# Entrepreneurship Development Program on

# *Agriculture Technologies*

## 01-06 March, 2021


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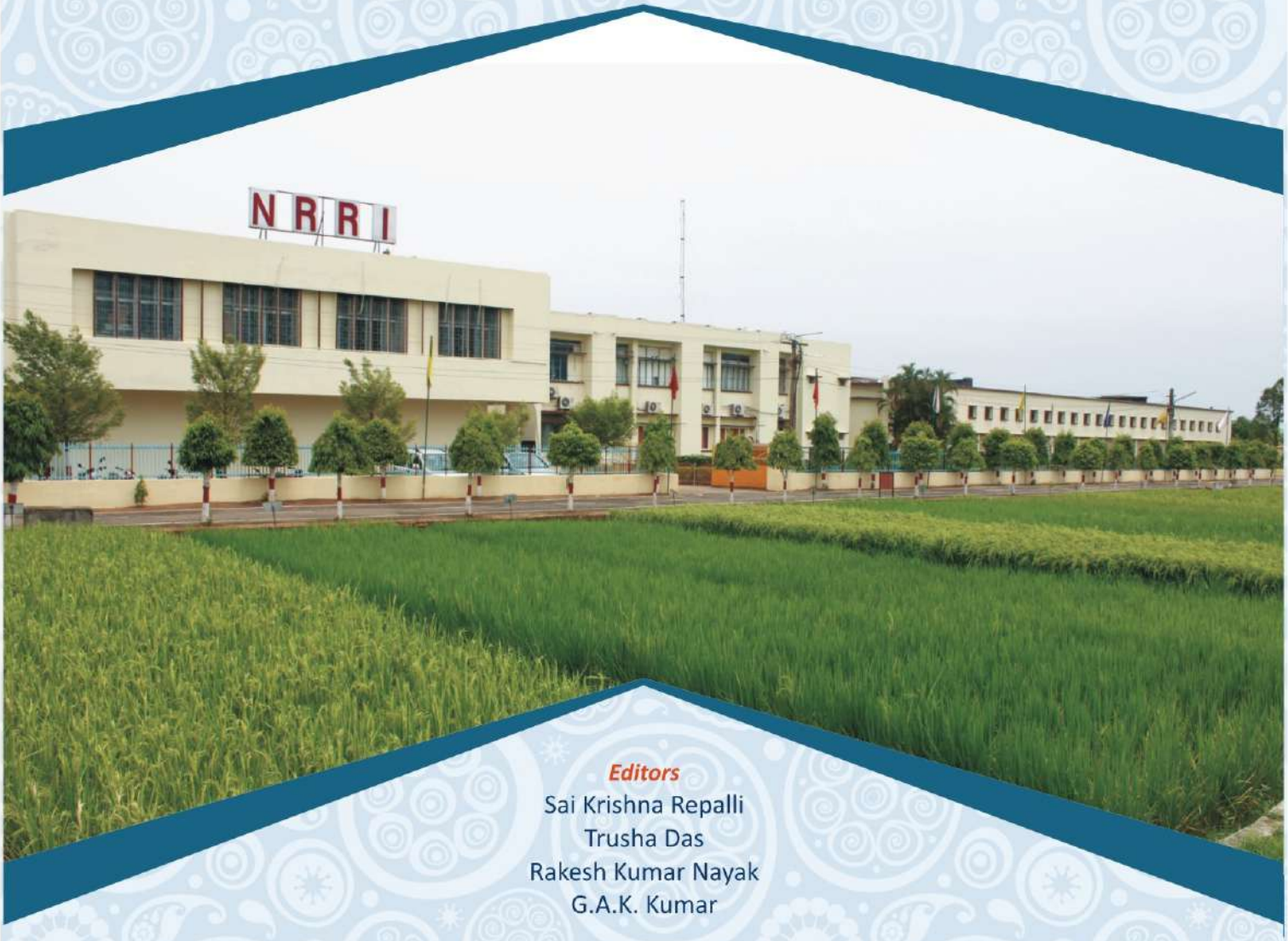
*Organized by:* Agribusiness Incubation (ABI) Centre
ICAR-National Rice Research Institute, Cuttack - 753006, Odisha

# Compendium on

# *Agriculture Technologies*

## 01-06 March, 2021

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भाकृअनुप-राष्ट्रीय चावल अनुसंधान संस्थान, कटक-७५३००६, ओड़िशा

## PREFACE

The Agribusiness Incubation Centre (ABI) at ICAR-National Rice Research Institute (NRRI), Cuttack is working with an objective to create an environment to foster farmers into agripreneurs, thereby improving their livelihoods and making their farming remunerative. Agrepreneurship development is the need of the day and it has potential to contribute to income enhancement and employment generation.

This online Course-Entrepreneurship Development Program on Agriculture Technologies has been designed for the budding entrepreneurs to improve their knowledge in various Agriculture Technologies.

This training program emphasizes on the potential areas of agriculture including Apiculture, Floriculture, Horticulture, Vermiculture, Tuber crops and biocontrol agents. These sectors have wide entrepreneurship opportunities. Agro-based industries provide an excellent opportunity to the farmers for local entrepreneurship and employment generation.

Beekeeping/apiculture is one of the best examples for building entrepreneurship by employment creation, resources utilization, and income generation.

Floriculture often termed as blossoming industry or sunrise industry offers good scope and career opportunities for the entrepreneurs. One can make career in commercial production of ornamental flowers, nursery development and landscape development.

Horticulture is yet another agro-based industry dealing with cultivation of fruits, vegetables and spices Horticulture seeks to create ample opportunities for employment, particularly for unemployed youth and women folk.

With the growing awareness for organic farming practices, there is an increasing demand for vermiculture. In addition to income generation, this entrepreneurship will also help in improving crop productivity of the region by increasing soil fertility through ecological methods of farming. This will not only result in productive waste management but also encourage organic farming which has growing demand for organic fertilizers. According to an estimate from each unit an entrepreneur with an investment of around Rs.3500 can earn a net profit of Rs.12000 annually.

Root and tuber crops are the third important food crops after cereals and grain legumes, and constitute either staple or subsidiary food for about $1/5^{th}$ of world population. Tuber crops

offers good scope for income generation, livelihood and nutritional security. They provide higher minerals and vitamins. Besides contributing to food and nutritional security, tuber crops also create employment and entrepreneurial opportunities with value addition.

Biointensive Integrated Pest Management(BIPM) is an effective way of managing pests and beneficial organisms in an ecological context. The flexibility and environmental compatibility of a BIPM strategy makes it useful in all types of cropping systems. Application of different biocontrol agents for pest management and the entrepreneurial opportunities involved will be dealt in this program.

This course comprises of interaction with scientists, professors, entrepreneurs, discussions and information/idea exchange with participants for the benefit of prospective entrepreneurs. This compendium comprises of the lecture notes given by eminent scientists and professors in the relevant fields. We had organized this course material for participant's future needs and reference. Contact details of all the participants and faculty members are furnished.

(G.A.K. Kumar)

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# Contents

# Apiculture and entrepreneurial opportunities involved

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## Practice of bee keeping

- Honey bees are the best known, most useful, social and most studied insects. They produce the precious natural product called Honey.
- Honey hunting is an age old practice documented and known from time immemorial.
- Use of honey is known to mankind since Vedic times.
- Honey is used as one of the important constituent of Panchamrut, thus associated with our cultural heritage.
- Bee keeping is a century old practice.
- Scientific bee keeping in India is a practice of only a few decades old.
- At present it has been evolved as an excellent enterprise for rural poor, rich commercial bee keepers and a constituent part of our integrated farming system.

## Importance of honey bees and bee keeping

- After independence bee keeping was taken as an avocation in small scale cottage industry providing income and employment to rural poor.
- Bee keeping was meant for production of honey and other hive products but importance of Bees as pollinators was hardly realized.

## What is bee keeping?

Bee keeping is an art and science of collecting / procuring colonies of desired honey bee species, hiving them in standard and specified bee boxes, installing in appropriate sites, managing optimum number of colonies scientifically round the year and harnessing both direct and indirect benefit of the activities

## Direct benefits of the activity

1. **The prime hive products**
   - Honey
2. **Other useful products**
   - Bee wax
   - Propolis
   - Pollen
   - Royal jelly

- Bee venom

**Honey:** Honey is the most important primary product of beekeeping both from a quantitative and an economic point of view. It was also the first bee product used by human kind in ancient times. The history of the use of honey is parallel to the history of man and in virtually every culture evidence can be found of its use as a food source and as a symbol employed in religious, magic and therapeutic ceremonies.

**Composition of honey**

| Constituent | % |
|---|---|
| Total dissolved solids | 70-80 |
| Sugars: Fructose<br>Glucose<br>Sucrose<br>Other higher sugars | 38<br>37<br>02<br>0.5 |
| Water | 20 |
| Minerals(Potassium, Calcium, Magnesium, Iron, Copper, Manganese, Phosphorus, Sulphur, Chlorine, and traces of Chromium, Nickel, Tin, Silver, Gold etc.) | 0.5 |
| Acids | 0.2 |
| Proteins and Amino Acids | 0.25 |
| Enzymes and Vitamins | Traces |

**Honey**

- Honey provides instant energy.
- Honey is used as carrier of Ayurvedic medicines.
- It is used to cure a host of ailments like cold, fever, piles, anemia and infections in the throat, skin, eye and intestine.
- Honey is used as ingredient in many commercial products

**Beewax**

- Bee wax occupies a very special position among waxes.
- It is secreted by young honey bees from their 8 wax glands located on the underside of the abdomen.
- Bee wax has extremely wide spectrum of useful applications
- **Uses:** Church candles, shoe polish, carbon paper, crayon colour pencil, metal castings and moldings, for polishing optical lens, in candy and chewing gums, cosmetics, for musical instruments etc.(Rs.70-120/kg).

**Propolis**

- Propolis is a mixture of various amounts of bees wax and resins collected by the honeybee from plants, particularly from flowers and leaf buds. Since it is difficult to observe bees on their foraging trips the exact sources of the resins are usually not known.
- *Apis mellifera* is a good PROPOLISER and produces Propolis

**Royal jelly**

- Royal jelly is secreted by the hypo pharyngeal gland of young worker (nurse) bees, to feed young larvae and the adult queen bee. Royal jelly is always fed directly to the queen or the larvae as it is secreted; it is not stored

  ***Uses:*** Premature babies, old age related problems, psychiatry, chronic tuberculosis, used in cosmetics, in dermatological preparations and creams/ointments (50-80 US $/kg).

