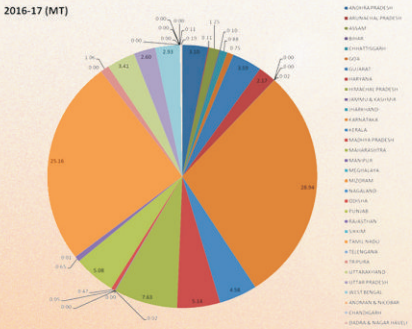
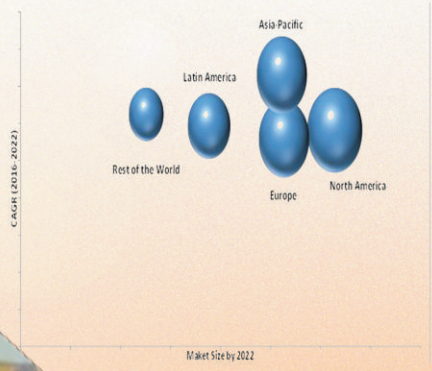
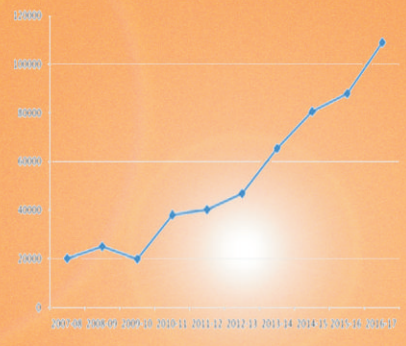
Status of Biofertilizer in India
(Last Decade)







Status of Biofertilizer in India (Last Decade)

STATUS OF BIOFERTILIZER IN INDIA (LAST DECADE)

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Preface

India is an agriculture based country. In order to feed the ever growing population, there is pressure to gain a higher crop yield. Unit area productivity of agricultural land can be enhanced by using different crop nutrients that can play a vital role. Some are needed by plant in macro amount and some in micro accordingly some are very essential nutrients that can't be ignored for plant growth and health, like Nitrogen and Phosphorous have an important role in increasing the crop productivity.

These nutrients are artificially introduced in soil in form of chemical fertilizers. These chemical fertilizers are in practice from a long time and now resulting in various harmful effects. Firstly, they are costly and expensive and their increased doses are causing environmental pollution and toxicity to soil as it kills the beneficial microorganisms and thereby disturbance in ecological balance. Also, harmful chemicals which through chemically treated soil or plant came in food chain tend to be persistent resulting in carcinogenic compounds causing cancer.

However, plant nutrients like N, P and K are highly essential for plant growth and metabolism. It is also proved that plants remove more nutrients from the soil in modern intensive cultivation and hence needs constant replenishment. Under such conditions Microorganisms offer good alternative technology to replenish the required deficient crop nutrients.

Bio-Fertilizers are inexpensive and eco-friendly. Many State Agricultural Universities, Govt. Agriculture/Forest Departments and a good number of commercial units in private and public sectors are producing and distributing Bio-Fertilizers. In addition to that, Govt. of India has established National Centre of Organic Farming (NCOF) to promote Organic Farming, give technical support and quality control of organic inputs. NCOF tried to solve the problem of Bio-Fertilizer at every stage in production units and also developed liquid formulations of biofertilizer. In order to acquaint the personnel involved in Bio-Fertilizers production or in quality control of Bio-Fertilizers, NCOF, Ghaziabad Govt. of India is organizing different types of training courses on Bio-Fertilizers as well as other organic inputs usage & its quality control aspects.

Now fruitful results are coming out, Biofertilizer production and utilization has increased in last decade all over the country. This reflects people are getting aware of using Biofertilizer and it is overall beneficial for soil health and our ecosystem. However, there is little awareness among organic growers about use of liquid biofertilizers in farming practices.

(Dr. Krishan Chandra)

CONTENTS

S.No. Topic **Page**

I. BIOFERTILIZER PRODUCTION/UTILIZATION-WORLDWIDE

With the increasing pressure on global food production and easily acceptable technology for improving soil fertility without harming natural balance of ecosystem, a demand based biofertilizers market is in existence worldwide. Growing awareness about product benefits is expected to augment demand over the forecast period. Increasing awareness among people about effect of hazardous chemical that was unknowingly introduced through food chain on human health as well as our ecosystem has opened the chances of adoption of organic farming practices and thus replacement of chemical fertilizer or pesticide by more potent and useful Biofertilizer and biocontrol agents.

Biofertilizer market can be divided into different geographical parts all over the world as North America, Europe, Asia-Pacific and Latin America, Middle East and Africa.

In last 3 years Asia Pacific accounted for over 15.0% of global revenue share in 2014. North America biofertilizers market was the largest regional industry in 2014 and 2015 followed by Europe and together accounted for over 54% of the global revenue. In North American countries Government banned use of harmful chemicals fertilizers which were used as organic inputs. This in turn enhanced market potential for biofertilizers in these region. In Asia Pacific regions biofertilizer market growth is noticed among the countries such as India and China having large population, vast landscape and booming economies. (1)

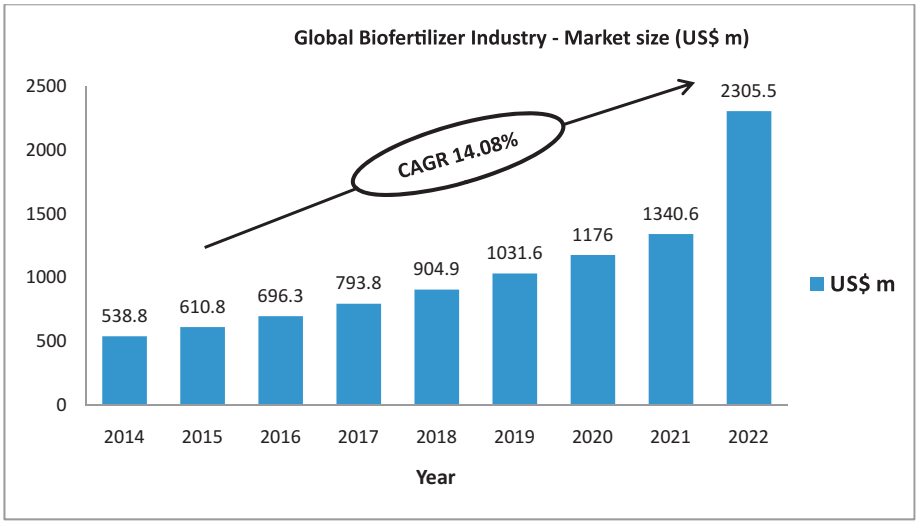

Fig 1(a) Biofertilizer Market, by Region, 2022 (USD Million)

Based on types, the global market for bio-fertilizers is segmented into nitrogen fixing, phosphate fixing, potash mobilizing and others. Nitrogen fixing was the largest product segment, accounting for over 75.0% of global revenue share in 2014. Nitrogen fixing biofertilizers comprise mixed strains of various nitrogen fixing bacteria such as Rhizobium, Azospirillum, Acetobacter and Azotobacter that help improve nitrogen content, organic and microbial population of the soil. Phosphate solubilizers were the second largest product segment, accounting for 15.0% of global revenue in 2014. Globally Biofertilizer market was valued at USD 946.6 Million in 2015 and this is projected to grow at a Compound Annual Growth Rate (CAGR) of 14.08% from 2016 to 2022. (Fig. 1)
CBF China Biofertilizers AG and Novozymes A/S are the largest players supplying products majorly to North America and Europe. The majority of these companies have established exclusive agreements with distributors to cater to end-users. Some companies have their distribution networks, thus increasing their revenues by distributing products of independent manufacturers.

Source: Press Releases, Investor Presentations, Expert Interviews, and MarketsandMarkets Analysis

II. BIOFERTILIZER PRODUCTION/UTILIZATION-INDIA

The Government of India introduced a national initiative which aims at increasing biofertilizer production, distribution and utilization thus favoring biofertilizers market growth. India is standing as leading Biofertilizer producing country among Asian market. In India some companies have their own retail & distribution outlets in order to cut-down on distribution costs, thus enabling them to sell products at competitive and even lower prices. Topmost Biofertilizer producers in India are T. Stanes, SIDDIBIO, KRIBHCO, IFFCO etc. Details on Production/utilization of Biofertilizer in India are discussed in later in this book.

III. BIOFERTILIZERS

When we talk about biofertilizers we mean living microorganisms that are doing various physiological activities in agriculture ecosystem and performing important role in fixing / solubilizing / mobilizing / recycling nutrients. Those microorganisms which are natively present in soil are not having that much population level so that they may not support higher crop yield, as microbial population is scanty and process of nutrient mobilization / mineralization / solubilization is not upto the mark. In order to deal with introduction of useful microorganisms in agriculture land for increased crop yield, microbiological technologies/practices are getting its space and promoting Biofertilizer market. The desired microorganism naturally present in rhizosphere are isolated and artificially cultured and mixed with suitable carriers in solid or liquid form. These formulations are known as Bio-Fertilizers or Microbial inoculants. It includes Rhizobium, Azotobacter, Acetobacter, Azospirillum, Phosphate solubilizing microorganisms, Phosphate mobilizing Microorganisms (VAM), Potash mobilizing bacteria, zinc solubilizing bacteria etc.

