Transition from Conventional farming to Organic Farming

Ministry of Agriculture and Farmers Welfare, Govt. of India

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PREFACE

The Government of India is promoting organic farming in different parts of the country through various schemes like National Project on Organic Farming (NPOF), Paramparagat Krishi Vikas Yojna (PKVY), Mission Organic Value Chain Development-NER (MOVCD-NER), National Horticulture Mission (NHM) etc.

The Regional Centre of organic farming (RCOF) Bhubaneswar, has taken up a much needed initiative in collaboration with the renowned Odisha University of Agriculture and Technology (OUAT) as "**Thirty Days Certificate Course on Organic Farming**" to make participants aware about the importance and gravity of organic farming, and 30 dedicatedly involved undergraduate, postgraduate, Ph.D students to formulate projects for profitable agri-business in the organic farming.

The primary objective of Thirty days certificate course, was to create job opportunities in organic sector with the involvement of skilled development of agriculture youth, to create work force in order to double up the farmers' income with reduced input, nutrient and water management, to develop trainers at rural level on organic management, to empower professionals for organic certification and to impart skills at village level required for organic farming practices and related marketing economics. The sessions were conducted by various invited speakers across the country.

The training course also involved a number of field visits and demonstration trainings. The participants were exposed to the projects and technologies undertaken at the esteemed NRRI Cuttack, CIFA Bhubaneswar, OUAT, Dew Born Agronutrients Industries, SRL Co. Limited, KVK Khordha. The participants were emphasized on the substantial production of different crops with the use of biofertilizers in the form of microbial consortiums, waste decomposer, ITKs, organic inputs, and applications of Azolla etc.

This compendium comprises of the lecture notes given by eminent scientists and professors in the relevant fields. This course material is especially designed for participants' future needs and reference. We hope this study material will be beneficial to the participants, students and farming community in future. I believe, this certification course will bring fruitful outcomes for the organic farming sector as this is the right time to look our land, again……

On this occasion, I would like to thank Mrs. Neerja Adidam, Hon'ble J.S. (INM) for providing the constant support in all the extension and farmers knowledge oriented activities in this region. I also would like to thank Dr. Krishan Chandra, Director, NCOF for providing us the opportunity and constant support to organize CCOF at BBSR. Without their encouragement and support, this publication was not possible.

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Dated the 22nd November, 2018

MESSAGE

Organic farming is gaining importance in the emerging scenario of changing climate and sustainable agricultural production. I am glad to know that Regional Centre of Organic Farming, Bhubaneswar is organizing a Certificate Course on Organic Farming by involving young students to enhance their knowledge on various aspects of organic agriculture. I hope, this programme will provide an excellent platform for the participants to strengthen their knowledge base that will reshape future of organic agriculture in India.

I wish this endeavor all success.

22/11/18

(S. Pasupalak)

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ड. अजय परिड़ा
निदेशक
Dr. Ajay Parida
Director

MESSAGE

I take great pride to congratulate all of the participants, faculty members, staff members who have attended 30 Days Certificate Course on Organic Farming from 24 October to 23November, 2018, organized by Regional Centre of organic farming Bhubaneswar.

This training course is definitely the step for a giant leap into the prospects of amalgamating conventional agriculture with the brilliance of the resurgence of Organic farming with the young and brilliant and talented students.

I applaud the publication of book Indigenous Technical knowledge (ITKS) - Crop wise with reference to organic progressive farmer practices for the benefits of farmers. Conventional approaches imply that development processes always require technology transfers from locations that are perceived as more advanced. This has led often to overlooking the potential in local experiences and practices. This book will provide an insight to local community in which the bearers of such knowledge live and produce.

I am particularly happy to be present on the valedictory function of this training program and to exchange views and share experiences with other high level professors, colleagues and friends. I extended my greetings and good wishes to the Regional Director RCOF, BBSR and his team, to organize such a needful program and said that it was an enriching experience for the participants and wish it all success.

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Regional centre of organic farming, Bhubaneswar

Introduction

The term **Organic farming** was coined by **Northbourne** (in 1940) based on his concept "farm as an organic whole" i.e. having a complex but necessary interrelationship of parts, similar to that in living things in his book titled, *Look to the Land*. Thereafter, **Albert Howard** adopted Northbourne's terminology of organic farming in his book entitled "*An Agricultural Testament"* and became as the **father of organic farming** for his dedication in applying scientific knowledge and principles to various traditional and natural methods.

The word organic means of plants or animal origin. Organic agriculture refer to the agricultural system that follows the logics of living organisms in which all the components including soil, plants, farm animals, insects, farmers etc. are closely linked with each other. In the words of Wendell Berry (1981) "Organic Farm, is not one that used certain methods and substances and avoid others. It is a farm whose system is formed in imitation of the structure of a natural system that has the integrity, the independence and the benign dependence of an organism." Moreover, management of organic farm requires monitoring of various activities at on farms. It is therefore important that all those interested (herein after hear to refers as operators) take a considered decision in promotion of organic farming.

Concept and Principles

The concept of organic believes in **feeding the soil to feed the plants**. Organic farming linked directly to the soil to make soil healthy and vital which ultimately affects the plant. The International Federation for Organic Agriculture Movement's (IFOAM) definition of Organic agriculture is based on: The principle of health, The principle of ecology, The principle of fairness and The principle of care. The principles are to be used as a whole.

1. Principle of health

Organic Agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible. This principle points out that the health of individuals and communities cannot be separated from the health of ecosystems - healthy soils produce healthy crops that foster the health of animals and people. Health is the wholeness and integrity of living systems. *Healthy Soils* produce *Healthy Crops* that fosters the health of people and animals. The high quality nutritious food contributes to preventive health care and well being of individuals.

2.*Principle of ecology*

The ecology of the specific production environment is important for the well-being of humans. Organic Agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them. This principle roots organic agriculture within living ecological systems. It states that production is to be based on ecological processes, and recycling. Nourishment and well-being are achieved through the ecology of the specific production environment.

*3. **Principle of fairness***

Organic Agriculture should ensure that everyone have a good quality of life and provide better life opportunities. Fairness is characterized by equity, respect, justice and stewardship of the shared world, both among people and in their relations to other living beings. This principle emphasizes that those involved in organic agriculture should conduct human relationships in a manner that ensures fairness at all levels and to all parties - farmers, workers, processors, distributors, traders and consumers. Organic agriculture should provide everyone involved with a good quality of life, and contribute to food sovereignty and reduction of poverty. It aims to produce a sufficient supply of good quality food and other products.

*4. **Principle of care***

Organic Agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of present and future generations and the environment (Fig 1). Organic agriculture is a living and dynamic system that responds to internal and external demands and conditions. Practitioners of organic agriculture can enhance efficiency and increase productivity, but this should not be at the risk of jeopardizing health and well-being. Consequently, new technologies need to be assessed and existing methods reviewed. Given the incomplete understanding of ecosystems and agriculture, care must be taken. This principle states that precaution and responsibility are the key concerns in management, development and technology choices in organic agriculture.

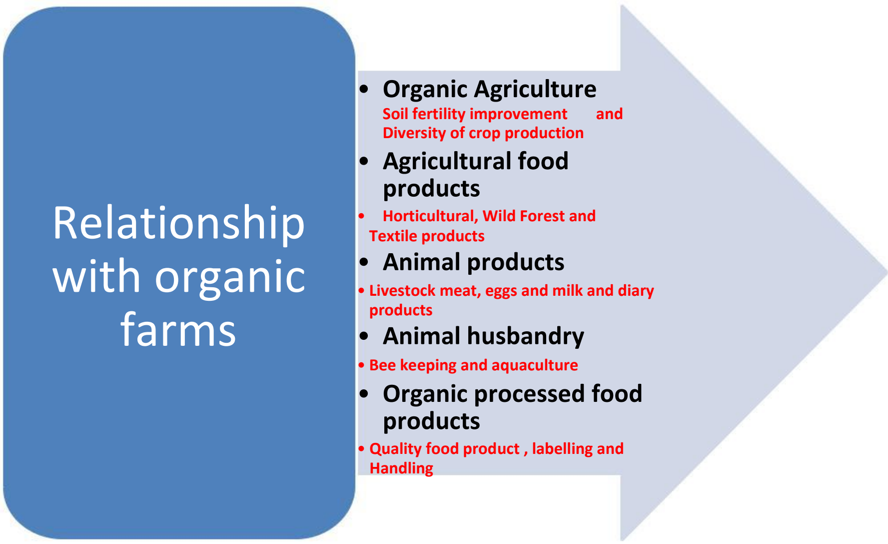

Fig1: Relationship between plants, animals and humans in organic agriculture

Land Requirements

An organic farming should have following requirements:

a) Well defined boundaries should be there throughout the area.

b) There should be buffer zones to avoid contamination from the prohibited substances applied to nearby lands.

c) The size of the buffer required depends on field site for organic certification.

d) The operators should provide effective hedge or wind break where there is a risk of spray/contamination.

e) There should not present any nearby factories, traffic and sewage sludge and residual pesticides.

f) Trees or Shrubs should be used as ideal or permanent buffers.

g) Awareness and cooperation from the neighbor's.

h) Attractive and message giving hoardings should be put up to inform all the concerned for the organic farm.

Transition to Organic Management of Farm

The time required for the establishment of the organic farm is called as **Conversion Period**. Depending upon status of farm, land and environmental condition, the certification body can extend or reduce duration of conversion period.

a) Twelve months reduction could be considered for annuals/perennials if the standard's requirement has been met for a minimum three years under Participatory Guarantee System (PGS).

b) Certification body shall also consider such a reduction if it has satisfactory proof to demonstrate that the land has been free.

c) Notwithstanding what has been stated above a full conversion period may not be required when standard requirement have been met for several years.

ORGANIC MANAGEMENT PLAN (OMP)

Organic System Plan (OSP) serves as the basis of the process of transition to organic Management. It has four major components.

1. ***General information***
   It contains information about the following such as:

a) Farm Map, land holding and infrastructure facilities.
b) Crop Production practices
c) Processing methods and labeling procedures
d) Livestock health care practices
e) Biodiversity protection
f) Contamination prevention

2. ***Inputs used***

a) Compost
b) Manure
c) Soil amendments
d) Crop production aids
e) Pest Control Inputs
f) Livestock feed
g) Livestock health care products
h) Post-harvest materials
i) Processing aids
j) Ingredients

3. ***Monitoring Practices***

a) Soil Testing
b) Monitoring soil moisture/water quality
c) Product quality testing
d) Monitoring crops/pasture quality
e) Use of body conditioning scores
f) Somatic cell counts
g) Pest monitoring

4. ***Record Keeping***

a) Buffer zones
b) Notification of neighbors and road departments
c) Organic products identification
d) Management Practices

LANDSCAPE MANAGEMENT

The organic operators should enhance landscape features, and facilitate biodiversity; and soil and water conversation etc with reference to environmental issues.

1. It has been suggested that at 5 per cent of the total farm area should be under native vegetation, trees, grassland or reserves, waterways etc.
2. Conversation of existing sites.
3. Selection of site for construction of new farm buildings should be done.
4. Local materials should be used in construction to the maximum feasible extent.
5. Use of wood preservatives should be avoided.

Fig2: Rice based Model organic farm

BIODIVERSITY MANAGEMENT

Biodiversity performs a variety of ecological services, namely, pollinators, natural enemies, and soil microorganisms and these all are the key components in agro-ecosystems. To connect whole farm integrated and management the biodiversity helps to address such synergies.

At the farm level, the organization of land use, e.g., the crop succession within the farming system is a key factor (Fig2 - 3). At field level, the different practices used by the farmers determine habitat quality and, hence species presence or abundance.

Fig3: Wheat based Model organic farm

SOIL AND WATER CONSERVATION

The organic operators are advised to carry out the needed soil conservation, soil reclamation or water management system in the guidance/ and or collaboration of the concerned Government departments, and make full use of the subsidies for various works available, if any, besides the technical help.

SOIL RECLAMATION

1. Acid Soils

Soils having pH below 7.0 are considered to be acidic. Soil acidity is neutralized by adding lime in the soil (Table 1& 2).

TABLE 1: Required amount of finely grounded limestone to raise the pH to 6.5

Soil Types	Tons/ha		
	pH 4.0	pH 4.50	pH 5.50
Temperate hilly region-			
Sand and loamy sands	7.50	5.0	2.50
Sandy Loam	-	7.50	5.00
Loam and slit loam	-	11.25	7.50
Clay loam	-	12.50	8.75
Valley soils-			
Organic, water logged	22.50	17.50	11.50
Warm humid plains-			
Sand and loamy sands	3.75	2.50	1.25
Sandy loam	-	5.0	2.50
Loam and slit loam	-	8.75	5.0
Clay loam	-	12.50	7.50

2. Salt Affected Soils

The soils which have sufficient neutral soluble salts in the root zone to interfere with the growth of plants is known as *Saline soils* whereas, the soils contain excessive exchangeable sodium which adversely affect crop production.

RECOVERY OF SALT AFFECTED SOILS

To recover soil from the excess salt, proper land leveling is required so that leaching will take place. Other than that, Gypsum can be added depending upon extent of soil deterioration.

Table: 2 Optimum pH ranges of crops

Crops	Optimum pH Range
Maize, Wheat, barley, sorghum, berseem, Sugarcane	6.0-7.5

Millers, cotton	5.0-6.5
Rice, tea	4.0-6.0
Oats	5.0-7.7
Field bean, soybeans, pea, lentil, gram	5.5-7.0
Groundnut	5.3-6.6
Potato	5.0-5.5

Alkali soils can be recovered by growing grasses, such as Karnal grass and para grass; khus grass and aromatic plants, such as Palma rosa, trees species such as *Acacia nilotica* and *Sesbania aegyptica.*

3. Water logged soils

Water logging lead to reduced aeration and root penetration which leads to reduced nitrogen in a form which cause yellowing of surface vegetation.

To overcome water logging

Promote the activities of burrowing earthworms and other organisms in creating stable aggregates. Compaction soil zones or plow pans may need to be broken by sub soiling or mole drains to allow water to penetrate.
In heavy soils vigorous crops help create and stabilize fissures, and deeper penetration can help dry put lower layers more during drought, encouraging the cracking process. Soils warm up faster, resulting in higher microbiological activity; increase level of nutrient supply and rates of nutrient cycling.

WATER CONVERSATION

Currently, there are on-going Government Schemes for setting up of sprinkler/ drip irrigation systems and water shed schemes involving construction of structures such as dams and storage systems. The organic producers are advised to make full use of the subsidies for various works for optimum utilization of water resources for irrigation of crops.

Conclusion

The transition from conventional to organic farming requires numerous changes. One of the biggest changes is in the mindset of the farmer. Conventional approaches often involve the use of quick-fix remedies that, unfortunately, rarely address the cause of the problem. Transitioning farmers generally spend too much time worrying about replacing synthetic input with allowable organic product instead of considering management practices based on preventative strategies. During transition, growers rely on cultural mechanisms and on organic and mineral sources to improve soil fertility, to build a population of natural enemies to suppress pest populations. Pest management practices during the transition period that reduce pest populations to economically manageable levels include crop rotation, cultivation, cover crops, mulches, crop diversification, resistant varieties and insect traps. These practices also enrich the soil biota and increase crop yields before produce is certified organically grown. Here the main focus is to make the soil healthy and vital so that the plants/crops may be healthy and sustainable for future generations. So, it is again right time to look our land again.

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Organic Farming for Regenerative and Sustainable Agriculture

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Introduction

One of humankind's most basic activities is agriculture because all people need to nourish themselves daily. Agriculture has transform the lives of millions of people in the world by providing food, fibre, milk, meat and various other useful materials. The success of Green Revolution in India has increased the yield of food grains significantly and made the country self-sufficient in food production. The dramatic improvement in food production and food surplus, notwithstanding, the intensive agricultural production systems based on fossil fuels, fertilizers, pesticides and high water use has led to soil degradation, contamination of air and water, depletion of ground water, outbreaks of insects and diseases and various ill-effects on human health. It is by now clear that the yield increases has tapered and plateaued while farmer's debt and discontent are growing.

Organic farming emphasis on natural process and ecological cycle has benefits that alleviate the problems modern conventional agriculture dependence on agri-chemical inputs has created. The abundance produced by conventional agriculture has created new scarcities at the ecosystem level. The importance of clean environment and healthy living soil that provides sustainable food cannot be understated. An environmentally sound and regenerative agricultural practice like organic farming has become more economically rewarding and sustainable for farmers

Definition and Theory

According to Codex Alimentarius (FAO/WHO), Organic Agriculture is a holistic production management system which promotes and enhances agro ecosystem health, including biodiversity, biological cycles and soil biological activity. Organic farming practices are designed to encourage soil and water conservation and reduce pollution. It is adapted to local conditions and combines tradition with science to benefit the environment and promoting good quality of life for all involved. By producing food while establishing an ecological balance, organic farming takes a proactive approach as opposed to treating problems after they emerge. The main philosophy behind organic farming is "feed the soil to feed the plant" with primary focus on soil health. Practices which promote soil health and quality like increasing organic matter and biological activity are emphasized.

Principles of Organic Farming

There are four principles of organic agriculture which has to be applied whenever people tend soils, water, plants and animals in order to produce, prepare and distribute food and other goods.

1.The Principle of Health: This principle is rooted in the concept that healthy soils produce healthy crops that promote the health of animals and people.

2.The Principal of Ecology: It states that production is to be based on ecological processes, and recycling. Organic farming should imitate nature which knows best.

3. The Principal of Fairness: It demands fairness at all levels and to all parties – farmers, workers, processors, distributors, traders and consumers.

4. The Principal of Care: It states that precaution needs to be taken and responsibility should be established for any activity. Practical experience, accumulated wisdom and traditional and indigenous knowledge are applicable in most situations and time tested.

Application in Organic Farming

Organic farming practices include various scientific techniques like use of bio- fertilizers, biopesticides and micro-organisms which facilitate composting. Biofertilizers are eco-friendly microorganisms which, when applied to seeds, plant surfaces, or soil, colonize the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant. They stimulate plant growth through nitrogen fixation, solubilizing phosphorus, and through the synthesis of growth-promoting substances. Use of biofertilizers is one of the important components of Organic farming as they are cost effective and renewable source of plant nutrients to supplement the chemical fertilizers for sustainable agriculture. Examples of biofertilizers include nitrogen fixers like *Rhizobium, Azotobacter, Azospirilium* and blue green algae (BGA) and phosphate-solubilizing bacteria, such as *Pseudomonas* etc.

Biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals. They are specific to a target pest and offer an ecologically sound and effective solution to pest problems. The most commonly used are biofungicides like *Trichoderma* and bioinsecticides like *Bacillus thuringiensis.*

The Waste Decomposer developed by National Centre on Organic Farming, Ghaziabad has been a boon to organic farmers. It is used for quick composting from organic waste, soil health improvement and as plant protection agent. By decomposing and recycling wastes and converting into organic fertilizers and enhancing soil fertility, it provides farmers with easily available natural fertilizer and very cheap fertilizer source. Sold in a bottle of 30 gm costing Rs. 20/- per bottle, a single bottle decomposes bio-waste of more than 10,000 metric tons just in 30 days and can be reuse after preparing the solutions.

Mission Organic Value Chain Development in NE Region (MOVCDNER) in Manipur

Mission Organic Value Chain Development for North Eastern Region (MOVCDNER), a Central Sector Scheme launched during the year, 2015-16 for North Eastern States including Sikkim has been implemented in Manipur from the year, 2016-17. The scheme emphasizes on grooming of individual farmer to convert into organic farmer and grouping them to form Farmers Interest Group (FIG) for production of organic commodities through standard Certification Norms of NPOP. The scheme also provide selected organic farmers with hand holding supports for quality production of identified crops right from quality planting materials (QPM), proper plantation, appropriate operational practices, standard ICS management, improved post-harvest technologies, setting up of primary processing, packaging and branding for onward marketing of organic products to National and International buyers. The scheme is committed to creating of Farmers Producer Company (FPCs) and sustaining them through bringing into agri-business activities with support and assistance for infrastructure and facilitating institutionalization and market linkage with genuine/ serious buyers & MNCs.

In Manipur, one agriculture crop, *Chakhao* (Black Aromatic Rice) and 6 horticulture crops viz; Pineapple (Kew & Queen) , Ginger (Nadia/ fibreless), Turmeric (Lakadong/ Megha-1),King Chilli, Kachai Lemon and Tamenglong Orange which are known for their unique characteristics and export potentials has been identified and promoted under the scheme. The scheme is implemented by Manipur Organic Mission Agency, a Government Society under the Department of Horticulture & Soil Conservation. Field level activities are implemented through four Service Providers engaged for the purpose. One Cert Asia Agri Certification Pvt. Ltd has undertaken the task of Organic Certification as per NPOP standard. *Chakhao* (Black aromatic rice) which is known for high anthocyanin content is grown by 2000 farmers in valley districts covering 2000 ha. All the hill districts have also been covered with 3000 farmers over an area of 3000 ha. Area covered for each crops are 600 ha for Pineapple, 400 ha for Tamenglong Orange, 200 ha for Kachai Lemon, 600 hafor King Chilli (U-morok) 600ha- Ginger, and 600 ha for Turmeric. 10 Farmers Producer Company (FPC) has already been formed constituting 500 farmers each. 2nd year scope certificate has also been acquired for all the 7 crops. Marketing of surplus produces of farmers to potential buyers from outside the State started from the year 2018-19.

Phase II of the Scheme has been approved during 2018-19 with a total area of 7500 ha and 7500 farmers. Crops covered under Phase II are *Chakhao* (Black aromatic rice) and HYV rice with an area of 2500 ha, Ginger – 1500 ha, Turmeric -2000 ha, Pineapple – 1000 ha, and King chilli- 500 ha allocated in all valley and hill districts of the State.

Success story

1. Mr. Kabilung Gonmei (34 yrs) and Mr. Pouchalung Gonmei (36 yrs) are organic farmers from Awangkhul Village, Noney District. They are both active members of Himdai FIG (Farmers' Interest Group) under Reangluang Organic Farmers Producer Company Limited, an FPC formed and promoted by Diocesan Social Service Society (DSSS), a service provider under Manipur Organic Mission Agency (MOMA). Prior to the MOVCDNER scheme intervention, they worked as a daily wage earner in order to support their family. In 2016, they were selected as beneficiary farmers. They do joint farming in 2 ha of farming land which is in 3rd year organic conversion period. They cultivate turmeric as major crop with the various assistance provided under the scheme. Their annual turnover value is estimated to be Rs. 3,50,000 in 2018. The increased farm income has resulted in better living outcomes.

2. Shri. Thingbaijam Amuchou Meetei, aged 67 years is an organic farmer from Irengbam Awang Mamang Leikai, Nambol, Bishnupur district, Manipur. At present he has

acquired 4(four) hectares of land in compact area in Irengbam Loukol (field) at the foot hill of Irengbam Maning Ching of Bishnupur District. He has a land holding of 4.0 hectares (farmland) located at the GPS co-ordinates of 24042‟27”.03 (N) and 93046‟34”.77 (E). He has been awarded Best Farmer Award (201617), Innovative Variety Grower and achieved 3rd position in District Level Paddy Crop Competition.

Since 2015-2016, he has started growing *Chak-hao* Amubi in 1.0 ha under MOVCDNER implemented by Manipur Organic Mission Agency (MOMA), Department of Agriculture, Manipur. He is a farmer registered under the Phouoibi Organic Producer Company Ltd., Bishnupur. Under the scheme, he was provided with quality seeds of Chak-hao for cultivation and has improved his cultivation practices making huge differences in his previous yield and returns. In addition the scheme provided him with financial assistance of Rs. 3750 for on-farm organic management and with the money he started producing compost and liquid manures which helped him in nutrient management in his field. With the financial assistance of another Rs. 3750 for off-farm organic management he procured bio-fertilizers, bio-traps, bio-pesticides and bio-fungicides to maintain the plant health of his field.

During 2017-18, he harvested 1.8 MT/ha of *Chak-hao* rice which was sold to the buyer outside the state through the e-auctioning done by MOMA and NERAMAC at the rate of Rs. 80.00 per Kg. He earned Rs. 1,49,760 by selling in the e-auction. After deducting Rs. 60,000.00 for cost of production, he had a net profit of Rs. 89,760.00. Earlier his net income from his farms was approx. Rs. 3,50,000 and with the intervention of MOVCDNER he has increased another additional income of Rs. 89,760. It made him feel proud that he could meet expenditures on proper education of his two sons and four daughters up to graduate level and had a happy family of eight members with the earnings from his farm.

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Organic input for growing field crops – Policy, Technology And Future

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The global population is expected to reach 9.7 billion by 2050 and an increase of 70–100% in farm productivity is considered necessary to meet the increased demand for food and fibre. This increase in agriculture productivity needs to be met from a shrinking arable land area due to multiple demands (e.g. food, fuel, fibre and climate mitigation) and land degradation. Current farming practices almost exclusively based on three major inputs *viz*. improved crop variety, abundant water supply and the use of chemical fertilizers and pesticides. Although these have contributed significantly to increase farm productivity but have also contributed, in some cases, to chemical contamination, soil degradation, loss of biodiversity and compromised soil and water quality, which together impact overall environmental sustainability and can impact human health. Agriculture productivity faces additional major challenges including structural decline in soil fertility (i.e. increase in inputs does not result in proportional yield gain) and negative impact of climate change including extreme weather events. Emerging microbial approaches have the potential to address most of these challenges as a complimentary approach to conventional farming.

