**Appeal to Readers**

NPK-LIQUID BIOFERTILIZERS
(Poly Culture)

Dr. Krishan Chandra

Abundance of glomalin in rhizosphere soils of Godavari belt region

Praveen Kumar V and S. Ram Reddy

National and International Events

Book Review

---

Biofertilizer Newsletter (BFNL) is a bi-annual publication under National Project on Organic Farming, Ministry of Agriculture, Government of India. BFNL is registered with Indian Scientific Documentation Centre. Scientific articles, extension news, results of field trials, information about recent events and review of books are especially welcome. Regarding articles, opinion expressed in BFNL is that of the author(s) and should not be attributed to this Centre. Acceptance of manuscripts for publication in BFNL shall automatically mean transfer of copyright to Biofertilizer Newsletter.
From the desk of Chief Editor........

National Centre of Organic Farming, Ghaziabad and its seven Regional Centres at Ghaziabad (at HQ) Bangalore, Bhubaneshwar, Panchkula, Imphal, Jabalpur and Nagpur are presently playing major role in implementing the objectives of National Mission for Sustainable Agriculture in India. At present Indian agriculture production is declining due to non judicious use of synthetic fertilizers and chemicals. The soil organic carbon content of soil has reached critically low level. It is essential to improve the organic matter content in soil in order to improve soil carbon contents and other minerals required for high crop production. The organic farming restricts the use of synthetic chemicals and fertilizers for crop production. Thus use of organic products like biofertiliser, farm yard manure, compost, vermicompost and other organic input application to soil are recommended. Increasing soil organic carbon and soil fertility is primary concern. Application of biofertiliser like nitrogen fixing organisms, phosphorus solubilizing bacteria, potassium mobilizers, sulphur mobilizers and waste decomposers is not only increase soil health, fertility status but also promote crop growth by suppressing disease pathogens. Biofertilisers have a great potential in improving soil health conditions and sustainable agricultural production. Presently in the market solid and liquid carrier based different biofertilizer formulation products are available. Presently the liquid formulations of biofertiliser have been developed by various institute and organizations gaining more importance due to long shelf life and high population. Increase in crop growth and production is observed when applied these biofertiliser through seed or irrigation or soil application. It has been scientifically proven application of biofertiliser to soil has a beneficial to both crop plants and soil. Thus understanding the beneficial effects of biofertiliser microbial inoculants on different crops, identification of new fast growing strains, formulations of novel biofertiliser, and its application is subject of curiosity around the world. Thus government of India is making serious efforts to fill this gap by introducing new schemes and policies.

In the present issue articles on NPK-LIQUID BIOFERTILIZER, Abundance of glomalin in rhizosphere soils of Godavari belt region presented apart from this other columns are as usual.

I wish this edition will helpful to the researchers, scientists, administrators, farmers, industrialists and others to understand the importance of biofertilisers in agriculture.

Dr. Krishan Chandra
Chief-Editor
**Appeal to Readers**

**Welcome readers – now you have opportunity to participate and be interactive with this publication.**

All the time the readers are made to read whatever is published and there is no way to understand the level of satisfaction the readers come to attain after going through its contents on publication of an issue. We think that reader's views are quite important to consider. The news / information being disseminated through this publication should have a reflection from the readers to complete the process of communication and to enable the readers to communicate if they expect any special reference or material. The choice of the readers should always be kept in mind while making efforts to give latest news / information on the subject. Thus to make it interactive, more informative and readers friendly we think that creating this column is quite important.

We welcome the communication from our valued readers for this column. The communication may contain views of readers on importance of material published and its extent of advantages to them beside the material they think to be given consideration for publication in the issue. The feedback so received from the readers would not only be accommodated in this column but also it would be considered to assess it if found significant to further improve the quality of material to be published. The communication may also be information about a particular event, news or literature on biofertiliser in the locality of the readers which could turn advantageous to other readers. Thus an interaction could be established among the readers through this publication. This would also inspire the others readers to be interactive and share their views / information and news which we think would ultimately benefit the all the stake holders including farmers.

With this we again welcome the letters from the readers addressed to the editor. The readers must write their complete name and communication address, mobile no. and e-mail IDs while making communication with us for this column.
NPK-LIQUID BIOFERTILIZERS (Poly Culture)

Dr. Krishan Chandra
Director, National Centre of Organic Farming, Ghaziabad (UP)

Introduction
The success of green revolution depends upon the availability of fertilizers, high yielding of seeds, improved agronomical practices and timely availability of water. The demand for nitrogenous fertilizers has been increasing but its production has always fallen short.

In such a scenario, the use of microbes who do not need fossil energy is of immense value, low input sustain farming through biological nitrogen fixation or increased efficiency of fertilizers applied. The part of increasing deficit of nitrogenous fertilizers can be made up if part of the vast reservoir of atmospheric nitrogen in a simpler way-in the nodules of roots of legume plants e.g. soybean, chickpea, etc. These are called natures mini fertilizer factories. Biofertilizers have an important role to play in improving nutrient supplies and their crop availability in the years to come. They are of environment friendly non-bulky and low cost agriculture inputs. Some specific bacteria or micro-organisms in the soil convert this nitrogen into ammonia and amino acids. These amino acids can be used by the plants to build up proteins. This process world wide is known as "biological nitrogen fixation" and the product is called biofertilizers. Biofertilizer is an organic product containing a specific micro-organisms in concentrated form which is derived either from the plant roots or from the soil root zone (Rhizosphere).

1. Nitrogen Fixing bacteria (NFB)
   a) Symbiotically by Rhizobium,
   b) Non symbiotically by Azotobacter, Azospirillum,

2. Phosphorous solubilizing microorganism (PSM)
3. Potassium mobilizing micro-organism (KMB-Frateuria aurentia)

Biofertilizers are the preparations containing cells of microorganisms which may be nitrogen fixers, phosphorus solubilizers, Potassium mobilizing micro-organism (Frateuria aurentia) sulphur oxidizers or organic matter decomposers. In short, they are called bioinoculants which on supply to plants improve their growth and yield. In recent years, a need has arisen for organic fertilizers including biofertilizers to minimize our dependence on fertilizer nitrogen, phosphorous or potassium. The reasons are many

i. crops suffer from potassium deficiency because of excessive use of nitrogen based fertilizers.

ii. Excessive potassium treatment decrease available nutritive food such as ascorbic acid etc.

iii. Continuous use of ammonium fertilizes increase soil acidity and radioactivity.

iv. Chemical fertilizers have less effect on succeeding crops.

On the other hand biofertilizers are advantageous over chemical fertilizers due to low cost, simple methodology of production, no any hazard to agroecosystem and considerable residual effect on succeeding crop, reported from the application of 30 - 40 kg/ha. N; Phosphorous 5-10 kg/ha. P2O5; Potassium 10-15 kg/ha. K2O. Biofertilizers makes a significant contribution towards the development of strategies for productivity improvement and helps for economizing the production cost. Since long effect of nitrogen fixers, phosphate solubilizers
singly has been studied by many workers on many crops. But no work on combined effect of inoculant has been reported.

TYPES OF BIOFERTILIZERS FORMULATION

1.1 INTRODUCTION

there are a wide variety of formulation types, both liquid and solid. The main types currently used for organisms have been classified by into dry products (dusts, granules and briquettes) suspension (water-based and emulsions). A wider range of intululation types, together with additive types are

1.2 CARRIER BASE BIOFERTILIZERS

1.2.1 Dry Products

These comprise dusts, granules a classification based on tom lit. or aggregate size also included in this group are wettable powders, which are formulated as dry powder designed to be added to a liquid carrier, normally water, just before application.

1.2.1.1 Dusts

Based on inert diluents or carriers, normally of low absorbent capacity, these have particle size ranging from 5-20 Iwo Particles of <10 mm are so an inhalation hazard, but the %manor particles adhere best. Minerals such as clays are often the first choice of manufacturers, but silica minerals are also used varying proportions to obtain the desired bulk density. Dusts typically contain <10% of an organism by weight. They are normally prepared by feeding the organism into an air stream from mixing with the mineral diluent in a blender or mixer. Particle else, bulk density and flow-ability are extremely important. The proportion of components is varied to form a free-flowing, fluffy powder which does not stick to machinery or allow separation of the organisms from the diluent during transport, storage and application. As, separation occurs if diluent particles are not within 10 mm of the size of the organism particles. Hence, the product is not accepted by the users.

