

Organic farming in tropical tuber crops:

Prospects, challenges and strategies

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Organic agriculture is an alternate management strategy that focuses on sustainable and safe production, soil health, environmental protection and human health by largely excluding the use of synthetic chemicals and with maximum use of on-farm generated resources. Tropical tuber crops form the most important staple or subsidiary food to about 800 million global population. These crops are mostly grown by small and marginal farmers in rainfed areas and tribal pockets with limited chemical inputs. Moreover, they do respond well to organic manures and there is ample scope for organic production in these crops. Bio-resources permitted for use in nutrient-pest-disease management in organic farming are summarized. Organic packages developed for tropical tuber crops based on long-term on-station and on-farm experiments for over 15 years are described. Organic farming resulted in 10-20% higher yield, quality tubers, 20-40% higher profit and improvement in soil health. A conceptual framework of the strategies for organic production of tropical tuber crops and the challenges faced by the organic tuber sector are also discussed.

Key words: Conceptual framework, ICAR-CTCRI developed tuber crops, Organic farming, Tropical tuber crops

Introduction

Indian agriculture witnessed a remarkable growth in the production front due to the technological revolution termed as Green Revolution since mid 1960s, wherein high input farming practices using high yielding varieties combined with chemical fertilizers, pesticides as well as intensive irrigation could enhance the food grain production from 50.8 million tonnes in 1950s to 295.67 million tonnes during 2019-20. India rose from the level of begging bowl to the status of self sufficiency (Fig. 1). However, the consequences of high input conventional agriculture are many viz., soil erosion, salinisation, poor soil fertility, poor surface water quality, pesticide pollution,

desertification, loss of biodiversity and adverse effects on human health. Hence, there has been a growing interest to practice alternative agricultural systems that are less exploitative, less dependent on nonrenewable fossil fuels like fertilizers, pesticides etc., which can conserve natural resources and protect the environment and human health.

Among the different systems, organic farming is gaining wide attention among farmers, trainers, agricultural scientists and extension personnel for varied reasons such as it minimizes the dependence of external inputs thus not only reduces the cost of cultivation but also safeguards the quality of resources and environment.

Organic agriculture is a unique

production management system, which promotes and enhances agro eco-system health, including biodiversity, biological cycles and soil biological activity and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs.

Globally, organic agriculture could significantly reduce global agriculture emissions of greenhouse gases by 20% through reduction of mineral fertilizer production and enhanced nutrient use efficiency and 40-72% from soil C sequestration. Organic agriculture has positive impacts on Millennium Development Goals (MDG) focusing on income and food security.

