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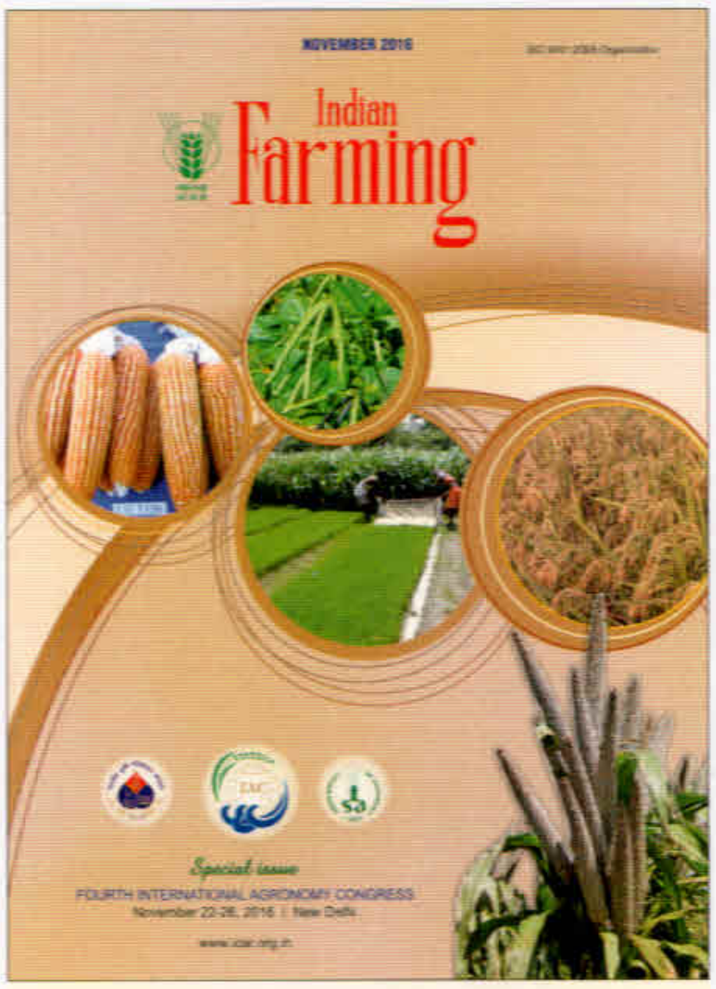

Cover I : Agronomy for Sustainable Management of Natural Resources, Environment, Energy and Livelihood Security to Achieve Zero Hunger Challenge

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In This Issue

Indian Farming **66**(8): 16–23; November 2016

Organic Farming in India

production issues and strategies

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ORGANIC farming systems are very much native to Indian Agriculture. As of now also, in more than 85% of the farm-households, crop + livestock farming system is prevailing. Nevertheless, during pre-green revolution period (up to 1960s) the rate of national agricultural growth was not able to keep pace with population growth and virtually 'ship to mouth' situation prevailed. This was the major factor for introduction and large-scale popularization of the high yielding varieties (HYVs) of crops, which were highly responsive to the chemical fertilizers and water use. As a result, the total food grain production increased phenomenally – from mere 50.82 million tonnes in 1950-51 to 264.00 million tonnes in 2013-14 – indicating a 5-times increase. This increase can be primarily attributed to large-scale adoption of HYVs, combined with other green revolution technologies (GRTs) in cereal crops, expansion of gross irrigated area (22.56 million ha in 1950-51 to 89.36 million ha in 2010-11) and increase in fertilizer consumption (0.07 million tonnes in 1950-51 to 25.54 million tonnes in 2012-13). All of them put together have led to substantial increase in the productivity of crops, especially food grains (from 522 kg/ha in 1950-51 to 2,125 kg/ha in 2012-13) culminating into the change in the status of India from a food importer to net food exporter in many commodities.