1.2.1.2 Granules, briquettes pellets and capsules

Granules are discrete masses 5-10 mm3, in size, pellets are>10mm3 and briquettes are large blocks up to several cubic centimeters; the sizes are defined in Like dusts, these products contain an inert carrier like charcoal, lignite, vermiculite, clay, coirpit etc. holding the organisms. Other Carriers include clay minerals, starch polymers, dry fertilizers and ground plant residues. Choice of carrier depends on absorption (mote important for formulating slurries of organisms), hardness, bulk density and product disintegration rate in water. Soft carriers, e.g., bentonite, disintegrate quickly to release the organism. The product can be coated with various materials to slow and control the rate of release, which also depends on unit size. Typically the concentration of organisms 5-12%, usually <15%. Some producers also use seaweed extract with bacteria the product is picking up in some states. However,

There are three types of granules:

1. The organisms are attached to the outer surface of a granular carrier in a rotating drum by a sticker
2. The organisms are sprayed onto a granular carrier without a sticker along with seaweed. Mostly, producer adopted this process.
3. The organisms are incorporated into a carrier paste or power which sets as a matrix size being controlled by passing the product through a sieve. Is the most common, but very few manufactures adopted it, perhaps, the cost of production is high and market competition. Although the process is most effective.

1.2.1.3 Wettable Powders and water dispersible granules

Prototype and early Rhizobium commercial products were wettable powders, because they are relatively easy to produce. It was now realized, however, that these formulations have two disadvantages: difficulty with mixing into water and comparatively large particle size. Wettable powders consist of technical powders plus additives to make them readily miscible
with water and stable during storage on the shelf. Up to 80% of the product can be technical powder the remainder being fillers surfactants dispersants included to improve application and handling.

1.3 LIQUID BASE BIOFERTILIZERS (FORMULATIONS)
What is formulation? Defined collectively, formulation comprises aids to preserving organisms, to delivering them to their targets and - once there - to improving their activities. A technical concentrate of an organism that has been formulated is termed a formulation, or product which may be stored and put on sale commercially.

The number of products are sold in market in the liquid form. Few of them have a good impact on the crops as well as the farmers' acceptability. All the product available in the market have a separate bacteria like Azospirillum, Azotobacter, Rhizobium, Phosphorous solubilizing micro-organism, Potassium mobilizing micro-organism (Frateria aurentia) and PGPR (Pseudomonas fluorescence). The use of these product in the field needs about 3-4 products to get the N,P,K nutrient for maximum yield. The price of these product varies from Rs. 200-400/- per liter, which is costly to afford by small and marginal farmer. Hence, the product is popular among few section of the farmers, either who have big holding or have a capacity to purchase these products. The growing demand of product shows that the performance of the liquid biofertilizers are incredible, provided the quality is maintained.

1.3.1 Dormant Aqueous Suspensions
Currently several commercial products are available in the market following the dormant technology. Generally, they are using growth suppressants, contaminant suppressant like Sodium azide, Sodium benzoate, Butanol, Acetone, Fungicides, Insecticides , etc., for the long term viability. It was experience, that these formulations are not suitable for short duration crops, where actions are required immediately. It was observed that the Rhizobium dormant liquid formulations ,when used after 8 months reduced the size of the nodules and minimize the nitrogen fixation process. In case of Azospirillum, Azotobacter, PSM, it was observed that these bacteria crossed the extreme dormant stage. Therefore, when they applied on crops they take prolonged reactivation time. This long time is not desirable for short duration crops (Chandra et.al 2005)

Use of PVP K-30 in Liquid Formulation:
It has been noted the number of workers are using PVP K-30 in their liquid formulation with amended media after it had been published by NIFTAL on trail basis. The same media was slightly changed by the Indian workers and published for the multiplication of different biofertilizers. PVP K-30 has the following disadvantage:

PVP K-30 contains nitrogen which provide faster growth of bacteria during multiplication in the small scale. However, when it start large scale production, it fails due to nitrogen content. It allows bulging/bursting bottle.

The use of PVP K-30 ensures maximum contamination due its, nitrogen content. Hence, the quality of the product deteriorates after 2-4 months.

It was also noted the efficiency of the nitrogen fixing bacteria like Rhizobium, Azospirillum, Azotobacter decrease drastically. The performance of the PSM culture is also affected as it's solubilizing power decrease about 60-80% in the field.

The PVP material available in the market is not of good quality contains heavy metals, which affects the quality of the product and also have no export value as it crossed the permissible limits of heavy metals.

1.3.2 Dormant Oil Suspension
Microorganisms can be suspended in oil at high concentration in various degrees of dehydration to remain viable. This formulation delivers organisms in a physiologically dormant state and does not encourage the growth of contaminants during the storage. The bacteria / fungus have been successfully dried by continuous aeration as a suspension in oil.
to provide inoculants with Shelf life of several years.

The oil suspension (mainly coconut oil) available are not so promising as claimed and also has the limitation in reactivating the bacteria. It generally takes 10 - 20 days to regenerate and the initial requirement of the plant is not fulfilled by them.

To cope up with this problem, the author developed a combined formulation of Nitrogen, Phosphorus, Potash culture in 2002. Number of trials had been conducted in different soils and climatic zones like Karnataka, Tamil Nadu, Kerala, UP, Gujarat, Orissa, West Bengal, Andhra Pradesh, North Eastern region etc. which revealed a good yield and maximum benefit about 15-30% over the conventional.

Apart from giving maximum benefit, the concept of combined culture (NPK) is cost effective i.e. about Rs.400-450 per litre. Manufacturing this culture is a very difficult task as each bacterium has different characteristics and secretes different enzymes and organic acids. The compatibility of bacterium is the main task in the manufacturing process.

The author had multiplied different cultures separately and mixed with the liquid base material which is suitable for all NPK bacteria. The survivability of the culture was recorded, which showed that Azospirillum could survive up to 12 months, whereas Phosphorus and Potash bacteria for more than a year except Rhizobium combination.

The salient features of the NPK formulations are as:

Due to bacterial secretion of organic acid and enzymes, this formulated product is high in nutrition. Hence, crop response can be noted within 5 days of application.

Even when the product expires and the bacteria die, the on the growth of crops is yet noticeable.

Each NPK bacteria survives for a year and its minimum $1 \times 10^8$ cells per ml (see table 1).

**NPK-LIQUID FORMULATION**

2.1 INTRODUCTION

Formulations of bacteria as aqueous suspension avoid the cost of drying and are easier to apply, but have the continuous problem of preservation in the presence of water. These key contrasting features should maintain a roughly equal market share for dry and liquid bacterial products. Formulation technology must be considered at all staged from production of an organism to its eventual action on the target. The method of production often dictates subsequent formulation activities, which in turn may lead to alterations being made in the production process.

There are four basic functions of formulation. These are:

- To stabilize the organism during production, distribution and storage;
- To aid handing and application of the product so that it is easily delivered to the target in the appropriate manner and form.
- To protect the agent from harmful environmental factors at the target site, thereby increasing persistence.
- To enhance activity of the organism at the target site by increasing its activity, reproduction, contact and interaction with the target crop.

A wide variety of approaches are available to the formulator to achieve these basic functions, ranging from production of liquid suspension, and even incorporation of the agent in a living organism. The final product developed depends on several factors, such as type and location of target, availability of formulation materials, as well as user preference. A formulator is, therefore, faced with several problems and challenges such as shelf-life, deterioration at high temperature, competition with local strain, etc. The aim of a formulation process is to address these problems. Optimization of formulation to address one
problem may result in an adverse effect on another aspect of the product’s function. Formulation, therefore normally represents a compromise between these opposing effects. Due to the diverse nature of climatic situations, targets and user preferences, a single organism will often be formulated in several different forms, each aimed at a particular market. Broadly formulation of organisms can be split into two groups, dry solid and liquid. All formulations, however, must still be practical and economically viable. For example, it is not practical to develop a product that includes a protective dye that also stains the skin of the operator. It is not economically viable to add expensive sunscreens to a product that will be applied at a high volume per unit area unless they are formulated to stay in close just a position to the organism to minimize the quantity required. This chapter elaborates the four basic functions of a formulation and how they affect formulation approach. It also reviews the main individual liquid formulation types suitable for use with organisms. Both function and type are interrelated, each influencing the other.