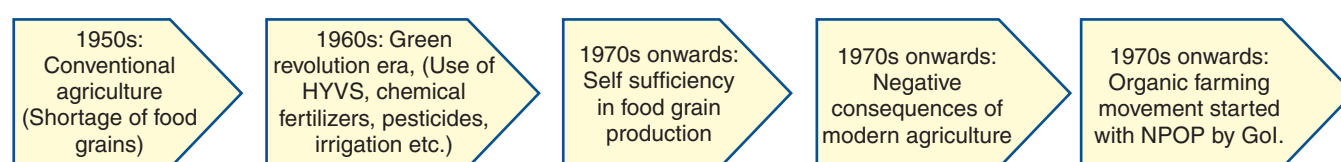


Fig. 1. Indian agriculture over the years

Status of organic farming in India

In India, a systematic and institutional framework started in May 2000 by launching the National Programme for Organic Production (NPOP) with the objective of promoting organic farming. Since then, Indian agriculture is showing rapid progress in the organic sector. National Steering Committee comprising of Ministry of Commerce, Ministry of Agriculture and Farmers Welfare, Agricultural and Processed Food Export Development Authority (APEDA), commodity boards, ICAR Institutes and various other government and private organizations associated with the organic movement is monitoring the overall organic activities. APEDA is the coordinating agency for organic production and export under the brand name "India Organic". India's rank in the World Organic Agricultural land was 8th as per 2018 data reported in FIBL & IFOAM Year Book (2020). The total area under organic certification in India is 3.67 million ha during 2019-20, which includes 2.30 million ha under cultivable area and 1.37 million ha under wild harvest collection area. According to APEDA, India produced about 2.75 million tonnes of certified organic products during 2019-20, which includes all varieties of food products namely sugarcane, oilseeds, cereals and millets, cotton, pulses, medicinal plants, tea, fruits, spices, dry fruits, vegetables, coffee etc. Among all the States, Madhya Pradesh has covered the largest area under organic certification followed by Rajasthan, Maharashtra and Uttar Pradesh. Organic products are exported to USA, European Union, Canada, Switzerland, Australia, Japan, Israel, UAE, New Zealand, Vietnam, etc. Soya meal (45.87 %) lead among the organic products exported followed by oilseeds (13.25%), tea and coffee (9.61%), cereals and millets (8.19%), spices and condiments (5.20 %), dry fruits (4.98%) and others.

Importance of organic farming in tropical tuber crops

Tropical tuber crops *viz.*, cassava, yams (greater yam, white yam and

lesser yam), sweet potato and aroids like elephant foot yam, taro and tannia form the most important staple or subsidiary food to about 800 million global population. Tuber crops are the third most important food crop of man after cereals and grain legumes. These crops possess high photosynthetic ability, capacity to yield under poor and marginal soils and tolerate adverse weather conditions. They are also recognized as the most efficient in converting solar energy, cassava producing 250×10^3 kcal ha⁻¹ and sweet potato 240×10^3 kcal ha⁻¹, as compared to 176×10^3 kcal ha⁻¹ for rice, 110×10^3 kcal ha⁻¹ for wheat and 200×10^3 kcal ha⁻¹ for maize; hence the tropical root crops are known to supply cheap source of energy. Besides they have potential as sources of alcohol, starch, sago, liquid glucose, vitamin C and as raw materials for many other industrial products and animal feed. In times of famine, tuber crops have come in handy to overcome catastrophes and provide relief from hunger.

Tuber crops are cultivated in India mainly as rainfed in the southern, eastern and north-eastern States. Cassava production is mainly from Kerala, Tamil Nadu, Andhra Pradesh and Northeast Hilly regions. Sweet potato is cultivated mainly in Odisha, Bihar, Jharkhand, Eastern Uttar Pradesh, West Bengal, Madhya Pradesh, Maharashtra and Karnataka. Other tuber crops like yams (greater yam, white yam and lesser yam) and aroids (elephant foot yam, taro and tannia), popular as vegetables, are not yet commercially cultivated, being confined only to the home gardens in almost all the States except elephant foot yam, which is cultivated on a commercial scale in Andhra Pradesh, Tamil Nadu and Bihar.

Tuber crops in general and aroids in particular, like elephant foot yam, do respond well to organic manures and there is considerable scope for organic production in these crops. Further, tropical tuber crops are well adapted to low input agriculture. They are less prone to pest and disease infestations. Moreover presently there is a great demand for organically produced ethnic

vegetables, particularly aroids and yams, among affluent Asians and Africans living in developed nations (Europe, United States of America and Middle East).

Organic farming practices in tropical tuber crops

Along with the organic farming practices, the best management practices to be followed in tuber crops are summarized below:

a. Best agronomic practices

The following best agronomic practices are adopted for getting sustainable yield and good quality produce:

