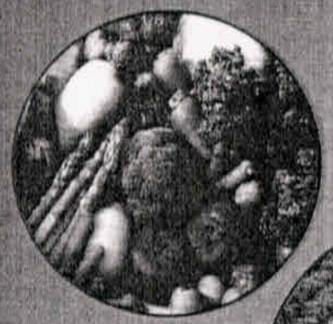
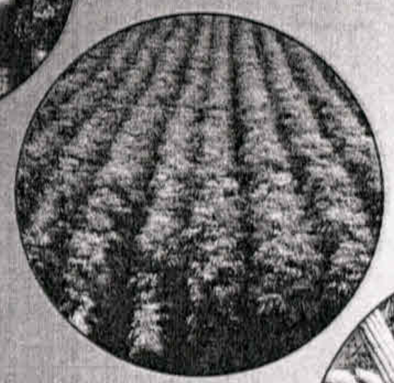
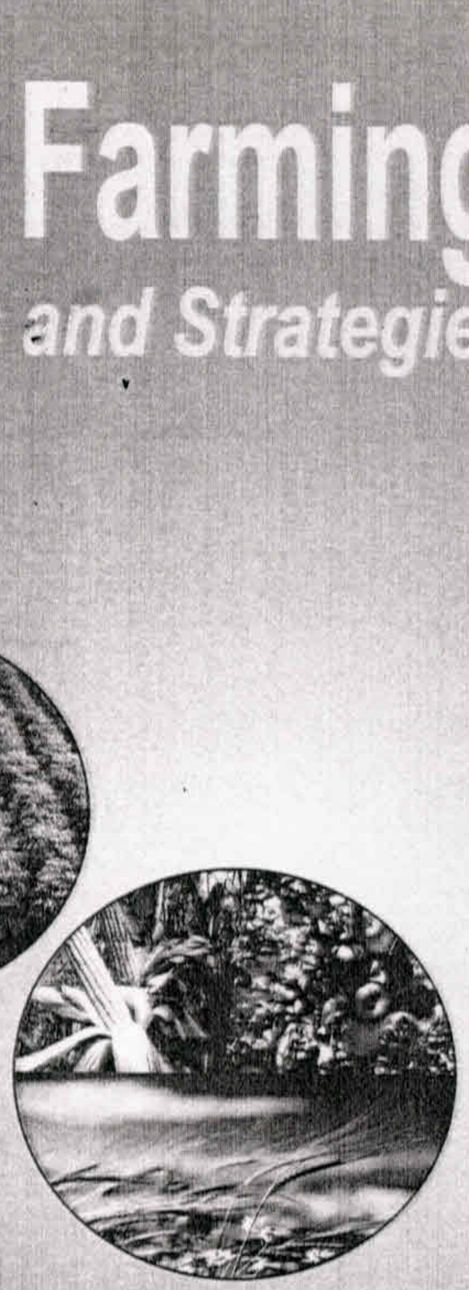
Organic Farming:

Technologies and Strategies







Edited by :
B. Gangwar
N. K. Jat

www.ttpp.in

Contents

Organic Farming : Technologies and Strategies (2016) : 1-24
Editor : B. Gangwar and N. K. Jat
Today & Tomorrow's Printes and Publishers, New Delhi - 110 002, India

1. Technologies and Strategies for Organic Farming in India- An Overview

B. Gangwar[1] and N. Ravisankar[2]

ICAR- Indian Institute of Farming Systems Research, Modipuram, Meerut – 250110

Organic agriculture is a production system, which avoids or largely excludes the use of synthetic compounded fertilizers, pesticides, growth regulators and livestock feed additives. To the maximum extent possible, organic farming system relies on crop rotations, crop residues, animal manures, legumes, green manures, off-farm organic wastes and aspects of biological pest control to maintain soil productivity and tilth, to supply plant nutrients and to control insects, weeds and other pests.

Organic farming systems offer some solutions to the problems, currently besetting the agricultural sector of industrialized/ green revolution countries. The broader aims of organic farming are; sustainability of natural resources, minimizing cost of cultivation, providing healthy food, augmentation of farm profits and improving soil health. Although, in the market place to provide clarity on the organic claim the organic agriculture requires certification, but broadly speaking, any system using the methods of organic agriculture and being based on four basic principles – the principle of health, the principle of ecology, the principle of fairness, and the principle of care; may be classified as organic agriculture.

The system of farming based on the traditional knowledge and practices handed down from generation to generation could not produce enough to feed the increasing population. Thus dependence of developing countries for food on the western developed nations and the politics of food-aid practiced by them added to the determination to produce more by modernizing agriculture. The green revolution technologies (GRT's)

[1] *Former Director* [2] *National PI (NPOF)*

superannua
Indian Instit
He has se
Directorate
Coordinato
(1994-19
(Agronomy
System Ma
Having s
Andaman-
Gangwar,
Ahmad A
Agronomi
Andama
Excelle
contributi
Manager
(2009) fo
large. T
(2001-0
scientific
Patrika"
Best Art
publishe
series (
Fellow
Scienc
croppin
Indian
contribu
Indian
Resea
contrib
Socie
Agricu
croppi
Fellow
outsta
Resea
"Gen
Asso
India
Pres
Soci
Chie
99),
and
Agri
Agro

fulfilled our aspirations by changing the image of India from a food importing to a food self-sufficient as well as exporting nation. The ability of developing country's agriculture (especially India) to meet the demand for food in the country during the post-independence had been a matter of pride for farmers, scientists and all the stake holders. Over the period of time, the growth of health sector from 1990's to 2010's has been at the level of 13% per annum and it is on the increasing trend. The reasons for phenomenally higher growth rate of health sector have been the effects of modern agriculture and it's aftermath effects. The achievement of food self-sufficiency and export was at the expense of ecology and environment and to the detriment of the well-being of the people. Modern agriculture system started showing increasingly unsustainability and once again the need for an appropriate method suitable to our requirements is being felt. The practice of organic farming, said to be the best known alternative to the conventional method. The principles underlying our traditional agriculture are also part of the organic farming concepts.