**Composition of royal jelly**

| Constituent | Minimum | Maximum |
|---|---|---|
| Water | 57% | 70% |
| Proteins | 17% of dry weight | 45% of dry weight |
| Sugar | 18% of dry weight | 52% of dry weight |
| Lipid | 3.5% of dry weight | 19% of dry weight |
| Minerals | 2% of dry weight | 3% of dry weight |

**Pollen**

- The pollen collected by honeybees is usually mixed with nectar or regurgitated honey in order to make it stick together and adhere to their hind legs. The resulting pollen pellets harvested from a bee colony are therefore usually sweet in taste.
- The partially fermented pollen mixture stored in the honeybee combs, also referred to as "beebread" has a different composition and nutritional value than the field collected pollen pellets and is the food given to honeybee larvae and eaten by young worker bees to produce royal jelly. It is said, pollen is the perfect food because it is the only food source for honeybees other than honey.

**Bee venom**

- Honeybee venom is produced by two glands associated with the sting apparatus of worker bees. Its production increases during the first two weeks of the adult worker's life and reaches a maximum when the worker bee becomes involved in hive defense and foraging.
- It diminishes as the bee gets older.

- Application methods for venom include natural bee stings, subcutaneous injections, electrophoresis, ointments, inhalations and tablets. Used against Rheumatoid Arthritis, Nervous disorders (Cost - Rs.4700-9400 per gram).
- The median lethal dose (LD50) for an adult human is 2.8 mg of venom per kg of body weight.

**Indirect benefits of the activity**

**Honeybees as pollinators**

- About 60-70% agricultural /horticultural crops depend upon honeybees for cross pollination.
- In oil seed crops 3 - 5 bee colonies/ha can enhance the yield by 33.0 - 69.0%.
- Honey bees enhances 11 – 79% yield in different crops through pollination.
- Value of additional yield obtained due to bee pollination alone is 15-20 times more than the value of all the hive products put together (Kaloo).
- Honey bees alone accounts for 80% of pollination service done by the insects.
- Bees have specialized adoption for pollination.

| **Increase in production due to bee pollination** | |
|---|---|
| Mustard | 10.6% |
| Sesamum | 25.0% |
| Niger | 33.0% |
| Safflower | 64.0% |
| Sunflower | 79.0% |
| **Fruit Yield** | |
| Litchi | 5.3 times |

**Scope of beekeeping in India**

India being one of the leading mega biodiversity countries have all the four important Honey bee species and750 species of bee flora

- Further, introduction of *Apis mellifera* has revolutionized the status of scientific bee keeping in the country
- Cropped area – 160 million ha.
- Crop needing pollination service- 55 million ha.
- Besides, forest, pastures, wastelands and non-cultivated lands are also inhabited by diverse vegetation suitable for beekeeping.

Thus, we have ample bee foraging plants for supporting sustainable bee keeping

**Scope of beekeeping in Odisha**

- **Agro-forestry Plants:** *Acacia, Cassia, Albizia*, *Eucalyptus*, Bael, Silk cotton, *Sesbania*, Cashew
- Forest covers 37.34% of the state's geographical area.
    - Dense forest: 55%
    - Open forest: 44%  Mangroves: 1%
- Horticultural crops - 115 thousand hectare
- Agricultural crops - 526 thousand hectare
- Crop needing pollination service-486 thousand hectare

**Bee keeping as an enterprise**

- Most suited to landless people or with small land holdings.
- Does not compete with any branch of agriculture.
- Does not require continuous labor.
- Does not require heavy investments.
- Some equipment is required.
- Provides multi source income.
- Improves crop yields through cross pollination

**Fear of bee stinging**

**Bee stings when: -**

- Adverse weather prevails,
- Queen cells are formed,
- Colony remains queen less for long time,
- Shaking bees off the frame,
- Any bee is injured while inspecting the box.

**Non availability of bee colonies**

- **India:** As per the minimum recommendation of 2-3 bee colonies /ha. requires about 150-200 million colonies as against present availability of 1million colonies.
- **Odisha:** Similarly, at recommendation of 2-3 bee colonies /ha. requires about 14.58 lakh colonies as against present availability of 64127 colonies.

**Lack of awareness**

- Honey bees are most fascinating creatures and have attracted attention of many people.

- Many people wish and many other start bee keeping without understanding the basics.
- Keeping bee is a very skillful activity.

**Constraints of beekeeping in Odisha**

- **Non-availability** of required number of colonies. Potentiality of our state is over 15Lakhs but present status of colony availability is nearly 1.2lakhs
- There is **no open market** for bee colonies and bee keeping equipment.
- **Lack of support of system** for honey collection, processing, distribution and marketing.
- Inadequate support from Government for HRD and periodic natural calamities adversely affecting the activity.
- Rapid deforestation, non-inclusion of bee friendly plants in avenue plantation and social forestry
- Indiscriminate use of novel insecticides (Neonicotinoids and Diamides) in development agricultural system which are extremely harmful to honeybees.

**Economics of bee keeping**

Estimated cost of 10-unit bee hive:

A) Total Expenditure:(For 10 colonies of *Apis cerana indica*

| Equipment | Numbers | Rate (Rs.) | Total Amount (Rs.) |
|---|---|---|---|
| Box | 10 | 2000.00 | 20000.00 |
| Colony | 10 | 800.00 | 8000.00 |
| Hive stand | 10 | 300.00 | 3000.00 |
| Smoker | 1 | 350.00 | 350.00 |
| Honey Extractor | 1 | 1600.00 | 1600.00 |
| Queen gate | 10 | 15.00 | 150.00 |
| **Total** | | | **33100.00** |

B) Total Expenditure:(For 10 colonies of *Apis cerana indica)*

| | |
|---|---|
| **Sugar 40kg (1kg@ Rs.40)** | **1600.00** |
| Medicines | 400.00 |
| Total | 2000.00 |
| **Grand Total (A+B)** | **35,100.00** |

C) Income from 10 colonies of *Apis cerana indica:*

| Product | Rate(Rs) | 1st Year | | 2nd Year & Onwards | |
|---|---|---|---|---|---|
| | | Production | Amount | Production | Amount |
| Honey | 1kg @ Rs.450 | 20 | 9000.00 | 60kg | 27000.00 |
| Wax | 1kg @ Rs.250 | 0 | 0.00 | 1kg | 250.00 |
| Colony | 1Colony @ Rs.600 | 10 | 6000.00 | 10nos. | 6000.00 |
| **Total** | | | **15000.00** | | **33250.00** |

D) Estimation of Profit and Loss:

| | **1st Year** | **2nd Year** | **3rd Year** |
|---|---|---|---|
| Income | 15000.00 | 33250.00 | 33250.00 |
| Expenditure | 35100.00 | 2000.00 | 2000.00 |
| Profit | (-)20100.00 | (+)31250.00 | (+)31250.00 |
| Cumulative Profit & Loss | (-)20100.00 | (+)11150.00 | (+)31250.00 |

- Pollinators helps in increased the productivity 25%-35%.
- Durability 15 years.

## Horticulture and entrepreneurial opportunities: An ICAR-IIHR perspective

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With growing awareness among the farming community and other stakeholders, horticulture has emerged as a major avenue to enhance the farm income with generation of higher value produce from the available land mass and has the potential to improve the livelihood, food and nutritional security with enhanced employment and increased income while playing a unique role in economy and achieving the national target of doubling farmer's income. Eastern India is endowed with rich genetic flora of horticultural crops and varied agro-climatic conditions providing opportunity to grow a wide range of horticultural crops. ICAR-Indian Institute of Horticultural Research, Bengaluru which has completed 50 years of existence has been working on 54 horticultural crops (13 fruits, 26 vegetables, 10 flowers and 5 medicinal crops) and released 302 varieties *viz*., 38 in fruits, 136 in vegetables, 115 in flowers and 13 in medicinal crops. Moreover, it has also released 163 technologies of crop production and protection.

Most of these varieties and technologies have a scope for scaling up and creating entrepreneurial opportunities. In this perspective it needs to be stressed that ICAR-IIHR has commercialized 104 technologies through executing 800 licenses to around 400 clients. The licensing is primarily ben give for Seed and Planting Material, Post-Harvest Technologies, Crop Nutrition & Plant Protection Technologies, Farm implements and Machinery and Biotechnological Products.

The varieties and technologies developed at ICAR-IIHR pass through a strict and professional system of procedures for identification of variety/technologies for commercial release. Firstly, the variety or technology to be identified is submitted to VTIC. The technologies are evaluated through in-situ inspection followed by a technical presentation on technology by the innovator. Thereafter the committee approves or rejects the release of technology.

The technology, thus identified by VTIC, is channelized either towards free popularization or towards commercialization through licensing. For free popularization the technology is provided to stakeholders for field demonstrations. The products are made available at ATIC, IIHR for nominal price for distribution/ sale for wider adoption. For commercialization of the technology

the technology needs to be disclosed to Institute Technology Management Unit (ITMU) for proper assessment of market potential and value of the technology. After evaluation offer price is arrived. ITMU facilitates the innovator for patent search, registration and intellectual property (IP) protection.

It also helps in identification and invites potential clients and organize ITMU-Innovator-Entrepreneur interaction and negotiations followed by preparation of MOA/ MoU and License and imparting training, if required or desired by the licensee. The 'Technology Licensing' is done on non-exclusive basis and one time 'Up front' license fee (Rs. 1000/- to Rs 400000/- depending on the technology) is charged with 18% GST as one-time payment. A technology is licensed for 5 to 10 years and renewable for another term. Royalty payment, if charged, continues as long as the licensee is producing.

