crops for increasing crop productivity. This issue has highlighted the contribution of biofertilizers in production of different vegetable crops. This issue has also dealt with current knowledge on biofertilizers in form of research notes,new reports, seminar/conferences/symposium news and book reviews.

Hope, this issue would be read with great spirit and enthusiasm.

Dr. R. N. Bisoyi

Editor

Nutrient Management in Vegetable crops Integration of Biofertilizers with Chemical Fertilizers

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Introduction

The green revolution brought impressive gains in food grain production for ever growing population in the country, but with insufficient concern for its sustainability. Chemical fertilizers although, played an important role in the green revolution process, but off late has generated lot of concern due to their adverse impact on environment and soil health. Long Term Fertilizers Experiments (LTFE) have established that sole dependence on chemical inputs based agriculture is not sustainable in the long run. Only the Integrated Plant Nutrient Management system involving judicious combination of inorganic fertilizers, organics and/or green manures and biofertilizers (BF) can sustain crop production, preserve soil health and soil biodiversity.

The bioinoculants, popularly known as biofertilizers are artificially multiplied cultures of latent cells of efficient strains of microorganisms capable of fixing atmospheric N_2, solubilizing phosphorus, mobilizing nutrients and absorption of water, decomposing cellulolytic and lignolytic waste materials and also for effective recycling of solid wastes. These micro-organisms also produce growth promoting substances like indole acetic acid, gibberlic acid, cytokinin and antibiotics which greatly influence the seed germination, root growth and proliferation, its density and volume with higher cation exchange capacity (CEC) for better and efficient nutrient exchange and absorption, flowering and fruiting and help in control of soil borne diseases. The biofertilizers not only save nearly 20 to 25 per cent of plant nutrients cost but also facilitate effective utilization of nutrients applied as chemical fertilizers and ultimately influence yield. These are applied to the seeds, seedlings (sets of sugarcane) or directly to the soil in the rhizosphere or to the decomposing materials so that their population is increased and they perform their activity. The BFs not only have multiple beneficial effects on soil and crop growth but are also relatively cheap and convenient to use.

Use of vegetables in Indian diet occupies a major share. For healthy living balanced diet is prescribed, which include 300g vegetable per capita per day. India will need 120 million tons of vegetables by the year 2011 for domestic consumption. These crops are mostly of short duration in nature, respond to added nutrients and remove large amount nutrients, hence need proper nutrient management. This sector of agriculture utilizes assured irrigation and plant protection measures. Farmers are also very much acquainted with the requirement of providing organic manures and fertilizers (though not sufficient) and water for growing vegetable crops. These conditions provide proper platform/environment for beneficial microorganisms to establish in soil and perform their activity. Therefore use of biofertilizers in vegetable crops can be an important strategy for their integrated nutrient management.

Among various biofertilizers *Rhizobium* is used for leguminous vegetables and *Azotobacter, Azospirillum* and phosphorus solubilizing microorganisms (PSM) for all other vegetable crops. Use of *Trichoderma* with above mentioned biofertilizers act synergistically. Combined inoculation of biofertilizers have always proved beneficial than lone inoculation. Among the methods of inoculation seed treatment is the most effective method. In some crops where seed treatment is difficult, use of inoculated and incubated FYM at the time of planting or seeding the crops has also been proved successful and has been accepted by the farmers.

Orrisa has been traditionally low synthetic input use state with average nutrient consumption at 53 kg NPK/ha. Under such circumstances biofertilizers can provide an ideal platform to supply nutrients and boost productivity. To develop appropriate integrated nutrient management strategy for some important vegetable crops of Orissa, experiments were conducted under All India Network Project on Biofertilizers. Azotobacter, Azospirillum and PSM biofertilizers were tested for non-leguminous vegetable crops while Rhizobium was used additionally for leguminous vegetables.

Enhancing inoculums efficiency by pre-incubation with composts

In this method the desired amount of inoculant (solid/liquid) was mixed with well decomposed FYM in 1:25 ratio, incubated at ordinary prevailing temperature under shade at about 30 per cent moisture for 7 days. This incubated biofertilizer-FYM mixture was applied as soil application just below the seeds/ seedlings or tubers in furrows. It was also top-dressed in long duration vegetables.

Microbial dynamics of native soil,biofertilizers, incubated FYM-biofertilizer mixture and of experimental soils, as recorded after7,21,49 and 91days of application is depicted in Table1.

Effect of integrated use of Diazotrophic and PSM biofertilizers on different non-leguminous vegetable crops

Okra

Combined inoculation of two diazotrophs *(Azotobactor* and *Azospirillum*) was found to be superior over lone inoculation of *Azotobacter* or *Azospirillum* (Table 2) for the production of fruits and recovery of added nutrients by the okra crop grown with recommended dose of fertilizers based on soil test. Comparative performance of individual and combined application of these two biofertilizers is given in Table 2. Use of these BFs not only increased the yield of crop, but also saved inorganic N fertilizer cost along with higher recovery of nutrients (Table 3). Under farmers field condition the use of BFs either alone or integrated with recommended dose of fertilizers resulted in significantly higher yields with higher nutrient recovery (Table 4).

Tomato

Effect of biofertilizer use on tomato yield, nutrient recovery and quality of fruit were observed under farmers field condition (Table 5) where BFs were used both under nursery and main fields at the time of sowing of seeds and seedling planting respectively.

Table 1. Proliferation of microorganisms in soil (CFU x 10^7/g)

Inoculant	Native soil	Solid inoculum	Incubated FYM	Days after application to soil			
				7	21	49	91
Azotobacter	0.005	2.7	41	0.5	1.5	38	34
Azospirillum	0.006	6.0	78	1.7	7.9	58	48
PSB	0.004	0.18	1.1	0.4	4.7	24	21

Table 2. Influence of combined inoculation of diazotrophs on okra crop (cv.BO-2)

Sl. No.	*Treatments*	Fruit yield (q ha^{-1})	Recovery (%)			Benefit in yield and value over control	
			N	P	K	Yield (q)	Value (Rs.)
1	No inoculation	45a	-	-	-	-	-
2	*Azotobacter* alone	50b	14	9	17	5	1500
3	*Azospirillum* alone	57c	20	21	29	12	3000
4	*Azotobacter + Azospirillum (1:1)*	60d	24	22	39	15	4500
	CD (P=0.05)	3.0	-	-	-	-	-
	CV (%)	11	-	-	-	-	-