Organic agriculture aims at the human welfare without any harm to the environment, which is the foundation of human life itself. The relatively high success of organic farming in some countries are due to the high awareness of the health problems caused by the consumption of contaminated food products, the ill effects of environment degradation, appropriate support by the government and organizations like the European union and International Federation of Organic Agriculture Movements (IFOAM). In India, also, the necessity of having an alternative agriculture method which can function in a friendly ecosystem while sustaining and increasing the crop productivity is realized. Organic farming is recognized as the best known alternative to the modern inputs based agriculture. The progress of organic agriculture in India is though very slow but steady. India has the potential to become a major organic producing country given the international demand for our diversified farm products from different agro climatic regions, the size of the domestic market and above all the long tradition of environment friendly farming and living. Indian agriculture in a way may be regarded as organic because majority of its cultivated area is under rainfed cultivation and only about 38% of cultivated land is under irrigation and in rainfed areas, there is little use of fertilizers and other agriculture chemicals on account of risks associated, resources poor farmers and smaller land holdings.

Historical background

The concept of organic agriculture is not alien to India. In fact, the first scientific approach to organic farming dates back to the *Vedas* of the later *Vedic* period, the essence of which is to live in harmony with, rather than exploit, Mother Nature. There is brief mention of several organic inputs in our ancient literatures like Rigveda, Ramayana, Mahabharata, Kautilya Arthasashthra etc. In fact, organic agriculture has its roots in traditional agricultural practices that evolved in countless village's and farming communities over the millennium. Major milestones in the area of organic farming are presented in Table 1.

Table 1 Historical perspective of organic farming in India

Ancient period	Oldest practice 10000 years old, dating back to 'Neolithic age, practiced by ancient civilization like Mesopotamia, Hwang-Ho basin etc.
Ramayana	All dead things - rotting corpse or stinking garbage returned to earth are transformed into wholesome things that nourish life. Such is the alchemy of mother earth – as interpreted by C. Rajagopalachari.
Mahabharata (5500 BC)	Mention of Kamadhenu, the celestial cow and its role on human life and soil fertility.
Kautilya Arthashastra (300 BC)	Mentioned several manures like oil cake, excreta of animals.
Brihad-Sanhita (by Varahmihir)	Described how to choose manures for different crops and the methods of manuring.
Rig Veda (2500-1500 BC)	Mention of organic manure in Ria Veda I, 161, 10, 2500-1500 BC, is Green Manure in Atharva Veda II 8.3, (1000 BC). In Sukra (IV, V, 94, 107-112) it is stated that to cause healthy growth the plant should be nourished by dungs of goat, sheep, cow, water as well as meat. A reference of manure is also made in Vrksayurveda by Surpala (manuscript, oxford, No 324 B, Six, 107-164)
Holy uan (590 AD)	At least one third of what you take out from soils must be returned to it implying recycling or post-harvest residue.

Source: Bhattacharyya and Chakraborty (2005)

Empirical evidence further suggests that while conventional agriculture goes better with large holdings, organic farming functions better in small farms. A study by Gupta *et al.*, (1997), comparing grain production in organic *vis-a-vis* conventional methods, observed that as farm size increases, the advantages of organic rotation become less visible. Further, the study reported that on a smaller scale, organic farming was more profitable and productive than conventional farming.

superannuatec
Indian Institute
He has serve
Directorate fc
Coordinator (A
(1994-1999
(Agronomy)/ F
System Mana
Having serv
Andaman-Nic
Gangwar, is
Ahmad Awa
Agronomic c
Andaman
Excellenc
contributions
Managemen
(2009) for di
large. Three
(2001-02, 2
scientific arti
Patrika". DI
Best Article
published ir
series of re
Fellow of **N**
Science, f
cropping/far
Indian Soc
contribution
Indian So
Research
contributior
Society f
Agricultur
cropping s
Fellow of
outstandin
Research
"**General**
Associatio
Indian S
President
Society of
Chief, J. A
99), Jour
and Deve
Agricultu
Agronom

Status of Organic Farming

Demand for organic products, especially in developed countries, has been increasing. Globally, organic agriculture is practiced in 162 countries and 37 m ha of land are managed organically by 1.8 million farm households. The global sale of organic food and drink reached 62.9 billion US dollors in 2011. The regions with the largest areas of organically managed agricultural land are Oceania (12.1 million hectares or 33 percent of the global organic farmland), Europe (10.6 million hectares or 29 percent of the global organic farmland) and Latin America (6.8 million hectares or 23 percent). On a global level, the organic agricultural land area increased by three percent compared with 2010. The countries with the most organic agricultural land are Australia (12 million hectares), Argentina (3.8 million hectares) and the United States (1.9 million hectares).

In Asia, land under organic management reached 3.6 million hectares for 2009 up from just under 3.4 million hectares reported for 2008 and under 2.9 million hectares for 2007. The expansion of over 0.2 million hectares, a growth rate of close to 6 per cent comes on top of a 17 per cent growth from 2007 to 2008. It maintains an upward trend albeit a slower pace of conversion. The main contributor of the expansion of cultivated acreage is India. With the increasing awareness about the safety and quality of foods, long term sustainability of the system and accumulating evidences of being equally productive, the organic farming has emerged as an alternative system of farming which not only addresses the quality and sustainability concerns, but also ensures a profitable livelihood option. Cultivated area under certified organic farming has grown almost 17 fold in last one decade (42,000 ha in 2003-04 to 7.23 lakh ha in 2013-14). The state wise area under organic farming during 2013-14 is given in Table 2.

The Government of India has implemented the National Programme for Organic Production (NPOP) in the year 2001. The national programme involves the accreditation programme for certification agencies, norms for organic production, promotion of organic farming etc. States like; Uttaranchal, Karnataka, Madhya Pradesh, Maharashtra, Gujarat, Rajasthan, Tamil Nadu, Kerala, Nagaland, Mizoram, Sikkim have been promoting organic farming.