- Intercropping of tuber crops with perennials and annual crops *viz.*, coconut + cassava/elephant foot yam/yams/arrowroot/tannia/taro/sweet potato/Chinese potato; arecanut + cassava/elephant foot yam/sweet potato/taro/arrowroot; rubber+elephant foot yam/greater yam/white yam/cassava; coffee+elephant foot yam; mango+cassava; sapota+elephant foot yam; banana+elephant foot yam/greater yam/white yam and maize+greater yam in major tuber crops grown in Kerala, Tamil Nadu, Andhra Pradesh, Odisha and Northeastern States.
- Sequential cropping with rice-pulse (black gram/green gram)-short duration cassava (*viz.*, Sree Vijaya, Vellayani Hraswa); rice-short-duration cassava+pulse (black gram).
- Intercropping elephant foot yam, taro and dwarf white yam with pulses to maintain the soil fertility.
- Maintaining field sanitation.
- Use of resistant and tolerant varieties (Cassava mosaic disease-resistant varieties *viz.*, Sree Reksha, Sree Sakthi and Sree Suvarna; Sweet potato variety as trap crop for root knot nematode-Sree Bhadra; Taro leaf blight resistant variety-Muktakeshi; Greater yam anthracnose disease resistant/tolerant varieties-Sree Keerthi, Sree Swathy/Sree Nidhi, Sree Karthika).
- Use of disease free planting materials of tuber crops by strictly following the seed quality

guidelines.

- Minisett technique for rapid multiplication of quality planting materials in cassava, elephant foot yam, greater yam and white yam.
- Adjustment in planting time, depth of planting, plant spacing etc.
- Use of locally available mulching materials like crop residues etc. for moisture conservation, soil temperature regulation and to minimize weed growth.

b. Nutrient management

The important principle of organic farming says that 'soil is the source of life', so we have to feed the soil not the plant. The following practices are recommended for nutrient management and organic inputs which are permitted are given in Table 1.

- Use of organic manures like farmyard manure, crop residues, vermicompost, poultry manure and coir pith compost improves the physical, chemical and biological properties of the soil.
- Liquid organic manures viz., *Jeevamrutham*, *Beejamrutham*, *Panchagavya*, Bio-digester slurry, vermi-wash, *Dasagavya*, cow urine, fish jaggery extract, egg lemon jaggery extract and activated EM solution.
- Use of oil cakes like neem, groundnut, *Pongamia* and castor increases soil fertility.
- Raising green manure crops like cowpea, sunhemp, *Sesbania* or daincha and incorporating into the soil at 50% flowering stage (45-60 days after sowing), besides using green leaf manures like *Gliricidia*, *Leucaena leucocephala* or biomass of other plant species helps in increasing the nutrient content of the soil.
- Use of bio-fertilizers like *Azospirillum*, Phosphobacteria and K solubilizers for increasing the nutrient use efficiency.

c. Pest and disease management

Organic inputs used for pest and disease management are given in Table 2.

- Use of different methods such as clean cultivation, adopting good

Table 1. Organic inputs permitted for nutrient management as per NPOP document

<i>On-farm resources permitted</i> • FYM, poultry manure, slurry, urine, crop residues, green manures, straw and other mulches <i>Off-farm resources of restricted use</i> • Blood meal, meat meal, bone meal, feather meal, compost made from any carbon based residues, FYM, slurry, urine, fish and fish products without preservatives <i>Permitted By-products from food and textile industries without synthetic additives</i> • Sea-weed and sea-weed products, sewage sludge and urban compost, vermicast, animal charcoal, compost and spent mushroom, compost from organic household waste substances, by-products from oil palm, coconut and cocoa, by-products of industries, processing ingredients from organic aquaculture	<i>Minerals permitted</i> • Calcified sea-weed, calcium chloride, limestone, gypsum, chalk and phosphate chalk, magnesium sulphate, sodium chloride, clay (Bentonite, Perlite, Zeolite) <i>Permitted off-farm products</i> • Peat without synthetic additives, sawdust and wood-shaving from untreated wood, compost from plant residues, wood ash from untreated wood, potassium sulphate <i>Other products permitted</i> • Bacterial preparation (Bio-fertilizers), bio-dynamic preparations, plant-based preparations and botanical extracts, vermiculite, peat <i>Minerals restricted</i> • Calcium and magnesium rock, mineral potassium with low chlorine content, natural phosphate (Rock phosphate)
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water management practices and application of neem cake, vermicompost etc. helps in preventing the pests and disease incidence.