* Sale price of okra fruit at farmers level Rs.300/quintal

Table 3. Nitrogen economy for okra crop as a result of BF application

Sl. No.	Treatments	Fruit yield (q ha^{-1})	Recovery (%)			Benefit over control	
			N	P	K	Yield (q)	Cost (Rs.)
1	No-N, No-BF	37a	-	-	-	-	
2	BF (Azot. + Azs.)	48b	-	19	27	11	3300
3	50% N	56b	24	20	28	19	5700
4	100% N	69c	31	24	48	32	9600
5	50 % N + BF	66c	40	29	40	29	8700
6	75 % N + BF	78d	55	40	62	41	12300
7	100 % N + BF	89e	42	37	64	-	
	CD (P = 0.05)	10.1	-	-	-	-	-
	CV (%)	11.0	-	-	-	-	-

Table 4. Fruit yield and nutrient recovery by okra crop as influenced by integration of BFs with chemical fertilizers (Tribal farmers of Dhenkanal , Orissa)

Sl. No.	Treatments	Fruit yield (q ha^{-1})	Recovery (%)				Benefit over control	
			N	P	K	S	Yield (q)	Cost (Rs.)
1	Farmers practice	39.3	-	-	-	-	-	
2	Biofertilizer (BF)*	47.0	-	-	-	-	7.7	2310**
3	Recommended dose based on soil test (RD)	87.4	38	24	100	10		-
4	RD + BF	99.9	44	35	113	13	12.5	3750**
	CD (P=0.05)	14	-	-	-	-	-	
	CV (%)	15	-	-	-	-	-	

* Except FP, lime was applied @ 0.2 LR to all other treatments .

** Benefit of BF use over FP recommended dose

Table 5.Influence of BF use on tomato crop yield, nutrient recovery and quality of fruit (cv. BT-10)

Treatment	**FP**	**BF**	**RD**	**RD + BF**	**CD (P = 0.05)**	**CV (%)**
Fruit yield (q ha^{-1})	93.2	105.8	214.0	232.7	3.3	14
Nutrient recovery (%)						
N	-	-	52	67	-	-
P	-	-	21	31	-	-
K	-	-	93	112	-	-
S	-	-	6	9	-	-
Fruit quality						
Lycopene (mg/g)	1.09	2.05	1.65	1.87	0.21	11
Ascorbic acid (%)	0.07	0.09	0.11	0.14	0.01	12
Citric acid (%)	0.56	0.62	0.81	0.93	0.05	11.9
TSS	2.9	3.4	3.90	4.20	0.20	13.5
Rotting (%)	26	22	44	31	5	14
Benefit						
Yield (q)	-	12.6	-	18.7		
Cash (Rs.)	-	2520.00		3740		

*Cost of tomato is Rs.200/q at farmers field level.

Brinjal

Combined inoculation of diazotrophs and PSB (*Azotobacter+ Azospirillum* + PSB : 1:1:1) not only influenced the fruit yield of brinjal but also the nutrient recovery by the crop when integrated with soil test based recommended dose of fertilizer (Table 6) ameliorated with locally available liming material-paper mill sludge under acidic soil condition.

Potato crop

Integrating the biofertilizer (*Azotobacter+ Azospirillum* + PSB : 1:1:1) use with 75 per cent and 100 per cent soil test based recommended dose of fertilizers resulted in 15 and 20 per cent higher tuber yields compared to the soil test based fertilizer dose alone (375 q ha^{-1}), respectively. Under the same situation tuber yield due to farmers practice was 25 per cent less compared to soil test dose (Table 7). The poor yield of tubers under farmers practice was due to use of sub optimal as well as unbalanced fertilizer application particularly less of K and more of P devoid of sulphur. The higher yields in biofertilizer integrated treatments were due to its influence on root growth (i.e., greater root length, volume, density as well as CEC hence higher nutrient absorption) under favourable nutritional environment created due to soil test based fertilizer recommendation.

Not only the tuber yield of potato is influenced by BF use but also the grades and rotting of tuber (Table 8 and Table 9). Greater percentage of marketable size tubers (grade III and IV) were produced as a result of biofertilizer use. Similarly less per cent of tubers were rotted when biofertilizers were used either alone or together with FYM. These effects were attributed to restricted absorption of Na compared to K and absorption of other essential nutrients through the potato roots (Data not presented). More over the BF use restrict some soil borne diseases.

Elephant foot yam (Local Oriya name *Olua*)

The underground grown vegetable crops are more influenced by biofertilizer application than above ground vegetable crops. The yam yield as well as the nutrient recovery by this crop were influenced significantly by the use of mixture of biofertilizers (*Azotobacter* + *Azospirillum* + *PSB* in 1:1:1 ratio) either alone or together with recommended dose of fertilizers (Table 10) under farmers field condition.

Table 6. Integrated effect of biofertilizers and chemical fertilizers on yield and nutrient recovery by brinjal crop grown under farmers field condition (Dhenkanal district, Orissa)

Treatments	Fruit yield (q ha^{-1})	Nutrient recovery (%)				Benefit	
		N	P	K	S	Yield (q)	Cost (Rs.)
FP	74.9						
BF*	87.0						
RP	151.0	22	35	82	24	-	-
RP + BF*	167.2	35	57	110	29	16.2	6480
CD (P = 0.05)	10.3	-	-	-	-		
CV (%)	15	-	-	-	-		

* Azot. + Azs. + PSB:: 1:1:1, FP = Farmer practices, RP = Recommended practices

Table 7. Tuber yield of potato under farmers field condition as influenced by use of soil test based fertilizers and biofertilizers.

Treatments	Tuber yield (q ha^{-1})
FP	281.0 a(-25)*
Soil test dose	375 b
75 % soil test dose + BF	429 c (-15)*
100 % soil test dose + BF	450 d (+ 20)*
CD (P = 0.05)	17
CV (%)	12

* Data in the parenthesis indicate per cent increase or decrease over soil test based dose alone. Farmers Practice : Dose of N-P-K = 160-50-60 kg ha^{-1} = 270 kg ha^{-1}. Soil test dose of N-P-K = 150-33-100 kg ha^{-1} = 283 kg ha^{-1}

Table 8. Percentage of grades of tuber as influenced by BF use.

Grades	Control	FYM	BF	FYM + BF
I (< 25 g)	30.3	28.6	18.3	16.0
II (26-50 g)	32.3	32.6	33.0	23.7
III (51-75 g)	20.7	233	25.6	28.7
IV (> 75 g)	16.7	18.7	23.0	31.7

parenthesis indicate per cent less rotting due to respective treatments.

Yam (*Diascoria alata*)

Similar to the elephant foot yam crop, the yam (*Diascoria alata*) locally called *Desialu* or *Khambalu* was also influenced by BF application when used alone or was integrated with soil test dose of fertilizers along with soil amelioration with paper mill sludge (Table 11).

Carrot

The carrot being a root crop received biofertilizers application right at the sowing of seeds as well as at top dressing after one and half month of sowing, responded significantly to biofertilizers use when used alone or together with soil test based fertilizer use ameliorated with paper mill sludge @ 0.2 LR (Table 12).