Organic produces are increasingly preferred by developed countries and major urban centres in India. Huge demand for Indian organic products especially tea, coffee, cotton etc. exists in the international market. A special class of consumers is also emerging in the domestic market who requires

Table 2. State wise Farm area (excluding Forest Area) under Organic Certification during 2013-14

S.No.	State Name	Organic Area (in Ha)
1	Andaman & Nicobar Islands	321.28
2	Andhra Pradesh	12325.03
3	Arunachal Pradesh	71.49
4	Assam	2828.26
5	Bihar	180.60
6	Chhattisgarh	4113.25
7	Delhi	0.83
8	Goa	12853.94
9	Gujarat	46863.89
10	Haryana	3835.78
11	Himachal Pradesh	4686.05
12	Jammu & Kashmir	10035.38
13	Jharkhand	762.30
14	Karnataka	30716.21
15	Kerala	15020.23
16	Lakshadweep	895.91
17	Madhya Pradesh	232887.36
18	Maharashtra	85536.66
19	Manipur	0
20	Meghalaya	373.13
21	Mizoram	0
22	Nagaland	5168.16
23	Odisha	49813.51
24	Pondicherry	2.84
25	Punjab	1534.39
26	Rajasthan	66020.35
27	Sikkim	60843.51
28	Tamil Nadu	3640.07
29	Tripura	203.56
30	Uttar Pradesh	44670.10
31	Uttaranchal	24739.46
32	West Bengal	2095.51
	Total	**723039.00**

Source: APEDA (2013-14)

superann
Indian Ins
He has
Directora
Coordina
(1994-1
(Agronon
System M
Having
Andamar
Gangwar
Ahmad
Agronom
Andama
Excelle
contributi
Manager
(2009) fo
large. T
(2001-02
scientific
Patrika".
Best Arti
publishe
series of
Fellow o
Science
cropping
Indian S
contribut
Indian
Resear
contribut
Society
Agricult
cropping
Fellow o
outstanc
Researc
"**Genera**
Associa
Indian
Preside
Society
Chief, J
99), Jou
and De
Agricult
Agronor

quality food. The global trade during 2013-14 was USD 60 billion (Rs. 3,60,000crores) and may touch USD 100 billion (Rs. 6,00,000 crores) within the next five years. Trade in India may reach Rs. 5000-6000 crore, which is about 1% of the global trade. The International Competence Centre for Organic Agriculture (ICCOA) estimated that the domestic market for organic products in the year 2011-12 was Rs. 300 crore and grew to Rs. 600 crore in 2012-13 i.e. a growth rate of 100%. Export volume to different countries during last 3 years are given in Table 3.

Organic agricultural export market is one of the major drivers of organic agriculture in India. India exports 31 organic products. It is estimated that more than 85% of total organic production, excluding wild herbs from Uttar Pradesh and Madhya Pradesh, is exported. India is best known as an exporter of organic tea and also has great export potential for many other products. Other organic products for which India has a niche market are spices and fruits. There is also good response for organic rice, vegetable, coffee, cashew, oil seed, wheat and pulses. Among the fruit crops bananas, mangos and oranges are the most preferred organic products.

Table 3: Export volume and value (Rs.) from India in last three years

Countries	2011-12		2012-13		2013-14	
	Export volume (MT)	Value (₹ crores)	Export volume (MT)	Value (₹ crores)	Export volume (MT)	Value (₹ crores)
European Union	51138.8	505.29	82835.37	678.51	56946.72	553.85
U. S. A.	37630.23	197.94	34292.35	228.72	74942.72	498.83
Canada	19848.91	66.66	33645.80	146.05	38545.57	182.41
Switzerland	2161.51	21.04	3455.27	27.57	4306.56	33.88
Japan	232.77	8.79	199.22	11.11	309.07	16.12
Australia	349.14	5.15	468.26	6.60	749.95	14.58
Rest	4055.78	34.47	5380.68	57.25	1964.66	28.94
Total	**115417.2**	**839.3**	**160276.9**	**1155.8**	**177765.2**	**1328.6**

Source: Ministry of Commerce and Industries, GOI, 2014

Government initiative

The lucrative market of the developed world has so far acted as the primary driving force behind the development of the 'certified organic' sector, which is still in a nascent stage in India. According to one estimate, in 1999 merely 0.001% of the total agricultural land in India was under certified organic cultivation. It is predominantly the NGOs and people's organizations that have been spearheading organic agriculture movement in different parts of the country during the last two decades.

The Government of India has set up a special cell under the Agricultural and Processed Food Export Development Authority (APEDA) of the Ministry of Commerce and Industries (MOCI). The MOCI has come out with the 'National Programme of Organic Products' (NPOP) in 2000, and the 'India Organic' logo in 2002. While these initiatives have been undertaken to promote exports of Indian organic products, the Department of Agriculture and Cooperation has formulated a 'National Project on Organic Farming' to promote organic agriculture as part of an exercise to curb the use of chemical pesticides and make agricultural activity more eco-friendly. Shifting to organic farming, even if it promises higher returns in terms of better prices and international acceptability in the long run, may not be preferred by the majority of farmers as they are dependent on the farm for livelihood and any departure would affect them immediately. To make majority of small farmers shift to organic farming, several subsidies have to be given on organic inputs.Such initiatives are a step in the right direction, but they should be weighed against the huge subsidies that the Central Government has been providing for the production and import of chemical fertilizers and pesticides. There is a great potential for organic farming to flourish in this country and given an appropri-ate institutional and policy framework, it will not be very difficult to promote the existing *'de-facto organic'* farms to the category of certified organic farms. This would enable the small farmers to take advantage of the lucrative market for certified organic products in the developed world, which could directly contribute towards the improvement of their economic well-being.

Technologies

Keeping in view, the prospective role of organic farming in mitigating the problems of resource (soil, water, and bio-diversity) degradation and minimize the implications of climate change on agriculture, Indian Council of Agricultural Research took up a research programme on organic farming during 10th Five-Year Plan, by establishing a 'Network Project on Organic Farming (NPOF)', to study some agronomic aspects of organic farming and develop package of practices in arable crops at 13 centres representing major agro-climatic zones and potential areas/states. Further, seven new centres were approved in XII plan to cover additional crops (seed spices and tuber crops) and potential nitel areas (hilly and rainfed regions). Analysis of research data from various centres revealed

superan
Indian I
He has
Director
Coordin
(1994 -
(Agronc
System
Having
Andam
Gangw
Ahmad
Agrono
Andan
Excel
contribu
Manag
(2009)
large.
(2001-
scientif
Patrik
Best A
publish
series
Fellow
Scien
croppi
Indian
contrit
Indian
Rese
contrit
Socie
Agric
croppi
Fellow
outsta
Resea
"Gen
Assoc
India
Presi
Socie
Chief
99), .
and I
Agric
Agror

the following.