- Collection and destruction of life stages of pests, infested old leaves and plants prevents the pests and diseases infestation to other plants.
- Biological control of diseases with the help of *Trichoderma viride*, *T. asperellum*, *Pseudomonas fluorescens* etc. reduces the pesticide residues in the produce and soil.
- Use of botanical pesticides like Neem seed kernel extract (3%), neem and other plant based extracts help in controlling various diseases of tuber crops.

Organic farming packages by ICAR-CTCRI

Organic farming experiments (Fig. 2) were conducted at the ICAR-CTCRI, Thiruvananthapuram, for more than one and a half-decade (2004-2021) to compare organic vs conventional farming in cassava, elephant foot yam, taro, yams, Chinese potato and arrowroot in an acid Ultisol (pH: 4.3-5.0). The on-station developed organic farming technologies for cassava, elephant foot yam, yams and taro were on-farm validated. Varietal response, tuber yield, economics, tuber quality, soil physico-chemical and biological properties were evaluated.

Organic farming resulted in 10-20% higher yield in elephant foot

Table 2. Organic inputs for pest and disease management

<i>Permitted products</i> • Chromatic traps, clay (Bentonite, perlite, vermiculite and zeolite), gelatin, mechanical traps, light traps, sticky traps, plant-based extracts (neem, custard apple, <i>Clerodendron infortunatum</i>, <i>Hyptis suaveolans</i>, <i>Andrographis paniculata</i>, <i>Chromolaena odorata</i>, Tulsi, <i>Lantana camara</i>, garlic, pongamia etc.), pheromones, herbal and bio-dynamic preparations, plant-based repellents, Bordeaux mixture, Bordeaux paste	<i>Bio-control agents permitted</i> • Viral preparations (Baculoviruses), fungal preparations (AMF, <i>Trichoderma viride</i>, <i>Trichoderma asperellum</i>, <i>Beauveria bassiana</i>, <i>B. brongniartii</i>, <i>Metarhizium anisopliae</i>, <i>Verticillium lecanii</i>), bacterial preparations (<i>Pseudomonas fluorescens</i>, <i>Bacillus thuringiensis</i>, <i>Bacillus sphaericus</i>, <i>Bacillus popilliae</i>, <i>Clostridium brevifaciens</i>, PGPR mix II), parasites, predators & sterile insects <i>ICAR-CTCRI developed bio-pesticides</i> • <i>Nanma</i> (aphids and thrips in vegetables, pseudostem weevil, leaf feeding caterpillars and rhizome weevil in banana), <i>Menma</i> (pseudostem weevil in banana), <i>Shreya</i> (mealy bugs in chilli, cowpea, tomato, bitter gourd, brinjal, cassava and elephant foot yam)
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Fig. 2. Organic farming experiments in tropical tuber crops by ICAR-CTCRI

yam, white yam, greater yam, lesser yam, dwarf white yam and Chinese potato (Fig. 3) i.e., 20, 9, 11, 7, 9 and 10.5% respectively (Table 3). Cost-benefit analysis indicated that the net profit under organic farming was 20-40% higher than chemical farming. In general, the tuber quality was improved in these crops under organic management with higher dry matter, starch, crude protein, K, Ca and Mg contents. The anti-nutritional factors, oxalate content in elephant foot yam and cyanogenic glucoside content in cassava were lowered by 21 and 19.6% respectively under organic farming (Table 4). Soil quality was improved due to significant improvement in water holding capacity, pH and soil organic matter.

Use of organically produced seed materials, seed treatment in cow-dung, neem cake, bio-inoculant slurry, farmyard manure incubated with bio-inoculants, green manuring, use of neem cake, bio-fertilizers and

ash formed the essential components of organic tuber production (Fig. 4).