Table 9. Rotting of tuber % as influenced by biofertilizer and FYM use

Treatments	Rotting (%)
Control	42.3
FYM	37.8(-11)*
BF	37.0 (-13)*
FYM + BF	34.9 (-18)*

Table 10. Corm yield and nutrient recovery by elephant foot yam as influenced by BF application

Treatments	Corm yield (q ha^{-1})	Nutrient recovery (%)				Benefit	
		N	P	K	S	Yield (q)	Cost (Rs.)
FP	103.4						
BF alone	147.5					44.1	11025
RD soil test based	364.8	98	38	180	44	-	
RDP + BF	409.0	124	42	260	53	44.2	11050
CD (P = 0.05)	42.5						
CV (%)	11						

* Sale price of yam corm at farmers field level is Rs.250/quintal.

Table 11. Yield and nutrient recovery by yam crop as influenced by BF use

Treatments	Yield (q ha^{-1})	Nutrient recovery (%)				Benefit	
		N	P	K	S	Yield (q)	Cost (Rs.)
FP	50.3	-	-	-	-	-	
BF alone	91.4	-	-	-	-	41.1	12330
RD soil test based	159.3	62	25	60	6		
RD + BI	204.1	87	36	80	9	44.8	13440
CD (P = 0.05)	10.7	-	-	-	-		
CV (%)	6		-	-	-		

Table 12. Yield and nutrient recovery by carrot crop

Treatments	Carrot yield (q ha^{-1})	Nutrient recovery (%)				Benefit	
		N	P	K	S	Yield (q)	Cost (Rs.)
FP	87.5						
BF alone	126.5					39	9750
RD soil test based	164.5	137	26	250	27		
RD + BF	207.0	231	32	290	39	42.5	10625
CD (P = 0.05)	4.3						
CV (%)	16						

***Sale price of carrot root at farmers level is Rs.250/q**

Onion:

In case of onion the biofertilizers were used right from the nursery stage to main field. Significant yield response as well as higher nutrient recovery were recorded when biofertilizers were used either alone or integrated with soil test based fertilizer doses in soil ameliorated with paper mill sludge (Table 13).

Chilli-Radish-Mustard

The associate effects of diazotrophs with PSB was evaluated on Chilli-Raddish-Mustard cropping system at OUAT farm. Among the crops, the root crop radish was more influenced by the biofertilizer application (Table 14). Not only the yield of the crops increased, but also the nutrient recovery and the fruit quality improved.

***Rhizobium* biofertilizer for legume vegetable crops**

Runner bean

The runner bean crop grown under farmers field condition also responded favourably to *Rhizobium* inoculation along with micronutrient applied as seed treatments either alone or together with recommended dose of soil test based fertilizers in terms of pod yield, N gain and nutrient recovery (Table 16).

Cowpea :

The symbiotic microbe *Rhizobium* was success fully used for leguminous vegetable crops. The cowpea crop responded positively and significantly to *Rhizobium* inoculation along with seed treatment with molybdenum as sodium molybdate @ 10 g per 25 kg seed and cobaltous chloride @ 1g per 25 kg seed and soil (acid) ameliorated with paper mill sludge @ 0.2 LR (Table 15).

Table 13. Onion crop as influenced by biofertilizers use.

Treatments	Bulb yield ($q\ ha^{-1}$)	Nutrient recovery (%)				Benefit	
		N	P	K	S	Yield (q)	Cost (Rs.)
FP	212	-	-	-	-		
BF alone	234	-	-	-	-	22	6600
RD soil test based	283	22	10	21	14		
RD + BF	349	34	28	72	28	66	19800
CD (P = 0.05)	15.2	-	-	-	-	-	-
CV (%)	14	-	-	-	-	-	-

Table 14. Effect of biofertilizers on yield of crops in chilli-radish-mustard cropping system

Biofertilizers	Yield (q/ha)		
	Green chilli	Radish (fresh)	Mustard seed
No inoculation	26.9	96.5	3.9
Azot + Azosp	30.1 (12)	125.9 (30)	4.5 (15)
PSB	28.1 (5)	120.1 (24)	4.2 (8)
Azot+Azosp+PSB	33.3 (24)	150.0 (56)	5.3 (36)
LSD (p-0.05)	0.97	8.8	0.4

Table 15. Influence of *Rhizobium* inoculation of cowpea on pod yield and its use as partial green manure crop

Treatments	Pod yield ($q\ ha^{-1}$)	*Biomass* ($q\ ha^{-1}$) fresh as GM	Nutrient recycled ($kg\ ha^{-1}$)		
No inoculation	30.8	80.8	67	7.5	72
Rhizobium	39.5	94.8	88	10.0	94
CD (P=0.05)	0.6	0.8	0.3	0.6	0.7

Table 16. Response of runner bean to *Rhizobium* inoculation

Treatments	Carrot yield (q ha^{-1})	Nutrient recovery (%)				Benefit	
		N	P	K	S	Yield (q)	Cost (Rs.)
FP	65.2	-					
BF alone	76.6	20	-	-	-		
RP soil test based	119.8	38	49	150	33	11.4	4560
RP + BI	158.2	59	62	200	41	38.4	15360
CD (P = 0.05)	21.5	-	-				
CV (%)	12	-	-				

Conclusion

From the results of the field trials conducted on use of biofertilizers for tropical vegetable crops, it can be concluded that it is essential and also mandatory to use specific biofertilizers for specific vegetable crops preferably integrated with required amount of chemical fertilizers based on soil test which will not only save the fertilizer budget but also yield higher quality produce with greater nutrient recovery increasing the nutrient use efficiency.

1st Asian Conference on Plant-Microbe Symbiosis and Nitrogen Fixation (1st APMNF)

First Asian Conference on Plant-Microbe Symbiosis and Nitrogen Fixation (1st APMNF) is scheduled for 20-24 September 2010 at Aoshima, Miyazaki, Japan. In Asian countries many scientists have carried out significant research work and developed knowledge on plant-microbe symbiosis including excellent basic researches and its applications.

