Organic Farming for Sustainable Agriculture

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Foreword

Organic farming is one of the several approaches to meet the objectives of sustainable development of agriculture. It avoids the use of synthetic chemicals as well as genetically altered organisms and usually subscribes to the principle of sustainable farming. Different stakeholders who promote Organic Farming need to follow a holistic approach which focus on reviving soils and organic matter, capacity building of farmers, supply of efficient organic inputs, comprehensive certification standards, marketing, branding, awareness of consumers and integrating farmers with the market-led value chain. They also need to build their capacities and knowledge in all these aspects for implementing Organic Farming initiatives.

In this context, MANAGE and Extension Education Institute(EEI) - Hyderabad have jointly organise an Online Training Program on Organic Farming for Sustainable Agriculture during 1-5 June 2021 and trained more than 45 agricultural extension officers, researchers and faculty from State Governments, KVKs, State Agricultural Universities and NGOs. Based on the course material of the training program, this e-book is published covering the overview of Organic Farming, Soil Health Management, Extension Strategies for Management, Climate Resilient Practices for Sustainable Agriculture, Organic Regulation and Certification Procedures, Integrated Farming System models for Sustainable Agriculture and Success Stories of Organic Farmers of Sikkim with the inputs from Scientists and Experts from ICAR institutes, SAUs and other reputed institutes.

I am sure that Agricultural Officers, Extension Professionals, Researchers and Academia who work for promoting Organic Agriculture would find this e-book is very useful and informative.

I thank Dr. M. Jagan Mohan Reddy, Director, EEI-Hyderabad at Professor Jayashankar Telangana State Agriculture University (PJTSAU), Hyderabad for partnering with MANAGE to organise the collaborative training programs on Organic Farming. I also appreciate Dr. Lakshmi Manohari, Deputy Director, MANAGE and Dr.A.Sailaja, Professor, EEI, Hyderabad for their effort in organising the training program and bringing out this e-book.

P. Chandra Shekara)
Director General, MANAGE

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Foreword

Organic farming is a type of farming that maintains and improves the natural balance of the environment. To put it another way, this farming technique is based on the usage of organic fertilizers. Traditional farming practices include the use of chemical fertilizers, harmful pesticides, and other practices that have a significant negative impact on the environment. As a result, this method of farming is used to create toxin-free food for consumers while also maintaining soil fertility and contributing to ecological balance. This form of farming promotes environmentally responsible, long-term economic development.

Although India has long been known for its organic agriculture, the rise of contemporary scientific, input-intensive agriculture has pushed it forward. Organic farming has risen to prominence as a viable alternative to conventional farming that not only solves quality and ecological concerns, but also ensures debt-free operation.

Organic farming systems can provide agronomic and environmental benefits through structural changes and tactical management of agricultural systems. Organic farming has advantages for both developed countries (environmental protection, biodiversity enhancement, reduced energy use and CO2 emissions) and developing countries like India (sustainable resource use, increased crop yields without over-reliance on expensive external inputs, environment and biodiversity protection, and so on). It reduces human and animal health hazards by reducing the level of residues in the product. It helps in keeping agricultural production at a sustainable level. It reduces the cost of agricultural production and also improves the soil health.

Organic farming as a system of crop production is to feed the soil rather than feed the plant. It is a production system which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators and livestock feed additives. Organic farming system rely or largely depends on crop rotation, crop residues, animal manures, legumes, green manures, off-farm organic wastes, mineral bearing rocks and aspects of biological pest control to maintain soil productivity and to supply plant nutrients and to control insects, weeds and other pests. Under the rapid changing environmental conditions organic farming can withstand the turbulences against the climate change.

There is every need to bring out a publication to sensitize the farmers and other stakeholders in production and consumption food ecosystem on organic farming. I appreciate the efforts of authors of book chapters and compilers Dr.A.Sailaja and Dr.Lakshmi Manohari for making efforts in this direction. The relentless efforts of Ms.G.Anulasa in moulding the book is highly appreciated.

MJMReddy

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Overview of Organic Farming in India

H. B. Bablad
Professor, UAS, Dharwad

With the increase in population our compulsion would be not only to stabilize agricultural production but to increase it further in sustainable manner. The scientists have realized that the, Green Revolution with high input use has reached a plateau and is now sustained with diminishing return of falling dividends. Thus, a natural balance needs to be maintained at all cost for existence of life and prosperity. The obvious choice for that would be more relevant in the present era, when these agrochemicals which are produced from fossil fuel and are not renewable and are diminishing in availability. It may also cost heavily on our foreign exchange in future

After effects of Green Revolution

- Reduction in natural fertility of the soil
- Destruction of soil structure.
- Susceptibility of soil to erosion by water and wind.
- Diminishing returns on inputs.
- Indiscriminate killing of useful insects, microorganisms and predators.
- Breeding more virulent and resistant species of insects.
- Reducing genetic diversity of plant species / crop varieties.
- Pollution with toxic chemicals from the agrochemicals and their production units.
- Poisoning of food with highly toxic pesticide residues.
- Change in natural taste of food due to chemicals.
- Depletion of fossil fuel resources.
- Depletion of ground water reserves.
- Increase in irrigation needs of the land and unscientific water management.
- Increase in cost of cultivation due to increased input costs.
- Increase in farmers work burden and tension.
- Imbalance in social and economic status

Organic Agriculture- An Ecological Approach

- ✓ Ecological intensification through biological and natural practices is an alternative approach for mainstreaming organic agriculture
- ✓ Ecological intensification aims to integrate the management of ecosystem services delivered by bio-diversity in to crop production systems (Dore, *et al.,* 2011).
- ✓ Adopt a natural resources management frame work to illustrate how ecological intensification can sustainably enhance food security.
- ✓ Organic agriculture has the potential to secure a global food supply, just as conventional agriculture is today, but with reduced environmental impact (FAO, International Conference on Organic Agriculture,2017)

All these problems of GRT lead to not only reduction in productivity but also deterioration of soil hearth as well as natural ecosystem. Moreover, today the rural economy is now facing a challenge of over dependence on synthetic inputs and day-by-day increase in price of these inputs. Apart from quantity, quality is another factor that considered most important in recent years. Such varieties of concern gave birth to various new concepts of farming such as organic farming, natural farming, biodynamic agriculture, do-nothing agriculture, eco-farming, etc.

The essential concept of all these forms of agriculture remains the same, i.e., back to nature, where the **philosophy is to feed the soil rather than the crops to maintain soil health** and it is a means of giving back to the nature what has been taken from it (Funtilana, 1990). Therefore, for sustaining the productivity of the crop, maintaining the soil health and healthy ecosystem, there is need for adoption of an alternative farming system, like **Organic Farming**.

What is scope of Organic Farming in India?

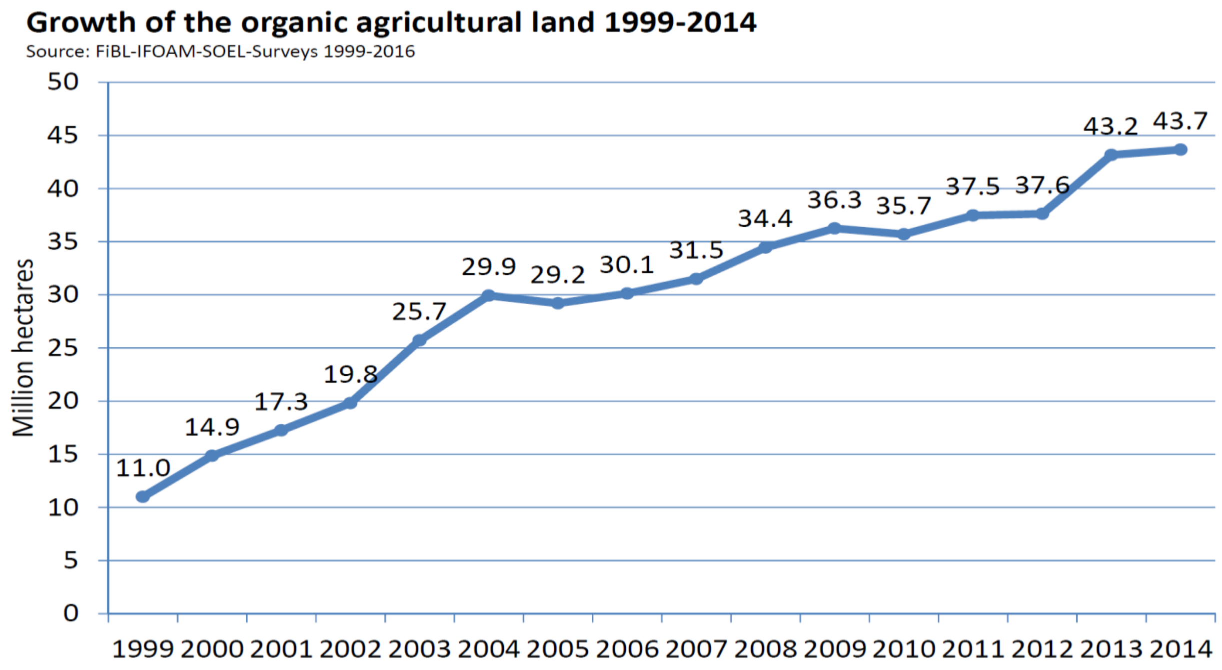
The available data seem to indicate the organic agriculture offers a comparative advantage in areas with less rainfall and relatively low natural and soil fertility levels. Further, **there are certain areas** (especially mountain areas) and communities (especially certain tribes) that didn’t adopt the use of agro chemicals, and therefore, such areas can be considered for organic agriculture. For example in the Bastar plateau of Chhattisgarh, the fertilizer consumption is less than 10 kg/ha.

Organic agriculture - viable alternative

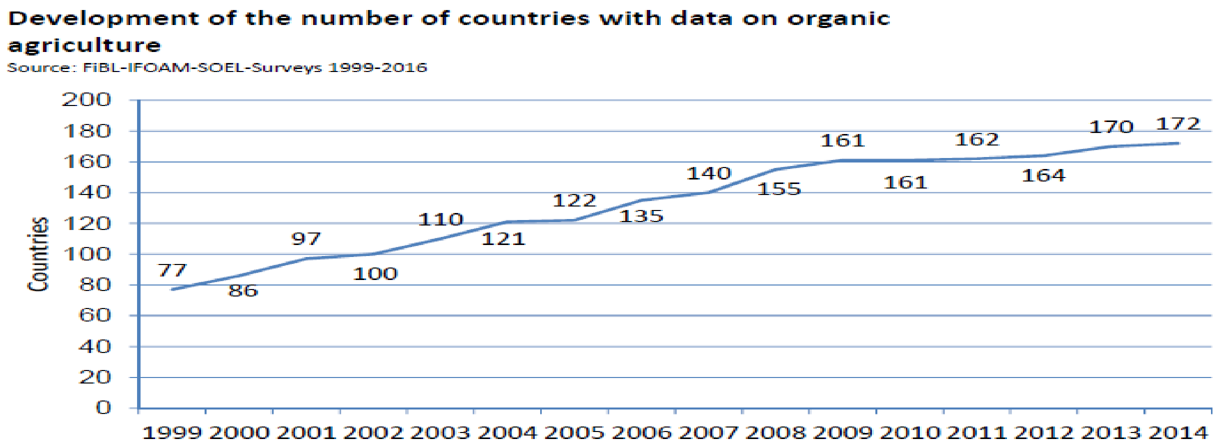
- It is happening out of economic and ecological necessity.
- It has been recognized as sustainable and ecological sound farming system.
- It is a specialized form of diversified agriculture aims to produce nutritious food of high quality
- Conserves natural resources, protects water quality & enriches the soil, encourage bio diversity and protects the environment *viz.*, reduced N leaching, pesticide residues etc.
- Farmers and development supports moving away from high input monoculture.
- Generates more income and employment opportunities for rural people.

According to *Codex-Alimentarius* (Food code) Commission (CAC), organic agriculture is holistic food production management system, which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity. It emphasizes the use of management practices in preference to the use of off-farm inputs, taking in to account that regional conditions require locally adapted systems.

Goals: Productive (Economic), Ecological (Environmental) and social.



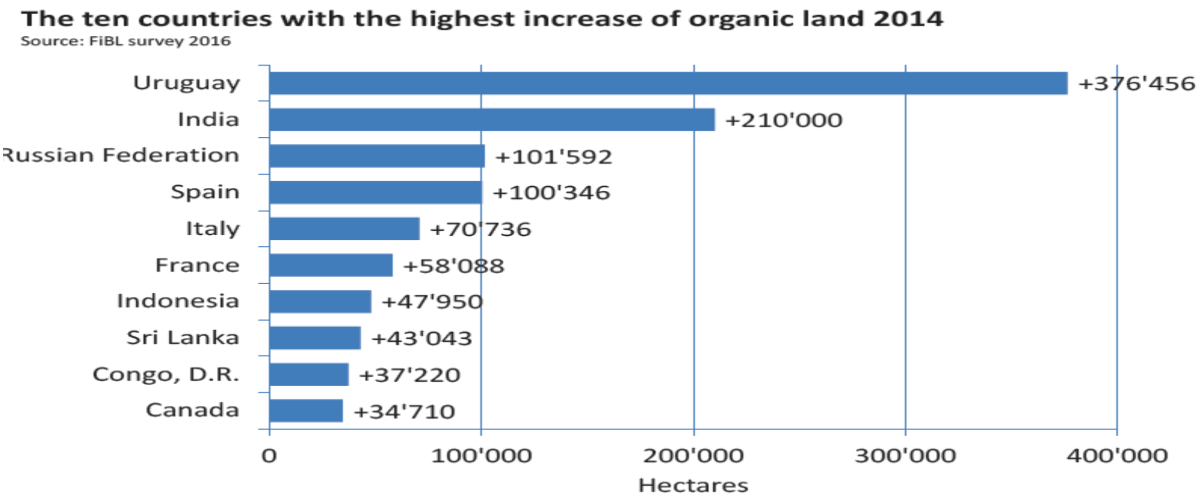
Development of the number of countries with data on organic agriculture

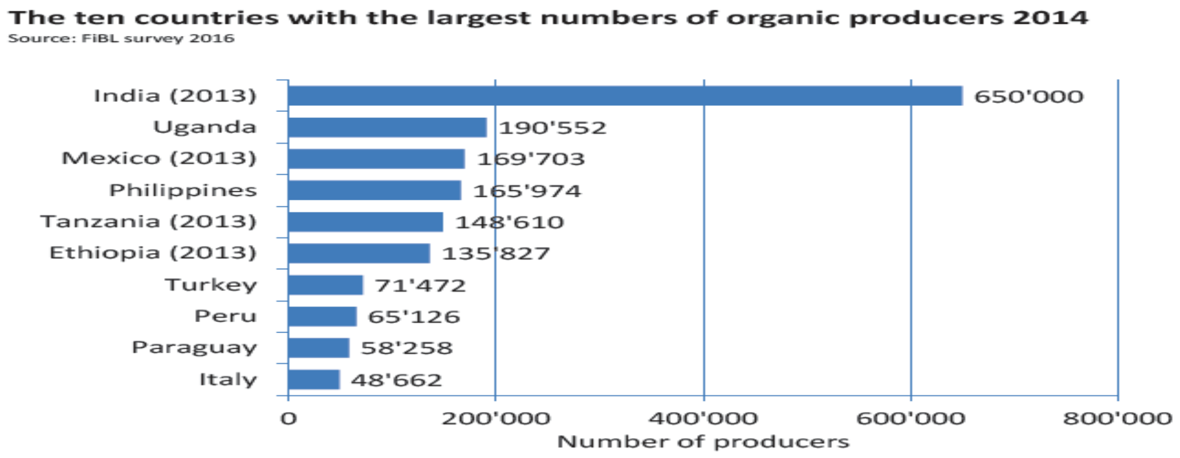


Steady Increase of Organic Farmland

- A total of 71.5 million hectares were organically managed at the end of 2018, Australia has the largest organic agricultural area (35.7 million hectares) followed by Argentina (3.6 million hectares), and China (3.1 million hectares).
- Due to the large area of organic farmland in Australia, half of the global organic agricultural land is in Oceania (36.0 million hectares).
- Europe has the second largest area (15.6 million hectares), followed by Latin America (8 million hectares).
- The organic area increased in all continents compared to 2017.
- Apart from agricultural land, there are further organic areas, most of these being areas for wild collection.

- Other areas include aquaculture, forests, and grazing areas on non- agricultural land.
- The areas of non-agricultural land constitute more than 37.6 million hectares.





Organic Producers Worldwide: In 2018, 2.8 million organic producers were reported. India continues to be the country with the highest number of producers (1’149’000), followed by Uganda (210’000), and Ethiopia (204’000).

Small Holdings- An Advantage

In India according to 2010-11census 85 % holdings (117.6 million) are small and marginal and out of this 80 % are marginal (92.8 million) with average holding size of 0.4 ha (Census, India 2010-2011). These small and marginal farmers group which occupy 50 per cent of farm land (71.2 million ha) and produce a higher share of the country’s food relative to the share of land they use, as they tend to have higher yields than larger farms and they are tending towards organic systems.

The Global Organic Market

The market research company, Ecovia Intelligence, estimates that the global market for organic food surpassed 100 billion US dollars for the first time in 2018 (almost 97 billion euros). The United States is the leading market with 40.6 billion euros, followed by Germany (10.9 billion euros) and France (9.1 billion euros). In 2018, many major markets continued to show double-digit growth rates, and the French organic market grew by more than 15 percent. Danish and Swiss consumers spent the most on organic food (312 Euros per capita in 2018). Denmark had the highest organic market share with 11.5 percent of its total food market.

Top ten Countries Export of organic commodities

1. USA
2. European Union
3. Canada
4. Switzerland
5. Vietnam
6. Israel
7. Australia
8. New Zealand
9. Japan
10. Korea Republic

Standards and Regulations

- According to the FiBL survey on organic rules and regulations, there are 87 countries with an organic regulation. Eighteen countries are in the process of drafting legislation
- Participatory Guarantee Systems (PGS) are locally focused quality assurance systems. They certify producers based on the active participation of stakeholders and are built on a foundation of trust, social networks, and knowledge exchange
- It is estimated that 123 PGS initiatives are now established an all continents, and another 110 are currently under development. PGS are spread over 72 countries
- It is estimated that more than 46’000 small operators are currently involved in PGS worldwide, of which more than 17’000 are certified through PGS
- It is also estimated that PGS certified producers are currently managing organically a total of at least 49’803 hectares of agricultural land.

Organic Agriculture in India

In India civil society organizations joined the movement for its potential in sustaining the soil health, preventing contamination in surface and ground water aquifers and ensuring safe and healthy food. To support the export prospects, Ministry of Commerce launched the “National

Programme on Organic Production" (NPOP) defining the National Standards for Organic Production (NSOP) and the procedure for accreditation and certification in 2000. India now has 30 accredited certification agencies for facilitating the certification to growers. For area expansion and technology transfer, Ministry of Agriculture launched a National Project on Promotion of Organic Farming (NPOF-DAC) and earmarked funds for setting up of organic and biological input production units, vermicompost production units and for organic adoption and certification under various schemes such as NHM, NMSA and RKVY. To empower farmers through participation in certification process and to make the certification affordable for domestic and local markets, Ministry of Agriculture has also launched a farmer group centric organic guarantee system under PGS-India programme. To augment the research needs ICAR launched a Network Project on Organic Farming (NPOF, ICAR) under Project Directorate of Farming System Research with 20 collaborating centre across the country. Organic package of practice for some important crops have been developed under the project

Area

As on 31st March 2020 total area under organic certification process (registered under National Programme for Organic Production) is **3.67 million Hectare** (2019-20). This includes 2.299 million ha cultivable area and another 1.37 million Hectare for wild harvest collection. Among all the states, **Madhya Pradesh** has covered largest area under organic certification followed by Rajasthan, Maharashtra, Gujarat, Karnataka, Odhisa, Sikkim and Uttar Pradesh. During 2016, Sikkim has achieved a remarkable distinction of converting its entire cultivable land (more than 75000 ha) under organic certification

Production

India produced around **2.75 million MT** (2019-20) of certified organic products which includes all varieties of food products namely Oil Seeds, Sugar cane, Cereals & Millets, Cotton, Pulses, Aromatic & Medicinal Plants, Tea, Coffee, Fruits, Spices, Dry Fruits, Vegetables, Processed foods etc. The production is not limited to the edible sector but also produces organic cotton fiber, functional food products etc. Among different states Madhya Pradesh is the largest producer followed by Maharashtra, Karnataka, Uttar Pradesh and Rajasthan. In terms of commodities Oil seeds are the single largest category followed by Sugar crops, Cereals and Millets, Tea & Coffee, Fiber crops, fodder, Pulses, Medicinal/ Herbal and Aromatic plants and Spices & Condiments.

Exports

Total volume of export during 2019-20 was 6.389 lakh MT. The organic food export realization was around INR 4,686 crore (689 million USD). Organic products are exported to USA, European Union, Canada, Switzerland, Australia, Japan, Israel, UAE, New Zealand, Vietnam etc. In terms of export value realization Processed foods including soya meal(45.87%) lead among the products followed by Oilseeds (13.25%), Plantation crop products such as Tea and Coffee(9.61%), Cereals and millets (8.19%), Spices and condiments (5.20%), Dry fruits

(4.98%,Sugar(3.91), Medicinal plants(3.84%) and others. The APEDA, Ministry of Commerce & Industries, Government of India is implementing the National Programme for Organic Production (NPOP). The programme involves the accreditation of Certification Bodies, standards for organic production, promotion of organic farming and marketing etc. The NPOP standards for production and accreditation system have been recognized by European Commission and Switzerland for unprocessed plant products as equivalent to their country standards. Similarly, USDA has recognized NPOP conformity assessment procedures of accreditation as equivalent to that of NOP of US. With these recognitions, Indian organic products duly certified by the accredited certification bodies of India are accepted by the importing countries. APEDA is also in the process of Bilateral equivalence with South Korea, Taiwan, Canada, Japan etc.

State Wise Export during 2019-20

S. No	State	Exported Qty (In MT)	Total Value (In Lakh Rs.)
1.	Madhya Pradesh	351814	167020
2.	Gujarat	58386	50917
3.	Maharashtra	73176	47143
4.	Kerala	8110	31034
5.	Karnataka	21763	28551
6.	West Bengal	4477	27081
7.	Haryana	31062	26542

Indian Perspective

In India Organic Agriculture is being viewed as two dimensional opportunity offering:

- Growing Export and Domestic Markets
- Important livelihood option for small and resource poor farmers with low input cost with greater sustainability and quality food production.
- It Offer a low cost farming system for better livelihood to farmers in rain-fed arginal land areas

Organic Agriculture also holds the last hope to the farmers in the so-called farmer suicide zones of India

Government Vision

1. No intention to convert country into organic.
2. Identified organic zones to take development programmes.
3. To bring about 10 million ha under certified organic by the 2020.
4. Create a nitch market for organic products.

Strategies

1. Paramparagat Krishi Vikas Yojana (PKVY)

- Paramparagat Krishi Vikas Yojana promotes cluster based organic farming with PGS (Participatory Guarantee System) certification.
- Cluster formation, training, certification and marketing are supported under the scheme.
- Assistance of Rs. 50,000 per ha /3 years is provided out of which 62 percent (Rs. 31,000) is given as incentive to a farmer towards organic inputs.

2. Mission Organic Value Chain Development for North Eastern Region (MOVCDNER)

- The scheme promotes third party certified organic farming of niche crops of north east region through Farmer Producer Organisations (FPOs) with focus on exports.

- Farmers are given assistance of Rs 25,000 per hectare for three years for organic inputs including organic manure and bio-fertilisers among other inputs.

- Support for formation of FPOs, capacity building, post-harvest infrastructure up to Rs 2 crore are also provided in the scheme

3. Capital Investment Subsidy Scheme (CISS) under Soil Health Management Scheme

- Under this scheme, 100 percent assistance is provided to state government, government agencies for setting up of mechanised fruit and vegetable market waste, agro waste compost production unit up to a maximum limit of Rs 190 lakh per unit (3000 Total Per Annum TPA capacity).

- Similarly, for individuals and private agencies assistance up to 33 percent of cost limit to Rs 63 lakh per unit as capital investment is provided.

4. National Mission on Oilseeds and Oil Palm (NMOOP)

Under the Mission, financial assistance at 50 percent subsidy to the tune of Rs. 300 per hectare is being provided for different components including bio-fertilisers, supply of Rhizobium culture, Phosphate Solubilising Bacteria (PSB), Zinc Solubilising Bacteria (ZSB), Azatobacter, Mycorrhiza and vermi compost.

5. National Food Security Mission (NFSM)

Regulatory Mechanism

For Export: Notified by Ministry of Commerce as NPOP. It is in operation since 2002

For Domestic: A framework is being worked out and is likely to be notified under the Agricultural Produce Grading and Marking Act on the similar lines of NPOP

Developing an alternative low cost certification system

- Ministry of Agriculture and FAO has developed a model Participatory Guarantee System (PGS).
- The system is now being tested under pilot project at 21 places in the country
- PGS eliminates the requirement of third party certification
- Since 2004, many states embraced organic farming and drafted policies.
- So far 11 states, namely Andhra Pradesh, Karnataka, Kerala, Uttarakhand, Maharashtra, Madhya Pradesh, Tamil Nadu, Himachal Pradesh, Sikkim, Nagaland and Mizoram have drafted the organic agriculture promotion policies
- Sikkim has taken up the task of converting the entire state into organic and declared organic during 2016 and has already brought more than 65,000 ha are under organic certification process

Research studies and technologies released on organic farming and biodiversity conservation at UAS, Dharwad.

- ✓ Long term study (2004-2014) showed integrated organic nutrient management and application of organic manures equivalent to recommended fertilizers +biofertilizers produced higher yield in groundnut, soybean, maize, sorghum, chickpea, cotton and chilli as compared to only chemical fertilizers.
- ✓ Integrated application organic manures through different sources equivalent to recommended fertilizers improved the soil physical, chemical and biological properties.
- ✓ Incorporation of crop residues @5 t/ha(produced in the system) in sugarcane, cotton ,rice, maize and soybean enhanced the crop productivity and soil health.
- ✓ Application of biofertilizers mainly Rhizobium, Azospirillum and PSB in different crops and liquid orgaic manures improved crop yield by15-20 per cent.
- ✓ Organic outperforms to conventional in years of drought.

Package for Organic Rice Cultivation:

- Eupatorium to supplement 75 kg N/ha (RDN).
- Instead, other organic manures viz., FYM / Vermicompost / green manure crop like sunnhemp alone or in combination can also be applied at quantities to supply 75 kg N/ha.
- Dipping rice seedlings roots in Bio-fertilizers slurry (***Azospirullum*** **+ PSB**) at the time of transplanting.
- Spraying of cow urine (10%) at about 45-55 DAP.
- 2 Sprays of ***Pseudomonas fluorescence*** (1%) to rice crop at about 20-25 and 40-45 DAP as prophylactic measure for control of blast disease.

- Plant based insecticides viz., neem pesticide with 3000 ppm concentration (3 ml/liter of water) or 10% extract of mukkadaka extraction or *Pnumeria reli* (1 g/liter of water) spray for control of insect pests of paddy.

I. Kadamba Marketing Federation:

- Kadamba has been associating with farmers, since its early days for the sheer joy and love of working with the farming community.
- Kadamba has been focusing on producing high quality products which can meet all the international organic standards.
- Providing place for marketing of all minor forest products as well as almost all organically produced agricultural products.

II. Green Valley Organic Spices (G.O.S.P)

- Green Valley Organic Spices is an Indian organic spices trading company based at the Taluq headquarters of Siddapur in the North Canara district of Karnataka.
- It is an association of organic farmers settled in the Western Ghats region of Karnataka.
- The company trades wide range of spices comprising organically grown and processed Black Pepper, Cardamom, Nut Meg, Cinnamon, Vanilla, Garcinia Cambodia & indica, rice, dried banana, and pineapple across India and even exports them overseas to Europe and USA.

Conclusion

- Organic farming does not result in neither catastrophic crop losses due to pests or in dramatically reduced yields.
- On the contrary, organic farming systems are able to increase current yield levels under rainfed farming systems, without any associated external costs to society.
- Organic and agro-ecological farming methods continually increase soil fertility and prevent loss of topsoil to erosion,
- Organic methods are improving the quality of our food, improving the health of our soils and water, and improving our nation’s rural areas.
- It is becoming imperative that we move away from organic versus conventional systems comparisons, to research into ways of improving organic farming methods.

Soil Health Management in Organic Farming

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Organic farming is a method of farming system which principally meant at cultivating the land and raising crops in such a way, as to keep the soil alive and in good health. Organic farming protects soil life by avoiding the use of synthetic fertilizers and pesticides, thus abating chemical soil disturbance. The saying, feed the soil and the soil will feed the plant, has been the guiding principle of organic farmers since the movement began. Organic farming system is based on the management of soil organic matter, which in turn maintains the physical, chemical, and biological properties of soil. Soil organic carbon and nitrogen are primary indicators of soil health in organic farming.According to the definition of the United States Department of Agriculture (USDA), organic farming is a system which avoids or largely excludes the use of synthetic inputs (such as fertilizers, pesticides, hormones, feed additives etc.) and to the maximum extent feasible rely upon crop rotations, crop residues, animal manures, off-farm organic waste, mineral grade rock additives and biological system of nutrient mobilization and plant protection.