- Yield advantage (after 8th cycle across the locations): Basmati rice, soybean, garlic, groundnut, cauliflower, tomato (4-6 %) &greengram, onion, chilli, cabbage, turmeric (7-14 %)
- Yield reduction (after 8th cycle across the locations): Wheat, mustard, lentil, potato, French bean (5-8 %)
- Soil organic carbon increased by 22 % under organic production over inorganic in 6 years
- Increase in soil microbes (fungi, bacteria, actinomycetes) was observed in all locations
- Slight improvement in nutritional quality was observed in soybean, turmeric and ginger under organic production

Conversion: The time between the start of organic management and certification is called conversion period. The farmers should have a conversion plan prepared if the entire field is not converted in to organic at a time. In that case, it is necessary to maintain organic and non-organic fields separately. In the long run the entire farm including livestock should be converted into organic. The conversion period is decided based on the past use of the land and ecological situation. Generally, the conversion period is two years for annual crops and three years for perennial crops. However, the conversion period can be relaxed based on the verification by certification agency if the requirements are fully met. During conversion, steps should be taken to maintain bio-diversity etc. The per cent change in the yield of major crops over the years is given in Table 4.

Mixed farming

Animal husbandry, poultry, fisheries, etc. should be practised in addition to agricultural farming. Shifting cultivation is not allowed. Integrated organic farming system model is being developed at Meghalaya and Coimbatore centres under Network Project on Organic Farming. The models could improve the net returns by 3 to 7 times compared to existing systems (Table 5).

Nutrient Management Package

Identified nutrient management package for various cropping systems through network project are given in Table 6.

Table 4. Mean yield of crops tested in cropping systems under organic input management and yield trend over the years

Crop	No. of observations	Mean yield (kg/ha) under organic input mgt.	Yield trend under organic system over the years (% increase (+) or decrease (-) over inorganic input management)						
			1st year	2nd year	3rd year	4th year	5th year	6th year	7th year
Basmati rice	67	3099	-13	-14	-3	2	2	8	7
Rice	56	3639	-12	-13	5	2	1	2	1
Wheat	56	2952	-15	-9	-7	-3	-7	-13	-4
Maize	55	4541	-5	9	4	0	3	10	16
Green gram	12	905	-	-4	-	-9	3	13	13
Chickpea	25	1269	-10	5	9	3	0	1	5
Soybean	58	1697	1	1	5	0	3	0	12
Cotton	29	1243	8	9	11	12	11	14	12
Garlic	9	7878	-10	-19	8	15	-	-	-
Cauliflower	12	10683	-8	-8	4	2	-	-	-
Tomato	11	20577	-13	-13	-30	-28	35	26	20
Mean			**-6.7**	**-4.8**	**0**	**1**	**8.4**	**5.6**	**9.0**

Pest, Disease and Weed management

Use of synthetic/chemical pesticides, fungicides and weedicides is prohibited. Natural enemies shall be encouraged and protected. (for e.g. raising trees in the farm attracts birds which kills pests of the crops, nest construction etc.). Products collected from the local farm, animals, plants and micro-organisms and prepared at the farm are allowed for control of pests and diseases. (eq. Neem Seed Kernel Extract, cow urine spray). Use of genetically engineered organisms and products are prohibited for controlling pests and diseases. Similarly, use of synthetic growth regulators is not permitted. Slash weeding is to be done between the plants. Weeds under the base of the plants shall be cleaned and put as mulch around the plant base. The weeded materials should be applied as mulch in the ground itself. The products that are permitted for control of pest & diseases are Neem oil and other neem preparations like Neem Seed Kernel Extract, Chromatic traps, Mechanical traps, Pheromone traps, Plant based repellants, Soft soap and clay. The following products shall be used when they are

Table 5. Performance of integrated organic farming system model

Location	Components	Area (ha)	Total cost	Net returns (Rs/year)				
			(Rs/year)	Crop	Livestock	Others	Total	Existing system
Coimbatore (Tamil Nadu)	Crop (Okra, cotton, desmanthus) + dairy (1 milch animal, 1 heifer & 1 bull calf) + VC+ 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

Table 6. Identified nutrient packages for various locations

Location	Cropping System (s)	Sources
Jabalpur (MP)	Basmati rice-wheat-berseem (seed)	Vermicompost (VC) + Farm Yard Manure (FYM) + Non Edible Oil Cakes (NEOC) *(a)* 1/3 N
Coimbatore (TN)	Cotton-maize-GMChillies-sunflower-GM	FYM + NEOC *(a)* ½ N each + Panchagavya (PG)
Raipur (CG)	Rice-chickpea	Enriched compost (EC) + FYM + NEOC *(a)* 1/3 N each + Bio dynamic (BD)+PG
Wheat (Kerala)	Ginger-fallow	FYM + Neem Cake (NC) + 2VC + PG + biodynamic + Rock phosphate(RP)
Dharwad (Karnataka)	Groundnut-sorghum Maize-chickpea Chilli +onion	EC + VC + Green leaf manure (GLM) + biodynamic spray *(a)* 12 g/ha with PG spray
Karjat (Maharashtra)	Rice-red pumpkin Rice-cucumber	FYM + rice straw + gliricidia *(a)* 1/3rd each of N during *kharif* and FYM + NC + VC *(a)* 1/3 each of N during *rabi*along with spray of PG
Ludhiana (Punjab)	Maize-wheat-summer moong	FYM + PG + BD in maize, FYM +PG in wheat and FYM alone in moong
Bhopal (MP)	Soybean-wheatSoybean-chickpeaSoybean-maize	FYM+PG + BD
Pantnagar (Uttarakhand)	Basmati rice-wheat Basmati rice-chickpea Basmati rice-vegetable pea	FYM + VC + NC + EC *(a)* ¼ N each + BD + PG
Ranchi (Jharkhand)	Rice-wheatRice-potato	VC+ Karanj cake (KC) + BD+ PG
Umiam (Meghalaya)	Rice-maizeRice-toria	FYM + VC + PG

absolutely necessary and taking environmental impact into consideration.