The first such conference is aimed at creating a common platform for sharing and disseminating the information among the microbiologists, plant molecular biologists and agronomists. In particular, Asian young scientists should be encouraged with the conference. The important subjects of deliberations include: (a) Plant-microbe signaling, (b) Model legume symbiosis, (c) Symbiotic N_2 fixation, (d) Bioresources for legume and rhizobia, (e) Genomics and functional genomics, (f) Nitrogen fixation in agriculture, (g) Associative N_2-fixing systems, (h) Taxonomy and evolution, (i) Non-legume symbiosis, (j) Mycorrhizal associations, (k) Frankia associations, (l) Endophyte associations, (m) Nitrogen cycle research, (n) Sustainable biomass production by associative microbes and (o) Applications for sustainable agriculture. Japanese Society for the Promotion of Science, Japanese Society of Soil Science and Plant Nutrition and Japanese Society of Plant-Microbe Interactions are its major promoters and sponsors. For further details contact **The 1st APMNF administrative planning committee,** E-mail: apmnf @ cc.miyazaki-u.ac.jp

Glimpses of Fertilizer (Control) Order, 1985 for Biofertilizers
(Amendment, November 2009)

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Background

Government of India through Gazette Notification dated 10.04.2008 incorporated Biofertilizers and Organic Fertilizers in FCO defining necessary requirement for registration, standards, procedures and testing protocols. After notification of the Schedule III and Schedule IV, wherein biofertilizers and organic fertilizers were included under the ambit of FCO, lot of representations were received by the Ministry raising doubt about the achievability of the standards of organic fertilizers and biofertilizers and on shelf life of biofertilizers. Testing laboratories also requested for some modifications in analytical procedures.

Keeping in view of such developments, DAC in the first instance deferred implementation of FCO and later the provisions were put on hold till further orders. To look into the feasibility and all technical and scientific aspects of organic fertilizers and biofertilizers included in the FCO, 1985, a Technical Group was constituted by DAC under the chairmanship of Dr. P.D. Sharma, ADG (Soils), ICAR, New Delhi.

The technical group examined all possible points of contention, generated required data for assessing the feasibility and achievability of standards vis-à-vis developing technologies, consulted industry representatives and examined the suggestions of testing laboratories on modifications in some testing protocols. After thorough deliberation the technical group finally recommended modifications in the standards and testing protocols for notification in FCO.

The modifications have been notified vide Extra Ordinary Gazette Notification of Ministry of Agriculture (Department of Agriculture and Cooperation), New Delhi Dated 3rd November 2009. All the State Governments vide DACs letter Dated 26th November 2009 have been advised to implement and enforce the provisions of FCO relating to Biofertilizers and Organic fertilizers.

All regulatory provisions such as Definition, restriction on manufacture, preparation, marketing, requirement for certificate for manufacture, grant, refusal, renewal etc of certificate of manufacture and marketing, requirement of packing and marking, details on registering and notified authorities, appointment of inspectors, analysis of samples, time limit for analysis, maintenance of records and fee etc have been retained without any change.

Analysis of samples by notified laboratories

A biofertilizer sample drawn by an inspector shall be analyzed in accordance with the instructions laid down in schedule III in the National Centre of Organic Farming, Ghaziabad or Regional Centres of Organic Farming at Bangalore, Bhubaneshwar, Hissar, Imphal, Jabalpur and Nagpur or any other laboratory notified by Central or State Government.

Notified modifications
Modified Specification of Biofertilizers
1. *Rhizobium*

(i)	Base	Carrier based* in form of moist/dry powder or granules, or liquid based
(ii)	Viable cell count	CFU minimum $5x10^7$ cell/g of carrier material or $1x\ 10^8$ cell/ml of liquid.
(iii)	Contamination level	No contamination at 10^5 dilution
(iv)	PH	6.5 – 7.5
(v)	Particles size in case of carrier based material.	All material shall pass through 0.15-0.212 mm IS Sieve
(vi)	Moisture percent by weight, maximum in case of carrier based.	30-40%
(vii)	Efficiency character	Should show effective nodulation on all the species listed on the packet.

***Type of carrier:** The carrier materials such as peat, lignite, peat soil, humus, wood charcoal or similar material favouring growth of organism.

2. *Azotobacter*

(i)	Base	Carrier based* in form of moist/dry powder or granules, or liquid based
(ii)	Viable cell count	CFU minimum $5x10^7$ cell/g of carrier material or $1x\ 10^8$ cell/ml of liquid.
(iii)	Contamination level	No contamination at 10^5 dilution
(iv)	PH	6.5 – 7.5
(v)	Particles size in case of carrier based material.	All material shall pass through 0.15-0.212 mm IS Sieve
(vi)	Moisture percent by weight, maximum in case of carrier based.	30-40%
(vii)	Efficiency character	The strain should be capable of fixing at least 10 mg of nitrogen per g of sucrose consumed.

***Type of carrier: -** The carrier material such as peat, lignite, peat soil, humus, wood charcoal or similar material favouring growth of the organism.

3. *Azospirillum*

(i)	Base	Carrier based* in form of moist/dry powder or granules, or liquid based
(ii)	Viable cell count	CFU minimum $5x10^7$ cell/g of carrier material or $1x\ 10^8$ cell/ml of liquid.
(iii)	Contamination level	No contamination at 10^5 dilution
(iv)	PH	6.5 – 7.5
(v)	Particles size in case of carrier based material.	All material shall pass through 0.15-0.212 mm IS Sieve
(vi)	Moisture percent by weight, maximum in case of carrier based.	30-40%
(vii)	Efficiency character	Formation of white pellicle in semisolid N-free bromothymol blue media.

***Type of carrier:-** The carrier material such as peat, lignite, peat soil, humus, wood Charcoal or similar material favouring growth of the organism.

4. **Phosphate solubilising Bacteria**

(i)	Base	Carrier based* in form of moist/dry powder or granules, or liquid based
(ii)	Viable cell count	CFU minimum $5x10^7$ cell/g of carrier material or $1x10^8$ cell/ml of liquid material.
(iii)	Contamination level	No contamination at 10^5 dilution
(iv)	PH	6.5-7.5 for moist/dry powder granulated carrier based and 5.0-7.5 for liquid based.
(v)	Particles size in case of carrier based material.	All material shall pass through 0.15-0.212 mm IS Sieve
(vi)	Moisture percent by weight, maximum in case of carrier based.	30-40%
(vii)	Efficiency character	The strain should have phosphate solubilizing capacity in the range of minimum 30%, when tested spectrophotometrically. In terms of zone formation, minimum 5 mm solubilization zone in prescribed media having at least 3 mm thickness..

***Types of Carrier:-** The carrier material such as peat, lignite, peat soil, humus, wood Charcoal or similar material favouring growth of the organism.

Part-B
Tolerance limit of Biofertilizers

$1x10^7$ CFU/g of carrier material in the form of powder or granules or $5x10^7$ CFU/gm of liquid material

Part –C
Procedure for drawl of sample of biofertilizer

Procedure for Sampling of Bio-Fertilizers.

1. General Requirements of Sampling

1.0 In drawing, preparing and handling the samples, the following precautions and directions shall be observed.

1.1 Sampling shall be carried out by a trained and experienced person as it is essential that the sample should be representative of the lot to be examined.

1.2 Samples in their original unopened packets should be drawn and sent to the laboratory to prevent possible contamination of sample during handling and to help in revealing the true condition of the material.