**Major areas of entrepreneurial opportunities**

| **Crop** | **Variety** | **Important features** |
|---|---|---|
| Tomato | Arka Samrat | ✓ High yielding $F_1$ hybrid with triple disease resistance to ToLCV+BW+EB<br>✓ Fruits high round, firm, deep red<br>✓ Fruit weight 100-110g<br>✓ Suitable for fresh market<br>✓ Yields 80-85 t/ha in 140 days |
| | Arka Ananya | High yielding $F_1$ hybrid with combined resistance to ToLCV+BW<br>Fruits round, medium firm, deep red<br>Fruit weight 65-70g.<br>Suitable for fresh market<br>Yields 65-70 t/ha in 140 days |
| | Arka Rakshak | High yielding $F_1$ hybrid with triple disease resistance to ToLCV+BW+EB<br>Fruits high round, firm, deep red with average<br>Fruit weight 90-100g<br>Suitable for both fresh market & processing<br>Yields 75-80 t/ha in 140 days |
| Chilli / Bell Pepper | Arka Suphal | Powdery Mildew & Virus resistant |
| | Arka Meghana | Powdery Mildew & Virus resistant |
| French Bean | Arka Sharath | Pods round, string less<br>Pod yield 18.0 t/ha. in 70 days.<br>Crisp with no parchment.<br>Plants bushy and photo insensitive |
| | Arka Anoop | Resistant to rust and Bacterial blight |
| | French Bean: IIHR 55-1 | It is an advance breeding line tolerant to Mung |

| | | |
|---|---|---|
| | | Bean Yellow Vein Mosaic Virus (MYMV)<br>• Pods are dark green, round smooth, straight and stringless, crisp with no parchment<br>• Plants bushy and photo insensitive.<br>• Pod yield: 12 t/ha in 70 days. |
| Onion | Arka Bheem (Syn-6) | • Tri-parental synthetic variety<br>• Bulbs are elongated globe with red -pink bulb colour Average bulb weight 120 g<br>• Yields 47 t/ha in 135-140 days<br>• Reduces the cost of seed<br>• A hybrid at OP cost |
| | Arka Akshay | • It is a tri-parental synthetic variety<br>• Bulb colour: Dark Red<br>• Bulb shape: globe<br>• Average bulb weight: 115 g<br>• Crop duration: 130 DAS<br>• Average yield : 45 t/ha |
| | Arka Kirthiman | • Medium size bulbs with globe shape and firm texture; Bulbs: red to light red in color<br>• Bulb weight :120 -125g<br>• Bulb Yield: 45t/ha<br>• Long storage (4-5 months)<br>• Suitable for Kharif and Rabi season<br>• Duration 125-130 days |
| | Arka Lalima | • Medium to big sized bulbs with globe shape and firm texture<br>• Bulbs: red to dark red in color<br>• Bulb weight :120-130 g<br>• Bulb yield: 47t/ha<br>• Long storage (4-5 months)<br>• Suitable for Kharif and Rabi seasons<br>• Duration 130-140 days |
| Dolichos | Arka Soumya | • Pods are slender (1.0 cm width), long (13-15 cm)<br>• Plants are medium tall, 50 % flowering in 45 days and pods are ready for harvest in 55 days<br>• Pod yield: 20t/ha in 90 day |
| | Arka Sambhram | • Pods are flat, light green, medium long (13-15 cm), medium width (1.5 cm)<br>• Plants are medium height, 50 % flowering in 40 days and pods are ready for harvest in 55 days<br>• Pod yield: 20 t/ha in 90 days |
| | Arka Amogh | • Plants are medium tall, 50 % flowering in 40 days and pods are ready for harvest in 55 days<br>• Photo insensitive<br>• Pods are long, light Green, slightly curved without parchment; Number of Pods: 45-50/plant |

| | | |
|---|---|---|
| | | ▪ Pod yield: 20 t/ha in 90 days |
| Pointed Gourd | Arka Neelachal Kirti | ▪ High yielding variety with solid core |
| Teasel gourd | Arka Neelachal Gaurav | ▪ Soft seeded variety |
| Ivy Gourd | Arka Neelachal Kunkhi | ▪ ivy gourd for salad purpose |
| | Arka Neelachal Sabuja | ▪ A high value culinary variety |
| Watermelon | Arka Madhura | ▪ It is a triploid seedless watermelon with yield potential of 60 t/h and T.S.S. is 14 %<br>▪ Fruits are dark green, red flesh, crispy granular texture and sweet taste. Suitable for protected cultivation ; Duration: 110 days |
| | Arka Muthu | ▪ High yielding variety with unique character of dwarf vine of 1.2 m vine length,<br>▪ Shorter internodal length and early maturing type (75-80 days)<br>▪ It has round to oval fruits with dark green stripes and deep red flesh<br>▪ Average fruit weight is 2.5-3 kg with T.S.S ranging from 12 to 14 %.<br>▪ Fruit yield: 55 to 60 t/ha. |
| Custard Apple | Arka Sahan | |
| Papaya | Arka Prabhath | ▪ (Surya x Tainung-1) x Local Dwarf<br>▪ Gynodioecious<br>▪ Pulp: Firm (5.9 kg/cm$^2$)<br>▪ Colour: Deep pink<br>▪ Fruit wt: 900-1200g<br>▪ TSS: 13-14° Brix<br>▪ Yield: 90-100 kg / plant<br>▪ Keeping quality: Good |
| Guava | Arka Kiran | ▪ Kamsari x Purple Local)<br>▪ Pulp: Pink in colour; Fruit wt: 200-220g<br>▪ Seed hardiness: 9 kg/cm$^2$<br>▪ TSS: 12° Brix ; Lycopene content: 7.45mg/100g |
| Mango | Arka Neelachal Kesri | Early maturing clone |
| Gladiolus | Arka Amar | ▪ Florets are red & white on tepals with yellow blotch<br>▪ Florets wavy and arranged in double rows.<br>▪ High yielding (30.24 spikes /m$^2$ / crop season) and has 8.5 days vase life |
| Carnation | Arka Tejas | ▪ Arka Tejas is an interspecific hybrid between *D. caryophyllus* and D. *chinensis*.<br>▪ Dark red flowers with contrasting white anthers and lush green foliage<br>▪ Attractive pot plant for landscaping and interior arrangements |
| | Arka Flame | ▪ First Indian variety in carnation |

| | | |
|---|---|---|
| | | ▪ Tolerant to nematodes<br>▪ Yields 300 to 360 flowers/sq.m./year |
| Crossandra | Arka Ambara | ▪ F1 hybrid, cross between Local X Lakshmi<br>▪ Bigger size flowers (4.16 cm diameter)<br>▪ Weight of 100 flowers: 13 g<br>▪ Suitable for loose flower & garland<br>▪ Yield almost double than local varieties<br>▪ Flower Colour: reddish orange |
| | Arka Kanaka | ▪ The F1 hybrid selection is a cross between 'Local Yellow'X 'Delhi crossandra'<br>▪ Bigger size flowers, which is 67% higher than the local cultivar.<br>▪ Novel flower colour of Orange.<br>▪ The weight / 100 flowers 11.9 g |
| Rose | Arka Parimala | ▪ Half sib selection<br>▪ Flowers red and fragrant<br>▪ Suitable for loose flower and short stock cuttings<br>▪ Yields 100 loose flowers/plant/year |
| | IIHR 9-1 | ▪ High yielding<br>▪ Identified for cut flower production under protected cultivation<br>▪ Medium sized flowers with good keeping quality (6 days)<br>▪ Flowers: 145 flowers/stalk/sq.mt/year<br>▪ Stalk length: 65-70cm<br>▪ Shining foliage & attractive red coloured flowers |
| Tuberose | Arka Nirantara | ▪ Days to flower – 90 days<br>▪ Spike length – 100 cm<br>▪ Flowers per spike – 59<br>▪ Yield – 22t/ha/yr<br>▪ Vase life – 7 days |
| | Arka Suvasini | ▪ Days to flower – 115 days<br>▪ Spike length – 95 cm<br>▪ Flowers per spike – 59<br>▪ Yield – 1.5 lakh spikes/ha/yr<br>▪ Vase life – 8 days |

| | |
|---|---|
| Fruit beverages/Squashes | • Concentrated juices have a desired quantity of pulp, TSS and<br>• acidity<br>• Products are free from added synthetic flavours or colours<br>• Products have a shelf life of six months under ambient conditions<br>• Products have good taste, flavour and overall acceptability |
| Ready to Serve Beverages | ▪ Ready to serve (RTS) juices without addition of synthetic colour flavour safe and good for health.<br>▪ RTS beverages from mango, banana, guava, pineapple, passion fruit, grapes, watermelon etc. have been standardized and |

| | |
|---|---|
| | commercialization |
| Fruit Bar Technology | Concentrated and dehydrated fruit product<br>Has good nutritive value and shelf life<br>Can be consumed as a confectionary product<br>For manufacture under micro/small & medium size industries.<br>Highly suitable for children, mountaineers, defense forces etc. |
| Osmotic dehydration technology for fruits | Flavor retention, Better colour, more nutritious<br>used as dried fruit by ice cream industry, confectionary etc.<br>Highly suitable for children, mountaineers, defense forces |
| Crushed Tomatoes | • Ready to Cook product<br>• Presence of seed and skin adds to the consistency and colour.<br>• Better retention of Ascorbic acid (17.55mg/100g) Lycopene (flavonoid antioxidant) (5.65mg/100g) and Acidity (0.90%) against ascorbic acid (20mg/100g), lycopene (3.2mg/100g) of fresh tomatoes<br>• Shelf life : 6 months (28-32ºC) and 9 months (8-10ºC) |
| Low cost ripening technology of fruits | • Safe, simple, easy to use and low cost method<br>• Used for uniform accelerated ripening as an alternative to banned calcium carbide<br>• Reduced weight loss compared to natural ripening<br>• Can be adopted by farmers in the field or by traders and retailers in mandis/markets |
| Individual Shrink Wrapping Technology | • Shrink wrapping reduces shrinkage, weight loss and maintains quality without refrigeration or humidity<br>• Individual shrink wrapping greatly reduces the weight loss<br>• keeps the produce fresh & extends the storage life both at<br>• ambient and low temperature<br>• Storage life: Pomegranate by 3-4 wk at RT and 3 months at 8°C<br>• Capsicum by 10-12 days at RT and 2 months at 7°C |
| Zero Energy High Humidity Storage Boxes | • Specially designed and fabricated for the freshness retention of vegetables at ambient conditions.<br>• Size of the box: 740mm x 515mm x 210mm<br>• Capacity: 10-12 kg<br>• Storage life extension for leafy vegetables (Amaranthus, Coriander, Mint, Curry leaves and Okra) by 2 days<br>• Zero power consumption<br>• Easy to install in retail outlets and supermarket |
| Specific solutions to address the spoilage of fresh cut vegetables | • Improvement in shelf life of minimally processed vegetables for their storage in commercial chillers<br>• Scientific information on antioxidants, flavour, microbiological quality. No Class II preservatives; GRAS chemicals only used<br>• Shelf life Improved from 6 days to 21 days through protocol optimization |