Use of microbes for agriculture has been practiced for several decades, mainly in the form of bio-fertilizers and bio-pesticides. Russia (previously USSR) and India have been in the forefront of agricultural productivity increase through microbial inoculation since early ‘60s. Production of biofertilizers in India over the years is listed in Table 1. These are mainly one-species products that either provide nutrients, particularly nitrogen (e.g. use of symbiotic rhizobia or free-living *Azotobacter*), mobilise phosphorus (e.g. *Penicillium* species) or protect against pests; insect (e.g. *Bacillus thuringienesis*) or fungus (e.g. *Trichoderma harzianum*) (Table 2). In recent years, a number of Indian companies (e.g. Lila Agrotech, Kolkata; Maharashtra Bio Fertilizers, Latur; Khandelwal Biofertilizer, Ichalakaranji) and large multi-national companies (e.g. Bayer Ltd, Nufarm, Monsanto BioAg) have commercialised microbial products for enhancing farm productivity. In fact, microbial products are one of the fastest growing start-ups and are expected to have a global market share of $6.4 billion by 2022.

Table 1 Total Biofertilizer production (carrier-based) in India (2003-04 to 2016-17)

Year	Biofertilizer production (MT)
2003-04	9,798.89
2009-10	20,040.35
2010-11	37,997.61
2011-12	40,324.21
2012-13	46,836.82
2013-14	65,527.87
2014-15	80,696.46
2015-16	88,029.30
2016-17	109,020.11

Source: Annual Report: National Centre of Organic Farming

Biofertilizers are the substances, prepared from living microorganisms which, when applied to the seeds or plant surfaces adjacent to soil can colonize rhizosphere or the interior parts of the plants and thereby promotes root growth. The term, biofertilizer should not be used interchangeably with green manure, manure, intercrop or organic-supplemented chemical fertilizer. Interestingly some PGPR species have appeared to promote plant growth by acting both as biofertilizer and biopesticide. For instances, strains of *Burkholderia cepacia* have been observed with biocontrol characteristics to *Fusarium* spp., while, can also stimulate growth of maize under iron-poor conditions via siderophore production. *Allorhizobium*, *Azorhizobium*, *Bradyrhizobium*, *Mesorhizobium*, *Rhizobium* and *Sinorhizobium* are reported as the potent PGPR strains for their ability to act as biofertilizers. The relationship between the PGPR and their host can be categorized into two basic levels of complexity: (1) rhizospheric and (2) endophytic.

Table 2. Biofertilizer production (by category) in India during 2017-16

Biofertilizer production	Amount (MT)
Azotobacter	12,712.94
Azospirillum	11,034.83

Rhizobium	7,520.93
P-Solubilizing Bacteria	26,916.28
K-Mobilizing Bacteria	5,884.03
Zinc- Solubilizing Bacteria	1,860.63
VAM (Arbusculuar mycorrhiza)	7,894.80
Acetobacter	1,027.00
NPK Consortium	2765.66

Source: Annual Report: National Centre of Organic Farming

Plant growth-promoting rhizobacteria (PGPR) are the rhizosphere bacteria that can enhance plant growth by a wide variety of mechanisms like phosphate solubilization, siderophore production, biological nitrogen fixation, rhizosphere engineering, production of 1-Aminocyclopropane-1-carboxylate deaminase (ACC), quorum sensing (QS) signal interference and inhibition of biofilm formation, phytohormone production, exhibiting antifungal activity, production of volatile organic compounds (VOCs), induction of systemic resistance, promoting beneficial plant-microbe symbioses, interference with pathogen toxin production etc. The potentiality of PGPR in agriculture is steadily increased as it offers an attractive way to replace the use of chemical fertilizers, pesticides and other supplements. Growth promoting substances are likely to be produced in large quantities by these rhizosphere microorganisms that influence indirectly on the overall morphology of the plants. Recent progress in our understanding on the diversity of PGPR in the rhizosphere along with their colonization ability and mechanism of action should facilitate their application as a reliable component in the management of sustainable agricultural system.

In addition to the use of bacterial inoculants as a specific input for increasing plant productivity, other organic residues are also used for restoring soil health and increasing overall fertility of the soil for an all-round crop growth. The composted residues have a narrow C:N ratio and thus can provide considerable amount of N to the crop that is grown in such amended soils. Apart from restoring organic matter exhausted due to intensive cropping, they also provide several micronutrients like Zn, Mo, and others. Farmers on their own apply several organic residues either composted or live. Composted organic residues like farm yard manure (FYM), while popular with the farmers, is not available in required quantities. Also, where available, digestate of biogas plants are also used as an organic supplement. Among the live organic matter, green manuring crops like *Sesbania* and *Aschynomene* are also popular with the farmers. In addition, *Azolla*, a water fern with N_2-fixing blue green algae *Anabaena*, is also used in field crop growing.

While benefits of using biofertilizers are well-acknowledged, use of biofertilizers has not been taken off to that anticipated grade. A few problems associated with biofertilizers include:

1. ***Isolation, identification and demonstration of effectiveness of a biofertilizer microbe***
2. ***Delivery of the candidate biofertilizer to the farmers***
    - ***a. Carrier, formulation***
    - ***b. Shelf-life***
3. ***Quality control***

While the step 1 is appropriated by research laboratories and various agricultural universities, step 2 is mostly centered on biofertilizer industry. One of the important components of efficient biofertilizer acceptance is the quality of the produce. National Centre of Organic Farming through its various regional centres are doing an excellent job in this aspect that is sure to restore the faith of farmers on such biological components as a regular input to farming.

The priorities for future research on bioinoculants is diverse and is focused on (1) in-depth evaluation of known carriers, (2) improvement of formulations that showed positive field results by fine-tuning key ingredients in the formulation (quantities, conditions, ratio of mixtures) or improvements in the process involved in their production, (3) increase survival of the microorganism in the inoculants, (4) increase in shelf life, (5) multi-strain inoculants and combination of containing rhizobia and a PGPB or biocontrol agent, (6) supplementation with additives to many formulations, (7) polymeric inoculants, (8) align inoculation technology with farming practices and (9) Low-cost technologies for extending the shelf life of inoculants at the farm level in developing countries need further development.

Microbial inoculants can fulfill diverse beneficial interactions in plants leading to promising solutions for sustainable and environment-friendly agriculture. The applications of rhizosphere soil of agricultural crops with desirable bacterial populations have established considerable promises in both the laboratory and greenhouse experiment. Further, improved understanding on the way by which PGPRs promote plant growth can lead to expanded exploitation of these 'biofertilizers' to reduce the potential negative environmental effects associated with the food and fiber production. An effort of applying genetically engineered PGPRs to remediate complex contaminated soil and thereby increasing the productivity of crop plants in agriculture is another attractive idea of research in recent decade. The rhizobacterial community can be specifically engineered to target various pollutants at co-contaminated sites to provide customized rhizoremediation system. Recent progress of molecular biology and biotechnology in the understanding of rhizobacterial interactions with the crop plants will encourage a suitable area of research in PGPR mechanisms relating to rhizosphere colonization.

Organic approaches for micronutrient availability to crop plants

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(The foundation of human health is lies on the quality of food we eat, which relies ultimately on the vitality of the soil on which it is raised. Soils seriously deficient in minerals cannot produce plant life competent to maintain our needs and with the continuous cropping and shipping away of those concentrates the condition become worse. Nobel laureate Dr. Alexis Carrel)

Out of seventeen essential plant nutrient elements discovered so far, eight (Fe, Mn, Cu, Zn, B, Mo, Ci and Ni) are considered as micronutrients because of their low quantity requirement. But functionally they are no way less important than major nutrients. Deficiency of any micronutrient in soil lead to it's deficiency in crop plant which results with malnutrition in animal and human body expressed in the form of disease and disorders. Some common information and functions of micronutrients are given in below table.

Table: Establishment of essentiality, plant concentration and metabolic function of Micronutrients

micronutrient	Essentiality established	Typical plant concentration (mg/kg)	Relative number of atoms required	Functions
Iron	E. Griss, 1844	100	2000	Catalase, peroxidase, chlorophyll
Manganese	Mc Hargue,1922	50	1000	Isocytricdehydroganase, photolysis
copper	Sommer ,1931	6	100	Cytochrome-oxidase, chloroplast,vit-A
Zinc	Sommer & Lipman,1926	20	300	Carbonic anhydrase, auxin, maturity
Boron	Warington, 1923	20	2000	Polyphenol oxidase, sug. Translocation
Molybdenum	Arnon & Stout, 1939	0.1	1	Nitrogenase, nitrate reductase
Chlorin	Broyer et.al. 1954	100	3000	Nitrification inhib., water& nutrient trans
Nickel	Brown et al. 1939	0.05	1	Coenzyme systems

Micronutrient deficient soils result in production of food/feed/fodder low in micronutrient content/density affecting human/animal health, distressing productivity and economy of nation**.** Micronutrients are central component of the sustainability agenda of soil. They significantly contribute in enhancing productivity, use efficiency of other nutrients and produce quality. In the Current level of production (263 Mt) food grain, about 188.4 thousand tonnes micronutrients (Zn-23.9, Fe-110.6, Cu-37.4, Mn-63.3, B-9.2 and Mo-0.99) are shipping away annually.Rampant micronutrients deficiency (Zn-36.5%, Fe-12.8%, Cu-4.2%, Mn-7.1% and B-23.2%) is taking a toll on the food and economic security.

Micronutrient deficiency in soils of Odisha

The percentage sample deficient of micronutrients in soils of Odisha are 44,19,2,1.6 and 0.65 for B, Zn, Cu, Fe and Mn respectively (AICRP on Micronutrients, OUAT, Bhubaneswar).

The deficiency of Micronutrients in soils of Odisha is due to –

Micronutrients deficiency status in Indian Soils
(based on 0.2 million soils samples collected using GPS during 2011-17)

Deficiency level	Zn	Fe	Mn	Cu	B	Mo
Deficient	36.5	12.8	7.1	4.2	23.2	0
Latent deficiency	14.7	6.4	10.3	3.2	21.5	2

Shukla et al., 2017

Global Micronutrients deficiency status
(based on 190 field trials across the world)

Deficiency level	Zn	Fe	Mn	Cu	B	Mo
Deficiency	25	0	1	4	10	3
Latent deficiency	24	3	9	10	21	12

Sillanppaa, 1990

-Inadequate application of organic manure

-Use of micronutrient free chemical fertilizers

-Comparatively more emphasis on major nutrients than micronutrients

-Soil related problems like: unfavourable pH, light texture, poor nutrient holding capacity etc.

To bridge the gap between crop demand and soil supply, micronutrients containing materials are to be added to soil. Organic sources are better options. Under the umbrella of organic farming micronutrient sources are –

- Natural rocks and minerals
- Soil amendments
- Organic sources

Natural rocks and minerals

These are primary source of plant nutrients. Upon disintegration and decomposition of these material micronutrients become plant available. These naturally occurring materials can be explored from lithosphere, grinded to smaller particles and applied to soil. A list of rocks and minerals containing micronutrient elements are given in below table.

List of Rocks and Minerals containing micronutrient elements

Micronutrient	Name of Rocks, Minerals
Iron	Hematite, Limonite, Goethite
Manganese	Manganite, Pyrolusite

copper	Cuprite, Chalcocite, Azurite
Zinc	Sphalerite, Smithonite, Hemimorphite
Boron	Borax, Tourmaline, Danburite
Molybdenum	Molybdenite, Powellite, Wulfenite
Chlorin	Halite, Silvite,Sodalite
Nickel	Olivine, Serpentine

Apart from rocks and minerals, some other sources are there which are considered as organic and allowed for organic farming are given in the table below-

Mineral Fertilizers in organic farming

Fertilizer	Origin	Characteristics	Application
Plant Ashes	Burned organic material	• Mineral composition similar to plants • Easy uptake of the minerals • Wood ashes rich in K and Ca	• To compost (best) • Around the base of the plants
Lime	Ground limestone, algae	• Buffers low pH (content of Ca and Mg secondary) • Algae: rich in trace elements	• Every two to three years when soil-pH is low (avoid excessive use: reduction of availability of P, more deficiencies of micro-nutrients)
Stone Powder	Pulverised rock	• Trace elements (depending on the composition of the source) • The finer the grinding the better the adsorbance.	• To farmyard manure (reduces volatilisation of N and encourages the rotting process)
Rock Phosphate	Pulverised rock containing P	• Easily adsorbed to soil-minerals • Weakly adsorbed to organic matter • Slow reaction	• To compost • Not to reddish soils (irreversible adsorbtion)

Soil amendments

Soil amendments make the edaphic condition congenial for micronutrient availability. Micronutrients are elements having their own physical and chemical properties. They become available under their favourable soil environment. Very often soil containing enough micronutrient fails to fulfil the crop need due to unfavourable condition. In light texture acid soil Boron is deficient. Similarly, in alkali soil Zn and Fe are unavailable. Hence, correction of adverse situation increases the availability of soil micronutrients. Some organic soil amendments are given below-

Organic sources

Organic sources of plant nutrients contain in less concentration of nutrients. But, as micronutrient requirement of crop is less application of adequate quantities of them will suffice the crop demand. Some of them are compost, green manures, crop residue, night soil, city waste, biofertilizers and vermicompost etc. the general nutrient contain of some organic manures are given in below table-

Micronutrient content of Organics (mg/kg)

	Fe	Zn	Mn	Cu	B	Mo
1. FYM	1788	34	137	2.5	4.6	2.1 2
2. Poultry Manure	1400	90	210	7.1	5.0	3.1 4
3. Rural compost	3600	85	200	14	10.0	2.0 5
4. City compost	7000	400	560	150	15.0	9.0 6
5. Vermi compost	4500	40	70	3	30	5

Orissa Review * April - 2006 Dr. S.K. Sahu Dr. P.K. Samant

Conclusion

Organic source for nutrient supply is a boon for crop, soil and environment. Micronutrient need of crop can be fulfilled by different organic sources and soil amendment. Location specific low cost, easily available and farmers' friendly organic sources should be identified, processed and used. Miles to go for organic farming, butour collective efforts can make an organic farming a grand success.

Crop Management in Organic Farming

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The environmental problems increased due to excessive, injudicious, imbalanced use of synthetic chemical fertilizers and pesticides in crop production became a matter of concern with modern farming, even though modern farming was able to feed growing population of the country. Intensive agricultural practices like use of high yielding, hybrid high nutrient responsive crop varieties, their succulence nature, quick growing habits, susceptibility to diseases and pests not only demanded higher inputs use (fertilizers and plant protection chemicals) but also high financial involvement. During last four decades there was tremendous pressure on natural renewable resources and environment, which compailed for search for "**alternate agriculture**."

The International Federation for Organic Agriculture Movement (IFOAM) was initiated in France with five members during 5th November 1972. Thereafter from Atlanta Conference of 1981 on "**Organic Farming**" have acted as catalyst in triggering interest in organic agricultural system across the world. The "**Organic Farming**" is defined as production system which avoids or excludes the use of synthetic fertilizers, growth regulators, pesticides and livestock additives. It depends upon (i) **crop rotation**, (ii) **use of crop residues**, (iii) **use of animal manures**, (iv) **legumes**, (v) **green manures**, (vi) **off farm organic wastes**, (vii) **biofertilizers-** the biological sources of nutrients and (viii) **biopesticides.** "Organic Farming" works in harmony with the nature, rather than against it. It involves use of techniques to achieve good crop yields without harming the natural environment or the people who live and work on it.

The expectations from "Organic Farming" are:

(i) Stabilization as well as increase in agricultural production in a sustainable manner

(ii) At all cost natural balance need to be maintained for proper existence of life

(iii) The use of non-renewable inputs should be replaced by renewable ones and

(iv) The cost involvement in organic farming should be small so that it will be affordable and acceptable for all category of farmers.

Important characteristics of "Organic Farming" include

(i) The long term protection of soil fertility by maintaining organic level.

(ii) Improving the biological activity in soil.

(iii) Careful and selective intervention of mechanization.

(iv) Nutrients supplementation from relatively insoluble or less soluble sources through microbial action.

(v) Managing N requirement through use of legumes fixing N_2 biologically, animal manures and proper crop residue incorporation.

(vi) Managing weeds, diseases and pests in integrated way.

Integrated approaches for crop management

a) Weeds are managed by adoption of crop rotation, cover cropping, optimum management of nutrients, timely cultivation of land and mulching.

b) Cover cropping with legumes prevent soil erosion, add organic matter, fix atmospheric N_2, utilize surplus N and suppress weeds.

c) Cycling of resources become possible with cover crops and green manure crops, use of animal manure sources, farm residues, growing of deep rooted crops followed by sallow rooted crops. Use of slow release sources of nutrients prevent nutrient loss through runoff and erosion losses in soil.

d) The ecological balance become possible for maintaining a healthy living soil by providing enough of N, P, K and S but not too much of these nutrients. The micronutrients and secondary nutrients requirement are managed by opting of crop residues cycling, use of FYM, vermicompost, city compost and green manuring. Use of cultural and biological pest control measures keep ecological balance. In extreme cases, less toxic or pesticides with low residual toxicity maybe used.

Inputs for nutrient supplementation

The FYM, vermicompost, city compost, rural compost, enriched compost, fortified compost, ash, dhaincha, sunhemp, cowpea glaricidia leaf manure, thornless mimosa, azolla (for rice) BGA (for rice), *Rhizobium*, *Azotobacter*, *Azospirillum*, phosphorus solubilizing micro-organisms, mycorrhizae, *Trichoderma* (decomposer), crop residues, oil cakes specifically of plant origin.

Realities

Case 1: Use of organic manures (FYM/VC/compost @ 5-10 t ha^{-1}) with cowpea seed inoculation of *Rhizobium* and soil applied with 6 kg PSB ha^{-1} produced 28 per cent higher fresh pod yield over no inoculation (pod yield of 3200 kg ha^{-1}). The biomass generated and nutrient recycling after incorporation of cowpea green stover as green manure crop restored the soil fertility by enriching organic carbon status and add other nutrients.

Case 2: Seed inoculation of green gram with *Rhizobium* and application of arbuscular mycorrhizae (AM) @ 15 kg ha^{-1} solid base inoculum (40 spores per gram) could double(670kg/ha) the seed yield from 330 kg ha^{-1}, due to no inoculation at Nayagarh, Odisha over and above FYM application of 3 t ha^{-1} as basal .

Case 3: At Gajamara village of Dhenkanal, combined inoculation of okra crop with *Azotobacter* and *Azospirillum* @ 4 kg each (8 kg ha^{-1}) to 200 kg vermicompost/FYM, incubating for 7 days at 30 per cent moisture (increase the microbial population 15-20 times) and applied as basal, increased the fruit yield from 4400 kg ha^{-1} due to no inoculation to 6100 kg ha^{-1} (41 % increase) over and above application of 5 t FYM ha^{-1}.

Case 4: In tribal village Majhisahi of Dhenkanal, liming of acid soil (pH < 5.5) @ 0.2 LR, FYM application @ 5 t ha^{-1} mixed with *Azotobacter, Azospirillum* and PSM @ 4 kg each ha^{-1} (12kg/ha) resulted in okra fruit yield of 6800 kg ha^{-1} against the yield of 3800 kg ha^{-1} without any input.

Case 5: Growing of raddish with the use of consortia biofertilizer (*Azotobacter* + *Azospirillum* + PSM, 1:1:1 ratio, 4 kg each ha^{-1} inoculated to 25 times (5 %) limed vermicompost) yielded tuber yield of 20.5 t ha^{-1} against 16.8 t ha^{-1} without any external input.

Case 6: Growing of elephant foot yam (cv. Gagendra), tomato (cv BT-10), carrot, cucumber with consortia biofertilizer (*Azotobacter, Azospirillum* and PSM in 1:1:1 ratio @ 4 kg each ha^{-1} inoculated to limed (5 %) FYM in 1:25 ratio as basal, yielded 43, 15, 87, and 6 per cent higher economic yields compared to the yields of 10.4, 16.5, 6.75 and 3.96 t ha^{-1} without any external source of nutrients at tribal village Majhisahi of Dhenkanal district.

Inoculation of bean (Trailing type) seeds with *Rhizobium* and soil application of 6 kg PSM ha^{-1} yielded 7.60 t ha^{-1} against 6.52 t ha^{-1} without any external source of nutrient in the same village.

Case 7: (Spices crop turmeric) : Rhizome yield of turmeric at Koraput district with biofertilizers use (*Azotobacter* + *Azospirillum* :: 1:1 @ 5 kg each ha^{-1} (10 kg ha^{-1}) with leaf litter 10 t ha^{-1} yielded 30.4 t ha^{-1} with curcumin content of 4.8 per cent against the rhizome yield of 26.9 t ha^{-1} with curcumin content of 4.36 per cent with only leaf litters of 10 t ha^{-1} as mulching.

Case 8: (Spices crop turmeric) : The rhizome yield of turmeric in Kandhamal district with FYM @ 20 t ha^{-1} and FYM (10 t ha^{-1}) + *Azospirillum* @ 10 kg ha^{-1} were 4.8 and 5.7 t ha^{-1} (dry) respectively against 4.1 t ha^{-1} without any external source of input.

Case 9: (Spices crop – turmeric) : In Kandhamal district (Kurupadi, Katargada, Badalbari and Pradhanpada villages) three package of practices namely (i) Farmers practice (using leaf litter only), (ii) organic-1 (using neem oil cake 50 kg ha^{-1} with leaf litter mulching + FYM 2 t ha^{-1}) and (iii) organic-2 (neem oil case 50 kg ha^{-1} + leaf litter + FYM 2 t ha^{-1} + consortia Biofertilizers (*Azotobacter* + *Azospirillum* + PSB :: 1:1 @ 12 kg ha^{-1}) were tested for growing of turmeric (cv. Roma) crop. Tribal farmers growing turmeric using leaf litter, organic package-1 yielded 20 per cent and 28 per cent extra yields (fresh and dry) respectively over farmers practice. Organic package-2 including use of biofertilizers yielded more and the rupee earned per rupee invest came to 4.80 against Rs.440 with organic-1 and Rs.3.6 with farmers practice (Table 1).

Table 1. Rhizome yield of turmeric with organic packages

Sl. No.	Package of practices	Rhizome yield (t ha^{-1})		Yield advantage (t ha^{-1})		Rupee earned per rupee invest
		Fresh	Dry	Fresh	Dry	
1	Leaf litter (FP)	19.0	4.94	-	-	3.60
2	Organic-1	22.8 (20)*	6.30 (38	3.8	1.36	4.40
3	Organic-2	23.9(26)	6.80 (38)	4.9	1.86	4.80

*Data in the parenthesis indicate per cent increase over FP.
Sale price of dry turmeric Rs. 30,000/tone

Case 10: (Traditional potato- Kandhamal): The tuber yield of local traditional potato at Kandhamal, yielded 18 per cent higher yield with organic package compared to local practice of using FYM and leaf litter compost @ 2 t ha^{-1} each yielding 12.2 t ha^{-1} (Table 2) with extra income of Rs. 22,000 ha^{-1}.

Table 2. Improving yield potential of traditional local potato of Kandhamal district using organics

Sl. No.	Package of practices	Tuber yield (t ha^{-1})	Response (%)	Extra income (Rs.)
1	Leaf litter compost (2 t ha^{-1}) + FYM @ 2 t ha^{-1})	12.2	-	-
2	Leaf litter compost + FYM + neem oil cake (50 kg h^{-1-} + consortia BFs (12 kg ha^{-1})	14.4	18	22000.00

Case 11: (Cashewnut crop – 5 years of establishment): The nut yield of 5 years old cashew nut crop under lateritic soils of Bhubaneswar yielded almost double the yield with full dose of inorganic N (400 g N/plant/year) compared to no N yield of 1.35 kg/plant. Full N through coir compost yielded 11 per cent less, with poultry manure 8 per cent less, with *Azospirillum* + 50 per cent N through coir compost, 19 per cent less compared to full inorganic N yield of 2.6 kg nut/plant/year. Integrated packages comprising of 75 % inorganic + 25 per cent organic sources yielded significantly higher nut yields (Table 3).

Table 3. Nitrogen management in cashew nut crop

Sl. No.	Package of practices	Nut yield (kg/plant/year)	Response (%)
1	Control (No N)	1.35	-48*
2	Full N (inorganic)	2.60	-
3	Full N (Poultry manure)	2.40	-8
4	Full N (coir compost)	2.32	-11
5	Azospirillum + 50 % N (coir compost)	2.20	-15
6	Azotobacter + 50 % N (coir compost)	2.11	-19
7	75 % inorganic +25 % PM	3.12	+20
8	75 % inorganic N + 25 % CC	3.05	
	LSD (P = 0.05)	0.34	

*Data in the parenthesis indicate decrease (-) or (+) increase compared to full dose of inorganic N.