These Bio -Fertilizers are microbial inoculants, which contain living cells of efficient nitrogen fixing microorganisms, which fix atmospheric nitrogen either symbiotically with host plant or free livingly. Phosphate Solubilizing/Mobilizing Microorganisms as well as potassium mobilizers / release or mobilize P_2O_5 and K_2O from soil respectively.

1. BIOFERTILIZER DEFINITION

According to Fertilizer Control Order (FCO, 1985) Biofertilizer means, the product containing carrier based (solid or liquid) living microorganisms which are agriculturally useful in terms of nitrogen fixation, phosphorus solubilization or nutrient mobilization, to increase the productivity of the soil and/or crop .

2. BIOFERTILIZER FORMULATION

Bio-Fertilizers are available in markets in carrier based powder form as well as in liquid form. The main types that are currently used for Bio-Fertilizers have been classified into dry products (dusts, granules and briquettes) and suspensions (oil or water-based and emulsions). In current scenario there is a huge range of formulations with additives available in Indian market (2).

2.1. DRY INOCULUM PRODUCTS

This type of product is prepared by feeding the microorganism into an air stream for mixing with a blender. For dry inoculum products particle size, bulk density and flowability are extremely important factors. Dusts mainly contain 30% of a microorganism in suspension by weight. The dusts formulations comprise dusts, granules and briquettes based on particle or aggregate size. Wettable powders are also included in this group which is formulated as dry powder mixed in water as a carrier just before use. Dusts based on inert diluents or carriers, normally with low absorbent capacity, have different particle sizes ranging from 5-20 micron particles of <10micron are hazardous when inhaled, but the smaller particles adhere best on the substrate.

2.2 GRANULES, PELLETS, CAPSULES AND BRIQUETTES INOCULUM

Granules are discrete particles 5-10mm3 in size, pellets are >10mm3, and briquettes are large one up to several cubic centimeters. These products also contain an inert carrier holding the microorganism as in dust. Carriers used may be clay minerals, starch polymers and ground plant residues. Choice of the carrier depends on the absorption property as it is related with formulating slurries of microorganism, hardness, bulk density and product disburse rate in water. Soft carriers, eg. Bentonite, disburse quickly to release the microorganism. The product can be coated with various materials to slow down or to control the rate of release, which also depends on the unit size.

The concentration of microorganism in granules should be 20-30%. There are three types of granular formulations: 1) the microorganisms are attached to the outer surface of a granular carrier by a sticker. 2) the microorganisms are incorporated into a carrier paste or powder which sets as a matrix size being controlled by passing the product through a sieve. 3) the microorganisms are sprayed onto a rotating granular carrier without a sticker. When the carrier forms a protective coat around a core aggregate of organisms then the unit is termed a capsule.

2.3. WETTABLE POWDERS INOCULUM

This type of formulations are popular in commercial products and comprises of charcoal, lignite, vermiculite powders blended with 3% gum to make them stable during storage and to readily stick on to seeds.

3. DIFFERENT TYPES OF BIOFERILIZERS COVERED UNDER FERTILIZER CONTROL ORDER, 1985

Following biofertilizers are specified in Schedule III of FCO, 1985. (3)

3.1. Rhizobium
3.2. Azotobacter
3.3. Azospirillum
3.4. Phosphate solubilizing bacteria (PSB)
3.5. Mycorrhiza (VAM)
3.6 .Potassium mobilizing bacteria (KMB)
3.7. Zinc solubilizing bacteria (ZSB)
3.8. Acetobacter
3.9. NPK Consortia

4. BIOFERTILIZER PRODUCTON IN LAST DECADE – SOLID CARRIER BASE (MT)

If we look at last decade biofertilizer production/utilization data it can be analyzed that there is an upward trend in demand and production of biofertilizers (Table 1). Biofertilizer (solid carrier based) production in India has taking momentum gradually during 2007-09 but fallen back on 2009-10 since then it escalating beyond the imagination (Fig.2)

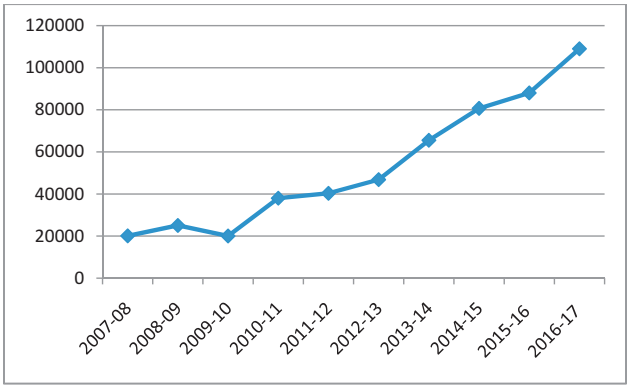

Fig.2. Biofertilizer Production (MT)

4.1. ZONE-WISE BIOFERTILIZER PRODUCTION

Zone-wise Biofertilizer Production
From the fig 3 it is evident that, there is a considerable increase in the biofertilizer production across the decade, wherein, south zone was in leading since the beginning and North east zone has no production at all in the beginning but it debuted the production from 2009-10. West zone production pattern showed ups and downs throughout the decade. North zone production has been also a fluctuating but not amounted to large production when compared with south and west zones.

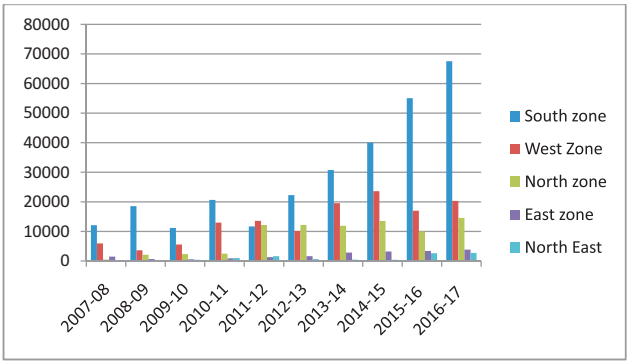

Fig.3. Zone-wise Biofertilizer Production (MT)

4. 1.1. SOUTH ZONE

Fig.4 elucidates solid based biofertilizer production pattern in the south zone, India during the last decade. Karnataka and Tamil Nadu are the leading producers and Daman & Diu and Lakshadweep has a negligible production levels, Pondicherry too has very little production. Andhra Pradesh production levels were highest during the beginning and has fluctuated production along the years and the recent production levels are found to be less than the beginning.

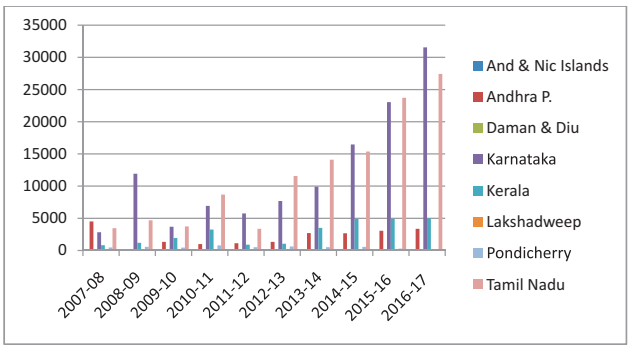

Fig. 4. Biofertilizer Production (MT) in South Zone

4.1.2. WEST ZONE

Fig. 5 elucidates Biofertilizer production in carrier/soild based formulation of India in west zone showing Maharashtra, Madhya Pradesh and Gujrat as leading producers, Chhattisgarh, Goa and Rajasthan are also producing Biofertilizer in a moderate pace, for Dadar and Nagar Haveli this seems to be negligible.