| | | |
|---|---|---|
| **Nursery machinery** | Rooting media cleaners and mixer | Complete management of nursery operations |
| | Rooting media filling in bags | |
| | Protray seeders | |
| Growing media siever; Bucket elevator; Chute for dense materials; Growing media; Growing media mixer | | |
| **End to end approach for mushroom spawn production:**<br>**Grain cleaner & grain conveyor** | | |
| • Grain boiler<br>• Boiled grain and chalk powder mixer<br>• Boiled grain and chalk powder mixer cum bag filler<br>• Spawn inoculator<br>• Solar energy integrated modified autoclave | | |
| Machinery for raw mango processing | Raw mango grader | Useful to grade raw mangoes into four grades based on size. Capacity – 500 kg/h |
| | Raw mango peeler | Useful to remove the peel of raw mango. Capacity – 500 kg/h |
| | Raw mango slicer | Useful to slice the raw mango. Capacity – 800 kg/h |
| | Raw mango cube cutter | Useful for dicing the raw mango slices. Capacity – 1 t/h |
| | Continuous hot water treatment for mango | Useful to treat the freshly harvested mangoes in hot water to control anthracnose and fruit fly. Capacitry- 500 kg/ batch |

| | |
|---|---|
| Machinery for onion cultivation and on-farm processing:<br>Onion seed extractor | Separates seeds from umbles<br>Capacity: 30 kg/h |
| Manual drawn onion seeder | Useful for sowing onion seeds in flat bed. Reduces seed rate by 40 % and maintains uniform crop stand.<br>Field capacity – 0.06 ha/h |
| Animal drawn onion seeder | Useful for sowing onion seeds in flat bed. Saves seed rate, time and labour by 40 – 50 % and maintains uniform crop stand. Field capacity – 0.4 ha/h |
| Tractor operated onion digger cum windrower | Useful to dig the onion bulb. Separates the dugout onion bulbs from soil and windrows at the rear side of the machine.<br>Field capacity – 0.3 ha/h |
| Motorized onion grader for common onion | Useful to size grade common onion into four grades.<br>Capacity – 2 tonnes/h |
| Technology for preserving natural flowers | Dried Roses<br>Dried flower boxes |
| Mushroom Rasam Powder | • A value added product for enhancing nutrition in the daily diet<br>• Adds nutrition to a daily diet product ‘Rasam’ used daily in every South Indian home.<br>• Daily intake of this product will enhance nutrition<br>• Also enhance income of rural women who can start an entrepreneurial |

| | | |
|---|---|---|
| | activity of producing this product as cottage industry. | |
| Plant health management technologies | • Biopesticides (432)<br>• Microbial Consortium (16)<br>• Banana Micronutrient formulation (20)<br>• 'Arka Saka Nivarak' -Technology for Prevention of Spongy Tissue<br>• 'Seed Pro Technology<br>• 'Para Pheromone trap | |
| Micronutrient Foliar Formulations | Banana Micronutrient Foliar Formulation | • Prepared based on symptoms, leaf & soil analysis<br>• Increased disease resistance<br>• Yield increase up to 10%<br>• Additional return up to 24 %<br>• Adoption > 400 ha<br>• Additional benefit up to Rs. 4 lakhs |

| | |
|---|---|
| Vegetable Micronutrient Formulation | • Recommended for all vegetable crops at different doses<br>• Can be mixed with any fungicide or insecticide<br>• Enhances fruit quality in terms of fruit appearance, fruit keeping quality and taste |
| Mango Micronutrient Formulation | • Recommended for all mango varieties<br>• Can be mixed with any fungicide or insecticide<br>• Enhances fruit quality in terms of fruit appearance,<br>• fruit keeping quality and taste |
| Citrus Micronutrient Formulation | • Recommended for all Citrus varieties<br>• Can be mixed with any fungicide or insecticide<br>• Enhances fruit quality, fruit keeping quality and taste |
| Neem Soap and Pongamia Soap | • User friendly formulation than Neem seed kernal extract and Neem oils.<br>• Alternative to the use of synthetic insecticides<br>• Effective on DBM in cabbage & cauliflower<br>• Serpentine leaf miner<br>• Red spiders etc. Low residual toxicity |
| Crop Protection Technology for Mango | • Mango fruit rotten due to fruit flies<br>• Improvement in impregnation pheromone technology for effective management of fruit fly; IPM in mango |
| Arka Microbial Consortium | • This is a carrier based product which contains N fixing, P & Zn solubilizing and plant growth promoting microbes as a single formulation<br>• Reduces the cost of cultivation, besides the synergistic effects of the formulated microbes can help in sustainable vegetable production Helps in early seed germination & Increased seedling vigor; Reduction of fertilizer requirement by 25 - 30 % |
| Arka fermented Coco Peat | • Arka fermented coco-peat, developed for vegetable seedling production<br>• This product is developed by the solid state fermentation of raw coir pith, by employing a fungal consortium<br>• Reduced cost & time of production, Environment friendly<br>• Can be done at the nursery itself<br>• Dispenses the need for sterilization of the growth media<br>• Better germination and vigorous uniform seedlings |

| | |
|---|---|
| Arka Actino Plus | • Benefits of the Actinobacterial Consortium<br>• Increased seedling vigour<br>• Creates a nutrient rich environment in the rhizosphere due to enhanced mineralization; Revitalizes plant health<br>• Reduces 25 % of N fertilizer requirement when recommended dosage of organic amendments are applied<br>• Reduces 25 % of P fertilizer requirement<br>• Enhances the nutrient uptake of plants<br>• Increases yields by 13 to 24 % in different vegetables |
| Sealer cum Healer for Mango Trunk Borer management | • Formulation to control & protect the tree from borer damage & also help in tree rejuvenation<br>• Cost Effective & No special training required for treating the plant<br>• The formulation completely blocks the unseen holes as well as visually seen holes. The tree is rejuvenated with nutrition |
| **SEEDPRO** a microbial growth promoter & fungal Disease Suppressor | • An immobilized product of *Bacillus subtilis* and *Hypocrea lixi*<br>• Efficacy of Seedpro tested on wide range of vegetable crops like brinjal, beans, cabbage, chilli, tomato etc., oil seed crop such as soya bean & fruit crops like papaya for growth promoting activities.<br>• Seedpro has effectively enhanced root length, shoot length, leaf area, seedling vigor &seedling biomass from 28.6% to 92.85%.<br>• Used for successful production of quality & disease free vegetable seedlings and reduction of seed and soil fungal diseases |
| **Bio-pesticides** (*Pseudomonas fluorescens* 1 % w.p. *Trichioderma harzianum* 1 % w.p. *Trichioderma viride* 1.5 % w.p. *Paecilomyces liacinus* 1 % w.p. *Pochonia chlamyosporia* 1 % w.p.) | ▪ Inherently harmless in comparison to chemical pesticides.<br>▪ Decrease the use of chemical pesticides.<br>▪ Increase the yield of the crop<br>▪ Leads to sustainable productivity in a long run.<br>▪ Eco- friendly & farmer friendly.<br>▪ Have specific mode of action on pathogens.<br>▪ Helps in developing disease suppressive soils. |
| 'Arka Saka Nivarak' – A Novel Technology for Prevention of Spongy Tissue in Alphonso Mango | ❖ Increased fruit weight (>250g)<br>❖ Attractive appearance<br>❖ Uniform external and internal color development<br>❖ Improved fruit firmness<br>❖ Better pulp texture<br>❖ Improved flavour and aroma and<br>❖ Extended shelf-life of fruits (up to 3 weeks under ambient conditions)<br>❖ Enhanced TSS &Enhanced antioxidant capacity of the fruit pulp |

**Major achievements so far…**

- *Total of 230 technologies licensed to over 476 licensees earning Rs. 8.71crores.*
- *Total of 22 patents have been filed. At least 'Seven' of these patented technologies have been commercialised to over 200 clients*
- *Effective Public Private Partnership models evolved.*
- *16 technologies licensed to 38 KVKs*

**How can you access these technologies from IIHR?**

- You can buy required quantities of seed / planting material and products from IIHR ATIC or seed counter for your personal use.
- You can also get some of these materials from any nearby KVK/ Government agencies
- You can take a 'license' from IIHR by paying the license fee and get trained about its commercial scale production and sale
- You could also become an 'on site or off site incubatee and get experience in the commercial scale production and sale of these products

**Start Up support through Incubation @ IIHR**

- Start Ups supported and incubated. IIHR provides onsite Incubation facility for select technologies
- More than 70 incubatees registered and ten of them have successfully initiated projects:

  *1. An Onsite incubatee for Crop Protection Technologies - M/s Natura Crop Care*

  *2. An Onsite incubatee for Crop Protection Technologies – Ms. Bhavani Biochemicals*

  *3. SM Plant Production Technologies Pvt ltd., incubated & graduated from IIHR in 2016 March, established a plant 6 Kms from IIHR*

**Our other Successful Incubatees**

- *Ms. Barrix, Mango fruit fly trap technology*
- *Ms. Krishi Biosys, Biopesticide producer*
- *Ms. Hi7agribiosolutions,*
- *Ms. MCI, Osmotically Dehydrated Products*
- *Ms. Divine Clique, Osmotically Dehydrated Products*
- *Most successful start-up with Venture capital funds*
- *First start up took 6 Patented technologies & broken even within two years*
- *First start up on site incubatee broken even within two years*

- *Licensee who has promoted our products in overseas market*

**Commercial scale production of 'Farmers Variety' Sidhu Halasa (Sidhu Jack)**

- *In a First of its kind 'market linkage', ICAR-IIHR assisted a farmer from Tumkur who has conserved a rare Jackfruit type popular as 'Red Jack locally, to register the variety as Farmers Variety under PVP& FRA.*
- *ICAR-IIHR has entered into an MOU with the farmer for multiplication and supply of truthful saplings of the local jack christened as 'Sidhu jack' on the name of the farmer*
- *Large quantities of the saplings are being produced and sold with 75% of the value going to the farmer.*

Disclaimer: The information on the development of a technology and its commercialization is highly dynamic and many changes and additions may have taken place in the above list of technologies. The information given in this write up is indicative of vast amount of experience and resources availability at the institute. For any further information please contact - **itmu@iihr.res.in**