1.3 Intact packets shall be drawn from a protected place not exposed to dampness, air, light, dust or soot."

2. Scale of sampling

2.1 Lot

All units (containers in a single consignment of type of material belonging to the same batch of manufacture) shall constitute a lot. If a consignment consists of different batches of the manufacture the container of the same batch shall be separated and shall constitute a separate lot

2.2. Batch

Inoculants prepared from a batch fermentor or a group of flask (container) constitutes a batch.

2.3. For ascertaining conformity of the material to the requirements of the specification, samples shall be tested from each lot separately.

2.4. The number of packets to be selected from a lot shall depend on the size of the lot and these packets shall be selected at random and in order to ensure the randomness of selection procedure given in IS 4905 may be followed.

3. Drawal of Samples

3.1 The Inspector shall take three packets as sample from the same batch. Each sample constitutes a test sample.

3.2 These samples should be sealed in cloth bags and be sealed with the Inspector's seal after putting inside Form P. Identifiable details such as sample number, code number or any other details which enable its identification shall be marked on the cloth bags.

3.3 Out of the three samples collected, one sample so sealed shall be sent to incharge of the laboratory notified by the State Government under clause 29 or to National Centre for Organic Farming or to any of its Regional Centres. Another sample shall be given to the manufacturer or importer or dealer as the case may be. The third sample shall be sent by the inspector to his next higher authority for keeping in safe custody. Any of the latter two samples shall be sent for referee analysis under sub-clause (2) of clause 29B.

3.4 The number of samples to be drawn from the lot

Lot/Batch	Number of Samples
Up to 5,000 packets	03
5,001-10,000 packets	04
More than 10,000 packets	05

Packing, Marking, Storage and Use

Packing - Biofertiliser shall be packed in suitable plastic bags/ packs thickness of which shall not be less than 75-100 micron or in suitable plastic bottles.

Marking - Each polyethylene pack shall be marked legibly and indelibly with the following information:

(a) Name of the product,
(b) Name and address of the manufacturer,
(c) Crops for which intended;
(d) Type of the carrier used;
(e) Batch number;
(f) Date of manufacture;
(g) "Expiry date which shall not be less than 6 months from the date of manufacture in case of carrier based powdered/granulated formulation of *Rhizobium, Azotobacter, Azospirillum* and PSB biofertilizers and liquid based Rhizobium biofertilizer, while it shall not be less than 12 months from the date of manufacture in case of liquid based *Azotobacter, Azospirillum* and PSB biofertilizers."
(h) Net mass in kg/gram and area meant for;
(i) Storage instruction worded as under; "STORE IN COOL PLACE AWAY FROM DIRECT SUN LIGHT AND HEAT"
(j) Any other information required under the standards of weights and Measure (Packaged Commodities) Rule.1977.

Modifications in analysis of Biofertilizers

Analysis of *Azospirillum* biofertilizer

In methods of analysis of total viable counts for Azospirillum, serial dilution, plate count method has been replaced with serial dilution MPN count method using semi-solid nitrogen free bromothymol blue malate medium.

Analysis of Phosphate Solubilising Bacterial Biofertiliser'

In method of Analysis of Phosphate Solubilising Bacterial Biofertiliser, in item No. 5 relating to 'Determination of Soluble Phosphorus Using Ascorbic Acid, the new method for sample preparation for estimation of phosphorus, has been specified.

The World of Biofertilizer Production in India -2008-09

A Compilation By
National and Regional Centers of Organic Farming under
National Project on Organic Farming

Background

With the increase in awareness about the ill effects of indiscriminate chemical use, farmer's inclination is growing towards environment friendly technologies. Growing demand for biofertilizers and biopesticides is an indication of such inclination. Biofertilizers or microbial inoculants are known for their contribution in organic nutrient management and integrated nutrient management systems. The journey started with Rhizobium during late seventies has grown into a well developed industry. Total production which was less than 1000 MT during 1988-89 has grown many folds and has crossed 25,000MT during the year 2008-09. Biopesticides are although relatively new entrants but has grown much faster and with in a period of 5-7 years have crossed the production figures of biofertilizers.

With the improvement in production technology and launching of long shelf life liquid formulations, more and more units are switching towards liquid biofertilizer production. A long standing contentious issue of short shelf life is also being addressed with liquid formulations.

Other biofertilizers such as K-mobilizers, zinc mobilizers and S-mobilizers are also proving their potential and likely to come up as commercial formulations in the next few years. Mixed inoculants have also been developed by some industries and likely to be available in market in next 1-2 years time.

Quality control mechanism- On the recommendations of Technical group the Department of Agriculture and Cooperation has modified the provisions of FCO covering biofertilizers. The revised norms have been notified vide Govt of India' Extraordinary Gazette Notification Dated 01.11.2009. Details in respect of this notification are being given in a separate chapter in this issue.

Current status of Biofertilizer industry in India

As per the information gathered by NCOF/RCOFs, the installed production capacity of the total biofertilizer production units in country is 68804.0 tons. Phosphate solubilizing bacterial (PSB) biofertilizer, *Azotobacter, Azospirillum* and *Rhizobium* are important biofertilizers followed by Mycorrhiza, and *Trichoderma* compost enhancers. As most of the biofertilizer production units are also producing bio-pesticides ,other inoculants in many cases also include bio-pesticides such as *Trichoderma viride, Pseudomonas florescens, Metarhizium anisopliae, Bauveria bassiana* and *Verticillium lacini etc.*

Overall production of different biofertilizers, including other inoculants during the year 2008-09 is given in Table 1. State-wise details in respect of actual production of different biofertilizers during the year 2008-09 are given in Table 2. State wise details in respect of installed production capacity and actual production of total biofertilizers and other inoculants are given in Table 3.