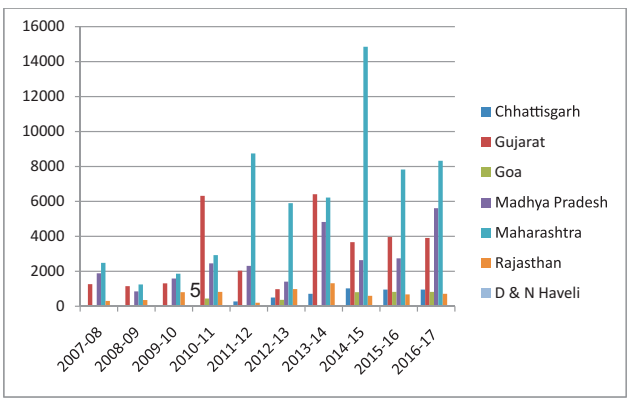

Fig. 5. Biofertilizer Production (MT) in West Zone

Table 1- Zone- Wise Bio-Fertilizer Production in India in last decade

Sl N.	State	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15		2015-16		2016-17	
		Carrier based (MT)	Carrier based (MT)	Carrier based (MT)	Carrier based (MT)	Carrier based (MT)	Carrier based (MT)	Carrier based (MT)	Carrier based (MT)	Liquid based (KL)	Carrier based (MT)	Liquid based (KL)	Carrier based (MT)	Liquid based (KL)
South Zone														
1	And & Nic Islands	0	0	0	0	0	0	0	0.0000	0.0000	0	0	0	0
2	Andhra P.	4515.81	168.136	1345.28	999.6	1126.35	1335.74	2714.22	2668.8000	274.8560	3062.6	317.811	3375.91	365.24
3	Daman & Diu	0	0	0	0	0	0	0	0.0000	0.0000	0	0	0	0
4	Karnataka	2841.269	11921.057	3695.5	6930	5760.32	7683.72	9907.337	16462.620	23.0561	23042.9	488.142	31553.06	993.443
5	Kerala	814.447	1187.001	1936.451	3257	904.17	1045.64	3520.66	4916.9700	10.5096	4926.04	56.5751	4993.8692	59.6143
6	Lakshadweep	0	0	0	0	0	0	0	0.0000	0.0000	0	0	0	0
7	Pondicherry	471.286	561.7924	452.79	783	509.45	621	516.98	560.9500	1.4976	283.641	4.088	203.966	11.197
8	Tamil Nadu	3466.966	4687.818	3732.5862	8691	3373.81	11575.7	14104.83	15373.290	11.3017	23721.2	861.953	27427.962	875.292
	Total	**12109.778**	**18525.804**	**11162.607**	**20660.6**	**11674.1**	**22261.8**	**30764.027**	**39982.6300**	**321.2210**	**55036.41**	**1728.57**	**67554.7672**	**2304.7863**
West Zone														
1	Chhattisgarh	0	0	0	0	276.34	501.63	712.07	1024.680	9.620	954.371	9.38	955.074	10.23
2	Gujarat	1263.301	1149.695	1309.19	6318	2037.35	978.48	6411.434	3667.929	2800.500	3963.42	2873.317	3909.82	2857.77
3	Goa	0	0	0	443.4	0	370	66.26	802.520	0.000	820.52	0	822	0
4	Madhya Pradesh	1884.867	848.448	1587.6775	2455.57	2309.06	1408.08	4824.194	2637.990	119.216	2741.30775	131.033	5609.006	238.103
5	Maharashtra	2486.41	1249.87	1861.33	2924.00	8743.69	5897.91	6218.607	14847.397	324.767	7825.142	389.665	8323.616	398.33
6	Rajasthan	302.30	353.67	805.571	819.75	199.78	982	1315	599.898	0.000	680	0	711	0
7	D & N Haveli	0	0	0	0	0	0	0	0.000	0.000	0	0	0	0
	Total	**5936.88**	**3601.6806**	**5563.764**	**12960.720**	**13566.220**	**10138.100**	**19547.565**	**23580.414**	**3254.103**	**16984.76**	**3403.395**	**20330.516**	**3504.433**

Sl N.	State	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15		2015-16		2016-17	
		Carrier based (MT)	Carrier based (MT)	Carrier based (MT)	Carrier based (MT)	Carrier based (MT)	Carrier based (MT)	Carrier based (MT)	Carrier based (MT)	Liquid based (KL)	Carrier based (MT)	Liquid based (KL)	Carrier based (MT)	Liquid based (KL)
North Zone														
1	Delhi	168.844	1165.1	1021.85	1205	1617	0	396	104.500	0.000	106.2	0	116.2	0
2	Chandigarh	0	0	0	0	0	0	0	0.000	0.000	0	0	0	0
3	Haryana	8.89	14.25	6.195	6.53	914.41	5832.61	1146.483	872.955	46.489	1097.45	58.032	2360.644	70.148
4	Himachal Pradesh	56.21	0	8.5	9	1.29	0	26.147	0.768	33.070	2.712	190.05	3.276	194.7
5	Jammu & Kashmir	0	0	0	0	0	0	45.26	0.000	0.000	0	0	0	0
6	Punjab	1.7	1.14	301.232	2.5	692.22	2311.33	2124.852	6305.453	74.278	2197.19	149.581	5533.774	210.177
7	Uttar Pradesh	250.057	885.5174	962.6417	1217.45	8695.08	1310.02	2682.221	4099.068	98.036	3053.11	223.34	2835.79	461.19
8	Uttarakhand	0	48.23	32.00	45.00	263.01	2758.21	5493.851	2129.952	208.034	3549.39	428.22	3720.68	696.9
	Total	**485.701**	**2114.2344**	**2332.419**	**2485.480**	**12183.010**	**12212.170**	**11914.814**	**13512.696**	**459.907**	**10006.0 7**	**1049.22 3**	**14570.364**	**1633.115**
East Zone														
1	Bihar	20	0	0	136.26	75	52.4	52.4	64.90	0.00	97	0	107	0
2	Jharkhand	201.68	15	15	0	8.38	35.3	14.2	9.08	0.00	9.172	0	18.552	0
3	Odisha	331.94	405.03	289.867	357.66	590.12	407.1	1097.61	1074.46	4.70	467.634	13.701	516.281	31.79
4	West Bengal	922.34	241.24	256.5	393.39	603.2	1110	1682.7076	2061.83	14.63	2826.27	23.537	3195.18	26.21
	Total	**1475.96**	**661.27**	**561.367**	**887.31**	**1276.7**	**1604.8**	**2846.9176**	**3210.27**	**19.33**	**3400.07 6**	**37.238**	**3837.013**	**58**
North East Zone														
1	Arunachal Pradesh	0	0	0	0	0	0	59	59	0	118	0	119.7	0
2	Assam	70.901	129.3552	121.04	130	68.33	89	149	88.000	0.000	1315	22.5	1359.05	26
3	Manipur	0	0	0	0	0	0	0	0.000	0.000	0	0	25	0
4	Meghalaya	0	0	0	0	0	0	0	0.000	0.000	0	0	0	0
5	Mizoram	3.58	1.996	2.5	2	0	0	4	3.600	0.000	4.2	0	2.5	0
6	Nagaland	13.98	16.0092	18.25	21.5	13	7.45	7.45	7.450	0.000	8.81	0	51.45	0
7	Sikkim	0	0	0	0	0	9.5	10.1	12.400	0.000	12.91	0	16.25	0
8	Tripura	14.27	14.68	278.402	850	1542.85	514	225	240.000	0.000	1143.07	0	1153.5	0
	Total	**102.73**	**162.04**	**420.19**	**1003.50**	**1624.18**	**619.95**	**454.55**	410.450	0.000	**5546.59**	**340.311**	**2727.45**	**26**
	Grand Total	**20111.05**	**25065.03**	**20040.348**	**37997.61**	**40324.21**	**46836.82**	**65527.87**	**80696.455 95**	**4054.5637 11**	**88029.3 0415**	**6240.92 6**	**109020.1102**	**7526.334 3**

Source: Compiled by NCOF (Data Provided by Production Units/State Government/ RCOF ***(4)***

4. 1.3. NORTH ZONE

North zone got activated in last decade as there was negligible production in solid as well as liquid form for Punjab, Uttarakhand and Haryana but in present scenario these states are doing well and producing noticeable amount of Biofertilizer (Fig.6)

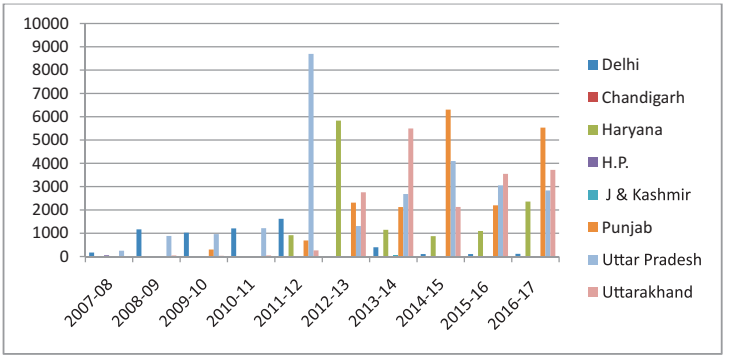

Fig. 6. Biofertilizer Production (MT) in North Zone

4. 1.4. EAST ZONE

Fig. 7 depicts Biofertilizer production in solid/carrier based formulation in East zone, West Bengal showing production rate higher than Odisha, Bihar and Jharkhand. West Bengal has increased approximate 3.5 fold production.