The organic farming package for

elephant foot yam was included in the Package of Practices Recommendations for crops by Kerala Agricultural University (2011) and for yams and taro included in POP Crops of Kerala Agricultural University (2016). Technologies for organic production of tuber crops is given in Table 6.

Challenges and strategies for organic farming in tropical tuber crops

It is a well known fact that the organic farming culture in our country is experiencing a transition regime and yet to be evolved as an organized practice, especially in the case of tuber crops. While proposing a shift to organic farming, it is imperative to recommend a comprehensive package. Therefore, an attempt has been made to devise the conceptual framework (Table 5) on strategies for organic farming in tropical tuber crops involving different components for large scale adoption and attaining sustainability in the long run. Important aspects which are to be followed in organic farming of tropical tuber crops are given below:

Building up of soil fertility:

Before the establishment of an organic management system, the fertility status of the land must be improved by growing green manure

Table 3. Yield of tuber crops under organic farming vs conventional farming

Name of the crop	Yield under conventional farming (t ha ⁻¹)	Yield under organic farming (t ha ⁻¹)	% yield increase/decrease under organic farming
Cassava	26.62	27.26	2.40
Elephant foot yam	47.61	57.10	19.93
White yam	20.31	22.21	9.35
Greater yam	19.87	21.96	10.51
Lesser yam	15.75	16.83	6.85
Dwarf white yam	12.18	13.23	8.62
Taro	11.12	10.61	-4.58
Chinese potato	12.61	13.94	10.50
Arrowroot	13.05	12.81	-1.84

Table 4. Biochemical parameters of tuber crops under organic farming in comparison to conventional farming (% increase/decrease)

Name of the crop	Dry matter	Starch	Crude protein	Oxalate*	HCN*	Total sugars
Cassava	2.72	8.60	7.72	-	-19.60	54.62
Elephant foot yam	7.42	12.67	12.09	-20.51	-	-16.86
Yams	7.02	-1.12	6.08	-	-	-25.39
Taro	7.29	10.78	-	-	-	31.55
Chinese potato	37.83	43.10	32.61	-	-	-1.69
Arrowroot	4.14	3.60	-7.29	-	-	-35.71

*-Antinutritional elements



Fig. 3. Organically produced tubers by ICAR-CTCRI

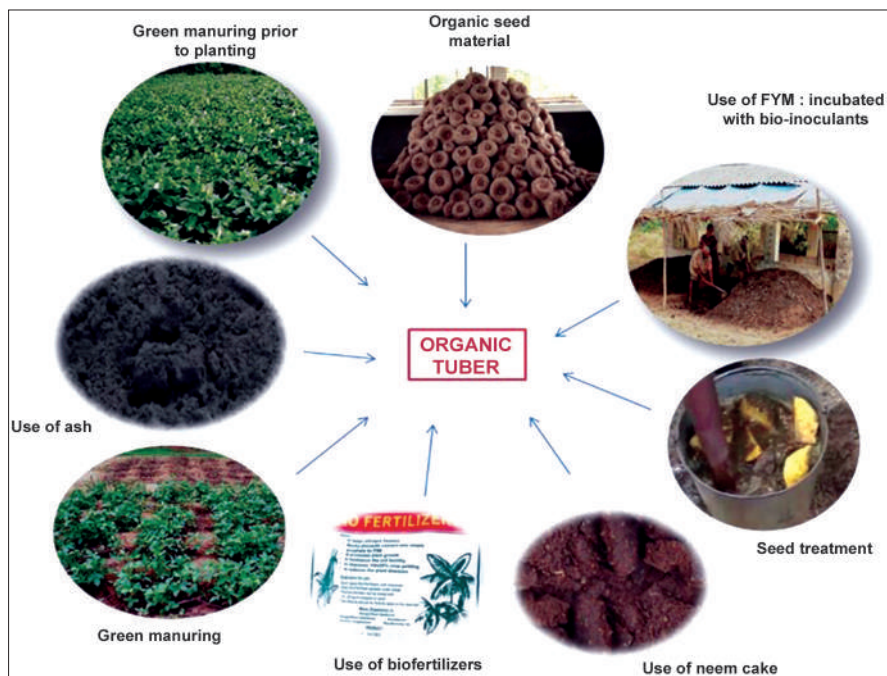


Fig. 4. Essential components of organic tuber production

crops twice or thrice during a year and incorporation the green leaf matter at the appropriate pre-flowering stage. This will help to re-

establish the balance of the ecosystem and offset the yield decline, if any, during the initial period of organic conversion.