Soil health, also referred to as soil quality, is defined as "the capacity of soil to function within ecosystem boundaries to sustain biological activity, maintain environmental quality, and promote plant and animal health" (Doran and Zeiss 2000). Soil health management means executing practices that either maintain or augment the soil's physical, chemical, and biological attributes to improve soil functions.These attributes function synergistically and interact in a complex way to deliver specific soil services and to enhance ecosystem functions, such as nutrient availability, erosion control, and water infiltration.The key characteristics of soil health management in organic farming is protecting the long term fertility of soils by maintaining organic matter levels, encouraging soil biological activity.Soil building practices such as crop rotations, intercropping, symbiotic associations, cover crops, organic fertilizers, minimum tillage are central to organic practices. Those practices encourage soil formation and structure and creating more stable systems.A healthy soil would ensure high organic matter, good soil tilth and structure, proper retention and release of water and nutrients, promote and sustain root growth, maintain soil biotic habitat, respond to management and resist degradation. Building and improving the soil health in organic farming will ensure continued productivity, enhance farmers' incomes, and promote food security

Strategies to Improve Soil Health in Organic Farming

To enhance factor productivity and increase yields, improvement of soil health is a requisite. Conservation practices *viz.*, zero tillage, inter and cover crops, moisture conservation etc. attaches great significance to improving soil health through improving soil structure and biodiversity. The potential of C sequestration in C depleted soils of India is high with adoption of conservation tillage. Soil carbon lost during tillage can be accrued through conservation practices viz., zero tillage, inter and cover crops, moisture conservation etc. (Conant et al., 2007). Soil organic matter is the pulse of the soil. This is reflected in its influence on both the chemical and physical properties and overall health of the soil. Usually, organic practices that build soil organic matter also enhance soil biology. The basic soil properties that are influenced by organic matter are, diversity and activity of soil organisms, nutrient availability, moisture holding capacity and soil structure.Organic matter additions as crop residues, and/or green manure crops in rotation or as intercrops must be the key components of soil health management in organic farming. A vegetal cover on soil surface create greater humidity in soil and keeps the soil relatively cooler than conventional systems. This is conducive to the activity of soil organisms. Crop rotations and cover crops involving legumes encourage N fixation. Enhanced population of beneficial organisms like nutrient mobilizers and PGPRs will enable the soil system in holding and releasing nutrients in most appropriate forms that are readily absorbed by the plant roots.

Organic manures

Organic manures are the excellent and balanced source of nutrients as it improves the soil health, quality of produce and safe environment. Organic manures are any material of plant or animal origin that can be added to the soil to improve soil health and stimulate biodiversity. Examples of organic manures includefarmyard manure (FYM), farm compost, night soil, sludge and green manure which are bulky in nature and supply large quantities of organic matter but small quantities of plant nutrients. Presently, FYM is a major source of organic matter and nutrients of conventional and some of the organic farms. Therefore, higher amounts of FYM ranging from 15 to 35 tones ha^{-1} are usually required to fulfil the nutrient demands of different crops and to maintain soil health.

Enrichment of FYM with Trichoderma and Bio-fertilizers: Well decomposed FYM is thoroughly mixed with *Trichoderma harzianum or T viride* , *Azatobacter* or *Azospirillum* and Phosphate Solubilizing bacteria (PSB) (all (@ 1 kg/tof FYM), moistened with sprinkling water and covered with wet gunny cloth and kept to incubate for 21 days under partial shade. This enriched FYM should be mixed with remaining FYM before applying to the field. About 35 to 40 tof well decomposed FYM, 1.5 - 2.0 t of vermicompost and 250 kg neem cake having 8 -10 % oil content is found to be good for most of the agricultural crops.

Using composted manure, which may build active and stable soil organic matter, organic N, and overall soil health more effectively than raw manure.Composting material addplenty of carbon and thus increases the heterotrophic bacteria and fungi and further increases the activity of soil enzymes responsible for conversion of unavailable to available form of nutrients. Vermicompost is organic manure or compost produced by the use of earthworms that generally live in soil, eat organic matter and excrete it in digested form. These are rich in macro and micronutrients, vitamins, growth hormones and immobilized microflora essential for plant growth. Concentrated organic manures are those materials that are organic in nature and contain higher percentage of essential plant nutrients such as nitrogen, phosphorus and potash as compared to bulky organic manure. The concentrated manures are made from raw materials of animal or plant origin. The concentrated organic manure commonly used is oil-cakes, blood meal, fish meal, meat meal and horn and hoof meal. As a source of P, rock phosphate or bone meal in combination with Phosphate solubilizing Bacteria can be used. Both contain about 20-22% P_2O_5. As a source of K, wood ash (2.5 to 3 % K_2O) or Sheep manure (3-4 % K_2O) can be used.Multiple studies have confirmed that good quality manure and compost builds long term soil health and fertility. However, compost and manure must be used judiciously to avoid nutrient excesses based on soil testing.

Biofertilizers

Biofertilizers contains living microorganism which, when applied to seed, plant surfaces, or soil, it promotes growth by increasing the supply or availability of nutrients. It enhance soil fertility and also crop productivity by fixing atmosphere N, mobilising sparingly soluble P and by facilitating the release of nutrients through decomposition of crop residues. Azotobactor, a free-living heterotrophic N fixing bacteria not only provides N but also produces a variety of growth promoting substances. The ICAR-Indian Institute of Horticultural Research, Bengaluru, has developed the "Arka Microbial Consortium" for sustainable soil health and crop production. It is a combination of N fixing, P and Zn solubilizing and plant growth promoting microbes in single carrier. This technology exploits the synergistic effects of the individual microbial strains and does away with the need for applying individual microbial inoculants.

Green manures

Green manures form an imperative part of soil heath management in organic farming systems. Green manuring is a practice of ploughing or turning undecomposed green plant materials into the soil either *in-situ* or *ex-situ*. The main advantage of green manuring is to add organic matter to the soil which improves the structure of soil and other physical properties, facilitates penetration of rain water, thus decreasing run-off and erosion, hold plant nutrients that would otherwise be lost by leaching, leguminous plants add nitrogen to the soil and increases the availability of certain plant nutrients like phosphorus, calcium, potassium, magnesium and iron etc. Leguminous crops such as *Peuraria javanica*, *Calopogonium mucunoides*, *Sesbania*, *Sunhemp* and *Centrosema pubescens* and *Glyricidia maculata* are common green manuring crops. Research has shown that green manures used regularly in the rotation for short periods of less than six months between cash crops can be as effective at maintaining soil N concentrations and yields.

Crop rotation

For maintaining / enhancing soil fertility and control of insects, weed and diseases there should be rotation of crops on the same land over a period of two years or more. Growing the same crop continuously in the same soil habitually leads to the buildup of disease causing organisms called pathogens. This can be avoided by growing a plant belonging to another family, the pathogen cycle becomes disrupted because the new crop belonging to a different family cannot serve as a host for the pathogen. Use of legumes in rotation improves soil fertility.Crop rotation is associated with the promotion of healthy and lively soils, thereby reducingpesticide and herbicide requirements, environmental pollution as well as enhancing naturalbiodiversity.

Cover cropping

Growing a cover crop is one way to increase the soil organic matter through the addition of biomass to the soil. A cover crop may be any crop grown within the system to provide soil cover, irrespective of whether it is later incorporated into the soil. Such cover crops may be an economically important crop like food legumes or *Mucuna* or sweet potato etc., or a green manure crop that produces huge biomass along with nitrogen fixation. These cover crops may be an annual or a biennial or even some perennial herbaceous plants grown in a pure or mixed stand mainly during monsoon period or may be throughout the year. Cover crop biomass must be returned to the soil after the desired growing period for the soil health benefit to be fully realized. However growing legume cover crops is still the best practice for improving organic matter levels and, hence, soil quality.Cover crops improve soil tilth and drainage. Deep-rooted cover crops penetrate subsurface hardpan and thereby, improve soil aeration.Some cover crops deliver other benefits to the soil. For example, legumes have the capacity to fix nitrogen in the soil by associating with a type of bacteria called rhizobium. The mainpurpose of such cover crops is to prevent soil erosion but they also reduce water losses, keepssoil surface cool, stimulate soil life, suppress weeds, promote an increased biodiversity in theorganic farming system and eventually add organic matter to the soil. Farmers can select such cover crops that have market value or as livestock fodder.

Crop residues management

Permanent crop cover with recycling of crop residues is a prerequisite and integral part of conservation agriculture, which is promoted as alternative to the conventional farming system for improving and sustaining soil health in organic farming.Incorporation of crop residues in soil or retention on surface has several positive influences on soil health. Crop residues in turn adds soil organic matter and facilitates availability of nutrients, prevent leaching of nutrients, increase cation exchange capacity, provide congenial environment for biological N fixation, increase microbial biomass and enhance activities of enzymes such as dehydrogenase and alkaline phosphatase. Increased microbial biomass can enhance nutrients availability in soil as well as act as sink and source of plant nutrients. It increases hydraulic conductivity and reduce bulk density of soil by modifying soil structure and aggregate stability. Mulching with plant residues increases the minimum soil temperature in winter and decreases soil temperature during summer due to shading effect. Retention of crop residues on soil surface slows runoff and thereby enhances infiltration. Combined with reduced water evaporation from the top few inches of soil and with improved soil characteristics, higher level of soil moisture can contribute to higher productivity and sustainability.

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Microbial Inoculations in Organic Farming

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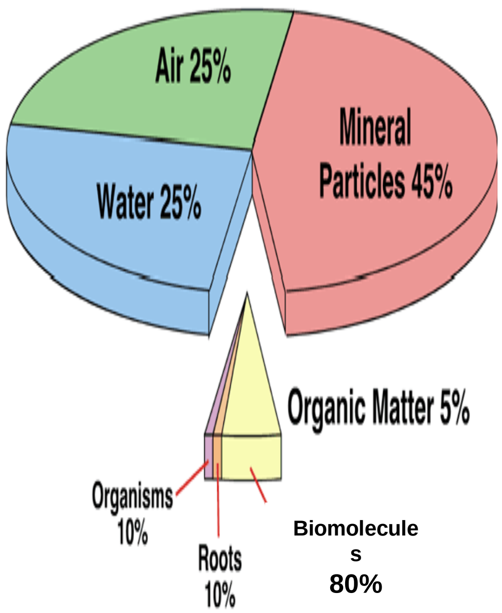
Microbial inoculants are **beneficiary microorganisms applied to either the soil or the plant in order to improve productivity and crop health**. ... Microbial inoculants can help reduce chemical fertilizer application. Microbial inoculants could include bacteria, fungi and algae

Microbial inoculants also known as **soil inoculants** or **bioinoculants** are agricultural amendments that use beneficial rhizosphericic or endophytic microbes to promote plant health. Many of the microbes involved form symbiotic relationships with the target crops where both parties benefit (mutualism). While microbial inoculants are applied to improve plant nutrition, they can also be used to promote plant growth by stimulating plant hormone production.

Soil Organisms: Mostly Unknown



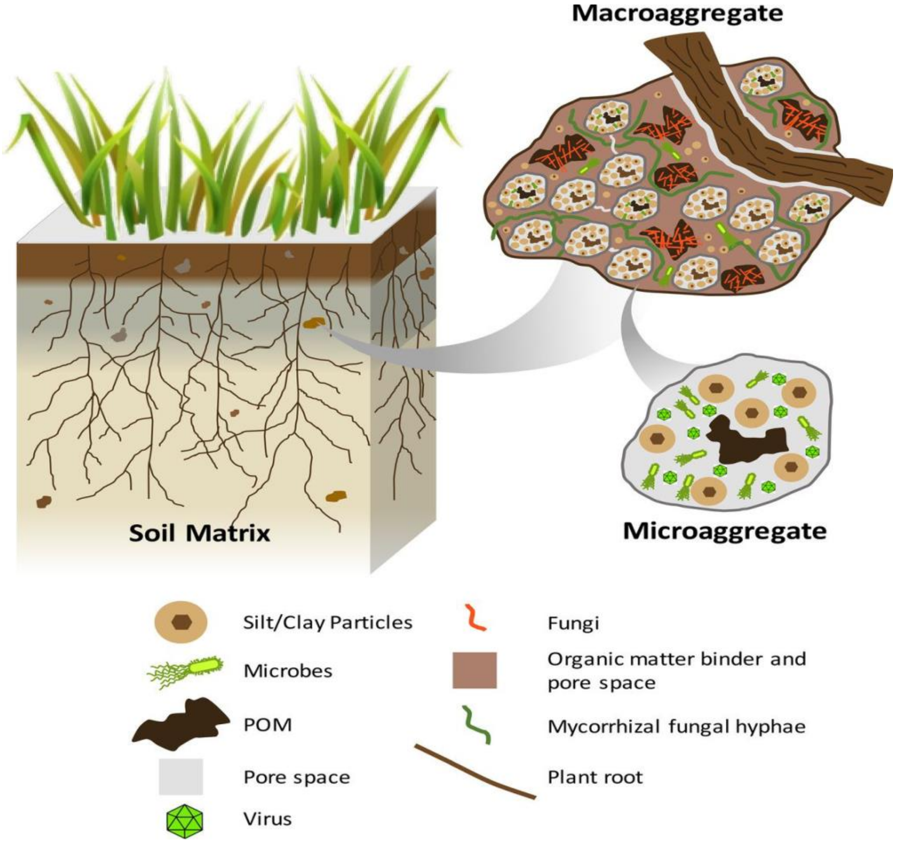
Group	Est.No.ofSp. (x10^6)	Known Sp.(%)
Bacteria	1.0	1
Fungi	1.5	1-2
Protozoa	0.2	7.5
Nematodes	0.4	1.5
Ants	0.015	60
Termites	0.003	53
Earthworms	-	-
Mites	0.9	2-3
Collembola	0.2	27

Advances of Soil Organisms in Soil

Organism	Number per gram soil (~1 tsp)	Biomass[1] (lbs per acre 6")
Earthworms	–	100 – 1,500
Mites	1-10	5 – 150
Nematodes	10 – 100	10 – 150
Protozoa	up to 100 thousand	20 – 200

Algae	up to 100 thousand	10 – 500
Fungi	up to 1 million	1,000 – 15,000
Actinomycetes	up to 100 million	400 – 5,000
Bacteria	up to 1 billion	400 – 5,000

Occurrence of microbes insoil



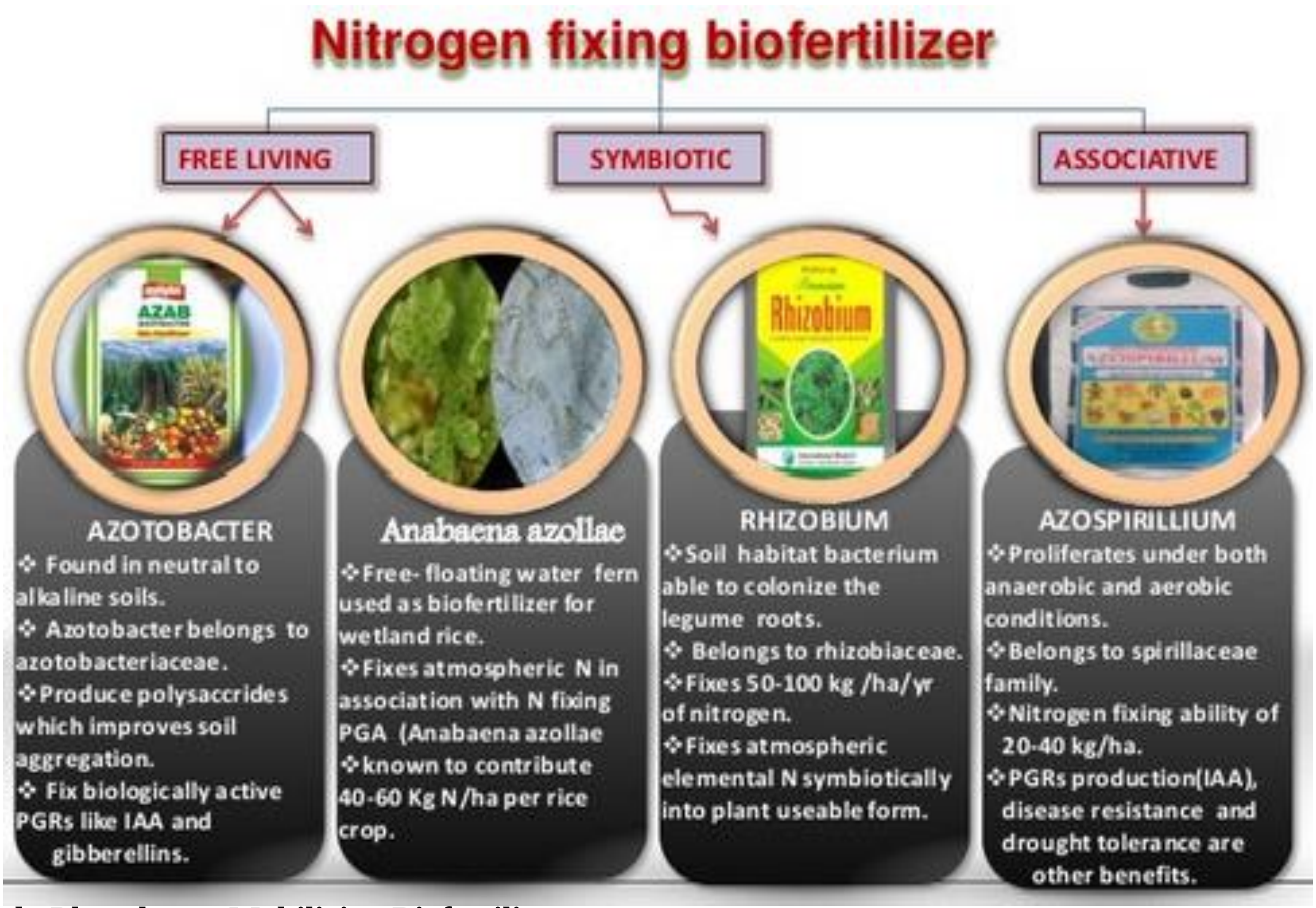
What is Biofertilizer?

Contains living microorganisms which, when applied to soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the availability of primary nutrients to the host plant.

Classification of Biofertilizers

***The various types of biofertilizers which help the plant to grow at different levels of its growth are*:**

1. Nitrogen Fixing Biofertilizers
2. Phosphate Biofertilizers
   a. Phosphorous Solubilizing Biofertilizers
   b. Phosphorus Mobilizing Biofertilizers (VAM)
3. Plant Growth Promoting Rhizobacteria
4. Compost



b. Phosphorus Mobilizing Biofertilizers

Phosphorus Solubilizing Biofertilizers

• Solubilize the insoluble phosphate from organic and inorganic phosphate sources

• Secrete organic acids and lower the pH to dissolve bound phosphates in soil

Examples: Species of *Bacillus*, *Pseudomonas*, *Penicillium*, *Aspergillus*

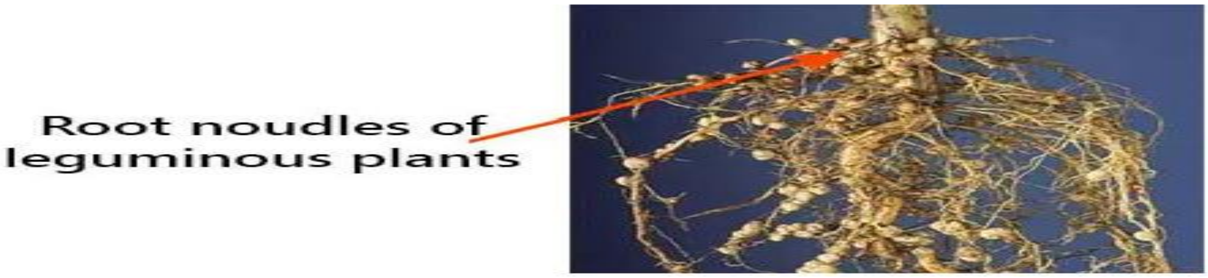
Biofertilizer Application

Seed treatment: 200 g of nitrogenous bio fertilizer and 200 g of Phosphoric are suspended in 300-400 ml of water and mixed thoroughly. Ten kg seeds are treated with this paste and dried in shade. The treated seeds have to be sown as soon as possible.

Seedling root dip: For rice crop, a bed is made in the field and filled with water. Recommended bio fertilizers are mixed in this water and the roots of seedlings are dipped for 8-10 hrs.

Soil treatment: 4 kg each of the recommended bio fertilizers are mixed in 200 kg of compost and kept overnight. This mixture is incorporated in the soil at the time of sowing or planting.

Rhizobium



Biofertilizer Preparation

Step 1: Mass culturing of microorganisms

Microbacterium, Cellulosimicrobium, Paenibacillus were cultured in Jenson’s broth (100 ml) and Okon’s broth (100 ml) used for Azospirillumzea. Microorganisms multiplied to 1010 to 1011cfu/ ml

Step 2: Processing of carrier material

Carrier material (talc-mineral form) is purchased from the local market in a powder form. Sieved and unsterilized talc powder is used as carrier material for biofertilizer

Step 3: Mixing with carrier material

Microbial inoculum is mixed with the carrier material -300 ml inoculated broth with 1 kg of talc. Moisture content 8-12%. Microbial population was > 108 cfu/ g dry weight

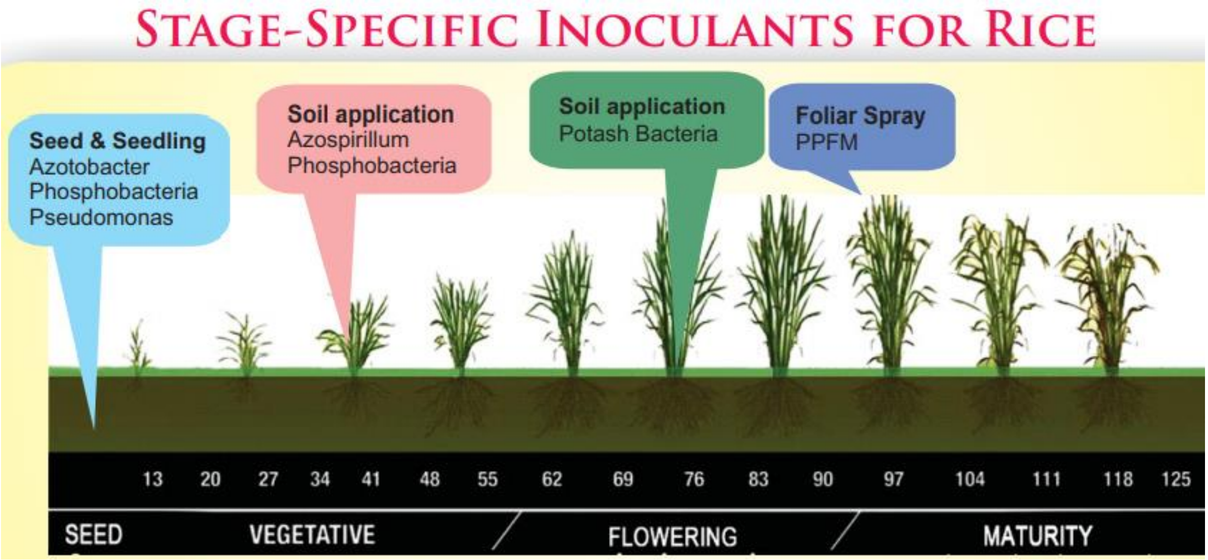
Biofertilizer Products and Application

Seed Coating Biofertilizer Application

Effect of Seed Coating Biofertilizer onCrop Yield

Crop	FLDs	Yield (kg/ha)			B:C ratio	
		Seed-coat bioinoculant	Control	% increase	Regular	Seed-coat
Maize	8	3150	2457	28	1.88	2.16
Ragi	1	310	250	24	1.68	1.91
Red gram	2	245	205	20	1.20	1.30
Ground nut	24	1225	892	37	1.81	2.17

Biofertilizer Technology forRice



Liquid Rhizobium Biofertilizer - Rhizoteeka

Protocol for field application:

1. Dissolve 50 g Sugar/Gur (Jagerry) or Gum aerobic (10%) in 250 ml of hot water.'
2. Add the jaggery solution to seed and mix thoroughly
3. Add biofertilizer to the sticky seeds
4. Air dry the seeds in shades on gunny bag
5. Sow the seeds as per recommendation
6. Seedlings of vegetable and rice crops can be done by root dipping in liquid biofertilizers diluted with water (1:4 ratio). After half an hourof root dipping, the seedlings can be transplanted.
7. The liquid biofetilizer can be poured in fieldduring irrigation

Recommended doses: 50 ml biofertilizer for 10 kgof seed

Liquid biofertilizer Azoteeka

Protocol of preparation:

1. Dissolve 50 g Sugar/Gur (Jagerry) or Gumaerobic (10%) in 250 ml of hot water.
2. Add the jaggery solution to seed and mixthoroughly.
3. Add biofertilizer to the sticky seeds.
4. Air dry the seeds in shades on gunny bag.
5. Sow the seeds as per recommendation

Recommended doses: 50 ml biofertilizer for 10 kg of seed

Benefits of the using biofertilizers:

- Crop yield increase : 5-15%
- Fertilizer saving: 20-25%
- Biofertilizers provides different growth hormones and protects plants from pathogens

Germination is also increased by the use of biofertilizers

Liquid biofertilizer Phosphoteeka

Benefits of the using biofertilizers:

- Crop yield increase : 5-15%
- Fertilizer saving: 20-25%
- Biofertilizers provides different growthhormones and protects plants from pathogens.

Germination is also increased by the use of biofertilizers

Recommended doses: 50 ml biofertilizer for10 kg of seed.

Liquid biofertilizerAzo-Phosphoteeka

1. It contains Azotobacter spp. andphosphorus-solubilizing bacteria(Pseudomonas spp)
2. Azo-Phosphoteeka are used for the cereals and non-legume crops like wheat, maize, pearl millet, sorghum,mustard, cotton, fruit and vegetables.
3. This Azo-phosphoteeka can be used for the seed treatment, root dip for the seedling in the transplanted crops andsoil treatment.
4. It can add 15-20 kg/ha of nitrogen and phosphorus to soil and also increases the crop yield

Extension Strategies for Management of Organic Agriculture

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Organic farming has been gaining renowned significance and importance and pursued with renewed interest in the country and in the world over due to increasing threat to soil health and fertility as well as dangers posed to human health and survival of friendly species to the mankind in particular and eco-friendly environment in general from the current farming practices.

The goal of extension and research is to increase the productivity of the agricultural production of farmer's especially small and marginal farmers. This involves technological modifications at the farm level and it depends on its turn on development and dissemination of improved technologies and involves socio-cultural and behavioural adjustments. All these can be institutionally possible only through well-established links between the research and extension services. This is more so in organic farming.

The Producer farmer is holding the key to the doors of Organic farming. He opens it if he finds it useful to him to improve his standard of living and solves his other problems of farming.In terms of promotion of organic farming, all other stakeholders like the Government or the scientists or the service providers or the production units are merely the agents trying to bring in the change in the mind sets of farmers.

Farmers are facing many challenges in promoting organic farming. We need a strategy for developing Organic Agriculture which is the need of the hour as mentioned below.

Training: Farmers need training in the following areas for expansion and strengthening of Organic Farming

Sl. No.	Areas of Training
1	Creating awareness on organic farming
2	Animal Husbandry Certification procedures
3	Organic Certification process
4	Collective farming
5	Constant maintenance of soil fertility
6	Cropping plan
7	Data maintenance and marketing
8	Documentation process
9	Organic pest control methods
10	Promotion of soil fertility and productvity
11	Inter cropping / Bio pesticide
12	Marketing &post harvest management
13	Marketing linkage and storage of vegetables

14	More on preparation of organic fertilizers and pesticides
15	More training field visit to be conducted
16	Post-harvest technology
17	Processing of organic products
19	Seed storage
20	Technical instructions or training to obtain more yield

Other strategies for promotion of organic farming are as mentioned below	
1	Cultivation of all crops shall be done using organic farming methods.
2	All farmers are to be converted to organic farming for better risk management.
3	All Training regarding organic farming must be available at tuluka level
4	subsidy for organic inputs
5	Availability of market for organic produce
6	Better premium price for organic produce on govt. declared rate
7	Organic producer Cooperatives be encouraged
8	Crop planning for more remunerative crops to be made
9	Marketing, certification, training has to be promoted
10	Educate more & more farmers on Organic agriculture
11	Exchange of idea among organic farmers should be arranged during cropping season
12	Exhibitions and farmers convention should be at least twice a year
13	Demonstrations will be arranged
14	Exposure visit to other established organic farms
15	Exposure visit to other states organic farms
16	Extend project period & arrange marketing system
17	Fees for certification of organic agriculture should be subsidized for tribal farmers or paid full by government
18	Government need to identify the real progressive farmers
19	Govt. Mandi for organic product
20	Govt. subsidies should be provided in establishment of Bio-fertilizer unit & training
21	Govt. subsidy on aid on Agri. Equipment
22	Input shall be made available at taluka place
23	Marketing Problems to be solved
24	Marketing tie-up
25	More and more new areas could be converted to Organic Agriculture
26	More environment organic growers should be invited to express their experience
27	More farmers should be included in this area.

28	More financial assistance.
29	More importance should be given on soil productivity
30	More no. of experts should visit the field and advise
31	More people and the expenses of farmer will be reduced
32	More trainings & field visit necessary
33	More trainings on recent technologies on organic farming market linkage
34	More field staff. Not only from Govt. departments but also from NGOs
35	More funds will be allocated to field demonstrations
36	New technologies on organic farming should be provided
37	Initiation of cold storage facilities exclusively for organic products
40	The technology for the better yield should be developed
41	The trainings should be more practically oriented
42	To provide better market to get the fair price
43	Training on production of organic fertilizer and botanical pesticides along with practical should be regularly taken up

Organic farming is an integrated approach, where all aspects of farming systems are interlinked with each other. Organic farming gives more stress to optimizing resource use and productivity rather than maximizing production through over exploitation of resources. Feeding the increasing population of India is difficult with organic farming alone. A sudden switch over to completely organic is not possible. Conversion periods have poor yields. The high cost and difficulties of organic certification and inspection is another constraint. But the strategies mentioned above can be followed for a gradual change. Moreover, higher premium prices exist for organic certified products in domestic and international markets. It is also a challenge for the common man to eat quality organic food.

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Climate Resilient Practices for Sustainable Agriculture

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A healthy soil produces healthy plant Human beings and animals eating such plants are obviously healthier. Hence the health whether of soil, plant, animal or human beings is one and indivisible. If this is accepted then we must look at the mechanisms or processes that transmit the health within the soil to plants, animals and human beings. Land on which soil, plant, animals and human beings exist can be compared to an electric circuit where soil-plant-animal-human beings are components of the circuit. Food chains are the living channels which conduct energy forward and Death and decay of plants and animals return it to the soil which in turn gets worked up with solar energy, microbes and mineral matter to produce humus. Consequently there is a relationship between humus and human health. But neither soil scientists nor medical professionals have paid due attention to the relationship between soil and human health

To some extent this important issue was touched upon by geo-chemists In exceptional cases by medical scientists. In ayurveda a discipline called "Dravya guna shasthra and desha vichara" links the medicinal properties of the herbs to the soil, location and region that produces it. Veterinary science has been much more aware of this kind of relationship and an extensive literature exists on the problem of deficiency and excesses of mineral elements in animal nutrition

Soil mineral depletion and human health:

Our body is made up of "Panchabhutas" (Earth, air, water, fire and Akash).About 500 years back the great Kannada philanthropist Purandaradasa said *"Manninda Kaaya Manninda"* meaning our body is made up of earth and is finally returned to earth there by defining the concept of cycle. The task is not so much to see what no one has yet seen, but to think what no one has yet thought about what everybody sees.