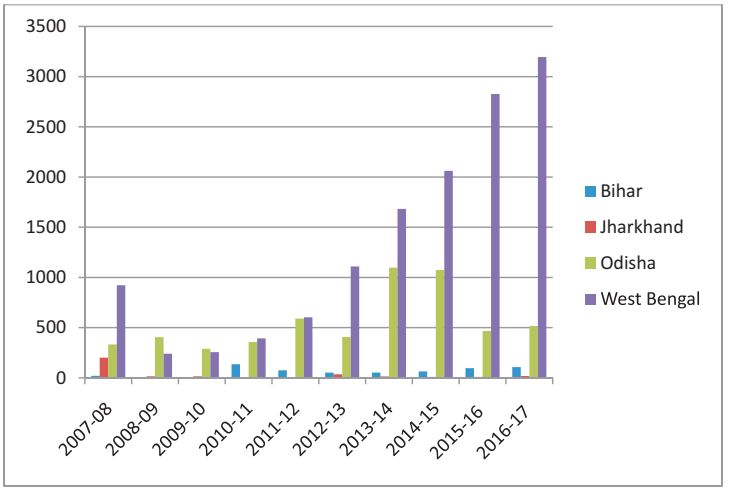

Fig. 7. Biofertilizer Production (MT) in East Zone

4. 1.5. NORTH EAST ZONE

North East zone reporting carrier based Biofertilizer with maximum production I Assam followed by Tripura and Arunachal Pradesh. Nagaland Manipur and Sikkim are also active in biofertilzier production (Fig.8)

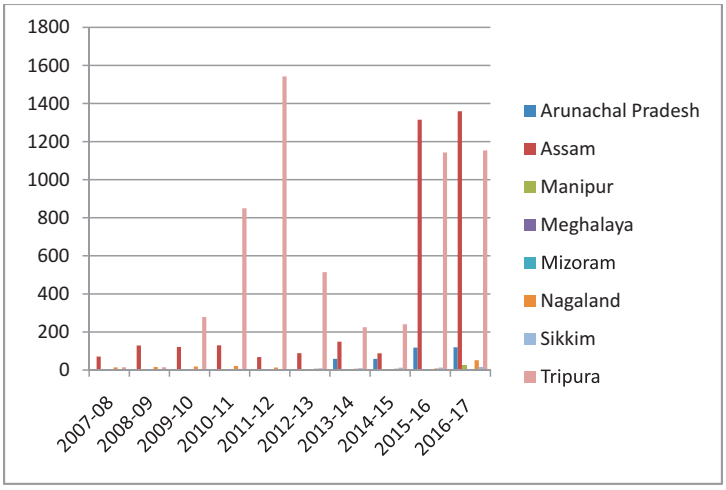

Fig. 8. Biofertilizer Production (MT) in North East Zone

5. BIOFERTILIZER PRODUCTON IN (2014-17)– LIQUID FORM- (KL)

Biofertilizer (liquid carrier based) production in India has initiated little late in comparison with solid carrier based biofertilizer but made considerable large amounts of production at greater pace (Fig.9). Use of liquid Biofertilizer is getting popularity all over the country because of its numerous advantages like longer shelf life, no contamination, cost effective, better survival etc. than carrier/soild based biofertilizer formulations.

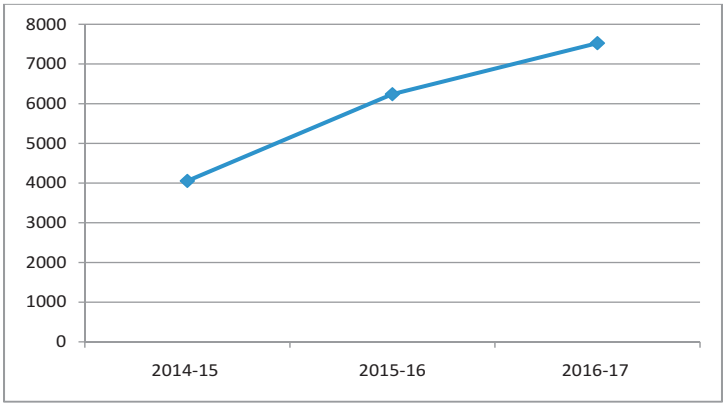

Fig. 9. Biofertilizer Production (KL)

5. 1. ZONE-WISE BIOFERTILIZER PRODUCTION (KL)

Liquid Biofertilizer production was found to be initiated from the last three years, west zone has been leading in production along the years and north east zone made very little production, whereas east zone made only little more production than north east. Among the better production zone the production was so less during 2014-15 and during 2016-17 has mentionable production (Fig. 10).

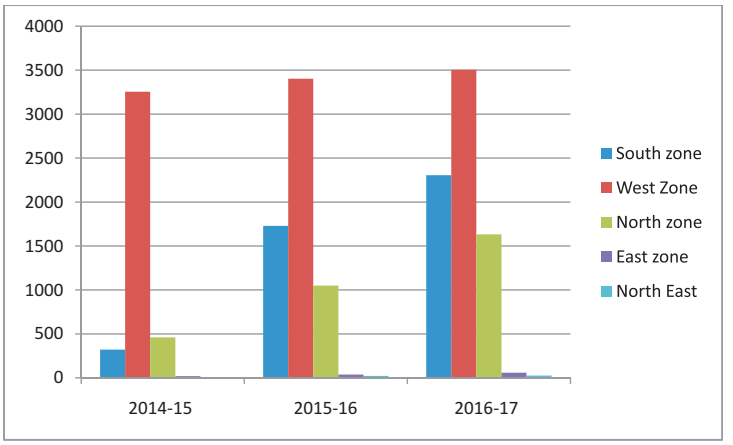

Fig.10. Zone-wise Biofertilizer Production (KL)

5. 1.1. SOUTH ZONE OF INDIA

It may be noted in Fig. 11 that Karnataka and Tamil Nadu are the leading in liquid biofertilizer production, whereas Daman & Diu and Lakshadweep has a negligible production rate and the Andhra Pradesh and Kerala has a moderate production pattern, whereas Pondicherry has a very little production.

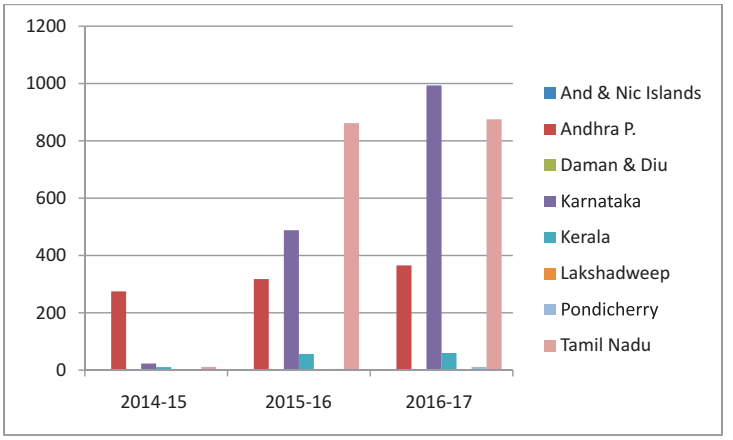

Fig. 11. Biofertilizer Production (KL) in South Zone

5.1.2. WEST ZONE

Fig. 12 elucidates Biofertilizer production in liquid based formulation of India in west zone showing maximum production in Gujrat, Madhya Pradesh and Maharashtra are also producing Biofertilizer to a little extent.

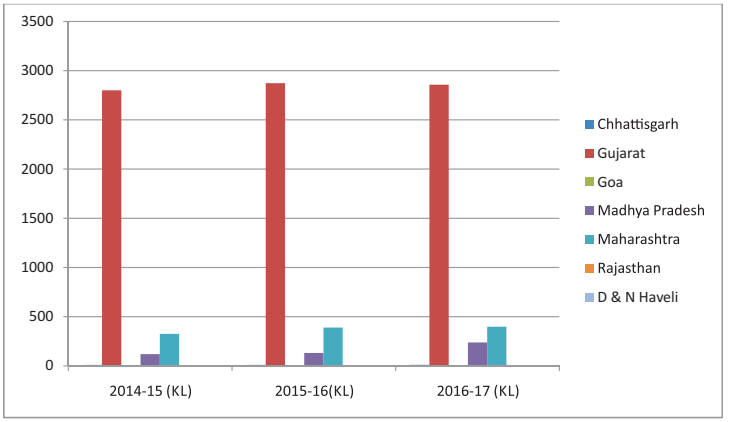

Fig. 12. Biofertilizer Production (KL) in West Zone

5.1.3. NORTH ZONE

In last three years Uttarakhand, Uttarpradesh and Punjab are found to be the leading producers of liquid Biofertilizer in North zone (Fig. 13)

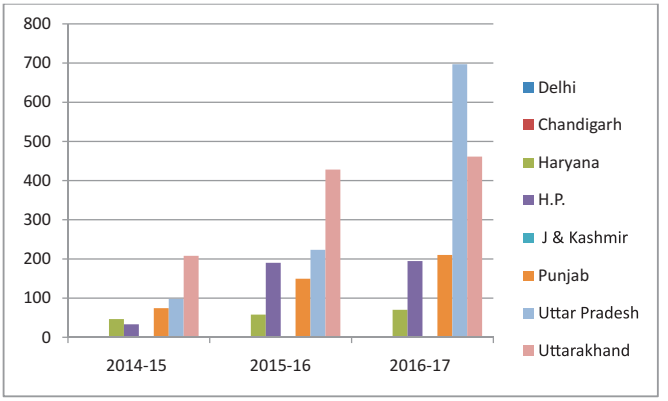

Fig. 13. Biofertilizer Production (KL) in North Zone

5.1.4. EAST ZONE

However, liquid biofertilizers are in demand but East zone is producing it in fewer amounts. Only Odisha and West Begal are showing interest in producing it , it is almost Nil for Bihar and Jharkhand states. (Fig. 14)