Quality planting materials: Varieties cultivated should be adapted to the soil and climatic conditions with local market demand and as far as possible resistant to pests and diseases. The planting materials should be produced by adopting organic management practices.

Nutrient management: Harnessing the easily available organic sources of plant nutrients judiciously to meet the nutrient needs which will definitely help to maintain/promote productivity in organic farming. The potential organic sources are farmyard manure, poultry manure, vermicompost, coir pith compost, mushroom spent compost, sawdust compost, press mud compost, green manures, crop residues, ash, neem cake, etc.

Weed management: Since most of the tuber crops (except sweet potato) take about 75-90 days for sufficient canopy coverage, raising a short duration intercrop (like green manure/ vegetable/grain cowpea, vegetables, groundnut etc in cassava, cowpea in yams and aroids) can also help to a great extent to reduce weed problem. Mulching the crop using any locally available plant materials (green leaves, dried leaves, etc.) immediately after planting (in yams and aroids) will help to conserve moisture and regulate temperature, apart from weed control.

Pest and disease management: Few pests and diseases like cassava mosaic disease (CMD), cassava tuber rot, sweet potato weevil (SPW), taro leaf blight (TLB), collar rot in elephant foot yam are causing economic loss. Use of tolerant/ resistant varieties, use of healthy and disease-free planting materials, strict field sanitation, deep ploughing (eg. tuber rot), roguing the field (eg. CMD), use of pheromone traps (eg. SPW), use of trap crops (eg. SPW, root knot nematodes), crop rotation, use of neem cake (collar rot, tuber rot), use of bio-control agents like *Trichoderma*, *Pseudomonas* (collar rot, leaf blight) etc. are the efficient management practices.

Table 5. Strategy for Organic Farming in Tropical Tuber Crops: A Conceptual Framework

Process	Practices/Inputs	Challenges	Promotional Programmes
1. Agronomic/Cultural practices			
1. Documentation	• Summer ploughing	• Educating / Motivating the farmers	• Success stories
2. Validation	• Timely planting	• Reinforcement of the practices for enhancing the adoption of technologies	• Mass media (AIR, TV, Social Media)
3. Technology Integration	• Mulching		• Exposure Visit
	• Crop rotation		• Seminars
	• Intercropping/Border crops		• Focus Group Discussion
	• Cropping system involving legumes		• Recognitions / Awards
	• Field sanitation		
	• Crop geometry / Spacing		
2. Farm level organic inputs			
1. Identification of inputs	• Green manure / Leguminous crops	• Availability	• Training programmes
2. Standardizing the protocols for preparing various farm level inputs and their use	• Green leaf manure	• Bulky in nature	• Demonstrations
	• Crop residues	• Labour involvement	• Model plots
	• Oil cakes	• Transportation cost	• Success stories / Case studies
3. Experimenting / Testing through OFTs / FLDs	• Farmyard manure	• Packing and labelling	• Recognitions / Awards
	• Composts (Different types)	• Certification and marketing	
4. Refinement of the protocols for preparation of inputs and their use	• <i>Jeevamrutham</i>	• Consumer acceptance	Reaching the Unreached
	• <i>Panchagavya</i>	• Organic seed production	• Farmers club, Cooperative society, Eco shops, VFPC / HORTI
	• Cow urine	• Creation of demand for organic products	CROP, Department of Agriculture, KVKs, NGOs, Nurseries / Seed entrepreneurs
5. Technology Integration	• Botanicals (Neem, Calotropis etc.)	• Remunerative price	
3. External Inputs (Research Institutes/NGOs/ Pvt.)			
1. Identification of problems	• Varieties for organic farming	• Availability	• Training programmes
2. Systematic on-station research for generating technologies	• Biofertilizers / PGPRs	• Affordability	• Supply of critical inputs
	• Biopesticides	• Quality	• Demonstrations
3. Assessment through OFTs/ FLDs	• Biocontrol agents	• Medium shelf life	• Model plots
	• Liquid organic manures	• Packing and labelling	• Success stories / Case studies
4. Refinement of technologies	• Enriched organic manure (Cocopeat, vermicompost etc.)	• Certification and marketing	• Recognitions / Awards
5. Technology Integration	• Neem cake	• Consumer acceptance	Reaching the Unreached
			• ICAR, KVKs, SAUs, Department of Agriculture, NGOs, VFPC, Eco shops, Cooperative societies, Farmers club, Amazon and Flipkart
4. Package for organic farming			
1. Amalgamation of all the above processes	• Package of practices	• Inclusion of POP in state government package of practices for large scale adoption	1. Amalgamation of all the above programmes and activities
		• Scaling up	Policy framework
			• AI-NPOF
			• State/National policies
			• Regulatory framework
			• Certification & marketing of organic produce