# *Commercial Floriculture in protected structure*

***Er. Asutosh Behera***
***Asst. Agril. Engineer***
***O/o the D.D.H,Cuttack***

# NVPGH

| Type of structure | Size Range | Cost norm Rs./Per /$M^2$) | 50% subsidy (Rs./$M^2$) | 20% subsidy (Rs./$M^2$) | Total subsidy limit @ 70% (Rs./$M^2$) |
|---|---|---|---|---|---|
| Naturally ventilated Poly house (NVPGH), tubular structure | ➢ Up to area 500$m^2$ | 1060.00 | 530.00 | 187.00 (20% of Rs 935.00) | 717.00 |
| | ➢ 500$m^2$ Up to 1008 $m^2$ | 935.00 | 467.50 | 187.00 | 654.50 |
| | ➢ 1008$m^2$ Up to 2080 $m^2$ | 890.00 | 445.00 | 178.00 | 623.00 |
| | ➢ 2080$m^2$ Up | 844.00 | 422.00 | 168.80 | 590.80 |

# Semi control type Green House

| Type of structure | Size Range | Cost norm Rs./Per /$M^2$) | 50% subsidy (Rs./$M^2$) | 20% subsidy (Rs./$M^2$) | Total subsidy limit @ 70% (Rs./$M^2$) |
|---|---|---|---|---|---|
| Green house with fan pad system | Up to area 500$m^2$ | 1650.00 | 825.00 | 187.00 (20% of Rs. 935.00) | 1012.00 |
| | ➢ 500$m^2$ Up to 1008 $m^2$ | 1465.00 | 732.50 | 187.00 (20% of Rs. 935.00) | 919.50 |
| | ➢ 1008$m^2$ Up to 2080 $m^2$ | 1420.00 | 710.00 | 187.00 (20% of Rs. 935.00) | 897.00 |
| | ➢ 2080$m^2$ Up to 4000 $m^2$ | 1400.00 | 700.00 | 187.00 (20% of Rs. 935.00) | 887.00 |

# Shadenet House (SNH)

| Type of structure | Size Range | Cost norm Rs./Per /$M^2$) | 50% subsidy (Rs./$M^2$) | 20% subsidy (Rs./$M^2$) | Total subsidy limit @ 70% (Rs./$M^2$) |
|---|---|---|---|---|---|
| Shadenet House Tubular Structure | With plastic top as addition. 4.00 m height | 710.00 | 355.00 | 120.00 (20% of Rs. 600.00) | 475.00 |
| Shadenet House Bamboo Structure | Each structure limited to 200 $m^2$ | 360.00 | 180.00 | 0 | 180.00 |

# Plastic Tunnel

| Type of structure | Size Range | Cost norm Rs./Per /$M^2$) | 50% subsidy (Rs./$M^2$) | 20% subsidy (Rs./$M^2$) | Total subsidy limit @ 70% (Rs./$M^2$) |
|---|---|---|---|---|---|
| Walk in Tunel (WIT) | 3.0 m and 4.25 m height | 600.00 | 300.00 | 0.00 | 300.00 |
| Plastic Tunnel | Limited to 1000$m^2$ per beneficiary | 60.00 | 30.00 | 6.00 (20% of Rs. 30.00) | 36.00 |

# *Commercial Rose Cultivation*

| Component | Rose |
|---|---|
| Plant density | 8 plant/sqm |
| No of plant Per Sqm per AC | 32000 plant/AC |
| Production (1-3 stick /plant) | 1.5 Stick/plant after 3 month |
| Total stick produced | 1.5x32000=48000stick |
| Sale cost | @4/stick Rs. 192000/- per month after 3 months |
| Cultivation cost<br>Per AC cost | @ Rs. 430/sqm<br>430x4000=17,20,000/- |
| BEP | 9+3=12 months |

# *Commercial Jerbera Cultivation*

| Component | Jerbera |
|---|---|
| Plant density | 6 plant/sqm |
| No of plant Per Sqm per AC | 24000 plant/AC |
| Production (3-4 stick /plant) | 2.5 flower /plant /month after 2 month |
| Total stick produced | 2.5x24000=60000 nos |
| Sale cost | Rs. 2.50/flower Rs. 1,50,000/- month after 3 month |
| Cultivation cost<br>Per AC cost | @Rs. 610/sqm<br>610x4000=24,40,000/- |
| BEP | 16+2=18 months |

# *Commercial Orchid Cultivation*

| Component | Orchid | | |
|---|---|---|---|
| Plant density | 10 plant/sqm | | |
| Total plant per AC | 40000 plant/AC | | |
| Production | 1st yr | 2nd yr | 3rd yr |
| | 1-2 stick 1.5 | 3-4 stick 3.5. | 6-7 stick 6.5 |
| Total stick | 60,000 nos | 1,40,000 nos | 2,60,000 nos. |
| Sale cost @ Rs. 8/- per stick | Rs. 4,80,000/- | Rs. 11,20,000/- | Rs. 20,80,000/- |
| | Total income after 3 years Rs.36,80,000/- | | |
| Cultivation cost Per AC cost | @Rs. 700/sqm 700x4000=Rs. 28,00,000/- | | |
| BEP (approx.) | 36 months | | |

smooth implementation of the scheme of Protected Cultivation under MIDH:

1. The eligible subsidy can be released soon after the project is sanctioned by the Bank and Department, Work Order is issued and construction materials for protected structures are deposited at the beneficiary's site by the selected erector. The admissible subsidy shall be released to the financing bank and in favour of the project.
2. The subsidy amount shall be kept in the Subsidy Reserve Fund Account. The adjustment of subsidy will be on the pattern of Back-Ended Investment Subsidy. The repayment schedule of the loan would be drawn in such a way that the subsidy amount is adjusted after loan portion of Bank is liquidated.
3. The subsidy amount in the borrowers term loan account should be adjusted only as the part of the recovery of last instalment. The Bank shall not charge interest on the equal amount of term loan.
4. Final settlement/adjustment of subsidy will be made only after completion of project & joint verification by the Team constituted by the DDH in consultation with the Collector-cum-Chairman, DMC and concerned Bank.
5. The verification team will comprise of members from lending bank, SHM, District Administration.
6. After completion of the project & on receipt of satisfactory verification report, the financing bank will release the eligible subsidy to the promoter's account & refund the balance subsidy amount, if any.
7. Bank will submit the utilisation certificate to Horticulture Department in prescribed format after release / credit of the above eligible subsidy amount to the term loan account of the promoter.
8. The Bank will refund the subsidy in case the project / borrowers account is declared Non Performing Asset (NPA).

***DHANYABAD***
***WISH YOU***
***ALL THE BEST***

**Tuber crops and entrepreneurial opportunities**

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## Introduction

The tropical tuber crops, including cassava (Manihot esculenta Crantz), sweet potato (Ipomoea batatas), yams (*Dioscorea sp*.), taro (*Colocasia esculenta*), elephant foot yam (*Amorphophallus paeoniifolius*) and other minor tuber crops play a crucial role in providing food security for about 2.2 billion people in the World besides contributing to animal feeds and industry. With a global per capita consumption of 110 kg in a year, these crops occupy a significant place in the food basket of developing nations. Among total World production, about 45% of root and tuber crop production are consumed as food, with the rest converted as animal feed or industrial products. The tropical tuber crops widely regarded as food security foods owing to their ability to provide sustainable yields even under adverse climatic and soil conditions, low input requirement, and ability to withstand natural calamities to provide life-saving foods to people during and after disasters.

Tuber crops are important sources of starch after cereals and used as staple or supplementary food in many of the tropical and sub-tropical countries. Cassava and sweet potato are the most important among the tuber crops and other tubers are grown as vegetable crops in home stead or semi commercial scale. In 2014, global cassava production was 270.29 million tonnes from an area of 24.22 million hectares. India has a leading position in global cassava scenario due to the high

productivity level of 35.31 tonnes per hectare compared to the world average of only about 11.16 tonnes per hectare. Sweet potato production was 102.94 million tonnes with a yield of 12.97 tonnes per hectare in which China contributing about 98.50 million tonnes with 43.78 tonnes per hectare whereas production in India is only 1.09 million tonnes with 10.28 tonnes per hectare (FAO, 2015).

The perishable nature of tropical tuber crops and the difficulties in long distance transport, storage and marketing constitutes major problems for farmers whose bargaining power is at its lower edge. In order to overcome this problem, in situ value addition near the farm site is recommended. The produce will also ensure promotion of cottage and small-scale industries besides ensuring food security by incorporating tuber flour/starch to a certain extent in various food preparations. Tuber crops, cassava in particular, being perishable deteriorate rapidly after harvest and are often unfit for food or feed within a few days. They are generally consumed as vegetable after boiling it in water and eaten along with some spicy curry or by extracting starch. Besides serving as an insurance crop during times of food scarcity, it can also function as an industrial raw material for a wide spectrum of products.

Tuber crops though branded as poor man's crops in rural areas have considerable unrealized potential for processing into high end products for food, feed and industrial uses. Agro-industrial transformation of these crops by linking improved production and processing technologies, marketing techniques and institutional innovation in processing technologies ensure food security, rural employment and adequate remuneration to the producers. Better post harvest management and diversification for the production of value added products for home, farm and industrial front are the only choice to elevate the status of these crops from subsistence level to a commercial commodity.

**Importance of tuber crops**

**Food Security**

Tuber crops are rich source of energy and carbohydrates although each of them also provides other important nutrients as well. They produce large quantities of energy (carbohydrate) in relatively less time than other crops. Tuber crops grow well in marginal soil with fewer inputs where other crops usually fail to grow. They are tolerant to drought and some of them grow fast and provide a wide soil cover to prevent erosion. These crops have great flexibility in mixed cropping system to generate additional employment and income. Crops like yam and elephant foot yam grow as intercrops in horticultural and plantation crops.

**Nutritional Security**

Tuber crops are rich in essential vitamins or minerals but poor in protein (Table 1 and 2). On an average cooked yams have about 2% protein, cassava and sweet potato provide ascorbic acid (vitamin C) whereas cereal based foods have none. Sweet potato also contains important amino acids while rice is deficient in lysine. The Orange and yellow-fleshed sweet potato roots and green tops are good source of vitamin A, which can prevent night blindness and malnutrition prevalent in many parts of the country. So regular intake (100 g per day) of orange or yellow fleshed sweet potato having moderate concentration of vitamin A (3 mg/100g) or greens or/of mixture of both to provide 100% of Recommended Daily Allowances (RDA) of vitamin A for children. Besides, sweet potato is rich in antioxidant, nutrients like Beta-carotene, ascorbic acid (vitamin C) tocoferol (vitamin E), which can prevent coronary disorder and cancer.