Case 12: System of rice Intensification (SRI): Four package of practices namely: (i) conventional, (ii) SRI with organic sources of nutrients, (iii) SRI – with inorganic sources of nutrients and (iv) SRI with integrated sources of nutrients were compared at Achyutpur village of Puri district, under Gop block. The cv. Swarna with integrated sources of nutrients yielded significantly higher than both the organics and inorganic sources (Table 4). Not only the grain but also tiller number/hill, effective tiller/hill, grains/panicle differed significantly (Table 4).

Table 4: Performance of rice cv. Swarna with organic, inorganic and integrated sources of nutrients at Achyutpur, Gop, Puri district

Sl. No.	Practices	Tiller /hill	Effective tiller/hill	Grains/ panicle	Grain (t ha^{-1})	Chaff (kg ha^{-1})
1	Conventional	26	13	140	3.99	41
2	Organic 0 SRI	28	21	165	5.11	44
3	Inorganic –SRI	35	23	176	5.32	42
4	Integrated-SRI	39	30	188	5.94	33
	LSD (P = 0.05)	2.1	1.7	8.8	0.32	1.8

Case 13: (Maize crop) : In order to study the right combination of both organic and inorganic sources of N for maize yield optimization , an experiment was conducted at Bhubaneswar, where the different combinations namely (i)):100, (ii) 25:75, (iii) 50:50, (iv) 75 : 25, (v) 100:0 and (vi) 0:0 were tested. The fresh crop yield of maize with 25 (organic-N): 75 (inorganic) combination yielded highest 12,640 kg ha^{-1} and 100 (organic-N):0 inorganic-N yielded 9700 kg ha^{-1}, 0 inorganic 23 per cent less than potential yield (Table 5).

Table 5 Cob yield of maize as influenced by different integrated combinations for supply of 100 kg ha^{-1}

Sl.No.	Organic:Inorganic N-combination	Cob yield (kg ha^{-1})	RAE (%)
1	0 : 100	11940	100
2	25:75	12640	113
3	50:50	11800	95
4	75:25	10700	77
5	100:0	9700	58
6	0:0	6500	-
	LSD(P = 0.05	230	-
	CV (%)	12	

The results of case studies (1 year, 3 years and 5 years) conducted over last ten years in the state indicated that managing the crops for lower yield targets can be possible with the organic sources. For cereals like rice, maize and plantation crops like cashewnut crop, integrated sources performed better than others. Only organic sources of nutrients will be better for spices crops like turmeric, zinger. It is better to declare the organic districts to produce specific crops like turmeric, zinger, pineapple, scented rice etc. in the state. The government should be in a position to purchase the entire produce with remunerative price to encourage the organic growers in the state.

Soil health build up as the prime need in organic management and conversion to organic with soil health management

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Introduction

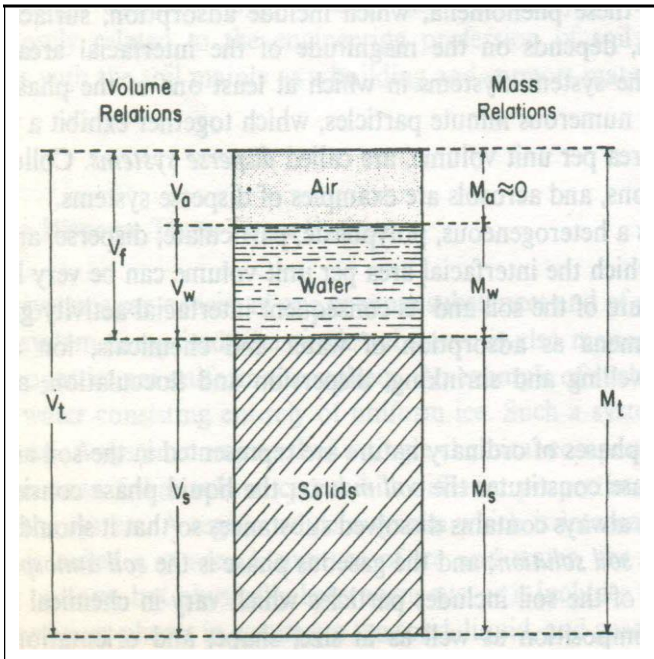
Soil is not a mere four-letter word but represents a whole system to live on. Anything required to live other than light is provided by the soil. Mechanical support to stand on; heat to maintain environmental temperature, air to provide oxygen, water for moisture and nutrients for food all these essential factors are driven by soil. Soil is a medium that is used to convert solar energy to chemical energy in an organic or natural way. Healthy soil is that soil which can supply all these materials adequately to living organisms for their optimum growth. A better understanding about the composition of soil helps us to identify the limitations and maintain its health properly through various management practices.

Soil is a three-phase system consisting of solid, liquid and gaseous state of matter. The solid phase is composed of (i) mineral matter derived from the weathering and breakdown of parent rocks as influenced by the various processes of soil formation and (ii) the organic components resulting from the accumulation and decomposition of plant animal residues. In addition, an arable (cultivable) soil contains innumerable living organisms, both macro and micro of plant and animal life, the most active and numerous among them being the microorganisms. The solids occupy nearly one-half of the soil volume and make up the major portion of soil mass. The liquid phase is constituted of water with small amounts of dissolved solids (mainly the soluble salts) in it. The gaseous phase, as compared to atmospheric air is relatively richer in carbon dioxide, due to respiration of soil microbes and plant roots. These phases are not physically separable but are intermixed in such a way that the solid particles are interspersed with pore spaces and capillaries which are filled with air and water. The space occupied by air and water together constitutes about 50 per cent of the soil volume and the two bear more or less an inverse relationship between them. As the volume of water in a soil mass increases due to rain or irrigation that of air decreases accordingly. The reverse is true when water is removed by drainage, evaporation and or transpiration of plants.

Soils vary considerably in their physical and chemical properties because of the nature, composition, distribution and orientation of soil constituents. These result from differences in weathering, mineralogical composition of parent rocks, vegetation, organic matter, activity of soil organisms, and climatic conditions. Various soil physical properties such as texture, structure, bulk density, porosity, water retentivity and water movement are determined by the relative proportion of soil particles of varying sizes (sand, silt and clay), nature and their arrangement. All arable soils contain variable amounts of organic matter formed from the decomposition of plant and animal residues, which constitutes an integral part of the soil and is known as humus. Humus and clay are very small sized particles in the range of colloidal dimensions. These exhibit colloidal properties and largely contribute to the physico-chemical behaviour and nutrient status of the soil.

Physical Properties

Bulk density, particle density, pore space, mass and volume wetness are some of the important physical characteristics of soil that governs the movement of water and nutrients in soil. For a better understanding of these characteristics, a schematic diagram along with derivatives is presented in fig 1. The bulk density (also known as apparent density) is defined as the mass per unit volume, which includes volume (space), occupied by solids as well as pore spaces. Particle density refers to the actual density of soil solids. It is defined as the mass per unit volume of soil solids only. Since the volume is exclusive of pore space, the value of particle density is higher than that of bulk density. Pore space refers to the portion of soil volume not occupied by the solid particles. It is filled with air, water or both. The amount of pore space in a soil is expressed as a percentage of the total volume. Similarly mass wetness, volume wetness, degree saturation, air filled porosity and void ratio are expressed. (Fig 1.)



Parameters	Derivatives	Unit
Particle Density (ρ_s)	M_s/V_s	Mg/m^3 (g/cm^3)
Bulk density (ρ_b)	M_s/V_t	Mg/m^3 (g/cm^3)
Porosity (f)	V_f/V_t	%
Void ratio (e)	$V_f/(V_t-V_f)$	-
Mass wetness (w)	M_w/M_s	%
Volume wetness (Θ)	V_w/V_t	%
Degree saturation (s)	V_w/V_f	%
Air filled porosity (f_a)	V_a/V_t	%

Fig 1. Schematic diagram of soil as a three phase system (Source Hillel 2004)

The bulk density is influenced by a variety of factors such as particle size and distribution, pore space, organic matter content, depth of soil and mechanical manipulation (tillage, ploughing, compaction, etc.). Increase in clay and organic matter content decreases the bulk density. The bulk density of the soil generally increases with depth, which is due to low organic matter content and compaction resulting from over-burden pressure. The particle density of most soils ranges between the narrow limits of 2.50 to 2.75 *g]* cc with an average value around 2.60 g/ cc. This is because most mineral particles are quartz, feldspars and other silicates whose densities also vary within the same limits. However, particle density of the soil may differ from the usual range due to presence of large amounts of organic matter and heavy minerals such as magnetite, garnet, epidote, zircon, etc. Unlike bulk density, particle density of a soil is not altered by mechanical manipulation.

Several important soil and plant processes such as retention and movement of water in soil, gas exchange between the soil and the atmosphere, solute movement and proliferation and penetration of roots depend on the amount and size distribution of pores. In general, two types of pores-micro (capillary pores) and macro pores (non-capillary pores) are recognised.

Generally, the micro pores hold water while air is held in macro pores. In order to maintain a favourable air-water relationship for plant growth, there should not only be sufficient total pore space but also a proper balance between the two kinds of pores. In an ideal soil, total pore space should be more or less equally distributed between two types of pores.

The total porosity of a medium (loamy) textured soil varies in the neighbourhood of 50 per cent. Sandy soils usually have lower porosity while clay and organic matter rich soils have higher values. Subsoils which are generally compacted have less pore space than the surface soils. In a coarse textured (sandy) soil, the proportion of macro pores is greater whereas in a fine textured (clay rich) soil the proportion of micro pores is greater. Compaction of a coarse textured soil reduces the total porosity but increases the proportion of micro pores. Since total porosity is estimated from bulk density of a soil, factors such as texture, structure, organic matter content and cultivation, influencing the latter, also affect the total porosity.

Texture

It indicates fineness or coarseness of the soil depending upon the relative proportion of the solid particles (sand, silt, clay) of varying sizes. The soil mineral particles which result from weathering of rocks vary greatly in size and shape. These are classified into gravel, sand, silt and clay on the basis of their size Gravels range from pebbles to particles of 0.20 cm and above. The various size groups (primary particles) are termed as soil separates. The general characteristics of the soil separates are presented in table 1.

The textural class of a soil can be determined with the help of the Triangle Diagram, if percentages of any two of the three primary particles (sand, silt and clay) are available. If a soil has equitable distribution of coarser and finer particles, it is known as a loam. According to United States Department of Agriculture (USDA) system, proportion of primary particles in various textural classes are given in table. The 12 textural classes may be regrouped, based on the relative ease of draught required to pull tillage equipment especially the plough. Please note that these terms are not related to particle or bulk density.

Table 1. Characteristics of soil separates as proposed by Atterberg.

Soil	Diameter (mm)*	Feel of Separate	*Composition*
Coarse sand	2.00-0.20	Very gritty	Primary minerals
Fine sand	0.20-0.02	Gritty	-do-
Silt	0.02-0.002	Flour like	Primary and secondary minerals
Clay	<0.002	Very smooth	Mostly secondary minerals

Textural name	**Ranges per cent**			
	Sand	**Silt**	**Clay**	**Group**
Sand	85-100	0-15	0-10	Light
. Loamy sand	70-90	0-30	0-15	Light
Sandy loam	43-80	0-50	0-20	Medium
Loam	23-52	28-50	7-27	Medium
Silt loam	0-50	50-88	0-27	Medium
Silt	0-20	80-100	0-12	Medium
Sandy clay loam	45-80	0-28	20-35	Medium
Clay loam	20-45	15-53	27-40	Medium

Silty clay loam	0-20	40-73	27-40	Medium
Sandy clay	45-65	0-20	35-45	Heavy
Silty clay	0-20	40-60	40-60	Heavy
Clay	0-45	6-40	40-100	Heavy

Plant available water

Water is held in soil on solid particle surfaces by adhesion and in the pores by matric forces. The forces of adhesion and cohesion (between water molecules themselves) are at a maximum near the particle surface and become negligible at a distance of about 0.06 mm. Hence, water molecules farther than 0.06 mm from the particle surface move freely without any tension through the soil towards downward direction because of gravitational force. Some quantity of water is held very tightly (at a high tension) in the micropores is almost immobile. This is called hygroscopic water. Therefore, the soil moisture can be classified as, hygroscopic water, capillary water (held less tightly in micropores) and gravitational water (free moving). This divides the soil moisture content into two classes namely water which is available to plants and that which is unavailable. Gravitational water, hygroscopic and part of the capillary water are not available to plants and the water actually available to plants is confined to relatively narrow range of soil moisture which at the wet end is field capacity and at the dry end is delineated by wilting point, corresponding to 1/3 bar and 15 bar (or atmosphere) moisture tension, respectively (Fig 2) . Whereas field capacity gives an indication of the potential supply of water to plants, wilting point indicates the stage at which plants show evidence of permanent wilting (not restorable by supplying water) due to severe lack of moisture. Irrigations are normally scheduled to maintain soil water contents in the range between field capacity and permanent wilting point

Sandy soils with high proportion of macropores have low water retention capacity and would need frequent irrigation for raising good crops. Heavy irrigation will be a wasteful practice. Medium textured or loamy soils retain more moisture as the fine clay and silt in these soils are usually aggregated, water enters readily through the macropores between the coarser particles and the aggregates and is retained in micropores within the aggregates. Clay soils have high proportion of micro pores and a large surface area. Hence, these soils can hold maximum amount of water. However, they are often not well aggregated and so water infiltrates very slowly (Fig 3). Run-off losses of water result even under normal rainfall condition and more so when there is a slope. The available moisture content in different textured soils are presented in table 2.

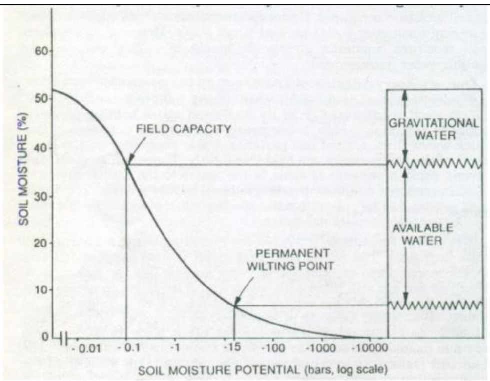


Fig 2. Soil moisture curve of a loamy soil

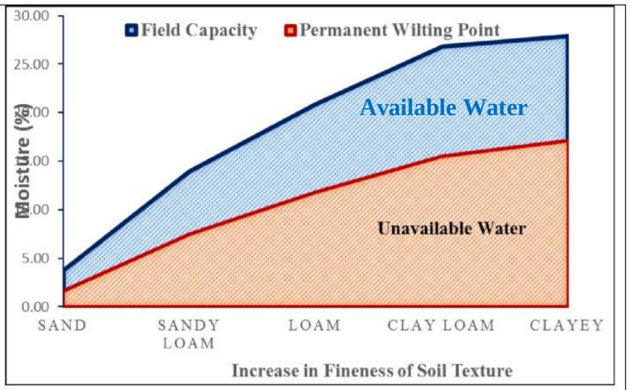
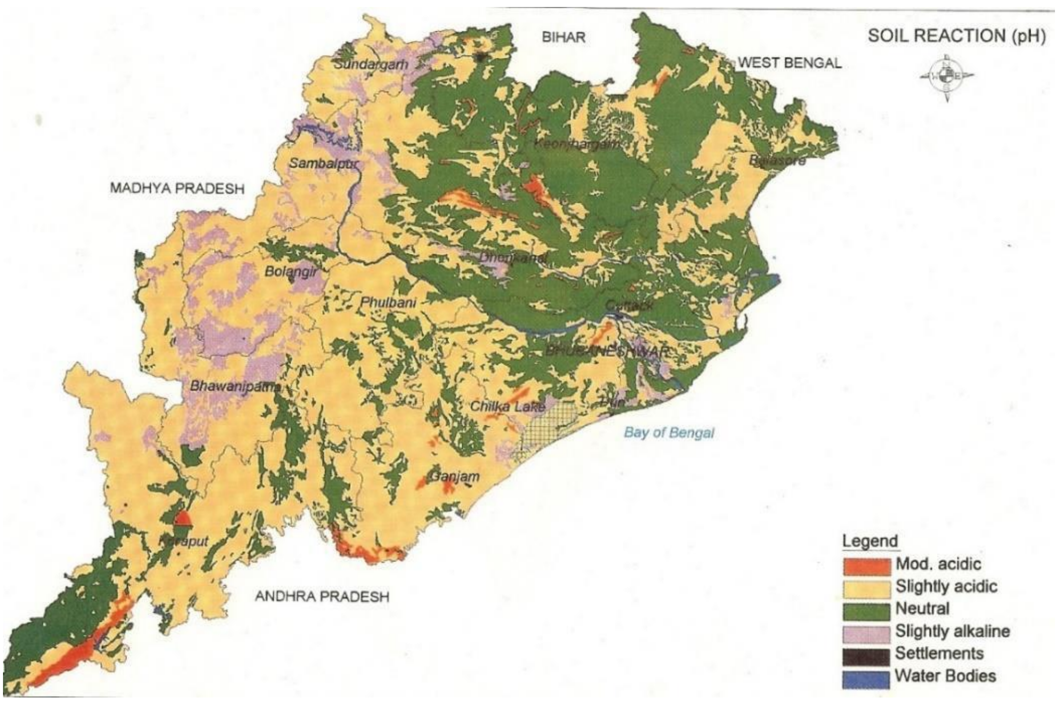


Fig 3. Texture and soil moisture constants

Figures in parenthesis are ranges

Table 2. Soil moisture constants and available water ranges of different soils

Soil Texture	Field Capacity		Permanent wilting point		Available moisture	
	(%)	cm/m	(%)	cm/m	(%)	cm/m
Sandy	9 (6-12)	15 (10-20)	4 (2-6)	7 (3-10)	5 (4-6)	8 (7-10)
Sandy Loam	14 (10-18)	21 (14-27)	6 (4-8)	9 (6-12)	8 (6-10)	12 (9-15)
Loam	22 (18-26)	31(25-36)	10 (8-12)	14 (11-13)	12 (10-14)	17 (14-19)
Clay Loam	27 (23-31)	36 (30-43)	13 (11-15)	18 (14-21)	14 (12-16)	19 (17-22)
Silty Loam	31 (27-35)	40 (34-46)	15 (13-17)	20 (16-23)	16 (14-18)	21 (18-23)
Clay	35 (31-39)	44 (37-50)	17 (15-19)	21 (18-25)	18 (16-20)	23 (19-26)



Source NBSS &LUP, Nagpur

The Essential Elements

Starting with the work of Liebig and other nineteenth-century research has shown that certain elements are essential for plant growth and that each element must be present in a specific concentration range for optimum plant growth (Fig 4). If the concentration of a given element in the plant root zone is too low, a deficiency of that element occurs and plant growth is restricted. Likewise, if the root zone concentration of that element is too high, toxicity occurs and plant growth is similarly limited. Only in a specific middle range of concentration is optimum plant growth attained. One of the principal objectives of soil management is to maintain concentrations of each essential element in this middle range. Some seventeen elements have been found to be universally essential for plant growth. Three of them viz., carbon, hydrogen and oxygen come from air, water, and fourteen from soil solids. Six of the fourteen viz., nitrogen, phosphorus, potassium, calcium, magnesium, sulphur are used in relatively large amounts and are called macronutrients, while the other eight, viz., iron, manganese, boron, molybdenum, copper, zinc, chlorine and cobalt are needed in only very small amounts, are called micronutrients. Even though the micronutrients are just as essential for plant growth as the macronutrients, they are required in such small quantities that most soils are able to provide them in sufficient quantities for normal plant growth. Other minor elements, such as sodium, fluorine, iodine, silicon, strontium, and barium, do not seem to be universally essential, although the soluble compounds of some will increase the growth of specific plants.

When these nutrients are deficient in soil it gets reflected as deficiency symptoms in plants (Fig 5) and accordingly application of deficient nutrients optimized crop growth.

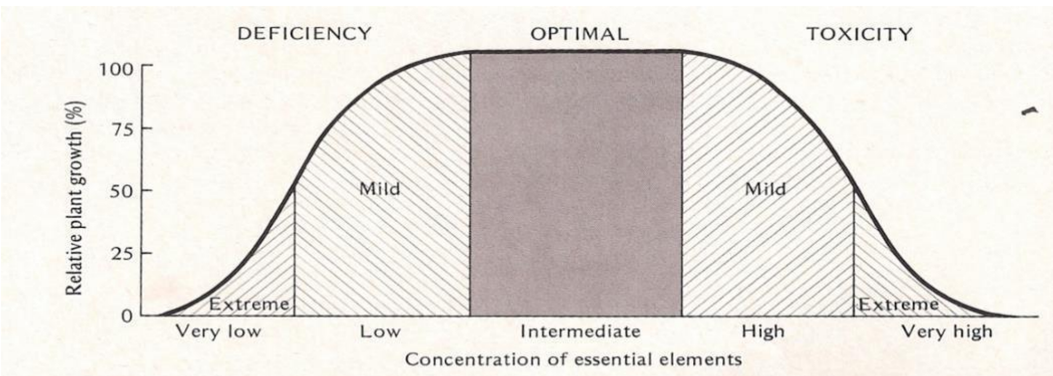


Fig 4. Specific concentration range of elements for optimum plant growth

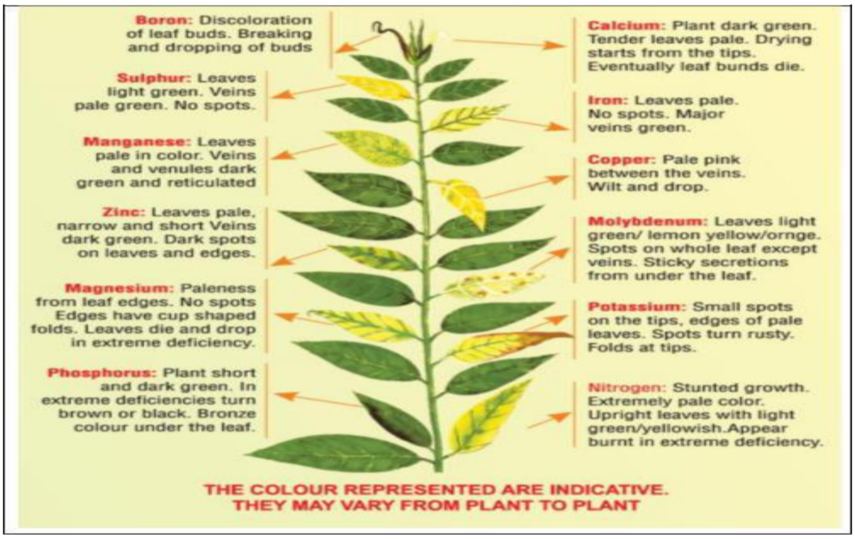


Fig 5. Deficient symptoms in plants

Supplementary additions through fertilizers provide nitrogen, phosphorus, and potassium, and to a lesser degree, sulfur. Limestone is usually applied to help supplement the system's needs for calcium and magnesium.

Soil health management

Most of the soils in India are associated with physical or chemical constraints with limited nutrient retention capacity and availability, soil acidity, salinity and alkalinity. Nitrogen and phosphorus are the most serious limiting factors for cereals and food legumes, Deficiencies of potassium in root crops, sulfur and zinc in maize, and boron in cotton and groundnuts have been reported in continuously cultivated fields, which have few or no inputs of crop residues or animal manure. Furthermore, aluminum toxicity and related calcium, magnesium and phosphorus deficiency also limit the growth and yield of cereals and legumes in acid soils in both humid and semiarid regions. To feed the burgeoning population of the country intensive cultivation caused significant decline in soil pH and exchangeable Ca and Mg levels. This is even more pronounced with injudicious use of acidifying fertilizers. Cultivated highly-weathered soils commonly suffer from multiple nutrient deficiencies, and nutrient imbalances. External nutrient inputs are essential to improve and sustain crop production on these soils. Nutrient inputs like crop residues, green manure, lime and animal manure are organic sources, which can be effectively used for organic farming. Besides native population of nitrogen fixing and phosphorous solubilizing and organic matter decomposing microbes can be enhanced or maintained through inoculation.

The decline of crop yields under continuous cultivation has been attributed to factors such as acidification, soil compaction and loss of soil organic matter. Thus, application of organic materials is needed, not only to replenish soil nutrients but also to improve the physical, chemical, and biological properties of soil. To a large extent, this may be achieved by managing the agroecosystem in such a way that nutrient sources are generated, recycled and maintained. Organic farming needs proper planning and understanding so that physical, chemical and biological condition of soil can be maintained well. Suitable site specific technologies like tillage, appropriate cropping systems, mulching, organic manures suitable amendments and land modifications improves soil health.

Tillage Practices

Tillage practices change the physical, chemical and biological environment of soil. These in turn, influence crop growth and yield and thereby, the input use efficiency of crops. Loosening of soil decreases and its compaction increases the Bulk Density. No tillage generally increases the bulk density of the surface soil layer. Tillage not only helps conserve moisture in the profile but also is carrying over the moisture towards the seed zone. Shallow tillage at tillable wetness after rain/irrigation reduces evaporation loss. Decrease in bulk density increases the amount of water held at higher water potentials and decreases it at low water potentials, which in turn, influence water availability. Water retention of a highly permeable sandy soil at field capacity can be increased by compaction and addition of clay.