However, total factor productivity growth score prepared by National Institute of Agricultural Economics and Policy Research has revealed that technology-driven growth has been highest in Punjab and lowest in Himachal Pradesh. It implies that some of the states like Himachal Pradesh, Uttarakhand, Madhya Pradesh, Rajasthan, Jharkhand and north-eastern region of India have not been influenced much by the modern inputs of agriculture like chemical fertilizers and pesticides. India's average fertilizer and pesticide consumption stands at 128.3 kg/ha and 0.31 kg a.i./ha, respectively. Moreover, despite all technological advancements, the nutrient use efficiency is on lower side (33% for N, 15% for P and 20% for K and micronutrients). On the other hand, it has been proved scientifically and convincingly that integrated use of organic manures with chemical fertilizers improves the use efficiencies of the latter owing to concurrent improvement of soil physical, chemical and biological properties. The water holding capacity of the soil also gets improved on account of regular use of organic manures. It is estimated that various organic resources having the total nutrient potential of 32.41 million tonnes will be available for use in 2025. Out of these organic resources, considerable tapable potential of nutrients ($N + P_2O_5 + K_2O$) from human excreta, livestock dung and crop residues have been worked out to be only 7.75 million tonnes.

Area under Organic Farming, Production and Export

In world, 78 million ha area in 170 countries is under organic agriculture which includes both cultivated and wild harvest. Emerging from 42,000 ha under certified organic farming in 2003-04, the organic agriculture has grown many folds and by 2014-15, India has brought 4.89 m ha area under organic certification process. Out of this cultivated area accounts for 1.18 m ha (24.1%) while remaining 3.71 m ha (75.9%) is wild forest harvest collection area. Currently, India ranks 10th among the top ten countries having the cultivable land under organic certification. In terms of wild collection, India ranks 3rd next to Finland and Zambia. Around 6.50 lakhs producers are engaged in the country in various forms. Sikkim state has been declared as organic state from January 2016 and has highest net sown area (100%) under organic certification while Madhya Pradesh is having largest area (2,32,887 ha) under organic production system. The domestic market for organic products in the year 2014-15 was estimated at ₹ 875

In its simplistic form, organic agriculture may be defined as "a kind of diversified agriculture wherein crops and livestock are managed through use of integrated technologies with preference to depend on resources available either at farm or locally". Other benefits of organic agriculture are its reliance on fossil fuel independent, locally available resources that incur minimal agro-ecological stresses and are cost-effective.

crores. India being a country with different agro-climatic zones, each state produces its own specialty products. Export volume and value from the country during last 3 years indicates highest volume of export to USA and in terms of Value to European Union during 2013-14 and over the years it has grown drastically. Among the various commodities exported, soybean shares 70%. India's first internationally certified organic products emerged in the mid 70's, supported by UK's Soil Association. Different parts of India have developed their own local or regional systems for ecological agriculture that are now gathered in one umbrella term *'Jaivic Krishi' or 'Jaivik Kheti'*.

Concept and Principles of Organic Farming

Historically, the concept of organic farming in India and China is based on following principles:

- Nature is the best role model for farming, since it does not use any inputs nor demand unreasonable quantities of water.
- The entire system is based on intimate understanding of nature's ways. The system does not believe in mining of the soil of its nutrients and do not degrade it in any way.
- The soil in this system is a living entity and the soil's living population of microbes and other organisms are significant contributors to its fertility on a sustained basis and must be protected and nurtured at all cost.
- The total environment of the soil, from soil structure to soil cover is more important.

The organic community has adopted four basic principles, and broadly speaking, any system using the methods of organic agriculture and being based on these principles, may be classified as organic agriculture:

- ***The principle of health***: Organic Agriculture should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible.
- ***The principle of ecology***: Organic Agriculture should be based on living ecological systems and cycles, work with them, emulate them and help sustain them.
- ***The principle of fairness***: Organic Agriculture should build on relationships that ensure fairness with regard to the common environment and life opportunities.
- ***The principle of care***: Organic Agriculture should be managed in a precautionary and responsible manner to protect the health and wellbeing of current and future generations and the environment.

Components of Organic Farming

Essential components of organic farming are keeping the soil alive through effective management of natural resources. They are as follows

- ***Enrichment of soil***: Abandon use of chemicals, use crop residue as mulch, use organic and biological fertilizers, adopt crop rotation and multiple cropping, avoid excessive tilling and keep soil covered with green cover or biological mulch.
- ***Management of temperature***: Keep soil covered, plant trees and bushes on bund
- ***Conservation of soil and rain water***: Dig percolation tanks, maintain contour bunds in sloppy land and adopt contour row cultivation, dig farm ponds, maintain low height plantation on bunds.
- ***Harvesting of sun energy***: Maintain green stand throughout the year through combination of different crops and plantation schedules.
- ***Self-reliance in inputs***: Develop your own seed, on-farm production of compost, vermicompost, vermiwash, liquid manures and botanical extracts.
- ***Maintenance of life forms***: Develop habitat for sustenance of life forms, never use pesticides and create enough diversity.
- ***Integration of animals***: Animals are important components of organic management and not only provide animal products but also provide enough dung and urine for use in soil.
- ***Use of renewable energy***: Use solar energy, bio-gas and other eco-friendly machines.