Horticulture sector

- Fruits and Nuts
- Vegetables and Tubers
- Plantation Crops
- Flowers
- Medicinal and Aromatic Crops
- Condiment and Spices
- Mushroom
- Honey Production Etc.

Crops

Fruits: Banana, Mango and citrus fruits contribute 70 % of overall production

Vegetables: Potato, tomato, onion, brinjal and cabbage contribute 80 % of production.

States: Andhra Pradesh, West Bengal, Uttar Pradesh, Maharashtra, Tamil Nadu, Bihar, Gujarat, Karnataka, Madhya Pradesh and Odisha are major contributors to horticultural production**.**

India is witnessing severe degradation of its farmlands. Much of this degradation can be attributed to common, but exploitative, farming practices

- Ploughing that destroys the soil structure and degrades organic matter, burning or removing crop residues, mono-cropping, and so on.
- Soil and water management practices that sustain and enhance the productivity of arable soils are a must and are a vital part of the long-term solution to food insecurity and poverty.
- Conservation horticulture aims to overcome these problems. It consists of three simple principles

a) *disturb the soil as little as possible*
b) *keep the soil covered* and
c) *mix and rotate crops*.

These principles can be put into practice in many different ways. Farmers throughout the world, are beginning to adopt them; they have seen their yields rise, their soil gain in health and fertility, and their labour needs reduced.

What conservation horticulture is, and why it is important

Conservation horticulture is not a single set of techniques – there is no one "best practice". Rather, its three principles can be applied in different ways in different situations

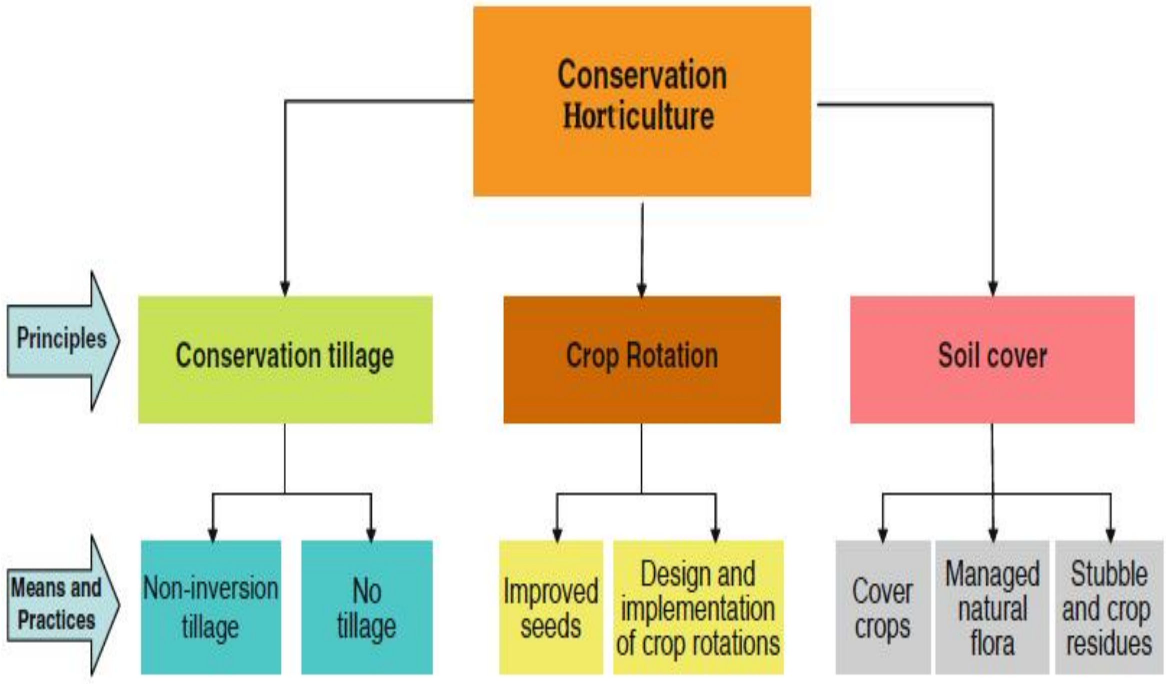
Fundamental to CH is continuous and simultaneous practice of minimal soil disturbance, permanent soil cover, and crop rotations in horticulture crop based systems be it perennial or annual. The objectives of CH is achieved by

- Planting without seedbed preparation through the soil cover to minimise the disturbance of the soil
- A permanent vegetative soil cover or mulch to protect the soil surface
- Management of crop residue and control of weeds with less minimal application of herbicides, to improve soil fertility and stimulate soil structure formation.
- Adhering to Integrated Pest Management technologies

Conservation Horticulture addresses

- **Horticultural production:** CH has tremendous potential for achieving sustainable yield increases by improving the growth conditions for crops and the efficiency of input.
- **Natural resource base:** CH builds up soil fertility by facilitating better infiltration of rainwater and enabling the recharge of groundwater and reverses soil degradation processes and which reduces erosion and leaching and, in turn, water pollution.

- **Biodiversity:** CH enhances and conserves biodiversity in the field.
- **Labour shortage:** CH works on minimum input principle and hence eliminates power-intensive soil tillage, thus reducing the drudgery and labour required for crop production substantially for small scale farmers. For medium and large farmers, it reduces fuel requirements and the need for machinery to a great extent.
- **Climate change:** In drought conditions, CH reduces crop water requirements by 30 to 40 per cent, by conserving water through surface mulch and enhanced organic matter, and facilitates deeper rooting of crops. Thus makes better use of soil water. During heavy rains under severe wet conditions, CH reducing the danger of soil erosion and downstream flooding by facilitating rain water infiltration. Thus CH reduces crop vulnerability to extreme climatic events.
- **Livelihoods:** Farmers who adopt CH saves time on tilling and can devote the saved time for additional income generation activities like processing, animal husbandry etc. Thus CH gives farm families opportunity to improve their livelihoods.



Conservation horticulture aims to

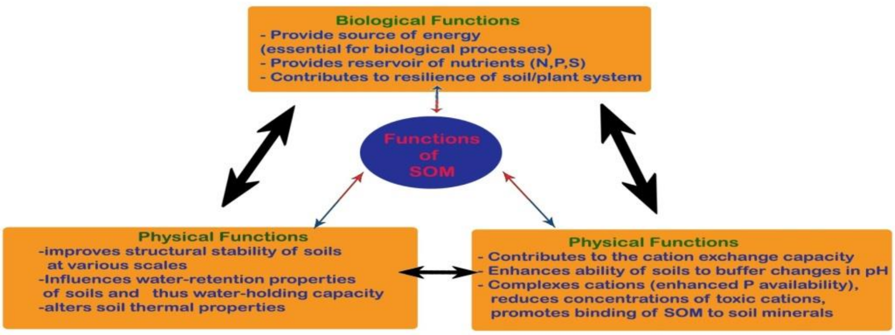
- Enable root-zone (maximum possible depth for crop roots) for roots to grow and function effectively exploiting full potential of roots in capturing plant nutrients and water
- Provide optimum and favorable conditions for water to enter the soil so that (i) soil profile has enough water for plants to express their full potential

- Provide vent for the excess water to passes through soil and reach groundwater and reduce loss of water through surface and prevent erosion.
- Enhanced cropping efficiency as more water and nutrients are made available
- Promote beneficial biological activity in the soil for maintaining and rebuild soil architecture for both enhanced profile storage and prevention of runoff, suppression of soil borne pathogens through efficient competition by beneficial organisms, improve organic matter decomposition and build various grades of humus; and contribute to the capture, gradual release and retention of plant nutrients
- Effective functioning of roots and soil organisms through avoiding all physical or chemical damage to the system.

Ways to reduce tillage and increase organic matter contents of soils

- As for as possible zero or minimum tillage
- Addition of organic matter in any form like FYM, Composts etc
- Maintaining land cover with cover crops and green manure crops
- crop rotation
- perennial fodder crops
- Enhancing biodiversity through agro-forestry

The functions of soil organic matter



Permanent Soil Cover

i. Crop Residue Management: Annual or perennial cropping systems where crop residues are well managed such systems:

- Return all residues to the system. This in turn add soil organic matter, which increases the water infiltration and retention capacity of the soil,improves the quality of the seedbed, buffers the pH and facilitates the availability of nutrients
- Helps in long-term storage of C in the soil
- Makes nutrients available for both plant uptake and for soil biological activity
- Reduces rain drop impact, slows down the rainwater on the surface and thus increase infiltration and the soil moisture content

- Prevents soil erosion by providing a cover reduce water loss through evaporation and avoid desiccation from the soil surface

Soil mulching can be done by any of the two methods like:

1. Produce mulch material in the farm where it is used -in situ mulching systems. Here the cover crop residue falls in the same place where it is produced – plant residues remain where they fall on the ground

2. Grow mulch material elsewhere and bring to use in a place where it is required- Cut-and-carry mulching systems

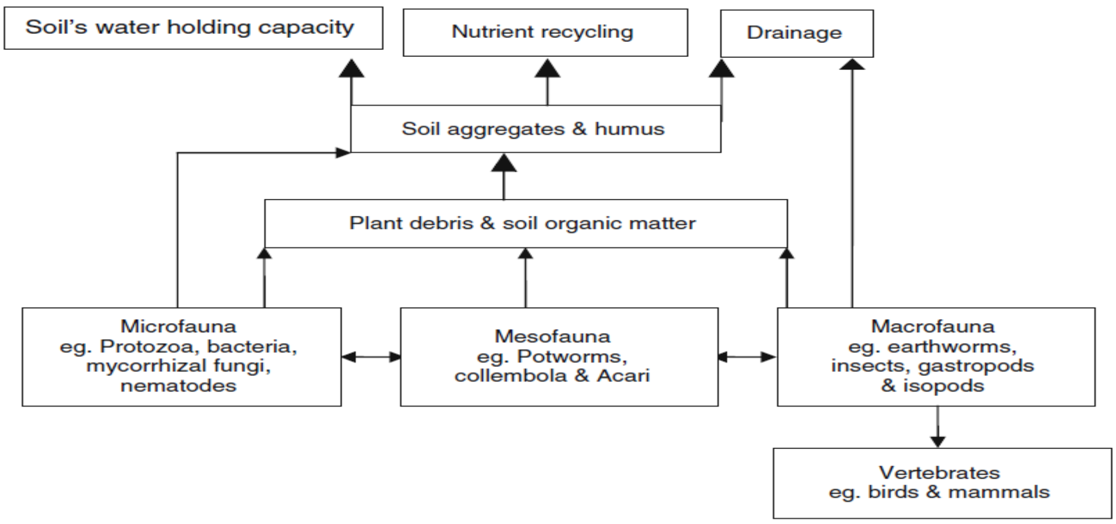
Increased infiltration and retention of soil moisture in the root-zone through CH systems will result in:

- Maximized rainfall utilization and improved yields
- recharging of groundwater with accrued benefits of securing the water level in wells and the continuity of streams and river flows
- insures crop against risk of yield losses during drought

In dry regions or in the event of a poor rainfall cover crops produce little biomass. Even in such situations the cover crops can yield benefits like:

- Protection of soil surface, when it is fallow
- Additional source of organic matter that improves soil structure
- Create an improved topsoil
- Helps in recycling of nutrients and mobilizing them in the soil profile
- Creating capillaries through deeply penetrated roots and sometimes penetrating even the hard pans in such poor soils, thereby increasing water percolation capacity of the soil
- Help break soil compaction, control weeds and pests

Interactions between soil-associated fauna and soil dynamics



Land use and land management determining whether soil will be a sink or source of atmospheric CO_2

Attribute	**Soil as a source of CO_2**	**Soil as a sink of CO_2**
Soil properties	Coarse textured soil, excessive drainage, high susceptibility to erosion	Clayey soil, poorly drained ecosystems, depositional sites, including foot-slopes
Land use	Seasonal crops, simple ecosystem, shallow roots and low root–shoot ratio	Perennial crops, diverse ecosystem, deep roots and high root–shoot ratio
Soil management	Intensive tillage based on plough, negative nutrient balance, residue removal and/or burning, continuous cropping, loss of soil and water by runoff and erosion	No tillage, positive nutrient balance, mulch farming, cover crops in rotation cycle, soil and water conservation

Our experience of conservation horticulture in mango orchard

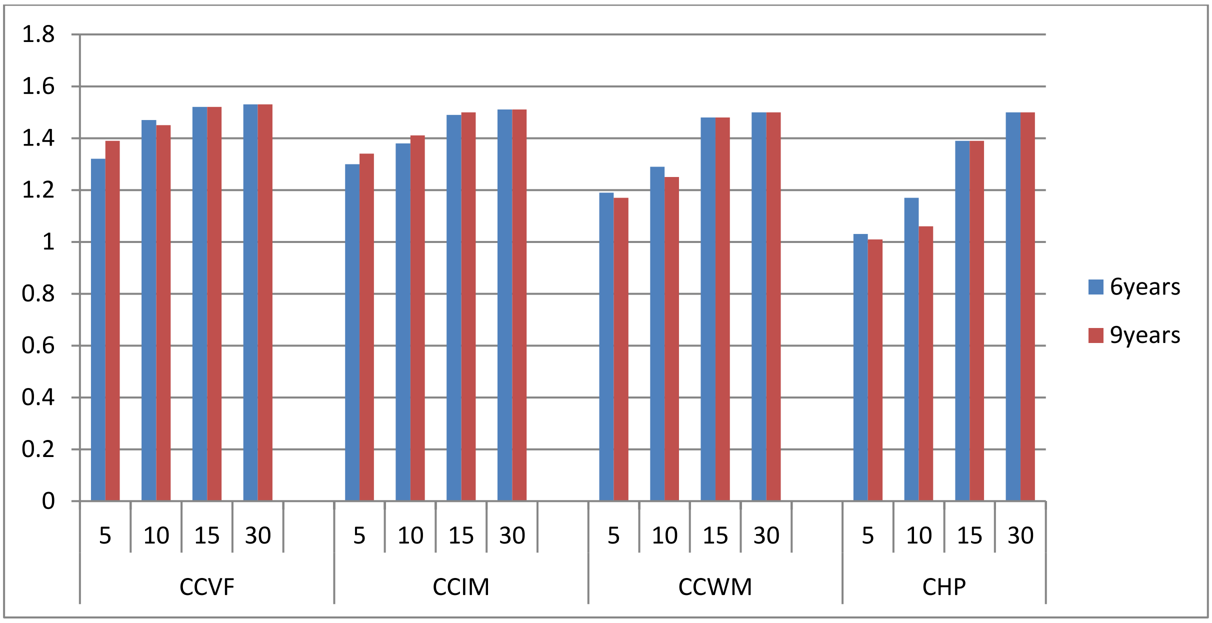
- CCVF
- CCIM
- CWIM
- CHS

Residue and fertilizers (kg ha^{-1}) added per year to the system:

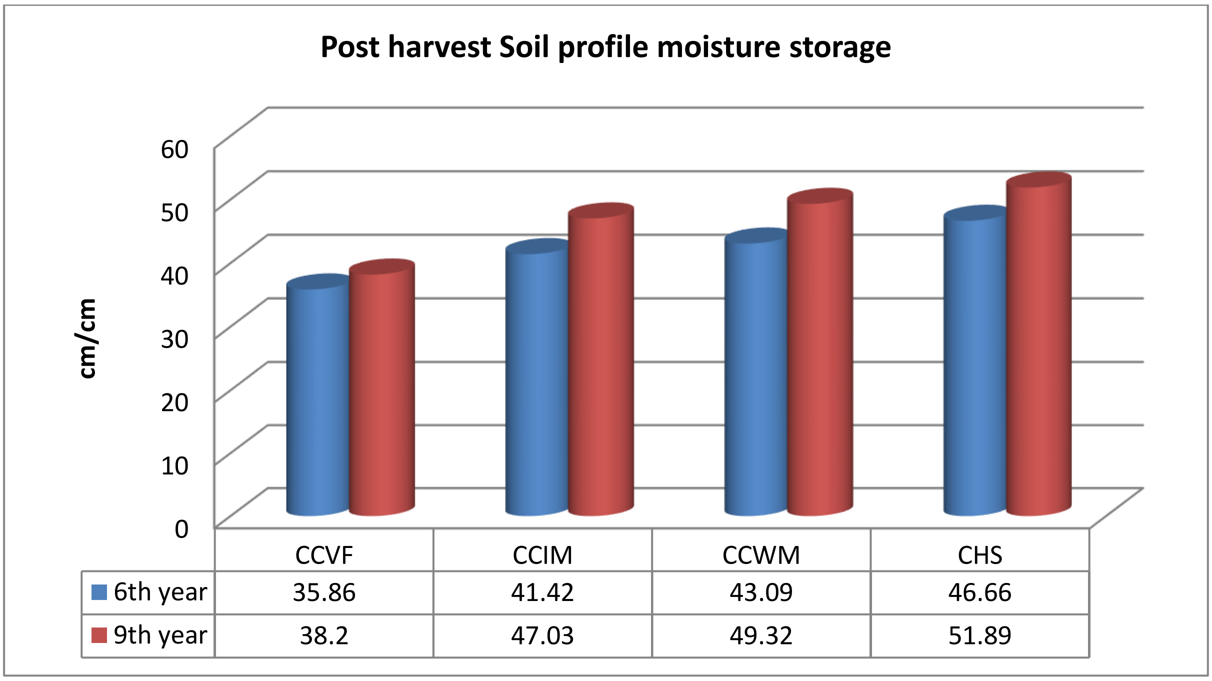
Organic residues/Fertz	CCVF	CCIM	WCIM	CHP	CCVF	CCIM	WCIM	CHP
	Organic residues (First six years)				Organic residues (Six to nine years)			
Plant residues	-	2000	4000	25000	-	2000	4000	25000
Organic manures(FYM)	10000	8000	8000	-	10000	8000	8000	-
Total	10000	10000	12000	25000	10000	10000	12000	25000
	Fertilizers				Fertilizers			
N	500	158	158	158	500	158	158	-
P_2O_5	200	158	158	158	200	158	158	-
K_2O	450	237	237	237	450	237	237	-

S	20	5	5	2	20	5	5	-
Zn	5	-	-	-	5	-	-	-
Fe	-	-	-	-	-	-	-	-
Cu	1	-	-	-	1	-	-	-

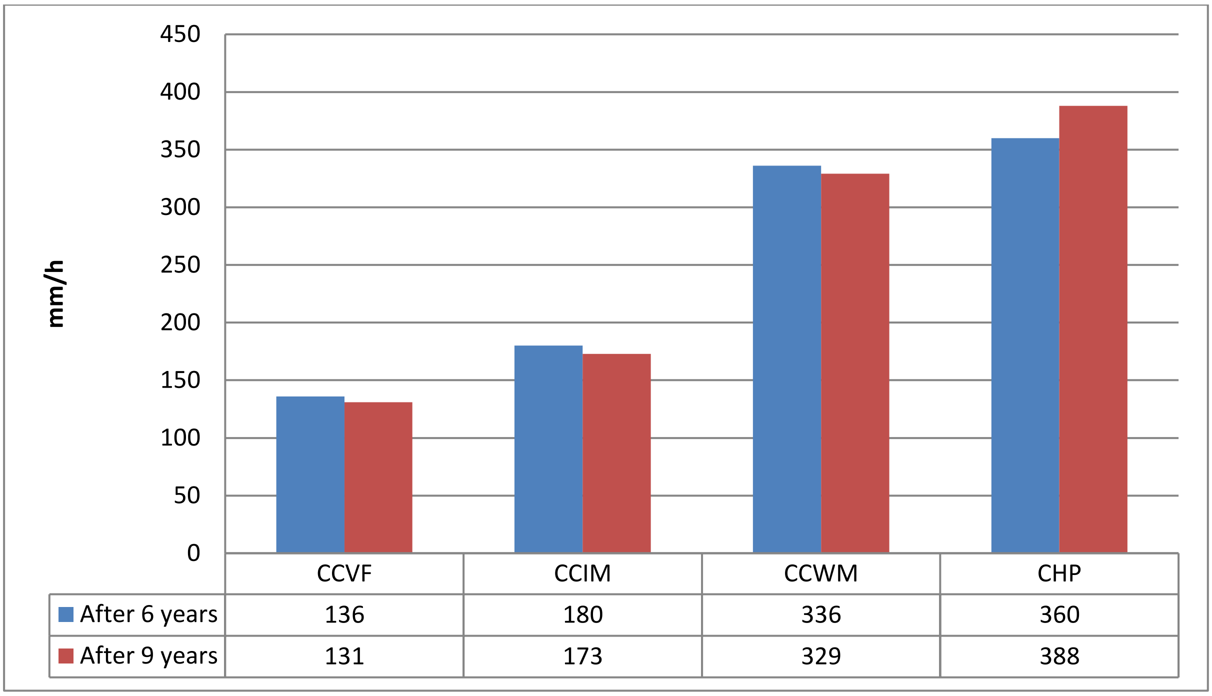
Soil bulk density under different conservation practices measured at the end of sixth and nine years of experimentation



Post-harvest Soil profile moisture (cm /cm)under different conservation practices measured during post monsoon of sixth and ninth year of experimentation(Initial storage in sixth year was 53.58 cm/150 cm. and 57.01cm /150 cm. in ninth year)



Steady state infiltration rate in different treatment plots after sixth and ninth year of experimentation



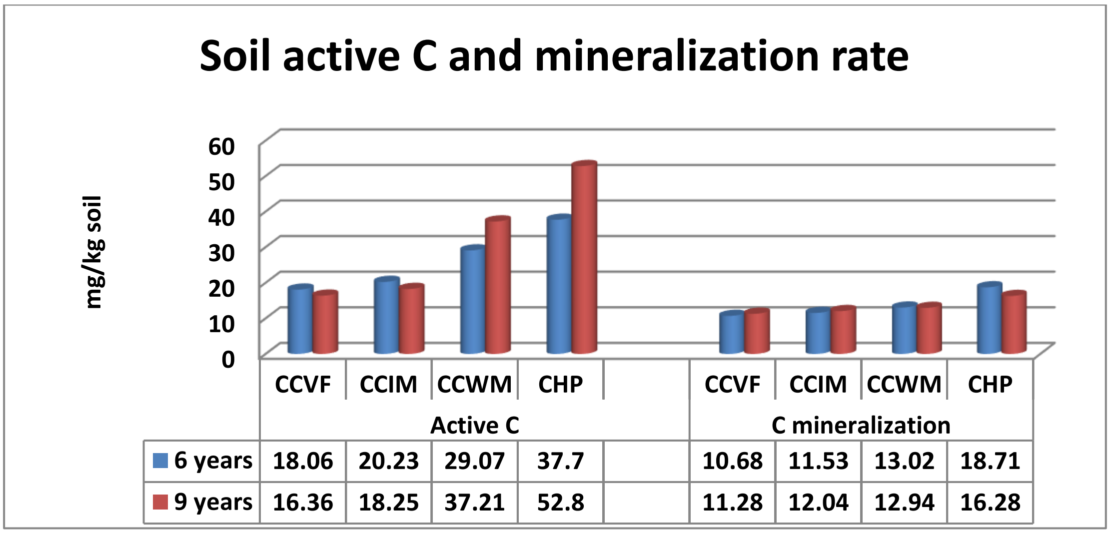
Aggregate distribution in different conservation plots

System	Dry aggregates							
	> 3 mm (% by volume)		Glomalin mg g^{-1} soil		< 3 mm (% by volume)		Glomalin mg g^{-1} soil	
	6 years	9 years	6 years	9 years	6 years	9 years	6 years	9 years
CCVF	59a	52	5.20a	5.04	29a	25	5.04a	4.87
CCIM	66a	57	5.78b	5.38	29a	26	5.59b	5.25
WCIM	78b	85	5.95b	6.18	33b	37	5.63c	5.94
CHP	84c	118	6.51c	8.36	40c	52	6.22c	8.17
Wet aggregates								
CCVF	40a	34	4.85a	4.31	53a	47	4.27a	4.01
CCIM	44b	35	5.04a	4.72	50a	42	4.83b	4.48
WCIM	51c	56	5.26b	5.35	23b	28	5.04c	5.26
CHP	57d	69	6.11c	7.88	16c	23	5.82d	7.22

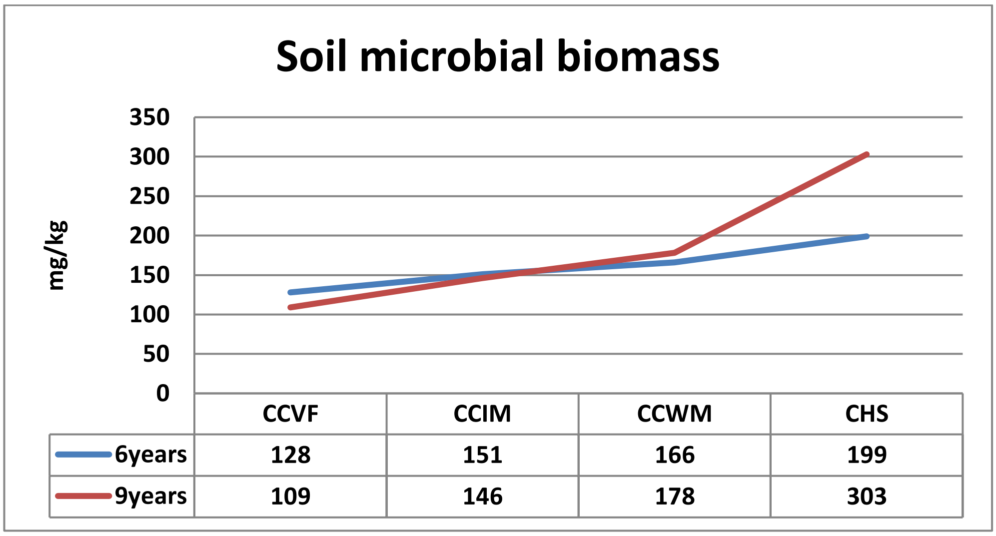
Soil organic carbon fractions in different conservation plots

Soil properties	CCVF		CCIM		WCIM		CHP	
	6 years	9 years	6 years	9 years	6 years	9 years	6 years	9 years
Loss on ignition(LOI), g kg^{-1}	9.86	8.24	10.98	9.15	11.03	11.76	11.85	14.54
Organic C(OC). g kg^{-1}	5.16	4.77	5.78	5.13	6.02	6.48	6.32	9.81

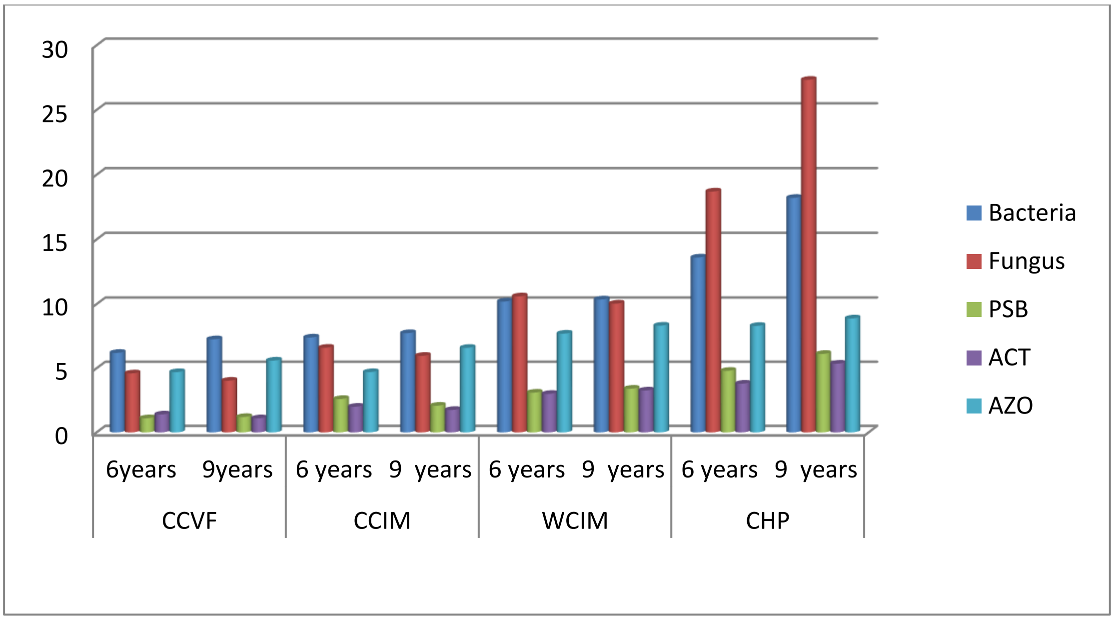
Soil active carbon and mineralization rate in conventional and conservation plots after six and nine years of experimentation



Soil microbial biomass in conventional and conservation plots after six and nine years of experimentation.



Soil microbial population after six and nine years of conservation practices



Soil faunal activity in conventional and conservation plots (no. 20cm^{-3}):

Soil organisms	**CCVF**		**CCIM**		**WCIM**		**CHP**	
	6 years	**9 years**	**6 years**	**9 years**	**6 years**	**9 years**	**6 years**	**9 years**
Earthworms	0	0	0	0	2	2	7	11
Centipede abundance	0	0	0	0	2	5	5	11
Springtails	76	82	108	127	412	445	776	1134
Termites	58	66	102	110	114	126	109	102
Ants	140	172	186	229	272	314	341	412
Nematodes	376	458	211	258	206	172	217	158
Mites	804	1028	1034	1178	1186	1342	1874	2276

Diversity indices of soil fauna in soils under different land uses

Diversity Indices	**CCVF**		**CCIM**		**WCIM**		**CHP**	
	6 years	**9 years**	**6 years**	**9 years**	**6 years**	**9 years**	**6 years**	**9 years**
Shanon Index -H	1.185	1.181	1.193	1.184	1.293	1.327	1.321	1.356
Simpson Index -D	0.614	0.599	0.626	0.619	0.646	0.660	0.663	0.668

CONCLUSIONS

Long-term soil conservation management in mango orchards improved the quality of soils through enhancing the organic carbon fraction and biological status, especially near the surface. Addition of litter and other crop residues lowered the soil bulk density and enhanced the infiltration rate. Soil aggregates and water stability improved under conservation treatments. Soil microbial diversity and extra cellular enzymes level improved over conventional management. Absence of earthworms and centipedes in vegetable plot and conventional mango orchards showed deterioration in soil properties under conventional intensive systems.