Cropping System

Cropping systems affect Soil Organic Matter (SOM) content, which in turn strongly influences soil physical properties. The cropping systems that take land out of native vegetation reduces SOM. Changing tillage systems or crop rotations can enhance the accumulation of SOM. Organic manure additions increase water-holding capacity, porosity, hydraulic conductivity, infiltration capacity, and water-stable aggregates while decreasing bulk density and surface crusting. Under no-till dry land cropping systems, the bulk density decreased and total porosity and effective porosity increased for continuous cropping.

Mulching

Crop residues, plastic or paper on soil surface changes through soil physical environment, which in turn improves the soil physical health. Mulching reduces evaporation from soil surface by retarding the intensity of the radiation and wind velocity on mulched surface. Higher mulch rate retards the energy reaching the soil surface and hence limits the evaporation at the constant rate stage. The retardation of initial evaporation can also allow more water to mitigate into the deeper layers of the soil profile, where it is conserved longer and is less likely to be lost by evaporation.

Organic Manures

Combined use of fertilizer and FYM improved soil physical health indicators such as bulk density (BD), water stable aggregates (WSA), available soil moisture (ASM), hydraulic conductivity(HC), infiltration rate(IR).application of organic manures improves soil physical properties through addition of SOM. Plant biomass produced return of organic material to soil in the form of decaying roots, litter, leaf fall and crop residues. Increasing SOM content characteristically leads to a decrease in BD and surface crusting and increase in WHC, macroporosity, infiltration capacity, hydraulic conductivity and aggregation.

Problematic/Degraded Soils

In fine textured soils the threat of salinisation remains appreciable even when the water table remains several meters below the surface due to high capillary conductivity. For arresting active salinisation, it is necessary to restrict the rate of capillary rise to the surface. This can be achieved by discontinuing the pore system by tillage. Disc ploughing was found to be the most effective in arresting the salt rise and its accumulation in the surface soil obviously by breaking the capillary conductivity at greater depth and pulverizing soil into a granular mass which provided granular mulch on the surface. This was followed by mould board plough, rotavator, and tine cultivator.

Leaching is the key step for improving physical health of salt affected soils. Salinity in the root zone needs to be kept below 4dS/m for realizing good yields of most of the crops. Leaching of salt depends on type of soil, type and quantity of available water for leaching.

Amelioration of acid soils using different liming materials helps in improving the physical health of acid soil. Liming in furrows @500 kg/ha are recommended along with nitrogen fixing and phosphorous soluble biofertilizers for oilseed and pulses in moderately acid soils. Farm yard manure @ 5 & 10 t/ha along with nitrogen fixing biofertilizers were also recommended for maize, oilseed and pulses.

Conclusion

Organic farming is a closed system where outputs are recycled to inputs without any incorporation of off farm materials. Organic farming is a philosophy to be learnt an essence to be felt a knowledge to be imparted and a skill to be practised. Understanding the soil-water-plant-residue continuum in a better way is one of the basic need of practicing and converting to organic farming. Maintaining physical chemical and biological characteristics of soil as discussed above to deliver to its fullest will definitely build up soil health and produce crops organically.

Biofertilizer Consortia: A sustainable approach in Organic Farming

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Exponential rise in population coupled with industrialization and urbanization has demanded an increase in food productivity with a decreasing availability of cultivable land. Irrigation, crop rotation and fertilizer applications were introduced in agriculture after the Neolithic revolution with an objective to increase production for an increasing population. In Green Revolution-I, emphasis was given on application of agrochemicals and introduction of HYV which significantly increased productivity. But indiscriminate use of agrochemicals resulted in environmental hazards drastically affecting agro-ecosystem which is a major concern today. It is assumed that in the next couple of decades, it will be a significant challenge to feed all of the world's population. Presently the world population is 7 billion which is expected to reach 10 billion by the next 50 years. So, it is very important to increase the agricultural productivity within the next few decades vis-a-vis maintenance of agro-ecosystem.

Agriculture in developed and developing nations have undergone large change with application of fertilizer and various agrochemicals like pesticides, weedicides, herbicides etc. with a view to increase productivity. Population explosion coupled with industrialization and urbanization has demanded enhanced productivity of agriculture produces. In this regard, Green revolution I led by the Noble Laureate Norman Borlaug witnessed large increase in productivity with use of HYV and agrochemicals. In India, Prof. M.S. Swaminathan is considered as the father of Green Revolution-I. Introduction of HYV and application of agrochemicals allowed overcoming poor agriculture productivity, elevating India from the backdrop of food crisis to a food surplus country. Over a span of 40 years, not only India but also the developed countries are harvesting the negative impact of Green Revolution I. The residuals of agrochemicals applied in the crop fields drastically affected the soil health; in terms of nutrient availability, in terms of soil fertility & microbial diversity and in terms of increased pathogen attack on the photo-insensitive crops. Over the period, the microbial population of the soil has decreased drastically. In Northern states of India like Punjab and Haryana, which are otherwise called as the kitchen house of the country, the soil health has been drastically affected in terms of nutrient recycling, microbial diversity, nutrient availability and fail to grow crops without application of agrochemicals in the crop fields. Today scientists are emphasizing on Green revolution II, where organic farming is prioritized through soil amendment with organic manures and biofertilizers to increase productivity. Emphasis is being given to reduce application of fertilizer or agrochemicals in agriculture with reduce application of chemical fertilizers and other agrochemicals.

Importance of biofertilizer over chemical fertilizer

Agriculture and agricultural products are the major source of national income in many developing countries while ensuring employment and food security. In the era of sustainable agriculture, much attention has been given to organic farming because it not only ensures food safety, but also addresses to the maintenance of soil biodiversity. The main objective of organic farming is application of compost, biofertilizers, biopesticides, bioherbicides etc. Organic farming does not necessarily aims at complete replacement of the chemical fertilizer, but it can reduce/minimize the application of agrochemicals. It mainly comprises of the natural & amended soil microflora which consists of all kinds of microorganisms viz. useful bacteria, cyanobacteria and fungi including the Arbuscular Mycorrhiza Fungi (AMF) and Plant Growth Promoting Rhizobacteria (PGPR).

In recent years much attention has been focused on the use of bio-fertilizers as an important alternative source of plant nutrition. More over the additional advantages of bio-fertilizers includes longer shelf life and no adverse effects on the agro-ecosystem. Living formulations or latent cells of efficient micro-organisms like bacteria, algae or fungi mainly constitute bio-fertilizers and it can be variedly applied; either to the soil or on the seed surface or composting areas with the objective of increasing number of such microorganisms and accelerate microbial processes. Such living formulations augment the availability of nutrients in soluble form which plants can uptake. They are biologically active products, having the innate capacity to provide plants with nutrients through nitrogen fixation, phosphate solubilization, sulphur oxidisation, organic matter decomposition etc. It can also make ensure bio-fortification of crops with essential nutrients. Briefly, biofertilizers are called as bio-inoculants which on supply to plants improve their growth and productivity.

Types of Biofertilizer

Bio-fertilizers can be divided into different groups based on their nature and function as mentioned below.

Groups	Examples
Nitrogen fixing Bio-fertilizers	
Free-living	*Azotobacter, Clostridium, Anabaena, Nostoc*
Symbiotic	*Rhizobium, Frankia, Anabeana azollae*
Associative	*Azospirrillum*
Phosphate solubilizing Bio-fertilizers	
Bacteria	*Bacillus megaterium, Bacillus subtilis, Bacillus circulans, Psudomonas striata*
Fungi	*Penicillum* sp. *Aspergillus awamori*

Phosphate Mobilizing Bio-fertilizers	
Arbuscular mycorrihiza	*Glomus* sp., *Gigaspora*sp., *Aculospora*sp., *Scutellospora* sp. &*Sclerocystis* sp.
Ectomycorrhiza	*Laccaria* sp., *Pisolithus* sp., *Boletus* sp., *Amanita* sp.
Bio-fertilizers for Micronutrients	
Silicate and Zinc solubilizers	*Bacillus* sp.
Plant Growth Promoting Rhizobacteria	
Direct & indirect mechanism	Bacteria isolated from the rhizospheric region of soil showing various plant growth promoting traits

Formulation of Bio-fertilizers and mode of its application

Bio-fertilizer has been emphasized of having paramount importance in agriculture. The question remains is how to apply? Can there be any formulation of biofertilizer which can be transported and applied to crop fields? Biofertilizer can be applied in the crop fields by developing different formulations; either singly or in consortium. There can be two forms of biofertilizer formulations.

1. Carrier based formulation (CBBF)
2. Liquid based formulation (LBF)

Carrier Based Formulation

Bio-fertilizers are usually prepared as carrier-based inoculants containing effective microorganisms. Incorporation of microorganisms in carrier material enables easy-handling, long-term storage and high effectiveness of biofertilizers. Among various types of bio-fertilizers, bacterial inoculants are one major group which includes rhizobia, nitrogen-fixing rhizobacteria, plant growth-promoting rhizobacteria, phosphate-solubilizing bacteria etc. Basically, the carrier-based inoculants of these bacteria can be prepared by a common procedure. Various types of material like peat, vermiculite, lignite powder, clay, talc, rice bran, seed, rock phosphate pellet, charcoal, soil, paddy straw compost, wheat bran or a mixture of such materials are used as carrier for seed or soil inoculation. For preparation of seed inoculants, the carrier material is milled to fine powder with particle size of 10-40 µm. A good carrier material should be non-toxic in nature, good moisture absorption capacity and good buffering (pH) capacity.

The most common way of inoculation of carrier based biofertilizer is "seed inoculation", in which the inoculants (bacteria-carrier mixture) is mixed with water to make slurry-form, and then mixed with seeds. In this case, the carrier must be a form of fine powder. To achieve the tight coating of inoculant on seed surface, use of adhesive, such as gum arabic, methylethyl cellulose, sucrose solutions, and vegetable oils, is recommended. Any locally available sticky material, which is non-toxic to bacteria and seeds, can be used as adhesive. Seed inoculation may not always be successful because of low establishment of the inoculated bacterial strain. This might be due to low population and/or low survival of the inoculated bacterial strain on the seed surface and in the soil. In such case, "soil inoculation" is the method, where a large population of a bacterial strain can be introduced into the soil. For soil inoculation in general, granular inoculants is placed into the furrow under or alongside the seed. This enhances the chance for the inoculated strain to be in contact with plant roots.

Liquid Bio-fertilizer formulation

Liquid bio-fertilizer formulation is the promising and updated technology of the conventional carrier based production technology which enthuse many advantages over the carrier based formulations. Shelf life is the first and foremost problem of the carrier based bio-fertilizers which is up to 3-6 months and it does not retain throughout the crop cycle. Liquid based bio-fertilizer (LBF) on the other hand facilitates a longer survival (12 months) of the organism by providing the suitable medium, which is sufficient for the entire crop cycle. Carrier based bio-fertilizers are not so tolerant to the temperature which is mostly unpredictable and uncertain in the crop fields while temperature tolerance is the other advantage of the liquid bio-fertilizers. Moisture retaining capacity of the Carrier based bio-fertilizer (CBBF) is very low which does not allow the organism viable for longer period and the LBF facilitates the enhanced viability of the organism. Moreover, the administration of LBF in the fields is comparatively easier than CBBF. The other disadvantages of CBBF like poor cell protection and dosage controversy, limited scope of export, expensive package and transport, very slow adaptation by the farmer community are some of the strongest problems which are effectively being solved by the Liquid bio-fertilizers. Therefore, LBF are believed to be the best alternative for the conventional carrier based bio-fertilizers in the modern agriculture research community witnessing the enhanced crop yields, regaining soil health and sustainable global food production.

Liquid formulations like dormant aqueous suspensions or dormant oil suspension are sprayable propagules of the microbial agents suspended in suitable liquid medium or a consortium of microorganisms provided with suitable medium to keep up their viability for certain period which aids in enhancing the biological activity of the target site. Liquid bio-fertilizers are special liquid formulation containing not only the desired beneficial microorganisms and their biological secretions, but also special cell protectants or substances that encourage the formation of dormant spores or cysts for longer shelf life and tolerance to adverse conditions. Generally, they are using growth suppressants, contaminants suppressant like sodium azide, sodium benzoate, butanol, acetone, fungicides, and insecticides etc. for the long term viability. For example *Rhizobium* dormant liquid formulations when used after 8 months reduce the size of nodules and effect nitrogen fixation process. This is due to the need of long duration of activation time. In case of *Azospirillum*, *Azotobacter*, PSM, it is observed that these bacteria crossed extreme dormant stage. Therefore, when applied in crops they take prolonged reactivation time. This long time is not desirable for short duration crops. Resolving this disadvantage a new technique was adopted in liquid formulations process involving the arrest of bacteria without preservatives. So the liquid formulations of the beneficial organisms (LBFs) or bio-inoculants are the promising inputs which can effectively combat the present agro adverse scenario, resolving the low viability of the organisms, maximizing the efficacy of the inputs and satisfying the concept of cost-effectiveness.

Biofertilizer formulations and its use through micro-irrigation

There are two types of micro-irrigation;

1. Drip irrigation
2. Sprinkler irrigation

Drip irrigation

In drip system water is conveyed through a system of flexible pipe lines. Drip system reduces water requirement of the plant by maintaining minimum soil moisture. The components of the system are,

- A pump to lift water
- A head tank to store the water and maintain a pressure head of 5 to 7 m
- Central distribution system
- Mains and secondary lines
- Trickle lines
- Plastic nozzles

Both carriers based and liquid biofertilizer can be applied through drip irrigation. The formulation can be mixed with the water and can be released at the root of the plant which provides an ideal environment for growth of the organisms. However, the liquid based formulation can be better applied through drip irrigation as it does not contain any suspended solid material.

Sprinkler irrigation

Sprinkler irrigation is a method of applying irrigation water which is similar to rainfall. Pressurized irrigation through devices called sprinklers. Sprinklers are usually located on pipes called laterals. It is suitable for almost all field crops like Wheat, Gram, Pulses as well as Vegetables, Cotton, Soya bean, Tea, Coffee, and other fodder crops. Sprinklers are best suited to sandy soils with high infiltration rate than any other form of soil. Both the formulations can be mixed with the water and sprayed in the crop field through sprinklers. Liquid based formulation can be better applied through drip irrigation as it does not contain any suspended solid material. However, there is more chance of loss of potential organisms in sprinkler irrigation than the drip irrigation.

Quality control of biofertilisers and organic fertilisers as per FCO norms

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Introduction

The Fertiliser Control Order (FCO) came into the force in 1957 to regulate the sale, the price and the quality of fertilisers. The seventeenth edition of FCO was published with all the updated amendments up to January, 2018. From the organic farming point of view, three categories of fertilisers are utmost important (Fig. 1); hence, quality control parameters of all three are discussed herewith.

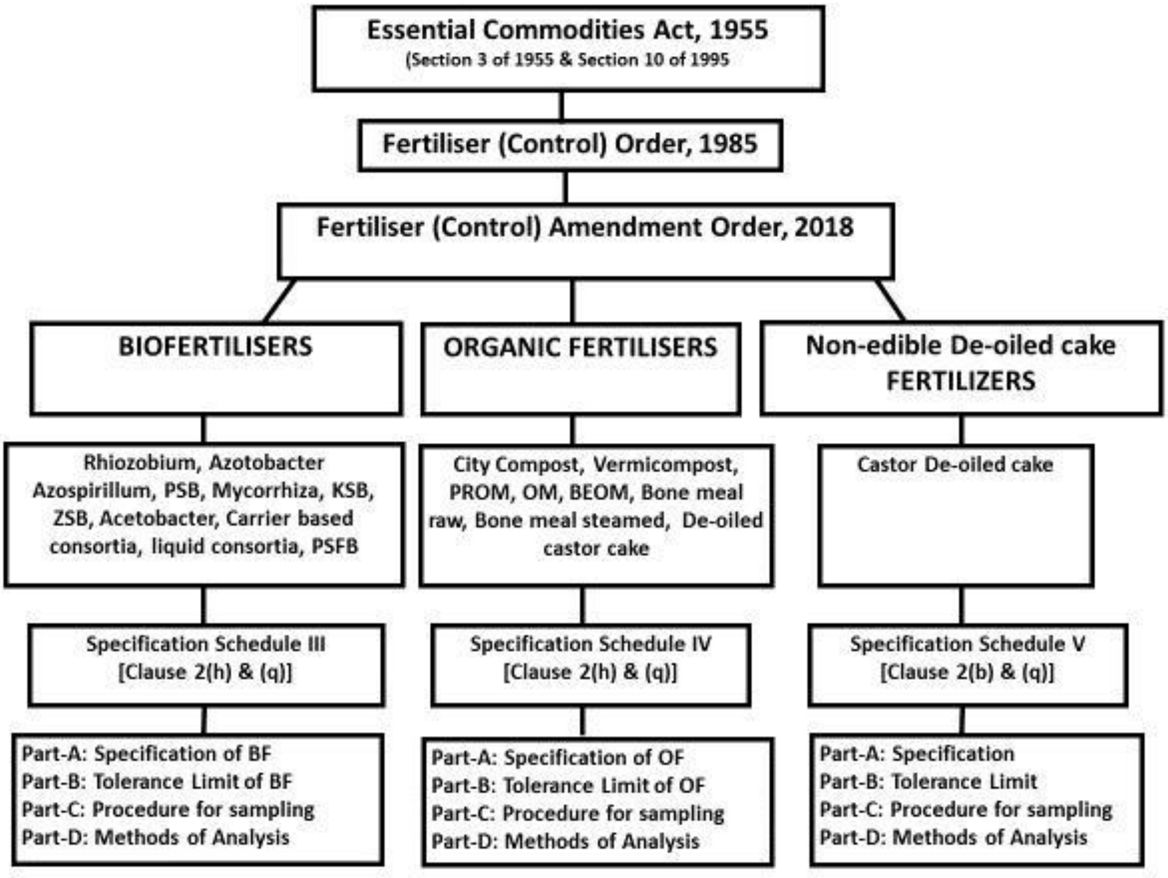

Fig. 1

Biofertilisers

As per Clause 2, sub-clause (aa) of FCO, 2006 "Biofertiliser" means the product containing carrier base (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.

Organic fertilisers

As per Clause 2, sub-clause (oo) of FCO "Organic Fertilisers" means substances made up of one or more unprocessed material(s) of a biological nature (plant/animal) and may include unprocessed mineral materials that have been altered through microbiological decomposition process.

Non-edible de-oiled cake fertilisers

As per Clause 2, sub-clause (nna) of FCO "Non-edible de-oiled cake fertiliser" means substance obtained as residue after oil extraction (by expeller and/or through solvent extraction) from crushed seeds of non-edible oilseeds (such as castor) for use in soil as fertiliser.

Notified testing laboratories for testing of Biofertilisers, Organic fertilisers and Non-edible de-oiled cake fertilisers

As per clause 2a, sub-clause (1) (1A) & (1B) samples of biofertilisers/ organic fertilisers are to be tested in following laboratories:

- National Centre of Organic Farming (NCOF), 19, Hapur Road, Near CBI Academy, Ghaziabad
- Regional Centre of Organic Farming (RCOF), Bhubaneswar, Bengaluru, Nagpur, Panchkula, Jabalpur, Imphal, Patna and Gandhinagar
- Or other notified State Laboratories

Quality control parameters of biofertilisers

In FCO, following eleven Biofertilizers are included:

- Rhizobium
- Azotobacter
- Azospirillum
- Phosphate Solubilising Bacteria (PSB)
- Mycorrhizal Biofertilisers
- Potassium Mobilising biofertiliers (KMB)
- Zinc Solubilising Biofertilisers (ZSB)
- Acetobacter
- Carrier based consortia
- Liquid Consortia
- Phosphate solubilizing fungal biofertilizer (PSFB)

The quality control parameters of each biofertiliser are mentioned in Table 1, 2, 3 and 4.

Table 1: Quality control parameters of Rhizobium, Azotobacter and Azospirillum

Specifications	Rhizobium	Azotobacter	Azospirillum
Base	Carrier based*or liquid based	Carrier based*or liquid based	Carrier based*or liquid based
Viable cell count	CFU minimum $5x10^7$ cell/g of carrier material or $1x10^8$ cell/ml of liquid material	CFU minimum $5x10^7$ cell/g of carrier material or $1x10^8$ cell/ml of liquid material	CFU minimum $5x10^7$ cell/g of carrier material or $1x10^8$ cell/ml of liquid material
Contamination level	No contamination at 10^{-5} dilution	No contamination at 10^{-5} dilution	No contamination at 10^{-5} dilution
pH	6.5-7.5	6.5-7.5	6.5-7.5
Particles size in case of carrier based material	All material shall pass through 0.15-0.212mm IS sieve	All material shall pass through 0.15-0.212mm IS sieve	All material shall pass through 0.15-0.212mm IS sieve
Moisture percent by weight, maximum in case of carrier based	30-40%	30-40%	30-40%
Efficiency character	Should show effective nodulation on all the species listed on the packet	The strain should be capable of fixing at least 10 mg of nitrogen per g of sucrose consumed	Formation of white pellicle in semisolid Nitrogen free bromothymol blue media

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

Table 2: Quality control parameters of PSB, KMB and ZSB

Specifications	PSB	KMB	ZSB
Base	Carrier based*or liquid based	Carrier based*or liquid based	Carrier based*or liquid based
Viable cell count	CFU minimum $5x10^7$ cell/g of carrier material or $1x10^8$ cell/ml of liquid material	CFU minimum $5x10^7$ cell/g of carrier material or $1x10^8$ cell/ml of liquid material	CFU minimum $5x10^7$ cell/g of carrier material or $1x10^8$ cell/ml of liquid material
Contamination level	No contamination at 10^{-5} dilution	No contamination at 10^{-5} dilution	No contamination at 10^{-5} dilution
pH	6.5-7.5for moist & dry powder granulated carrier based and 5.0-7.5 for liquid based	6.5-7.5for moist & dry powder granulated carrier based and 5.0-7.5 for liquid based	6.5-7.5for moist & dry powder granulated carrier based and 5.0-7.5 for liquid based
Particles size in	All material shall pass	All material shall pass	All material shall pass

case of carrier based material	through 0.15-0.212mm IS sieve	through 0.15-0.212mm IS sieve	through 0.15-0.212mm IS sieve
Moisture percent by weight, maximum in case of carrier based	30-40%	30-40%	30-40%
Efficiency character	The strain should have phosphate solubilizing capacity in the range of minimum 30% when tested spectrophotometrically. In terms of zone formation, minimum 5mm solubilization zone in prescribed media having at least 3mm thickness	Minimum 10mm solubilization zone in prescribed media having at least 3mm thickness	Minimum 10mm solubilization zone in prescribed media having at least 3mm thickness

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

Table 3: Quality control parameters of Acetobacter, Carrier based consortia and Liquid consortia

Specifications	Acetobacter	Carrier based consortia	Liquid consortia
Base	Carrier based*or liquid based	Carrier based*	liquid based
Viable cell count	CFU minimum $5x10^{7}$ cell/g of carrier material or $1x10^{8}$ cell/ml of liquid material.	CFU minimum in a mixture of any 2 or maximum three of following microorganisms:CFU minimum:Rhizobium or Azotobacter or Azospirillum: $1x10^{7}$/gPSB: $1x10^{7}$/gKSB: $1x10^{7}$/g	CFU minimum in a mixture of any 2 or maximum three of following microorganisms: CFU minimum: Rhizobium or Azotobacter or Azospirillum: $1x10^{8}$/ mL PSB: $1x10^{8}$/ mL KSB: $1x10^{8}$/ mL
Contamination level	No contamination at 10^{-5} dilution	No contamination at 10^{-4} dilution	No contamination at any dilution
pH	5.5-6.0 for moist & dry powder granulated carrier based and 3.5-6.0 for liquid based	-	5.0-7.0
Total viable count of all the biofertilizer	-	CFU minimum $5x10^{7}$/g of carrier/powder	CFU minimum $5x10^{8}$/mL of liquid based

organisms in the product			
Particles size in case of carrier based material	All material shall pass through 0.15-0.212mm IS sieve	All material shall pass through 0.15-0.212mm IS sieve	-
Moisture percent by weight, maximum in case of carrier based	30-40%	30-40%	-
Efficiency character	Formation of yellowish pellicle in semisolid medium N free medium	As mentioned for individual strains in Table 1, 2 and 3	As mentioned for individual strains in Table 1, 2 and 3

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

Table 4: Quality control parameters of Mycorrhizal biofertilisers and PSFB

Specifications	Mycorrhizal biofertilisers	PSFB
Base	Fine powder/ tablets/ granules/ root biomass mixed with growing substrate	Carrier based in form of moist powder or granules or liquid based
Particle size for carrier based powder	90% should pass through 250 micron IS sieve (60 BSS)	-
Spore count (per ml or gram)	-	Minimum $1x10^6$/ spores/g $1x10^7$ viable fungal spores/ ml of liquid
Contamination level	-	Nil for liquid inoculum $1x10^3$ cells/g for carrier based
Moisture content percent maximum	8-12	10
pH	6.0-7.5	Liquid: 3.5-7.5 Carrier: 6.0-7.0
Total viable propagules/gm of product, minimum	100 gm of finished product with minimum 60 spores per gram	CFU minimum $5x10^7$/g of carrier/powder
Infectitvity potential	Inoculum potential: 1200 IP/g [determined by MPN method with 10 fold dilution]	All material shall pass through 0.15-0.212mm IS sieve
Efficiency character	-	The strain should have phosphate solubilizing capacity in the range of minimum 30% when tested spectrophotometrically. In terms of

		zone formation, minimum 10mm solubilization zone in prescribed media having at least 3mm thickness

Tolerance limit of biofertilisers

1. Tolerance Limit of Biofertiliser as specified in the Schedule III (Clause 2& (q)] Part-B of FCO is $1x10^7$ CFU/g of carrier or $5x10^7$ per ml of liquid material is admissible during the entire period of shelf life.