Table 1. Overall Production of Different Inoculants in the Country during the Year 2008-09

Sr. No.	Name of Biofertiliser/ Inoculants	Production (in tones)
1.	*Azotobacter*	7588.45
2.	*Azospirillum*	1548.07
3.	*Rhizobium*	2385.56
4.	Phosphate solubilising Microorganism	14019.87
	Total Biofertilizers	25541.95
5.	Other Inoculants*	39562.59
	Grand Total (all inoculants)	**65104.55**

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Table 2. State Wise Production of Biofertilizer in 2008-09

Sl. No.	Name of State	**Biofertilizer Production during the year 2008-09**						
		Azoto	Azospi	Rhizobi	PSB	Total BF	Other *	Grand Total
1	Andhra Pradesh	14.72	38.20	34.77	80.42	168.13	7	175.13
2	Assam	26.52	28.87	5.98	67.97	129.35	5680.0	5809.30
3	Bihar	0	0	0	0	0	0	0
4	Delhi	1014.21	45.99	11.19	93.71	1165.1	189.35	1354.45
5	Gujarat	300.92	117.915	69.91	660.95	1149.69	28.06	1177.76
6	Goa	0	0	0	0	0	28.33	28.33
7	Haryana	4.87	0	2.02	7.36	14.25	0	14.25
8	Himachal Pradesh	1.5	2.0	1.5	5.0	10.00	0	10.00
9	Jharkhand	4.00	0	6.00	5.00	15	0	15
10	Kartnataka	4730.73	282.40	761.77	6146.13	11921.05	8890.98	20812.03
11	Kerala	8.93	276.78	49.88	851.39	1187.00	2920.90	4107.90
12	Madhya Pradesh	100.94	18.1	171.92	557.48	848.44	0.2	848.64
13	Maharashtra	268.15	3.726	169.268	933.7205	1374.8645	160.436	1535.30
14	Mizoram	0.32	0.19	0.58	0.9	1.99	0	1.99
15	Nagaland	4.28	0.60	2.65	8.47	16.00	0	16.00
16	Orissa	43.24	37.29	169.80	146.40	396.73	8.30	405.03
17	Punjab	0	0	1.14	200.00	201.14	0	201.14
18	Pondicherry	11.34	69.14	57.23	424.07	561.79	1252.6	1814.39
19	Rajasthan	41.04	0	53.67	258.96	353.67	0	353.67
20	Tamil nadu	467.81	599.97	616.08	3003.94	4687.81	19997.39	24685.11
21	Tripura	7.3	0	2.2	5.18	14.68	0	14.68
22	Uttar Pradesh	281.67	0.2	146.17	457.47	885.51	7.5	893.01
23	Uttarkhand	17.66	7.5	5.24	17.81	48.23	0	48.23
23	West Bengal	238.30	19.20	46.60	87.54	391.64	391.64	783.28
	Total	**7588.45**	**1548.071**	**2385.56**	**14019.87**	**25541.95**	**39562.5**	**65104.54**

* Others include compost enrichers (Trichoderma, Paceliomyces etc.), PGPRs, Biopesticides such as Trichoderma, Pseudomonas, Metarhizium, Bauveria and Verticillium etc

Table 3. State Wise Installed Production Capacity and Actual Production of Biofertilizer in 2008-09

S. No.	State	Capacity	Total Biofertilizer Production (MT)	Other Inoculants *	Total Production (in MT)
1	Andhra Pradesh	7150	168.14	7	175.14
2	Assam	290	129.3552	5680	5809.36
3	Bihar	150	0	0	0.00
4	Delhi	2000	1165.1	189.35	1354.45
5	Gujarat	1850	1149.70	28.07	1177.76
6	Goa	150	0	28.33	28.33
7	Haryana	50	14.25	0.00	14.25
8	Himachal Pradesh	75	10.00	0	0.00
9	Jharkhand	10	15.00	0	15.00
10	Kartnataka	26425	11921.06	8890.982	20812.04
11	Kerala	5855	1187.00	2920.90	4107.91
12	Madhya Pradesh	1725	848.45	0.2	848.65
13	Maharashtra	6425	1374.8645	160.436	1535.30
14	Mizoram	25	2.00	0	2.00
15	Nagaland	20	16.01	0	16.01
16	Orissa	854	405.03	0	405.03
17	Punjab	2	1	0	1.14
18	Pondicherry	890	561.79	1252.60	1814.39
19	Rajasthan	1000	353.67	0	353.67
20	Tamil nadu	12825	4687.82	19997.39	24685.21
21	Tripura	20	14.68	0	14.68
22	Uttar Pradesh	333	885.52	8	893.02
23	Uttarakhand	350	48.23	0	48.23
24	West Bengal	330	391.64	0	241.24
	Total	**68804.0**	**25190.0245**	**39162.757**	**64352.7908**

Research Notes

Response of biofertilizers, on the growth and yield of blackgram (Vigna mungo L.) - An experiment was conducted to determine the effect of biofertilizers on growth and yield of blackgram in field condition. The experiment was a randomized complete block design with five replication. The different inoculation (single and duel) of biofertilizers *Azotobacter, Azospirillum, Rhizobium,* phosphobacteria were incorporated into the top 15 cm of the soil. During the experiment period the plant samples were analysed, such as root length, shoot length, fresh and dry weight, leaf number, leaf area, root nodules and the biochemical content such as chlorophyll ‘a’, ‘b’, total chlorophyll, carotenoid, protein content, nodules and yield were analysed. The results revealed that the combination inoculation of *Rhizobium* + phosphobacteria significantly increased growth and yield of blackgram compared with control (without biofertilizers). (Source – Selvakumar et al 2009, Recent Research in Science and Technology, Vol 1, No 4)

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 2007, Journal of Medicinal Plants Research Vol. 1(1), pp. 005-008)

Influence of bio-fertilizers on the biomass yield and nutrient content in *Stevia rebaudiana* Bert. grown in Indian subtropics - A pot culture experiment was conducted at Indian Institute of Horticultural Research, Hessaraghata, Bangalore, India to study the effect of bio-fertilizers on the biomass yield and NPK content in Stevia (*Stevia rebaudiana*). The results show the yield and NPK content in stevia plant has been found to be increased initially and thereafter, the amount of the same decreased with the progress of plant growth up to 60 days with the combined treatment of bio-fertilizers rather than individual treatment. This is due to their ability to fix atmospheric nitrogen (symbiotic and asymbiotic) and transform native soil nutrients likely phosphorus, zinc, copper, iron, sulfur from the non-usable (fixed) to usable form and decompose organic wastes through biological processes which in turn releases nutrients in a form which can be easily assimilated by plants resulting in an increase in biomass production of stevia plant. (Source - Das et al 2007Journal of Medicinal Plants Research Vol. 1(1), pp. 005-008)

Interaction Effect of some Biofertilizers and Irrigation Water Regime on Mung bean (*Vigna radiata*) Growth and Yield - The interactive effect of biogin and nitrobin biofertilizers and compost on growth, yield and metabolic products of mung bean (*Vigna radiata* L.) cv. Kawmy I under different irrigation water regimes of 5d, 10d & 15d drying cycle studied. Growth and yield were suppressed in plants of water regime II (10d drying cycle), while plants under regime III (15d drying cycle severely and harmfully affected. Addition of biofertilizers mitigated the harmful effect of water stress. The greatest yield/plant was obtained in plants of water regime I (5d drying cycle) treated with biogin amounting to 282% of unfertilized plants. Plants treated with biogin under regime II (10 d drying cycle) yielded 145% of unfertilized control (regime I). Biofertilized plants exhibited higher values of leaf metabolic products than nonfertilized plants. The response of leaf metabolic products to nitrobin was more marked than for the other biofertilizers. Commonly slightly higher amounts of total carbohydrates, lipid and total crude protein contents were obtained in seeds of plants irrigated every 5 d than those of 10 d drying cycle while they were more or less comparable for the biofertilized and nonfertilized plants. Plants treated with nitrobin produced the highest level of genistein (isoflavonoid) under water regime I or II and the least level of quercetin (flavonoid). (Source - Sheteawi and Tawfik, 2007 Journal of Applied Sciences Research, 3(3): 251-262