- Bordeaux mixture
- Plant & animal preparations e.g. Cow urine spray, Garlic extract, Chilli extract
- Light mineral oils e.g. Kerosene

The certification agency shall be consulted before using these inputs.

Natural enemies of crop pests and diseases such as Coccinellids, syrphids, spiders, Micromus, Chrysopa and campoletis were higher under

superannual
Indian Institu
He has ser
Directorate
Coordinator
(1994-19
(Agronomy
System Ma
Having s
Andaman-
Gangwar,
Ahmad A
Agronomi
Andama
Excelle
contributi
Managen
(2009) fo
large. T
(2001-0
scientific
Patrika"
Best Art
publishe
series
Fellow
Scienc
croppir
Indian
contrib
Indian
Rese
contri
Socie
Agric
cropp
Fello
outst
Rese
"**Ger**
Asso
Indi
Pre
Soc
Chi
99)
and
Ag
Ag

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. 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 (Annual Progress Report, 2010-2013, Network Project on Organic Farming, University of Agricultural Sciences, Dharwad, Karnataka). Identified pest, disease and weed management package for various cropping systems through network project are given in Table 7 and 8.

Table 7. Identified weed management packages for various locations

Centre	Cropping System	Recommended practice
Raipur (CG)	Rice-mustard	Cono-weeder with square planting for rice Stale seed bed for mustard
Coimbatore (TN)	Rice-blackgram-GM	2 hand weeding + spray of aqueous leaf extract at 3-4 leaf stage of weeds
Jabalpur (MP)	Rice-wheat	2 hand weeding + spray at 3-4 leaf stage aqueous spray of weeds
Dharwad (Karnataka)	Groundnut	Spray of cassia and *Prosppis juliflora* as post emergent
Ludhiana (Punjab)	Basmati rice-wheat	High density planting + hand weeding at 25-30 DAT
Pantnagar (Uttarakhand)	Basmati rice-wheat-sesbania	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 (GC)-mustard	Mulching with fresh eupatorium/ ambrosia @ 10 t/ha (after earthing up)

Indigenous technologies for organic management of major crops

Rice

- Grind one kg of garlic and mix in one litre of kerosene. Keep it overnight and filter. Mix in 200 lit of water and spray to control brown planthopper, green leafhopper. This practice is widely

Table 8. Identified pest and disease management packages for various locations

Centre	Cropping System	Pest/disease	Recommended practice
Modipuram (Uttar Pradesh)	Basmati rice-chickpea Basmati rice-mustard	-	Summer ploughing + green manure incorporation
Calicut (Kerala)	Gninger-fallow	Shoot borer	GEB 17 & 18, GRB 57
Bajaura (Himachal Pradesh)	Cauliflower-peas-tomato	Fruit borer & Fruit rot	Karvi (Royleacinerea) @ 10% aqeous leaf extract + cow urine (3%) + tween-80 (0.05%) as emulsifier
Umiam (Meghalaya)	Maize +Soybean	Monolapta Mylloceros Ephilechma Leaf folder	Derisom (3 ml/l) + PG @ 10% and cow urine 3% Anomin 3 ml/litre or PG @ 3%.
		Rust	PG @ 3% + lantana @ 10% + vermiwash @ 10%

practiced in Tirunelveli district of Tamil Nadu.

- 4 kg of neem leaves + 4 kg of citronella grass + 4 kg of rhizome of *Alpiniagalanga*are chopped and ground in a mortar. Mix the materials in 40 lit of water and leave it for a day. Filter the mixture and dilute with water at 1:60 ratio to control stem borer and leaf-folder.
- Ducks are allowed inside the fields after the harvest of rice crop. The ducks feed on snails and insects found on the boundary. This is common in Trichirapalli and Thanjavur districts of Tamil Nadu.

Millets

- Lab lab or cowpea intercropping in sorghum controls sorghum stem borer incidence.
- Application of ash during flowering phase controls earhead bugs in sorghum.
- Application of onion bulb extract (2-3 kg) control grasshoppers incidence in maize crop.

- Planting of napier grass (2-3 rows) along the maize field border controls maize stem borer attack.
- Intercropping of lucerne in maize crop controls maize stem borer effectively.

Pulses

- Mixture of 3-5 lit of Cow urine and equal quantity of cow dung, kept for four days and filtered. To this 200 g of lime is added and made up to 80 litre and sprayed to control red gram pod borers.
- Spray application of butter milk in cowpea controls yellow vein mosaic virus (YMV) disease where in the buttermilk act as a good barrier of vectors of the YMV.
- Spreading castor oil coated polythene sheet in cowpea field traps sucking pests.
- Coriander intercropping in bengalgram controls gram pod borer.
- Application of tobacco decoction mixed with soap emulsion controls aphids.

Oil seeds

- Digging trench around groundnut field and spreading *Calatropis*leaves in trenches kills red hairy caterpillars trapped in trenches.
- Spreading one kg of popped sorghum grains around castor field attracts birds which pick up semiloopers attacking castor leaves.
- Application of sand and salt crystals in leaf axils controls rhinoceros beetle in coconut.
- Spray application of diluted cow urine controls leaf webber in gingelly.
- *Helicoverpa armigera* in groundnut is controlled by spraying leaf extract of *Prosopis juliflora* in which 200 ml of *Prosopis* leaf extract is mixed with 10 litres water and sprayed. This practice is common in Thummanayakkanpatty village of Madurai district in Tamil Nadu.
- Roasted seeds of maize or sorghum (5 kg/ac) are broadcasted in groundnut field. This attracts birds which pickup the leaf eating caterpillars.

- Cooked rice mixed with turmeric powder is placed in castor field during morning and late in the evening for 2 to 3 days continuously attract birds which devour the semilooper larvae.