2. In case of mycorrhizal biofertilisers, the viable propagules shall not be less than 80 per gram

Quality control parameters of organic fertilisers

In FCO, following seven organic fertilisers are included:

City Compost, Vermicompost, Phosphate Rich Organic Manure (PROM), Organic Manure (OM), Bio-enriched Organic Manure (BEOM), Bone meal raw, and Bone meal steamed

The quality control parameters of each organic fertilisers are mentioned in Table 5, 6 and

7. **Table 5: Quality control parameters of City Compost, Vermicompost and PROM**

Specifications	City Compost	Vermicompost	PROM
Moisture percent by weight	Maximum 25.0	15.0-25.0	Maximum 25.0
Colour	-	Dark brown to black	-
Odour	-	Absence of foul odour	-
Particle size	Min. 90% material should pass through 4. mm IS sieve	Min. 90% material should pass through 4.0mm IS sieve	Min. 90% material should pass through 4.0mm IS sieve
Bulk Density (g/cm^3)	<1.0	0.7-0.9	<1.6
Total Organic Carbon, % by weight, minimum	12.0	18.0	7.9
Total of Nitrogen (as N), Phosphates (as P_2O_5) and Potash (as K_2O) % by weight, Minimum	1.2	-	-
Total Nitrogen (as N)% by weight, Minimum	-	1.0	0.4
Total Phosphates (as P_2O_5) % by weight, Minimum	-	0.8	10.4

Total Potash (as K_2O) % by weight, Minimum		-	0.8	-
C: N ratio		<20	-	<20
pH		6.5-7.5	-	6.7
Conductivity (as dsm^{-1}) not more than		4.0		8.2
%	Arsenic (as As_2O_3)	10.00	-	10.00
	Cadmium (as Cd)	5.00	5.00	5.00
	Chromium (as Cr)	50.00	50.00	50.00
	Copper (as Cu)	300.00	-	300.00
	Mercury (as Hg)	0.15	-	0.15
vy	Nickel (as Ni)	50.00	50.00	50.00
	Lead (as Pb)	100.00	100.00	100.00
	Zinc (as Zn)	1000.00	-	1000.00

Table 6: Quality control parameters of OM and BEOM

Specifications	OM	BEOM
Moisture percent by weight	Maximum 25.0	30-40
Particle size	Min. 90% material should pass through 4.0mm IS sieve	Min. 90% material should pass through 4.0mm IS sieve
Bulk Density (g/cm^3)	<1.0	<1.0
Total Viable count (N,P,K and Zn bacteria) or (N and P bacteria) or (N and K bacteria)	-	$5.0X10^6$ (within 3 months from the date of manufacture)
Total Organic Carbon, % by weight, minimum	14.0	14.0
Total of Nitrogen (as N), Phosphates (as P_2O_5) and Potash (as K_2O) % by weight, Minimum	-	Should not be <3%
Total Nitrogen (as N)% by weight, Minimum	0.5	0.8
Total Phosphates (as P_2O_5) % by weight, Minimum	0.5	0.5
Total Potash (as K_2O) % by weight, Minimum	0.5	0.8
C: N ratio	<20	<18
pH	6.5-7.5	6.5-8.0

Conductivity (as dsm^{-1}) not more than		4.0	4.0
Pathogens		Nil	-
	Arsenic (as As_2O_3)	10.00	10.00
	Cadmium (as Cd)	5.00	5.00
	Chromium (as Cr)	50.00	50.00
	Copper (as Cu)	300.00	300.00
	Mercury (as Hg)	0.15	0.15
	Nickel (as Ni)	50.00	50.00
	Lead (as Pb)	-	100.00
	Zinc (as Zn)	1000.00	1000.00

Table 7: Quality control parameters of Bone meal, Raw and Bone meal, steamed

Specifications	Bone meal, Raw	Bone meal, steamed
Moisture percent by weight	Maximum 8.0	Maximum 7.0
Acid insoluble matter % by weight, maximum	12.0	-
Total Phosphorus (as P_2O_5) % by weight, minimum	20.0	22.0
2 % citric acid soluble Phosphorus (as P_2O_5) % by weight, minimum	8.0	16.0
Nitrogen content of water insoluble portion % by weight, Minimum	3.0	-
Particle size	Material shall pass wholly through 2.36 mm IS sieve of which not more than 30 % shall be retained on 0.85 mm IS sieve	Not less than 90% material should pass through 1.18 mm IS sieve

Tolerance limit of organic fertilisers

A sum total of nitrogen, phosphorus and potassium nutrients shall not be less than 1.5% in City Compost and shall be not less than 2.5% in case of Vermicompost.

Quality control parameters of non-edible de-oiled cake fertilisers

In the FCO, castor de-oiled cake is included whose specification is mentioned in Table 8.

Table 8: Quality control parameters of castor de-oiled cake

S.No.	Parameter	Requirement
(i)	Moisture percent by weight	Maximum 12.0
(ii)	Colour	Brown to black
(iii)	Odour	Typical only odour specific to the

		oil of that seed and no foul odour
(iv)	Ash content, % by weight, maximum	15.0
(v)	Total Organic Carbon, % by weight, minimum	25.0
(vi)	Total Nitrogen (as N) % by weight, Minimum	4.5
(vii)	Total Phosphates (as P2O5) % by weight, Minimum	1.0
(viii)	Total Potash (as K2O) % by weight, Minimum	1.0
(ix)	C: N ratio	<10
(x)	pH	6.0-8.0
(xi)	Conductivity (as dsm^{-1}) not more than	4.0
(xii)	Particle size	Not less than 75% material should pass through 4.0mm IS sieve

Tolerance limit of non-edible de-oiled cake fertilisers

0.5 unit of nitrogen, phosphorus and potassium nutrients combined.

Reference

The Fertiliser (Control) Order 1985 (As amended upto January 2018) by The Fertiliser Association of India, New Delhi.

Can biopesticides alone capable to replace chemical pesticides in Agriculture?

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The highest yield of any crop is based on the improved variety, appropriate pest and disease management, and recommended fertilization. Adequate pest management is essential for sustainable agricultural production. In the worldwide agriculture system, the commonly used pesticides come under synthetic origin, such as, carbamate, halogenated, organophosphorus compounds etc. Excessive use of these synthetic compounds led to creation of new resistant strains besides environmental pollution. Hence, biopesticides are considered as an alternative to synthetic pesticides that are highly effective, target specific and reduce environmental risks.

What are Biopesticides?

Biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals. For example, canola oil and baking soda have pesticidal applications and are considered biopesticides. As of April 2016, there are 299 registered biopesticide active ingredients and 1401 active biopesticide product registrations.

Classes of Biopesticides

Biopesticides fall into three major classes:

1. Biochemical pesticides are naturally occurring substances that control pests by non-toxic mechanisms. Conventional pesticides, by contrast, are generally synthetic materials that directly kill or inactivate the pest. Biochemical pesticides include substances that interfere with mating, such as insect sex pheromones, as well as various scented plant extracts that attract insect pests to trap. Because it is sometimes difficult to determine whether a substance meets the criteria for classification as a biochemical pesticide, EPA has established a special committee to make such decisions.

2. Microbial pesticides consist of a microorganism (e.g., a bacterium, fungus, virus or protozoan) as the active ingredient. Microbial pesticides can control many different kinds of pests, although each separate active ingredient is relatively specific for its target pest[s]. For example, there are fungi that control certain weeds and other fungi that kill specific insects.

3. Plant-Incorporated-Protectants (PIPs) are pesticidal substances that plants produce from genetic material that has been added to the plant. For example, scientists can take the

gene for the Bt pesticidal protein and introduce the gene into the plant's own genetic material. Then the plant, instead of the Bt bacterium, manufactures the substance that destroys the pest. The protein and its genetic material, but not the plant itself, are regulated by EPA.

What are the advantages of using biopesticides?

- ❖ Biopesticides are usually inherently less toxic than conventional pesticides.
- ❖ Biopesticides generally affect only the target pest and closely related organisms, in contrast to broad spectrum, conventional pesticides that may affect organisms as different as birds, insects and mammals.
- ❖ Biopesticides often are effective in very small quantities and often decompose quickly, resulting in lower exposures and largely avoiding the pollution problems caused by conventional pesticides.
- ❖ When used as a component of Integrated Pest Management (IPM) programs, biopesticides can greatly reduce the use of conventional pesticides, while crop yields remain high.

Biopesticides as biological control

Biological control is the control of one living organism by another one. Strictly, the process is called "Biological Suppression" because control (eradication) of any organism is almost impossible. Predation, parasitism, pathogenesis are the different types of biological control methods, which are practiced against the insect pests. The emphasis of biological control is to induce disease and (or) epidemics for suppression of the pests.

Microorganisms, such as, viruses, bacteria, fungi and protozoa are the pathogens or antagonists of all types of living organisms. The diseases of various pests have been used as biocontrol agents. This group of pathogen can control various pests' *viz.* vectors of human, animal and plant diseases, and insect pests of agricultural crops. Oppositely, the diseases of vectors and other pests are studied to induce or augment epizootics. However, principles and procedures used for insect pathology follow exactly the methods of medical microbiology. Biological control of insects is a complex phenomenon and is dependent on the virulence of the pathogen, resistance of the host and effects of the environment. Virulence of the pathogens is assessed by LD_{50} or LC_{50} and LT_{50} values.

Although microbial pesticides (Fig. 1) are effective but not popular as these are not readily available in the local market. Action of these pesticides is relatively slower than chemical insecticides. Also currently microbial pesticides are costlier than some of the popular insecticides. Microbial pesticides are host-specific and their pathogenicity to un-related hosts may also be tested and considered. These pesticides may be applied before out-break of the pest. Most vital criteria for successful introduction of microbial pesticides application are knowledge of the reliable and cost effective technology, no or negligible toxicity to human beings, non-target species and plants, proven and preferably rapid effect against the intended target pest, and ideal conditions required for efficient performance in the fields are not fully understood (Sahoo *et al.*, 2013).

Types of microbial pesticides

All groups of microbes have several potent pathogens for insect pests and the important groups of the pathogens and their diagnostics are given below. Different groups of pathogens are:

1. Viruses (NPV, GV, CPV), including phages.
2. Bacteria:
    (a) Spore and crystal formers-*Bacillus thuringiensis. B. sphaericus, B. popilliae* etc.
    (b) Spore formers- *B. cererus, B. subtilis, Clostridum* spp.
    (c) Non-spore forming bacteria- *Pseudomonas* spp., *Serratia spp*. etc.
    (d) Rickettsiae
    (e) Mycoplasma/spiroplasma
3. Fungi- all groups
4. Protozoa
5. Nematodes

Fig.1: Some entomopathogenic fungi grown on plates in the laboratory

Bacteria based microbial pesticides

Bacterial pathogens are most widely used to control a wide variety of insects. The bacterial pathogens are divided into following groups:

1. Obligate pathogen – Difficult to grow *in vitro*, require special ingredient, spore (if, spore-former) may not form except in the host. Host specific or narrow spectrum.

2. Facultative pathogen – Grow easily *in vitro* and form spores (if, spore former), capable to invade the gut and grow in haemocoel, may produce toxins or enzymes, low infective dose ($ID_{50}<10^4$). Mostly non-specific.
3. Potential pathogen – Require stress of the host like weakness, wound on the gut wall to enter the haemocoel. Low ID_{50} ($5\text{-}10^3$, at least, less than 10^4), capable to combat host defence at low dose, produce of toxin or enzymes.

Important pathogens of different bacterial groups

1. Obligate: *Bacillus popilliae, B. larvae, B alvei, B. lentimorbus, Clostridium* spp. etc.
2. Rrickettsiae, mycoplasma, spiroplasma etc.
3. Facultative: *B. thuringiensis, B. cereus* etc.
4. Potential/facultative: *Pseudomonas* spp., *Proteus* spp., *Brevibacterium* spp., *Aerobacter* spp., *Serratia* spp. etc.

Some of the important biocides used in agriculture to control different pests are listed in Table 1

Table 1: Biocides used against pests of different crops

Bio-agents	**Efficacy**	
	Pest	**Crop**
1. Baculovirus	Rhinoceros Beetle	Coconut
2. Cryptolemus	Mealy bug	Citrus, guava, custard apple, brinjal
3. Chrysopa	*Heliothis*	Pulses, 0il seeds, vegetables
	White fly	Vegetables
	Aphid	Oil seeds
4. Trichogramma	*Heliothis*	Oil seeds, vegetables, pulses
	Earias	Bhindi
	Borers and Leaffolder	Rice.
	Borers	Sugarcane
	Butterfly	Citrus.
5. Trichoderma	Wilt and Damping off	Pulses, oil seeds, vegetables, Citrus.
6.*Metarhizium anisopliea*	Rhinoceros Beetles	Coconut
	White grubs	Groundnut.
7. *Bacillus popilliae*	White grubs	Ground nut
8. NPV	*Heliothis*	Pulses, vegetables, oil seeds.
	Spodoptera	Oil seeds, vegetables

Work done so far at NRRI, Cuttack

At NRRI Cuttack, we are actively working since long to identify efficient entomopathogens to manage rice leaf folder and finally able to identify the following bacterial and fungal strains *viz.*, *B. thuringiensis*, *B. bassiana* and *M. anisopliae*, and formulations of these strains were also filed for Indian patents. In addition, recently we have identified one efficient entomopathogenic bacterium (*Skermanella* sp.) against rice leaf folder and pink stem borer.

Way forward

Up to now, there are more than 3000 kinds of microbes reported to cause diseases in insects. However, further research is required to find out the remaining undiscovered or unidentified microorganisms that are used in insect pest management. So far, nearly one hundred bacteria identified as entomo-pathogens, among them *Bacillus thuringiensis* (Bt), *Metarrhizium* sp. and *Beauvaria* sp. have got the maximum importance as microbial control agents. Many microbial biocontrol agents have been documented, however, *B. thuringiensis* is considered as one of the desirable alternatives to chemical pesticides. *B. thuringiensis* accounts for about 5-8% of total *Bacillus* spp. in the environment. Till date, more than 130 species of coleopteran, dipteran, and lepidopteran insects are found to be controlled by *B. thuringiensis*. So far, 71 serotypes (84 serovars) of *B. thuringiensis* having a wide array of host range have been commercially exploited directly as a native form or indirectly as transgenic microbes or plants. Bacteria, especially *B. thuringiensis* and *B. sphaericus* are the most potent and successful group of organisms for effective control of insect pests and vectors of diseases. Similarly, *Beauveria bassiana*, and *Metarhizium anisopliae* are reported to have strong biocontrol activity against rice leaf folder.

Conclusion

In the present scenario, pesticides application is a necessary evil, however unnecessary evil towards non-targeted beneficial organisms, therefore disturbing the whole ecological systems. To maintain the ecological balance, could we replace the whole chemical pesticides? The answer is “yes” but with the cost of yield, hence, the wise idea is to considerably reduce the synthetic pesticides with biopesticides rather than complete replacement to feed growing population.

Waste Decomposer technology and its application – A farmer's friendly approach

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There is an environmental imperative to reduce the amount of resources we consume and to minimize the production of waste. A large portion of the waste we generate is biodegradable, recent research suggesting that up to 68 per cent of household waste is biodegradable including kitchen waste, garden waste, paper, card and natural textiles. When biodegradable waste breaks down in the absence of oxygen it releases methane, a powerful greenhouse gas. Most of the UK's waste is currently buried in the ground in landfill sites, which pollutes the soil and water as well as producing methane. The EU Landfill Directive in 1999 set targets for diverting the biodegradable fraction of municipal waste from landfill sites, which means that by 2010 the UK has to reduce the amount of biodegradable municipal waste landfilled to 75% of that produced in 1995.The present practice is usually to burn agricultural residues or to leave them to decompose. National Centre of Organic Farming, Ghaziabad has developed a product called Waste Decomposer to overcome this problem. It is a consortium of few beneficial microorganisms which is isolated by Krishan Chandra 2004 from desi cow dung. Waste decomposer works as Biofertilizer, Biocontrol, and as well as Soil health reviver. It can also be used in various ways such as quick composting of bio wastes, drip irrigation, foliar spray as biopesticide against most of the plant diseases for all types of agriculture and horticulture crops, in-situ composting of crop residue and seed treatment. Waste decomposer microorganism produces primary metabolites that are a precursor of anti-microbial compounds; it also produces a variety of antimicrobial secondary metabolites including polyketides and alkanes. These antimicrobial metabolites facilitating in the field crop which controls the number of diseases. Besides this, it also produces glucanase and â-1,3glucanase enzymes which trigger defence mechanism of the plant.

Salient Features of waste decomposer

1. Simple & Reliable
2. Ready to use (within 5 days)
3. Longer shelf-life (3 years)
4. No Structure, Pit or equipment require
5. Recommended for all crops
6. Better crop response
7. Works as a great component for clean India Movement (Swachh Bharat Mission) by converting bio-waste into organic Manure
8. Low cost (only Rs. 20 per bottle)
9. Quick and healthy compost
10. 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 given to the farmers in small bottles and they themselves mass multiply this product without using any sophisticated technique.

Process of Mass multiplication

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 jiggery 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 5 days the solution of drum turns creamy.

Fig: Waste decomposer

Application of Waste Decomposer

Waste decomposer not only decomposes the bio-wastes, but it can be used in multiple ways.

1. Biopesticide

The mass multiplied liquid waste decomposer culture is diluted in the ratio of 1:3 with water and applied as a foliar spray to control pest and diseases. It can control all types of soil borne, foliar diseases, insects, and pests.

2. In-situ composting of crop residue

a) Spray the solution on the post-harvest stalks of crop plants flooded with water and leave it for few days.
b) In water stress areas just sprinkle the solution on crop residue and when the farmer does the irrigation in field the process of decomposition starts. The above 200 litre preparation can be used for 1 acre crop residue as in-situ composting.

3. Drip irrigation

For the revival of soil health and as biofertilizer for the crop, waste decomposer is used during irrigation in the field by mixing the mass multiplied solution with water. 200 litres of waste decomposer solution is enough for 1 acre land.

4. Seed Treatment

Simply spray/sprinkle the waste decomposer solution uniformly over any type of seeds. Leave the treated seeds under shade for 30 minutes. After 30 min. the seeds are ready for sowing. Various seed borne diseases are controlled by waste decomposer.

5. Foliar Spray

The mass multiplied liquid waste decomposer culture is diluted in the ratio of 1:3 with water and applied as a foliar spray to control pest and diseases.

Multi-potent efficiency of Waste Decomposer

1. Disease Management

Waste Decomposer has a great potential to control a variety of fungal bacterial and viral diseases effectively in different crops. Damping off disease in Chilli, Tomato, Brinjal peanut, potato soybean, maize cabbage etc, Rhizome rot disease in Ginger, turmeric, onion etc, Root rot disease in citrus, methi, berseem, pineapple, etc, Wilt disease in Banana, Cotton, Tomato, Brinjal, Chilli, peanut, potato, coffee, balck pepper, lychee etc, Sheath blight disease in rice, maize etc. Apart from the above said farmers have reported that their crops have no attack of any pests and diseases due to the usage of waste decomposer solution spray at regular interval and leaving the solution with irrigation water. Therefore, farmers found happy due to the luxuriant crop growth and good yields.

2. Crop quality and yield

Good quality of crop and high yields are the desired feature of any crop by any farmer/producer across the globe. Waste Decomposer is a promising tool for good quality of crop and high yields. It was reported by the farmers that usage of waste decomposer in their fields has resulted in the luxuriant growth of the crop. Potato producers have reported that they have harvested the potatoes with bare hands only as the soil has become soft and tender due to the usage of waste decomposer. Pomegranate producers have reported that they have harvested good quality and very shiny pomegranates than that of yester years.

Application of waste decomposer in soil

1. Soil Physicochemical and Biological Properties

Waste Decomposer application changes the biological and physico-chemical properties of soil, thereby soil becomes favorable for plant growth. The biological properties of the soil seemed to change tremendously in terms of increase in beneficial macro and micro soil biota, as already mentioned, innumerable quantity of earthworms in the field is the identifiable aspect of the Waste Decomposer soils. The texture and structure of the soil are changed in tune with supporting plant growth. Further, farmers reported that weed pattern/system slowly declined.

It is also noted that the Waste Decomposer microorganisms have the potential for producing extracellulytic enzymes which help in inhibiting the growth of soil borne pathogens. Biological control by Waste Decomposer is known as a combination of different mechanisms among which the most important are 1. Competition for nutrients 2. Production of volatile & non-volatile antibiotic compounds adhering the plant roots and root hairs.

2. Soil salinity

Soil salinity refers to the presence of high concentrations of soluble salts in the soil moisture of the root zone. These concentrations of soluble salts, through their high osmotic pressures, affect plant growth by restricting the uptake of water by the roots. All plants are subject to this influence, but sensitivity to high osmotic pressures varies widely among plant species. Salinity can also affect plant growth because the high concentration of salts in the soil solution interferes with a balanced absorption of essential nutritional ions by the plants.

The main effects of salinity on plant growth and crop production are: The spread of plant pathogenic fungi which cause damping-off, wilt and root-rot diseases, agricultural soil Slow and insufficient germination of seeds, Physiologic drought, wilting, and desiccation of plants; Stunted growth, small leaves, short stems and branches; Blue-green leaf color; Retarded flowering, fewer flowers, sterility, and smaller seeds; Growth of salt-tolerant or halophilous weed plants; As a result of all these unfavorable factors, low yields of seeds and other plant parts. As a result, the need of an hour is selection for some eco-friendly biocontrol agent that is resolving the above mentioned problems.

3. Seed Germination

Waste decomposer is a new technique of seed treatment that involves the application of beneficial microorganisms on seed surface followed by seed hydration. Seed treatment is an ecological management strategy to control much seed and soil-borne pathogens which provide an alternative to chemical treatment. Seed treatment enhances the initial step of plant development by increased seed germination and provides protection before seedling emergence. The growth of seed can be observed at least 4 days in advance over chemical. Some farmers reported 98% seed germination after sowing with waste decomposer treated seeds. It has a remarkable effect on alleviating the adverse effects of salt stress on seedlings and seed germination.

Waste Decomposer seed treatments help to control soil borne diseases and also enhances plant growth and yield as it got the ability to alleviate biotic stress (seed and seedling disease caused by soil borne pathogens) and abiotic stresses (osmotic, salinity, chilling, or heat shock). Further waste decomposer proved to have the ability to overcome physiological stress (poor seed quality induced by seed aging).

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Recycling organic matter in organic agriculture

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Introduction

The Indian population passing the 1.36 billion mark. The debate continues on our ability to maintain adequate food production for a rapidly growing population. Though, India is self-reliant in food-grain production through 'Green Revolution'. But worrying for the poor conditions of Indian farmers and the environment is more intense. The commercial industrial technologies that are used in agriculture today to feed the world are not inherently sustainable which is also popularly known as Green Revolution Technologies in India. The increased use of chemical which GRT entailed and to the vulnerabilities which arose through the spread of monoculture leading to genetic erosions are now leading to second generation problems like depletion of natural fertility and water resources, increased salinity, loss of soil micro-flora and fauna, resurgent of pests and diseases, thereby, declining productivity. In this context, organic agriculture has got tremendous relevance for sustainability. It is known by many names or forms of practice like biodynamic, biological, natural, alternative, regenerative, low-input, bio-intensive, holistic etc. But the central dogma of all these manifestations of organic agriculture converge on building up of soil health or soil quality through conservation and augmentation of biological diversity, particularly, microbial diversity.

Organic farming – Principles and Practices

Organic farming systems rely on the management of soil organic matter to enhance the chemical, biological and physical properties of the soil (www.fao.org). One of the basic principles of soil fertility management in organic systems is that plant nutrition depends on 'biologically-derived nutrients' instead of using readily soluble forms of nutrients; less available forms of nutrients such as those in bulky organic materials are used. This requires release of nutrients to the plant via the activity of soil microbes and soil animals. Improved soil biological activity is also known to play a key role in suppressing weeds, pests and diseases. What is now required is to harmonize and bind the components in a system synergy and all round complementarity.