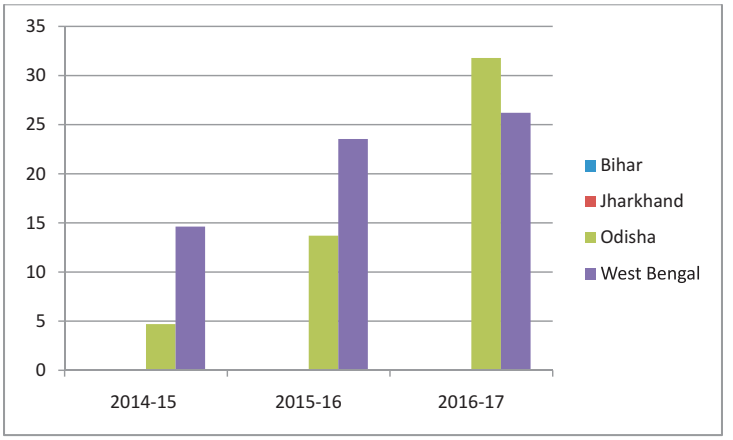

Fig. 14. Biofertilizer Production (KL) in East Zone of India (2014-17)

5.1.5. NORTH EAST ZONE

North East zone is showing lesser production of Biofertilizer than other zones of the country. Only Assam is involved in liquid formulation (Fig. 15)

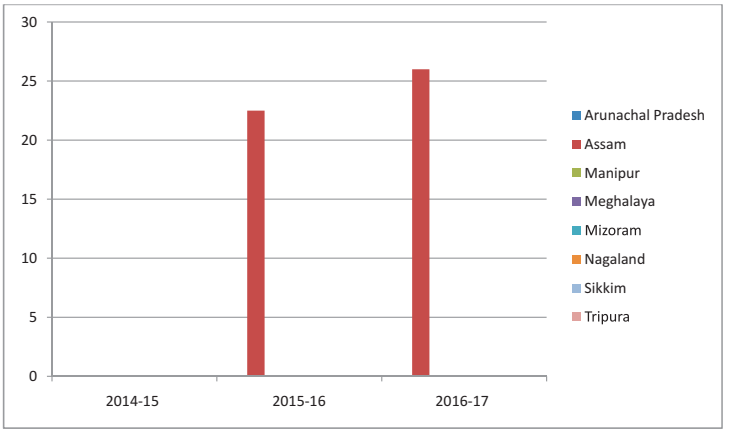

Fig 15. Biofertilizer Production (KL) in North East Zone

Table 2- Bio-Fertilizer Production units and their Capacity-current scenario (upto 2016-17)

Sl. No.	Name of State/UTs	Solid Carrier based biofertilizer		Liquid Carrier based biofertilizer	
		No. of Units	Capacity (MT)	No. of Units	Capacity (KL)
1.	Andhra Pradesh	17	3375.91	7	365.24
2.	Arunachal Pradesh	1	119.70	0	0
3.	Assam	5	1359.05	1	26
4.	Bihar	1	107.00	0	0
5.	Chhattisgarh	6	955.07	2	10.23
6.	Goa	1	822.00	0	0
7.	Gujarat	11	3909.82	11	2857.77
8.	Haryana	3	2360.64	3	70.148
9.	Himachal Pradesh	2	3.28	1	194.7
10.	Jammu & Kashmir	1	0	0	0
11.	Jharkhand	2	18.552	0	0
12.	Karnataka	47	31553.06	32	993.443
13.	Kerala	24	4993.87	10	59.6143
14.	Madhya Pradesh	36	5609.01	9	238.103
15.	Maharashtra	87	8323.62	10	398.33
16.	Manipur	1	25.00	0	0
17.	Meghalaya	0	0	0	0
18.	Mizoram	1	2.50	0	0
19.	Nagaland	2	51.45	0	0
20.	Odisha	9	516.28	2	31.79
21.	Punjab	11	5533.77	11	210.177
22.	Rajasthan	1	711.00	0	0
23.	Sikkim	1	16.25	0	0
24.	Tamil Nadu	116	27427.962	22	875.292
25.	Telangana	0	0	0	0
26.	Tripura	1	1153.50	0	0
27.	Uttarakhand	5	3720.68	5	461.19
28.	Uttar Pradesh	34	2835.79	3	696.9
29.	West Bengal	17	3195.18	2	26.21
30.	Andman & Nicobar Islands	0	0	0	0
31.	Chandigarh	0	0	0	0
32.	Dadra & Nagar Haveli	0	0	0	0
33.	Daman & Diu	0	0	0	0
34.	Lakshadweep	0	0	0	0
35.	Delhi	1	116.20	0	0
36.	Pondicherry	3	203.97	2	11.197
	TOTAL	**447**	**109020.11**	**133**	**7526.334**

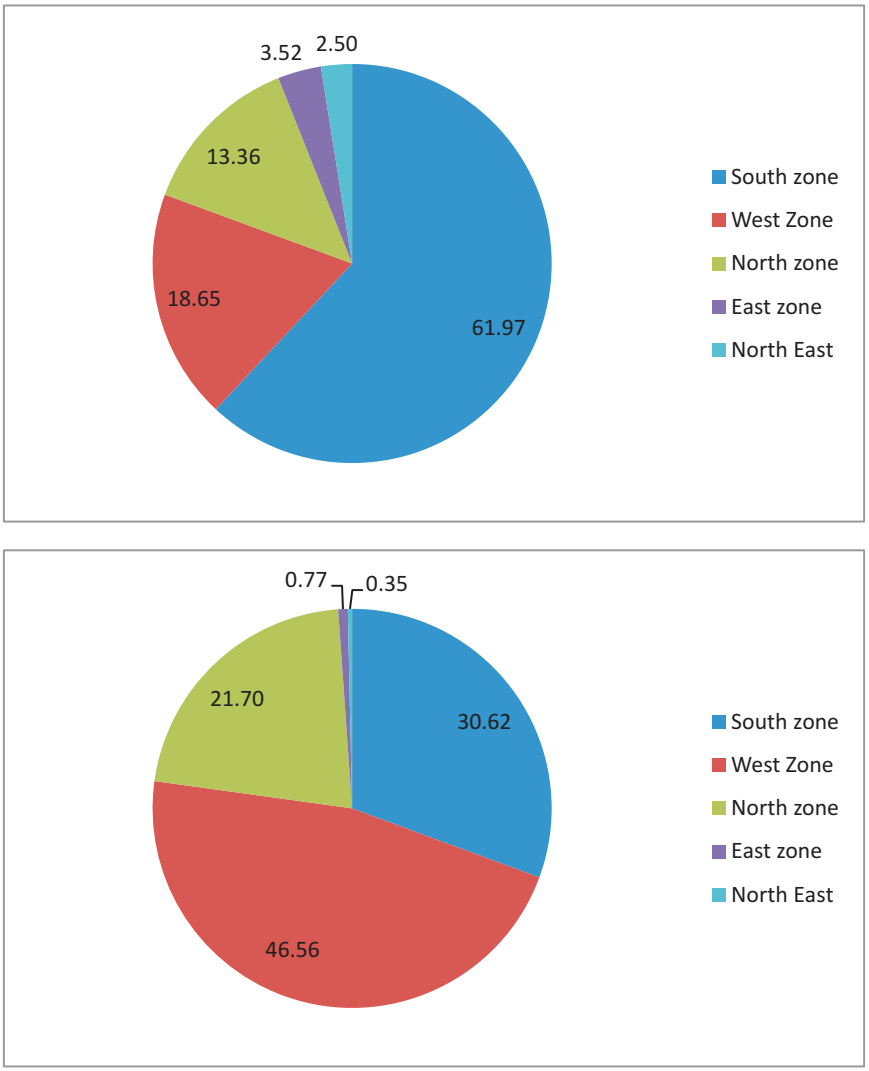

Fig 16. Zone-wise Biofertilizer Production (%) in India (2016-17)