**Economic Security**

Tuber crops, besides providing food and nutritional security, contribute to the economic security of the farmers with an array of value added products. Cassava is an essential commercial crop as its roots are utilized into array of products for human food as fresh or processed roots, starch and flour for food and industry, and animal feed. Cassava starch finds application in array of industrial products, textiles, corrugation box, paper conversion, liquid gum for domestic sector, paper industry etc. Besides food, sago industry is the major one. A number of stable and marketable food products as well as less stable snack food can be made from tuber crops. Cassava rawa, semolina and fried cassava chips are successful stable products that can be made from cassava tubers. Besides, cassava flour fortified with cereals and legumes flours can be used for making extruded fried foods which also have good post product shelf life.

Sweet potato is an important crop for food, feed and raw material industries. For industrial processing, starch and dry chips of sweet potato have been used as raw materials in the manufacture of products such as deep processing starch, alcohol, liquid glucose, high fructose syrup, maltose and for food processing fresh roots dry flour or starch can be used for noodles, fried chips and canned flakes production. In feed processing the main product is sweet flour used by the compound feed industry. The industrial utilization of sweet potato is rudimentary in India. Starch of colocasia is very fine and it is used in cosmetic industries and also as filler for biodegradable plastic.

**Table 1**. Concentration of Beta-carotene, vitamin C and Vitamin E in sweet potato and other vegetables (Per 100g fresh)

| Vegetable | Beta-carotene (mg) | Vitamin C (mg) | Vitamin E (mg) |
|---|---|---|---|
| Sweet potato | 1.8-16 | 23 | 4.56 |
| Carrots | 4-11 | 6 | 0.56 |
| Onion | 0.01 | 5 | 0.31 |
| Tomatoes | 0.64 | 17 | 1.22 |
| Pumpkin | 0.45 | 120 | 0.80 |

**Table 2**. Comparative proximate composition of tuber crops

| Tuber crops | Grams per 100 g on dry weight basis | | | | | |
|---|---|---|---|---|---|---|
| | Protein | Fat | Minerals | Fibre | Carbohydrate | Calories |
| Sweet potato | 3.8 | 0.9 | 3.1 | 2.5 | 88.5 | 377 |
| Potato | 7.3 | 0.4 | 2.4 | 1.6 | 89.0 | 382 |
| Cabbage | 1.3 | 1.2 | 7.4 | 2.3 | 56.6 | 332 |
| Cassava | 1.7 | 4.9 | 2.5 | 1.5 | 84.9 | 386 |
| Yam | 4.7 | 0.3 | 5.3 | 3.3 | 86.6 | 370 |
| Colocasia | 11.6 | 0.4 | 6.3 | 3.7 | 78.5 | 361 |
| Elephant foot yam | 5.6 | 0.5 | 3.8 | 3.8 | 86.3 | 371 |
| Rice | 7.8 | 0.8 | 0.7 | 0.4 | 89.9 | 397 |
| Wheat | 13.5 | 1.7 | 1.7 | 10.4 | 81.2 | 393 |

**Novel Value Added Products from Cassava**

**Cassava rawa and porridge**

Cassava or tapioca (*Manihot esculenta Crantz*) is one of the important tuber crops valued for its high starch content (20-35%). Cassava rawa is a pre-gelatinized granular product similar to wheat semolina and finds use as a breakfast recipe product. For the preparation of cassava rawa, the tubers are peeled and sliced into round chips. It is then partially cooked by boiling in water for 5 min, decanting the steep water, sun-drying the parboiled pieces and powdering coarsely in a hammer mill. This is then sieved through fine sieve to separate out the finest fraction which can be converted to porridge powder by flavouring with cardamom and fried powdered cashew nuts. The residue is sieved through larger mesh size sieve to obtain rawa. The uneven large pieces are again powdered to recover the rawa.

**Fried cassava chips**

Fried cassava chips presently available in the market are often too hard to bite and bear no comparison with potato chips. This leads to poor acceptability of the product and lower price. Research at CTCRI has shown that excellent quality fried chips can be made from cassava tubers, by soaking the chips in acetic acid-brine solution for 1 h, parboiling for 5 min, surface drying and deep frying in oil. This facilitates in the removal of excess starch and sugars from the

cassava slices, with the result that light yellow crispy chips can be obtained, having soft mouth feel and good texture.

**Cassava based extruded products**

The demand for extruded snack products is expanding at a phenomenal rate in developed and developing countries. Extrusion cooking is a high temperature short time cooking process designed for processing of starchy as well as proteinous materials. The use of extrusion cooking has distinct advantages like versatility, high productivity, low cost, product shapes, high product quality and production of new products. Several cereal based extruded products are available commercially. But tuber crop based extruded snack product has yet to appear in the market as we lack both technologies for value addition and products acceptable to elite/urban populace. Being the treasure house of starches with complex physico-chemical properties, cassava can be extruded to obtain a variety of nutritionally enriched, ready to eat/cook products. Cassava tubers after washing, peeling and slicing into chips are dried and powdered in a hammer mill. The dry flour after conditioning to 12-15% moisture content is extruded by maintaining appropriate temperatures at different sections of the barrel and die of the food extruder. Cassava being rich in carbohydrates and lacking in protein content, addition of low cost protein sources like wheat, finger millet, soy flour etc. gave more nutritional and market value products.

**Protein and fibre enriched functional foods**

The cost of making value added snack foods from cassava could be considerably reduced, if wet cassava paste is used instead of cassava flour. Such an innovation was made in making a highly acceptable crisp snack food viz., chitchore from cassava. The wet cassava tuber paste is mixed with ingredients like maida, cheese, salt, sugar, baking powder and white pepper. The dough after proofing for 1 h is spread into sheets and cut into small discs of 1 cm diameter. These are then deep fried in oil. Keeping an eye on the health conscious consumers, mini-papads are developed from cassava flour by adding fibre sources like wheat bran, oat meal, rice bran and cassava fibrous residue. The fibre sources are added to gelatinized cassava slurry and mixed thoroughly. The spicy condiments are also added and spread on plastic sheets which are then dried in the sun for 36 h. The papads are peeled off from the sheets and packed. The deep fried products have soft and crisp texture. Mini- papads with high protein content (7-15%) could be made from cassava flour by adding protein sources like cheese, defatted soy flour, prawn

powder and whey protein concentrate along with other spicy condiments. The papads are allowed to dry for 36 h and deep fried in oil before use.

**Fried snack foods from cassava**

**Cassava Pakkavada:** This is a hot snack food having good texture and taste made out of cassava flour. The other ingredients include maida, bengal gram flour, salt, chilli powder, asafoetida, baking soda and oil. The ingredients are thoroughly mixed and made into dough with hot water (50°C), proofed for 1 h and then extruded through hand extruder having flat rectangular holes, into hot oil.

**Cassava Sweet Fries:** This is a sweet snack food made out of cassava flour, maida, baking soda and oil. The ingredients are mixed well and made into dough with hot water (50°C). The dough after proofing for 1 h is hand extruded through die having round holes, into hot oil. The fried product is then coated with sugar by dipping for a few minutes in sugar syrup having thick consistency.

**Cassava Nutrichips:** This is a high protein snack food made out of cassava flour by mixing with other ingredients like maida, groundnut paste, egg, salt, sugar, sesame, coconut milk, baking soda and oil. After mixing the ingredients, hot water is added and mixed to form smooth dough. The dough after proofing is made into small balls which are then spread into sheets of 2 mm thickness. This is then cut into diamond shape using a sharp knife and deep fried in oil.

**Cassava crisps:** This is a soft and good textured crispy snack food made from cassava flour, maida, rice flour, bengal gram flour, salt, baking soda, turmeric powder and oil. The dough made with hot water is proofed for 1 h and then extruded through the small pore size die having round holes. The deep fried material is mixed with fried nuts, curry leaves etc. before packing.

**Cassava starch, sago and wafers**

The process of extraction of starch consists of peeling, rasping, and screening, settling and drying. Peeled roots of cassava are disintegrated into pulp by a rasper who releases the starch granules from the fibrous matrix. The resulting slurry is pumped onto a series of vibratory screens and the fibrous waste (thippi) is retained on them and the starch milk passing through the sieves are channelled into sedimentation tanks. After at least 8 hours of settling, the supernatant liquor is run off and the starch cake settled at the bottom is scooped up for sun drying on a cement floor. Sago (Saboo dana) is manufactured from the partially dehydrated (35-40% m.c.) starch cake. The lumps are broken in a spike mill and then globulated on a gyratory shaker. The

globules are graded according to size and then partially gelatinized by roasting on shallow metal pans. Finally, the sago pearls are dried in the sun on cement floor. The agglomerates are separated by means of a spike beater and polished before bagging. Wafers are made by arranging the wet granules in suitable dies and steaming. The steamed granule takes the shape of the die and after drying, it can be separated out from the dies and packed.

**Functional pasta from sweet potato and cassava**

Cassava is known to be a high starch, high glycaemic food, while sweet potato is a low glycaemic health food. Whilst the global prevalence of diabetes is projected to increase from 4% in 1995 to 5.4% by 2025, approximately 170% increase in diabetic population has been predicted in developing countries, with India topping the list, followed by China. FAO-WHO Expert Consultation recommends the increased consumption of low glycaemic foods rich in resistant starch, non-starch polysaccharides and oligosaccharides. Foods with low glycaemic response are reported to be of use in the treatment of obesity, type 2 diabetes mellitus and in weight management. Considering the projected rise in diabetic population in India to 80 million by 2030 and in an attempt to diversify the use of these root crops, studies were made at ICAR-CTCRI to develop an array of pasta products having high functional value coupled with low starch digestibility. Besides, pasta getting wide popularity among the young Indians and in the metros as a convenient food, transformation to new health and wellness foods is essential to add value to cassava and sweet potato and sustain their cultivation of in India.

**i) Protein-enriched pasta**

As protein content and gluten strength are critical factors deciding the cooking quality of pasta and since sweet potato lacks gluten, fortification with protein sources like whey protein concentrate (WPC), defatted soy flour (DSF) and fish powder (FP) was attempted to understand their impact on starch-protein network formation. The study showed that slowly digestible functional pasta with good quality could be developed form sweet potato, which also has high

protein content. Lack of protein in cassava flour is a major impediment to the development of pasta type of products from it. Nevertheless, technology for making protein rich pasta from cassava through fortification with other ingredients was standardized at ICAR-CTCRI.