Animal dung, crop residues, green manure, biofertilizers and bio-solids from agro-industries and food processing wastes are some of the potential sources of nutrients of organic farming. While animal dung has competitive uses as fuel, it is extensively used in the form of farmyard manure. Development of several compost production technologies like Vermi composting, Microbe Mediated, Phospho composting, N-enriched Phospho composting, etc. improves the quality of composts through enrichment with nutrient-bearing minerals and other additives. These manures have the capacity to fulfil nutrient demand of crops adequately and promote the activity of beneficial macro-and micro-flora in the soil.

Organic farms and food production systems are quite distinct from conventional farms in terms of nutrient management strategies. Organic systems adopt management options with the primary aim to develop holistic farms, like a living organism with balanced growth, in both crops and livestock holding. Thus nutrient cycle is closed as far as possible. Only nutrients in the form of food are exported out of the farm. Crop residues burning is prohibited, so also the unscientific storage of animal wastes and its application in the fields. It is, therefore, considered more environment friendly and sustainable than the conventional system. Farm conversion from high-input, chemical-based system to organic system is designed after undertaking a constraint analysis for the farm with the primary aim to take advantage of local conditions and their interactions with farm activities, climate, soil and environment, so as to achieve (as far as possible) closed nutrient cycles with less dependence on off-farm inputs. This implies that the only nutrients leaving the farm unit are those for human consumption. I would suggest to minimize the loss of nutrients, which otherwise continues without any let off.

Crop rotations and varieties are selected to suit local conditions having the potential to sufficiently balance the nitrogen demand of crops. Requirements for phosphorus, potash, sulphur and micronutrients are met with local, preferably renewable resources. Organic; agriculture is therefore, often termed as knowledge-based rather than input-based agriculture. Furthermore, organic farms aim to optimise the crop productivity under a given set of farm conditions. There are ample evidences to show that agrochemical-based, high input agriculture is not sustainable for long periods due to gradual decline in factor productivity, with adverse impact on soil health and quality. Harnessing the varietal potential by appropriate biotechnology input is neglected area and needs adequate attention.

The impact of organic agriculture on natural resources favours interactions within the agro-ecosystem those are vital for both agricultural production and nature conservation. Ecological services derived include soil forming and conditioning, soil stabilization through buffering and structural improvement, waste recycling, carbon sequestration, nutrient cycling, predation, pollination and habitats. The environmental costs of conventional agriculture are substantial, and the evidence for significant amelioration via conversion to organic agriculture is over-whelming. There are also high pre-consumer human health costs to conventional agriculture, particularly, in the use of pesticides. It is estimated that 25 million agricultural workers in developing countries suffer from pesticide poisoning each year.

Case studies

Christos Vasilikiotis (USA) tried to find the answer looking at some of the experiments conducted at different levels (source : www.researchgate.net retrieved on 2.11.2018).

(a) Sustainable Agriculture Farming Systems project (SFAS) at UC, Davis, 95616

An ongoing long-term comparison study, SFAS is an interdisciplinary project that compares conventional farming systems with alternative production systems that promote sustainable agriculture. The study examines four farming systems that differ in crop rotation design and material input use: a 2-year and a 4-year rotation conventional system, an organic and a low-input system. Results from the first 8 years of the project show that the organic and low-input systems had yields comparable to the conventional systems in all crops which were tested - tomato, safflower, corn and bean, and in some instances yielding higher than conventional systems. Tomato yields in the organic system were lower in the first three years, but reached the levels of the conventional tomatoes in the subsequent years and had a higher yield during the last year of the experiment (80 t/ha in the organic compared to 68 t/ha in the conventional in 1996). Corn production in the organic system had a higher variability than conventional systems, with lower yields in some years and higher in others.

Both organic and low-input systems resulted in increases in the organic carbon content of the soil and larger pools of stored nutrients, each of which are critical for long-term fertility maintenance (Clark, 1998). The most important limiting factor in the organic system appeared to be nitrogen availability (Clark 1999b). The organic system relied mainly on cover crops and composted poultry manure for fertilization. One possible explanation for a lower availability in the organic system is that high carbon inputs associated with nitrogen to build soil organic matter, thus reducing nitrogen availability for the organic crops. During the latter 2 years of the experiment, soil organic matter levels appeared to be stabilized resulting in more nitrogen availability. This was in agreement with the higher yields of organic crops that were observed during those last two years. The organic systems were found to be more profitable in both corn and tomato among the 4-year rotations mainly due to the higher price premiums (Clark, 1999b).

(b) ***Farming Systems Trial at the Rodale Institute — Soybean study***

Initiated in 1981, the Farming Systems Trial compares intensive soybean and maize production under a conventional and two organic management farming systems. The first organic cropping system simulates a traditional integrated farming system. Leguminous cover crops are fed to cattle and the resulting manure is applied to the fields as the main source of nitrogen. In the second organic system, the leguminous cover crops were incorporated in to the soil as the source for nitrogen before corn or soybean planting.

Corn yields were comparable in all three cropping systems (less than 1% difference) (Drinkwater, 1998). However, a comparison of soil characteristics during a 15-year period found that soil fertility was enhanced in the organic systems, while it decreased considerably in the conventional system. Nitrogen content and organic matter levels in the soil increased markedly in the manure—fertilized organic system and declined in the conventional system. Moreover, the conventional system had the highest environmental impact, where 60% more nitrate was leached into the groundwater over a 5 year period than in the organic systems (Drinkwater, 1998).

Soybean production systems were also highly productive, achieving 40 bushels/acre. In 1999 however, during one of the worst droughts on record, yields of organic soybeans were 30 bushels /acre, compared to only 16 bushels/acre from conventionally- grown soybeans (Rodale Institute, 1999). "Our trials show that improving the quality of the soil through organic practices can mean the difference between a harvest or hardship in times of drought" writes Jeff Moyer, farm manager at The Rodale Institute in Kutztown, Pennsylvania (Rodale Institute, 1999). He continues, "Over time, organic practices encourage the soil to hold on to moisture more efficiently than conventionally managed soil." The higher content of organic matter also makes organic soil less compact so that root systems can penetrate more deeply to find moisture. These results highlight the importance of organic farming methods and their potential to avert future crop failures both in the US and in the rest of the world (http://www.newfarm.org/research/2005).

(c) Broadbalk experiment at the Rothamsted Experimental Station, UK

One of the longest running agricultural trials on record (more than 150 years) are the Broadbalk experiment at the Rothamsted Experimental Station in the United Kingdom. The trials compare a manure based fertilizer farming system (but not certified organic) to a synthetic chemical fertilizer farming system. Wheat yields are shown to be on average slightly higher in the organically fertilized plots (3.45 tones/hectare) than the plots receiving chemical fertilizers (3.40 tones/hectare). More importantly though, soil fertility, measured as soil organic matter and nitrogen levels, increased by 120% over 150 years in the organic plots, compared with only 20% increase in chemically fertilized plots (Jenkinson, 1994; Stephen et al, 2004).

(d) Organic and soybean production in the Midwestern United States

A comprehensive review of a large number of comparison studies of grain and soybean production conduct by six Midwestern universities since 1978 found that in all of these studies organic production was equivalent to, and in many cases better than, conventional (Helmers, 2004). Organic systems had higher yields than conventional systems which featured continuous crop production (no rotations) and equal or lower yields in conventional systems that included crop rotations. In the drier climates such as the Great Plains, organic systems had higher yields, as they tend to be better during droughts than conventional systems. In one such study in South Dakota for the period 1986-1992, the average yields of soybeans were 29.6 bushels/acre and 28.6 bushels/acre in the organic and conventional systems respectively. In the same study, average spring wheat yields were 41.5 bushels/acre and 39.5 bushels/acre in the organic and conventional systems respectively.

Conclusion

The ‘organic farming’ is often termed as Traditional, Biodynamic, Biological, Regenerative etc. to say a few. However, they are basically knowledge intensive rather than input based; labor is the only significant input. The success of any system relying on knowledge and labor only succumbs to wisdom. The advocators of modern agricultural practices fray the proponents of organic systems arguing the risks of deficient productivity. Where the consequential Natural disasters, Greenhouse gases, degraded soils, polluted water sources and air quality from input intensive agriculture is underplayed. The fanaticism on organic to convert the whole country is far off the practicality at this juncture. A balanced approach is the requirement, where organic agriculture can play important role in appropriate niches of commodities and areas of subsistence farming. Modern agricultural practices seem to be indispensable at the moment albeit reduction in use of non-renewable energy sources is obligatory where recycling of resources is vital.

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Extension approaches for diffusion of organic farming technology in rural community

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Introduction

Organic agriculture is now a buzz word in development community. Individuals, groups and community as a whole are sensitized through various forums, media and dissemination of knowledge and skill on this crucial issue is taking place throughout the globe regularly. The concern for soil health, degradation of natural and physical resources due to no judicious use of chemicals and dangerous pesticides is gaining importance within the people. Public awareness is increasing about organic fruits and vegetables and even buyers are ready to pay more for these types of commodities. The media awareness campaign and mass sensitization regarding the pivotal issue paved the pathway for critical thinking for the organic way of agrarian culture.

The transfer of technology mechanism is a complex and time taking process through involvement of heterogeneous groups and community. The role and importance of extension workers are immensely crucial for this stupendous task. The change agents need a strong service support system to translate the technology adoption policy to action. Organic agriculture is a need based technology keeping in view of increasing prices of production inputs in agriculture and allied sectors. The crucial health issues due to chemical residues in food materials gained immense momentum in recent era globally particularly in the developing countries. The technology to be disseminated in the social system needs a strong input-output approach of field level extension.

Principles of extension approach

A. ***Changing the unfelt need to felt need-*** In most of the cases the community could not see or feel the bad effects of the agri-chemicals on the environment including the human and animal lives. The basic principle of extension agents is to see that the client should feel this as a felt need just like the hunger, sleep and thirst. A need based approach on the organic food must be perceived by the clients. The extension agency should translate the problems faced into the need for the social system. Once the clients feel the necessity for the commodity, they will hunch for the ways to fulfil the gap.

B. ***Seeing is believing-***Large scale interactive demonstrations on the benefits, production technology, and productivity on organic agriculture will create a baseline infrastructure for the client system to see and believe the technology in field condition. The effect of demonstration by the extension agencies will build up confidence and authenticity about the said technology.

C. ***Sensitization campaign-***The extension agents may initiate periodical sensitization trainings, community campaign, media coverage on the issue to motivate the audience for popularizing the technology. Campaigns like polio vaccination with its tremendous impact and success rate may be taken as an example here.

D. ***Grass root principle-*** The adoption programme for the organic farming should start from the bottom most layer of the community. The rural hamlets, small informal dwelling units, villages and other ecological entities of our rural society should be involved in the mission due to predominant agrarian occupation of rural community.

E. ***Learning by doing-*** The end user of the technology should learn the application part of the recommended technology by doing it on own. The expert and subject matter specialists will help and facilitate the method demonstration in an interactive way.

Motivation

Concept of motivation comes from the root word "inner urge or motive". The client should see one inner urge for the adoption of the technology.

Motivating factors

1. Inner urge
2. Need satisfaction
3. Clear goal
4. Form of behaviour to achieve the goal
5. Satisfaction ensured
6. Case studies and success stories

Technology adoption stages

1. Awareness generation
2. Interest development
3. Mental evaluation for acceptance of the technology
4. Trial of technology in limited scale(Situation specific)
5. Adoption of the technology
6. Confirmation of the technology

Extension methodology

1. Individual methods
2. Group methods
3. Mass methods

Diffusion process

This is the process of spreading the innovation in the society.

The elements are-

1. Need based innovation
2. Communication
3. Suitable social system
4. Time period for the spreading process

Desirable Character of the technology to be adopted by the community

1. Relative advantage over the previous technology
2. Compatibility of the technology with the society
3. Simplicity of adoption
4. Observability of the result of the technology
5. Communicability of the result of the technology
6. Group action in the community
7. Need base for the technology

Marketing, Value Addition and Processing –Sikkim Success Story

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Agriculture in the 21 Century

After achieving Independence in 1947, attaining food security was one of the foremost priorities of the government. After nationalization of banks in 1969 investment in agriculture got a boost and governments' efforts for development of Agriculture started yielding results. There was significant increase in production and productivity of food grains and cereals. During 1967-77 Green Revolution came with its own benefits and shortcomings. During this time the population of the country grew faster than food production.

The Developing countries were witnessing an extraordinary period of food crop productivity even after 50 years. With Great Progress in agriculture there is increased use of fertilisers, toxic pesticides, improved agri machinery, adverse impacts on environment, pests and diseases more, genetic erosion, yield stagnation that has brought harmful effects with high cost of cultivation, deteriorating human health, high incidence of cancer. The Bio-monitoring Research helps correlate facts to an extent. There is a Cocktail of chemicals which brings about Developmental disorders, neuro disorders, fertility problems. These get into our Blood, urine, breast, milk, fat, lipids and other tissues.

Organic Farming

To combat all these harmful effects, we went back to learning the old approaches and are trying to integrate biological and ecological processes to minimize the use of these non-renewable inputs that cause harm to environment. Organic Farming as a concept came in 1940. Principles of farming by Albert Howard, Rudolf Steiner, Asanobu Fukoka etc were around sustainability. Modern revival of Organic farming started in the 20 century when people started having alarming effects of these chemicals in the body. A recent shift is being done by the Govt, Individuals and NGOs. They are all trying their level best to Transform Agriculture into a Climate resilient production system.

The revival of the traditional agricultural practices, the first of its kind in the world took place in India, all started with Sikkim's Honorable Chief Minister and his untiring efforts.

INDIA and Its Organic Future

India has been a part of the organic farming revolution and has over 160 million hectares of cultivable land. According to the World of Organic Agriculture Report 2018, India has the largest number of organic producers in the world!

With over 835,000 certified organic producers, it is home to more than 30 percent of the total number of organic producers (2.7 million) in the world. Uganda (210,352) and Mexico (210,000) being the second and third largest organic producers, respectively. In India we have Sikkim who is a fully Organic State in 2016 with 76,000 hectares organic (FAO, Reports).

State of Sikkim

The State of Sikkim is nestled in the beautiful foothills of the Himalayas. Sikkim is a Small state of the country and is the Foremost Democratic model in the world for Organic Farming. SIKKIM has a beautiful and impressive journey imprinted in the hearts and mind of people all over the world.

The action plan began in 1995 with the people's participation in "Harit Kranti"— *Greening Sikkim*. Over the years, the concept grew to include, among others, the ban of non-bio-degradable materials by law (1997), the founding of an Eco-club and a Green Fund for schools and colleges (2000), environmental education (2001), smoke free state (2008), Sikkim Eco Tourism Directorate (2009), Ten minutes to Earth program (yearly planting event) (2009), Sikkim Organic Mission (2010), and the ban of packaged drinking water bottles at government functions and meetings. And these are just a few of the many steps undertaken to make Sikkim as green as possible.

In the early 2003, Mr Pawan Chamling Our Honorable Chief Minister had a vision for chemical-free farming in Sikkim and he foresaw the damage that using pesticides can cause. Sikkim was untouched by developments that was taking place in the other parts of the country and the use of synthetic chemicals was already minimal and much below the national average. Additionally, owing to difficult terrain and low cultivable land where agriculture was practiced on a sustainance level, going the organic way was seen as an opportunity that was lying untapped so far by the Honorable Chief Minister. Mr Pawan Chamling, The Honorable Chief Minister of Sikkim's farming roots and his strong belief that the so-called Green Revolution is not an option for the social, cultural and environment setting of Sikkim, he **campaigned intensely for organic agriculture. Organic farming**, a programme had gradually been rolled out across the state and it was named **"Sikkim Organic Mission"** and was launched in **2010.** The movement started in Sikkim State Legislative Assembly during **2003** with the historic declaration. **In 2003, his govt commenced the process of bringing the entire 76,000 hectares of agricultural land in Sikkim under organic management**. The conversion was not forced on the people but built on a clever strategy of reducing subsidies on chemical fertilizers by 10 % each year, till finally there was no more demand for them. Simultaneously, all the institutions and govt departments received special training in organic farming practices so that they could reach out to farmers who needed technical assistance. There started the journey of Sikkim in to a fully Organic State in 2016.

Vision, Mission and Goals

Vision: To promote Sikkim to become a green, healthy and prosperous Sikkim

Mission: To achieve agricultural sustenance, biodiversity conservation and environment protection

Goal: To bring the entire agricultural land under organic management leading to healthy soil, healthy food and healthy society.

Milestones in the Journey

Some major Policy decisions of the Government

1."Sikkim State Organic Board" in 2003 was the first official notification to achieve the Sikkim Organic goal. The Government of Sikkim through Gazette notification Dated 17th September 2003 notified the constitution of the "Sikkim State Organic Board" (SSOB).

2. Banning of Synthetic Fertilizers and Pesticides.

In May 2003, the State Government withdrew its subsidy on fertilizers. From 2006-07 onwards transport and handling subsidy and commission to retailers were also withdrawn. Simultaneously, the Government adopted a seven-year plan to wipe out the use of chemical fertilizers and to gradually replace them with organic sources.

3. 15 August 2010: Sikkim Organic Mission was launched.

4. Sikkim Organic Policy framed in the year 2010.

5. The Sikkim Agricultural and Horticultural Input and Livestock feed Regulatory Act, 2014 enacted.

6. SSOCA (Sikkim State Organic Certification Agency) was established in 2015.

7. 2015:75,000 hectares of agricultural land, where 6000 farmers were gradually converted to certified organic land by implementing organic practices and principles as per guidelines laid down in National Programme for Organic Production.

8. In 2016, Sikkim's state government made the use of chemical pesticides a criminal offence, carrying a heavy penalty of 100,000 rupees and up to three months in jail.

Journey into a fully Organic Farming State: Sikkim Story

Conversion was a very slow process and in the First phase of the Implementation strategy the area to be covered was 14,000 ha among 4 crops into 41 clusters; Buckwheat, Large Cardamom, Ginger and Turmeric. 28 FPC/FPO were formed in SIKKIM.

Awareness cum Interaction Programmes on Hort, Agri and Allied Sectors and State Level awareness meetings in NHB schemes were done all over Sikkim. Interactive Sessions for sensitization of policies and programmes of Agricultural and Horticultural Sector and Capacity building through training and exposure visits were also done.

As a first step two Government farms at Nazitam (East Sikkim) and Mellidara (South Sikkim) were converted to **"Centre of Excellence for Organic Farming"** and necessary research and adaptive trials were started to work out appropriate organic package of practices. First physical step towards conversion of Sikkim agriculture to organic was adoption of bio-village programme using EM technology; Starting from 2003-04 till 2009-10. A total 396 villages were adopted as bio-villages by the Department of Food Security and Agriculture

The Focused approach was adopted to direct resources to implement the following strategies:

- Creation of rural compost units at farmstead
- Construction of vermicompost units

- Integrated Nutrient Management demonstrations with on-farm and off-farm organic and biological inputs
- Biofertilizer demonstrations
- EM technology demonstrations
- Establishment of biofertilizer production unit was constructed during 2009 at Mazitar using the funds provided by NEC
- During 2009-2010, 200 units of Azolla pond have been developed at farmers' field benefiting 200 farmers
- Amendment of acidic soil
- Development of organic package of practices through research

Integrated Pest Management Training introduced to the farmers. Encouraged use of Locally Available materials to make pesticides like herbal plants and cow urine to make Bio Insecticide, Bio Pesticide and Bio Fungicides and Upgradation of soil testing Laboratory was also done. Mobile Soil Testing Laboratories were set up to reach farmers in remotest areas of Sikkim and Biofertilizer Units were established and Ginger Processing units established. Cold Seed Storage units established and Integrated Packaged house and Organic certification form within SIKKIM (SSOCA) agency was established.

The Sikkim Organic Mission was rolled out in 5 stages

2010-11: Phase I-1800, Phase II-1800

2011-12: Phase I-1800, Phase II-1800

2012-13: Phase I-18000, Phase II-18000, Phase III-18000

2013-14: Phase I-18000, Phase III-14000

2014-15: Phase III-14000

Marketing of Sikkim Organic Products

Organic farming has led to sustainable agriculture production and has been instrumental in adding value to the State's reputation and economy. The state has a huge potential for diversified horticulture development with a thrust on cultivation of high value crops, which would fetch higher prices to the farmers ensuring higher net returns even if the production is low. Farmers are grouped under ICS, as per the mandatory requirement of certification process; this is an added advantage by which small-scale farmers can work together for traceability. This system help the major buyers to access the farmers and meet various other needs to create a network for timely and accurate market information.

There are three modules developed for approaching the marketing strategies in the State of Sikkim.

1. In order to enhance the farmers' shares in consumer price, forward linkages to the domestic and international markets, standardization of quality and grades were the pre requisites and so we worked towards that. In addition to the creation of infrastructure, an eco-system is being developed for creating conducive trading environment close to the production areas.

2. After achieving efficiencies in entire supply chain of the produce, the international market with premium consumers will be reached with a value added product range. This study analysis product/sector wise profitability of the possible export ventures in both Indian as well as international markets and acceptance of these products in traditional markets of USA, EU, Japan etc as well as new emerging markets of Africa and Middle East.

3. The third module covers a commodity specific market plan for identified crops. Commodity plan incorporates an in-depth analysis of the consumption status reflected through import trends of product groups identified by the Sikkim Government. Analysis of situation analysis, production base, price spread, rate of return, value chain analysis has been done to draw an action plan under Mission on Organic Value Chain Development (MOVCD).

Government Agencies Involved in MARKETING

Sikkim Organic Mission also prompts the State Government to ensure development of markets for organic food produce though effective marketing is still evolving. In view of the tremendous demand for Sikkim organic products a state of the art whole sale cum retail outlet has been established in New Delhi for boosting marketing.

1.Sikkim Organics outlet at New Delhi inaugurated by Shri Sharad Pawar, Union Agriculture Minister in presence of Smt. Shiela Dixit and Shri Pawan Chamling and other dignitaries. To promote the Sikkim Organic Products and to give better market to Sikkim Farmers, Government of Sikkim was kind enough to allot Sikkim Organic outlet situated at South Delhi in Greater Kailash – I, New Delhi in September 2010. SIMFED is sending local vegetables and other products from local cooperative, NGOs, Temi Tea, GFPF to Sikkim Organic on regular basis and supplies to the various markets and outlets in Delhi.

2. Sikkim's own apex Marketing Agency named SIMFED (Sikkim State Cooperative Supply and Marketing Federation Ltd.) is marketing the most valuable Products of Sikkim like Buck wheat, Large Cardamom, Ginger and Turmeric under its own Brand SIMFED. SIMFED has got trail order of 15MT Organic Ginger from one of International Exporter after which they confirmed regular order of 100MT Ginger per month. SIMFED also got order of Large Cardamom which to be supplied every month to them in Kerala. SIMFED is working continuously to promote the Organic Products of Sikkim in National and International Market and fulfill the dreams of the Sikkim Organic Mission and Chief Minister of Sikkim with the help and support of the Agriculture & Horticulture Department officials. SIMFED has 30 retail locations all over Delhi and NCR and 13 retail locations. SIMFED's main location is at Krishi Bhavan, New Delhi and was inaugurated by Shri Radha Mohan Singh, Honorable Union Minister for Agriculture in 2017.

3. New Farmers' Markets

Sikkim government has started constructing a Kisan Market in the capital city exclusively for organic produce. The New organic farmer's market was opened in Gangtok, outside Denzong Cinema in Gangtok's Lal Bazar. It is also called the 'Sikkim Organic Market'. While earlier the farmers did not have a dedicated area in the market, now they do. It is a part of the state government's plan to push organic farming.

Farmer Producer Organization (FPO), a cooperative of farmers was formed in 2013, with 1,069 farmer-members from the East Sikkim district. The FPO sources produce from farmers and sell it directly in the Organic Market.

In order to help farmers increase their earnings, the Lum/Gor/Sangtok GPU of Lower Dzongu has established an organic stall near Pheedang Bridge in North Sikkim which will sell the vegetable produce of Lower Dzongu farmers. The stall is run by Phugureep Self Help Group of Lower Dzongu where organic vegetables will be available along with traditional Lepcha equipments made of bamboo. Agriculture is the main source of income for the people of Dzongu.

As the farmers need to get maximum price of their produces for which a need to develop marketing network has been felt and for that a joint venture with IFFCO, one of the biggest farmer's cooperative societies in the country, has been formed. Following in the footsteps of the Central governments thrust on cashless transaction, the farmers will get various incentives and payments through e-vouchers under organic farming programme in the state. The State government is to provide a vehicle in each Assembly constituency for bringing fresh organic produces to the market. The system of government vehicles bringing organic produces to markets would help Sikkim become a self-sufficient and self-reliant state in agriculture and horticulture sectors.

Private Agencies Involved in MARKETING

1. The Kolkata-based Parvata Foods Pvt. Ltd, is also primarily into marketing Sikkim's organic produce in Delhi before expanding to other cities. Parvata is also building integrated value chains for the organic produce of Sikkim farmers by building marketing linkages along with packaging and branding. It eliminates several non-value-adding middlemen, passing on the value to the farmers. It is thus integrating Sikkim farmers into the main value chain and elevating their living standards. Parvata is also creating an identity for the organic produce of Sikkim and communicating its better characteristics to the consumers. Parvata's primary products are ginger and turmeric and it is currently building a pipeline to expand into large cardamom, buckwheat, chili, pineapple and mandarin. It looks to expand into exporting processed spices to Europe and US.