Vegetables

- Border cropping of *Tagetes* in brinjal controls shoot and fruit borer pests.
- Syrianangai *Andrographispaniculata* (3-5%) decoction spray controls brinjal shoot and fruit borer, ribbed gourd stem borer, hairy caterpillar of drumstick and armyworms. For that one kilo gram of plant is cut into small pieces and mixed with 4 lit of water and placed in a mud pot, boiled and reduced to 1 lit and 500 ml of this extract is mixed with 100 ml of soap solution and 9.4 lit of water and used for spraying.
- One kg of cow dung is mixed with 10 lit of water. Filter the extract with a gunny cloth and add 5 litres of water to the filtrate and again filter. Spray the clear filtrate on plants to control pumpkin beetle, **Epilachna** beetle and pod bugs.
- Planting of coriander, mint, ginger and turmeric in mango orchards deters mango pests.
- Application of cow urine or tobacco decoction controls insect pests in grapevines.
- Basin (*Ocimum sanctum*) in mango orchard acts as a trap crop for fruit flies.

Economics of Organic Farming

The studies conducted under Network project on Organic Farming revealed that across the locations, net return was 17 % higher (at 20-25 % premium price) under organic production system compared to inorganic production system.The cost of cultivation was found to be 13 % higher under organic production system mainly due to handing of bulky nature of organic manures. Benefit: Cost ratio of important cropping systems experimented under NPOF is given Table 9.

The cost of organic source of nutrients under organic cultivation varied between 28 to 85 % of the operational cost across different crops, whereas, under non-organic cultivation, the cost of nutrient sources predominantly constituted by inorganic sources ranged between 16 to 68 %.

Charyulu and Biswas (2010) examined the economic viability and efficiency of organic farming in India. The study is based on farm production data from the four states *viz.*, Punjab, Uttar Pradesh, Gujarat and Maharashtra. A field survey was conducted in 2009-10 among 120 farmer households, 15 organic and 15 inorganic farmers in each province. The crops covered are paddy, wheat, cotton and sugarcane. The authors also conducted a Data Envelope Analysis (DEA) using per acre figures of gross value of output and four input costs (seeds, fertilizers, pesticides and inter-culture to measure the efficiency of organic and conventional farming for the sample. The findings reveal that for paddy cultivation, the organic method is less profitable than the conventional paddy farming. The net returns per acre were less for organic paddy by 15 per cent in Punjab and 33 per cent in Uttar Pradesh than that for conventional input-intensive paddy cultivation. In Punjab, the cost of cultivation for organic farming was higher than its conventional counterpart though it was compensated to some extent by premium prices for organic paddy. In contrast, the organic paddy cultivation in Uttar Pradesh had a lower unit cost of cultivation but the lack of premium prices rendered it less attractive than conventional cultivation. In contrast, wheat cultivation is more remunerative when done organically than using conventional methods. In both Punjab and Uttar Pradesh, the net returns per acre were higher for organic farming, mainly due to the much higher output prices that organic wheat fetched in the markets.

Srikrishnasudheer (2013) compared the economics of organic farmers (N=350) and chemical farmers (N=200) for three crops, paddy, redgram, and groundnuts, in the state of Andhra Pradesh during 2010-11. It was found that organic farmers are earning a gross income of 5%, 10% and 7% more compared to the chemical farmers of paddy, redgram and groundnut, respectively, and with lower input costs, the profits earned by the organic farmers are higher by 37%, 33% and 59% for the selected crops respectively. Organic farming is generally more profitable in terms of financial costs and returns than chemical farming, irrespective of the crop or the size of farm (the exceptions being small redgram farms and large goundnut farms). An analysis of the farmers' perception of organic farming reveals that electronic media (television) is the prime motivator for farmers to adopt organic practices.

Scientific Constraints of Organic Farming

- Very high volume of organic materials required to meet the nutrient demand. [Eg. Average application of 234 kg N/ha/year for a system,

Table 9. Economics of organic management of crops in different cropping systems

Cropping System (s)	B:C ratio*	Cropping System (s)	B:C ratio*
Babycorn -Potato-Greengram	2.38	Rice -Lentil-Sesbania (GM)	0.97
Brinjal-Sunflower	1.41	Rice -Mustard-Sesbania (GM)	1.19
Cabbage-Radish-Capsicum	0.81	Rice -Pea (veg.)-Sesbania(GM)	2.16
Cauliflower-Radish-Tomato	1.42	Rice-Dolichos bean	0.94
French bean-Cauliflower-French bean	0.86	Rice-G.Nut	1.35
Ginger - Fallow	1.97	Rice-Maize	1.12
Groundnut -Sorghum	3.52	Rice-Mustard	0.75
Maize-Cotton	2.60	Rice-Pea-Sorghum F	2.99
Maize-Garlic	1.83	Rice-Potato-Radish	1.91
Maize-Mustard-Radish-G. gram	1.87	Rice-Wheat-Sesbania (GM)	1.35
Maize-Potato-Okra	1.73	Sorghum (F)-Pea-Okra	2.69
Potato-Chickpea	3.06	Soybean- Wheat	3.00
Rice – Berseem	3.46	Soybean-Berseem	1.58
Rice - Carrot	4.34	Soybean-Chickpea	2.11
Rice – French bean	3.18	Soybean-Isabgol	2.44
Rice -Mustard	1.04	Soybean-Mustard	1.94
Rice - Potato	2.06	Turmeric	1.91
Rice – potato -Okra	3.34	Turmeric+ Onion	1.26
Rice – Barley+mustard-Green gram	1.90		

* Benefit cost ratio worked out by taking 20 to 25 % premium price for organic products & it is mean of over the years and across the locations

requires either 46 t of raw FYM (0.5 % N) or 15.5 t vermicompost (1.5 % N)]. **Finding the right combination of sources are essential to meet the demand?**

- Efficiency of organic manures is higher than inorganic? Hence, **standardization of frequency and quantity of application of manures are essential to develop package of practices in a system mode.**

- Mismatch between time of nutrient release from organic materials and crop nutrient demand (Mineralization of N from VC is high in first 30 days) in most of the cases affects the yield. **Hence, split application of enriched manures for various crops and systems needs to be standardized.**
- Higher incidence of weeds under organic conditions is reported by organic growers. **There is a need to identify crop specific non-chemical weed management strategies.**
- Estimation of heavy metals and other residues are essential when the different kind of organic inputs (including municipal waste) are used. **There is need to create infrostructural facilities for estimation at selected locations.**
- Development of climate friendly smart farms and carbon farming techniques are essential to promote organic farming.
- While a great deal of research has been conducted on the impact of non-organic farming systems on the environment, there are very little data available on the positive impacts of organic farming.
- Great need for research on the human health benefits of consuming organic foods compared to non-organic food diets. The conversation needs to be expanded beyond the argument over "is organic more nutritious or not" and encompass full analysis of different agriculture and food systems, their environmental impacts, and their impacts on public health.