2.2 REVIEW LITERATURE

Review literature on formulation requirements of organisms has not kept pace with the development of the subject. These reviews, however, have concentrated on general principle and have not presented data about formulation processes additive or effects. Some earlier reviews giving limited data have been confined to products aimed at specific narrow target ranges and even these lack practical information on specific formulation ingredients and methods (Angus and Luthy, 1971; Ignoffo and Falcon, 1978; Couch and Ignoffo, 1981; Young and Yearian, 1986; Connick et al., 1990; Diagle and Connick, 1990).

They claimed no loss of activity after 2 years in storage at 34°C. Xylem was successfully used in early B.thuringiensis products, and no deterioration was detected by bioassay with Galleria mellonella in an exceptionally stable ssp. Galleriae. In general, with both species of bacteria, manufacturers have difficulty in maintaining good storage of formulated products containing water for longer than 18 months without refrigeration (Devisetty, 1988).

Cells of Rhizobium entrapped in polyacrylamide gels remained viable for over 3 years when stored remained at 28°C and a water activity. Consequently, the use of bacteria inoculants in tropical areas can be severely limited (Somasegaran et al. 1984). Wolf and Hoflich (1986) have shown that the growth rate of rhizobia in peat was increased by adding molasses, bu emphasized that storage of the inoculant at cool temperatures was most important if viability of the bacteria was to be maintained for long periods.

2.3 NPK-LIQUID COMPOSITION

Water-based formulations have rarely been marketed, except in developing countries like India, because of the difficulty of curbing growth of contaminants in less pure preparations. Growth is easily arrested by drying in wettable powders. However, currently there is more interest in developing liquid concentrates with multi bacteria at present on the market. In contrast to emulsions, formulation of an amended medium with preservatives. The attempt was made by many workers but not succeeded in product outcome.

2.3.1 Selection of NPK-bacteria

Before formulation can begin, the NPK organism must be cultured in such way that the desired propagules are produced. For bacteria, the long-term survival form is usually the most durable and will often be the preferred propagule for formulation. Most microbes survive best when dried, and this is the basis for laboratory techniques such as storage of microbes on silica gel. One important function of a formulation is to regulate where availability. Increased moisture often causes microbes to break dormancy prematurely and encourages growth of contaminants. So, the desired organism should have following characteristics in formulation.

2.3.2 Azotobacter in NPK liquid formulation

This is a group of bacteria which are free living nitrogen fixer. The mechanism by which the plants, inoculated with
Azotobacter; derive possible benefits in terms of increased grain, plant biomass and nitrogen uptake which in turn are attributed to small increase in nitrogen input from biological nitrogen fixation, development and branching of roots, production of plant growth hormones, vitamins, enhancement in uptake as NO3, NH4, I-PO4, K and Fe, improved water status of the plant, increased nitrate reductase activity and anti-fungal compounds. The Azotobacter strain was screened before using in formulation the strain chosen survive at low pH and able to tolerate organic acid produced by PSM and KSM bacteria, besides above features.

2.3.3 Azospirillum in NPK liquid formulation

It is an associative micro-aerophilic nitrogen fixer. It colonizes the root mass and in an environment of low oxygen tension. These bacteria induce the plant roots to secrete a mucilage which aerates low oxygen environment and helps to fix atmospheric nitrogen. High nitrogen fixation capacity, low energy requirement and abundant establishment in the roots plants and tolerance to high soil temperature make these most suitable for tropical condition. Use of Azospirillum under saline-alkali conditions is also possible because their strains are known to maintain high nitrogen activities under such stress conditions. The Azospirillum acid tolerant strain was chosen before using in formulation the strain was tested to survive at low pH and able to tolerate organic acid produced by PSM and KSM bacteria. Azospirillum nitrogen fixating capacity was evaluated fixes 30-40 kg N/ha.

2.3.4 Phosphate solubilizing microorganism in NPK liquid formulation

Phosphorus is the most important micro-nutrient required by all crops and microorganisms for their normal growth and development. However, India soil test, generally low to medium in available phosphate and not more than 30% of applied phosphate is available to the current crop, remaining part gets converted into relatively unavailable forms. Some common heterotrophic bacteria like Bacillus megatherium, Bacillus polymyxa, Pseudomonas strata, Pseudomonas rathonis possesses the ability to bring sparingly soluble/insoluble in organic and posses the ability to soluble forms by secreting organic acids. These organic acids lower soil pH and turn brings about dissolution of unavailable forms of soil phosphorus. Some of the hydroxyl acids chelate Ca, Al, Fe and Mg resulting in effective availability of soil and hence it’s the inoculation as NPK-biofertilizer reduced the phosphate dose by 50% and could be applied in the form of the of rock phosphate which is the cheaper source of phosphorus. The selection of phosphorus solubilizing bacteria is play an important role in formulation the strain must have quick spores forming capacity besides few mentioned above, and should tolerate base material used in composition.

2.3.5 Potash Mobilizing Bacteria (Fratreuria aurentia) in NPK liquid formulation

The readily exchangeable fraction of the potassium is believed to be present especially on the surface of the clay components, so that the finer the clay the greater the amount of this fraction. The non-exchangeable fraction is believed to reside in those expandable constituents of the clay which ‘gorge’ the potassium into the interstices between the crystal layers and thereby trap the potassium. Use of K-bacteria (Fratreuria aurentia) into the clay is believed to release some of this gorged potassium. The Potash Mobilizing Bacteria is a gram negative roc type bacteria, can grow about pH 3.5-11 and capability of mobilizing the mineral potash in the tonne of 40-60 kg per ha. As the potash is producing the organic acids, therefore combination of the potash bacteria in the formulation was quite typical. Some physical characteristic of KMB-Fratreuria aurentia as mentioned in the below table.

<table>
<thead>
<tr>
<th>TESTS</th>
<th>RESULTS (K-10)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth at temperature</td>
<td></td>
</tr>
<tr>
<td>4°C</td>
<td>+</td>
</tr>
<tr>
<td>15°C</td>
<td>+</td>
</tr>
<tr>
<td>42°C</td>
<td>-</td>
</tr>
</tbody>
</table>
55°C  - 
65°C  + 
Growth at pH
5.0  + 
8.0  + 
9.0  + 
11.0 + 
Growth on NaCl (%) 
2.5  + 
5.0  - 
7.0  - 
9.0  + 
10.0 RESULTS (K-10)*
Growth under anaerobic condition  - 

The main function of K is the activation of numerous enzyme systems involved in the formation of organic substances and in build-up of compounds such as starch or protein.

- K is involved in cell enlargement and in triggering the growth of young (meristematic) tissues.
- K improves the water status of the plant and water use efficiency in general (Sahoo, 2002).
- K promotes photosynthesis and the transport of the assimilates (carbohydrates, etc.) to the storage organs (fruits, Roots).
- K is essential for the development of the root syste (Ramarethinam at .al, 2006).
- K increases the sugar content of crops such as fruit carrots and sweet potatoes.
- K increases the size of fruits.
- K improves the colour of fruits and flowers.
- K improves the keeping quality of fruits and vegetables.

- K is essential for the efficient nitrogen fixation by leguminous crops.

PRODUCTION OF NPK-LIQUID BIOFERTILIZERS

3.1 INTRODUCTION
The bacteria of NPK were multiplied in fermented liquid suspension concentrate is formulated from ex-fermenter slurry of each organism. The base material which contains emulsifier, dispersant, cell protectant, moisturizer, humectants, etc., and 1.0 ml of micronutrient per liter of NPK broth. Their importance are as follows

3.2 PREPARATION OF MICRONUTRIENT — STOCK SOLUTION
Ingredients per liter:
Boric Acid (H₃B0₃)  3.780 g
Manganese sulphate  1.540 g
Zinc Sulphate  0.210 g
Sodium molybdate  5.060 g
Ferric chloride  5.000 g
Cobalt sulphate  0.004 g
Lactic acid (88%)  670.0 ml
Distilled water for make up to 1 liter
*Addition of 1.0 ml per liter in NPK medium

3.3 USE OF DYE IN MEDIUM
Dyes can be incorporated in base material it had a adverse effect on the growth of bacteria the choice of dye individual preference rather than any specific reason however any one dye may be used in formulation.

3.3.1 Borothymol Blue (BTB)
Stock solution: 0.5 g/100 ml ethanol
Add 5 ml stock/liter NPK base material
Final concentration of BTB : 25 ppm.