Different Forms of Organic Agriculture

Rishi Krishi: Drawn from Vedas, the Rishi Krishi method of natural farming has been mastered by farmers of Maharashtra and Madhya Pradesh. In this method, all on-farm sources of nutrients including composts, cattle dung manure, green leaf manure and crop biomass for mulching are exploited to their best potential with continuous soil enrichment through the use of Rishi Krishi formulations known as "*Amritpani*" and virgin soil.

Panchgavya Krishi: Panchgavya is a special bio-enhancer prepared from five products obtained from cow; dung, uine, milk, curd and sometimes ghee. Panchgavya contains many useful microorganisms such as fungi, bacteria, actinomycetes and various micronutrients. The formulation act as tonic to enrich the soil, induce plant vigour with quality production.

Natural farming: Natural farming emphasizes on efficient use of on-farm biological resources and enrichment of soil with the use of Jivamruta to ensure high soil biological activity. Use of Bijamruta for seed/planting material treatment and Jivamruta for soil treatment and foliar spray are important components.

Natueco Farming: Natueco Farming emphasizes 'Neighborhood Resource Enrichment' by 'Additive Regeneration' rather than through dependence on external, commercial inputs. The three relevant aspects of Natueco Farming are:

- Soil - Enrichment of soil by recycling of the biomass by establishing a proper energy chain.
- Roots - Development and maintenance of white feeder root zones for efficient absorption of nutrients.
- Canopy - Harvesting the sun through proper canopy management for efficient photosynthesis.

Homa Farming: Homa farming has its origin from vedas and is based on the principle that "you heal the atmosphere and the healed atmosphere will heal you" The practitioners and propagators of homa farming call it a "revealed science". It is an entirely spiritual

practice that dates from the Vedic period. The basic aspect of homa farming is the chanting of Sanskrit mantras (Agnihotra puja) at specific times in the day before a holy fire.

Biodynamic Agriculture: Method of farming that aims to treat the farm as a living system which interacts the environment, to build healthy, living soil and to produce food that nourishes and vitalizes and helps to develop mankind. The underlying principle of biodynamics is making life-giving compost out of dead material. The methods are derived from the teachings of Rudolf Stainer and subsequent practitioners. The important components of bio-dynamic farming are turning in plant materials such as green crops and straw, not using chemical fertilizers and pesticides, avoiding soil compaction by machinery or animals, particularly in wet-weather, keeping soil covered by pasture, crops or mulch not destroying the soil structure by poor farming practices such as excessive use of rotary hoe or cultivation in unsuitable weather (too wet or too dry), fallowing the land by planting deep-rooting permanent pasture species or using green crops, use of preparations BD-500 and BD-501, compost made with pre-parations BD-502 – BD-507, liquid manure made with preparations BD-502 – BD-507 and cowpat pit manure made with preparations BD-502 – BD-507. Till now, 9 biodynamic preparations have been developed, named as formulation 500 to 508. Out of these, formulation-500 (cow horn compost) and formulation-501 (horn-silica) are very popular and are being used by large number of organic farmers. Formulations-502 to 507 are compost enrichers and promoters, while formulation 508 is of prophylactic in nature and helps in control of fungal diseases.

Organic and Towards Organic Agriculture

Organic is more of a description of the agricultural methods used on a farm, rather than food itself and those methods combine tradition, innovation and science. Organic agriculture, in simple terms, requires a shift from intensive use of synthetic chemical fertilizers, insecticides, fungicides, herbicides, PGRs, genetically engineered plants to extensive use of animal manures, beneficial soil microbes, bio-pesticides, bio-agents and indigenous technological knowledge, based on scientific principles of agricultural systems. Scientific evidences clearly establish that conversion of high intensive agriculture areas to organic systems lead to reduction in crop yields considerably (up to 25-30%), especially during initial 3-4 years; before soil system regains and crop yields come to comparable level. In this scenario, if all the cultivated areas are brought into organic production systems, the national food production system may get jeopardized; hence a phased approach may be desirable. Considering this fact on one hand and looking into global scenario of organic agriculture, working group on Horticulture, Plantation Crops and Organic Farming for the XI-Five-Year Plan suggested a spread of organic farming on 1-5% area in the high productive zones and larger spread in the less exploited areas, such as, rainfed and hill areas. Nevertheless, integrated approach of crop management – including integrated nutrient management and inter/mixed cropping – is also considered as "towards organic" approach; and at the same time has been found to increase the use efficiency of all costly inputs especially fertilizers and water, it would be appropriate to adopt it in the food bowl areas contributing major share to the food basket. This approach will also contribute to 'more crop per drop and less land, less resource/time and more production' strategies of the government.