Thus, Conservation practices in orchard based cropping systems are designed to:

- reduce reliance on cultivation
- reduce fuel and labour inputs
- reduce soil erosion and land degradation through mulch cover
- reduce soil temperature and conserve moisture
- increase organic matter and improve soil structure and fertility
- enhance soil health through increased soil biodiversity
- reduce CO_2 emissions and build carbon levels leading to enhanced carbon sequestration
- achieve viable and sustainable productivity
- improve yields over the long term
- reduce vulnerability to climate change
- improve environmental and social outcomes in terms of cleaner air and water and more resilient and stronger communities

Eco-services of Conservation Horticulture practices in mango based cropping system

1. Zero tillage, permanent soil cover and cover crops have prevented erosion of soil due to wind and rain
2. inter crops and legume cover crop like M*ucuna* added significant organic residues to the system resulting in higher build-up of soil organic carbon over a period of 6-9 years
3. Improved soil physical, chemical and biological properties owing to increased Glomalin content
4. Significantly decreased soil bulk density and enhanced aggregation leading to better rain water infiltration and storage in the profile
5. Significantly increased soil water holding capacity
6. Significantly enhanced soil nutrient dynamics
7. significantly enhanced microbial diversity and their population in the soil
8. Significantly improved soil macro-fauna population and diversity including earthworms
9. Increased both above and below biodiversity and pest dynamics

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Government Initiatives to Support Organic Farming

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In India, organic farming is practiced for thousands of years. Organic farming in India is an agricultural method, uses pest control derived from organic manure and animal or plant waste. Organic farming started to respond to the environmental suffering caused by chemical pesticides and synthetic fertilizers.

Different schemes

1. Paramparagat Krishi Vikas Yojana (PKVY)
2. Mission Organic Value Chain Development for North Eastern Region (MOVCDNER)
3. Capital Investment Subsidy Scheme (CISS) under Soil Health Management Scheme
4. National Mission on Oilseeds and Oil Palm (NMOOP)
5. National Food Security Mission (NFSM)
6. Bharatiya Prakritik Krishi Padhati (BPKP)
7. National Horticulture Mission
8. National Mission for Sustainable Agriculture
9. Rashtriya Krishi Vikas Yojana
10. National Project on Management of Soil Health and fertility
11. National Project on Organic Farming (NPOF) Scheme-NCOF
12. National Programme for Organic Production (NPOP) –by apeda
13. Macro Management of Agriculture

Beneficiaries of All Schemes

- Farmers group
- Agril. Entrepreneur/Pvt.agencies
- Individual farmer

1. Paramparagat Krishi Vikas Yojana (PKVY)

A sub- component of Soil Health Management (SHM) scheme under National Mission of Sustainable Agriculture (NMSA) - implemented by SDA in 29 States and Union Territories.

Funding pattern in the ratio of 60:40 (Sixty-forty) by the Central and State Governments respectively.

In case of North Eastern and Himalayan States, Central Assistance is provided in the ratio of 90:10 (Centre: State) Union Territories, the financial assistance is 100%.

PKVY is exclusively framed for holistic promotion of Organic farming from seed to certification and marketing.

PGS is a participatory approach, wherein farmers living in similar geographical area (in the same of close-by villages) inspect and verify each other's process and confirms the adoption of standards, while third party certification (TPC) system is based on verification of process by an external agency

Organic Area Selection Criteria

- In hilly, tribal and rain-fed areas where utilization of chemical fertilizers and pesticides is less and the area has good accessibility for developing market linkages.
- Cluster approach will be adopted in large patches of up to 1000 ha area(contiguous patch)
- Formation of Gram Panchayat based Farmer Producer Organizations will be encouraged or promotion of already existing FPOs
- The ceiling of subsidy a farmer is eligible will be for a maximum of one hectare. In a cluster, there should be at least 65% of small and marginal farmers. Women farmers/ SHGs should be given preference

Under PKVY Organic farming is promoted through adoption of organic village by cluster approach and PGS certification

Adoption of Participatory Guarantee System (PGS) certification through cluster approach:

- Mobilization of farmers
- Capacity building (Trainings/demonstrations)
- Formation of clusters
- Adoption of various components of organic agriculture (bio-fertilizers, compost, green manure, custom hiring centres)
- PGS certification
- Increase in organic certified area/labelling and branding Linkages with domestic and international markets

Beneficiaries

- Farmers Groups
- Agril. Entrepreneur
- Service Provider
- Consumers

Any model of Organic Farming can be tried by States

This Hyderabad-based organisation Aranya Agricultural Alternatives (Narsanna and Padma Koppula) has helped over 2.5 lakh farmers through permaculture(ecology-environment-agriculture) is striving to achieve ecological and sustainable agricultural livelihoods through permaculture farming. (integrated agri systems and tree-based farming). The organisation runs a training centre which trains in capacity building of farmers (awareness, trainings, demonstrations, exposure visits, Aranya has been striving to promote biodiversity conservation, natural resources management with emphasis on climate change mitigation

- Cropping techniques like promoting an organic nursery to develop organic seeds will be implemented.
- Production of bio – fertilizers, bio – pesticides and other organic manures will be done. These will add to the production yield as they are rich in manures and they are also good for health.
- Organic manure management will be performed in the clusters of the PKVY.
- the farmers will also be assisted how to market the organic products from their cluster farms.
- Branding and labelling of the organic products will be done which will prove the authenticity of the organic materials.
- Proper certification of the organic products will be done.
- Transportation assistance to the farmers

Jaivik Kheti Portal

A Jaivik Kheti Portal will be developed for organic farming acting as both a knowledge platform as well as marketing platform. Farmers Details involved in Organic farming, input supplier, certification agency (PGS) and marketing agencies will be available for smooth implementation from production to marketing.

PKVY/PGS groups can take the advantage of Jaivik Kheti Portal for capacity building, technical know-how, communicating with marketing channels/ other groups and direct marketing of their produce to prospective buyers and consumers.

2. Mission Organic Value Chain Development for North Eastern Region (MOVCDNER)

Aims:

- Development of certified organic production in a value chain mode to link growers with consumers
- To support the development of entire value chain starting from inputs, seeds, certification, to the creation of facilities for collection, aggregation, processing marketing and brand building initiative.

Final aim:

- To develop commercial organic farming clusters with end-to-end.

- Facilitates from production to processing, marketing and finally delivering to the customer.
- Farmers are given assistance of Rs 25,000 /ha for three years for organic input procurement.
- Support for formation of FPOs, capacity building, post-harvest infrastructure up to Rs 2 crore are also provided in the scheme.

3. Capital Investment Subsidy Scheme (CISS) under Soil Health Management Scheme-sub scheme MIDH

100 percent assistance to

- Setting up of mechanized fruit and vegetable market waste, agro waste compost production unit up to a maximum limit of Rs 190 lakh per unit.
- Similarly, for individuals and private agencies assistance up to 33 percent of cost limit to Rs 63 lakh per unit as capital investment is provided.

4. National Mission on Oilseeds and Oil Palm (NMOOP)

50 % subsidy (Rs.300/ha) for supply of bio-fertilisers, rhizobium culture, PSB, Azatobacter, Mycorrhiza and vermi compost.

5. National Food Security Mission was launched to increase the production of rice, wheat, pulses, coarse cereals & commercial crops (cluster demos)

- Through area expansion and productivity enhancement (Seed production & distribution of HYVs at ICAR/SAUs)
- Restoring soil fertility and productivity INM, bioagent labs strengthening- financial assistance is provided for promotion of bio-fertiliser (Rhizobium/PSB) at 50 % (Rs 300/ ha)
- Creating employment opportunities;
- Enhancing farm level economy(micro-irrigation equipment)

The interventions covered under NFSM-Pulses include Cluster Demonstrations on improved package of Practices, Demonstration on cropping system, Cropping system based training of farmers, Seed Distribution of HYVs , Manual Sprayer, Power sprayer, tractor mounted sprayer, Chiseller (Deep Ploughing), Water carrying pipes, Mobile raingun, Sprinkler set, Pump set (up to 10 HP), Seed drill, Zero till seed drill, multi crop planter, Zero till multi crop planter, Ridge furrow planter, Rotavator, Multi crop thresher, Laser land leveller,Plant protection chemical and bio pesticides, weedicides,gypsum/phosphogypsum/bentonite sulphur, bio-fertilizers, micro nutrients, Local initiatives.

During 2016-17, new initiatives like distribution of seed minikits of newer varieties of pulses free of cost to farmers, production of quality seed, creation of seed hubs at SAU and KVKs, **strengthening of bio-fertilizers and bio agent labs at SAUs/ICAR Institutes,** cluster front line demonstration by KVKs and enhancing up breeder seed production at ICAR institutes and SAUs have been included under NFSM during 2016-17 for enhancing pulses production and productivity.

6. Bharatiya Prakritik Krishi Paddhati Programme (BPKP) under centrally sponsored scheme- Paramparagat Krishi Vikas Yojana (PKVY)

- NITI AYOG INITIATIVE (The National Institution for Transforming India, also called **NITI** Aayog- Think Tank' of the Government of India, providing both directional and policy inputs.
- Agroecology based diversified farming system.
- Promotes traditional indigenous practices & reduces externally purchased inputs

Promotion of natural farming under **Bharatiya Prakritik Krishi Padhati** (BPKP) of PKVY has been initiated to encourage use of natural on-farm inputs for chemical free farming.

Similarly, continuous area certification and support for individual farmers for certification have also been initiated during 2020-21 to bring in default organic areas and willing individual farmers under the fold of organic Farming State agencies, **Primary Agricultural Credit Societies** (PACS), **Farmer Producer Organisations** (FPOs),entrepreneurs among others can avail loans for setting up of post-harvest infrastructure for value addition to organic produce under 1 lakh crore **Agriculture Infrastructure Fund** (AIF) of **Aatmanirbhar Bharat**.

7. National Horticultural Mission

National Horticulture Mission is a Centrally Sponsored Scheme in which Government of India provides 100 percent assistance to the State Mission

The main objective of the Scheme is to develop horticulture to the maximum potential available in the states and to augment production of all horticultural products including fruits, vegetables, flowers, plantation crops, spices and medicinal and aromatic plants

The objectives of the mission are highlighted below:

- To provide holistic growth of the horticulture sector through an area based regionally differentiated strategies; ·
- To enhance horticulture production, improve nutritional security and income support to farm households; ·
- To establish convergence and synergy among multiple on-going and planned programmes for horticulture development; ·
- To promote, develop and disseminate technologies, through a seamless blend of traditional wisdom and modern scientific knowledge;
- To create opportunities for employment generation for skilled and unskilled persons, especially unemployed youth

To achieve the above objectives, the mission would adopt the following strategies:

- Ensure an end-to-end holistic approach covering production, post harvest management, processing and marketing to assure appropriate returns to growers/producers;
- Promote R&D technologies for production, post-harvest management and processing;
- Enhance acreage, coverage, and productivity through

(a) Diversification, from traditional crops to plantations, orchards, vineyards, flower and vegetable gardens; and

(b) Extension of appropriate technology to the farmers for high-tech horticulture cultivation and precision farming.

- Assist setting up post harvest facilities such as pack house, ripening chamber, cold storages, controlled atmosphere (CA) storages etc, processing units for value addition and marketing infrastructure;
- Adopt a coordinated approach and promotion of partnership, convergence and synergy among R&D, processing and marketing agencies in public as well as private sectors, at the National, Regional, State and sub-State levels;
- Where appropriate and feasible, promote National Dairy Development Board (NDDB) model of cooperatives to ensure support and adequate returns to farmers;
- Promote capacity-building and Human Resource Development at all levels

8. National Mission for Sustainable Agriculture (NMSA)

Sustaining agricultural productivity depends on quality and availability of natural resources like soil and water.

Agricultural growth can be sustained by promoting conservation and sustainable use of these scarce natural resources through appropriate location specific measures.

Indian agriculture remains predominantly rainfed covering about 60% of the country’s net sown area and accounts for 40% of the total food production. Thus, conservation of natural resources in conjunction with development of rainfed agriculture holds the key to meet burgeoning demands for food grain in the country. Towards this end, National Mission for Sustainable Agriculture (NMSA) has been formulated for enhancing agricultural productivity especially in rainfed areas focusing on integrated farming, water use efficiency, soil health management and synergizing resource conservation.

NMSA aims at promoting location specific improved agronomic practices through soil health management, enhanced water use efficiency, judicious use of chemicals, crop diversification, progressive adoption of crop-livestock farming systems and integrated approaches like crop-sericulture, agro-forestry, fish farming, etc.

Objectives

- To promote location specific Integrated/composite Farming System to make agriculture more productive, **sustainable, remunerative and climate resilient.**
- To adopt **comprehensive SHM practices**
- Optimize utilization of water resources through efficient water Management for achieving '**more crop per drop'**
- To pilot models in selected blocks for improving productivity of rain fed farming by mainstreaming rainfall technologies refined through **NICRA**

Assistance

- Setting up of vegetable market waste/agro waste compost production units, through NABARD @25% of total financial outlay (TFO)
- Setting up of state of the art liquid/ carrier based bio fertiliser/ bio-pesticide units, again through NABARD @33% of TFO.
- Setting up of bio-fertiliser and organic fertilisers testing quality control laboratory or strengthening of existing laboratory under FCO @ 85 lakh/unit for new and 45 lakh/unit for strengthening.
- Promotion of organic inputs on farmer's field with assistance of 50% of cost subject to a limit of Rs.5000/ hectare and Rs.10000 per beneficiary, with a target of 1 million hectares.

Under this mission, Rainfed Area Development (RAD) component is being taken up in convergence with other schemes to promote Integrated farming system and to provide value added developmental activities to the farmers to improve their economic status, inspite of the failure of crop due to insufficient rains or drought.

Implementation Strategy: The financial pattern for implementation of RAD program shall be shared at 60:40 between Central and State Government. As indicated in the GoI guidelines, the program shall be implemented in cluster mode, focusing on true spirit of the mission with integrated farming system as the core approach of development.

9. Rashtriya Krishi Vikas Yojana

- ★ To impetus the States to increase public investment in agriculture and allied sectors.
- ★ To provide flexibility and autonomy to the States in planning and executing agriculture and allied sectors schemes.
- ★ To ensure the preparation of plans for the districts and the States based on agro-climatic conditions, availability of technology and natural resource
- ★ To ensure that the local needs/crops/priorities are better reflected.
- ★ To achieve the goal of reducing the yield gaps in important crops, through focused interventions.
- ★ To maximize returns to the farmers.

Beneficiaries

Farmers association, Unemployed youth, Researchers Extension workers, Processors, Registered Farmers Societies

Assistance

RKVY funds would be provided to the state as 100% grant by the central government in production growth (35% of annual outlay), infrastructure and assets (35% of annual outlay), special scheme (20% of annual outlay), flexi fund (10% of annual outlay) Activities/component proposed under RKVY are generally covered under various on-going schemes/programmes of central government and the technical support or financial norms will be according to the scheme/programme.

1. Expanding agriculture by land terracing. Subsidy linked area expansion programme through land terracing program-Rs.50,000 subsidy /ha of land terracing
2. Convergence of land terracing program was made with various state and central sector projects being undertaken by allied departments such as rural works department and department of horticulture.
3. The beneficiaries were provided with seeds, organic manure, bio-fertilizers and bio-pesticides. Department of Horticulture, Government of Arunachal Pradesh also initiated a project under RKVY in the same year to provide low cost polyhouses for vegetable cultivation.
4. Increasing Cropping Intensity through Irrigation

10. National Project on Management of Soil Health and fertility(NPMSHF)

To aid and promote Integrated Nutrient Management (INM) through considerate use of chemical fertilisers, including secondary and micro nutrient, in conjunction with organic manure and bio-fertilisers, for improving soil health and its productivity.

To strengthen soil testing facilities and provide soil test based recommendations to farmers for improving soil fertility and economic return to farmers

- Data bank for balanced use of fertilisers
- A soil fertility monitoring system by ICAR SAUs.
- New STL's , Mobile STL's & FTL's
- A soil fertility monitoring system by ICAR SAUs.
- Pattern of assistance
- Arrange new soil testing laboratories & Mobile Soil Testing Laboratories (MSTLs) ,
- Strengthening of existing static STLs for micronutrient analysis, Capacity building through training and demonstration. ,·
- Creation of data bank for balanced use of fertilisers
- Adoption of village by STLs through frontline field demonstration.
- Preparation of digital district soil matter, a soil fertility monitoring system by ICAR SAUs.

- Setting up of fertilisers testing laboratories for advisory purpose, under the private/cooperative sector.

11. National Project on Organic Farming (NPOF) scheme

To popularize organic farming for enhancing farm income

Assistance

- Human Resource Development by providing training to state government officers, Fertilisers Inspector, organic Fertilizers Analysts.
- Statutory Quality Analysis of Bio fertilizers and Organic Fertilizers under Fertilizer Control Order (FCO) and Testing of other organic inputs for study purpose.
- Capacity building for low cost alternative, farmers group centric certification system-PGS
- Support for organic input production units under Capital Investment back ended subsidy scheme through NABARD
- Awareness creation through publicity, publication and other print and electronic media.

NPOF is implemented by National Centre of Organic Farming at Ghaziabad and its six Regional Centres at Bangalore, Bhubaneshwar, Hisar, Imphal, Jabalpur and Nagpur

Specific activities of NCOF/RCOFs

1. To collaborate all stakeholders of organic farming in the country and abroad and act as main information centre on various aspects of organic farming.
2. Documentation of indigenous knowledge and practices, compilation of integrated organic packages and publication of technical literature in all the languages.
3. Preparation and publication of uniform and authentic training literature and training course contents.
4. Publication of Biofertilizers and Organic Farming Newsletters for national and international updates on quarterly and half yearly basis.
5. To provide necessary technical assistance to production units for quality production of various organic inputs such as biofertilizers, composts etc.
6. To serve as data collection centre for biofertilizers and organic fertilizer production, biofertilizer and organic fertilizers production units and their production capacities and for details on total area under certification and various crops being grown under organic management.
7. To maintain National and Regional culture collection bank of biofertilizer organisms for supply to production units.
8. Development, procurement and efficacy evaluation of biofertilizer strains and mother cultures.
9. To act as nodal quality control laboratory for analysis of biofertilizers and organic fertilizers as per the requirement of Fertilizer Control Order.

10. To provide all sorts of technical assistance to implementing agencies for successful implementation of project targets

Activities of NCOF:

- main information centre
- publication & authentic training literature
- collection bank of biofertilizer organisms for supply to production units.
- efficacy evaluation of biofertilizer strains and mother cultures.
- nodal quality control laboratory for analysis of biofertilizers

12. National Programme for Organic Production (NPOP)

APEDA, Ministry of Commerce & Industries, Government of India is implementing the National Programme for Organic Production (NPOP). The programme involves the accreditation of Certification Bodies, standards for organic production, promotion of organic farming and marketing etc.

13. The Macro Management of Agriculture Scheme (MMA)

The Revised scheme has 10 Sub-schemes which are related to crop production and natural resource management.

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Residue Management in Organic Farming

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Introduction

Residue Management has become one of the biggest problems we are facing today. The per capita waste generation rate in India has increased from 0.44 kg/day in 2001 to 0.5 kg/day in 2011. Recycling of wastes through mineral enrichment resulted in greater amount of available plant nutrients. For efficient recycling of biodegradable organic wastes, composting technologies such as vermicomposting, phosphor-sulpho-nitro compost and P enriched vermicompost have been developed utilizing agro-industrial wastes, municipal solid wastes, distillery effluents, press mud, poultry waste and are also composted with certain mining wastes material such as rock phosphate, pyrites and mica for increasing the nutrient supplying potential of the compost. On the basis of crop production levels, it is estimated that ten major crops (rice, wheat, sorghum, pearl millet, barley, finger millet, sugarcane, potato tubers and pulses) of India generate about 679 million tonnes of crop residues, in which 226 million tonnesis actually available that has nutrient potential of about 5.6 million tonnes of NPK. The potential availability of all animal excreta is about 369 million tonnes of which 119 million tonnes is available that potentially supply 1.7 million tonnes of NPK. Thus, the estimated NPK supply from all the wastes including crop residues is 5.0, 6.25 and 9.25 million tonnes, respectively during the year 1991, 2011 and 2025. Urban wastes contain about 40% biodegradable matter, but only 14% (9.1 million tonnes) of the municipal solid wastes were composted during the year 2010, which may increase to about 15 million tonnes during the year 2030. The chemical analysis of the municipal solid wastes showed that the total amount of N, P and K is about 0.1322 million tonnes currently and that would be about 0.2175 million tonnes during 2030. Thus, the waste generated from agriculture and urban areas has huge potential for utilization in crop husbandry if appropriate and efficient technological interventions are provided.

Efficient decomposition process brings down the composting period from six to eight months to around 2- 3 months. Composting technologies viz; use of microbial multibio-inoculums such as cellulose decomposers (*Paecilomyces fusisporus* and *Aspergillus awamori*), P- solubilizers (*Bacillus polymyxa* and *Pseudomonas striata*) and free living N-fixer (*Azotobacter chroococcum*), earth worm inoculation (*Eudrillus euginea*, *Eisenia foetida*, and *Perionyx excavates* accelerated the decomposition processes and enrichment with pyrite, rock phosphate and mica for enriched the available plant nutrients in the compost. Organic manures application plays a vital role in maintenance of chemical, biochemical and biological properties of soils, besides supplementing macro and micro nutrients to crop. The deficiency of micro nutrients particularly of Zn, Fe, B, Mn, Cu and Mo is becoming a yield limiting factor in most of the soils.

Availability of organic wastes

Crop residues, which are not fed to animals or in excess on the farm such as straws of cereals, oilseeds etc can supply about 1.13, 1.41 and 3.54 million tonnes of nitrogen, phosphorus and potassium, respectively. On the basis of crop production levels, it is estimated that ten major crops (rice, wheat, sorghum, pearl millet, barley, finger millet, sugarcane, potato tubers and pulses) of India generate about 312.5 Mt of crop residues that have nutrient potential of about 6.46 million tonnes of NPK (Table -1) . It has been estimated that all animal excreta potentially can supply 15.5 million tonnes of plant nutrients. But only 1/3rd of it is used as manure. Annually, most of the metropolitan cities of India are generating about 150 million tonnes of city refuse that has nutrient potential of about 2.72 million tonnes of N, P and K (Table 2) . It was estimated that about 57 million tonnes of city wastes is being generated every year from different cities of India that will be increased to 104 million tonnes per year during 2025 (Agricultural Statistics, 2004). About 41% of these wastes contain biodegradable matter, but only 8.6 % of the municipal solid wastes are composted which is about 8.9 million tonnes per year. This could be increased to 20.8 million tonnes per year during 2025 by improved technologies. By adopting the efficient composting techniques, the produced compost contains high nutrient value compared to conventional compost. The chemical analysis of municipal solid waste showed that the total contents of N, P_2O_5 and K_2O is about 2.85 lakhs tonnes that would be about 5.4 lakh tonnes during 2025. As on today, municipal solid waste compost can save fertilizer amounting to about Rs.189 crores by improved method (with high management intervention).

Table 1: Organic matter quantity and utilizable nutrient potential from different sources of crop residues

Agricultural Wastes	Residues quantity(Mt)	N P K ....%...........	Nutrient total(Mt) NPK	Potential utilizable (Mt) NPK
Rice	110.5	0.61 0.18 1.38	2.39	0.77
Wheat	82.6	0.48 0.16 1.18	1.50	0.50
Sorghum	21.0	0.52 0.23 1.34	0.44	0 .15
Maize	12.5	0.52 0.18 1.35	0.26	0.09
Pearl millet	15.6	0.45 0.16 1.14	0.27	0.09
Barley	2.5	0.52 0.18	0.05	0.02

		1.30		
Finger millet	5.3	1.00 0.20 1.00	0.12	0.04
Sugarcane	40.9	0.40 0.18 1.28	0.76	0.25
Potato	7.9	0.52 0.21 1.06	0.14	0.05
Pulses	13.7	1.60 0.51 1.75	0.53	0.18
Total	312.6	- - -	6.46	2.15

Manna and Ganguly (1998) Agric. Review 19(2):86-104

Table 2: Organic matter quantity and nutrient potential from animal, poultry, city refuse and sewage-sludge water*

Different wastes	Quantity(Mt)	N P K ………Mt……….
Wet dung, cattle and buffaloes	1227.8	1.84 1.23 0.61
Animal urine	800	1.60 0.08 1.60
Sheep and goat	45	0.27 0.06 0.45
Poultry wastes	1.00	2.17 2.00 2.20
Horses	0.48	1.51 0.35 1.80
City refuse	150	0.75 0.34 1.63
Sewage-sludge water	1460M tm^2 year^{-1}	0.04 0.01 0.18
Total	-	8.18 4.07 9.47

Manna and Ganguly (1998) Agric. Review 19(2):86-104

Efficient Composting Techniques

Different composting techniques, application levels, techniques of enrichment and turning would affect composting which is classified into different categories, namely, direct and indirect recycling, dumping method, composting and mechanical sorting. The process of composting is mainly of two types aerobic composting and anaerobic composting. The gaseous oxygen is necessary to facilitate the proper aerobic decomposition. Rapid decomposition takes place and thereby, C: N ratio narrows down earlier than anaerobic process. Anaerobic decomposition is only a partial break down of organic matter and produces foul gases due to predominance of anaerobic organisms but this process is very slow. There are many factors which affect on composting process such as size of heap, pit and organic materials used for composting, aeration, temperature etc. While traditional composting procedures take as long as 6-8 months to produce finished compost, efficient composting techniques offer possibilities for reducing the processing period to 3 months. The following are the efficient technologies developed for the recycling of organic wastes in to nutrient enriched composts:

Vermicomposting

i) P-enriched vermicomposting
ii) Phosphcompost
iii) Phospho-sulpho-nitro-compost
v) Microbial enriched compost

i) Vermicomposting

Vermicomposting is a method of composting with worms and differs from conventional composting in several ways. In vermicomposting, there is a saving of nearly two months in composting time compared to conventional compost. Vermicompost is rich in nutrients, microbial activity and enzymes. In general, there are two methods of vermicomposting under field conditions.

1. Vermicomposting of wastes in field pits.
2. Vermicomposting of wastes on heaps

For production of vermicompost, open permanent pits of 10 feet length x 3 feet width x 2 feet deep were constructed under the tree shade, which was about 2 feet above ground to avoid entry of rainwater into the pits. Brick walls were constructed above the pit floor and perforated into 10 cm diameter 5-6 holes in the pit wall for aeration. The holes in the wall were blocked with nylon screen (100 mesh) so that earthworms might not escape from the pits. Partially decomposed dung (dung about 2 months old) was spread on the bottom of the pits to a thickness of about 3-4 cm. This was followed by addition of layer of litter/residue and dung in the ratio of 1:1 (w/w). A second layer of dung was then applied followed by another layer of litter/crop residue in the same ratio up to a height of 2 feet. Two species of *epigeic* earth worm viz., *Eisenia foetida* and *Perionyx excavatus* were inoculated in the pit. Moisture content was maintained at 60-70% through-out the decomposition period. Jute bags (gunny bags) were spread uniformly on the surface of the materials to facilitate maintenance of suitable moisture regime and temperature conditions. Watering by sprinkler was often done. The materials was allowed to decompose for 15-20 days to stabilize the temperature because to reach the mesophilic stage, the process has to pass the thermophilic stage, which comes in about 3 weeks. Earthworms were inoculated in the pit or heap with 10 adult earthworms per kg of waste material and a total of 500 worms were added to each pit or heap. The materials were allowed to decompose for 110 days. The forest litter was decomposed much earlier (75 to 85 days) to farm residue (110 $\pm$ 5 days).

Silpaulin Portable Vermi-bed

For production of vermicompost, silpaulin portable vemi-bed of 12 feet length X 4 feet width X 2 feet deep were kept under the tree shade, which was about ½ feet above ground to avoid entry of rainwater into the beds. In portable vermi-bed, partially decompose organic wastes was added crop residues and dung in the ratio of 1:1 (w/w). Two species of earthworms viz., *Eisenia foetida* and *Perionyx excavatus* were inoculated in the bed. Moisture content was maintained at 60-70% through- out the decomposition period. Jute bags (gunny bags) were spread uniformly on the surface of the materials to facilitate maintenance of suitable moisture regime and temperature conditions.

Table 3: Chemical composition of vermicompost and P-enriched vermicompost prepared from soybean straw

Parameters	***Vermicompost***	***P-enriched vermicompost***
Ash (%)	51.0	52.5
TOC (%)	27.2	26.5
C/N ratio	14.3	13.6
N (%)	1.90	1.95
P_2O_5 (%)	2.05	4.0
K_2O (%)	0.80	0.86
WSC (%)	0.94	0.88
Mn (ppm)	500	540
Zn (ppm)	100	100
Cu (ppm)	44	46

Singh et al, (2005)

Vermiwash:

Advances in vermiculture technology have recently led to novel products like vermiwash. This product has now not only caught the attention of commercial vermiculturists but also the farmers. Farmers in their own way have started collecting vermiwash for foliar application. For preparation of vermiwash, one-kilogram adult earthworms devoid of casts (approximately numbering 1000-1200 worms) is released into a trough containing 500 ml of lukewarm distilled water (37^{o}C-40^{o}C) and agitated for two minutes. Earthworms are then taken out and again washed in another 500 ml at room temperature ($\pm$ 30^{o}C) and released back into the tanks. The agitation in lukewarm water makes the earthworms to release sufficient quantities of mucus and body fluids. Transferring into ordinary water is to wash the mucus sticking still on to their body surface and this also helps the earthworms to revive from the shock.

ii) P- Enriched Vermicompost

In India, about 260 million tonnes of rock phosphate deposit has been estimated at present, the low-grade rock phosphate is used as direct source of P for crop production, especially in acid soil and long-duration plantation crops only. However, there is very little experimental work available on the effect of mixing rock phosphate with different qualities of organic sources and their application in neutral or alkaline soils. For production of P enriched vermicompost, earth worms species viz., *Eisenia foetida* and *Perionyx excavatus* were inoculated in the pit. Moisture content was maintained at 60-70% through out the decomposition period. Jhabua rock phosphate (30-32% P_2O_5) was used @ 2.5 % P_2O_5 of waste material with the same dimension of pit or heap as mentioned earlier. Jute bag (gunny bags) spread uniformly on the surface of the materials to facilitate maintenance of suitable moisture regime and temperature conditions. Watering by sprinkler was often done. The materials was allowed to decompose for 15-20 days to stabilize the temperature because to reach the mesophilic stage, the process has to pass the thermophilic stage, which comes in about 3 weeks. Earthworms were inoculated in the pit or heap with 10 adult earthworms per kg of waste material and a total of 500 worms were added to each pit or heap. The materials were allowed to decompose for 110 days. The forest litter was decomposed much earlier (75 to 85 days) to farm residue (110 $\pm$ 5 days). The composition of vermicompost and P-enriched vermicompost are given in Table-4.