Their joint venture with the state government, a food processing plant in Sikkim, has just started production; Parvata Foods has tied up with Mother Dairy's 372-strong Safal chain of stores in Delhi to market organic products, primarily ginger; and the company is all set to launch its own organic brand, making sure to mention "Himalayan Origin from Sikkim" as part of the packaging.

2. The startup firm Nature Gift was set up in 2013 and now has a processing capacity of 200 tonnes for ginger, turmeric, buckwheat and millets. He sells processed organic products not only in Sikkim but also supplies to companies like Lucknow-based Organic India, Jaipur-based Vision Organic, among others.

3. Organic Sikkim, a company has an outlet in south Delhi for the state's products

4.Salghari Multi-Purpose Co-operative Society, Namchi launched **"Sikkim Harvest**" a range of organic products in Namchi on August 1, 2018. **S**alghari Multi-Purpose Cooperative Society Ltd conceived with an idea of establishing a small scale agro processing plant catering to this area that will procure, process, grade and market these produces to the open market so that value addition to these product give a better output and better bargaining power to the farmers. SIKKIM HARVEST is a result of this potential.

New Marketing Strategies

While Sikkim sets an example to the other States of the country, it is only a first step in the long term sustainability of organic agriculture, the next steps requires market linkages with domestic and International consumers

In context of the scope for leveraging the advantages of high value organic agriculture produce for high end market, It has now zeroed in on four high-value crops including—large cardamom, ginger, turmeric and buck-wheat—for profitable domestic sale and export. Spices are one of the strengths of Sikkim "Under the Mission for Value Chain Development for North East Region (MOVCDNER), the plan is to process these four crops, package them, brand them and send them to other parts of the country or export them".

Buckwheat

Important minor cereal crop of Sikkim. It is cultivated in the mountain region at elevation above 1400 m for grains and green leaves. In the higher elevation of Himalayas at up to 4500 m height, the only crop which grows successfully. It is a health food because of high essential nutrients content including protein and minerals. It is also used for livestock and poultry feeds. Buckwheat has potential to be processed and exported. The market potential of Buckwheat is required to be developed.

Large Cardamom

India is the world leader of Cardamom producing over 50 per cent of the global yield. Within the country, the Sikkim state is the second-largest producer of cardamom and is considered as a huge cardamom epicentre of the world. It is home to the largest cultivated area of cardamom producing around 80 per cent of large cardamom in the country. The Spices Board has proposed to replant 5,000 hectares and rejuvenate 2,500 hectares of large cardamom in Sikkim during the 12th Five Year Plan. The dried capsules are marketed at Amritsar, Delhi, Kanpur, Kolkata and Lucknow for further distribution**.**

Ginger

Mostly marketed in the fresh form. 70- 80 per cent of the total production is reportedly available as marketable surplus. The main marketing centres are Gangtok, Pakyong, Singtam and Rangpo in East district; Gyalshing, Reshi, Legshep and Nayabazar in West district; Namchi, Jorethang and Melli in South district and Mangan and Dikchu in North district of Sikkim. Delhi market is the major consumer of Sikkim ginger (70%), followed by Punjab (10%), Uttar Pradesh (10%), West Bengal (5%) and others (5%). The largest exporters in the world are: Thailand, China, India, Brazil and Indonesia. The biggest importers of ginger are: Japan, USA, UK, Netherlands, Canada, Singapore and others. The organically-produced ginger from Sikkim is being exported to the Netherlands by SIMFED and it has widely been accepted in the European market making its presence felt in a bigger way. It is expected to make headway in the European market in the years to come thereby throwing more challenges before farmers and entrepreneurs in Sikkim to carry on the momentum.

Turmeric

There are several cultivated types of turmeric available in the region, which are generally named after the localities they are being grown. Dry matter recovery of these varieties has been found to be even equal or better than certain improved types.

Potential Products for Marketing

Baby Corn and Maize

Baby Corn cultivation is a recent development in Sikkim. Major motive behind popularization of the crop is to increase the economic condition of farmers. The potential of growing the crop in the state is visualized from the production and productivity of maize. Thought less remunerative, maize is the only crop in Sikkim which is successfully grown in approximately 39,000 ha area across different agro ecological conditions.

Sikkim Mandarins

In Sikkim, only one variety, Sikkim mandarin is cultivated on commercial scale. It is also known as Darjeeling or Sikkim orange. Most of the orange fruits of Sikkim are sent to Kolkata and nearby markets. The fruits are brought to important marketing centres such as Singtam, Jorethang, Melli, Legship and Rangpo. The fruits are graded into three grades — large, medium and small. One box contains 400 fruits of large size or 500 fruits of medium size or 800 fruits of small size.

Processing Story

The major crops of the state are maize, rice, buckwheat among cereals, Black gram (Urad) and rice bean among pulses, soybean and mustard among oilseeds. The main horticultural crops are orange & pears among fruits, ginger, cardamom, turmeric and cherry pepper among spice crops, cole crops, peas & bean, tomato, potato among vegetable crops. Besides, production of potato & pea seeds and off-season vegetables cultivation at high altitude is done extensively. Of late, cultivation of flowers such as cymbidium, rose, gerbera, anthurium, lilium etc. is generating good income for farmers and a large number of farmers have adopted floriculture as a commercial venture.

Major strength of Sikkim’s food processing industry lies in the following

Spices- Turmeric, Cardamom, Ginger, Cherry

Pepper Pulses- Black gram (Urad), Rice Bean

Cereals- Rice, Maize, Buckwheat, Barley, Finger Millet

Oilseeds- Soybean, Rapeseed, Mustard

Commercial crops- Large Cardamom, Orange, Ginger, Turmeric, Cherry Pepper

Processing Industries (Large Scale and Small Scale) of Sikkim

1. Government Fruit Preservation Factory at Singtam

It is a enterprise of Government of Sikkim and markets its range of products under the brand name "Sikkim Supreme". The factory has an area of 10 acres and its range of products includes Orange squash, lemon squash, passion fruit squash, tomato ketchup, tomato puree, orange, marmalade, mixed fruit jam, synthetic vinegar, mango pickle, Dallae chilly (hot balls) pickle, dallae chilly with bamboo shoot pickle, mixed pickle, pineapple squash, orange juice in 800ml cans, Mango juice, pineapple juice, litchi juice, orange juice, guava juice and canned fruits and jams both in 800ml and 4000ml. Sikkim Supreme products have huge demand in United States of America and other countries. Sikkim Supreme has started rolling its Organic Product range also.

2. TEMI TEA ESTATES

Temi estate is only organic tea estate in the upper Himalaya region of Sikkim. It was established in the year 1969.

3. An integrated ginger processing unit has been operationalised in Sikkim which is expected to be a major turning point to take ginger cultivation to further heights.

4. An integrated mushroom unit has been set up in the State to promote mushroom cultivation.

5.Sikkim Marketing Federation (SIMFED) was linked up directly with the farmers for marketing of the husked corn at the farm gate itself which was later processed and canned at Sikkim Fruit Preservation Factory, Singtam.

6. Bee keeping has developed into a popular diversification in Sikkim. Bee boxes have been distributed to households all over the State.

7.The Horticulture & Cash Crop Development secretary said integrated processing units would be set up by next year-end under under Sikkim-IFFCO Joint Venture.

8. Government has planned for setting up of turmeric drying and processing unit in the state for value addition.

Value Addition Story

After 2018, only processed products will be sent out of Sikkim. Sikkim has clustered areas for growing these above said crops, which will be grown by farmer grower groups and is trying to create an organic value linked chain for these groups. However, not every crop can be processed and marketing of fresh produce such as fruits and vegetables remains a challenge and the government is supporting in collection, transportation and storage of food.

1.Considerable quantity of fruits, chillies etc including mandarins are consumed by Government Fruit Preservation Factory located at Singtam, East Sikkim. Orange squash ‘Sikkim Supreme’ is a famous product of this factory.

SIKKIM SUPREME Bamboo Shoot pickles, Dalle chilli pickles, Dalle in Vinegar, Kiwi Jam, Passion fruit Squash, Orange Squash, and Pineapple Squash.

2. Canning and preservation of Baby corn was done on a pilot project by SIMFED. SIMFED is already working on this area in association with SIKKIM SUPREME. There already exists lot of demand for baby corn in the hotels of the state. Domestic demand will also increase owing to the changing food habit of local population. It is expected that organically grown baby corn from Sikkim will find its place in international market in near future.

3. Department of Horticulture has also introduced the var. Lakardang from Meghalaya in the state. In addition to improved yield, the introduced variety also contains higher (7-9 %) curcumin content.

4. Turmeric powder from Sikkim is already been marketed by SIMFED, Sikkim. They are concentrating on bringing more Value Added products in Turmeric like Turmeric latte powder, Turmeric Soaps, Turmeric beauty products like soaps and lotions, Turmeric paste etc.

5.Ginger powder and Ginger Candy is already been marketed by SIMFED, Sikkim. Value Added products in Ginger like Ginger powder, Ginger Churan, Ginger Candy, Ginger Toffee, Ginger pastes etc are being made and marketed by SIMFED. Different products like ginger oil, ginger oleoresin can be prepared for export, which are very common in developed countries are being researched into. The varieties with less fibre, high dry matter recovery, and high oil and oleoresin contents are having great export potential in international markets.

6.Different Value added products of Buckwheat Flour, Buckwheat cookies, Bread

The flour of buckwheat is used as bread, 'dhenro' and a considerable amount is malted to prepare liquor. Dehusked buckwheat is taken as food. In Western countries it is used as animal feed, poultry feed and used for green manuring. Since the crop flowers profusely it is also used in bee keeping as bees collect nectar from this crop and the honey from such bees have enhanced antioxidant properties.

7.Young entrepreneurs like Abhinandan Dhakal has an organic business growing and selling Peruvian ground apple, or yacon, a crisp, sweet-tasting tuber. Yacon is a high-value product that is often eaten raw or consumed for its health benefits in the form of syrup and powder. Dhakal's Shoten Network Group has tied up with marketing firms in Bangalore and Delhi to sell yacon to retailers and pharmaceuticals companies both inside and outside India.

8.Dharni Sharma, organic farmer from Linkey in east Sikkim, said growing Peruvian ground apple had "brought a refreshing change.

9.Mevedir a Sikkim-based company that offers farmers services such as export and processing, said the shift to organic agriculture could lure back young people who had left for urban centres to find work in recent years.

Thrust Areas to be Worked on

The 85 per cent of land in Sikkim is forest land. A little over 11 per cent land is agricultural. Sikkim Government is working on bottle neck problems like transporting produce to market, because the tiny landlocked state has no airport nor railway station. Thrust areas needed for improvement is proper facilities like refrigeration, processing equipment and packaging materials. The necessity of bridging the gap to bring more reforms in the agri marketing system in the state both operational and infrastructure which could help in creating an enabling condition for state producers to take benefit of marketing of organic products.

More importantly nothing is perfect and we still have much to learn. A lot of things are possible through optimism and hard work. Sikkim is working to update the "Sikkim Organic Mission" and we can only thank "Sikkim Organic Mission" for providing stakeholders certain fundamentals.

SECOND PHASE OF THE Sikkim Organic Mission

Sikkim to become the first fully organic state in the country by banning the entry and sale of 26-odd non-organic horticultural and agricultural products.

Consolidating its organic stance further, the government of Sikkim has recently announced a ban on the supply of all perishable vegetables, mangoes and bananas into the state, from March 31 onwards. The ban forms the 2nd phase of the state's *Organic Mission*. Following the 2nd phase, after 2019, Sikkim will also ban onions and potatoes, as well as, livestock products from outside the state, in its endeavour to remain a 100% chemical free.

FSSAI, labelling, packaging and Marketing of Organic Produce

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1. Introduction

In recent years, the Government of India has come up with policy initiatives to promote organic food for domestic market and exports. Such measures are expected to increase investment in organic food manufacturing and retailing, and create employment. Indian entrepreneurs have responded positively to these initiatives and a number of start-ups have come up in this sector. Many conventional food manufacturers, retailers, and exporters have diversified their businesses to include organic food products. India's trade in organic food products has also increased (Mukherjee et al., 2017). Globally, there is growing awareness of environmental protection, sustainable agricultural practices, and the adverse impact of chemical inputs on the soil, environment and human health. This has prompted a shift towards organic farming and consumption of organic food.

In India, the traditional method of agriculture was by default organic with negligible use of chemical inputs. However, the need to ensure food security led to the Green Revolution, which began in 1967.While India reached self-sufficiency in food grain production (Singh, 2000; Pearse, 1980), post-Green Revolution, the excessive use of chemical inputs resulted in the rapid degradation of soil (Murgai et al.,2001; Singh, 2000) and adversely impacted farmers' health (Mittal et al., 2014). From a consumer perspective, the increasing quantities of pesticides and fertilizers led to contamination of food and associated health damage (Pandey and Singh, 2012). In the 1970s and 1980s, when consumers in the developed countries were shifting towards organic food products, the demand for products like organic tea and spices in key export markets such as the US, United Kingdom (UK), Germany, and Japan increased.

To understand the government policies and initiatives to support organic food business, it is important to look at the institutional framework and governance structure. India follows a quasi-federal governance structure with a division of responsibility between the Centre and states. According to the Indian Constitution, "agriculture" is under the state list and, therefore, is under the jurisdiction of the state governments. The central government provides broad policy directions, negotiates trade agreements (including on agriculture), and provides support and subsidies for the promotion of the agricultural sector and trade.

At the Centre, the Ministry of Agriculture and Farmers' Welfare is the nodal authority for the promotion of agriculture and farmers' welfare, while the Ministry of Food Processing Industries is the nodal ministry for food processing. The Agricultural & Processed Food Products Export Development Authority (APEDA) under the Ministry of Commerce and Industry is the nodal agency for designing policies related to organic food exports. The Food Safety and Standards Authority of India (FSSAI),under the Ministry of Health and Family Welfare, is the nodal authority for designing policies related to organic food imports and domestic food business (Mukherjee et al., 2017).

2. FSSAI and its role

Food Safety and Standards Authority of India (FSSAI) is an autonomous body established under the Ministry of Health & Family Welfare, Government of India. The FSSAI has been established under the Food Safety and Standards Act, 2006 which is a consolidating statute related to food safety and regulation in India (FSSAI, 2012). FSSAI is responsible for protecting and promoting public health through the regulation and supervision of food safety. It ensures the food products undergo quality checks thereby curtailing the food adulteration and sale of sub-standard products.

FSSAI lays down science-based standards for articles of food and regulates their manufacture, storage, distribution, sale and import to ensure availability of safe and wholesome food to 130 crore citizens of the country. The authority is also responsible for creating an information network across the country so that the public, consumers, etc. receive rapid, reliable and accurate information about food safety and hygiene and related issues of concern.

- Framing of regulations to lay down food safety standards.
- Laying down guidelines for accreditation of laboratories for food testing.
- Providing scientific advice and technical support to the Central Government.
- Contributing to the development of international technical standards in food.

- Collecting and collating data regarding food consumption, contamination, emerging risks etc.
- Disseminating information and promoting awareness about food safety and nutrition in India.

The FSSAI has its headquarters at New Delhi. The authority also has 6 regional offices located in Delhi, Guwahati, Mumbai, Kolkata, Cochin, and Chennai, 14 referral laboratories notified by FSSAI, 72 State/UT laboratories located throughout India and 112 laboratories are NABL accredited private laboratories notified by FSSAI (FSSAI, 2012).

3. Regulations of FSSAI

3.1. Food Safety and Standards (Organic Foods), 2017

3.1.1. **Food Safety and Standards Act, 2006 (34 of 2006)**

- "Accredited Certification Body" means organization duly accredited by an Accreditation body for certification of organic products and for granting the right to use the certification mark to the food business operators on behalf of the Accreditation body;
- "Claim" means any representation which states, suggests or implies that a food has particular qualities relating to its origin, nutritional properties, nature, processing and composition;
- "Food Authority" means the Food Safety and Standards Authority of India established under section 4 of the Food Safety and Standards Act, 2006;
- "National Programme for Organic Production" means a programme of the Government of India which provides an institutional mechanism for implementation of the National Standards for Organic Production with a third party certification control system as notified by the Director General of Foreign Trade under the Foreign Trade (Development and Regulation) Act, 1992(22 of 1992);
- "Organic food" means food products that have been produced in accordance with specified standards for organic food production;
- "Participatory Guarantee System for India" means a quality assurance initiative by the Department of Agriculture Co-operation and Farmer‘s Welfare, Ministry of Agriculture and Farmer‘s Welfare, Government of India for organic production which emphasizes the participation of producers, consumers and other stakeholders and operate outside the framework of third party certification.

3.2. FSSAI Regulations for Certification: Organic Food

FSSAI operationalized the Food Safety and Standards (Organic Food) Regulation, 2017[2]. The regulation recognizes both NPOP (National Programme for Organic Production) and PGS-India (Participatory Guarantee System for India) as certified organic products[2]. However, in addition to this, the packaged food will require meeting both the conventional food standards and organic food standards. The key features of this regulation include the following:

No person can manufacture, pack, sell, offer for sale, market, distribute or import any organic food products unless they comply with the regulations; Organic foods should comply with provisions from at least one of the following, NPOP, PGS-India or Other system or standards notified by the Food Authority

- Organic food that is marketed through direct sales by the small original producer or producer organization is exempted from the provisions.
- Organic labeling requirements should be accurate, in addition to the standard labeling requirements.
- Traceability should be established up to the producer level.
- All organic foods should comply with the Food Safety and Standards (Food Product Standards and Food Additives) Regulation 2011, and the Food Safety and Standards (Contaminants, Toxins, and Residues), Regulations, 2011.
- Sellers of organic foods will be required to display organic food items in a distinguishable manner from conventional food items.
- Organic food imports under bilateral or multilateral agreements on the basis of the equivalence of standards between NPOP and the organic standards of the exporting countries shall not be required to re-certify on import.

All organic food consignments should be accompanied by a Transaction Certification (TC) issued by an accredited certification body covered under the terms of equivalence agreement.

3.3. Quality Assurance

FSSAI has been mandated to perform various functions related to quality and standards of food. These functions in addition to others include “Laying down procedure and guidelines for notification of the accredited laboratories as per ISO17025.” The FSSAI notified laboratories that are classified as FSSAI notified NABL accredited labs- 112, State Labs-72 and Referral Labs-14.

3.4. FSSAI Standards

Standards framed by FSSAI are prescribed under Food Safety and Standards (Food Product Standards and Food Additives) Regulation, 2011, Food Safety and Standards (Packaging and Labelling) Regulation, 2011 and Food Safety and Standards (Contaminants, Toxins, and Residues) Regulations, 2011.

The FSSAI has prescribed standards for following food products:

- Dairy products and analogues
- Fats, oils and fat emulsions
- Fruits and vegetable products
- Cereal and cereal products
- Meat and meat products
- Fish and fish products
- Sweets & confectionery
- Sweetening agents including honey
- Salt, spices, condiments and related products
- Beverages, (other than dairy and fruits & vegetables based)
- Other food product and ingredients
- Proprietary food
- Irradiation of food

4. FSSAI licensing & registration

FSSAI issues three type of license based on food business and turn over

- Registration: Turn over less than12 lakhs per annum
- State FSSAI license: Turnover 12 lakhs to 20 crore per annum
- Central FSSAI license: Turn over more than 20 Crore

4.1. Punishment for carrying on business without FSSAI license

The Food Safety and Standards Act, 2006 strictly prohibits any person or food business operator to engage into manufacturing, selling, distribution or imports of any food product without FSSAI license, punishment with imprisonment for 6 months and also with a fine upto Rs. 5, 00,000.

5. Packaging and Labelling of Food Products

In the food and beverage packaging, there is one important aspect called food labelling. On the food labelling, there are crucial aspects related to the product and even of the producer.

F.No. 2-15015/30/2010 Whereas in exercise of the powers conferred by clause (k) of subsection (2) of section 92 read with section 23 of Food Safety and Standards Act, 2006 (34 of 2006) the Food Safety and Standards Authority of India proposes to make Food Safety and Standards Regulations in so far they relates to Food Safety and Standards (Packaging and Labelling) Regulations, 2011.

The information is usually for the safety of the consumer and it is mandatory that every packaged food article has to be labeled and it shall provide the following information.

5.1. General Requirements for packaging

(a)A utensil or container made of the following materials or metals, when used in the preparation, packaging and storing of food shall be deemed to render it unfit for human consumption:

- containers which are rusty;
- enameled containers which have become chipped and rusty;
- copper or brass containers which are not properly tinned
- containers made of aluminium not conforming in chemical composition to IS:20 specification for Cast Aluminium & Aluminium Alloy for utensils or IS:21 specification for Wrought Aluminium and Aluminium Alloy for utensils.

(b)Containers made of plastic materials should conform to the following Indian Standards Specification, used as appliances or receptacles for packing or storing whether partly or wholly, food articles namely :—

i. IS : 10146 (Specification for Polyethylene in contact with foodstuffs);
ii. IS : 10142 (Specification for Styrene Polymers in contact with foodstuffs);
iii. IS : 10151 (Specification for Polyvinyl Chloride (PVC), in contact with foodstuffs);
iv. IS : 10910 (Specification for Polypropylene in contact with foodstuffs);
v. IS : 11434 (Specification for Ionomer Resins in contact with foodstuffs);
vi. IS: 11704 Specification for Ethylene Acrylic Acid (EAA) copolymer.
vii. IS: 12252 - Specification for Poly alkylene terephathalates (PET).
viii. IS: 12247 - Specification for Nylon 6 Polymer;
ix. IS: 13601 - Ethylene Vinyl Acetate (EVA);

x. IS: 13576 - Ethylene Metha Acrylic Acid (EMAA);

xi. Tin and plastic containers once used, shall not be re-used for packaging of edible oils and fats;

(c)General packaging requirements for canned products, All containers shall be securely packed and sealed. The exterior of the cans shall be free from major dents, rust, perforations and seam distortions. Cans shall be free from leaks.

Product specific requirements

5.2.Packaging requirements for Milk and Milk Products

(a) Bottling or filling of containers with heat-treated milk and milk product shall be carried out mechanically and the sealing of the containers shall be carried out automatically.

(b) Wrapping or packaging may not be re-used for dairy products, except where the containers are of a type which may be re-used after thorough cleaning and disinfecting.

(c) Sealing shall be carried out in the establishment in which the last heat-treatment of drinking milk or liquid milk-base products has been carried out, immediately after filling, by means of a sealing device which ensures that the milk is protected from any adverse effects of external origin on its characteristic. The sealing device shall be so designed that once the container has been opened, the evidence of opening remains clear and easy to check.

(d) Immediately after packaging, the dairy products shall be placed in the rooms provided for storage.

5.3. Packaging requirements for Edible oil/ fat

Tin Plate used for the manufacture of tin containers for packaging edible oils and fats shall conform to the standards of prime grade quality contained in B.I.S. Standards No. 1993 or 13955 or 9025 or 13954 as amended from time to time and in respect of Tin containers for packaging edible oils and fats shall conform to IS No. 10325 or 10339as amended from time to time.

5.4. Packaging requirements for Fruits and Vegetables Products

(i) Every container in which any fruit product is packed shall be so sealed that it cannot be opened without destroying the licensing number and the special identification mark of the manufacture to be displayed on the top or neck of the bottle.

(ii) For Canned fruits, juices and vegetables, sanitary top cans made up of suitable kind of tin plates shall be used.

(iii) For Bottled fruits, juices and vegetables, only bottles/ jars capable of giving hermetic seal shall be used.

(iv) Juices, squashes, crush, cordials, syrups, barley waters and other beverages shall be packed in clean bottles securely sealed. These products when frozen and sold in the form of ice shall be packed in suitable cartons. Juices and Pulps may be packed in wooden barrels when sulphited.

(v) For packing Preserves, Jams, Jellies, and Marmalades, new cans, clean jars, new canisters, bottles, chinaware jars, aluminium containers may be used and it shall be securely sealed.

(vi) For Pickles, clean bottles, jars, wooden casks, tin containers covered from inside with polythene lining of 250 gauge or suitable lacquered cans shall be used.

(vii) For Tomato Ketchups and Sauces, clean bottles shall be used. If acidity does not exceed 0.5% as acetic acid, open top sanitary cans may also be used.

(viii) Candied fruits and peels and dried fruits and vegetables can be packed in paper bags, cardboard or wooden boxes, new tins, bottles, jars, aluminium and other suitable approved containers.

(ix) Fruits and Vegetable products can also be packed in aseptic and flexible packaging material having good grade quality conforming to the standards laid down by BIS.

5.5. Packaging requirements for Canned Meat Products

(i) New sanitary top cans made from suitable kind of tin plate shall be used. The cans shall be lacqueredinternally; they shall be sealed hermetically after filling. The lacquer used shall be sulphur resistant and shall not be soluble in fat or brine.

(ii) Cans used for filling pork luncheon meat shall be coated internally with edible gelatin, lard or lined with vegetable parchment paper before being filled.