Constraints expressed by organic growers in Madhya Pradesh (Bhopal, Sehore and Raisen districts, total number of organic farmers surveyed: 98) are as follows:

- Lack of marketing facilities (43.7 %),
- Non availability of premium prices (39.5 %),
- Difficulty in control of weed, pest and diseases (35.4 %),
- Limited availability of organic manures (31.3 %)

Strategies

Niche crops and areas

In order to fillip to organic farming growth, niche areas and crops needs to be identified based on the unit area fertilizer and pesticide use.

rainfed and hilly areas considered to be low or no user of synthetic compounds for crop and livestock production. Hence, these areas may be dealt in the first instance. Further, based on the market requirements and suitability, location specific niche crops should be identified and promoted.

Potential zones needs to be identified on the line of "Special economic zone" and be named "Special organic farming system zone". For example, potential exists for creation of "Organic Spice" zone in Kerala, "Organic Coconut zone" in Nicobar district of Andaman and Nicobar Islands, "Organic Basmati rice zone" in Uttarakhand, Haryana and Punjab, Hi-value vegetables in selected states like Himachal Pradesh, tuber and special root crops in NEH region and seed spice zone in Rajasthan & Gujarat. These zones can also be made as Agro-eco tourism centres for attracting the eco-tourists. Tax holidays for private players who are investing in the zone should be given. The zone should be planned in such a way that all the input required for organic farming are produced with in the zone by setting up the organic manure, bio-fertilizer, bio-pesticide production units etc. Integrated organic farming system models should be developed in all the niche areas, which should serve as research-cum-demonstration unit. Cluster of villages can also be encouraged for organic farming depending upon the niche. The niche area and crops are presented in Fig 1 & Table 10.

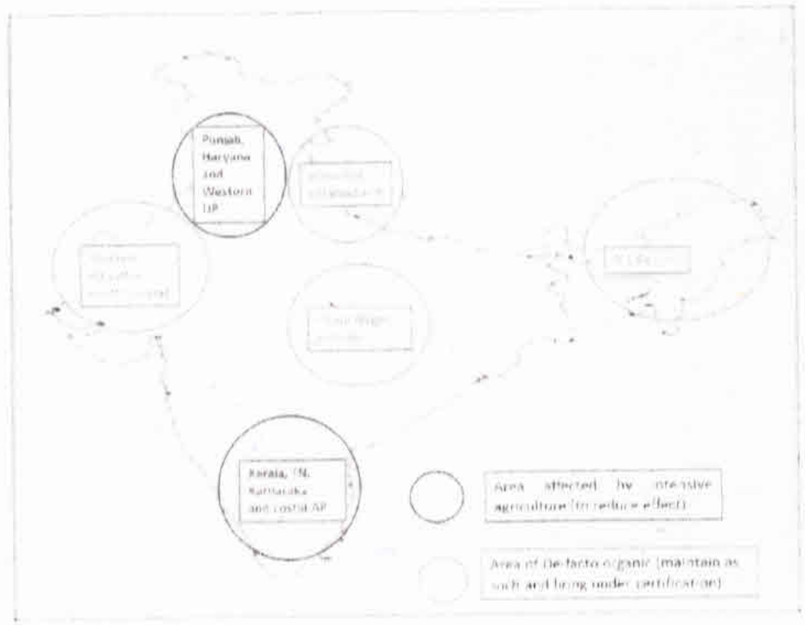


Fig 1. Intensive agriculture and de-facto organic farming areas

Towards organic approach

Organic growers generally resorts to immediate conversion of their lands/soils to organic which leads to yield loss during the initial 3 to 4 years depending upon the conditions. The yield and income loss in the initial years can be minimized by adopting "towards organic approach" means slowly increasing the organics and reducing the inorganics. Organic agriculture is always compared with conventional yields which receives 100 % recommended quantity of major nutrients. However, in the real sense, the organic agriculture yield should always be compared with the yield obtained under farmer's package of nutrient management; then only, the real issue of food security can be discussed. The large number of on-farm data available indicates, existence of nutrient application gap between farmers and recommended package with farmers package receiving 33, 37, 77 and 62 % lesser quantity of N, P_2O_5, K_2O and micro nutrient respectively for major food crops namely rice, wheat and maize. The farmers are resorting to under dose application of nutrients due to various factors such as affordability, availability and knowledge. Once, farmer resorts to application of organic manures and recycling of residues, balanced supply of nutrients to crops can be ensured. Studies indicate, in case of paddy and maize, there will not be any decrease in production due to moving towards organic farming rather the production will increase.

Research priorities

While there is a strong and growing body of scientific literature on organic agriculture in the world, further research is urgently needed to fill gaps in information. A number of long-term trials have been conducted to investigate the transition from non-organic to organic management of field crops and to study the performance of increasingly mature organic systems. The literature on organic horticultural and specialty crop production is much more limited and is greatly needed by a majority of organic growers. Though more organic research is being conducted, many questions remain open about how best to optimize organic farming systems. Some of the areas which need better attention of researchers for in depth study are given below.

- Study the Human Health Benefits of Consuming Organic Food
- Better Understanding of the Economics of Organic Farming and the Potential for Environmental Markets
- Conduct Interdisciplinary Systems Research

Table 10 Products for which Indian production has a comparative advantage.