3.3.2 Congo Red (CR)
Stock solution: 0.25 g/100 ml
Add 10 ml stock/liter NPK base material
Final concentration of CR : 25 ppm.
3.3.3 Bromcresol Purple (BCP)
Stock solution: 1 g/100 ml ethanol
Add 10 ml stock/liter NPK base material
Final concentration of BCP: 100 ppm.

3.3.4 Brilliant Green (BG)
Stock solution: 125 mg/100 ml ethanol
Add 1 ml stock to liter of NPK base material
Final concentration of BG: 1.25 ppm.

3.4 Use of additives in NPK-formulation
Additives were used in the formulation which helps a spray/drip irrigation to reach its target and improve performance once it is there. The efficiency of each type of additive in functionally increasing the potency of a NPK inoculants or decreasing the adverse effects of the hazards.

3.5 Use of wetters in NPK-formulation
They improve spray coverage on hydrophobic leaf surfaces. They facilitate mixing into water of hydrophobic spores toxic crystals.

They are also used to form emulsions between chemical used and water by reducing interfacial tension and surface tension summarizes uses, qualities and performances of many wetters, as well as the concentrations in formulation depends upon at which they are applied. However, the author used at 0.01-5% in fermenter base material. Briefly, the best include the Tritons, Tweens and the new organosilicone super spreaders: non-ionic wetters are preferable.

3.6 Use of stickers in NPK-formulation
Sticker plays an important role in NPK liquid formulation in ensuring that the inoculant adheres to seed. They also protect the bacteria from desiccation and therefore contribute to the shelf-life and efficacy of the inoculant. Much work has evaluated the effectiveness of a wide range of potential stickers.

(40% w/v) and carboxymethylcellulose (4% w/v) were excellent stickers, binding over $10^3$ - $10^4$ inoculant per seed and protecting the bacteria from desiccation. Readily available wallpaper glue (10% w/v) bound more inoculant per seed. Water, sugar, corn syrup, honey and evaporated milk were poor stickers and did not protect the bacteria. NPK-liquid culture contains sticker which absorb excess moisture and provide better survivability of microorganism (Chandra et al. 1995b).

3.7 Use of humectants in NPK-formulation
For maximum microbes, it may be necessary to increase the water availability in a formulation by addition of humectants. Humectants, such as glycerol, glycols or molasses, increase hygroscopicity to reduce evaporation. Suspended particles, such as microbes, also alter physical aspects of drops. Humectants in the fermentation medium also increase the subsequent shelf-life of NPK organism.

Base material was sterilized separately after adjusting pH 6.8. Autoclave at 121° C and 15 lbs. Autoclaving time depends upon volume of media to be sterilized, the following data given on experience basis's as

<table>
<thead>
<tr>
<th>Volume (ml)</th>
<th>Autoclaving Time (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 500 ml</td>
<td>20</td>
</tr>
<tr>
<td>1000 ml</td>
<td>30</td>
</tr>
<tr>
<td>2.0-4.0 liters</td>
<td>40</td>
</tr>
<tr>
<td>5.0-10.0 liters</td>
<td>45</td>
</tr>
<tr>
<td>11.0-50 liters</td>
<td>50</td>
</tr>
<tr>
<td>51-70 liters</td>
<td>55</td>
</tr>
<tr>
<td>80-120 liters</td>
<td>80</td>
</tr>
<tr>
<td>130-500 liters</td>
<td>1 hour 30 minutes</td>
</tr>
</tbody>
</table>

30% of the broth material was added to base material and left for curing to 72 hours for stabilization. In general, stabilization of activity in aqueous
emulsions is more difficult and shelf-life is shorter if not allowed 72 hours for curing. The formation of emulsions from the aqueous concentrate improves stabilization of the physical state of a product. It reduces sedimentation of particles during storage. It mainly involves the prevention of microbial growth and the action of enzymes, most of which have alkaline or near neutral optima. It is achieved by lowering the pH of raw ex-fermenter material and by adding preservatives such as xylem sugar concentrates or antibiotics, and preservatives common in the food and cosmetics industries. Suitable preservatives include sodium benzoate, benzalkonium chloride, sorbic acid and propionate.

Organisms are particulate, which further complicates formulation. Since beneficial organisms are regarded as environmentally friendly, it is advisable that any formulation additive also should be environmentally friendly. In order to retain this advantage.

SURVIVAL OF NPK-PRODUCT

4.1 INTRODUCTION

The formulation requirements are more stringent than those for chemical products. The active ingredient is often a living organism, which must be kept alive and in good health in order to achieve the desired effect. It should not, therefore, be subjected to harsh chemical or physical treatment during the formulation process. There may also be critical nutrition or physical requirements for organisms’

Although growth of bacteria in the liquid formulation is beneficial, viability of the bacteria over a long time period is the most important factor. Survival of NPK - bacteria in inoculants depends on type of liquid base material used, the method of sterilization, and temperature during incubation, storage and distribution High temperatures above 40°C should be avoided as they can cause desiccation of the bacteria. NPK inoculants should contain enough N-fixing, P-solubilizing and K-mobilizing bacteria to ensure that effective of nitrogen-fixing, phosphate solubilizing and Potassium mobilizing, and that the inoculated bacteria can compete successfully with the indigenous soil population so the strain selection is the key factor of success.

4.2 SHELF LIFE OF NPK-LIQUID INOCULUM

Table 1. shelf life of NPK-Liquid Inoculums

<table>
<thead>
<tr>
<th>Inoculum</th>
<th>Month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Azosp</td>
<td></td>
</tr>
<tr>
<td>Azoto</td>
<td></td>
</tr>
<tr>
<td>P.S.M</td>
<td></td>
</tr>
<tr>
<td>K.M.B</td>
<td></td>
</tr>
<tr>
<td>Rhizo(F)</td>
<td></td>
</tr>
<tr>
<td>Rhizo(S)</td>
<td></td>
</tr>
</tbody>
</table>

Contd. in next issue........

Government of India is promoting the use of NPK biofertilizer by giving subsidy under Paramparagat Krishi Vikas Yojana scheme
**Abundance of glomalin in rhizosphere soils of Godavari belt region**

Praveen Kumar V and S. Ram Reddy*
National Centre of Organic Farming, Ghaziabad (UP)
*Department of Microbiology, Kakatiya University, Warangal (TS).

**Introduction**
Arbuscular mycorrhizal fungi form mutualistic associations with about 70% of plant families (Newman and Reddell, 1987) and are abundant in all major terrestrial biomes (Treseder and Cross, 2006). These fungi before they turn over quickly deposit significant quantities of relatively recalcitrant carbon compound glomalin which is a carbon-nitrogen-iron rich glycoprotein within their hyphal walls (Treseder and Turner, 2007). As the hyphae senesce, glomalin is deposited within the soil, where it accumulates until it represents as much as 5% of soil C (Rillig et al., 2001, 2003) and N (Lovelock et al., 2004). It is not exuded by AM hyphae, instead contained within hyphal walls (Driver et al., 2005). During hyphal decomposition, glomalin joins hyphae in binding small soil particles, thus promoting aggregation and soil stability. Although it constitutes only 0.4-6% of hyphal biomass, glomalin accumulates in soil macro-aggregates at much higher masses (e.g., >100 mg g-1) than does hyphae. In soil aggregates, glomalin carbon is protected from decomposition by chemicals and soil organisms, allowing it to remain in soils for decades and accumulate over time (Rillig et al., 2001; Zhu and Miller, 2004). Carbon in bulk soil, by contrast, is more vulnerable to decomposition. Hence, AM glomalin represents a large pathway for storage of stable carbon in soils. Glomalin content of soils generally increases with the abundance of AM plants (Rillig et al., 2001).

Thus, hyphal standing stocks, hyphal glomalin content, and hyphal turnover rate determine the rates at which glomalin is deposited in the soil. Standing stocks of hyphae in soil are on the order of 5 to 90 g cm-2 (Zhu and Miller, 2004). Since AM fungi produce glomalin, soil stocks of glomalin may be indirectly influenced by factors that control AM growth. Globally, AM fungi are most abundant where standing lengths of fine roots and host plant availability are greatest (Treseder and Cross, 2006). According to Wright et al. (1996) and Lovelock et al. (2004), glomalin constitutes a modest proportion (0.4–6%) of this biomass. Life span of AM hyphae are not well documented in natural systems, but laboratory studies indicate they might survive on the order of a few days to a few months (Staddon et al., 2003; Zhu and Miller, 2004; Olsson and Johnson, 2005). Altogether, the deposited glomalin could represent a reasonably large influx of soil organic matter possibly on the order of tens to hundreds of grams of C per square meter per year. Production rates of glomalin are not always correlated with AM abundance in soil.