Towards organic approach (integrated crop management) in wheat (Source: NPOF centre, Bhopal)

Further, India has a sizable cropped area in different states, which is more prone to weather vagaries; especially those located in rainfed, dryland and hilly areas. Increasing the agricultural productivity and income of the farmers as well as sustaining soil resource in these agricultural systems has always been a challenging task for researchers and policy planners. Presently, in these areas use of fertilizers and pesticides is minimal and much below the national average. At first instance, these are the areas which need to be targeted for organic production by devising proper strategies and identifying niche crops (crops which yield higher under organic production systems and have adequate market demand). The domestic and export markets must be exploited for increasing the income of the farmers, as it is important to note that 78% of Indian organic consumers prefer Indian brand of organic and many other countries also require diversified organic foods of tropical fruits, vegetables, essential oils, flowers, herbs, spices and organic cotton from India. In addition, large-scale adoption of organic agriculture in such areas will not only help in conserving the environmentally fragile ecosystems but also help in supplementing overall food production of the country. This can be clearly brought out by the example of Sikkim – an agriculturally weak state located in north-eastern hills region of the country. During 2002-03 (before Sikkim Organic Mission) fertilizer consumption was the highest (21.5 kg/ha), the productivity of rice was 1.43 t/ha but 11 years later, i.e., during 2013-14, it increased to 1.81 t/ha, and more interestingly, no yield reduction was observed during conversion period. Productivity increase in other crops was also noted to the tune of 11, 17 and 24% in maize, finger millet and buckwheat, respectively.

Practical Production Issues and Strategies for Success

Although several issues exist for

organic growers, practically there are three major issues which constraints the productivity of crops under organic farming compared to conventional farming. These issues are:

Supply of sufficient nutrient through organic management: Crop needs nitrogen, phosphorus, potassium and several other secondary and micro nutrients for assimilation and better biomass output. These nutrients need to be supplied in a form which does not have synthetics and environmental degradation. Organic farming discussion starts with the question that how to meet the nutrient requirement of crops through organic manures and where it is available?

Insect and disease management: Another important issue which directly related to crop productivity and environment. Is it possible to manage the pests and diseases without using synthetics?

Weed management: It is the major issue for many of the organic growers as it has been observed that under organic management, weeds grow intensively if manures from outside the farm are used?

STRATEGIES FOR SUCCESS

Supply of Sufficient Nutrient Through Organic Management

Enough scope for production of sufficient organic inputs exists in India and it works out to 7 mt in terms of nutrients. Among different sources, livestock accounts for major share (nearly 40%). It is followed by crop residues (30 per cent) and other sources (15%). Other sources include the rural compost, vermi-compost and agricultural wastes. Further,

Integrated Organic Farming System (IOFS) model established at Umiam (Source: NPOF centre, Umiam)

concept of promoting organic farming in individual crops should be done away and it should be practiced in cropping/farming systems. The issue of sufficient nutrient supply under organic systems can be addressed through following measures.

Practice through farming system: Organic farming is considered incomplete without livestock as livestock alone contributes nearly 40% of total organic manures in the country. Crop + dairy are the predominant farming system practiced traditionally by Indian farmers over the centuries. Analysis of farming systems practiced by 732 marginal households across the 30 NARP zones indicated existence of 38 types of farming systems. Out of this, 47% of households have the integration of crop + dairy, 11% have crop + dairy + goat and 9% households have crop + dairy + poultry systems. Hence, natural strength exists in the country for promotion of organic and towards organic agriculture. Integrated Organic Farming Systems (IOFS): Integrated organic farming system models established at Coimbatore (Tamil Nadu) and Umiam (Meghalaya) under Network Project on Organic Farming (NPOF) could improve the net returns by 3 to 7 times compared to existing systems (Table 1) and meet up to 90% of seeds/planting materials, nutrients, bio-pesticides and other inputs with in the farm in the two years of establishment.