**ii) Fiber enriched pasta**

Sweet potato flour based pasta rich in dietary fibre was made at ICAR-CTCRI using dietary fibre sources like oat bran, wheat bran, and rice bran, with the objective of enhancing the functional value of sweet potato pasta as a prophylactic/therapeutic diet in the prevention or management of conditions like diabetes, cardiovascular conditions, and cancer. Fortification of sweet potato flour with dietary fibre sources resulted in products having slow and progressive starch digestibility and very high percentage of starch remained undigested (RS) after 2 h of digestion under in vitro conditions. The slow digestibility of the fibre enriched sweet potato pasta coupled with the high level of residual undigested starch make these pastas ideal foods for diabetic and obese people.

**iii) Low glycaemic spaghetti from tuber crops**

The high incidence of metabolic diseases such as type-2 diabetes, cardiovascular conditions and obesity, among people consuming foods rich in carbohydrates has led to increased research

efforts in the development of low glycaemic foods. The effect of fortification of sweet potato flour with banana and legume starches as well as sweet potato starch itself in producing low glycaemic spaghetti (flour based noodles) from sweet potato was investigated. Also the effect of three gum sources such as guar gum, xanthan gum locust bean gum in improving the cooking characteristics and reducing the starch digestibility of sweet potato spaghetti was studied. Sweet potato: maida flour blend was fortified with commercial (edible) gum sources such as guar gum, xanthan gum and locust bean gum at three levels viz., 0.5%, 1.0% and 1.5%. The formulation contained 10% whey protein concentrate which by virtue of its ability to mimic gluten, helped to give excellent binding with starch and also elevated the crude protein content.

**iv) Starch noodles from sweet potato**

Starch noodles, presently known by different names such as glass noodles, cellophane noodles, vermicelli, bihon noodles etc. have been a favourite food in China since 1400 years. They are now produced from purified starches of various plant sources and have become popular in several Asian countries as well. Starch noodles differ in their quality and texture from Asian or Italian pasta/spaghetti, as the latter are made from flour or semolina, although many fortified pasta and noodle products have been attempted by subsequent researchers with a view to improving the quality. Starch noodles have been classified according to the type of raw materials, size of the noodle strands, manufacturing method etc. Traditionally, starch noodle made from green gram starch is considered as the best owing to the transparent appearance, fine threads, high tensile strength and low cooking loss.

**v) Gluten-free spaghetti from sweet potato**

Celiac disease patients have intolerance to gluten, the proteins in wheat, rye and barley. Consumption of gluten leads to inflammation of the small intestine ultimately damaging the villi and affecting the absorption of iron, vitamins, minerals etc. A strict gluten free diet as a lifelong diet strategy is the only treatment for celiac disease. Several researchers have attempted the development of gluten-free pasta and spaghetti products using materials such as buckwheat, maize, quinoa, sorghum etc. However, there was only limited information on the production of gluten-free pasta from sweet potato (Ipomoea batatas Lam.). Hence studies were made to develop gluten-free pasta from sweet potato flour, rice flour blends along with additives such as WPC and guar gum.



**Sweet Potato Based Products**

Sweet potato (Ipomoea batatas Lam.) is cultivated throughout the tropics and warm temperate regions of the world for its starchy roots, which can provide nutrition, besides energy. A number of novel food products with functional value are being developed worldwide. Sweet potato tubers with their low glycaemic index have additional value as a food for diabetics. There are a range of primary food products that could be made from sweet potato like chips, flakes, frozen products, French fries, puree etc., while it is also the raw materials for a host of secondary products like noodles, sugar syrups, alcohol, pasta etc.

Sweet potato roots are transformed into more stable edible products like fried chips, crisps, French fries etc. Sweet potato puree, is a primary processed product from the roots, which is used directly as a baby food or used for mixing various food items like patties, flakes, reconstituted chips etc. High quality puree can be made from white, cream or orange- fleshed sweet potatoes and also from tubers of any size or shape.

Sweet potato roots can be termed as a '3-in-1' product, as it integrates the qualities of cereals (high starch), fruits (high content of vitamins, pectin etc.) and vegetables (high content of vitamins, minerals etc.). The beneficial effects of these ingredients have been appropriately put to use by converting the roots into a number of intermediary food products like jam, jelly, soft drinks, pickles, sauce, candies etc.

**Sweeteners from starch**

Liquid glucose and high fructose syrup are made from cassava starch by liquefying the starch and saccharifying it using enzymes or acids. After saccharification, decolourisation is done using charcoal to produce glucose syrup. Fructose syrup is obtained from glucose syrup using glucose isomerase at $62^0$C for 2 h. This is then decolourised and concentrated. HFS is a highly valued product for the confectionery industries, due to its specific properties like non-crystallising nature, extra sweetness etc. Maltose syrup is another product which is commercially prepared from starch, which finds application in food and confectionery industries. The essential composition includes maltose, glucose, maltotrioses, and higher oligosaccharides. The process

consists in hydrolysing the starch using alpha-amylases from native sources like the rice seedling extracts. CTCRI has also standardized techniques for the production of maltodextrins with different dextrose equivalents (DE), which can be used as fat replacers in low calorie foods. The process involves the treatment of starch with heat-stable bacterial amylase and purification of the product.

**Bio ethanol from starch**

Fresh cassava tubers, dry chips/flour or starch can be used for the production of ethanol. The process consists of three steps viz., liquefaction, saccharification and fermentation. During liquefaction, the cooked starch slurry is hydrolysed to maltose and low molecular weight dextrin using either acids or alpha-amylase. In the saccharification step, hydrolysis to glucose is achieved using acids or glucoamylases. During fermentation, the glucose formed is fermented to ethyl alcohol using yeast, *Saccharomyces cerevisiae*. The optimum concentration of sugars for ethanol fermentation is 12-18% and optimum pH and temperature are 4.0 to 4.5 and 28-32$^0$C respectively. After 48-72 h of fermentation, alcohol is recovered through distillation. This process is highly energy-intensive and involves use of costly enzymes and hence the overall energy balance is negative. However, presently, improved enzymes are available and a global shift has already occurred. Research under a Department of Biotechnology (DBT) funded project led to the development of new technology for ethanol production from cassava. This new process has saving of time and energy over the earlier process patented in 1983, as the process could be done at room temperature.

**Starch based adhesives**

Liquid adhesives and gum pastes can be made from cassava starch using simple low cost technologies. Starch is cooked with water, cooled and preservatives like formaldehyde or copper sulphate are added. The shelf life of the gums can be improved by adding borax, urea, glycerol,

carboxymethyl cellulose etc. These chemicals help in improving and stabilising the paste viscosity. Another potential area is the development of corrugating adhesives from starch.

**Biodegradable plastics**

One of the innovations in the potential use of cassava starch is in the production of biodegradable plastics. In the context of increasing risk of pollution from plastics, use of biodegradable plastics can help in a big way to provide a healthy and pollution less environment for the future generations. Research has shown that cassava starch incorporated into polypropylene granules can yield products having good strength and enhanced biodegradability. The starch incorporated plastic films (up to 25-40%) possess adequate mechanical strength and flexibility and can be processed just like normal plastics, i.e., heat sealed, printed, coloured etc. The granules and finished products can be stored almost like synthetic plastics and biodegradable under soil burial conditions. From the outdoor weathering and soil-burial tests, the biodegradation time has been reported to vary from 6 months to 5 years depending on its composition and soil conditions.

**Starch based edible films and composite films**

The high viscosity of cassava starch enables its use as binding material in pelleted fish feeds and is being practised in Latin American countries. Economical fish feeds leading to remunerative and sustainable aquaculture systems, can be made using cassava flour as the energy component and cassava starch as the binder. Cold water miscible starch prepared from cassava starch is a new innovation of CTCRI. The technology has been perfected and process optimised through a series of trials. Cassava and sweet potato starch based edible films are developed by incorporating various hydrocolloids and glycerol in starch. These films can be utilized as edible coatings for various food products. Presently we are working on the development of starch based nano composite films for specialized applications such as edible coatings for food, packaging films and slow release matrices for tablets.

**Future potential of Tuber Crops**

Cassava and sweet potato are used in three sectors viz., human consumption, animal feed and industrial sector. The market structure differs in each sector of its use. Though cassava and sweet potato production and processing centres are concentrated in Southern and Eastern India, it is interesting to note that marketing centres are distributed throughout the country especially in the western and northern parts for different value added products produced from cassava and sweet potato.

**Cassava starch**

Currently cassava starch is being used in large scale in adhesive industry in the form of corrugation, paper conversion and stationery adhesives then followed by paper and textile industry. The use of cassava starch as adhesive is likely to go up in future due to its suitability to make good adhesive. Cassava starch requirement projections are based on the possible growth of the respective industries and the use of cassava starch as raw material and also on the population growth rate in India.

It was projected that by 2015-16, cassava starch required in adhesive sector alone will be 3.5 lakh tonnes followed by paper industry (2.0 lakh tonnes), textile industry (78, 000 tonnes) and other sectors like food, laundry, pharmaceuticals etc. shall be 40,000 tonnes. Thus there will be a total demand of 3.12, 4.30 and 6.05 lakh tonnes of cassava starch for various industrial applications by 2005-06, 2010-11 and 2015-16 respectively.

From the supply side, it was estimated that only 2.65 lakh tonnes, 3.09 lakh tonnes and 3.54 lakh tonnes of cassava starch can be produced in India by 2005-06, 2010-11 and 2015-16 respectively. These projections are based on the growth rate of starch sales through SAGOSERVE, growth rate of starch industry in Tamil Nadu, Andhra Pradesh in traditional states and in non-traditional areas like Maharashtra, Gujarat and North Eastern states.

It was estimated that there will be a gap of 0.47, 1.20 and 2.50 lakh tonnes between demand and supply of cassava starch in India by 2005-06, 2010-11 and 2015-16 respectively. (Table 9.3)

**Sago**

It is used as a snack food in preparation of porridge and also popular as an infant food. Nearly 400 units are producing sago in Tamil Nadu and 28 factories in Andhra Pradesh. It is estimated that 1.5 lakh tonnes of sago in 85:15 ratio between Tamil Nadu and Andhra Pradesh is produced in our country; Moti dana, medium dana, bada dana and nylon sago are the four different types

of sago produced commercially in our country. It is mostly used as a food item in the preparation of snacks, sweets etc.

Demand -Supply projections for sago in India for 2005-06, 2010-11 and 2015-16 were presented in Table 1. From the table, it can be observed that there will be a demand of 2.62, 2.85 and 3.05 lakh tonnes of sago by 2005-06, 2010-11 and 2015-16 respectively. Demand projections were based on the population growth rate and per capita availability of sago in India.