In addition, the ecophysiological function of glomalin remains unknown; although Gadkar and Rillig (2006) have found evidence that glomalin may be related somewhat to a heat shock protein. Using tandem liquid chromatography-mass spectrometry, Gadkar and Rillig (2006) demonstrated that the amino acid sequences of glomalin are related to hsp60, thereby confirming the speculations by other studies (Rillig and Steinberg, 2002; Driver et al., 2005) that glomalin may be serving a protective function for AMF as a stress-induced protein. Relating glomalin with heat shock protein clarifies how stress imposed by heavy metals may rapidly increase glomalin production by AMF and glomalin related soil protein (GRSP) concentrations in polluted soils (Cornejo et al., 2008).
Material and Methods
All experiments pertaining to this thesis were carried out in the laboratory of Department of Microbiology, Kakatiya University, Warangal. Field experiments were carried out in greenhouse and experimental fields attached to the department. Uniform laboratory conditions were maintained and standard procedures were employed in all experiments. Throughout the experiments, unless and otherwise mentioned Merck or Sigma analytical grade of chemicals were used. The glassware was of Merck or Borosil mark and was thoroughly washed in chromic acid before every use. Each experiment was performed twice with three replications each time.

Soil samples
Soil samples from 33 different locations, representing most of the edaphic conditions of Adilabad, Karimnagar, Khammam and Warangal districts of A.P. were selected and rhizotic soils of plant/tree species were collected. Plants of age group six to seven months, growing in these soils were used for collecting roots and rhizosphere samples. Different samples of soil from the field were carried to laboratory in an ice-box and stored in a refrigerator.

Sterile soil preparation
Soil used for the experiment was collected from soil profile at Kakatiya University (pH 7.0, 0.10% organic matter, 0.56 mhos/cm Electrical conductivity (EC), >50 Kghec-1 available phosphorus, 467 Kghec-1 available potassium) and sieved through a 2 mm sieve, autoclaved for 2 hrs at 121°C before mixing with sterile sand. polythene bags (32 x 18 cm) or pots were filled with sterile sand and soil (1:3).

Enumeration of AM fungal population
Resting spores of AM fungi consisting of sporocarps, chlamydospores, azygospores, and soil borne vesicles were extracted by wet sieving and decanting method (Gerdemann and Nicolson, 1963; Pacioni, 1992). One hundred grams of rhizosphere soil including the roots was collected from the respective plants for qualitative and quantitative estimation of AMF resting spores. This was added into 500 ml of water and gently shaken on a horizontal shaker for 10 min and later allowed to settle down. The supernatant liquid was passed through different sieves consecutively (500-800, 250, 106 and 45 μm pore size). This process was continued till all colloidal material passed through the sieves. All the debris collected on sieves was taken into petridish and was carefully observed for resting spores under stereobinocular microscope. Spores were carefully extracted with needles and brushes and their slides were made in lactophenol for further study and identification. Wherever necessary, photomicrographs were taken. The resting spores were identified by following the key provided by Hall (1980) and Schenck and Perez (1990).

Glomalin extraction (Wright and Upadhyaya, 1996)
Easily extractable glomalin (EGG): The extraction of EEG was done in the following way, 1.0 g of soil was placed in an autoclavable centrifuge tube with 8 ml of 20 mM sodium citrate (citric acid, tri-sodium salt dihydrate), pH 7.0. The mixture was autoclaved for 30 min at 121°C. Immediately after autoclaving, the contents were centrifuged for 15 min at 8000 xg so as to pellet soil particles. The supernatant that contain the protein was collected in a conical flask and its total volume was measured with a graduated cylinder. The protein samples were stored at 4 °C until used i.e., for two to four weeks.

Total Glomalin (TG): The extraction of TG was carried out in the following way, 1.0 g of soil was placed in an autoclavable centrifuge tube with 8 ml of 50 mM sodium citrate (citric acid, tri-sodium salt dihydrate), pH 8.0. The mixture was autoclaved for 60 to 90 min at 121°C (a 60 min extraction is usually performed). Immediately after autoclaving the contents were centrifuged for 15 min at 8000 xg so as to pellet soil particles. The supernatant that contain the protein was collected in a conical flask. Steps 2 to 4 were repeated until the extract was easily see through. The extracts obtained in each round was pooled and, the final total volume was measured with a graduated cylinder and stored at 4°C until used i.e., for two to four weeks.
Quantitative estimation of glomalin
The quantitative estimation of glomalin was done using the method suggested by Lowry et al., (1951). To 1 ml of extract, 5 ml of alkaline copper sulphate reagent was added and incubated at room temperature for 10 min. To this 1 ml of 1 N NaOH and later 0.5 ml of FC reagent were added and the optical density of the resultant blue colour was read at 660 nm. The concentration of glomalin was calculated from the standard graph plotted for bovine serum albumin (BSA).

Results and Discussion
In the present investigations, an attempt was made to assess the abundance of glomalin in the rhizosphere soils of different locations (Table 1). Later isolated glomalin fractions were partially purified to assess the glomalin effect on the germination of seeds of five plants viz. Zea mays, Sorghum vulgare, Oryza sativa, Acacia nilotica and Albizia lebbeck.

In the present study table 1 reveals the amount/quantity of ‘Easily extractable glomalin’ (EEG) and ‘Total glomalin’ (TG) in the rhizosphere soils of different host plants in 33 locations with respect to the spore density. The levels of EEG and spore density were found to be highest in rhizosphere of Sapindus emerginatus (Kuntala) 3.6±0.07 mg g-1 soil and 512 g-100 soil respectively, followed by Punica granatum (Boorgampad) 3.31±0.04 mg g-1 soil and 495 g-100 soil and lowest in Emblica officinalis (Ghanpur) 0.8±0.11 mg g-1 soil and 173 g-100 soil. On the other hand, the highest TG levels and spore density were noticed from the rhizosphere of Calotropis gigantea (Bheemdevarapally) 3.33±0.22 mg g-1 soil and 482 g-100 soil respectively, followed by Anona squamosa (Bheemaram) 2.69±0.09 mg g-1 soil and 362 g-100 soil, whereas both rhizosphere soils of Acacia melanoxylon (Ashwapuram; 0.66±0.07 mg g-1 soil & 154 g-100 soil) and Cassia fistula (Mangapet; 0.66±0.27 mg g-1 soil & 168 g-100 soil) was found to be lowest. There was no correlation found between the quantities of EEG with TG, but the quantities of EEG and TG indicate the occurrence of AM fungi in the rhizosphere soils. But there exists a positive correlation between the glomalin levels and spore density. Recently, Bai et al. (2009) reported a significant and positive correlation between spore density and Bradford-related soil protein (BRSP) i.e., glomalin. Thus, given that the available evidence indicates that glomalin is located in AMF spore and hyphal walls (Driver et al., 2005; Purin and Rillig, 2007), greater spore production by AMF may indicate higher glomalin production. Production rates of glomalin are not always correlated with AM abundance in soil (Treseder and Turner, 2007). Praveen et al. (2012) found a positive correlation between spore number and EEG and stated that amount of glomalin is determined by the spore number and host species rather than soil. The amount of BRSP extracted ranged from 1.09 to 1.72 mg g-1 soil, which falls at the lower end of the range reported by Wright and Upadhyaya (1998). These investigators reported BRSP concentrations ranging from 1 to 21 mg g-1 soil in thirty-seven soils from five geographical locations. On the other hand, BRSP concentrations in the study by Antibus et al. (2006) ranged from 1 to 5.5 mg g-1 soil. Moreover, Lovelock et al. (2004) reported lower GRSP concentrations for pot cultures.

Acknowledgement
Thanks are due to Head, Department of Microbiology, for providing necessary facilities. The financial assistance received in the form of UGC- MRP No: 34-239/2008-(SR) is gratefully acknowledged.