Multiple cropping and crop rotation: Mixed cropping is the outstanding feature of organic farming in which variety of crops are grown simultaneously or at different time on the same land. In every year, care should be taken to maintain legume cropping at least 40%. In selecting crop combinations, it is also to be kept in mind that plants also have their feelings, likes and dislike e.g. maize gets along well with beans and cucumber, tomatoes go well with onions and marigold. On the other hand beans and onions do not go well with each other. Entire farm should have at least 8-10 types of crops at all the times. Each field/plot should have at least 2-4 types of crops out of which one should be legume. In case if only one crop is taken in one plot then adjacent plots should have different crops. For maintenance of diversity and pest control, vegetable seedlings can be planted randomly @ 50-150/acre which can be used for home

Direct seeded rice + soybean under organic management (Source: NPOF centre, Pantnagar)

Table 1. Performance of integrated organic farming system models

Components	Area (ha)	Total cost (₹/year)	Net returns (₹/year)				
			Crop	Livestock	Others	Total	Existing system
		Coimbatore (Tamil Nadu)					
Crop (Okra, cotton, desmanthus) + dairy (1 milch animal, 1 heifer & 1 bull calf) + vermicompost + boundary plantation	0.40	1,10,109	64,500 (87%)	8,216 (11%)	1,600 (2%)	74,316	27,200*
		Umiam (Meghalaya)					
Crops (Cereals + pulses + vegetables + fruits + fodder) + Dairy (1 cow + 1 calf) + Fishery + Vermicompost	0.43	68,255	33,531 (57%)	13,252 (22%)	11,538 (21%)	58,321	8,618**

* fingermillet – cotton - sorghum, ** rice-fallow.

consumption and 100 plants/acre of marigold in all crop fields. Crop rotation is the succession of different crops cultivated on same land. Follow 3-4 years rotation plan. All high nutrient demanding crops should precede and follow legume dominated crop combination. Rotation of pest host and non pest host crops helps in controlling soil borne diseases and pest. It also helps in controlling weeds. It is better for improving productivity and fertility of soil. Crop rotations help in improving soil structure through different types of root system. Legumes should be used frequently in rotation with cereal and vegetable crops. Green manure crops should also find place in planning rotations. Principles with examples for selecting the crops and varieties for organic farming are given below.

- Non–leguminous crops should be followed by leguminous crops and vice-versa, eg. green gram – wheat/maize. If preceding crops are legume or non-legume grown as intercrops or mixed crops, the succeeding crop may be legume or non-legume or both.
- Restorative crops should be followed by exhaustive or non-restorative crops e.g. sesame – cowpea/green gram/blackgram/ groundnut.
- Leaf shedding crop should be followed by non-leaf shedding or less exhaustive crops e.g. pulses/ cotton – wheat/rice.
- Green manuring crop should be followed by grain crops, e.g. *dhaincha* - rice, green gram/ cowpea – wheat/maize.
- Highly fertilized crops should be followed by less-fertilized crop e.g. maize - black gram/gourds.
- Perennial or long duration crops should be followed by seasonal/ restorative crops e.g. napier/ sugarcane - groundnut/cowpea/ green gram.
- Fodder crops should be followed by field or vegetable crops e.g. maize + cowpea-wheat/potato/ cabbage/onion.
- Multicut crops should be succeeded by the seed crops e.g. green gram/maize.
- Ratoon crops should be followed by deep rooted restorative crops e.g. sugarcane/jowar-pigeonpea/ lucerne/cowpea.
- Deep rooted crops should be succeeded by shallow rooted crops e.g. cotton/castor/pigeonpea – potato/lentil/green gram etc.
- Deep tillage crops should be followed by zero or minimal tillage crops e.g. potato/radish/ sweet potato/sugarcane - black gram/green gram/green manuring crops.

Green manures: Green manures are the principal supplementary means of adding organic matter to the soil. The green-manure crop supplies organic matter as well as additional nitrogen, particularly if it is a legume crop, due to its ability to fix nitrogen from the air with the help of its root nodule bacteria. The green-manure crops also exercise a protective action against erosion and leaching. Green manure is to be incorporated in soil before flowering stage because they are grown for their green leafy material, which is high in nutrients and protects the soil. Green manures will not break down in to the soil so quickly, but gradually, add some nutrients to the soil for the next crop. Green manure crops can also be inter cropped and incorporated which will have dual advantage of managing weeds and soil fertility. Popularly grown green manures are Sesbania aculeate (Dhaincha), *Sesbania rostrata*, sunhemp etc.