The Study of Shelf Life for Liquid Biofertilizer from Vegetable Waste - Liquid biofertilizer is increasingly available in the market as one of the alternatives to chemical fertilizer and pesticide. One of the benefits from biofertilizer is a contribution from population of microorganisms available. Traditionally, liquid biofertilizer produced from fermentation of effective microorganisms (EM) was recommended to be used within three months. This experiment showed that shelf life of the liquid biofertilizer produced from vegetable waste contains high amount of viable microbial population after four months of storage. The two conditions of storage, with and without light were tested and it was found that there was no significant difference ($p>0.05$) upon viable microbial population, chemical and physical characteristics. However, there was significant difference from batch to batch of production due to raw materials. (Source - Ngampimol and Kunathigan, 2008, AU J.T. 11(4): 204-208)

Role of blue green algae biofertilizer in ameliorating the nitrogen demand and fly-ash stress to the growth and yield of rice (*Oryza sativa* L.) plants - Rice is a major food crop throughout the world; however, accumulation of toxic metals and metalloids in grains in contaminated environments is a matter of growing concern. Field experiments were conducted to analyze the growth performance, elemental composition (Fe, Si, Zn, Mn, Cu, Ni, Cd and As) and yield of the rice plants (*Oryza sativa* L. cv. Saryu-52) grown under different doses of fly-ash (FA; applied @ 10 and 100 t ha^{-1} denoted as FA_{10} and FA_{100}, respectively) mixed with garden soil (GS) in combination with nitrogen fertilizer (NF; applied @ 90 and 120 kg ha^{-1} denoted as NF_{90} and NF_{120}, respectively) and blue green algae biofertilizer (BGA; applied @ 12.5 kg ha^{-1} denoted as $BGA_{12.5}$). Significant enhancement of growth was observed in the plants growing on amended soils as compared to GS and best response was obtained in amendment of $FA_{10} + NF_{90} + BGA_{12.5}$. Accumulation of Si, Fe, Zn and Mn was higher than Cu, Cd, Ni and As. Arsenic accumulation was detected only in FA_{100} and its amendments. Inoculation of $BGA_{12.5}$ caused slight reduction in Cd, Ni and As content of plants as compared to NF_{120} amendment. The high levels of stress inducible non-protein thiols (NP-SH) and cysteine in FA_{100} were decreased by application of NF and BGA indicating stress amelioration. Study suggests integrated use of FA, BGA and NF for improved growth, yield and mineral composition of the rice plants besides reducing the high demand of nitrogen fertilizers. (Source Tripathy et al 2008, Chemosphere Volume 70, Issue 10, Pages 1919-1929)

Biofilmed Biofertilizers, Crop Production and Carbon Trading - Application of synthetic or chemical nitrogen fertilizers has been shown to deplete soil organic carbon in a long run (Khan et al., 2007). Instead, potential use of microbial biofertilizers in agricultural soil carbon sequestration, as an additional advantage has been merely mentioned recently (Ellis, 2008), but no data have been reported. Growth increases of rice roots after biofertilizer application have been observed in Vietnam (Hien, 2008). However, its effect on soil carbon sequestration has not been evaluated. I have been conducting studies on biofertilizers based on microbial biofilms and their effects on soil carbon accumulation. Biofilms are complex communities of microorganisms attached to surfaces or associated with interfaces. They are found in many environments, including the soil. They can be harmful/pathogenic or beneficial. Beneficial biofilms can be developed *in vitro* and used more effectively as biofertilizers (biofilmed biofertilizers, BBs) for non-legumes, by combining a higher number of microbes (Seneviratne et al., 2009). Apart from their plant growth promoting effects, they help increase soil carbon accumulation. In a nursery tea soil, a liquid formulation of BBs together with 50% of recommended chemical fertilizers for tea increased soil organic carbon by 30%, compared to the application of 100% of the recommended fertilizers alone (Jayasekara et al., 2008). When translated to the field tea soil, this is a considerable carbon sequestration. Application of BBs to rice in a field increased root growth by ca. 2-3 fold (Figure 1, unpublished), compared to the application of recommended chemical fertilizers alone. This should contribute to increased soil carbon storage. Thus, these biofertilized fields can be employed for Clean Development Mechanism (CDM) project activity, which is an added advantage of using BBs in agriculture. Because this field of research is still in its infancy, both laboratory and field experiments are required to fully explore the potential of using BBs in simultaneous crop production and carbon trading in the future. (Source - www.scitopics.com)

Forecasting of Rhizobial Biofertilizer Technology Using Maturity Mapping - The world population and food consumption rates continue to rise dramatically over the next 40 years. The challenging task is supplying enough food to meet increasing population in the future, while preserving and enhancing natural environment for the future generation. To achieve the first task, chemical fertilizers were used intensively around the world to increase crop yield. However, they started displaying their harmful effects to the environment. Therefore, the biofertilizers were introduced as alternative fertilizers to the farmers for reducing usage of the chemical fertilizers and preserving the environment in the long run. In this study, the rhizobial biofertilizers are the most interested because their technologies are more developed and advanced, and their markets are larger than any other types of the biofertilizers today. Because of their huge markets, many biofertilizer companies invest a large amount of money in Research and Development (R&D) of rhizobial biofertilizer technology. To be competitive in the global market, the companies must know its future technology and make the right strategic decisions for product development. Therefore, the overall objective of the study is to determine the current stage of rhizobial biofertilizer technology in the world on the technological s-curve and give the recommendation to R&D department of biofertilizer companies in the world whether optimizing the existing rhizobial biofertilizer technology or developing the new technology (optimization vs innovation). This study used the phase I of TRIZ technology 2 forecasting (maturity mapping) to plot all four Altshuller's descriptive curves. The patent databases used were the US and UK Patent Office's online database. From the study, it may be concluded that the current stage of rhizobial biofertilizer technology in the world is in the growth, nearly maturity stage of its technological S-curve. As a result, it is recommended that R&D department of the biofertilizer companies should optimize the existing rhizobial biofertilizer technology to move it up its S-curve until the end of its technological evolution. (Source – www. icbm.bangkok.googlepages.com).