Table4: Chemical composition of vermicompost and P-enriched vermicompost

Parameters	*Vermicompost*	*P-enriched vermicompost*
TOC (%)	27.2	26.5
N (%)	1.90	1.95
P_2O_5 (%)	2.05	4.00
K_2O (%)	0.80	0.86
Mn (ppm)	500	540
Cu (ppm)	44	46

Singh *et al.* (2005)

iii) Phosphocompost:

1. Crop residues/straws usually contain high C: N ratio. This can be lowered by either using nitrogen fertilizer or residues from legumes crops. **Phosphocompost production technology:** Most of the Indian Most of the Indian soils are deficient in phosphorus. Also, yearly removal of P is more than its addition through P fertilizers during continuous and intensive cropping. Bio-solids produced in cities, agro-industries and at farms normally have low nutrient value, particularly of P content. Compost production from these bio-degradable

wastes is presently not an economically viable proposition. The traditional technology of composting, if improved in terms of nutrient content, may help in arresting trends of nutrient depletion to a greater extent. Further, the use of mineral additives such as rock phosphate and pyrites during composting has been found beneficial. A phosphocompost/N-enriched phosphocompost technology has been developed using phosphate solubilizing microorganisms, namely, *Aspergillus awamori*, *Pseudomonas straita* and *Bacillus megaterium*; phosphate rock, pyrite and bio-solids to increase the manurial value compared to ordinary FYM and compost (Singh, 2003).

For making phosphocompost crop residues or farm wastes are valuable resources for the preparation of good quality compost having nutrient contents higher than FYM or ordinary compost. Cereals straw usually contains high C: N ratio. This can be lowered for favourable C: N ratio either by using nitrogenous fertilizers or legumes residues. Chopped rice straw, amended with phosphate rock (10-25% w/w); pyrite (5-10% w/w) and mixed with soil. The whole mixed material is either heaped layer by layer over the ground or put inside a pit. Sufficient water is added to each layer to bring its moisture content between 60-75% water holding capacity. Mixture of decomposing microorganisms and phosphate solubilizing fungi like *Aspergillus awamori* are sprayed on the decomposing material. The material is turned after 30, 60 and 90 days. Chemical analysis of the composted materials has been found to contain N 1.4-2.0%; P_2O_5 3-7%; K 1.5-2.0% with C: N ratios ranging from 8-15 (table-5).

Table 5: Chemical composition of phosphocompost

Treatments	**O.C (%)**	**TN (%)**	**C:N**	**P_2O_5 (%)**
Crop residue (CR)	21.45	1.35	15.9	0.36
CR+ RP (12.5%)	18.68	1.62	11.5	3.92
CR+ RP (25%) + Pyrite (5%) + N (0.5%)	18.45	1.65	11.2	7.42
CR+ RP (25%) + Pyrite (10%) + N (1.0%)	17.86	1.87	9.6	4.21
CR+ RP (12.5%)	17.89	2.12	8.4	7.30
Initial	50.43	1.24	40.66	0.29

Singh (2003)

iv) Phospho-sulpho-Nitro- Compost

To prepare the mineral enriched compost, each residue was first mixed with fresh cow dung in the ratio of 1:1(w/w) on material dry matter basis. Cheap low-cost mineral amendments such as rock phosphate (Mussouri rock phosphate, 100mesh), pyrite and urea-N were added in the mixture. The indigenous rock phosphate, pyrite and nitrogen were added @ 5% P_2O_5, 10% (w/w) and 0.5% urea-N, respectively, and mixed thoroughly with fresh cow dung slurry (60-70% moisture). Nitrogen was added to stimulate the microbial activity at a narrow C: N ratio because the organism's proliferation was maximum at C: N ratio of 30:1 to 40:1. Pyrite was added to acidify the mixture during composting so as to prevent the volatilization losses of nitrogen and also to progressively increase the phosphorus solubilization.

Table6: Effect of phosphor-compost and fertilizer N, P and K on grain yield (q ha^{-1}) of sole soybean-wheat , sorghum-wheat and soybean+sorghum-wheat

Treatments	Soybean	Wheat	Sorghum	Wheat	Soybean+Sorghum	Wheat
Control	6.55	13.29	13.30	6.67	11.59	9.28
75% NPK	8.00	23.58	27.58	16.14	17.59	22.50
100% NPK	8.76	28.12	31.53	17.80	22.96	27.94
75% NPK+compost	10.12	32.84	34.90	24.42	2810	32.10

Economic advantages of Phospho-sulfo-nitro compost

- In a three-years field study on soybean-whea system, application of 100% NPK through enriched compost to soybean and 50% NPK to succeeding wheat produced the highest yield and saved 25kg N and 39.2kg P/ha.
- A five years-field study on Vertisols revealed that compost application @ 5 t ha^{-1} in combination with 75% NPK to soybean followed by 75% NPK applied to wheat produced higher productivity in soybean-wheat, sorghum-wheat and soybean+sorghum-wheat system compared to 100% NPK treatment and saved 37kg N, 30kg P and 15kg K.
- To improve soil biological activities phosphor-sulpho-nitro compost along with chemical fertilizer application is the best option compared to inorganic fertilizer alone.
- Phosho-sulpho-nitrocompost contains relatively higher amounts of available plant nutrients compared to conventional compost.
- Thus, phosphor-sulpho-nitro compost helps to produce higher yields of crops, quality of produce and maintain fertility status of soils. The use of enriched manure in field crops is also economically viable and safe to the environment.

V) Microbial enriched compost

To accelerate the decomposition process, the above ingradients and the multi- bioinoculum such as cellulose decomposers (*Paecilomyces fusisporus* and *Aspergillus awamori*), P-solubilizers (*Bacillus polymyxa* and *Pseudomonas striata*) and free living N-fixer (*Azotobacter chroococcum*) etc. were added at 5 and 30 days of decomposition to hasten the decomposition process, phosphorus solubilization from insoluble rock phosphate, and N_2- fixation by free living N-fixer as well. Fungal culture was added at 500 g mycelial mat per tonne of materials where as bacterial culture was added at 50 ml kg^{-1} of material having 10^8 viable cell/ ml. initially for 1-3 days, bio-inoculums was added twice in the mixture of owing to a high initial temperature (55 to 70^0c) and thereafter, the frequency of addition of inoculums decreased gradually. Thus, to improve the overall manurial quality of decomposed wastes and to accelerate the decomposition process, mineral amendments and bio-inoculums are needed to be added during the manure preparation (Table-7).

Table 7: Chemical parameters of matured microbial enriched Phosphocompost prepared from different organic wastes

Chemical parameters	Soybean straw	Wheat straw	Mustard straw	City garbage
TOC (%)	28	24	32	13
Total N (%)	2.32	1.93	1.47	1.58
C/N ratio	12.1	12.4	21.7	8.2
CEC(C mol (p^-) kg^{-1})	68	113	53	66
CEC/TOC	2.32	4.70	1.65	6.0
Lignin (%)	31	37	30	13
Cellulose (%)	10	11	12	4
Lignin/cellulose ratio	3.1	3.4	2.5	3.2
Water-soluble C (%)	0.28	0.25	0.30	0.26
Water-soluble carbohydrates (%)	0.30	0.23	0.43	0.23
Available NH_4-N (g/kg)	0.54	0.45	0.26	0.12
Available NO_3-N (g/kg)	0.76	0.88	0.35	0.28
Water soluble- P (g/kg)	0.88	0.82	0.48	0.31
Citrate soluble- P (g/kg)	7.85	8.83	3.15	2.31
Total-P (%)	4.13	4.25	3.43	3.23

Manna *et al.* (2006)

Effect of organic manure application on crop yield

Under organic farming manures were applied to *kharif* and *rabi* crops based on N equivalent basis. Phosphorus was supplemented through rock phosphate along with PSB. Application of poultry manure @ 5 t/ha was found to give higher grain yield of both macroni and bread wheat varieties compared to the vermicompost @ 7.5 t/ha or cattle dung manure @ 10 t/ha. Productivity of crops under different management systems is presented in table 7.

Table 8: Productivity of crops (kg ha^{-1}) as influenced by management practices

Management practices	**Soybean**	**Durum wheat**	**Mustard**	**Chickpea**	**Isabgol**

Organic	1144	4915	1948	1890	1249
Inorganic	1030	4862	1890	1813	1123
Integrated nutrient management	1090	5160	2156	2056	1228
CD (P=0.05)	**78.3**	**NS**	**NS**	**NS**	**54.9**

Ramesh *et al.,* 2006.

Effect of Organic Manures on Crop Quality:

Incorporation of organics in the rainy season either in the form of FYM or compost or poultry manure improved all the nutritional quality of wheat and was significantly higher over control and 75% NPK. Nutritionally better quality of wheat grains obtained in organically treated plots (table 9 & 10) may be ascribed to the availability of the essential nutrients in the organic matter due to its continuous mineralization. Kler *et al.* (2002) have reported that application of organic manures improved the protein content of wheat compared to chemical farming.

Table 9: Effect of various organic manures combinations on wheat grain quality Singh et al (2008)

Treatment	Mineral (%)	Protein (%)	Tryptophan (g /16 g N)	Methionine (g /16 g N)	Grain yield (kg/ ha)
Cattle dung manure + poultry manure	1.55	12.14	1.30	1.58	3942
Cattle dung manure + vermicompost	1.55	11.61	1.32	1.53	3770
Poultry manure + vermicompost	1.58	11.90	1.34	1.57	3860
Cattle dung manure + vermicompost+ poultry manure	1.54	11.74	1.39	1.59	4130
Control	1.50	11.31	1.28	1.52	2925
CD (0.05)	NS	0.20	NS	NS	219

Table10: Effect of nutrient management practices on yield and quality of soybean

Treatment	**Protein**	**Oil**	**Methionine**	**Cysteine**	**Tryptoph**

	(%)	**(%)**	**(g /16 g N)**	**(g /16 g N)**	**an (g /16 g N)**
Organic	35.48	18.67	1.75	1.65	1.83
Inorganic	34.69	17.55	1.63	1.56	1.76
INM	35.44	18.71	1.74	1.65	1.87
Control	34.22	16.75	1.57	1.55	1.74
CD(P=0.05)	78.6	0.24	0.04	NS	NS

Singh *et al*, (2008).

Regnold et al (2001) have reported that the organic system produced sweeter and less tart apple, higher profitability and greater energy efficiency. In pomegranate, fruit quality parameters such as sugars, TSS and ascorbic acid content increased significantly with the application of INM, organic and inorganic management systems (Table 11**)**. The maximum TSS was recorded in cattle dung manure treatment. The minimum juice acidity was recorded due to application of organic, inorganic and integrated nutrient sources, while, it was maximum in control. Higher accumulation of ascorbic acid was recorded in INM treatment followed by organic and inorganic treatments and was the lowest in control.

Table 11: Effect of different nutrient sources on pomegranate quality

Treatments	TSS (%)	Sugar (%\	Acidity (%)	Vitamin C (mg/100g)	Carotene (mg/100g)	Tannin (%)
Control	15.5	10.4	0.31	16.0	2.10	0.48
Vermicompost	16.8	11.7	0.26	17.5	2.29	0.42
Phosphocompost	16.7	12.0	0.24	17.7	2.25	0.41
CDM	17.4	12.5	0.25	17.8	2.37	0.40
RDF (400:250:200 g NPK plant^{-1})	16.5	11.5	0.27	17.4	2.29	0.47
50% RDF+ 50% CDM	17.3	12.6	0.25	17.9	2.48	0.40
CD (P=0.05)	0.09	0.11	NS	0.12	NS	NS

Singh, 2009

Effect of organic manure application on soil properties

To avoid the wastage of resources and to minimize the environmental damage there is a need to adopt better nutrient management practices like balanced fertilization or application of organics in combination with chemical fertilizers to increase nutrient availability (N, P, K, Ca, Mg and S) and improve soil physical, chemical and biological conditions, thereby, enhancing quality of produce and helping in sustainability of Agriculture.

The post harvest soil analysis data indicated that 100 % organic treatment improved the soil organic carbon and slightly increased the available N, P and K status compared to either 100 % chemical or integrated management practice (table 12). Among the cropping systems, soybean-durum wheat recorded higher organic carbon content and available N, P K status of the soil. The bulk density of the soil is low in organic treatment compared to the other treatments. The effect of different cropping systems was not conspicuous on the bulk density and aggregate stability of the soil

Table 12. SOC, available NPK, bulk density and aggregate stability of soil after 4 years of cropping

Treatment	O.C. (%)	Soil available nutrients (kg/ha)			B.D. (g/cc)	MWD (mm)
		N	P	K		
Management Practice						
100 % Organic	0.71	189.5	27.66	611	1.36	0.917
100 % Chemical	0.55	175.1	20.85	580	1.41	0.890
Integrated (50:50)	0.67	186.3	24.44	599	1.37	0.895
CD (P=0.05)	0.06	NS	4.09	18.4	NS	NS
Cropping system						
Soybean-Durum wheat	0.71	193.2	33.45	624	1.38	0.915
Soybean-Mustard	0.68	184.3	25.66	598	1.37	0.908
Soybean-Chickpea	0.62	187.4	20.78	589	1.39	0.884
Soybean-Isabgol	0.57	169.3	17.77	575	1.39	0.896
CD (P=0.05)	0.07	13.2	4.73	22.8	NS	NS

Ramesh et al, 2008

Recommendations of Practical Utility

1. It is recommended to apply organic manures to crop irrespective of season.
2. The quantity of organic manures should be applied in sufficient quantities so as to fulfill the nutrient requirement of crops. It is observed both in field experiments and in our survey work, one of reasons for reduced yields in experiments and in organic farming was due to application of less quantities of organic manures which were not able to supply required quantities of nutrients for the crops.

3. The quantity of organic manures/composts and applied should be equal to the nitrogen equivalent of each crop requirement. For example, soybean crop should contain not less than 30 kg N/ha.
4. It is always better to apply more than one source of organic manures of composts, which are readily available in the particular region. This combination of organic manures was found to release nutrients close to the crop nutrient requirement.
5. Phosphorus requirement may be supplemented with the application of locally available mineral rock phosphates like Jhabuwa /Mussorie /Udaipur rock phosphate.
6. In high nitrogen requirement crop like maze or wheat, we can apply part of organic manures as split dose also. In our studies, we found good response to application of well composted poultry manure or vermicompost when applied 25-30 days after sowing to maize, and placed near to rows followed by light earthing up operation.
7. From our studies/observation, we found the following plant protection measures were beneficial to successful crop production in organic farming.
    - Summer ploughing
    - Soil application of biofungicide, Trichoderma viride @ 5 kg/ha
    - Soil application of bioagent-enttomopathogenic, Beauveria bassiana @ 2 kg/ha
    - Dhaincha as border crop/trap crop for soybean girdle beetle
    - Neem oil (Azadiractin 0.03%) spray.
    - Pheromone trap for Spodoptra and Helicoverpa (Helilurs).
    - Spodoptera NPV (SNPV) and Helicoverpa NPV (HNPV) spraying for the control of defoliators and pod borers, respectively,
    - Keeping bird perches in the field.

Future strategies for organic farming

- Based on soil and climatic conditions, it is a well known fact that pulses and horticultural crops should be given priority since they fetch huge premium price.
- To reduce heavy doses of fertilizers, herbicides, fungicides and insecticide application and to get better yield and quality of crops, organic farming is now regarded as the best solution. Hence, for drawing any future policy on organic farming in the region the following points need to be considered:
- Research effort is required to develop fine-tune the organic nutrient management technologies to suit different ago-ecological and site-specific requirements.
- Generation and mobilization of manures is a big constraint. There is a need to develop rapid composting techniques to recycle available biomass and crop residues to make good quality organic manures along with nutrient enriched organic manures.
- There is a need to develop effective pests and disease management in organic farming by introducing suitable combination of inter-crops, crop rotations, use of botanical and biological pest control methods etc.

- There is a need for development of efficient technology for processing, value addition, product development, storages and transportation techniques for perishable commodities.
- Efforts should be initiated on marketing policy, market intelligence and trade. In order to safeguard the interest of growers of organic produce, scheme for buy-back policy should be introduced and also ensure high premium prices for their farm produce.
- There is a need to develop linkage of farmers with marketing network with the help of information technology, so that the information on day to day production and supply made available to all concerned.

Conclusions:

Organic manures application plays a vital role in maintenance of chemical, biochemical and biological properties of soils, besides supplementing macro and micro nutrients to crop. The deficiency of micro nutrients particularly of Zn, Fe, B, Mn, Cu and Mo is becoming a yield limiting factor in most of the soils. Organic farming is an alternative agriculture, which has been proposed as a solution to problem associated with intensive use of agro-chemicals. Manures and crop residues are carefully managed to recycle nutrients in the system. Efficient decomposition process brings down the composting period from six to eight months to 2- 3 months. Composting technologies viz; use of microbial multibio-inoculums such as cellulose decomposers (*Paecilomyces fusisporus* and *Aspergillus awamori*), P- solubilizers (*Bacillus polymyxa* and *Pseudomonas striata*) and free living N-fixer (*Azotobacter chroococcum*), earth worm inoculation (*Eudrillus euginea*, *Eisenia fetida*, *Perionyx excavatus* and *Perionyx sansibaricus* as prominent composting earthworms), enrichment with pyrite, rock phosphate and zinc sulphate for recycling of organic wastes into nutrient enriched compost. Mineral enriched compost has greater amount of available plant nutrients and contains less phyto-toxic materials and pathogens. Application of 100 % NPK through enriched compost to soybean and 50 % NPK to succeeding wheat produced the highest yield and saved 25 kg N and 39.2 kg P/ha. Thus, enriched compost helps to produce higher yields of crops, quality of produce and maintain fertility status of soils. The use of enriched manure in field crops is also economically viable and safe to environment.

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Insitu Composting Techniques

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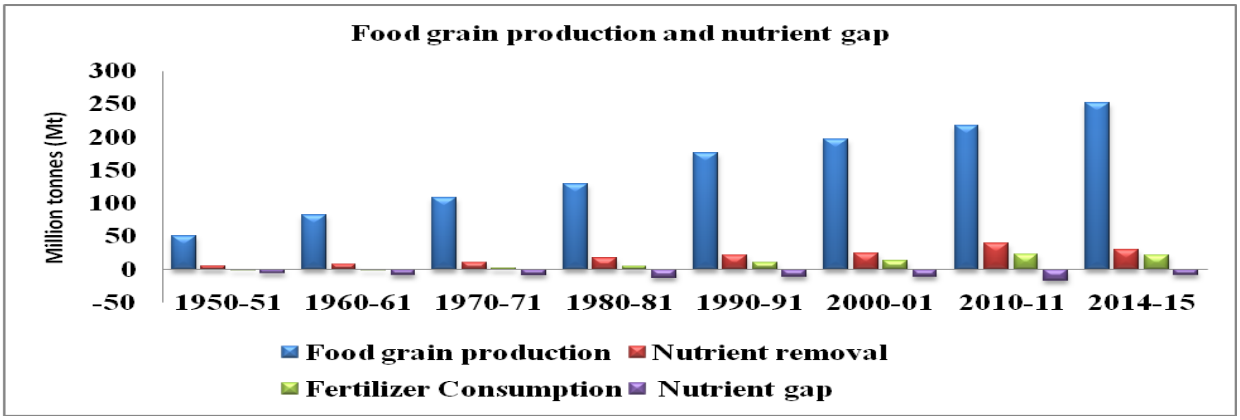
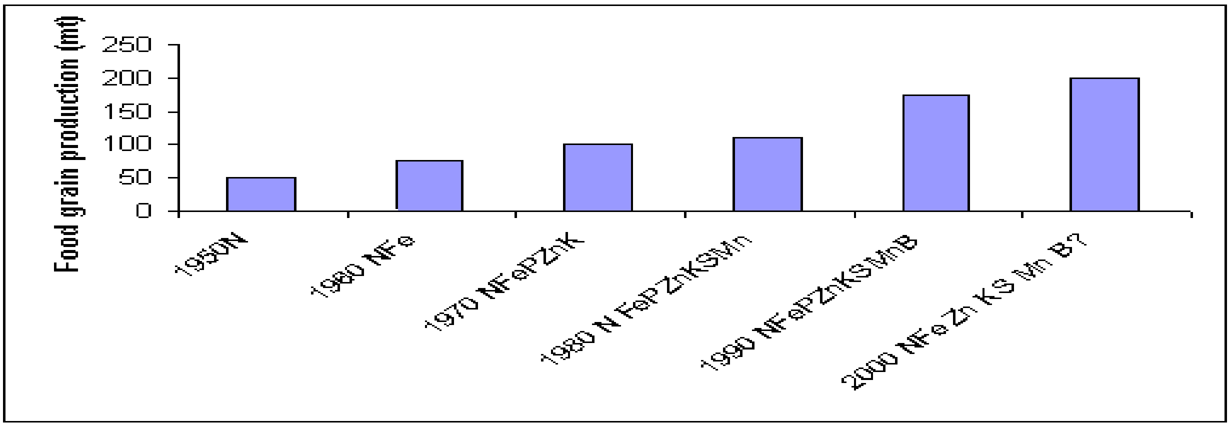
Why Poor Soil Health?

- Wide gap- nutrient demand and Supply
- Emerging deficiency of nutrients
- Acidification
- Development of salinity and alkalinity
- Development of heavy metal toxicity
- Disproportionate growth of microbial population
- Natural and manmade calamities
- Insect and Pest cause of soil health
- Improper use of inputs - fertilizers, water pesticides etc.
- Low/ Imbalanced use of fertilizer
- Insufficient use of organics

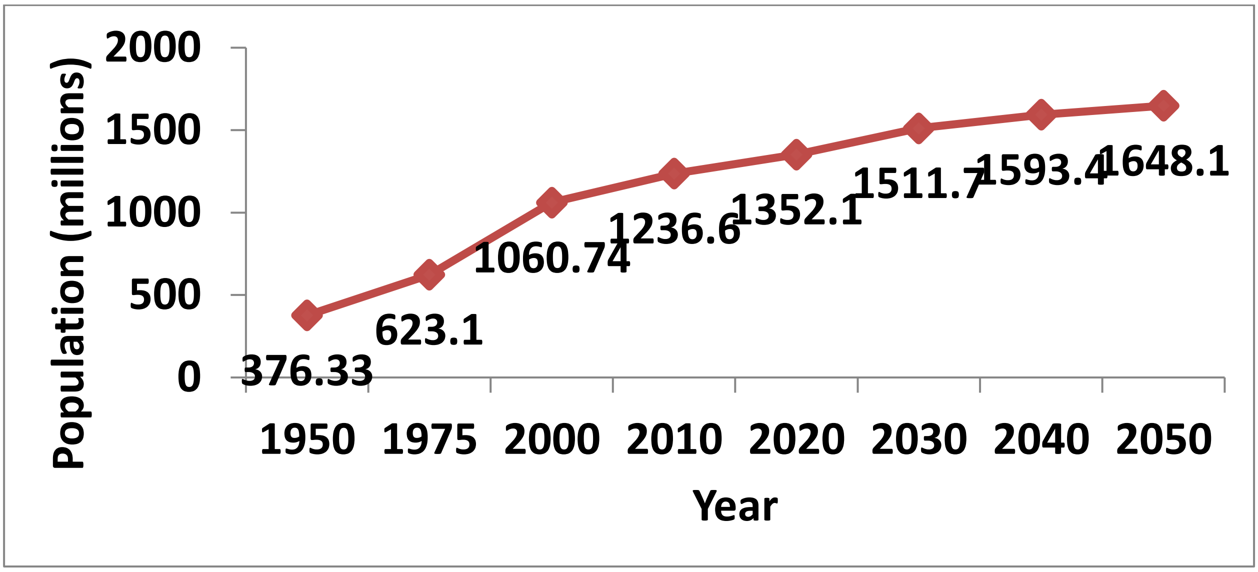
Soil Nutrient (NPK)



Food grain production and emerging nutrient deficiencies in soils of the country due to intensive cropping. Source: Swarup and Ganeshamurthy (1998)



Population trend in India



Consequences

- Ground water Pollution
- GHGs emission
- C-loss
- Global warming
- Health Hazards

IMPACT OF CROP RESIDUES BURNING ON SOIL

Impacts

- Loss of soil organics
- 27-73 % of N lost
- 50% reduction in bacterial population on burning
- Exchangeable NH_4^+ - N & biacarbonate extractable P content show immediate increase

Existing Problems of Sugarcane Growers

- Declining productivity
- Increasing cost of cultivation
- Fluctuating sugar and sugarcane prices
- Sugarcane industrial management problems
- Recycling of sugarcane crop residues and disposal of industrial wastes after harvest and processing

Alternatives to Sugarcane Residue Burning"

In-situ/ Ex-situ Decomposition
Availability of Microbial Consortia of fungi, bacteria and actinomycetes, economics, farmers acceptability, duration of composting

Conservation agriculture
Mulching, minimum tillage, zero tillage, economics

Biochar application
Nutrient release, microbial biodiversity, C-sequestration, GHGs emission, economics, farmers acceptability

Gasification for energy conversion
Removal from field, loss of carbon, biodiversity, availability, acceptability

Industrial use
Cupboard, paper mill, wooden industries , Biofuel (Bioethanol) production

Soil Organic Matter: Keeping Soil Alive

Soil Organic matter multifunctional role

- ✓ Soil health
- ✓ Biodiversity
- ✓ Sustaining Productivity
- ✓ Reduce GHGs
- ✓ C-sequestration
- ✓ Climate Change aberration

Environmental Pollution and Public Health

- ✓ Residue is a rich source of organic carbon and plant nutrients
- ✓ Conversion of residues into compost helps augment needed organic carbon in the soil, besides cleaning the environment.
- ✓ This is adversely affecting soil biological reactions.
- ✓ Impaired soil health is due to declining SOM levels and associated nutrients.
- ✓ Adequate amount of organic matter can enhance 20 % efficiency of nutrients in the form of fertilizer when used in conjunction
- ✓ SOM plays a key role in saving fertilizer and improving soil health
- ✓ Green house gases and production of other obnoxious gases due to rice/trash burning
- ✓ Respiratory trouble caused by unbearable smokes

Points to Ponder Why not???

- Waste or Wealth?
- Carbon Storage and Sequestration?
- Soil Health & Productivity?
- Nutrient Mining or Recycling?

- Water and Nutrient Storage Capacity?

Action Plan

- Accelerate the decomposition process for through rapid composting technique
- Maximum use of indigenous source of plant nutrients such as rock phosphate, pyrites, waste mica, Gluconite rock etc.
- Waste Management (farm, city and forest litter)
- Enriched the manure with beneficial microbes at cooling phase of manure
- Minimum content of Heavy metals and pathogens

Methods of Composting

Abroad

- Indore process of USA (Wiley, 1967 and Poincelot & Day, 1973)
- Berkley method (University of California, 1953)
- Windrow method (Randazzo, 1970 and Rodale, 1971)
- Beccari process (Rodale and Staff, 1971)
- Vuil- Afvoer- Maatschappij process (Netherlands)
- Chinese high temperature stack
- North Dacota state university hot composting
- EM (Effective Microorganisms) based quick compost production process

Available methodology in India

- ADCO-Process –Hutchinson and Richards-1921
- Indore –Process-Howard and Wad-1931
- Bangalore Process Acharya& Subhramanyam-1939
- NADEF-method
- Mechanical Plant Compost
  - Windrow composting
  - Aerated Static Pile composting
  - In-vessel Composting
- Water hyacinth compost
- Vermicompost

Factors affects on composting process

Size of the pit in feet	7-12 x5-6 x3-4::LxWxH
Size of the heap in feet	10-15 X 5-7 X 3-4: LxWxH
Size of the wastes material	3-5 cm length
C/N ratio of the material	30-40:1
Aeration	0.8 to 1.8 m3 O2 per kg per day
Moisture content	60-70 %
Initial temperature	$50-60^{0}C$
Additives	Lignicellulolytic organisms/ mineral amendments

Typical organisms development during composting

Thermophilic organisms

Bacteria

- *Bacillus*
- *Streptothermophilus*

Fungus

- *Humicolla*
- *Absidia*
- *Chectonium*

Actinomycetes

- *Micro-monosperma*
- *Nocardia*
- *Streptomyces*
- *Termonospora*
- *Thermopolyspora*

Mesophilic Bacteria

- *Bacillus sps.*
- *Cellumonas*
- *Thiobacillus sps.*
- *Pseudomonas sps*

Off-Situ Composting of trash

Compost and Vermicompost

Urea-N helps to improve overall biological activity Because organisms require 1to 1.5 %, However, The microbial proliferation is more active at the C: N ratio of 30 to 40: 1

$$(NH_2)_2C=O + H_2O \rightarrow NH_4HCO_3 \rightarrow (NH_4)_2CO_3 \longrightarrow NH_3$$

$$NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$$

Pyrites acidify the system and minimize the volatilization loss of N

$$FeS_2 + 7O_2 + 2H_2O \longrightarrow 2FeSO_4 + 2H_2SO_4$$

$$FeSO4 + H_2O \longrightarrow H_2SO_4 + FeO$$

$$Ca_{10}(PO_4)_6F_2 + 10H_2SO_4 + 20H_2O \longrightarrow 6H_3PO_4 + 10CaSO_4 + HF + 20H_2O$$

$$2Ca_3(PO_4)_2 + 6H_2SO_4 \longrightarrow 4H_3PO_4 + CaSO_4$$

$$[Ca_3(PO_4)_2]_3CaCO_3 + 7H_2SO_4 \longrightarrow 3Ca(H_2PO_4)_2 + 7CaSO_4 + H_2CO_3$$

Microbial Enrichment

Cellulolytic cultures/N_2Fixers/P-solubilizers and other PGPR can be added after the compost is cured properly.