Intercropping of *dhaincha* in rice and incorporation through cono weeder

Combination of organic nutrient sources: Combining more than one organic source for supplying nutrients to crops has been found to be very effective as meeting the nutrient requirement by single source is not possible. For example, rice-wheat system requires around 30 t FYM/year to meet its nutrient demand. This can be very easily managed by adopting strategies of cropping systems involving green manures, legumes and combined application of FYM + vermicompost and neem cake. This type of management also helps in reducing the insect/disease incidences as incorporation of neem cake in soil has been found to much effective. FYM (partially composed dung, urine, bedding and straw), edible and non-edible oil cakes, enriched composts and effective micro-organisms are some of the combinations which can be used for meeting the nutrient demand of crops. FYM contains approximately 5-6 kg nitrogen, 1.2-2.0 kg phosphorus and 5-6 kg potash per tonne. Though FYM is the most common organic manure in India, the farmer, in general, do not give adequate attention to the proper conservation and efficient use of the resource. For preparing better quality FYM, the use of pit method for areas with less than 1,000 mm precipitation and heap method for other places is recommended. Some of the non-edible oilcakes such as castor and neem cakes are having the insecticidal properties also. Among the edible oil cakes, coconut, groundnut, niger, rapeseed and sesame cakes have higher nutrients (N ranging from 3 to 7.3%; P_2O_5 ranging from 1.5–2% and K_2O ranging from 1.2 to 1.8%). In case of non-edible oil cakes such as castor, cotton, karanj, mahua, neem and safflower cakes, neem cake is having higher N (5.2%), while castor and Mahua cake is having higher P_2O_5 (1.8%) and K_2O (1.8%), respectively. Depending upon the nature and quantity of raw material available with the farmer, any one or combination of composting methods such as Indore method, NADEP compost, NADEP phospho compost, IBS rapid compost, coirpith, sugarcane trash,

Table 2. Identified nutrient management packages for cropping systems at different locations

Location (State)	Cropping System (s)	Sources to meet nutrients
Coimbatore (Tamil Nadu)	Cotton-maize-green manure (GM) Chillies-sunflower-greenmanure	Farm Yard Manure (FYM) + Non Edible Oil Cakes (NEOC) + Panchagavya (PG)
Raipur (Chhatisgarh)	Rice-chickpea	Enriched compost (EC) + FYM + NEOC + Bio dynamic (BD)+PG
Dharwad (Karnataka)	Groundnut-sorghum Maize-chickpea	EC + VC + Green leaf manure (GLM) + biodynamic and PG spray
Ludhiana (Punjab)	Maize-wheat-summer greengram	FYM + PG + BD in maize, FYM + PG in wheat and FYM alone in moong
Bhopal (Madhya Pradesh)	Soybean-wheat Soybean-chickpea Soybean-maize	FYM+PG + BD
Pantnagar (Uttarakhand)	Basmati rice-wheat-greenmanure Basmati rice-chickpea Basmati rice-vegetable pea	FYM + VC + NC + EC + BD + PG
Ranchi (Jharkhand)	Rice-wheat-greenmanure	VC + Karanj cake + BD+ PG

pressmud composts, poultry waste compost using paddy straw, vermicompost, pitcher khad and biogas slurry can be adopted to make compost within the farm. Effective microorganism is a consortium culture of different effective microbes commonly occurring in nature. Most important among them are : N_2-fixers, P-solubilizers, photosynthetic microorganisms, lactic acid bacteria, yeasts, plant growth promoting rhizobacteria and various fungi and actinomycetes. In this consortium, each microorganism has its own beneficial role in nutrient cycling, plant protection and soil health and fertility enrichment. Identified nutrient management packages for various cropping systems are given in Table 2.