Hypersaline Cyanobacterium: A Potential Biofertilizer for *Vigna mungo*. L (Black Gram) - The present study highlights the effect of interspecific competition between natural fertilizers, (cow dung), chemical fertilizer (urea), and biofertilizer (*Phormidium tenue, Bradyrhizobium* sp) on the overall growth performance and reproductive yield of *Vigna mungo* L. All the observations were done under the same experimental and environmental conditions. The differences in the growth parameters such as shoot length, root length, number of nodules, 100 grain weight, number of flowers, shoot and root weight were studied at different stages i.e., vegetative, flowering and pod forming. The biochemical constituents of leaf and seed were analyzed for chlorophyll, protein and total free amino acid content. (Karthikeyan, et al Am.-Eurasian J. Sustain. Agric., 2(1): 87-91, 2008)

Impact of Microbial Inoculant Application on Agrostis stolonifera var. `Penn A4' Performance under Reduced Fertilisation - Microbial inoculants have been used as turf management aids with more frequency in recent years. Several product manufacturers assert that the application of these products to turfgrass boosts nutrient uptake, enhances rootzone bacterial and fungal populations and activity, and improves turf stress tolerance. However, little scientific information is available concerning the reliability of these assertions, especially the actual benefits of commercially available microbial inoculants, which frequently contain mixtures of bacteria and fungi. An experiment was established to test the veracity of some of the putative claims. The microbial inoculant tested did not affect turfgrass or rootzone nutrition. However, the application of the microbial inoculant increased rootzone microbial activity and turfgrass stress tolerance, indicating that microbial inoculants may help turfgrass managers to maintain healthier turfgrass swards under intensive and unforgiving management regimes even during the establishment years. (Source – Butler and Hunter 2008, ISHS Acta Horticulturae 2008, 783 : 333-340)

Effect of liquid and cyst formulations of *Azospirillum* with inorganic nitrogen on the growth and yield of rice - The nitrogen-fixing rhizobacterium *Azospirillum* lives in close association with plant roots, where it exerts beneficial effects on the plant growth and yield of many crops of agronomic importance. As carrier-based inoculants have a short shelf life and poor quality, new liquid and cyst formulations of inoculants have been developed and standardized for *Azospirillum* . In the present investigation, experiments were conducted to study the effect of liquid and cyst formulations of *Azospirillum* , combined with inorganic nitrogen, on the growth and yield of rice. Inoculation with the cyst formulation of *Azospirillum* enhanced the plant height, biomass and N uptake of the plants, the available nitrogen content of the soil and the yield of rice to the greatest extent when compared to carrier-based *Azospirillum* , followed by the liquid formulation. The results of the present study clearly indicated that the cyst and liquid formulations of *Azospirillum* could be used as bioinoculants more effectively than the carrier-based one. (Source - Vendan and Thangaraju, 2009, Acta Agronomica Hungarica, Volume 57, Number 1/March 2009)

Efficacy of microbial inoculants on reducing the phosphatic fertilizer input in chrysanthemum - In recent years, vesicular arbuscular fungi (VAM fungi) and phosphate solubilizing microbes (PSM) have become important biotechnological tools and are being employed to reduce the input of fertilizers and irrigation. In the present study, number of VAM fungi and PSM were evaluated for their efficacy in improving the performance of chrysanthemum. A package of specific VAM-*Glomus fasciculatum* and PSM-*Aspergillus niger* was developed for less expensive cultivation of this important floricultural crop (Source - Chandra et al 2009 Indian Journal of Horticulture, Vol : 66, (1)

Book Reviews

Organic Farming and Mycorrhizae in Agriculture/edited by Pravin Chandra Trivedi. New Delhi, I.K. International Pub., 2007, viii, 290 p., Price $60. ISBN 81-88237-63-9 - "Organic farming is a crop production system that avoids the use of synthetic and chemical inputs like fertilizers, pesticides, growth regulators and livestock feed additives. Indiscriminate use of synthetic chemicals and the problems arising from them forced us to think about the alternative means. Organic manures such as farmyard manure, compost, vermicompost, biofertilizers, biopestcides, etc. can be used at least as complement, if not a substitute. The present book "Organic Farming and Mycorrhizae in Agriculture" incorporates articles on organic farming, biofertilizers, PGPR bioinoculant, role of mycorrhiza in agriculture, biopesticides, VAM biotechnology, use of Azolla for sustainable crop production and economics of bio-inputs usage in agriculture. This book provides excellent information on the subject and would prove to be a very useful reference for agriculturists, botanists and environmentalists looking for the worldwide demand of organically produced crops and commodities." (jacket)

Organic Recycling and Bioinoculants For sustainable Crop Production Edited by LL Somani and S.C. Bhandari, 2007, Published by Agrotech Publishing Acadaemy, ISBN 81-8321-066-X, pages-368, Price Rs. 1080 – Fertilizers are responsible for 50% crops yield increase in recent times. The continuous use of high levels of chemical fertilizers is adversely affecting the sustainability of agricultural production and causing environmental pollution. In coming decades a major issue in designing sustainable agriculture system will be the management of soil organic matter and the rational use of organic inputs such as animal manures, compost and biofertilizers in an integrated manner. The present book is a compilation of chapters on all these relevant aspects, each one contributed by the experts in the field. It is hoped that the book will help the scientists, planners and extension workers in achieving sustained productivity while decreasing dependence on non-renewable sources of nutrients. (Jacket)

Biofertilizer Technology By Tanuja Singh and S.S. Purohit, Agrobios, 2008, xviii, 390 p, ISBN : 81-7754-382-2, Price - $55.00 - Biofertilizer is still an unclear term. It can be easily found that biofertilizers are identified as plant extract, composted urban wastes, and various microbial mixtures with unidentified constituents and chemical fertilizer formulations supplemented with organic compounds. Likewise, the scientific literature has a very open interpretation of the term biofertilizer, representing everything from manures to plant extracts. However biofertilizer is most commonly referred to the use of soil microorganisms to increase the availability and uptake of mineral nutrients for plants. The book tries to answer all these issues and covers all important biofertilizers. Important chapters include: 1. Biofertilizers and sustainable agriculture. 2. Nitrogen fixation. 3. Microbial inoculants for nitrogen fixation. 4. Rhizobium biofertilizer. 5. Application of biofertilizers in field crops. 6. Production of rhizobium biofertilizer. 7. Azospirillum biofertilizer. 8. Azotobacter biofertilizer. 9. Blue green algae and azolla as biofertilizer. 10. Estimation of nitrogen fixation. 11. Biological mobilization of phosphorus. 12. Vesicular-arbuscular mycorrhizae (VAM). 13. The cyclic system of nutrient management. 14. Laboratory culture of microbial biofertilizers. 15. Mass production of biofertilizers. 16. Quality control in bioinoculants. 17. Perspectives. Selected bibliography. (Jacket)