Paecilomyces fusisporus
Aspergillus awamori
Bacillus polymyxa
Pseudomonas striata
Azotobacter chroococcum

$$Ca_3(PO_4)_2 \quad H^+ \quad Ca(H_2PO_4)_2$$

Phospho-sulpho-nitro compost

- For production of a ton of P-S-N Compost, Waste-1000kg, Cow Dung-200kg, Rock phosphate-333kg, Pyrites-120kg, Urea-13kg and Soil-50 kg is required.
- Prepared Phospho-Sulpho-Nitro compost after 110 days of decomposition contain approximately 3.2 to 4.2 % P and 1.5 to 2.3 % N. The content of NH_4-N and NO_3-N varied from 0.12 to 0.54 and 0.28 to 0.90 g kg1, respectively. Citrate-soluble P in phospho compost ranged from 0.23 to 0.98 %. The content of water soluble P was about 6 to 10 fold lower than citrate-soluble-P in all the composts.
- Therefore, addition of one tone (1000 kg) P-S-N compost will substitute about 15-23 kg of N,32-42 kg of P_2O_5 and 20-30 kg of K_2O, respectively.

Economy of Enriched Phosphocompost

- Total cost of production for enriched phosphor compost is around Rs. 1500=/ 1000 kg. Or Rs. 1.5 /kg of enriched phosphor-compost.
- First year , by pit method construction of pit with bricks wall is included (around Rs. 4000=00), therefore, the cost will be Rs.5500=00/ 1000kg Or Rs.5.5/ kg of enriched compost.
- Since, from second year onwards, the total cost of production is Rs.1500/1000 kg.
- The cost incurred to obtain one kg P_2O_5 through phosphocompost is around Rs. 16 as compared to Rs. 16.0-23.0 supplied through single super phosphate or Diammonium phosphate.

Cost of Vermicompost Technology

About 3 tonnes of vermicompost can be produced from 10 beds of 10 x 3 x 1.5 feet size bed. The cost of earthworms is Rs 400 per kg. A 50 kg bags of vermicompost can be sold for Rs 150 (Rs 3000/tonne). Basically, vermicompost is used like any other manure. Application of vermicompost @ 5 tonne/ha in cropping system and 1-10 kg/tree in plantations, depending on the size of trees is recommended

Vermicomposting

Vermicomposting is a very effective method of converting wastes into useful manure with the help of earthworm.

Performance results

- Under organic farming systems, combined application of cattle dung manure (2 t/ha) + vermicompost (1.5 t/ha) and poultry manure(1.5 t/ha) + biofertilizer @ 5 kg/ha sustained the productivity of soybean, chickpea and mustard and isabgol crops as well as biological health of soil.
- The forest litter decomposes faster (75 to 85 days) than farm residues (110-115 days).

Steps in Rapo- Composting Technique

Step 1- Collection of wastes and Segregation
Step 2- Mixing wastes and fresh cow dung
Step 3- Inoculation with the consortium of organisms
Step 4- Mixing of consortium with wastes and cow dung mixture and putting whole mixture into the Rapo-compost machine
Step 5- View of Rapo-compost

Sugarcane Trash Burning

Western part of India, sugarcane is an important cash crop in Indian agriculture occupying 2.5 % of India's gross cropped area and sharing 7 % of total value of agricultural output. Common practice of sugarcane trash management is

- Gasification in sugar industry
- Roof thatching
- A major portion is burnt in field for next cultivation
- Slurry makes pollution in a large scale

Existing sugarcane residues utilization practices

- ✓ Pre harvest Sugarcane trash burning
- ✓ In-situ trash burning after harvest and removal of stubbles for fuel
- ✓ Trash removal from field for domestic uses and commercial uses as fuel.
- ✓ In-situ trash management in Sugarcane plant cane and ratoon crop as mulch
- ✓ Trash removal from field for preparation of compost
- ✓ In-situ and ex-situ incorporation of trash in soil

Needs holistic in-situ recycling technique for sugarcane crop residues (sugarcane trash and stubbles) and industrial waste (press mud and spent wash) after harvest of sugarcane ratoon crop

Crop residues and industrial wastes production from experimental site of sugarcane crop

S No.	Particulars	Quantity (t ha^{-1})
1	Sugarcane production	112.00
2	Sugarcane trash	13.60
3	Sugarcane stubbles	3.29
4	Pressmud	3.98
5	Pressmud compost	1.99
6	Post biomethenated spent wash (PBSW)	14.89 (16352 L ha^{-1})
7	Glyricidia leaves	5.00

Scope of cost reduction

- ✓ Multiplication of mother culture at local area than research station
- ✓ Multiplication of mother culture using [5 %Cow urine, 20% fresh cowdung,1% DAP, 10% molasses and 5% Hay , 50% water and 10% of microbial inoculum from mother culture.
- ✓ The cost may be reduce to Rs.5000

- ✓ Thus, 50% of the cost would be born by the concerned farmer in terms of labour and other inputs

In situ Recycling of Sugarcane Trash as Mulch in Sugarcane Ratoon

Don’ts :

- Burning of trash
- Removal of trash from field
- Placement of trash in alternate furrows
- Interculturing operations
- Off barring and earthing up

Do’s:

- Keeping trash in furrows
- Stubble shaving/Shredding
- Management of sugarcane trash (application of 8 kg Urea + 10 kg SSP +1 kg cellulolytic microbial culture for 1 ton trash)
- Application of irrigation
- Localized placement of recommended dose of fertilizers in two equal splits (1st at the time of ratooning and 2nd after 90 to 120 days after ratooning)

Lessons Learnt from Field Experiments

- Enhancing the concentration of the consortium in the culture and apply twice for accelerating decomposition.
- Field capacity should be maintained.
- Field should be ploughed after two weeks of treatment

Economic Saving from Residue Retention

- ➢ It is estimated that from 23 million tonnes of rice residues in North West India about 3 MT million tonnes of C shall be returned back to the soil per year and save about 1.4×10^5 t of N (equivalent to Rs 200 crores) annually.
- ➢ Soil microbial biomass carbon, enzymatic and hormonal activity shall increase about 2.5 to 3 fold as compared to the burning of crop residues in the field.
- ➢ Farmers’ can save about 1600 kg C, 20-30 kg N, 4-7 kg P, 60-100 kg K, 4-6 kg S in addition to micronutrients, which is equivalent to Rs. 1500-2000/ha for plant nutrients for a long drawn process
- ➢ It is estimated that one tonne of rice residue contains about 400 kg of C, 5-7 kg N, 1-1.7 kg P, 15-25 kg K and 1.1-1.4 kg S in addition to the significant amounts of micronutrients.

- Total amount of N, P, K and S (NPKS) in 23 million tonnes of rice residue (currently burnt in NW India annually) is equivalent to 7 lakh tons N, P, K, S valued at > Rs. 1000 crores.
- Toxic elements viz. Cd, As also forms chelates with the organic components and thus the harmful effects on soil and human beings are overcome.

Policy and financial incentives

- Farmers should be granted a minimum of Rs. 200 /quintal of crop residue so that they don't burn it. In other words, a maximum Rs 3000/ha may be fixed as incentives.
- It also warrants to develop innovate residue management practices such as conservation agriculture, in-situ residue recycling involving rapid composting techniques, mulching, etc.

Environmental, Economic, and Social Benefits of C-sequestration

- Enhances soil fertility and soil quality
- Increases yields
- Increases income
- Rehabilitates degraded lands
- Enhances water storage
- Reduces animal pressure
- Enhances food and livelihood security
- Improves human well-being
- Reduces risk for crop failure

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Weed Control in Organic Farming

Dr. M. Madhavi
Associate Dean, Aswaraopet

Farmers have struggled with the presence of weeds in their fields since the beginning of agriculture. Weeds can be considered a significant problem because they tend to decrease crop yields by increasing competition for water, sunlight and nutrients while serving as host plants for pests and diseases. Since the invention of herbicides, farmers have used these chemicals to eradicate weeds from their fields. Using herbicides not only increased crop yields but also reduced the labor required to remove weeds. Today, some farmers have a renewed interest in organic methods of managing weeds since the widespread use of agro-chemicals has resulted in purported environment and health problems. It has also been found that in some cases herbicides use can cause some weed species to dominate fields because the weeds develop resistance to herbicides. In addition, some herbicides are capable of destroying weeds that are harmless to crops, resulting in a potential decrease in biodiversity on farmers. It is important to understand that under an organic system of seed control, weeds will never be eliminated but only managed.

Pests can be classified into

- Insects
- Vertebrates
- Weeds
- Plant disease

Weeds

- Plant out of place
- High economic, Social & Environment Cost
- Harmful
- Human beings
- Animals
- Cultivated crops

Types of weeds

1. Grasses
2. Sedges
3. Broad leaved weeds

WHY WEEDS ARE PROBLEMATIC?

- Short life cycle
- Prolific seed production
- More viability

Potential

- Pig weed – 1,17,400 seeds
- Stink grass – 82,100 seeds
- Parthenium - 15,000 to 1,00,000 seeds

Longevity of Weeds

Weed Species	Viability Period (Years)
Cynodon dactylon	2
Tribulus terrestiris	5
Solanum elaegnifolicum	10
Parthenium hysterophorus	20
Cyperus rotundus	20
Convolvulus arvensis	50

- Critical period of weed competition? **1/3rd life cycle of any crop**

Weeds: Top Issue for Organic Farmers

Successful Management Requires

- Multiple approaches Continual effort
- Knowledge of the biology of weeds species
- Reproduction, lifecycle, establishment annual, perennial, wandering perennial, broadleaf, grass

Basic Weed Ecology

- Weeds are nature's way of keeping bare ground covered and increasing biodiversity
- Dynamic system involving the interaction of weeds, crops, humans and environment

- Factors affecting weed ecology are identical to those affecting crop ecology:
- Light, temperature, water, pH, nutrients, organic matter, insects and diseases, etc

Impact of High Weed Pressure

- Compete with crops for nutrients, water, and light
- Reduced yields Lower crop quality

- Harbor pest insects and diseases
- Increase irrigation costs
- But, complete elimination of weeds is unnecessary

Multiple Prevention and Elimination Strategies

- Cultural
- Mechanical
- Biological
- Chemical **(organically approved)**

"Many hammers approach."

Tools for prevention

- ❑ **Avoid the entry of weed seeds onto the farm through**
  - Manures
  - Mulching material
  - Intercultivation equipments
  - Animals
  - Water etc.

Instead of using manure - Use compost.

Organic weed management practices

Practice	Effect
Tillage	**Kills growing weeds; damages perennial roots & rhizomes; buries seeds too deeply to emerge; brings weed seeds to surface.**
Post-planting cultivation	**Removes weeds from the crop.**
Stale seedbed	**Flushes weeds from the soil before planting.**
Organic fertility sources	**Favor crops over faster-growing weeds due to slow release of nutrients.**
Drip irrigation	**Directs water to the crops rather than to weeds.**
Mulch	**Smothers weeds: delays emergence of weeds**
Using transplants	**Competitive advantage to crop**
Competitive cultivars	**Improves competitive ability of crop against weeds.**

Increase plant density	**Suppress weeds by shading**
Rapid cleanup after harvest	**Prevents seed set by residual weeds.**
Cover crops	**Suppress weeds, improves soil health**

Cultural Strategies

- Buy quality crop seed with low/no weed seeds present
- Do not allow weeds to form seed
- Thoroughly compost (>130°F for ≥15 days) all manure and plant residues to ensure destruction of weed seed
- Stale seedbed technique
- Prepare soil for planting and bring weed seeds to the surface; allow weeds to germinate, kill weeds with light tillage/minimal soil disruption. May be repeated. Plant main crop.

Cultural Practices

Improve crop competitiveness

- Improve soil tilth, aeration, and fertility to optimize crop growth
- Increase crop density through narrow row spacing and increased seeding rate
- Use transplants, rather than seed, when possible
- Plant at optimal soil temperatures to prevent slow germination of crop
- Choose competitive crop cultivars
- Manage fertility according to crop needs; avoid excess application

Reduce weed numbers

- Mulch (wood chips, mow and blow, paper, living, plastic, etc)
- Use weed-suppressive cover crops
  - Quick germinating, high biomass
  - Field with high weed pressure may warrant full year of
- cover cropping and fallow to reduce weeds
- Crop rotations

- altering narrowly spaced crops with closely spaced crops, shallow rooted/deep rooted crops, cold/warm season crops
- Intercrop
- Clover under seeded in sweet corn

Mulch

- Prevent seeds from germinating by blocking light, can smother out some weeds
- Conserve water, minimal soil disruption
- Use local resources: straw, fabric, wood, newspaper, plastic etc.
- Be careful of weed seeds in straw or hay
    - Avoid hay, unless you know its free of weeds
- Especially good for perennial systems:
- blueberries, blackberries, flowers, trees
- Living mulches – i.e. constant cover of clover on orchard floor

Cover Crops

- Smother weeds by out- competing for light, water, nutrients Ex: Cowpea
- Release allelopathic chemicals that suppress weed germination
- May reduce weed emergence by 75-90%
- Ex: sudan grass, buckwheat, annual rye grass, sesbania, many more

Crop Rotations

- Weeds tend to infest crops with similar life cycles
- **Change crop ecology:** shallow/deep roots, cold/warm season, row/drilled crops, foliage density, and heavy/light feeders
- **Change cultural practices:** cultivation, mowing, fertilization, herbicide application, and planting/harvest dates
- Crop rotations limit the buildup of weed populations and prevent major weed species.
- Altering, narrowly spaced crops with closely spaced crops, shallow rooted with deep rooted crops, cold with warm season crops

Intercropping

Having different plant types growing together enhances weed control by increasing shade and increasing crop competition with weeds through closer crop spacing.

Ex: soybean +wheat, Sugarcane + finger millet , Sunflower + groundnut

Smother Crops

- Prevent seeds from germinating by blocking light, can smother out some weeds.
- In northern states, oats are commonly planted as a “nurse crop” for alfalfa, clover.
- Oats grow between in the place of weeds and avoid weed emergence.

Ex: Mustard as cover crop in Ragi

Irrigation

- Drip irrigation is more water efficient
- Also by directing water to the crop it minimizes weed germination and reduces need to cultivate

Solarizing the soil

- Cultivate soil properly
- Irrigate soil completely
- Put plastic over the soil

– Weed get cooked

(Effective for control of parasitic weeds)

Physical and Mechanical Practices

Mowing

Prevents seeding Depletes storage reserves

Better control for broadleaves

Soil solarization

Effective control of winter annuals

Limited control of perennials Cost prohibitive

on large

acreages

Avoid tillage deeper than 3” after solarization

Cultivation

- Should be shallow to lessen disturbance to weed seed bank
- Better for perennial and biennial control than annual weed control
    - ★ Exhaust root system by depleting storage reserves
    - ★ Requires 6-8 timely treatments in yr 1, then 3-5 the following year

Thoroughly clean equipment before moving it between fields to prevent weed transport

Potential Downsides of Cultivation

- Exposes bare ground:
    - ★ increased erosion, decreased biodiversity,
    - ★ speeds decomposition of OM,
    - ★ increases water run-off
- Major cause of soil compaction
- Cost: expensive equipment, fuel
- Should not be done in wet conditions

Use Cultivation Wisely

- USDA-ARS research showed organic methods can increase OM more than conventional no-till

- Negative effects of tillage may be offset by the use of cover crops and additions of organic matter (compost, manures, mulch, etc)

- Must still use caution to avoid negative effects of cultivation

Flaming

- Intense heat *sears* the leaf, causing the cell sap to expand and disrupt cell walls
- Seedlings are most
- Susceptible
- Broadleaf weeds are more susceptible than grasses

May be used in wet soil conditions

Chemical Control

Organic options (Bioherbicides)

Corn gluten meal (pre-emergent herbicide)

Suppresses many common grasses and herbaceous weeds

Weed Ban and Corn Weed Blocker Look for non-gmo sources

Commonly based on vinegar or lemon juice or clove oil ingredients (post-emergent burn down herbicide)

- Perennials may require multiple applications
- Corrodes metal sprayer parts
- Burnout, Bioganic™, AllDown , MATRAN™, and Weed Bye Bye

Post-emergent chemicals are phytotoxic (burn plant tissue); use caution when applying in crops

Cost can be decreased by knowing pattern of weed distribution (spot treatment v. overall application

Biological Control Practices

Insects: May consume large numbers of weed seeds or feeding injury to plant

Zygograma beetles bioagents for Parthenium control

Neochetina weevils bioaents for control of Waterhyacinth

Selective grazing

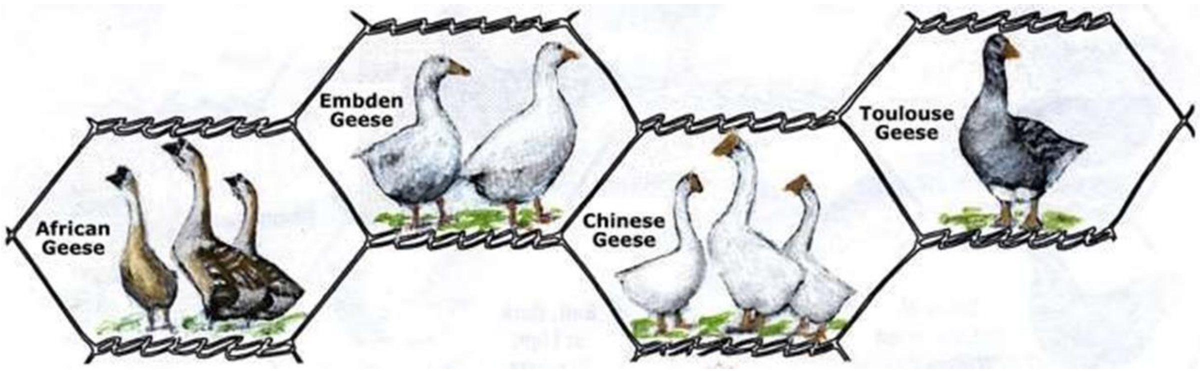
Sheep: clean fields after harvest

Weeder geese: useful against grass weeds and in perennial systems

Biofumigation

- ✓ Use of *Brassica* species (canola, Indian mustard) as cover crop or in rotation
- ✓ May be incorporated or left as residue
- ✓ *Brassica spp* produce **glucosinolates**, which may be converted to **cyanate** compounds during decomposition
- ✓ **Cyantes toxic** to many bacteria, fungi, nematodes, insects, and germinating seeds

Biological control Weeder Geese(ducks)



They are particularly used as grass weeders in a variety of crops.

Crops: cotton, strawberries, tree nurseries, corn, fruit orchards, tobacco, potatoes, onions, sugar beets etc**.**

Steps to Sustainable Weed Management

Pre-season Planning

Step 1. Know the weeds on your farm.

Step 2. Plan cropping systems to minimize open niches for weeds

Step 3. Keep the weeds guessing?

Step 4. Design the cropping system and select tools for effective weed control.

Preventive (Cultural) Practices

Step 1. Grow vigorous, competitive crops.

Step 2. Put the weeds out of work – grow cover crops.

Step 3. Manage the weed seed bank: minimize deposits and maximize withdrawals.

Control Tactics

Step 1. Knock the weeds out at critical times.

Step 2. Utilize biological processes to enhance weed control.

Step 3. Bring existing weeds under control before planting weed-sensitive crops and long-term perennial crops.

Enhancing and Fine-tuning the Weed Management Strategy

Step 2. Keep observing the weeds and adapt practices accordingly. Keep notes what is suitable for one crop may not be for another

Step 2. Experiment and stay educated. Keep up on new developments and practices. Night time cultivation Soil solarisation others…

Conclusion

Using multiple approaches ("many hammers") to manage weeds will yield greater impact than relying on a few practices.

Develop a weed management strategy that is designed for the needs of your farm**.**

Big Hammers

-Competitive crops

-Rotation
-Cover Crops
-Mulches
-Weed predators
-Livestock/grazers
-Cultivation tools
-Rollers/roller-crimper
-Flamers
-Growers Observation

Little Hammers

-Solarization
-Organic herbicides
-Bioherbicides
-Soil microorganisms
-Crop-weed interactions

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Organic Regulation and Certification Procedure

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Regulatory Scenario

Regulatory Requirements for manufacture, process sale and trade

FSS Act 2006 regulates the organic food

No person shall manufacture, pack, sell, offer for sale, market or otherwise distribute or import any organic foods unless they comply with the requirements laid down under these regulations.

- It will be mandatory to obtain FSSAI Organic food license for selling any organic food
- License shall be granted only to those products which are certified under NPOP or PGS-India
- Non- compliance of any organic food with the provisions shall attract penal provisions

Regulatory Framework

For Exports

As per DGFT (under FTDR act) notification no products can be exported as organic unless it is certified as per the provisions of National Programme for Organic Production (NPOP) and consignment is accompanied by Transaction certificate issued from TRACENET - Effective since 2004

For Import and Domestic Market

Food Safety and Standards Authority of India (FSSAI) is the regulatory body – Mandates certification

- ✓ Products certified under NPOP or PGS-India only shall qualify for Organic Food in domestic market
- ✓ Organic food in imports shall require to be certified under NPOP or the exporting country having equivalence with NPOP

Exception under FSSAI Rules

- However, organic food that is marketed through direct sales by the original producer/producer organization to the end consumer is exempt from the need of verification of compliance.

- Means they can use word organic on packets but can not use certification or FSSAI Jaivik Bharat Logo
- Small producer – having annual turnover of Rs. 12 lakh (16,500 US$)

FSSAI Rules for Imports

- Any imported food shall also be subject to compliance of these rules
- Organic food imports under bilateral or multilateral agreements on the basis of equivalence of standards between National Programme for Organic Production and the organic standards of the respective exporting countries shall not be required to be re-certified on import to India

Labeling under FSS Act in Domestic Market

Products certified under NPOP

Products certified under PGS

Organic Certification

- Organic certification system is a quality assurance initiative, intended to assure quality, prevent fraud and promote commerce, based on set of standards and ethics.

- It is a process certification for producers of organic food and other organic plant products
- It assures consumers that the product certified as organic has been grown, handled, stored, processed, packed and transported in accordance with organic standards

Purpose of certification

- Organic certification addresses a growing worldwide demand for organic food.
- It is intended to assure quality and prevent fraud.
- For organic producers, certification identifies suppliers of products approved for use in certified operations.
- For consumers, "certified organic" serves as a product assurance, similar to "low fat", "100% whole wheat", or "no artificial preservatives".
- Certification is essentially aimed at regulating and facilitating the sale of organic products to consumers

Why Certification?

- Gives third party assurance from producer to the consumers separated by distance
- Provides uniform label as indication of quality
- Assurance to the consumers that its concern for Quality has been addressed.
- Effective marketing tool for image, credibility, visibility, transparency and traceability

Labelling

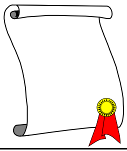
- Easy recognition of organic quality and certification system
- Confirms the fulfilment of the label regulations and of legal rules
- Helps to achieve better price for organic products

Organic Certification process

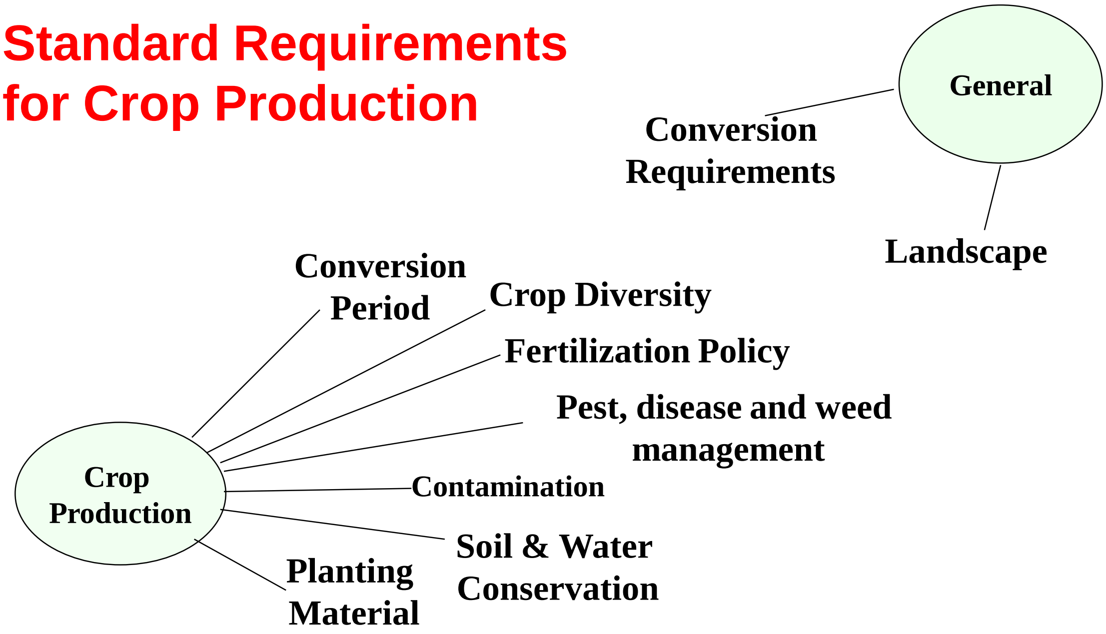
- It is a Process Certification
- Product is certified based on the verification of process as per standards
- World over there is no test available which can prove that a product is grown as per organic standards
- Residue tests only indicate that the product does not have residues. A conventional produce with judicious use of degradable pesticides in early stages can also be pesticide residue free

- Chemical fertilizer residues are not easily detectable

Certification Process

			
Certification Program and Standards	Accreditation of Certification agencies	Third party certification agencies	Farmer Operator
			
Certifcation	Farm Inspection	Farm/ Process documentation	Processing industry Operator

Standard Requirements for Crop Production

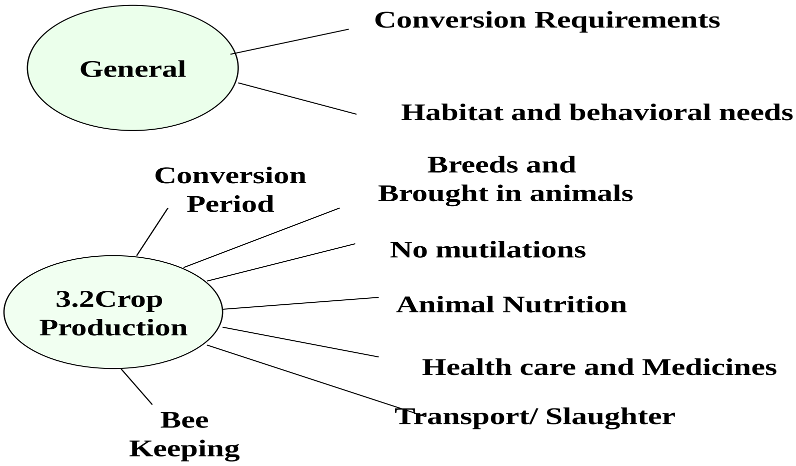


Basic standards for Crops Certification

- **Conversion -**Soil has been made free for chemicals through conversion period

- **Resource conservation -** Practices lead to sustenance of diversity, resource conservation and soil health build up
- **Seeds -** All inputs including seeds are from organic origin and without chemical treatment
- **No chemicals and GMOs -** Use of synthetic chemicals and GMOs are strictly prohibited
- **Management -** Nutrient and Pests are managed by multi-cropping, crop rotation, use of manures, minerals and diversity management
- **Contamination control -** Adequate arrangements are made to prevent contamination
- **Handling and processing –** Physical, mechanical and biological. No chemical additives allowed. No irradiation

Standard Requirements for Livestock Production



Basic standards for Livestock Certification

General Requirements

- Natural breeding
- Protection of animal health & welfare
- Organic feed & fodder
- Access to grazing
- Freedom for natural behavior
- Reduction of stress
- Prohibition on use of allopathic drugs/ hormones/ chemical additives
- Landless husbandry not allowed
- Animals in cages not allowed

Standard Requirements

- Breeds suiting to climate & region
- Animal identification
- Proper housing management and good living conditions
- Not to be kept tied, no stall feeding (some exceptions)
- All feed/ fodder from organic source
- Health care system based on prevention
- Reduction of stress
- Prohibition on use of allopathic drugs/ hormones/ chemical additives
- Vaccinations allowed
- Proper waste management

Can Organic Certification be made product certification?