GOALS: 1. Enhancing productivity and profitability 2. Sustaining the Natural Resources 3. Doubling Farmers Income

Table 6. Technologies for organic production of tuber crops

Crop	Organic farming practices
Cassava	FYM @ 12.5 t ha ⁻¹ , <i>in situ</i> green manuring (green matter @ 15-20 t ha ⁻¹), crop residue incorporation (generates dry biomass @ 3 t ha ⁻¹), <i>Azospirillum</i> @ 3 kg ha ⁻¹ , phosphobacteria @ 3 kg ha ⁻¹ and K solubilizer @ 3 kg ha ⁻¹ . Use of disease-free healthy planting materials and cultivation of cassava mosaic disease (CMD) resistant varieties viz., Sree Reksha, Sree Sakthi and Sree Suvarna will help to manage cassava mosaic disease.
Elephant foot yam	Seed treatment of corm pieces of 500-750 g with slurry containing cow-dung, neem cake and <i>Trichoderma harzianum</i> (5 g per kg of seed) and dry under shade before planting. Application of FYM @ 36 t ha ⁻¹ (FYM: neem cake mixture (10:1 ratio) incubated with <i>Trichoderma harzianum</i>), <i>in situ</i> green manuring with cowpea (green matter @ 20-25 t ha ⁻¹), neem cake @ 1 t ha ⁻¹ , ash @ 3 t ha ⁻¹ . Seed treatment with <i>Trichoderma</i> as above, incubation of FYM with <i>Trichoderma</i> as above and application of <i>Trichoderma</i> enriched vermicompost @ 150 g per plant after weeding and interculturing.
Taro	FYM @ 15 t ha ⁻¹ , <i>in situ</i> green manuring with cowpea (green matter @ 15-20 t ha ⁻¹), neem cake @ 1 t ha ⁻¹ , ash @ 2 t ha ⁻¹ , <i>Azospirillum</i> @ 3 kg ha ⁻¹ , mycorrhiza @ 5 kg ha ⁻¹ and phosphobacteria @ 3 kg ha ⁻¹ . Use of healthy planting material of taro leaf blight resistant variety 'Muktakeshi', mulching using paddy straw or crop residue, seed treatment in cowdung slurry enriched with <i>Trichoderma asperellum</i> (5 g per kg of seed), application of vermi compost

Contd.