References

Bedini S, Pellegrino E, Avio L, Pellegrini S, Bazzoffi P, Argese E and Giovannetti M. 2009 Changes in soil aggregation and glomalin-related soil protein content as affected by the arbuscular mycorrhizal fungal species Glomus mosseae and Glomus intraradices Soil Biology and Biochemistry 41: 1491–1496


Gerdemann J W and Nicolson T H. 1963 Spores of mycorrhizal endogone species extracted from soil by wet sieving and decanting Transactions of the British Mycological Society 46: 235–244


Lovelock C E, Wright S F and Nichols K A. 2004 Using glomalin as an indicator for arbuscular mycorrhizal hyphal growth: an example from a tropical rain forest soil Soil Biology and Biochemistry 36:1009–1012


Morton J B. 1990 Species and clones of arbuscular mycorrhizal fungi (Glomales, Zygomyctes): Their role in macro-scale and microevolutionary processes Mycotaxon 37: 493-515


Olsson P A, Thingstrup I, Jakobsen I, and Baath E. 1999
Estimation of the biomass of arbuscular mycorrhizal fungi in linseed field
*Soil Biology and Biochemistry* 31: 1879-1887

Paul E A and Clark F E. 1996

Purin S and Rillig M C. 2007
The arbuscular mycorrhizal fungal protein glomal: Limitations, progress, and a new hypothesis for its function
*Pedobiologia*. 51: 123-130

Rillig M C, Wright S F, Nichols K A, Schmidt W F and Torn M S. 2001
Large contribution of arbuscular mycorrhizal fungi to soil carbon pools in tropical forest soils
*Plant and Soil* 233: 167-177

Rosendahl S. 2008
Communities, populations and individuals of arbuscular mycorrhizal fungi
*New Phytologist* 178: 253–266

Siddiky M R K. 2011
Soil biota interactions and soil aggregation. Ph.D Thesis, p. 8, Freie Universität Berlin, Germany

Smith S E and Read D J. 1977
Mycorrhizal symbiosis, 1st edn. San Diego, CA, Academic Press, USA

Smith D L and Almaraz J J. 2004
Climate change and crop production: contributions, impacts, and adaptations
*Canadian Journal of Plant Pathology* 26:253-266

Smith S E, Smith F A and Jakobsen I. 2004
Functional diversity in arbuscular mycorrhizal (AM) symbioses: The contribution of the mycorrhizal P uptake pathway is not correlated with mycorrhizal responses in growth or total P uptake
*New Phytologist* 162: 511-524

Steinberg P D and Rillig M C. 2003
Differential decomposition of arbuscular mycorrhizal fungal hyphae and glomal in
*Soil Biology and Biochemistry* 35: 191-194

Tisdall J M Smith S E, and Rengasamy P. 1997
Aggregation of soil by fungal hyphae
*Australian Journal of Soil Research* 35: 55–60

Treseder K K and Allen M F. 2000
Mycorrhizal fungi have a potential role in soil carbon storage under elevated CO2 and nitrogen deposition
*New Phytologist* 147:189-200

Treseder K K, and Turner K M. 2007
Glomalin in ecosystems
*Soil Science Society of America Journal* 711: 257–1266

Mycorrhizal fungal diversity determines plant biodiversity, ecosystem variability and productivity
*Nature* 39:69–72

Varma A. 1995 Arbucular mycorrhizal fungi: The state of the art
*Critical Reviews in Biotechnology* 15: 179–199

Density dependence and interspecific interactions between arbuscular mycorrhizal fungi mediated plant growth, glomal in production, and sporulation
*Canadian Journal of Botany* 85: 63–75

Soil aggregation and carbon sequestration are tightly correlated with the abundance of arbuscular mycorrhizal fungi: results from long term field experiments
*Ecology Letter* 12: 452-461

Wright S F, and Millner P D. 1994
Time-course study and partial characterization of a protein on hyphae of arbuscular mycorrhizal fungi during active colonization of roots
*Plant and Soil* 181: 193–203

Wright S F, and Upadhyaya A. 1996
Extraction of an abundant and unusual protein from soil and comparison with hyphal protein from arbuscular mycorrhizal fungi
*Soil Science* 161: 575-586

Wright S F, and Upadhyaya A. 1998
A survey of soils for aggregate stability and glomalin, a glycoprotein produced by hyphae of arbuscular mycorrhizal fungi
*Plant and Soil* 198: 97–107

Wright S F, Starr J L, and Paltineanu I C. 1999
Changes in aggregate stability and concentration of glomalin during tillage management transition
*Soil Science Society of America Journal* 63: 1825–1829

Wright S F, and Upadhyaya A. 1999
Quantification of arbuscular mycorrhizal activity by the glomalin concentration on hyphae. *Mycorrhiza* 8: 283–285
Table-1: Quantitative estimation of easily extractable glomalin (EEG) and total glomalin (TG) isolated from the rhizosphere soils of some plants of Godavari belt area