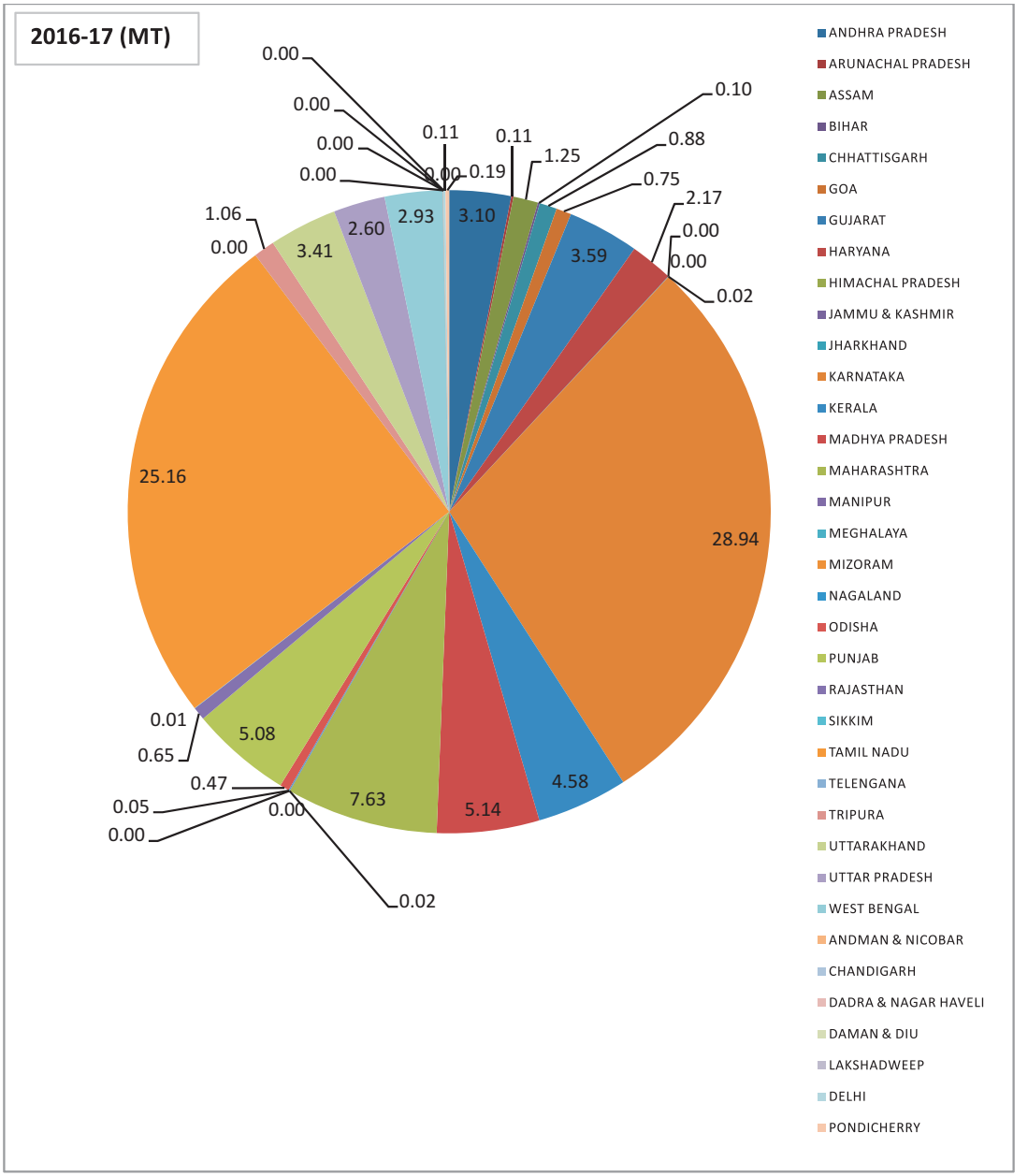

Fig 17. State-wise Biofertilizer Production (MT;%) in India (2016-17)

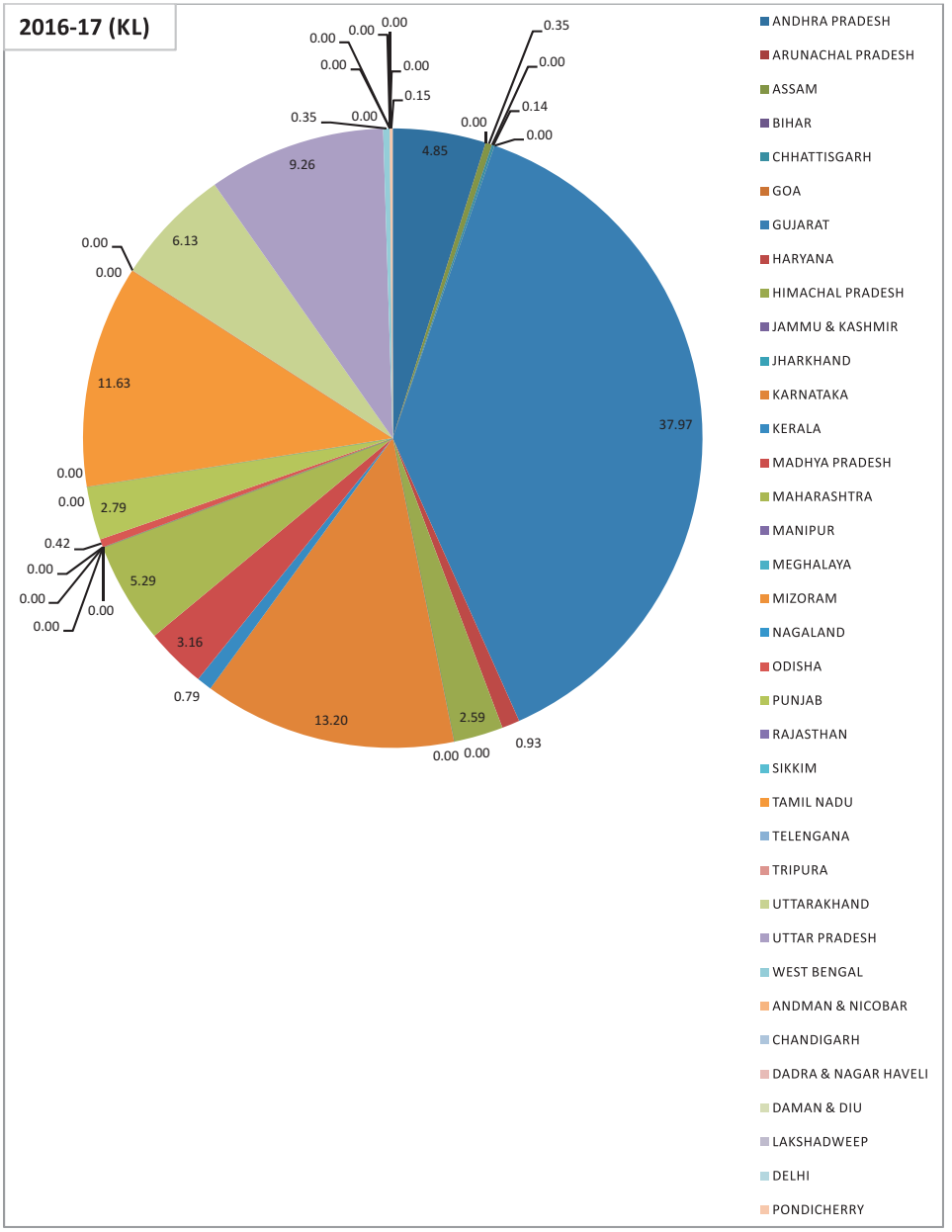

Fig 18. State-wise Biofertilizer Production (KL; %) in India (2016-17)

6. TECHNOLOGY DEVELOPMENT BY NATIONAL CENTRE OF ORGANIC FARMING

Government of India has restructured National Centre of Organic Farming (NCOF) to promote Organic Farming, give technical support and quality control of organic inputs. A detail on Technologies developed under NCOF is given below:

DETAILS OF TECHNOLOGIES DEVELOPED

6.1 PEAT AS GOOD CARRIER (1994)

A good quality carrier is required to formulate solid based biofertilizer which should be non toxic, have good absorption capacity for the microorganism, inexpensive and can assure good stability and viability properties.

In 1994, RCOF Imphal (RBDC erstwhile) investigated peat soil in Lamphelpat for the first time which is a well known best carrier for all types of microorganisms i.e. bioferilizer and biopesticide. It was estimated about more than 1000 MT deposit was available in the area. This was tested as a carrier for Bradyrhizobium japonicum and found survivability of bacteria upto 1 year. The same was acknowledged by NIFTAL centre Howaii.

6.2 KMB LIQUID BIOFERTILIZER (1999)

In India liquid based Biofertilizer were first time formulated by NCOF. This work was performed at RCOF Bhubnaeswar. Liquid biofertilizers has various advantages over solid Biofertilizer with longer shelf life, no contamination, not affected by temperature variations, good storage properties, higher microbial load, cost effective, easily applicable and the main thing microorganism in liquid suspension is more active and live, and easy to apply in field (2).

NCOF focused on problem of Potash availability in Indian soil and it was a great achievement to successfully isolate Potash mobilizing bacteria (KMB) and development of its liquid formulation. The KMB is being commercially produced potential biofertilizer by different Biofertilizer production units across the country.