5.6. Packaging requirements for Drinking Water (Both Packaged and Mineral Water)

It shall be packed in clean, hygienic, colourless, transparent and tamperproof bottles/containers made of polyethylene (PE) (conforming to IS:10146 or polyvinyl chloride (PVC) conforming to IS : 10151 or polyalkyleneterephthalate (PET and PBT) conforming to

IS : 12252 or polypropylene conforming to IS : 10910 or foodgradepolycarbonate or sterile glass bottles suitable for preventing possible adulteration or contamination of the water.

All packaging materials of plastic origin shall pass the prescribed overall migration and colour migration limits.

6. General Requirements for Labelling

1. Every pre-packaged food shall carry a label containing information as required here under unless otherwise provided, namely,—

2. The particulars of declaration required under these Regulations to be specified on the label shall be in English or Hindi in Devnagri script:

Provided that nothing herein contained shall prevent the use of any other language in addition to the language required under this regulation.

3. Pre-packaged food shall not be described or presented on any label or in any labelling manner that is false, misleading or deceptive or is likely to create an erroneous impression regarding its character in any respect;

4. Label in pre-packaged foods shall be applied in such a manner that they will not become separated from the container;

5. Contents on the label shall be clear, prominent, indelible and readily legible by the consumer under normal conditions of purchase and use;

6. Where the container is covered by a wrapper, the wrapper shall carry the necessary information or the label on the container shall be readily legible through the outer wrapper and not obscured by it.

6.1. Labelling of Pre-packaged Foods

Name of the food: Name of the food/product is one of the first FSSAI Guidelines on Labelling of Food Products. As the name suggests, the name of the food product should be in clear format on the packaged product in clear font.

List of Ingredients: List of Ingredients means the elements which have been utilized for making the final product. It is very necessary that the manufacturer mentions all the ingredients fairly and do not cheat the end-consumer. The manufacturer can land in problem if tends to cheat the consumer.

Nutritional Information: Nutritional Information means the calories which gets from fats, saturated fat, trans fat, cholesterol, sodium, carbohydrates, dietary fiber, sugars, protein, vitamin A, vitamin C, calcium, and iron present in the product. The calories are mentioned on all the products labels.

Declaration regarding Vegetarian or Non-Vegetarian: India is land where the eating of non-vegetarian for some is against the religious practices. Hence, according to the FSSAI Guidelines on Labelling of Food Products, the manufacturer on the label should mention whether the product is vegetarian or non-vegetarian. Whether the product is vegetarian or non-vegetarian can easily be known by just looking at the small sign present on the corner of the label. Green colour indicates the product being vegetarian and red colour indicates that the product is non-vegetarian.

Declaration regarding Food Additives: Food additives are substances which are added to food in order to preserve flavor or enhance its taste and appearance. Hence, it is very necessary to give a declaration regarding the additives added on the label or the package.

Name and Address of the Manufacturer: In this, the name of the manufacturer and place of the manufacturing is usually mentioned. The manufacturer has to give complete address of his factory which includes street address, city, state, and zip code. Without mentioning any of these, products can be considered fake in the market.

Net Quantity: Net Quantity is also FSSAI Guidelines on Labelling of Food Products. Net Quantity here refers to the weight of the product. The weight of the product and the packaging weight are usually combined together and then mentioned in the Net Quantity.

Code No. /Lot No. /Batch No: A batch number or code number or lot number is a mark of recognition through which the food can be found in the manufacture and even recognized in the distribution. Therefore, the Code No. /Lot No. /Batch No should be definitely mentioned by the manufacturer according to FSSAI Guidelines on Labelling of Food Products.

Date of Manufacture and Best before & Use by Date: The date of manufacture is when the product has been manufactured and best before & Use by Date means by what date and month should the product be consumed. If the product is consumed after expiry date, it usually can harm the health of the human.

The consumer also should check Date of Manufacture and Best before & Use by Date before purchasing the product.

Country of Origin for Imported Food: The country of origin of goods means the nationality of imported goods and even refers to the area where such goods have grown up or have been produced, manufactured or processed.

According to the FSSAI Guidelines on Labelling of Food Products, this also should be mentioned.

Instructions for Use

According to FSSAI Guidelines on Labelling of Food Products, the Instructions for Use should be mandatorily mentioned. As the name suggests, it usually instructing or guiding the consumer on how to utilize the product.

7. Marketing Organic Produce

The organic markets in India are largely spread across the food and beverages, health and wellness, beauty and personal care and textile industries. The highest growth is observed in the organic food segment, followed by textile, beauty and personal care. The current Indian domestic market is estimated at INR 40,000 million which is likely to increase by INR 100,000 million - INR 120,000 million by 2020 with a similar increase in exports. Organic packaged food and beverages is an emerging niche market in India and its primary consumers are high-income urbanites. The total market size for organic packaged food in India in 2016 was INR 533 million, growing at 17% over 2015, and is expected to reach INR871 million by 2021. India's exports of organic products increased by 17% between 2015-16 and 2016-17.

India currently holds the ninth position among 178 countries that actively practice organic agriculture. At present, the country is home to more than 835,000 organic producers, 699 processors, 669 exporters and 1.49 million ha area under organic cultivation. However, with only a meager 0.4% of the total agricultural land area designated for organic cultivation, the industry presents extensive scope for expansion. There was an increase in area at a (compound annual growth rate) CAGR of 6% from 2010- 11 to 2015-16 and absolute growth of 29% during the same period. It is likely to grow at a rate of 8% -10% till 2020 Among the states, Madhya Pradesh has the largest area under organic certification (4.62 lakh ha) followed by, Maharashtra (1.98 lakh ha) Rajasthan (1.55 lakh ha), Telangana (1.04 lakh ha), Odisha (0.96 lakh ha), Karnataka (0.94 lakh ha), Gujarat (0.77 lakh ha) and Sikkim (0.76 lakh ha). These states had a combined share of 90% of the area under organic certification in 2015-16.

There are more than 2.7 million organic producers globally, with India having the maximum share (835,00 farmers), followed by Uganda (210,352 farmers) and Mexico (210,000 farmers). More than 84% of the producers are in Asia, Africa, and Latin America. In terms of organic area cultivation, the highest area is in Oceania (27.3 million ha), Europe (13.5 million ha) and Latin America (7.1 million ha).

In terms of trade, India ranked 11 with a share of 3.6 per cent in global organic food exports. In 2016-2017, export of organic products from India was valued at USD 370 million, which increased by approximately 17.5 per cent compared to 2015-2016. Data on India's import of organic products is not available. Some of the key organic products that are exported from India include oilseeds, cereals and millets, tea, pulses, and spices.

7.1. Trade in organic products

Out of the 75 companies that were surveyed, 39 companies are engaged in exports and 6 companies are engaged in imports. The survey found that there are certain products like organic tea, organic rice, and organic spices, which have a high demand in the export market. Comparatively, export of organic herbs(in fresh format), and fresh fruits and vegetables is low.

Out of the 39 companies, 25 companies are exporting only one product, out of which 21 are in tea, two are in rice, and one each is in spices, and fruits and vegetables respectively. Four companies are exporting across two product categories, and the remaining nine are dealing with three or more product categories. The EU is the largest export market and within the EU, the UK is the largest market followed by Germany. Other key markets are the US, Canada, and Southeast Asia. Japan and Korea are new and growing markets but the certification process in these countries is more difficult.

The domestic market for organic products, although growing at a fast pace, is still nascent. Companies try to publicize their products through fairs and exhibitions, and a number of state governments, such as Karnataka Government through its "Organics & Millets 2018 International Trade Fair", are supporting such exhibitions. Processors with well-developed supply chain and ability to cater to a large demand are selling their products through multi-brand retailers, while smaller players are trying other modes such as selected health stores, standalone organic retail outlets, and home delivery through telephone order or websites.

Companies, on an average, forecast a growth rate of approximately 14 per cent in the organic food market in India in the current year, and an annual growth rate of 20 per cent in the next five years. This indicates that the organic market is a fast growing market in India.

8. Benefits of an FSSAI License

A food license issued by the FSSAI is regarded as a permit which is required to operate a food-related business and also in order to ensure good quality of food in your business and for the benefits one from government actions on non-compliances.

Consumer awareness

In this age of information technology, consumers are becoming more aware about food quality and its standard and hygiene. Before purchasing any food from outside consumers prefer to have food which is FSSAI compliant which them more assurance in aspect of the food quality, free of any contamination, adulteration. In addition to this, this gives the consumer a valid proof to complain if there is anything wrong with the food which is sold. So with the fear of legal actions there is very less chance of food quality being poor amongst the sellers having food safety license. Thus having a Food Business Registration gives you a clear advantage to increase the consumer base at a faster rate.

Legal Advantage

Generally all feel that getting a food license must be a tedious job with lot of complications involving paper-work and excess documentation and also time consuming. Also there is this false notion that a lot of money is needed to get a food license. So instead of getting a food license would be a great loss to a new business. But the reality is exactly antithesis (opposite) of this. Food license can be easily obtained by paying nominal fees through various FSSAI License consultants. In fact, hefty penalty is imposed on the business which is being done without a food license. This cost is very large as compared to getting a Food license which also gives you a authorized registration proof.

Using the FSSAI Logo

FSSAI issues license to only those business which have a minimum hygienic standards. So if you have a food license you can show it on the menu-cards, pamphlets, packing bags etc. FSSAI logo on the food item will give your product a superior quality over others. FSSAI license has a valid FSSAI number which gives customers more assurance about the standard of the food. Nowadays customers purchase only that food item which has a FSSAI logo and a number. So it increases your customer base by a very good margin.

Business Expansion

Every new business started is desirous to expand its business to new places and explore a new market or a customer base. But starting a business at a new location, the customer should feel safe to purchase a new product. If you possess a valid food license it becomes much easier to expand the business at new areas or open new outlets. In addition to this, it will make it easier to get a loan or any funding required to expand the business as it gives a sense of assurity to the person or bank giving loan. It is reported that India has over 5 crore food businesses but only 33 lakh out of it have a valid food license. So considering, this ratio possessing food license gives a new direction to your business to expand even more and in a short time.

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Soil strength improvement by organic methods

SUBHASH RAMCHANDRA NALANGE

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INTRODUCTION

In this advanced age of science and technology, man has made rapid strides in agricultural sector. All human technologies helped in rapid production of agricultural produce but it had several bad impacts on environment.

Excess use of pesticides and chemical fertilizers damage soil health and human health as well extremely. Now a day we are focusing on only plant health and productivity no one care about soil health and the quality of food we are producing. Many people suffering from cancer due to accumulation of toxic pesticides through their food.

Excess use of chemical in agriculture land leads to death of microbes as we as insect who are maintaining the fertility of land. Further these chemicals up-taken by the plants results in formation of toxic produce and land also become infertile cannot produce anything without external support of nutrients.

Now people getting more conscious about health and preferring organic food only. So, there is need of change in farming system. There are many natural techniques which can maintain soil fertility and helps in improving soil strength as well in very low cost.

PRINCIPLE OF ORGANIC FARMING

Principle of health

Organic Agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible.

The role of organic agriculture, whether in farming, processing, distribution, or consumption, is to sustain and enhance the health of ecosystems and organisms from the smallest in the soil to human beings. In particular, organic agriculture is intended to produce high quality, nutritious food that contributes to preventive health care and well-being. In view of this it should avoid the use of fertilizers, pesticides, animal drugs and food additives that may have adverse health effects.

Principle of Ecology

Organic Agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.

Organic agriculture should attain ecological balance through the design of farming systems, establishment of habitats and maintenance of genetic and agricultural diversity. Those who produce, process, trade, or consume organic products should protect and benefit the common environment including landscapes, climate, habitats, biodiversity, air and water.

Principle of Fairness

Organic Agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities.

This principle emphasizes that those involved in organic agriculture should conduct human relationships in a manner that ensures fairness at all levels and to all parties - farmers, workers, processors, distributors, traders and consumers. Organic agriculture should provide everyone involved with a good quality of life, and contribute to food sovereignty and reduction of poverty. It aims to produce a sufficient supply of good quality food.

Principle of Care

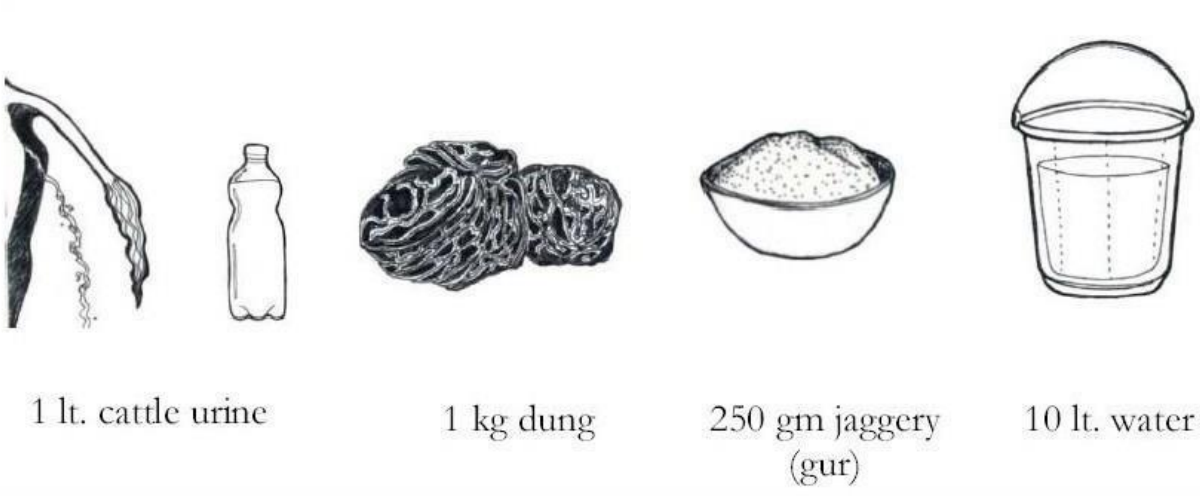
Organic Agriculture should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment.

Science is necessary to ensure that organic agriculture is healthy, safe and ecologically sound. However, scientific knowledge alone is not sufficient. Practical experience, accumulated wisdom and traditional and indigenous knowledge offer valid solutions, tested by time. Organic agriculture should prevent significant risks by adopting appropriate technologies and rejecting unpredictable ones, such as genetic engineering. Decisions should reflect the values and needs of all who might be affected, through transparent and participatory processes.

APPLICATION IN ORGANIC FARMING

Amudham Solution

<u>Ingredient</u>



<u>Preparation</u>

- Mix the dung thoroughly in water. Add urine in it and mix well.

- Powdered the jaggary and dissolve it in small quantity of water or urine and the above and mix it well.
- Make sure there is no lump in solution.
- Cover the set mixture aside for 24 hours in shade.

Use

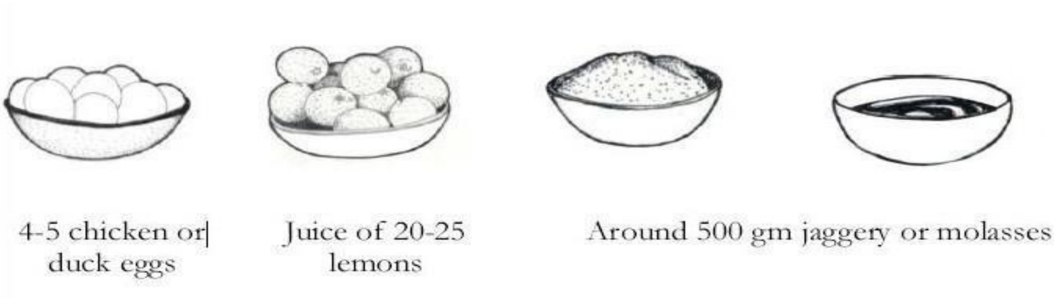
This solution helps in growth promotion activity in leaves directly. It also repels insects.

Note

Make 10% solution for foliar spray. Solution must be diluted otherwise leaves can be get scorched.

Egg extract

Ingredient



Preparation

- Cut and squeeze the lemons into a bucket.
- Empty the juice in a plastic/ glass or mud jar and place the eggs inside it in such a way that all the eggs are well immersed inside the lime solution. Never use metal container.
- Close the jar with an airtight lid and keep it in the shade for about 10 days.
- On the 10th day, the eggs along with the shells inside the solution would have become rubbery, like a rubber ball. Use your hands to mix the eggs (along with the shell) in the lime solution.
- Take about 250 gms of jaggery and boil it in 1/2 liter of water. Once the jaggery dissolves, keep it aside and let it cool.
- After thorough mixing, add this lime-egg solution to the jaggery solution and let it ferment for 10 more days.
- For example, if there is 2 liters of lime egg solution, then add 2 liters of jaggery solution; if there is 3 liters of lime egg solution, add 3 liters of jaggery solution and so on.

Use

About 10 to 50 ml of the formulation can be diluted in 10 liters of water and sprayed. The concentration varies according to the growth of the crop. This solution is a great nutrient for the plants and will boost plant growth.

Note

This formulation can be sprayed for any crops such as paddy, wheat, banana, vegetables, greens and fruit trees. It is important that the spraying be done either in the morning or late evening.

Fish extract

It is fermented mixture of fish or fish extract and jaggary solution. Fermented liquid extract obtain after 30 days can be used as growth regulator.

Ingredient

- Fish or fish waste
- Jaggary
- Water

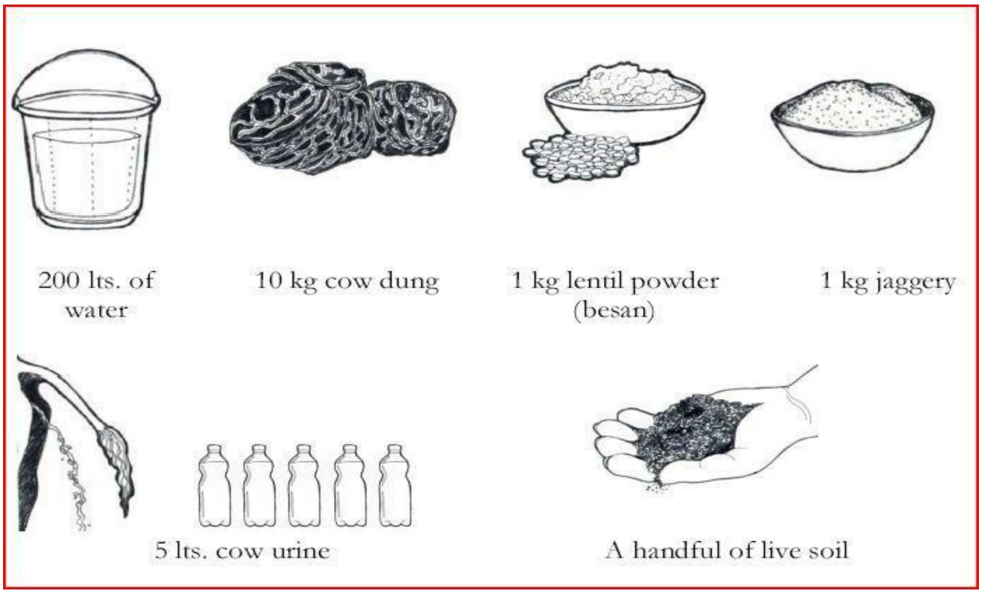
Preparation

- ➢ Chop the fish into fine pieces.
- ➢ In a container that is just the size, measure the same quantity of fish, jaggery or molasses: For 1 kg fish, 1 kg jaggery. For 1 kg of fish waste, add 11/2 kg of jaggery.
- ➢ Tie the mouth of the container with the piece of jute or cotton cloth to prevent the entry of flies and place the container out of the house and far away from animals, as during the first four days, the bad smell of the preparation can be very attractive for them.
- ➢ On the 5th day and during the next 20-30 days, you have to stir the mix once a day every day. During this time, you will notice how the smell changes from bad to sweet.
- ➢ By around the 10th day, the solution will be fermented but you can keep it 15-20 days more. You can judge by the smell: when the smell disappears, the solution is ready to use.
- ➢ Decant the solution through a strainer and the filtrate looks like honey-like syrup.
- ➢ Keep the filtrate in a glass jar or another container with cover and close it tight. The extract will remain in good condition for 6 months.
- ➢ If you use fresh fish in 1" pieces, you can use these a second or third time to prepare the solution, but fish waste can be used only once. Every time you have to add an equal quantity of jaggery to the remaining fish and keep it for fermentation for 15-20 days.
- ➢ Use

It is a rich source of amino acids, microbes, micro and macro nutrients which also help to enhance the soil fertility. it contains desirable macro (N, K, Ca, Mg, P and S) and micro elements (Cl, Fe, B, Mn, Zn, Cu, Mo and Ni) found in the viscera and head of fish.

Jivamrut

Ingredient



Preparation

- ➢ Add 10 kg cow dung, 5 liters. of cow urine, 1 kg black jaggery, 1kg lentil powder, handful of soil in 200 liters. of water. First lentil powder and jaggery are mixed and then cow dung is added.
- ➢ Keep the solution for 2 to 7 days in the shade or fermentation. The lid should be kept loose or should have holes for gases to escape.
- ➢ During the fermentation, the solution is stirred daily.

Use

For a liquid foliar spray. Apply 5% to 10% in water, and for soil, use 100-200 liter. per acre during irrigation. According to growth of the crop and convenience one can use it once at an interval of 7 – 15 days.

Note

Spray during dawn or dusk on any crop, for promoting growth, flowering and yield increase.

Buttermilk Arappu Solution

Ingredient

- 5liters of buttermilk
- 1-liter tender coconut water
- 1-2 kg arappu leaves (Albizia amara) or, 250-500 gm leaf powder

- 500 gm fruits reject or one liter of juice made out of fruit rejects
- 100 gms of turmeric powder
- 10-20 gems of asafoetida

Preparation

- Mix the buttermilk, tender coconut water, turmeric powder and asafoetida powder.
- Crush the leaves well.
- If you are using fruits rejects, add it to the crushed leaves and put this mixture in a nylon mesh and tie it.
- Immerse the mesh in buttermilk-tender coconut solution.
- If you are using arappu leaf powder, use fruit juice instead of fruit rejects.
- Mix all four ingredients and let the mixture ferment for seven days.
- By using the nylon mesh, we could avoid the need for filtering the solution while spraying.

Use

This helps plant growth, repels insects and adds resistance against fungal diseases.

Note

Mix ten liters of water with half to one liter of solution and spray. For irrigation, use 5-10 liters of water solution per acre.

Buttermilk – Coconut Solution

Ingredient

- 5-liter buttermilk
- 1-liter tender coconut water
- 1-2 coconuts
- Asafoetida powder 10-20 gm
- Turmeric powder 100 gm
- 500 ml - 1-liter juice from waste fruit

Preparation

- Mix the buttermilk, tender coconut, turmeric powder and asafoetida powder.
- Grate the coconuts, add to the mixture and let it soak. Or, mix grated coconut and fruit (if not in juice form).
- Put the mixture in a nylon mesh and tie it.
- Immerse it in the buttermilk solution. This solution ferments well in seven days.
- The contents of the nylon bag could be reused a few times in subsequent solutions by adding a small quantity of grated coconut every time.

Use

It helps enhance plant growth, repel insects and increase resistance to fungal diseases. Also, it enhances flowering in plants. This solution has the same growth enhancing potential as that of any other chemicals.

Note

Mix 10 liters of water with 1/2 to one-liter solution and spray. This can also be used in irrigation at the rate of 5-10 liters per acre.

Panchagavya

Ingredient

- 2 liters of toddy, papaya or grape juice
- 2 liters of cow milk
- 3 liters of tender coconut water
- 3 liters of cow urine
- 1/2 liter of cow ghee
- 2 liters of cow curds
- 3 liters of sugarcane juice or 1 kg jaggery
- 12 ripe bananas

Preparation

- For preparing Panchagavya, we need a wide-mouthed mud pot, concrete tank or plastic cans.
- Put the fresh cow dung, cow ghee and sugar cane juice or jaggery into the container and mix thoroughly twice daily for four days. Cover it with a wet cloth to avoid drying up of the mixture in shade.
- On the fifth day, add the rest of the ingredients and stir twice daily for 15 days.
- The Panchagavya stock solution will be ready after the 20th day.
- It should be stored in the shade and covered with a wire mesh or plastic mosquito net to prevent house flies from laying eggs and the formation of maggots (worms) in the solution.
- If sugarcane isn't available, add 1 kg of jaggery dissolved in 3 liters of water. Likewise, if toddy isn't available, add 100 grams of yeast powder and 100 grams of jaggery to 2 liters of warm water. After 30 minutes, add this solution to replace toddy.
- Another method is to take 2 liters of tender coconut water + 100 grams of jaggery and keep this in a closed plastic container for 10 days. After fermentation, it becomes toddy. This solution can be prepared beforehand and used to replace toddy.
- When stirred twice daily, the Panchagavya solution can be kept for six months without any deterioration in its quality. Whenever the solution becomes thick due to evaporation of water over a long period, suitable quantity of water can be added to keep it in a liquid state.

Use

It enhances the growth of microbial population in soil and also it plays the role of promoting growth and providing immunity in plant system

Reference

All India Organic Farming Society, Mapusa, Goa