Insect and Disease Management

In general, the incidence of pests and diseases are comparatively low under organic production system compared to inorganic systems due to several factors such as application of oil cakes having insecticidal properties, use of green leaf manures such as calotrophis and slightly higher content of phenols in plant parts under organic management. Further, organic management also increases the natural enemies in the farm. Natural enemies of crop pests and diseases such as Coccinellids, syrphids, spiders, Micromus, Chrysopa and campoletis were higher under organic management compared to integrated and inorganic management. Coccinellids, which naturally reduce the hoppers and leaf folders was found to be two to three times higher under organic management in cotton, groundnut, soybean, potato and maize crop fields (Table 3). Similarly, spiders which also control the pests are found to be twice higher under organic management compared to inorganic management. The diversity of arthropod population in soil viz., collembola, dipluran, pseudoscorpians, cryptostigmatids and other mites population was also found to be higher under organic management compared to integrated and chemical management.

Products collected from the local farm, animals, plants and microorganisms and prepared at the farm are allowed for control of pests and diseases. (e.g. Neem seed kernel extract, cow urine spray). The products that are permitted for control of pest and diseases are neem oil and other neem preparations like Neem Seed Kernel Extract, pheromone traps, mechanical traps, plant based repellants, Soft soap and clay. Identified pest and disease management packages for various cropping systems are given Table 4.

A popular natural pest repellent paste mixture prepared by Tamil Nadu farmers containing each 1kg leaves of *Vitex nigunda*, *Agave cantala* , *Datura metha*, *Calotropis* and neem seeds and dissolved in 5 litres of cow urine are kept in plastic or earthen ware. After 15 days of fermentation,

Table 3. Changes in *Coccinelids* and other natural enemy population in various crops under organic and chemical management practices

Crops	*Coccinelids*		Other natural enemies (*Syrphids, Micromus, Chrysopa, spiders*)		Cumulative% reduction of natural enemies/year under chemical management
	Chemical	Organic	Chemical	Organic	
Maize (nos/m)	0.80	2.65	0.50	1.53	68
Groundnut(nos/m)	0.69	2.58	0.76	2.15	69
Soybean (nos/m)	0.35	1.35			74
Cotton (nos/plant)	1.60	4.15	0.88	2.67	63
Potato (nos/m)	0.30	1.25	0.09	0.30	74

Table 4. Identified pest and disease management packages at various locations for different cropping systems

Location (State)	Cropping System	Pest/disease	Recommended practice
Modipuram (Uttar Pradesh)	Basmati rice-chickpea	Soil borne pests and diseases	Summer ploughing+ green manure incorporation
Calicut (Kerala)	Ginger	Shoot borer	Seed treatment with Ginger Endophytic Bacteria 17 and 18, Ginger Rhizobacteria 57
Bajaura (Himachal Pradesh)	Cauliflower-peas-tomato	Fruit borer & fruit rot	Karvi (*Roylea cinerea*) @ 10% aqueous leaf extract + cow urine (3%) + tween-80 (0.05%) as emulsifier
Umiam (Meghalaya)	Maize + Soybean	Monolapta Mylloceros Ephilechma Leaf folder Rust	Derisom (3 ml/l)+Panchagavyya @ 10% and cow urine 3% Anomin 3 ml/litre or Panchagavyya @ 3%. Panchagavyya @ 3% + lantana @ 10% + vermiwash @ 10%

Table 5. Identified weed management packages for various locations and cropping systems

Location (State)	Cropping System	Recommended practice
Raipur (Chhatisgarh)	Rice-mustard	Conoweeder with square planting for riceStale seed bed for mustard
Coimbatore (Tamil Nadu)	Rice-blackgram-greenmanure	2 hand weeding + spray of aqueous leaf extract at 3-4 leaf stage of weeds
Dharwad (Karnataka)	Groundnut	Spray of *cassia* and *Prosppis juliflora* as post emergent
Ludhiana (Punjab)	Basmati rice-wheat-greenmanure	High density planting + hand weeding at 25-30 DAT
Pantnagar (Uttarakhand)	Basmati rice-wheat-*greenmanure*	one hand weeding at 25-30 DAT during *kharif* and 2 hand weeding at 25-30 and 45-50 DAS during *rabi*
Umiam (Meghalaya)	Maize (green cob)-mustard	Mulching with fresh eupatorium/ambrosia @ 10 t/ha (after earthing up)

100 liters of water are added and the filtrate is sprayed in the field. It has been observed by farmers that most of the insect pests are repelled from the treated area.