6.3 LIQUID NPK BIOFERTILIZER (2000)

This kind of formulation was first made successfully at RCOF Bhubaneswar. Nitrogen, Phosphorous and Potassium are essential nutrients required by plants and helpful in increasing biomass. Rhizobium is important in nitrogen fixation; this bacterium infects root of the specific plant and make nodules in root. The bacterium helps in providing atmospheric nitrogen to plant in easily acceptable form. Azotobacter is important free-living nitrogen fixing bacterium and used for crops like cotton, rice and vegetables. This bacterium can't proliferate effectively where there is lack of organic content in soil and that's why an application of this biofertilizer becomes necessary in soil. Potash availability to plant can be assured using phosphate solubilizers like Psedomonas, Bacillus etc. All these biofertilizers are available in solid as well as liquid forms currently. Liquid formulation of NPK Biofertilizer (Rhizobium/Azotobacter, PSB and KMB) was successfully formulated with advantages of higher shelf-life of more than two years, zero contamination and better efficacy even in adverse climatic condition by RCOF Bhubaneswar.

6.4 LIQUID BIOPESTICIDES FORMULATION (2004)

Biopesticides comprises of microorganisms which can effectively protect the plant from infection and disease these can kill, control, infest, or feed on disease causing entity. Trichoderma viride is potent microbial pesticide that can protect plant against various pathogens including Rhizoctonia, Pythium etc. When seed coated with this microbe is sown it makes the seed disease free and protects from soil borne disease also by colonizing on the seed surface. Beauveria bassiana is entomopathogenic fungi and very much effective for controlling thrips, termites, aphids and beetles. Other popular biopesticide are Pseudomonas flurescens and Verticellium lecanii.

Liquid formulation for these biopesticides (Trichoderma viridae, Beauveria bassiana, Pseudomonas flurescens, Verticellium lecanii, etc) developed in 2004 at RCOF Bengaluru

6.5 NPK CONSORTIUM PASTE (2004)

NPK consortium was first made successfully in 2004 at RCOF Bengaluru. Experiments were performed to make NPK consortium that contains nitrogen fixing, phosphopros solubilizing, potash mobilizing bacteria together.

Formulations of this NPK consortium was made in both paste and tablet form. It was found that only 50 g of NPK consortia is sufficient for 1 acre crop area and also its shelf-life is more than one year.

6.6 PORTABLE FERMENTERS (2004)

Fermenters are the containers in which process of fermentation take place. This provides microbes a controlled atmosphere with regulated temperature, pH and feed etc. It has an inlet and outlet. Fermenters can be made of any size depends on requirement. The choice of material to be used

for fermentation is an important factor. NCOF developed various portable fermenters with steel head assembly and poly-culture fermenter which are being commercially used by production units. Steel is an alloy having high tensile strength and low cost.

6.7 OIL FORMULATIONS OF BIOPESTICIDES (2004)

For the first time this kind of work is done at Bengaluru, Regional centre of organic farming. The efficacy and survivability of potent microbicidal agents like Trichoderma, Verticillium etc. can be enhanced in oil based formulations. Basic concepts behind oil based formulation are they can stabilize the microorganism during production, distribution and storage, easy handling and transport, protection from harmful environmental factors at the target site and also helpful in making microorganism more active (5). This is advantageous when seed treatment is done to protect the plant from seed and soil borne disease.

Successful trials were made using these cultures in oil base in 2004. The salient feature is its small ampoule of 20 ml has more than 107 cells/ml with oil based formulation and shelf life more than 5 years and also it is easy to carry. This ampoule is much enough effectively to manage the crop in1 acre land.

6.8 DEVELOPMENT OF LIQUID VAM (2015)

Vesicular-arbuscular mycorrhiza is formed by the symbiotic association between certain fungi and plant roots. This symbiotic association is helpful for the plant in terms of phosphorus availability to plant from soil mainly. This is environmental friendly and VAM can be used as effective biofertilizer. VAM has several benefits like it can make available nutrients to plants in easily accessible form, has better nutrient mobilization/absorption etc.

VAM is commonly available in solid formulation, but now, technology has been fruitfully developed by NCOF for its liquid formulation. Such work is done for the first time in India.

6.9 Development of Waste Decomposer Culture (2015)

This can be said as wonderful microbial input. NCOF launched 'Waste Decomposer' culture which is proving as miracle all over the country. It is used for quick composting of organic waste, soil health improvement and as plant protection agent. It is worth to mention that on farm production of liquid decomposer culture not only reduces the cost of cultivation by eliminating the use of chemical fertilizers and chemical pesticides but also simultaneously improves soil health and productivity as well as reduces incidence of pest and diseases.

Till date more than 2.5 Lakh villages and approx. 50 Lakh farmers have already been benefitted by using this culture across the country. Recently, during "Swacchhata Pakhwada" programme in 16-31 May 2017, a total of 148 campaigns were organized all over the country to learn people about waste decomposer technology and easy compost preparation using kitchen waste, agrowaste and other organic waste material.

Salient feature of waste decomposer:

- Simple & Reliable
- Ready to use (within 5 days)
- Longer shelf-life (3 years)
- Recommended for all crops
- Better crop response
- Works as a great component for clean India Movement (Swachh Bharat Mission) by converting bio-waste into organic Manure
- Low cost (only Rs. 20 per bottle)
- More than 1 lakh metric tonne organic manure could produce from 1 bottle per year by farmers.

MASS MULTIPLICATION OF WASTE DECOMPOSER

Waste decomposer is being provided to farmers in small bottles and this can be multiplied by farmers in easy manner without using any sophisticated technique.

Mass Multiplication Process

Take 2 kg jaggery and mix it in a plastic drum containing 200 litres water. Now take 1 bottle of waste decomposer and pour all its contents in a plastic drum containing jaggery solution. Mix it properly with a wooden stick for uniform distribution of waste decomposer in the drum. Cover the drum with a paper or cardboard and stir it every day once or twice. After 3-5 days the solution of drum solution turms creamy (6).

USES OF WASTE DECOMPOSER

I. Composting
ii. In-Situ Composting of Crop Residue
iii. Seed Treatment
iv. Foliar Spray
v. Drip irrigation

Report on Waste Decomposer by-ICAR-Indian Institute of Farming Systems Research, Modipuram

ICAR-Indian Institute of Farming Systems Research, Modipuram

Report on Waste Decomposer

Waste decomposer obtained from National Centre of Organic Farming (NCOF), Ghaziabad was evaluated for its efficacy of decomposition of wastes such as rice straw, wheat straw and sugarcane trash through lab and pot culture experiments. The basic characterization of Waste Decomposer was done at NPOF centre, Narendrapur (West Bengal).

Characterization of Waste Decomposer

The pH, organic carbon and microbial parameters were analysed at different days. It was found that pH was in the range of 4 to 6 while organic carbon in the range of 0.40 to 0.60 (Fig 1 & 2). The microbial load indicated waste decomposer was having cellulose &xylan degrading bacteria besides the phosphorus and Potassium solubilizes which contributes for enhanced decomposition of residues (Table 1).

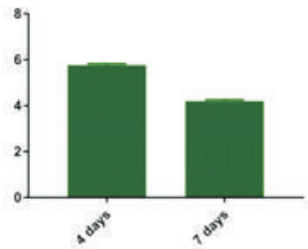

Fig 1.pH

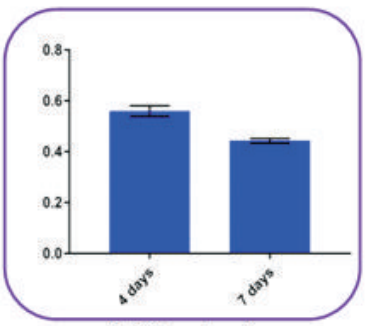

Fig 2.Organic carbon

Table: Population of micro-organisms in Waste Decomposer

Type of bacteria	Bacterial population
Cellulose degrading bacteria	$10.0x10^7$
Xylan degrading bacteria	$2.4x10^6$
PSBs	$2.0x10^7$
KSBs	$8.0x10^4$

Nutrient release and decomposition

Nutrient release and decomposition pattern in different residues was studied at ICAR-IIFSR, Modipuram with different combinations of residues, water, decomposer, FYM and mulching. The details of the treatment evaluated with 4 replications are given below. It was found that carbon mineralization and soil available nitrogen was higher under waste

decomposer applied treatments in all the residues from 42 days onwards (Table 2 & Fig 3-5). Waste decomposer could able to enhance the decomposition rate of all the residues and also makes available nitrogen, phosphorus and potassium from soil due to presence of cellulose degrading bacteria besides phosphorus and potassium solubilizes.