<table>
<thead>
<tr>
<th>Location</th>
<th>Host plant</th>
<th>EEG code</th>
<th>EEG $\mu$g ml$^{-1}$</th>
<th>EEG mg g$^{-1}$ soil</th>
<th>TG code</th>
<th>TG $\mu$g ml$^{-1}$</th>
<th>TG mg g$^{-1}$ soil</th>
<th>Spore density g$^{-1}$ºº soil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ashwapuram</td>
<td><em>Acacia melanoxylon</em></td>
<td>Ash-EG</td>
<td>140</td>
<td>1.15±0.15*</td>
<td>Ash-TG</td>
<td>80</td>
<td>0.66±0.03*</td>
<td>154</td>
</tr>
<tr>
<td>Basar</td>
<td><em>Brassica nigra</em></td>
<td>Bas-EG</td>
<td>150</td>
<td>1.22±0.05</td>
<td>Bas-TG</td>
<td>190</td>
<td>1.47±0.23</td>
<td>269</td>
</tr>
<tr>
<td>Bayyaram</td>
<td><em>Nerium indicum</em></td>
<td>Bay-EG</td>
<td>170</td>
<td>1.31±1.02</td>
<td>Bay-TG</td>
<td>170</td>
<td>1.34±1.12</td>
<td>289</td>
</tr>
<tr>
<td>Bhadrachalam</td>
<td><em>Albizia lebbeck</em></td>
<td>Bhd-EG</td>
<td>240</td>
<td>1.89±0.17</td>
<td>Bhd-TG</td>
<td>180</td>
<td>1.43±0.15</td>
<td>320</td>
</tr>
<tr>
<td>Bheisa</td>
<td><em>Peltophorum pterocarpus</em></td>
<td>Bhai-EG</td>
<td>260</td>
<td>2±0.02</td>
<td>Bhai-TG</td>
<td>240</td>
<td>1.91±0.02</td>
<td>319</td>
</tr>
<tr>
<td>Bheemaram</td>
<td><em>Anona squamosa</em></td>
<td>Bhrm-EG</td>
<td>300</td>
<td>2.39±0.07</td>
<td>Bhrm-TG</td>
<td>330</td>
<td>2.69±0.09</td>
<td>362</td>
</tr>
<tr>
<td>Bheemdevarapally</td>
<td><em>Calotropis gigantea</em></td>
<td>Bhdply-EG</td>
<td>260</td>
<td>1.98±1.13</td>
<td>Bhdply-TG</td>
<td>420</td>
<td>3.33±0.22</td>
<td>482</td>
</tr>
<tr>
<td>Boorgampad</td>
<td><em>Punica granatum</em></td>
<td>Boor-EG</td>
<td>420</td>
<td>3.31±0.04</td>
<td>Boor-TG</td>
<td>280</td>
<td>2.25±0.31</td>
<td>495</td>
</tr>
<tr>
<td>Dharmapuri</td>
<td><em>Azadirachta indica</em></td>
<td>Dhar-EG</td>
<td>165</td>
<td>1.32±0.21</td>
<td>Dhar-TG</td>
<td>180</td>
<td>1.13±1.15</td>
<td>283</td>
</tr>
<tr>
<td>Enkoor</td>
<td><em>Bauhinia purpurea</em></td>
<td>Enk-EG</td>
<td>180</td>
<td>1.51±0.08</td>
<td>Enk-TG</td>
<td>310</td>
<td>2.46±0.24</td>
<td>293</td>
</tr>
<tr>
<td>Eturnagaram</td>
<td><em>Cassia occidentalis</em></td>
<td>Et-EG</td>
<td>390</td>
<td>3.17±0.01</td>
<td>Et-TG</td>
<td>320</td>
<td>2.49±0.41</td>
<td>325</td>
</tr>
<tr>
<td>Ghanpur</td>
<td><em>Emblca officinalis</em></td>
<td>Ghan-EG</td>
<td>100</td>
<td>0.8±0.11</td>
<td>Ghan-TG</td>
<td>180</td>
<td>1.15±0.33</td>
<td>173</td>
</tr>
<tr>
<td>Godavarikhani</td>
<td><em>Eucalyptus globulus</em></td>
<td>Gdk-EG</td>
<td>200</td>
<td>1.65±0.25</td>
<td>Gdk-TG</td>
<td>190</td>
<td>1.44±0.35</td>
<td>295</td>
</tr>
<tr>
<td>Govindaraopet</td>
<td><em>Dalbergia sissoo</em></td>
<td>Grp-EG</td>
<td>250</td>
<td>1.97±0.15</td>
<td>Grp-TG</td>
<td>150</td>
<td>1.25±1.25</td>
<td>309</td>
</tr>
<tr>
<td>Hanamkonda</td>
<td><em>Mangifera indica</em></td>
<td>Hnk-EG</td>
<td>165</td>
<td>1.31±0.23</td>
<td>Hnk-TG</td>
<td>190</td>
<td>1.53±0.38</td>
<td>285</td>
</tr>
<tr>
<td>ITC Bhadrachalam</td>
<td><em>Ficus benghalensis</em></td>
<td>Itcb-EG</td>
<td>230</td>
<td>1.8±0.03</td>
<td>Itcb-TG</td>
<td>130</td>
<td>1.09±0.29</td>
<td>302</td>
</tr>
<tr>
<td>Location</td>
<td>Species</td>
<td>Variety</td>
<td>Y1</td>
<td>Y2</td>
<td>Y3</td>
<td>Y4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------------------</td>
<td>---------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jakaram</td>
<td><em>Polyalthia longifolia</em></td>
<td>Jak-EG</td>
<td>140</td>
<td>1.21±0.15</td>
<td>Jak-TG</td>
<td>90</td>
<td>0.73±0.12</td>
<td>274</td>
</tr>
<tr>
<td>Jannaram</td>
<td><em>Casuarina equisetifolia</em></td>
<td>Jan-EG</td>
<td>210</td>
<td>1.61±0.06</td>
<td>Jan-TG</td>
<td>130</td>
<td>1.03±0.05</td>
<td>298</td>
</tr>
<tr>
<td>Kommagudem</td>
<td><em>Psidium guava</em></td>
<td>Kom-EG</td>
<td>150</td>
<td>1.29±0.01</td>
<td>Kom-TG</td>
<td>100</td>
<td>0.96±0.44</td>
<td>270</td>
</tr>
<tr>
<td>Kothagudem</td>
<td><em>Jatropha gossypifolia</em></td>
<td>Kot-EG</td>
<td>220</td>
<td>1.74±0.21</td>
<td>Kot-TG</td>
<td>220</td>
<td>1.74±0.13</td>
<td>297</td>
</tr>
<tr>
<td>Kuntala</td>
<td><em>Sapindus emerinatus</em></td>
<td>Kun-EG</td>
<td>450</td>
<td>3.6±0.07</td>
<td>Kun-TG</td>
<td>260</td>
<td>2.08±0.19</td>
<td>512</td>
</tr>
<tr>
<td>Lokeshwar</td>
<td><em>Saraka indica</em></td>
<td>Lok-EG</td>
<td>340</td>
<td>2.7±0.12</td>
<td>Lok-TG</td>
<td>175</td>
<td>1.35±0.21</td>
<td>353</td>
</tr>
<tr>
<td>Mangapet</td>
<td><em>Cassia fistula</em></td>
<td>Mngpt-EG</td>
<td>147</td>
<td>1.24±0.01</td>
<td>Mngpt-TG</td>
<td>95</td>
<td>0.66±0.27</td>
<td>168</td>
</tr>
<tr>
<td>Manuguru</td>
<td><em>Pongamia pinnata</em></td>
<td>Mngr-EG</td>
<td>150</td>
<td>1.22±0.05</td>
<td>Mngr-TG</td>
<td>190</td>
<td>1.47±0.23</td>
<td>181</td>
</tr>
<tr>
<td>Medaram</td>
<td><em>Tectona grandis</em></td>
<td>Med-EG</td>
<td>170</td>
<td>1.31±0.22</td>
<td>Med-TG</td>
<td>170</td>
<td>1.34±0.19</td>
<td>212</td>
</tr>
<tr>
<td>Palvancha</td>
<td><em>Sesbania grandiflora</em></td>
<td>Pal-EG</td>
<td>240</td>
<td>1.89±0.13</td>
<td>Pal-TG</td>
<td>180</td>
<td>1.43±0.26</td>
<td>224</td>
</tr>
<tr>
<td>Parnashala</td>
<td><em>Vitex negundo</em></td>
<td>Par-EG</td>
<td>200</td>
<td>1.65±0.45</td>
<td>Par-TG</td>
<td>190</td>
<td>1.44±0.31</td>
<td>219</td>
</tr>
<tr>
<td>Pasra</td>
<td><em>Acalypha indica</em></td>
<td>Pas-EG</td>
<td>250</td>
<td>1.97±0.32</td>
<td>Pas-TG</td>
<td>150</td>
<td>1.25±0.22</td>
<td>245</td>
</tr>
<tr>
<td>Sathupally</td>
<td><em>Terminalia catappa</em></td>
<td>Sat-EG</td>
<td>165</td>
<td>1.31±0.18</td>
<td>Sat-TG</td>
<td>190</td>
<td>1.53±0.02</td>
<td>195</td>
</tr>
<tr>
<td>Sirpurkhagznagar</td>
<td><em>Punica granatum</em></td>
<td>Srkz-EG</td>
<td>218</td>
<td>1.65±0.21</td>
<td>Srkz-TG</td>
<td>130</td>
<td>1.09±0.18</td>
<td>231</td>
</tr>
<tr>
<td>Tadwai</td>
<td><em>Ziziphus jujuba</em></td>
<td>Tad-EG</td>
<td>140</td>
<td>1.23±0.34</td>
<td>Tad-TG</td>
<td>92</td>
<td>0.71±0.25</td>
<td>177</td>
</tr>
<tr>
<td>Thandur</td>
<td><em>Acacia nilotica</em></td>
<td>Than-EG</td>
<td>210</td>
<td>1.61±0.28</td>
<td>Than-TG</td>
<td>128</td>
<td>1.03±0.21</td>
<td>227</td>
</tr>
<tr>
<td>Warangal</td>
<td><em>Tamarindus indica</em></td>
<td>Wgl-EG</td>
<td>150</td>
<td>1.28±0.25</td>
<td>Wgl-TG</td>
<td>103</td>
<td>0.98±0.34</td>
<td>191</td>
</tr>
</tbody>
</table>

*Means of triplicate values with standard errors*
National and International Events

Organic production, Research and Innovation: setting priorities for the future" (Expo Milano, 28-29/05/2015) The European Commission organised the conference "Organic production, Research and Innovation: setting priorities for the future", as foreseen in the Action Plan on organic food and farming, adopted by the Commission on 24 March 2014. The aim of the conference was to: bring together researchers, farmers, farm advisors and other stakeholders to discuss and share ideas and knowledge on research and innovation in the organic production sector; gather the research needs directly linked to the production of organic inputs, organic raw materials and organic products. This conference shed light on the needs and priorities in this sector and provided the necessary input for the European Commission in developing further its research and innovation policies. The European Commission would like to warmly thank every single participant who actively contributed to fruitful discussions and to the success of the conference which brought together 200 actors in the organic sector.

"Towards a long-term strategy for European agricultural research and innovation by 2020 and beyond" (Expo Milano, 19/06/2015) The European Commission organised a workshop to launch the discussion on the future of European agricultural research and innovation until 2020 and, beyond, for the following decade. The workshop was a first step towards a bigger agricultural research and innovation conference which will take place in Brussels on 26-28 January 2016. Jerzy Plewa, European Commission’s Director-General for Agriculture and Rural Development, opened the workshop. The objective of this workshop was two-fold: Kick-start the discussion on a long-term strategy for the future of EU agriculture research and innovation which is highly needed to address the challenges of tomorrow in a consistent and efficient way; Contribute to the discussion and outcomes of EXPO on ‘Feeding the planet – energy for life’ by providing views on agricultural research and innovation priorities.