Table 6. (Concluded)

Crop	Organic farming practices
	100 g per plant for the management of leaf blight disease in taro. As a prophylactic measure against taro leaf blight, spray vermin wash @ 100 ml per litre of water and repeat at fortnightly intervals, especially during the rainy season (or) Akomin @ 3 ml per litre from one month after planting at fortnightly intervals up to 4 months to manage taro leaf blight.
Tannia	FYM @ 20 t ha ⁻¹ , <i>in situ</i> green manuring with cowpea (green matter @ 15-20 t ha ⁻¹), neem cake @ 1 t ha ⁻¹ , ash @ 2 t ha ⁻¹
Yams (Trailing)	FYM @ 15 t ha ⁻¹ , <i>in situ</i> green manuring (green matter @ 15-20 t ha ⁻¹), neem cake @ 1 t ha ⁻¹ , ash @ 1.5 t ha ⁻¹ , <i>Azospirillum</i> @ 3 kg ha ⁻¹ , mycorrhiza @ 5 kg ha ⁻¹ and phosphobacteria @ 3 kg ha ⁻¹ . Use of disease-free planting materials, seed treatment with 5 g of <i>Trichoderma asperellum</i> per kg of tuber in fresh cow dung slurry for managing anthracnose disease.
Dwarf white yam	FYM @ 15 t ha ⁻¹ , <i>in situ</i> green manuring with cowpea (green matter @ 15-20 t ha ⁻¹), neem cake @ 1 t ha ⁻¹ , ash @ 1.5 t ha ⁻¹ , <i>Azospirillum</i> @ 3 kg ha ⁻¹ and mycorrhiza @ 5 kg ha ⁻¹
Chinese potato	FYM @ 10 t ha ⁻¹ , green manure @ 15-20 t ha ⁻¹ , neem cake @ 1 t ha ⁻¹ , biofertilizers (<i>Azospirillum</i> , P solubilizer and K solubilizer @ 3 kg ha ⁻¹ each)
Arrowroot	FYM @ 10 t ha ⁻¹ , green manure @ 10-15 t ha ⁻¹ , biofertilizers (<i>Azospirillum</i> , P solubilizer, and K solubilizer @ 3 kg ha ⁻¹ each)

SUMMARY

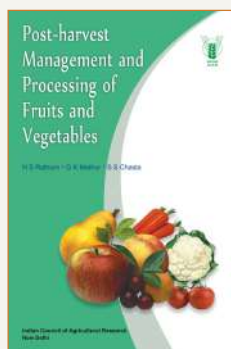
In order to attain sustainable food-cum-livelihood-cum environmental security in India, we may require an array of alternatives to chemical-intensive agriculture. It has been conclusively proved in tuber crops that organic management is an alternative viable option for sustainable and safe food production with less soil degradation and environmental pollution. Generation of sufficient biomass, addition of crop residues, green manuring, farm

waste recycling, fortification of manures through proper composting, adoption of crop rotations involving legumes, establishment of biogas plants and development of agroforestry for an alternate source of fuels are some of the strategies that will help to promote organic farming of tuber crops. Organic farming practices are suitable for small and marginal farmers especially for their livelihood security and to free them from the debt trap. Sustained efforts from research institutes,

developmental organizations, progressive farmers, input dealers, processors and other stakeholders are warranted for better adoption of organic farming in tuber crops in the long run.

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Post-harvest Management and Processing of Fruits and Vegetables



Post-harvest management technology offers promising option for increasing production of vegetables and fruits quantity-wise and also in maintaining quality of the products. It involves all the activities that occur after production or harvesting of commodities, including procurement, removal of field heat, sorting, grading, packaging, storage, transportation, primary and secondary processing and marketing of agricultural products from farm-gate to distributors. This book is an effort to document vast available knowledge on the various aspects of post-harvest management and processing, and it will prove worthy for teachers, students and extension workers for understanding post-harvest management and processing of fruits and vegetables. It has 16 chapters covering storage, packaging, advanced preservation technology and value-addition of fruits and vegetables.

TECHNICAL SPECIFICATIONS

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