Treatment	Rice residue	Wheat residue	Sugarcane residue
T_1	Rice residue+Water	Wheat residue+Water	Sugarcane residue+Water
T_2	Rice residue+Water+Waste decomposer	Wheat residue+Water+Waste decomposer	Sugarcane residue+Water+Waste decomposer
T_3	Rice residue+Water+FYM	Wheat residue+Water+FYM	Sugarcane residue+Water+FYM
T_4	Rice residue+Water+Wasted ecomposer+FYM	Wheat residue+Water+Wasted ecomposer+FYM	Sugarcane residue+Water+Wasted ecomposer+FYM
T_5	Rice residue+Water+Wasted ecomposer+mulching	Wheatresidue+Water+ Wastedecomposer+mulching	Sugarcane residue+Water+Wasted ecomposer+mulching

Table 2. Soil available nitrogen (kg/ha) due to decomposition

Treatments	30 days	42 days	54 days
RICE			
T1	179.80	142.16	150.53
T2	163.07	142.17	**175.62**
T3	196.53	175.62	175.62
T4	175.62	137.98	167.25
T5	150.53	**200.70**	**188.16**
WHEAT			
T1	179.80	171.43	179.80
T2	179.80	133.80	**183.98**
T3	175.62	150.53	175.62
T4	204.88	146.35	171.44
T5	137.98	**213.25**	**150.53**
SUGARCANE			
T1	171.44	158.89	167.25
T2	150.53	142.17	**183.98**
T3	163.07	146.35	196.52
T4	209.07	163.07	179.80
T5	175.62	**225.79**	**175.62**

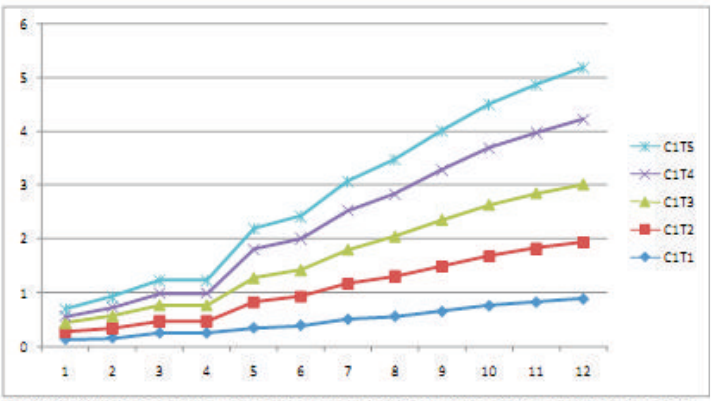

Fig 3. CO_2-C release due to waste decomposer addition in rice residue (1▪24 hrs, 2▪4 days, 3▪10 days, 4▪21 days, 5▪28 days, 6▪35 days, 7▪42 days, 8▪49 days, 9▪56 days, 10▪63 days, 11▪70 days, 12▪77 days)

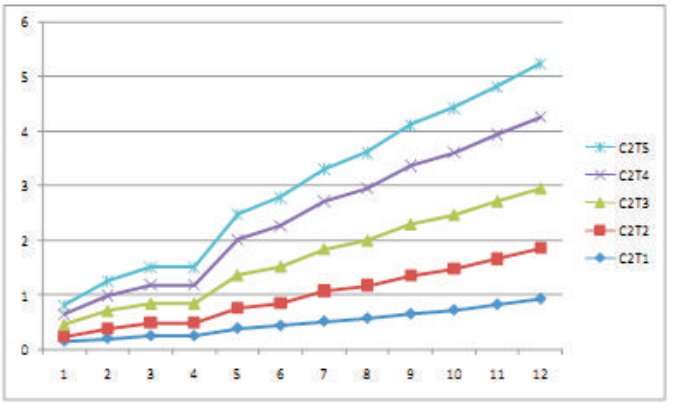

Fig 4. CO_2-C release due to waste decomposer addition in wheat residue (1▪24 hrs, 2▪4 days, 3▪10 days, 4▪21 days, 5▪28 days, 6▪35 days, 7▪42 days, 8▪49 days, 9▪56 days, 10▪63 days, 11▪70 days, 12▪77 days)

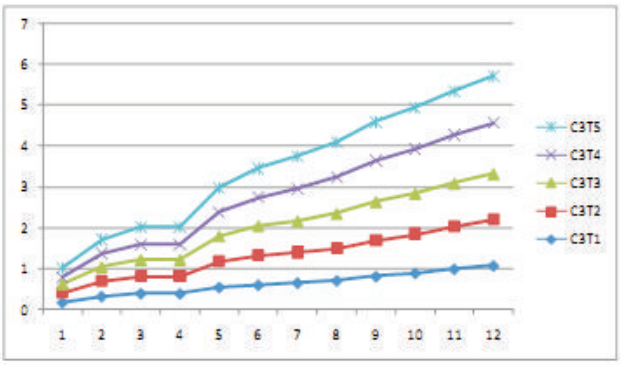

Fig 5. CO_2-C release due to waste decomposer addition in Sugarcane trash (1▪24 hrs, 2▪4 days, 3▪10 days, 4▪21 days, 5▪28 days, 6▪35 days, 7▪42 days, 8▪49 days, 9▪56 days, 10▪63 days, 11▪70 days, 12▪77 days)

Whereas the detailed and further evaluation report on waste decomposer through on-station and farmers field is in progress through NPOF centres of Coimbatore (Tamil Nadu), Karjat (Maharashtra) and Narendrapur (West Bengal).

7. SUPPLY OF MOTHER CULTURES

7. For continuous supply of microbial germplasm NCOF and RCOFs are maintaining more than 261 strains of different beneficial microbial organisms which includes Rhizobium, Azotobacter, Azospirillum, Phosphate solubilizing bacteria, Trichoderma, Beauveria, Pseudomonas, Verticellium, Metarhizium, Paecilomyces , Bacillus etc. As per the need slants of such strains are distributed to the industry. NCOF/RCOFs accounts for 80% of the total requirement of such strains in the country.

8. GOVERNMENT OF INDIA SUPPORT FOR PROMOTION OF BIOFERTILIZERS

In India the total requirement of various bio-fertilizers (quantity-wise) that are required for seed/root treatment and soil is estimated to be about 0.426 million ton, based on net cultivated area. Government is promoting bio-fertilizers through various schemes like National Mission for Sustainable Agriculture (NMSA)/ Paramparagat Krishi Vikas Yojana (PKVY), Rashtriya Krishi Vikas Yojana (RKVY) and National Mission on Oilseeds and Oil Palm (NMOOP), National Food Security Mission (NFSM) and Indian Council of Agricultural Sciences (ICAR).

Under the Integrated Scheme of Oilseeds, Pulses, Oil Palm and Maize (ISOPOM), assistance is provided for supply of Rhizobium culture/Phosphate solubilizing bacteria, Azotobacter and Azospirillum culture @ 50% cost of culture or Rs.100/- per hectare whichever is less. Under National Food Security Mission (NFSM) on Pulses, including Accelerated Pulses Production Programme (A3P), assistance for popularizing Rhizobium culture/PSB is provided to the farmers under cluster demonstrations and financial assistance is provided for promotion of Bio-Fertilizer (Rhizobium/PSB) @50% of the cost limited to Rs.300 per ha. Similarly, under Initiative for Nutritional Security through Intensive Millets Promotion (INSIMP) Programme, PSB/Azotobacter culture is provided to the farmers as part of technology demonstration. In addition, states are free to provide funds under RKVY for promoting use of Biofertiliser with the prior approval of State level sanctioning committee under the chairmanship of Chief Secretary.

Rs.500/ acre for suppression of disease in crop plant. (7)

Further under Paramparagat Krishi Vikas Yojana, Govt. of India giving financial support for usage of Biofertilizer is given as follows:

- Farmer member of PKVY cluster will be assisted for procuring liquid bi-fertilizer consortia (Nitrogen fixing/ Phosphate Solubilizing/ potassium mobilizing bio-fertilizer) @ Rs.500/acre and its application to soil/seed to increase crop production.
- Each farmer member of PKVY cluster will be assisted for procuring and application of liquid bio- pesticides (Trichoderma viridae, Pseudomonas, fluorescens, Matarhizium, Beauveria bassiana, Paecilomyces, Verticillium) Rs.500/ acre for suppression of disease in crop plant. (7)

The Government of India is encouraging the establishment of biofertilizer/ biopesticides (200 TPA or 50000liter/annum) production units by providing 100% financial assistance to State Government upto a maximum limit of Rs 160.00 lakhs per unit and financial assistance to farmers/individual/private agencies @ 25% of total financial outlay (TFO) or Rs.40 lakh, whichever is less under CISS through NABARD.

Table 5. State-wise total number of Biofertilizer production units established under National Project of Organic Farming through NABARD Since inception (October 2004 till 2017) under Capital Investment Subsidy Scheme

S.N.	STATE	BIOFERTILIZER UNIT
1.	Andhra Pradesh	04
2.	Arunchal Pradesh	-
3.	Assam	03
4.	Bihar	-
5.	Chhattisgarh	-
6.	Delhi	-
7.	Goa	01
8.	Gujarat	06
9.	Haryana	01
10.	Himachal Pradesh	02
11.	J & K	-
12.	Jharkhand	-
13.	Karnataka	05
14.	Kerala	03
15.	Madhya Pradesh	01
16.	Maharashtra	10
17.	Manipur	-
18.	Meghalaya	01
19.	Mizoram	-
20.	Nagaland	-
21.	Orissa	-
22.	Punjab	05
23.	Rajasthan	01
24.	Sikkim	-
25.	Tamil Nadu	04
26.	Telangana	06
27.	Tripura	01
28.	Uttar Pradesh	02
29.	Uttara khand	02
30.	West Bengal	02
	Total	**60**

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