- No
- Organic continues to remain process certification
- Compliance of standards in production process (crop, livestock, food processing) is important
- Does not rely on product quality based on lab testing
- Can’t we create a system based on product testing
- Yes but it will not qualify as organic
- It can be Safe, healthy and residue free (but not organic)
- One can create a new category for such products

Organic Certification Systems in India

Two certifications systems in India

- **National Programme for Organic Production (NPOP)** under Ministry of Commerce and Industry- Effective since 2001 – Launched mainly to regulate the quality for exports

- **PGS-India programme** under Ministry of Agriculture and Farmers Welfare- A farmer group centric participatory guarantee system

Note 1: Although both the systems are based on the same National Standards for Organic Production notified under NPOP but have independent systems of documentation and verification

Note 2: Both systems are parallel to each other. Product certified under one system cannot be processed and certified under another one both maintain separate identity

National Program on Organic Production (NPOP)

Launched during 2001 internationally recognized

- Equivalence with EU and Switzerland
- USDA recognized conformity Assessment system
- Equivalence with Canada, Japan, South Korea and Taiwan - expected soon

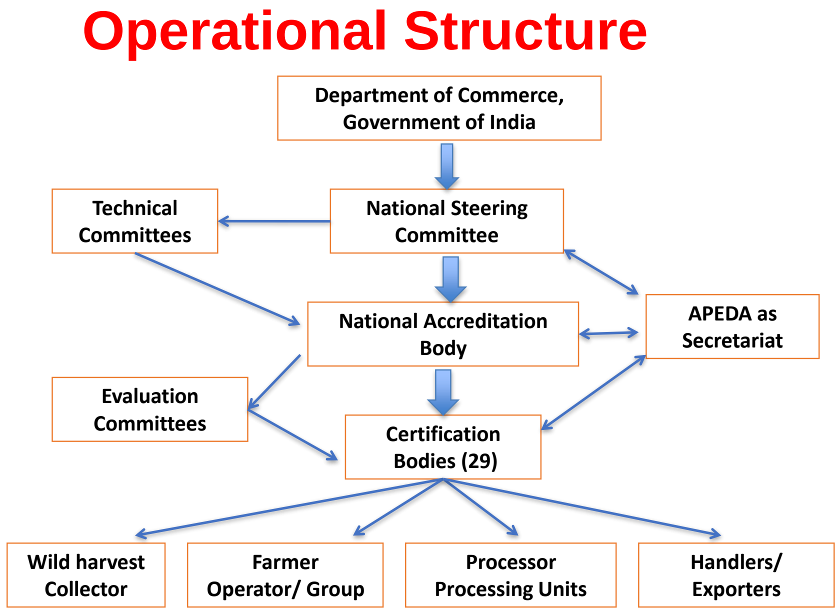
30 Accredited certification bodies

- 11 in public sector
- 19 in Private sector

Scope categories

a. Crop production
b. Wild harvest collection
c. Livestock

d. Apiculture
e. Aquaculture
f. Food Processing and Handling
g. Animal Feed Processing and Handling
h. Mushroom Production
i. Sea weeds, Aquatic plants including micro algae and Green House Crop Production
j. Organic Textiles and Organic Cosmetics soon



TRACENET

An on-line Traceability and monitoring system (First of its kind in the world)

- Ensures uniformity in operation documentation and practices
- Maintains chain of custody
- Provides end-to-end traceability
- Instant on-line query redressal
- Help desk 24x7 looks after grievances and provide quick solutions
- Serious issues referred to Technical committee
- Redressal time 1 hr to 24 hrs

Process of Certification by Accredited agency under NPOP

- Receipt of applications
- Providing standards and operational documents
- Agreement
- Demand for Fee
- Document audit
- Physical field inspection
- Risk assessment
- Compliance verification
- Reporting by inspector

- Review by reviewer
- Certification decision

Inspection methods

- Visits of facilities, fields, etc.
- Review of records and accounts.
- Calculation of input/output norms, production estimates etc.
- Assessment of production system
- Interview with responsible persons
- Risk assessment
- Part Conversion and Parallel Production
- Inspection for Use of Genetically Engineered Products
- Use of off-farm inputs
- Analysis for residue testing (if required)
- Inspection and study of entire production/ processing process

Smallholder Grower Group Certification

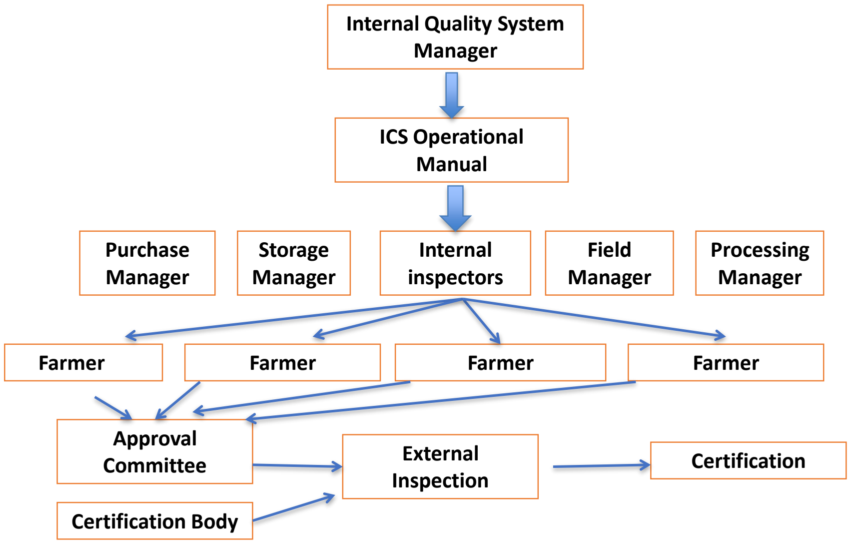
Grower Group Certification

- Based on internal quality system
- Applicable to producer groups, farmer's cooperatives, contract production and small scale processing units.
- The producers in the group must apply similar production systems and the farms should be in geographical proximity.
- Group needs to develop an Internal Control System (ICS)

What is Internal Quality System

- A group of producers create internal team for some tasks
- External certification agency delegates some inspection tasks to this group (known as IQS)
- IQS undertakes inspection on behalf of CB
- Certification agency evaluates the working of IQS and do random field inspection for verification
- Certification is granted to group as a whole as one unit

Typical ICS Structure



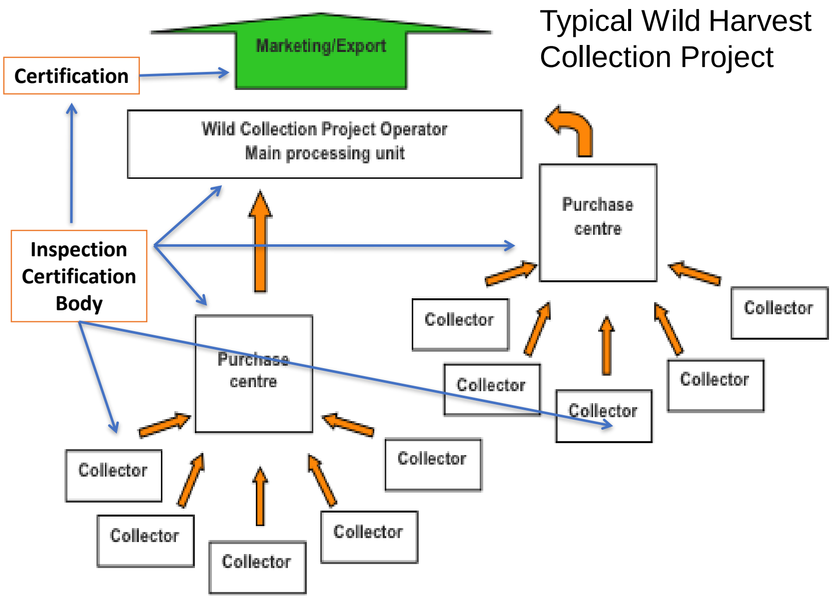
ICS Procedure

- Registration of members
- Train members in standard implementation and risk management
- Register group with certification agency
- Maintain each member's documents
- Internal inspections
- Submission of report to certification agency
- External inspections
- Compliance of deficiencies
- Yield estimates
- Grant of certification

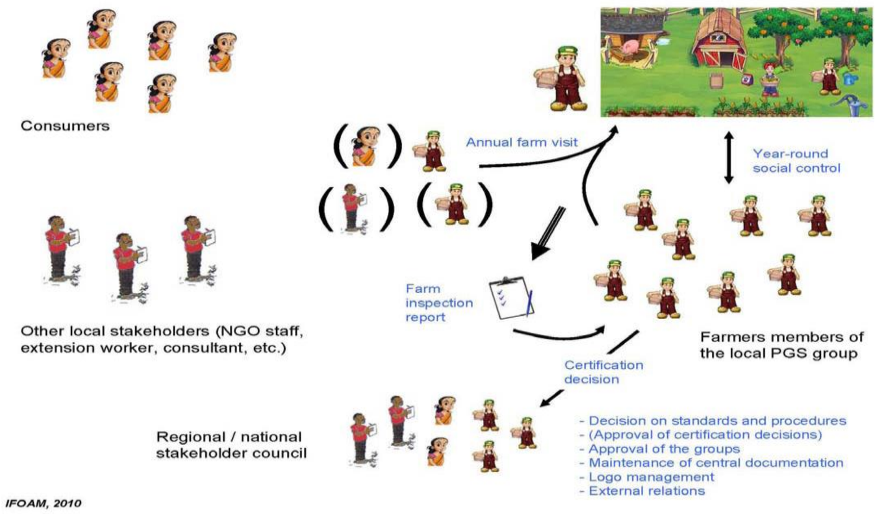
Organic Certification for Wild Harvest Collection

NPOP Requirements for wild harvest certification

- Natural forest with no prohibited input use history
- Collection not to exceed sustainable yield of species and do not threaten the local ecosystem
- Positively contribute to the maintenance of natural areas.
- Derived from a stable and sustainable growing environment
- Derived from a designated area for collection, clearly depicted in the map
- Collection area shall be at a distance from conventional farming, pollution and contamination
- The operator shall be clearly identified and be familiar with the collecting area



PGS-India – A Participatory Guarantee System



PGS-India at a Glance

Essential features

- A farmer group centric de-centralized certification system
- Based on common national standards
- Launched in 2016 under Ministry of Agriculture
- Provides end to end traceability in public domain

Product categories

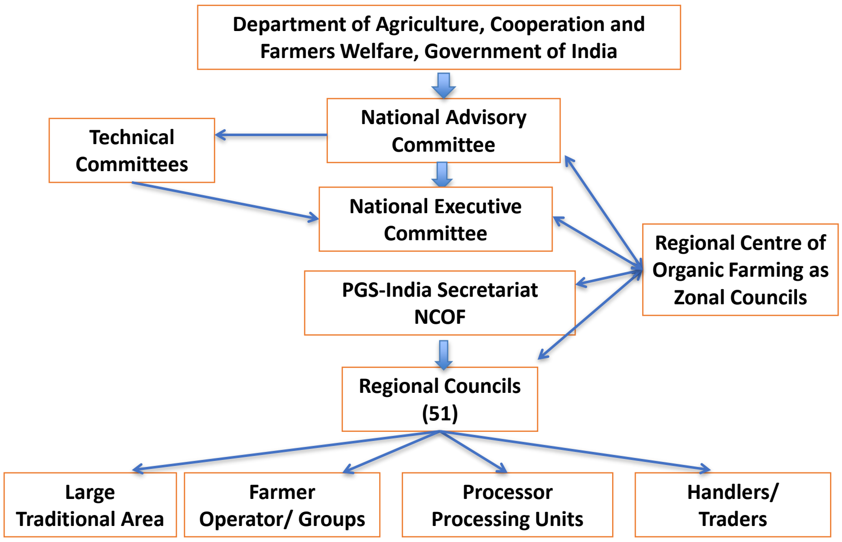
- Crop production and wild harvest

- Livestock and apiculture
- Food processing and handling

Types of Operators

- Individual farmers
- Groups
- Stand alone processors and handlers/ traders
- Large traditional/default area certification

New Operational Structure



Certification Procedure 1/3

At Farmers end

- Makes a group (5-50 farmers)
- Individual farmers can also join but in 24 months make own group
- Fill application forms, farm history sheet and submit to group
- Start adopting organic practices with due care for contamination control
- Participate in group meetings and trainings
- Participate in group activity such as peer appraisal
- Participate in group decisions
- Each member needs to bring entire land holding under organic (in 24 months)
- One member's land should not be more than one third of the total group's land
- Keep surveillance on other members
- Notify group of infringements

Certification Procedure 2/3

- Register with Regional Council
- Adopt organic standards

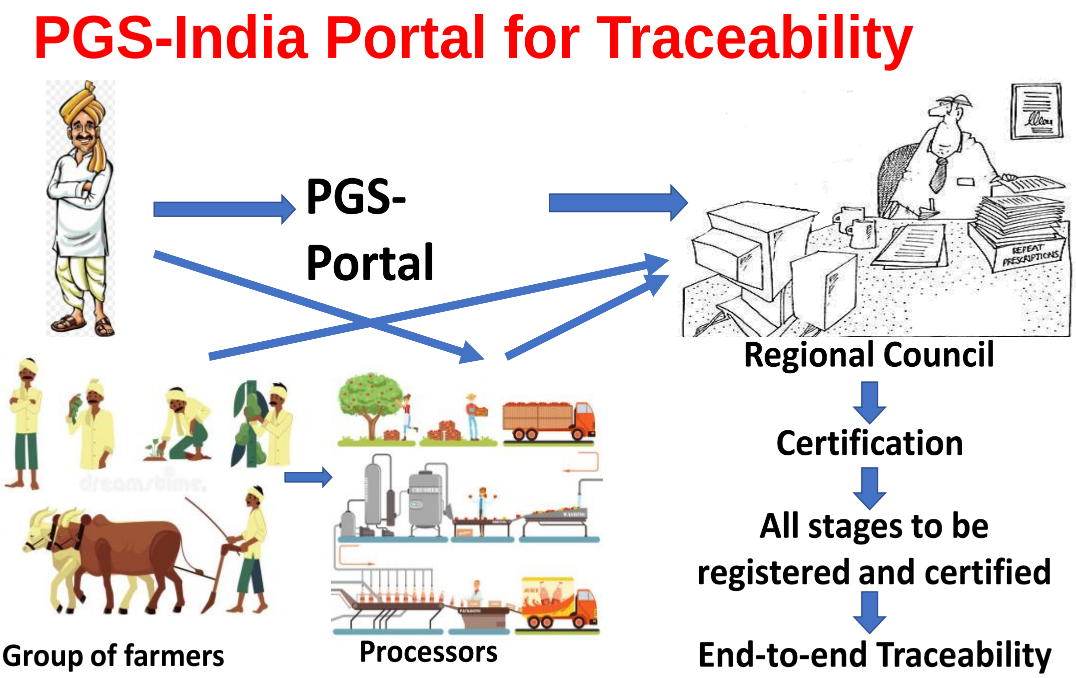
- Group undertake peer appraisals twice a year. Members are drawn from within the group
- Submit peer appraisal to Regional Council
- RC verifies the details and if satisfied endorse the decision of the group
- RC physically verifies the group once in 2 years

Remember – All activities need to be done by group members. External persons can act as facilitators but neither can do peer appraisals nor can decide on certification status

Certification Procedure 3/3

At Regional Council level (Step 2)

- RC cannot pick and choose, it has to approve the decision or reject it
- RC can also return the decision in case of irregularities and ask LG to make corrections
- LG resubmits its decision after necessary correction.
  RC can now approve the decision, if not satisfied can reject the decision
- On approval RC issues individual certificates On-line
- Farmers can sell their produce individually or collectively with PGS logo
- In case if group also undertake processing then the group under take same procedure as per processing standards, submit summary sheet to RC and RC on being satisfied can approve the decision



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Branding, Packaging and Marketing of Organic Products

Dr. Satish Chandra Pant
Assistant Professor, CCS NIAM, Jaipur, Rajasthan

Marketing of Organic Produce

- **Planning: Pre Production Activities** (Understanding Market and Customer)
- **Production Activities** (Input arrangement, Package of Practices, Harvesting Techniques)
- **Post Harvest Management** (Storage, Processing, Packaging, etc.)

Success Stories

- Abhinav Farmer Club
- Farmer Supriya Dalal
- Farmer Bheem Singh Dagar
- Bhairavi Women Agro FPO, Odisha

Brand Building | Brand Identity

Visual Identify

Core Identity

Emotional Aspect

Functional Aspect

Instructor: Dr. Satish Ch Pant

Image 1

Image 2

Brand Building | Framing effect

Instructor: Dr. Satish Ch Pant

Brand Building

Plan and Implement Brand Marketing Mix

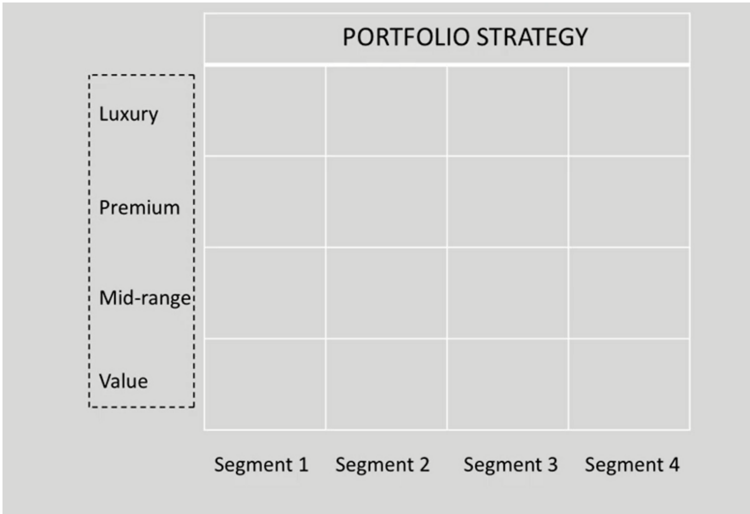
Instructor: Dr. Satish Ch Pant

Competitive Frame of Reference

POINT OF PARITY

POINT OF DIFFERENCE

Instructor: Dr. Satish Ch Pant



Brand Positioning

Instructor: Dr. Satish Ch Pant

Branding Strategies to Promote Farming Business

- **Agro Tourism**
- **Branding through professionals**
- **Certification**
- **Retailing, Packaging and labelling**
- **Participation in Fairs and Exhibition**

Instructor: Dr. Satish Ch Pant

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Success Stories of Organic Farmers of Sikkim

Dr. I. Sreenivasa Rao
Senior Professor, EEI and University Head, PJTSAU,
Rajendranagar, Hyderabad

Only about 10 per cent is farmed. The topography of the region is not suited for intensive industrial farming. Hence, Sikkim was a state where the impact of the Green Revolution was marginal

The farms are small and numerous, situated on terraced and precipitous slopes of the Himalayas

- ❖ The smallest and the youngest state of India has the most inspiring tale to tell.
- ❖ Once considered to be one of the poorest states in India with 35 per cent of the people living below the poverty line
- ❖ Sikkim now stands amongst the top income generating states with a substantially low level of poverty.

Sikkim Worlds First Organic State

The Indian state of Sikkim is now the world's first 100 per cent organic state. The state won the prestigious Future Policy Gold Award from the UN Food and Agriculture (FAO), after beating 51 nominations from around the world.

How Sikkim became India's First Organic State?

- ✓ Sikkim was the first state in India to officially adopt organic farming in 2003
- ✓ In 2003, declared a resolution to make Sikkim a completely "organic state".
- ✓ This was the first such commitment of a state in India or indeed the world.
- ✓ In 2003, there was still no clear agreement on how to progress towards the goal of a fully organic state. In 2003 the "Sikkim State Organic Board" was created

Crucial Strategy

To go all-organic in 2003 by reducing government subsidies on synthetic inputs by 10% each year coupled with education and investments in compost collection. A full ban on synthetic inputs went into effect in 2014.

In 2004, the government came up with a working policy and in August 2010, it launched

Challenges Encountered

- Transition Period Yields Low Productivity
- Organic Farming Prohibits use of Synthetic Pesticides
- Organic Farms Face Severe Pest Attacks
- New variants of Pests, Diseases cause more Trouble
- Traditional Method of Pest Control Fail to contain the Damage
- Farmers demand Education, Training on how to Tackle Pest Attacks
- Underdeveloped Supply Chain Affects Small and mid-sized Farmers
- Organic Products must be stored Separately from Conventional Products
- Existing Supply Chain Fails to keep it Separate
- Consumers find Organic Produce Expensive, Discouraging them from Buying
- Rs. 1,200 – 1,500 per month Additional Expenditure for Switch to Organic Food
- Lack of Organic Policy
- Without Logo or Labelling, Organic products difficult to distinguish
- Existing Certification System Expensive, Cumbersome and Time Consuming
- Severe lack of Sustainable Infrastructure
- Organic Produce Mostly High Perishable in Nature
- Inadequate Agricultural Infrastructure and lack of Cold Storage Facilities
- In the first few years, many crops failed, and the agriculture production drastically decreased.
- The synthetic inputs in the soil were suddenly removed and it took several years for the soil to regain its natural fertility.

- ✓ Traders in revolt
- ✓ Opposition party protests
- ✓ No premium price for products
- ✓ High incidence pest & diseases
- ✓ Influx of non organic products
- ✓ Can't meeting the local demand of fruits and vegetables
- ✓ No fixing prices of organics
- ✓ Non availability of organic inputs
- ✓ Middlemen problem
- ✓ Scientists and Agri officials
- ✓ Capacity building of officials
- ✓ Meetings of Farmers
- ✓ Awareness and motivation among Village Sarpanches
- ✓ Campaigns
- ✓ Trainings and exposure visits

Bio Villages

More than 100 Villages with 10,000 Farmers in all four districts of the State Benefited from these Training Programmes during the First Pilot Phase of the Mission

- Farmer Field Schools

- Creation of local organic outlets
- Development of export markets
- Procurement of organic products
- Inclusion of OM in school syllabus
- Soil Testing and Issuing of Soil Health Card to all Farmers
- Static Soil Testing Laboratory in all the Districts
- 2 Mobile Soil Testing Laboratory Vehicle Equipped with Latest Instruments are Operational

SOIL ACIDITY AND FERTILITY STATUS OF SIKKIM

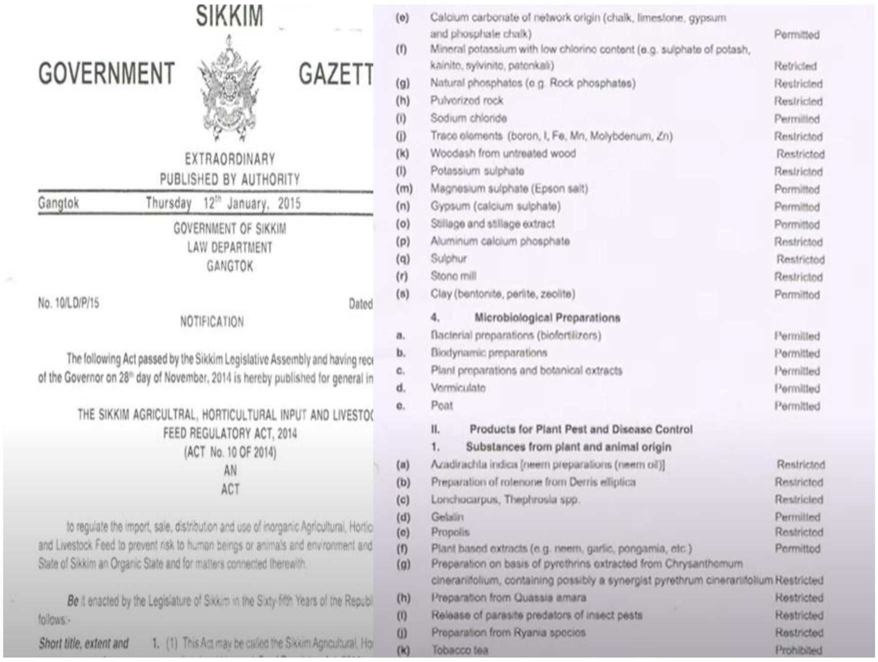
1.Soils under different reaction classes:

Soil reaction	% (Percentage)
Extremely acidic(pH < 4.5)	14.9
Very strongly acidic (pH 4.6 – 5.0)	29.4
Strongly acidic(pH 5.6 – 5.5)	28.7
Moderately acidic (pH 5.6 – 6.0)	18.3
Slightly acidic (pH 6.1 – 6.5)	6.5
Neutral (pH 6.6 – 7.3)	2.2
Total	100

- ★ The above data show that in Sikkim nearly 73% of cultivated area in under Strongly to Extremely Acidic in Soil Reaction
- ★ 91% Cultivated area under Low to Medium in Nitrogen Content
- ★ However Organic Carbon, Phosphorous and Potassium Content are Medium to High
- ★ The Deficient Micro Nutrients are Zinc, Copper and Manganese

Reclamation of acidic soils

Local available Pant Species are uses to Prepare Concoctions for using as bio-pesticides in addition to the use of bio-control agents and other Integrated Pest Management tools along with conservation of natural enemies through non-use of chemicals and crop rotation.



SIKKIM
GOVERNMENT GAZETT
EXTRAORDINARY
PUBLISHED BY AUTHORITY

Gangtok Thursday 12th January, 2015

GOVERNMENT OF SIKKIM
LAW DEPARTMENT
GANGTOK

No. 10/LD/P/15 Dated

NOTIFICATION

The following Act passed by the Sikkim Legislative Assembly and having rec
of the Governor on 28th day of November, 2014 is hereby published for general in

THE SIKKIM AGRICULTRAL, HORTICULTURAL INPUT AND LIVESTOC
FEED REGULATORY ACT, 2014
(ACT No. 10 OF 2014)
AN
ACT

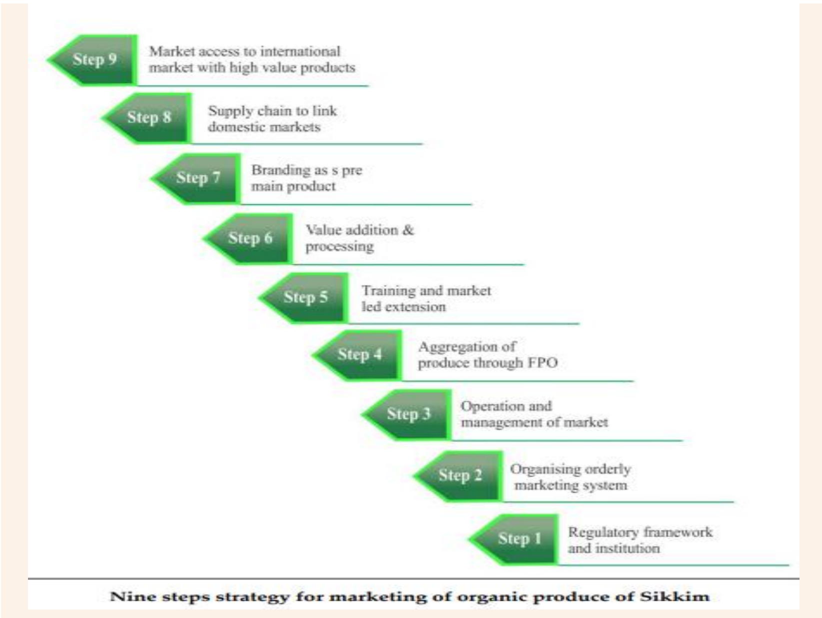
to regulate the import, sale, distribution and use of inorganic Agricultural, Hortic
and Livestock Feed to prevent risk to human beings or animals and environment and
State of Sikkim an Organic State and for matters connected therewith.

Be it enacted by the Legislature of Sikkim in the Sixty-fifth Years of the Republ
follows:-

Short title, extent and 1. (1) This Act may be called the Sikkim Agricultural, Ho

(e)	Calcium carbonate of network origin (chalk, limestone, gypsum and phosphate chalk)	Permitted
(f)	Mineral potassium with low chlorino content (e.g. sulphate of potash, kainito, sylvinito, patonkali)	Retricted
(g)	Natural phosphatos (e.g. Rock phosphates)	Restricted
(h)	Pulvorizod rock	Restricted
(i)	Sodium chloride	Permitted
(j)	Trace elements (boron, I, Fe, Mn, Molybdenum, Zn)	Restrictod
(k)	Woodash from untreated wood	Restrictod
(l)	Potassium sulphate	Restricted
(m)	Magnesium sulphate (Epson salt)	Permittod
(n)	Gypsum (calcium sulphate)	Permittod
(o)	Stillage and stillage extract	Permittod
(p)	Aluminum calcium phosphate	Restrictod
(q)	Sulphur	Restrictod
(r)	Stone mill	Restrictod
(s)	Clay (bentonite, perlite, zeolite)	Permittod
	4. Microbiological Preparations	
a.	Bacterial preparations (biofertilizers)	Permitted
b.	Biodynamic preparations	Permitted
c.	Plant preparations and botanical extracts	Permitted
d.	Vermiculate	Permitted
e.	Peat	Permitted
	II. Products for Plant Pest and Disease Control	
	1. Substances from plant and animal origin	
(a)	Azadirachta indica [neem preparations (neem oil)]	Restricted
(b)	Preparation of rotenone from Derris elliptica	Restricted
(c)	Lonchocarpus, Thephrosia spp.	Restricted
(d)	Gelatin	Permitted
(e)	Propolis	Restricted
(f)	Plant based extracts (e.g. neem, garlic, pongamia, etc.)	Permittod
(g)	Preparation on basis of pyrethrins extracted from Chrysanthemum cinerariifolium, containing possibly a synergist pyrethrum cinerariifolium	Restricted
(h)	Preparation from Quassia amara	Restricted
(i)	Release of parasite predators of insect pests	Restricted
(j)	Preparation from Ryania species	Restricted
(k)	Tobacco tea	Prohibited

- ✓ Establishing automated greenhouses for quality organic seedling production
- ✓ Network - marketing



Nine steps strategy for marketing of organic produce of Sikkim

The main beneficiaries are the more than 66,000 Sikkimese farming families, managing more than 76,000 ha of land.

Impact

- All of the state’s farmlands are organically certified, which is a great achievement for any state
- January 2016 PM Narendra Modi Declared Sikkim as Organic State
- 51 Nominations from 25 countries on 15th October, 2018 future policy award

- This has not only increased the income but also the life expectancy of its entire population.
- In 2016, Sikkimese people lived ten years longer than in 1990 and the state administration has data showing the connection with healthy organic biodiverse food.
- In its Organic Policy Document, the State Government noted that Organic Farming would reduce the cost of production by 25-30 percent

In addition to this, the number of tourists increased by over 50 % between 2014 to 2017, setting a fine example for other Indian states and other countries.

Sikkim IFFCO Organics Limited is a joint venture of world’s biggest fertilizer Cooperative, IFFCO and Government of Sikkim-2019.

Sikkim IFFCO has already signed two MOU’s one with Blossoms Biodynamics, USA for the utilizing their marketing and distribution in the North American markets and other with Centar Dr Rudolfa Steinera, Croatia for marketing its products in Croatia and the European Union.