Product	Season	States	Major Locations
Tea	Throughout the year	Assam, West Bengal, Uttranchal	Darjeeling, Guwahati, Dehradun
Spices	Throughout the year	Kerala, Tamil Nadu, Karnataka	Cochin, Coimbatore, Idduki, Coorg
Coffee	Throughout the year	Kerala, Tamil Nadu, Karnataka	Coimbatore, Coorg, Wayanadu, Peeremade
Rice	*Kharif& Rabi*	Punjab, Haryana, Assam, Maharashtra, Tamil Nadu	Amritsar, Jalandhar, Darrang, Ratnagiri, Kanchipuram, Thiruvallur
Wheat	*Kharif & Rabi*	Punjab, Haryana, Uttar Pradesh	Ambala, Patiala, Bhatinda, Faridkot
Vegetables	Throughout the year	All India	Various locations
Fruits	Throughout the year	All India	Various location
Cotton	*Kharif*	Maharashtra, Gujarat Madhya Pradesh,	Akola, Amravati, Amreli, Kheda, Indore

Source:Salvador and Katke, 2003.

- Developing Climate-Friendly Farms
- Assessing the Environmental Impacts of Organic Farming

Research priorities identified by organic farmers include safe, speedy and cost effective technologies for soil fertility restoration, weed management, biological pest and disease control and breeding for low input farming.

Extension priorities

Organic farming holds the great promise to solve some of the environmental and social problems caused by conventional agriculture. To play this role at the global level, farmers need access to essential knowledge on efficient ways, sustainable means and support structures that encourage organic practices and incentives to adopt them. Public and private support for organic farming research, extension and education lag far behind the funding, infrastructure and staff involved in conventional and biotech agriculture. While most organic agricultural research is carried out in temperate climates, the need to conduct organic agriculture research is arguably greater in the tropics, with their more dynamic and fragile ecosystems. Farmer education facilities for organic farming in terms of whole farm organic concept are almost non-existent which needs to be created in the potential areas of organic agriculture.

- **Cluster Approach:** Organic farming practices are for the farmers, by the farmers and of the farmers. All locality based scientific research should include an analysis of farmers knowledge. The organic farming practices should be implemented in farmers participatory mode right from the planting, implementation and monitoring. Further, cluster approach of demonstrating the organic farming can help to reach organized organic market.
- **Farmer education**: As a farmer-centered and grassroots movement, organic agriculture has largely relied on farmer-to-farmer networks and exchanges to disseminate information. Research has to support the linking of the farmers with the other stakeholders in the food supply chain, specifically markets for organic food in developing countries. At the same time, farmer knowledge needs to be valued as a source of experience and a base for innovation. This can be accelerated by investing in farmer education, which will also empower the rural communities.
- **Networking:** Organic agriculture research is still at a formative stage, and needs to build related human capacities. Farmer innovators and farmer organizations grouped around value chains have to build networks to commonly solve their many problems and address their specific research needs to the scientists.
- **Knowledge dissemination:** Organic farming research stands to benefit all farmers and consumers. Organic food should not be limited to affluent consumers in wealthy countries – as access to

healthy food is a fundamental human right. Organic farmers have pioneered a number of sustainable technologies, allowing researchers to fine-tune solutions that can inturn be adopted by non-organic farmers, as was the case for the use of pheromones and the introduction of beneficial fungi as antagonists to soil-borne pathogens.

Certification

Presently, third party certification promoted by Agricultural Exports Development Authority (APEDA) is in vogue especially for export purposes. Grower Group Certification (GGC) or Participatory Organic Guarantee System (PGS) is being promoted in the country by some organizations for domestic market. However, the main constraint expressed by organic growers is costly certification and complicated process of record keeping. Hence, simplified methods of self-certifications like PGS and GGCshould be adopted by government for increasing the area under organic farming.

Success story

Mr.Sundara Raman of M/s Thayalu Ammal farms lives in Sathyamangalam near Erode district in Tamil Nadu. Mr.Sundara Raman tried a few of the new options but stood out as the only 'organic farmer' in the zone. "Everyone thought I was impractical," he adds. "I tried farming with my own methodology but I knew there was a better way." By cutting his inputs and chemical costs, he kept the farm alive and profitable. He also formulated many forms of plant and microbial consortia to put into various uses as growth promoters and pest management. To address soil fertility and other natural resource concerns on the farm, Raman developed and implemented a Conservation Plan. A number of practices like micro irrigation with microbial consortia, bird perches, livestock waste management system, multiple cropping and an agro-forestry unit. Organic crops grown on Raman's farm included a variety of marketable organic grains like corn, hybrid seed corn, vegetables, redgram, turmeric and organic lime. Over the years, the Tamil Nadu Agricultural University recognized his hard efforts and offered a number of farmer to farmer collaborations. Mr.Sundara Raman took the plunge and got involved with these programmes and with those of other conservation-oriented farmers as much as he could. He worked and collaborated with other organic farmers within and from other states, sharing his own knowledge and successes as well.

References

Annual Progress Report. 2010-2013. Network Project on Organic Farming, University of Agricultural Sciences, Dharwad, Karnataka.

APEDA.2013-2014. Agricultural and Processed food product Export Development Authority, Ministry of Commerce and Industries, GOI, www.apeda.gov.in.

Bhattacharyva P and Chakraborty G. 2005.Current Status of Organic Farming in India and other Countries, *Indian Journal of* Fertilisers. **1**(9): 111-123.

GOI, 2014.Ministry of Commerce and Industries, LokSabha Question no. 2393, answered on 25th July, 2014.

Gupta A, Verma J et al. (1997). Vanishing breeds. Down to Earth, **11**(15):27-37.

Kumar Charyulu, D and Subho Biswas. 2010. Organic input production and marketing in India: Efficiency, Issues and Policies. CMA publication No. 239, Centre for Management in Agriculture, Ahmedabad p. 258.

Network project on organic farming. Consolidated report .2004-05 to 2009-10. Project Directorate for Farming Systems Research (Indian Council of Agricultural Research), Modipuram, Meerut.

Sri Krishna Sudheer.2013.Economics of organic versus chemicalfarming for three crops in Andhra Pradesh.India, *Journal of organic systems* **8**(2): 36-49.

super
Indian
He ha
Direct
Coord
(199
(Agro
Syste
Havir
Andar
Gang
Ahma
Agror
And
Exce
contri
Mana
(2009
large
(2001
scien
Patri
Best
publi
serie
Fello
Scie
cropp
India
contr
India
Res
contr
Soci
Agri
cropp
Fello
outst
Rese
"**Ger**
Asso
Indi
Pres
Soci
Chie
99).
and
Agri