"Geographical Indications in a globalised world: a win-win for producers and consumers" (Expo Milano) The European Commission will be organizing the seminar "Geographical indications in a globalised world: a win-win for producers and consumers" in the EU pavilion at Expo Milano 2015 on 6 July, 2015. Geographical indications are a worldwide phenomenon contributing to the development of rural areas and facilitating the participation of often small producers in global trade. Producers of geographical indications from within and outside the EU were invited to tell their stories and share their experience. Discussions would on two aspects: the contribution of geographical indications to the sustainable development of rural areas; the experience with the various registration and protection systems, including legal and practical problems encountered. The exchange in Milano aimed at increasing mutual knowledge and at providing tools and models to be used and reproduced in different contexts.

Student Organic Seed Symposium (Date: August 9-12, 2015; Location: Madison, WI). Entering its fourth year, this symposium was originally incepted to create a scientific community in which graduate students, researchers, farmers,
and industry professionals could build relationships and form collaborations to develop the organic seed movement. Planned by a team of graduate students from across the country, this year’s three-day event is being hosted by University of Wisconsin-Madison’s Department of Horticulture and will take place August 9th-12th, 2015. The symposium will provide an environment that facilitates the continued network established in the previous years, which has led to new research initiatives and post-graduate career opportunities in the organic seed sector. It will also foster the free exchange of ideas, knowledge, and research surrounding organic seed breeding, production, and ethics. The conference theme, “Growing the Organic Seed Spectrum, a Community Approach,” will be explored through lectures from invited organic community experts and field trips showcasing the Midwest’s organic seed spectrum— from local to global integration. Each year, our outreach and momentum build as new graduate students, faculty members, farmers, and industry stakeholders participate in our authentic community experience. Wisconsin is home to vibrant agriculture, and will serve as an ideal setting to explore new models and ideas for our organic community. The symposium will include field trips, workshops and keynote addresses given by distinguished speakers. The preliminary agenda includes touring University of Madison-Wisconsin research programs and partners, a student-led field day to showcase student research projects, and field visits to local farms, seed companies, and food artisans.

THE 3RD AFRICAN ORGANIC CONFERENCE, NIGERIA October 5 - 9, 2015. Following the great success of the 2nd African Organic Conference held in Lusaka, Zambia, in May 2012, the Third African Organic Conference (3rd AOC) will take place in Nigeria, from October 5 - 9, 2015. The conference aims to: – showcase the potential of organic agriculture in the context of poverty alleviation, climate change adaptation, food security and trade. – facilitate the sharing of knowledge, information, experiences and skills among key stakeholders in the organic sector. – explore partnerships and cooperation opportunities for the implementation of the African Ecological Organic Agriculture Action Plan, which aims to mainstream “Ecological Organic Agriculture” into national and continental agricultural production systems in Africa by 2020. – encourage the uptake of organic alternatives through south–south collaboration, especially in the sharing of experiences. The conference will provide a valuable platform for: Exchanging and sharing experiences of agricultural research pursuits and practical applications; Presentation of scientific evidence on capability of organic agriculture to contribute to food security, income generation, employment, systems resilience, among others; – Appraising progress of the Ecological Organic Agriculture Initiative underlying the The conference targets consumers, farmers, researchers, trainers, academics, extension practitioners, policy makers, private sector actors, financiers in the agriculture value chains and promoters of organic agriculture.
Book Review

The Organic Farmer's Business Handbook by Richard Wiswall, Published by Chelsea Green Publishing Inc. Harford VT, USA, 224 pages; Price Rs. 1,800; - Contrary to popular belief, a good living can be made on an organic farm. What’s required is farming smarter, not harder. In The Organic Farmer’s Business Handbook, Richard Wiswall shares advice on how to make your vegetable production more efficient, better manage your employees and finances, and turn a profit. From his twenty-seven years of experience at Cate Farm in Vermont, Wiswall knows firsthand the joys of starting and operating an organic farm as well as the challenges of making a living from one. Farming offers fundamental satisfaction from producing food, working outdoors, being one’s own boss, and working intimately with nature. But, unfortunately, many farmers avoid learning about the business end of farming; because of this, they often work harder than they need to, or quit farming altogether because of frustrating and often avoidable losses. In this comprehensive business kit, Wiswall covers: Step-by-step procedures to make your crop production more efficient Advice on managing employees, farm operations, and office systems Novel marketing strategies What to do with your profits: business spending, investing, and planning for retirement A companion CD offers valuable business tools, including easy-to-use spreadsheets for projecting cash flow, a payroll calculator, comprehensive crop budgets for forty different crops, and tax planners.

Organic Dairy Production by Sarah Flack, Published by Chelsea Green Publishing Inc. Harford VT, USA, 104 pages; Price Rs. 2,199 – This book is a part of the NOFA guides. Includes information on: Soils, the foundation of health (manure management) Crop production and grazing management (forage species, pasture management, setting up a grazing system) Livestock (selection, nutrition, winter and summer feed considerations, seasonal milking, habitat, herd health, milk quality) Marketing (selling fluid milk, regulations, facility and equipment, selling raw milk) Recordkeeping. The transition to organic.

Organic Farming: Everything You Need to Know by Peter V. Fossel, Published by Voyageur Press, Minneapolis, MN 55401 USA; 160 pages; Price Rs. 2,010 – Going organic may be a clear way of getting back to basics—and getting away from the havoc chemicals can wreak on our health and our environment—but the basics themselves may not be so clear. How to begin? What kind of fertilizer and feed are allowed? Is there natural pest management? What does certification entail? And is this the way to go? This book covers the basics and then some. Whether you’re thinking of starting an organic farm or making the transition to organics, whether you’re growing crops or raising animals, you’ll find everything you need to know in these pages—from getting started to developing a marketing strategy. A list of resources also points the way to other books, websites, and organizations focusing on every aspect of organic farming, including state standards and more information.

Agriculture Extension; The Changing Structure by Parveen Kumar, Published by Westville Publishing House, New Delhi-110 063; 2014, 152 pages; Price Rs. 800 – This book focuses on the structural changes in the agriculture extension. The book has eleven chapters. Chapter 1 starts with a longitudinal study of the agricultural extension programmes. The chapter summarizes the historical development origin of agricultural extension and advisory systems worldwide. It describes the pre as well as post independence efforts starting from the Gurgoan and Sevagram attempts of the thirties to Community development programmes
and the National Extension services of the sixties. It outlines and describes the major conventional linear technology transfer model that dominated extension systems in the twentieth century and the drawbacks of such linear technology transfer models. Chapter 2 describes the change of paradigm from prescription to participation. It dwells on the participatory approaches, the emergence of FSR, FSR/E, Rapid Rural Appraisal, Participatory Rural Appraisal, CORMA and the present day ATMA. Chapter 3 is devoted to the farmer led extension. It describes at length on the changing structure of the agricultural extension from once being production led to farmer and market led now. Extension which until now has largely been production led is now reorienting itself to Market led extension and what is expected of agricultural extension in the wake of market led extension is also contained in this chapter. Chapter 4 carries the debate on Privatization, the strengths and weaknesses of privatization of extension services, various forms of privatization, the privatization of agricultural extension services in different countries including vouchers, outsourcing, contracting etc. It also focuses on country specific forms of privatization. Chapter 5 discusses in detail the information and communication technology enabled extension, the role of ICT in agricultural development. It documents some of the success stories of the use of ICT in agriculture. Chapter 6 describes in detail how the extension architecture can be strengthened. It elaborates on how the input dealers, the agricultural professionals and the para extension workers are providing extension services and how their role can be further strengthened in the extension system. Chapter 7 describes the various innovative techniques that need to be replicated in other regions. Social capital has been one of the area which has not been paid due attention. Chapter 8 has tried to make some lost ground by focusing on building social capital. The role of farmer associations and Nongovernmental organizations in different countries has been highlighted in this chapter. Chapter 9 has exclusively dealt with feminisation of extension services. Climate change is of grave concern for all. While the new technologies are being devised for climate resilient agriculture, extension strategies for climate change are presented in Chapter 10. Chapter 11 has been exclusively kept for what should be the future of the agricultural extension. The eleven chapters of the book highlight the drawbacks of the conventional extension system, changing structure of agricultural extension including the privatization of agricultural extension services, strengthening the extension architecture, feminization of agricultural extension services, role of ICT in agricultural development, extension strategies for tackling climate change and the future of the agricultural extension. This book would become a valuable resource to extension professionals in the future as all of us work together to continue the process of improving agricultural extension to meet the needs of farm families in a rapidly changing world.

Dr. V. Praveen Kumar