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Integrated Farming System models for Sustainable Agriculture

N. Ravisankar[1], Meraj Alam Ansari[2], Raghuveer Singh[3], A.K. Prusty[4], M. Shamim[5] Raghavendra KJ[6] and AS Panwar[7]

[1]Principal Scientist and Project Coordinator (Acting), [2,3,6]Scientist, [4,5]Senior Scientist, [7]Director,
ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250 110, Uttar Pradesh

The philosophy behind shifting from cropping system to the farming system mode involves (i) in situ recycling of organic residues including farm wastes generated at the farm to reduce the dependency on market inputs (ii) decrease in cost of cultivation through enhanced input use efficiency, (iii) effective use of bye-products / wastes of one component for the benefit of other component/components to generate additional income (iv) upgrading of soil, water quality and bio-diversity, (v) increased water productivity, (vi) nutritional security and (vii) environmental improvement by moderating flow of greenhouse gases from the soil to environment. Integrated Farming system can provide a sustainable livelihood, a better risk coping strategy, continuous flow of income and employment throughout the year for small landholders.

Integrated Farming System (IFS) is a judicious mix of two or more enterprises having minimum competition and maximum complementarity to increase environment friendly production, farm income and family nutrition. Creation and preservation of biodiversity and maximum recycling of farm-residues by using recyclable output of one enterprise as input for another enterprises is basic principle (Singh and Ravisankar, 2015).

A typical IFS prototype design involves integration of location and societal specific modules such as cropping systems including fodder, fruit orchards intercropped with vegetables/fodder, dairy, goatary, poultry, piggery, aquaculture, mushroom, apiary, biogas, sericulture, roof-top gardening, compost yards, kitchen garden, boundary/bund plantation, agroforestry, horti-pasture, small scale processing and value addition of marketable surplus produces. These modules can be selected by the farmers based on the resource availability such as land, labour and capital available for investment. Agro-ecology specific development and implementation of IFS are essential due to diverse nature of climate, soil, crops, length of growing period, livestock, social preferences, availability of resources and support in India.

Prototype IFS models

Indian Council of Agricultural Research through Indian Institute of Farming Systems Research, Modipuram with component schemes of All India Coordinated Research Project on Integrated Farming Systems and All India Network Programme on Organic Farming (AI-NPOF) have developed 60 prototype IFS models (including 8 integrated organic farming system models; IOFS) involving ICAR Institutes and SAUs suitable to 26 States and Union Territories. These tailor-made prototype models established at 30 State Agricultural Universities, 9 ICAR institutes and 1 Central University have the potential to increase the income by 3 to 5 times than existing systems/practices of farmers in a period of 3 to 4 years with the one-time capital investment ranging from Rs 2.2 to 4.6 lakhs/ha on farm infrastructure (farm development, livestock sheds, purchase of large animals, farm ponds, bio-gas, composting unit *etc)* depending upon the location and modules integrated.

The prototype IFS models established at various ICAR institutes and SAUs with common criteria of resource allocation and selection of enterprises are catering for the basic research, educating the students, capacity building of extension agencies and developing business model to attract rural youth. Promising prototype IFS models developed for various ecosystems are given below.

Promising prototype IFS models in different ecosystems

Eco-system	**AER* (Number)**	**Net income with existing systems (Rs/ha/year)**	**Promising Tailor-made prototype IFS components**	**Net income (Rs/ha / year)**	**Improvement in net income (Number of times)**	**Reference location of prototype IFS model**
Arid	2	87,743	Cropping systems, arid horticulture, buffalo, farm pond, boundary plantation	3,61,416	**4.1**	SK Nagar (Gujarat)
Semi Arid	4, 6,7, 8, 9	74,254	Cropping systems, horticulture, Cow, buffalo, back yard poultry, goat/sheep, fishery, Mushroom, Boundary Plantation, farm pond	2,76,396	**3.7**	Varanasi (Uttar Pradesh), Siruguppa (Karnataka), Rajendranagar (Telangana), Thanjavur(Tamil Nadu), Pantnagar (Uttarakhand)
Sub humid	10, 11, 12, 13, 14, 15	66, 919	Cropping systems, horticulture, cow, goat Poultry, duckery, Fishery, Mushroom, Apiary, Biogas, boundary plantation, Agro-forestry	2,46,875	**3.7**	Jabalpur (Madhya Pradesh), Raipur (Chhattisgarh), Ranchi (Jharkhand), Sabour (Bihar) ,

						Jammu (Jammu and Kashmir), Jorhat (Assam)
Humid	17, 18, 19, 20	57,619	Cropping systems, Horticulture (Cashew, coconut with pine apple, arecanut + banana), cow, pig, Poultry, fishery, duckery, Boundary Plantation, land configuration based systems	2,08,134	**3.6**	Umiam (Meghalaya) Bhubaneswar (Odisha), Goa (Goa), Port Blair (Andaman and Nicobar Islands)

*2 (Hot arid agro-eco region with desert and saline soils), 4 (Hot semiarid agro-eco region with coarse loamy alluvial soils), 6 (Hot semiarid to sub humid agro-eco region with alluvial and tarai soils), 7 (Hot semiarid agro-eco region with moderately deep black soils), 8 (Hot semiarid agro-eco region with mixed red and black soils), 9 (Hot semiarid agro-eco region with red loamy soils), 10 (Hot sub humid agro-eco region with moderately deep black soils), 11 (Hot sub humid agro-eco region with red and yellow soils), 12 (Hot sub humid agro-eco region with red lateritic soils), 13 (Hot sub humid agro-eco region with alluvial soils), 14 (Warm sub humid to humid (with inclusion of per humid) agro-eco region with sub montane shallow and skeletal soils), 15 (Hot sub humid agro-eco region with loamy to clay alluvial soils), 17 (Warm per humid agro-eco region with shallow and skeletal red soils), 18 (Warm per humid agro-eco region with red and yellow soils), 19 (Hot sub humid (with humid to per humid inclusion with coastal and deltaic alluvial soils) and 20 (Hot humid / per humid agro-eco region with red and lateritic and alluvial soils)

Integrated Organic Farming System (IOFS) models

India is ninth largest in terms of total arable land under organic farming and largest in terms of total number of organic producers in the world. Sikkim State of India has been brought under complete organic certification and production from 2016. Third party certified and in conversion cultivated area under organic farming reached to 2.66 million ha by March 2021 (Fig1, APEDA, 2021) while around 0.73 m ha is brought under participatory Guarantee System (PGS) of certification. Currently around 2.4 % of net cultivated area is either under certified or in conversion process of organic farming. Conducive policy, technological advancements, demonstrations, and farmer led innovations have contributed for increase in area. In the past 6 years, the area under organic farming is growing at the annual growth rate of 22 %. Development of scientific technologies for organic farming, developmental schemes, introduction of user-friendly and cost effective PGS system of certification and development of online and offline jaivik kheti markets resulted in phenomenal increase and involvement of communities under organic farming.

Country is producing wide range of crops under organic management with oilseeds, sugar crops, fiber crops, cereals, millets and pulses occupy the large chunk of the basket. Government of India has set a target of bringing minimum 4 % of net cultivated area under organic farming by March 2026. Several Central Sector and Centrally Sponsored specific schemes such as ICAR-All India Network Programme on Organic Farming, *Parambharaghat Krishi Vikas Yojana (PKVY),* Mission Organic Value Chain Development for North-Eastern Region and Modern Organic Agriculture Development Initiative for Ladakh are in operation to promote the eco-friendly and sustainable farming practices among farming communities. Besides, these State specific schemes are also being formulated for promotion of organic farming.

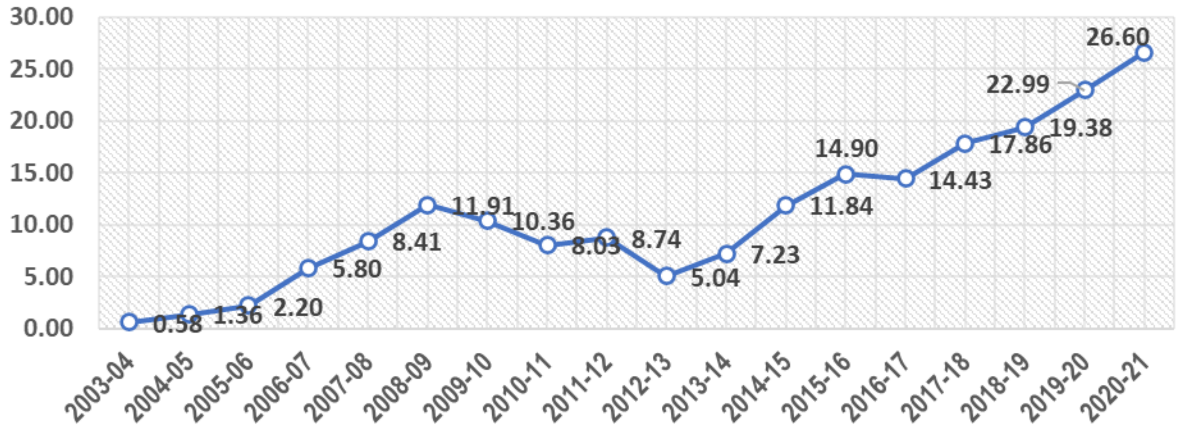


Fig 1. Growth of area (lakh ha) under organic farming in India

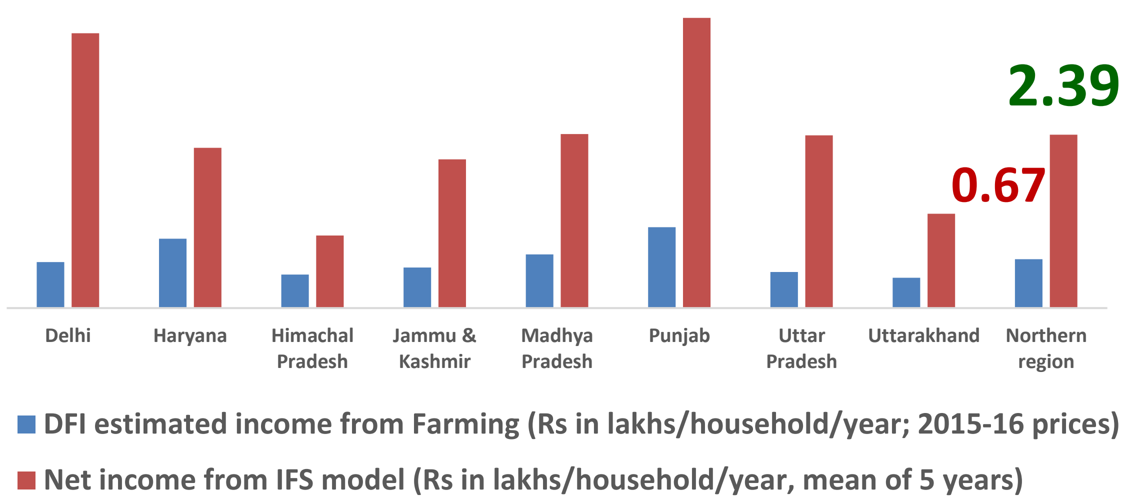
Indian Council of Agricultural Research through All India Network Programme on Organic Farming (AINP-OF) under ICAR-Indian Institute of Farming Systems Research, Modipuram is conducting the multi-location long-term research on organic farming from 2004. Over the years, research done on organic farming resulted in development of package of practices for 51 cropping systems suitable to 12 States, identification of 104 varieties for 20 crops, 8 integrated organic farming system models, characterization and utilization of indigenous inputs such as *panchagavya,* sashagavya, dasagavya, *jeevamrit, ghanjeevamrit* for organic farming. Developmental programmes such as demonstration clusters, capacity building of stake holders was also undertaken.

Integrated Organic Farming Systems (IOFS) models and clusters developed by the Indian Council of Agricultural Research addresses the input-output supply chain in holistic way under organic farming besides improving the productivity, profitability, and sustainability. These models involve cropping systems including high value crops such as spices, livestock components, agroforestry, fodder production and holistic societal development. Recycling for waste to wealth, biodiversity conservation and utilization are the core principles on which the IOFS operates there by it provides opportunities for rural entrepreneurship and soil-plant-human-livestock health at the landscape level.

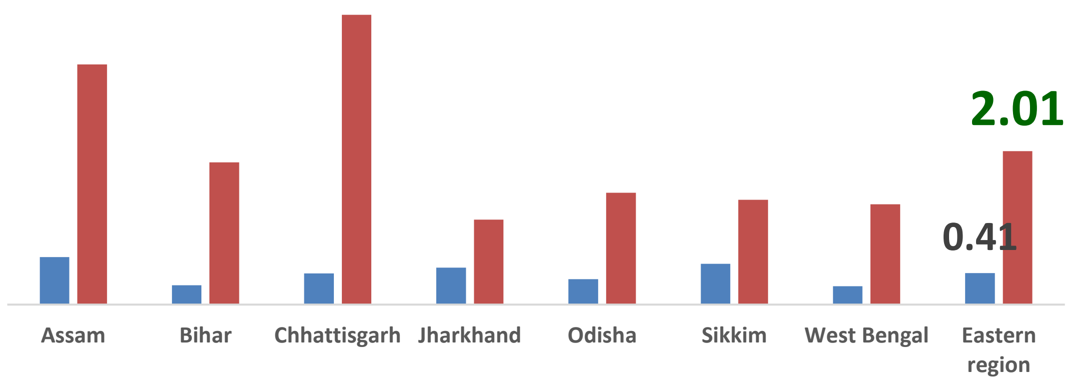
Doubling farmers' income

Integrated farming system models offers scope to improve the income of farm households provided required combination of enterprises, skill, knowledge and resources are provided. Analysis of prototype IFS models established at various States indicates that the profitability can be enhanced to Rs 654/day against the DFI committee estimated level of Rs 183/day from farming in northern and Central States resulting in 3.6 times improvement. Similarly, the scope is there improvement in Eastern States (Rs 550/day against Rs 112/day with 4.9 times improvement), Western States (Rs 460/day against Rs 128/day with 3.6 times improvement) and Southern States (Rs 504/day against Rs 145/day with 3.5 times improvement) (Fig 2 a-d).

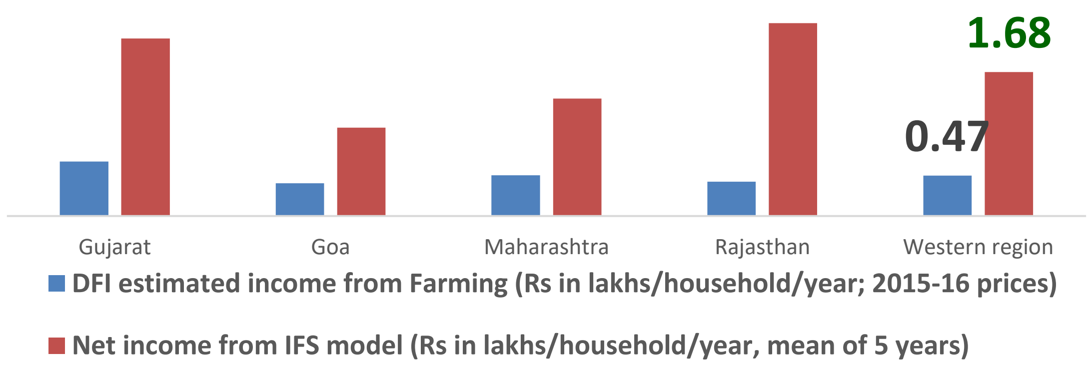
a. Northern region (Rs in lakhs/household)



b. Eastern region (Rs in lakhs/household)



c. Western region (Rs in lakhs/household)



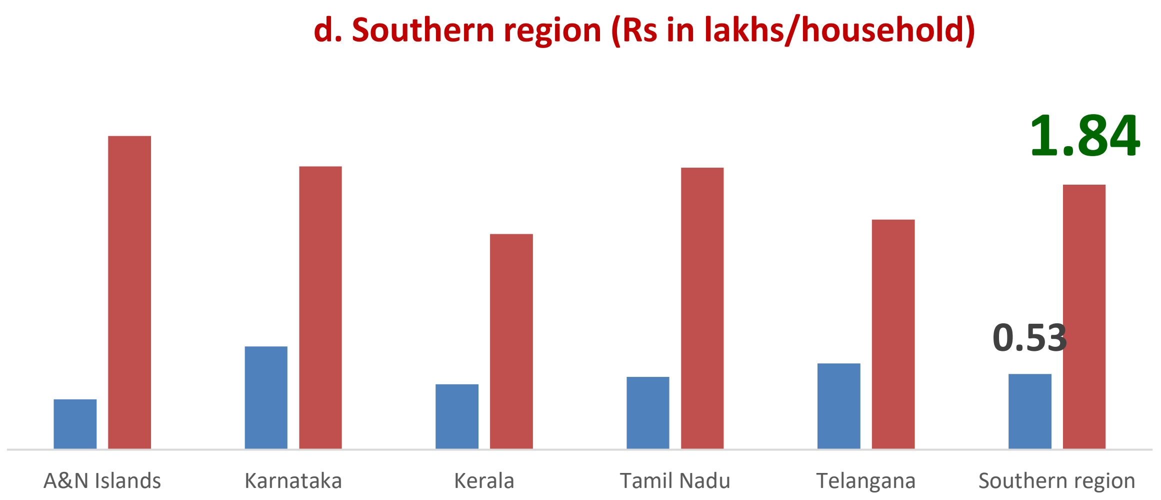


Fig 2 (a-d): Comparative improvement in net income under prototype IFS models established in various regions

Complementary benefits of IFS

Besides improvement in income, IFS results in several other benefits which includes greater sustainability in production and income due to diversity, round the year income and employment, improving the land use efficiency, cropping intensity especially in waterlogged and rainfed lowlands, improvement in share of renewable energy, increase in water productivity and addressing the sustainable development goals. The major complementary benefits which can be achieved through implementation of IFS models are described below.

- Improvement in cropping intensity (up to 300 %) especially in waterlogged and rainfed low lands through land configuration-based farming systems such as raised and sunken bed system, three /multi-tier farming systems.
- Due to recycling and re-use, the market input costs can be saved which ranges from 30 to 72 % in different IFS and IOFS models. The recycling of organic wastes generated with in the farm results in on-farm generation of nutrients to the tune of 134 kg N, 55 kg P_2O_5 and 106 kg K_2O /ha (on an average).
- Soil organic carbon improves by about 22 % in 5 years while the microbial biomass carbon increases by 9 % which ensures nutrient availability to crops from soil.
- IFSs also increases the share of renewable energy and improves the system energy efficiency.
- Water productivity is also improved due to the integration of advanced management practices in all the modules of farming systems and effective recycling of water within the system. The water productivity ranges from 5.9 to 12.6 kg/m^3 in various models which can be further enhanced with integration of precision water management technologies.
- IFS provide opportunity to create round the year income from own farm besides significant improvement in income. The model developed at Bihar Agricultural University (BAU), Sabour, Bihar comprising of diversified cropping systems + orchard + cow + goat + fishery + duckery + vermicompost + boundary plantation resulted in annual net income of Rs 3.14 lakhs/ha/year which is 5 times higher than the existing system of cropping systems (Rice-Wheat; Rice-Maize) +dairy cow (2 milch animals)]. The monthly flow of income is given in Fig 3.

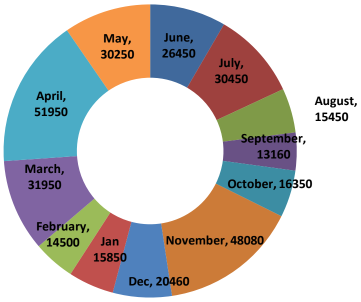


Fig 3. Monthly income from IFS (Sabour,

- Due to the diversification and integration of various components, creates the year-round self-employment (ranges from 400 to 950-man days) ensuring decent livelihood for the farm family. Around 2 to 3 persons can be employed with in the farm and can easily address the reverse migration issue at the village level.
- Sustainable index ranges from 0.50 to 0.90 while the farm diversity index increases to 0.82 compared to mono-cropped areas such as rice-fallow system. Due to the maintenance of diversity, the local varieties of crops and breeds of livestock can be conserved besides improving their productivity.
- Integration of modules such as orchards, boundary plantations, agroforestry, recycling units, biogas *etc* helps to reduce emission of green house gases from farming. Among the models developed, 22 models are emission neutral or negative offering scope to further intensification with economic activities.
- IFSs effectively addresses the Sustainable Development Goals (SDGs). Out of 17 SDGs, 13 (no poverty, zero hunger, Good health and wellbeing, Gender Equality, Clean water and Sanitation, Affordable and Clean energy, Decent work and economic growth, reduced inequalities, responsible consumption and production, climate action, life below water, life on land and partnerships for the goals) are addressed directly at the individual prototype basis while 4 SDGs (quality education, industry, innovation and infrastructure, Sustainable cities and communities, peace, justice and strong institutions) can be addressed through implementation of landscape and cluster based IFSs. It provides more weightage for the life on land and responsible consumption and production.

Bankable Projects on IFS

Any enterprise needs finance or money to pay their overhead costs or day to day and variable expenses. Agriculture is no exception which needs more impetus to finance for attracting the rural youth who have lost their interest in agriculture. The normalized capital investment of Rs. 2.2 to 4.6 lakhs /ha required for farm development, livestock sheds, improved breeds of large and small ruminants, farm ponds, biogas, waste recycling units *etc* needs to be supported through financial institutions. Further, during the initial period, the farmers need to be supported for recurring costs as well. Based on the prototype IFS models developed, 31 bankable projects suitable to 22 states have been prepared which meets the financing criteria for medium term loan for capital investment and short term (yearly) credit for recurring under Kisan Credit Card. Interest rate of 11 % for medium term loan and 4 % for KCC have been considered while developing bankable projects. Since, over the years, the recycling from IFS models will increase and the recurring costs will reduce, the variable rate of recurring cost financing (80, 70, 60 and 36 % financing in 1-4 years respectively) is proposed for better viability and net surplus. The 30 bankable projects meet the banking parameters such as B:C ratio (1.03 to 1.80), internal rate of return (16 to 98 %), Net Present Worth (Rs 1.70 to 7.05 lakhs) with payback period ranging from 3 to 5 years.

Development of Climate Smart IFS villages (CS-IFS)

Considering the multiple benefits of IFS and its contribution to meeting the Sustainable Development Goals (SDGs), there is a need to develop model Climate Smart IFS (CS-IFS) village covering most vulnerable eco-systems (Arid and coastal). Under on-farm research component of AICRP on Integrated Farming Systems, module (cropping, livestock & product diversification with capacity building) based low-cost interventions were implemented in 36 experimental farm households in 58 districts. The results suggest that scaling-up of module-based interventions can result in to increased income to households by 2.7 times (on an average) in 2 to 3 years besides the other benefits of IFS. Based on the experience, the following six modules with 4 interventions in each module are suggested for scaling up and preparing villages to be climate smart.

Module	**Suggested interventions**
Field crops	1. Crop diversification (for family nutrition, livestock nutrition, soil health and income generation) 2. Integration of improved and specialty varieties 3. Good Agricultural Practices 4. Round the year fodder production
Horticulture	1. Fruits / Plantations intercropped with vegetables & medicinal plants 2. Quality planting materials 3. Improved varieties 4. Good Agricultural Practices
Livestock	1. Integration of small ruminants 2. Preparation and supply of area specific mineral mixture 3. Proper housing and management 4. Breed improvement through Artificial Insemination
Fishery	1. Proper stocking (species and ratio) 2. Pond management 3. Integration of poultry, duck, pig *etc* 4. Fruits and vegetables on embankments
Processing	1. Small scale processing (Cleaning, grading, milling *etc*) 2. Aggregation 3. Value addition through small and medium enterprises (SMEs) 4. Packaging, branding and marketing
Supplementary	1. Apiary 2. Biogas 3. Boundary plantation 4. Mushroom

Skill development and custom hiring of machineries are to be made integral part for all the modules.

Key actions for successful IFS

Diversity: Maintaining diversity is essential to achieve all the direct and indirect benefits of meeting the household level food, nutrition for human, livestock and soil besides enhancing the income and other complementary benefits. Across the prototype IFS models developed, the diversity of crops (count of crops) is found to be cereals (19 %), millets (4 %), pulses (15 %), oilseeds (7 %), fodder (15 %), vegetables (15 %), fruits (18 %) and flowers (7 %). The diversity also helps to improve the biological nitrogen fixation to the tune of 119 kg/ha by growing green manures, leguminous plants including pulses and vegetables, nitrogen fixing leguminous trees *etc.*

Recycling: Recycling of wastes from one module to another module is very essential to ensure sustainability and reduce external dependence for inputs. This is very critical for IFS as recycling and preservation of biodiversity is the core concepts on which all the modules are integrated. Recycling can be of through various modules such as composts, vermicompost *etc* and practices such as crop residue mulching. IFS model should recycle at least 30 % of total value of inputs within the system.

Aggregation and Value addition: Due to the diversified nature of IFS farms, the marketable surplus produce from individual household shall be lower. Therefore, aggregation and small-scale processing such as preparation of value-added products such as multi-grain flour, jam, jelly, pickles, oils, powders *etc* plays a vital role in collection of produces at the cluster level for small scale processing. Mobilization of rural youth for aggregation (Uber model) and marketing at local level can be encouraged. Around 10,000 FPOs are proposed to be created by the Government out of which some FPOs can be identified and promoted as IFS FPOs to produce, aggregate and market. Entrepreneurs and Start ups can also be encouraged for processing, branding, and marketing at national and international level.

Implementation

Few states have initiated the promotion of IFS models through formulation of schemes converging the central sector and centrally sponsored schemes. During the period of 2017-21, two States namely Kerala (21,040 farm households in 14 districts during 2017-18 to 2020-21) and Tamil Nadu (19590 farm households in 35 districts during 2018-19 to 2020-21) have promoted the IFS models developed by ICAR-IIFSR, AICRP on IFS, AI-NPOF and SAUs with a financial outlay of about 229.14 crores. IFS models are promoted through *Rebuild Kerala development programme* (Establishment of IFS models project) in Kerala and *Integrated Farming Systems scheme* in Tamil Nadu. DAC&FW of Ministry of Agriculture, GoI also asked all the State Governments to include these IFS /IOFS models in the action plan of Rainfed Farming Systems programme and National Mission on Sustainable Agriculture for promotion at large scale. A webinar was organized during May to June 2020 in which IFS and IOFS models developed for various States and UTs have been shared with DAC&FW and respective States for scaling-up.

Strategy to be adopted for scaling up

Strategy	**Cost**	**Number of blocks / villages**	**Total Amount (Rs in crores)***	**Purpose**

Establishment of One tailor made prototype IFS model (one ha) in each block of 734 districts **(1 model per block)**	Rs 4 lakhs per block	7185** blocks	287.40	Popularize the concept of IFSs among the farmers with in the block, training of rural youth and capacity building activities
Creation of Climate Smart-IFS (CS-IFS) village cluster ***(A village cluster comprising of five contiguous gram panchayats having beneficiary of around 2500 marginal/small households)***	Rs 2.87 crores / cluster	100 villages in the first phase	287.00	Sustainable development of villages by implementation of 6 modules with 4 interventions in each module
		Total	574.4 **(575 crores)**	

*5 % amount to be earmarked for meeting the expenditure of Project Implementation Units (PIU)

** https://lgdirectory.gov.in/

Prototype model at each block

1. IFS model may be established in progressive farmer field in each block. Progressive farmer to be identified by State officials and AICRP-IFS centres/ SAU's.
2. Allocation of area for enterprises needs to be made as per scientific principles in consultation with ICAR-IIFSR, AICRP-IFS/AI-NPOF centres located in the State.

Agencies/departments which can be involved in convergence mode

- Department of Agriculture, Horticulture, Animal Husbandry, Local Administrative bodies, rural development, and NGO's. Director of Agriculture in the district to be made as nodal officer for implementation.
- Technical backstopping to be provided by ICAR-Indian Institute of Farming Systems Research, Modipuram and AICRP on Integrated Farming Systems and All India Network Programme on Organic Farming centres in respective states

Convergence of schemes for scaling up: Different modules of Integrated Farming Systems can be scaled up by leveraging the Centrally Sponsored and Central Sector Schemes of Ministry of Agriculture and Farmers Welfare, Ministry of Fisheries, Animal Husbandry & Dairying and Ministry of Rural development. The list of schemes of different ministries and its components are given below for convergence and implementation to harness the benefits of IFS by marginal, small and under privileged farm households in rural areas.

IFS component can be a part of Centrally Sponsored Schemes

Ministry	Scheme	Components/ purpose of the scheme	Suggested intervention / IFS module
Ministry of Agriculture and Farmers Welfare	Formation and Promotion of 10,000 FPOs	Enhance cost effective productivity and higher net incomes to the member farmer producers' group	Creation of Farmer Interest Groups (FIGs) and FPOs specialized in IFSs
	Pradhan Mantri Krishi Sinchai Yojana (PMKSY)	Increased agricultural production and productivity by increasing availability and efficient use of water	Diversified cropping systems of IFS for improving the water productivity
	Mission Organic value chain development for NEH region (MOVCD for NEH region)	Organic farming in NEH region	Integrated Organic Farming Systems
	Paramparagat Krishi Vikas Yojna (PKVY)	Organic village by cluster approach	Integrated Organic Farming System models and climate smart-IFS village
	Rainfed area development and climate change	Promotion of activities of IFS	Location specific modules of IFS and establishment of prototype IFS models at block level
Ministry of Fisheries, Animal Husbandry and Dairying	Rashtriya Gokul Mission	Conserve and develop Indigenous Breeds in a scientific and holistic manner	Integration and conservation of indigenous breeds of dairy through IFS
	National livestock Mission	Cattle, small ruminants and other livestock	Integration of small ruminants
	Integrated development and management of fisheries	Inland fishery and aquaculture development	Fishery module of IFS in Inland and coastal areas
Ministry of Rural development	National Rural Livelihood	*Mahila Kisan Sashkitikaran Pariyojna* (MKSP) under Deendayal Antyodaya	Strengthen the existing agriculture based livelihoods of the poor

	Mission (NRLM)	Yojana- National Rural Livelihoods Mission (DAY-NRLM)	and participation of women in agriculture and improve productivity Women centric components of IFS such as flowers, vegetables, fruits, dairy, poultry, goat, piggery , mushroom, apiary etc can be promoted Small Scale processing and value addition of marketable surplus produces from IFS clusters by women self help groups
		Start-up Village Entrepreneurship Programme (SVEP)	Self Help Group (SHG) to set-up small enterprises for aggregation, processing, value addition, branding and marketing of marketable surplus produces
		Deen Dayal Upadhyaya Grameen Kaushalya Yojana (DDU-GKY)	Component aims to add diversity to the incomes of rural poor families and cater to the career aspirations of rural youth. Prototype IFS model as such can be promoted under this.

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