Weed Management

Weeds are major problem under organic management and almost 43% of organic growers expressed; low and no cost weed management techniques should be identified for successful practicing of organic farming. Slash weeding is to be done between the plants. Weeds under the base of the plants can be cleaned and put as mulch around the plant base. The weeded materials should be applied as mulch in the ground itself. Stale seed beds, hand and mechanical weeding are the other options available for managing weeds under organic management. Further, effective crop rotation, mixed and intercropping is also essential for reducing the weeds. Few identified weed management practices for various locations and cropping systems are given in Table 5.

The other important practical constraints faced by organic growers are incidence of termites and rats. Some of the Indigenous Technical Knowledge (ITKs) practiced for termite management include application of dye prepared from Noni (*Morinda citrifolia*) mixed with garlic extract on trees, application of tank silt in sandy wetlands, *use of alotropis* plant material (8-10 kg) soaked in sufficient quantity of water for 24 hr and filtered and poured on termite infested soil and application of sheared human hair obtained from barber's shop, applied on live mounds and along the infested pathways. ITKs used for rat management include pieces of cotton or thermocole, dipped in jaggery solution, made into small packets and spread in field/orchard and partly cooked sorghum grains coated with cement or white cement and packed into small packets and spread in the field.

Crop Productivity and Economics under Organic Management

Available records on grain yield of paddy under traditional farming practices indicates yield up to 2.95 t/ha (2,605 lbs/acre) in the first crop (*Kuruvai*) and 2.81 t/ha (2,484 lbs/acre) in the second crop (*Thaladi*) [1925-26] has been recorded by Lalgudi Sivagnanam Co-operative Agricultural Society in the Madras Presidency. Similarly in case of wheat, yield of 2.41 t/ha has been reported from West Bengal during 1970-71. Analysis of yield recorded at various locations under organic management over inorganic indicated many crops (Table 6) responded positively to yield higher under organic systems. Sustainable yield index of basmati rice, rice, cotton, soybean, sunflower, groundnut, lentil, cabbage and french bean are higher under organic management compared to integrated and inorganic management systems. Long-term results of organic management clearly establishes that the scientific Package of Practices (PoP's) for organic production of

Organic production of basmati rice (PB-1)
(Source: NPOF centre, Pantnagar)

crops in cropping systems perspective should be adopted for keeping the crop productivity at comparable or higher level than chemical farming. Under ICAR-Network Project on Organic Farming (NPOF), location specific package of practices for organic production of crops in cropping systems (42 no's) suitable to 11 states have been developed which can be practiced for getting optimum productivity under organic management. Among the pulses, greengram, chickpea and cowpea responds better.

Cost of production per unit area is comparable or less under organic agriculture than inorganic management when on-farm organic inputs are used. However, if organic inputs from outside the farm are purchased and utilized, the cost of

Table 6. Number of data entries, averages and ranges (%) of relative yields between organic over inorganic for selected crops in India

Crops	n[a]	Organic over inorganic		Crops	n[a]	Organic over inorganic	
		Mean	Range			Mean	Range
Basmati rice	67	104	88-121	Okra	10	118	90-142
Rice	52	100	89-122	Chilli	12	109	107-112
Maize	37	110	62-137	Onion	13	107	87-127
Sorghum	17	114	89-132	Garlic	9	104	86-121
Greengram	12	107	96-122	Cauliflower	12	104	90-117
Chickpea	24	100	65-114	Cabbage	5	111	81-142
Soybean	54	104	96-123	Tomato	11	106	83-130
Groundnut	16	103	83-116	Ginger	12	120	108-129

[a]n= the number of yield entries.

production increases by about 13%. Therefore, organic agriculture should naturally depend on on-farm generation of inputs including mixed cropping, crop rotation, residue recycling, composting etc.

Environment saviour: Continuous practice of raising the crops organically has good potential to sequester the C (up to 63% higher C stock in 10 years), higher soil organic carbon (22% increase in 6 years), reduction in energy requirement (by about 10-15%) and increase in water holding capacity (by 15-20%), thereby promoting climate resilience farming.

It can be concluded that scientific organic farming packages with ecological perspective needs to be maintained for obtaining comparable or higher yield of crops and income with that of chemical farming.

SUMMARY

Accelerated adoption of "towards organic" (integrated crop management) approach in intensive agricultural areas (food hubs) and "certified organic farming" with combination of tradition, innovation and science in the de-facto organic areas (hills) and rainfed/dryland regions can contribute towards safe food security and climate resilience, besides increased income of farm households. This approach will also positively contribute to the cause of human, livestock and eco-system health, the basic objective of organic agriculture.

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