Supply projections were based on the growth rate of sago sales through SAGOSERVE, growth of sago industry in Tamil Nadu and Andhra Pradesh in traditional states and in non-traditional areas like Maharashtra, Gujarat and North Eastern states. It was estimated that there is a possibility of supply of 2.09, 2.41 and 2.74 lakh tonnes of sago by 2005-06, 2010-11 and 2015-16 respectively.

Thus there will be a gap of 0.55, 0.44 and 0.32 lakh tonnes of sago between demand and supply by 2005-06, 2010-11 and 2015-16 respectively in India.

**Sago Wafers**

Sago wafer manufacturers market wafers through WAFERSERVE. At present 50 % of the wafer production is routed through WAFERSERVE. Though production center is located in Tamil Nadu, only 10 % of production is marketed in Tamil Nadu while 90 % is sold in states like Madhya Pradesh, Uttar Pradesh, Delhi, Maharashtra, Gujarat, Karnataka, Andhra Pradesh and West Bengal. Primary wholesaler located in these marketing centers supply to retailer for further distribution to consumer.

Different states have demands for different varieties of wafers in different periods in a year. During Sravana month (August), only white colour wafers are in demand in Gujarat. In Maharashtra, colour wafers are preferred. During festivals like Ramjan and Holi, colour wafers are in demand in Uttar Pradesh, Madhya Pradesh and Andhra Pradesh.

**Table 1**: Demand-Supply for cassava starch in India

| **Period** | **Demand (t)** | **Supply (t)** | **Gap (t)** |
|---|---|---|---|
| 2005-06 | 3,12,897 (15,64,485) | 2,65,387 (13,26,936) | 47,510 (2,37,549) |
| 2010-11 | 4,30,148 (21,50,740) | 3,09,791 (15,48,957) | 1,20,357 (6,01,783) |
| 2015-16 | 6,05,113 (30,25,565) | 3,54,196 (17,70,978) | 2,50,917 (12,54,587) |

Note: Figures in the parentheses indicate cassava tubers equivalent of starch in the respective box.

**Table 2**: Demand-Supply for Sago in India

| Period | Demand (t) | Supply (t) | Gap (t) |
|---|---|---|---|
| 2005-06 | 2,64,793 (16,25,245) | 2,09,441 (12,56,644) | 55,352 (3,68,601) |
| 2010-11 | 2,85,341 (17,51,372) | 2,41,724 (14,50,342) | 43,617 (3,01,030) |
| 2015-16 | 3,05,819 (18,77,054) | 2,74,007 (16,44,040) | 31,812 (2,33,014) |

Note: Figures in the parentheses indicate cassava tubers equivalent of sago in the respective box.

**Sweet potato and their value added products**

As sweet potato is used in food and can be used in feed and in the preparation of value added products, there is an urgent need to improve the status of this crop. As a mixed crop, it can increase the earnings of small and marginal farmers as well as growing entrepreneurs. Sweet potato finds its major use in production of starch, liquid glucose, thickener, chips and other processed products. As far as marketing of sweet potatoes is concerned, there is no organised marketing system in India. Majority of the farmers sell them to the commission agents or contractors where there is maximum scope for exploitation.

The major utilisation of sweet potatoes in the form of vegetables and subsidiary food in the case of weaker sections and tribes. However, in the recent years, the value addition in the form of industrial and snack products have also taken place in India. The commercial sweet potato starch production units have started in West Bengal, Maharashtra, Tamil Nadu, Karnataka and Delhi. The sweet potato chips/ flour and other value added products like jam, pickle, beverages are also entering into the markets.

India exports raw sweet potatoes mainly to United Arab Emirates, Nepal, Maldives and other Asian countries. During 2014-15, the total export of sweet potatoes was 632.49 metric tonnes valued at Rs.10.421 million.

**Table 3.** State-wise Area and production of sweet potatoes in Top 10 States of India during 2014-15

| States/union territories | Area (hectares) | Production (metric tonnes) |
|---|---|---|
| Odisha | 43.46 | 410.10 |
| West Bengal | 22.90 | 236.10 |

| | | |
|---|---|---|
| Uttar Pradesh | 17.74 | 235.16 |
| Assam | 9.62 | 40.97 |
| Chhattisgarh | 3.71 | 37.80 |
| Karnataka | 2.80 | 35.90 |
| Madhya Pradesh | 2.40 | 26.47 |
| Meghalaya | 4.44 | 15.06 |
| Nagaland | 1.50 | 15.00 |
| Tamil Nadu | 0.41 | 8.47 |
| **Total (including others)** | **112.01** | **1090.11** |

**Table 4.** Country-wise export of sweet potatoes in 2014-15

| **Country** | **Quantity (metric tonnes)** | **Value (Rs million)** |
|---|---|---|
| UAE | 535.83 | 9.263 |
| Nepal | 54.00 | 0.424 |
| Maldives | 19.85 | 0.353 |
| Bahrain | 18.21 | 0.296 |
| Oman | 3.00 | 0.053 |
| Myanmar | 1.10 | 0.018 |
| Kuwait | 0.50 | 0.014 |
| **Total** | **632.49** | **10.421** |

**Conclusion**

The role of tuber crops in the future is bright in India. With the capacity to survive in wide range of environments, ability to provide staple food to disadvantaged population, nutritious animal feed and ability to provide various farm, home and industrial products, the tuber crops can consistently cater to the food and nutritional security of the people.

Semi-organised to organised marketing system with well-established marketing channels for cassava and its value added products was observed in India. Pune, Mumbai and Kolkata are the important national markets for Sago and Starch in India

As far as cassava and sweet potato exports are concerned, it will be a tough time ahead in the current situation of globalisation and liberalisation unless the quality of the value added products from cassava and sweet potato is given due care to meet the international standards. There is always threat to our native cassava starch industries from Thailand as the starch production cost is much lower than that is produced in India. There will be a possibility of dumping cassava starch by Thailand in our markets. Therefore, efforts have to be made to reduce starch production costs in order to compete with the prices in the international market.

The future of cassava and sweet potato in India lies in its diversified uses in the industrial sector. In the industrial sector, cassava and sweet potato starch demand is more in adhesive sector

especially in the corrugation gums and textile industry. It finds good demand in the paper industry also. R & D efforts in modifying starch for meeting the quality standards of these industries have to be strengthened.

The socio-economic strategies like popularisation of tuber crops as alternate crops, integrated product development, production and distribution of quality planting materials, participatory technology development, capacity building and market regulation with government policy support will improve tuber crops scenario in the country. So it is time to understand, accept and promote tuber crops among the farming and industrial community.

# Vermiculture and entrepreneurship opportunities involved

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***Introduction***

Vermicomposting is a biological process by which all types of organic waste like crop residues, kitchen wastes, market wastes, bio-wastes of agro based industries, livestock wastes, spent waste of mushroom and weeds are converted into value added product like vermicompost. It is a simple technology for converting partially decomposed organic wastes into organic manures with the help of earthworms. It involves breaking down of complex organic materials into nutrient rich compost by earthworm by its ingestion and digestion. In this process worms help in transforming organic waste materials into high quality manure with ample amount of macro and micro nutrients for plant growth and development. The process is very simple and can be easily executed by the farmers and farm women in their back yards. It is not only a cost-effective method to convert organic waste into useful nutrient rich manure but the method is also an environmentally friendly technology which can easily be adopted by the small and marginal farmers of Odisha. It is helpful in sustainable agricultural production without pollution hazard to soil, water and environment. The technology is very useful for kitchen gardens and urban horticulture. Demand for vemicompost in present scenario of crop production particularly under organic farming and availability of sufficient raw materials for vermicomposting encourages unemployed youth and farmers to take vermicomposting as enterprise to meet their livelihood. Vermicomposting is an emerging sector which can potentially create employment opportunities in rural India and also help in the promotion of organic farming.

***How vermicompost differ from compost?***

Vermicomposting is a simple biotechnological process of compost making and differs from normal composting in several ways. It is a mesophilic process, utilizing microorganisms and earthworms that are active at 10–32°C (not ambient temperature but temperature within the pile of moist organic material). The process is faster than composting, because the material passes through the earthworm gut and worm manure are rich in microbial activity and plant growth regulators, and fortified with pest repellence attributes.

***Importance of vermicompost***

- Vermicompost is rich in plant nutrients like potassium, nitrate, sodium, calcium, magnesium, and chloride and have the potential for improving plant growth than fertilizer (Kandan and Subbulakshmi 2016). A comparative statement of nutrient status of vemicompst and some other organic manures are presented in Table 1.
- Nutrients in vermicompost are in readily available form and are released within a month of application.
- It also contains growth promoting hormone "Auxins", "Cytokinins" and flowering hormone "Gibberellins" and soil enzymes secreted by earth-worms (Ndegwa *et al.*, 2001) thus has a positive effect on vegetative growth, stimulating shoot and root development.
- It contains some antibiotics and actinomycetes that help in increasing resistance of crop plants against pest and diseases.
- Vermicompost also has very high porosity, aeration, drainage and water holding capacity which will be helpful for maintenance of soil health. Ansari and Jaikishna 2011 reported significant improvement in the soil quality with the application of vermicompost produced from sugarcane bagasse and rice straw.
- The fruits, flowers vegetables and other plants grown using vermi-compost are reported to have better keeping quality (Singh *et al.*, 2015).

***Advantages of vermicompost***

- It provides efficient conversion of organic wastes/crop/animal residues.
- It is a stable and enriched soil conditioner.
- It helps in reducing population of pathogenic microbes.
- It helps in reducing the toxicity of heavy metals. Heavy metal content in the vermicompost produced from industrial waste has no adverse effects to the environment and for human health when applied as biofertilizer since its content was for below the limits set (Baker *et al.*, 2014)
- It is economically viable and environmentally safe nutrient supplement for organic food production.
- It is an easily adoptable low cost technology.

**Types of earthworms:**

Earthworms are small, soft, cylindrical bodied invertebrates that play a vital role in soil ecosystem maintenance. About 3600 types of earthworms are reported in the world and they are mainly divided into two types: (1) burrowing; and (2) non-burrowing.

1) Burrowing earthworms (*Pertima elongata* and *Pertima asiatica*) are pale, 20 to 30 cm long and live for 15 years and live deep in the soil and come onto the soil surface only at night. Make holes in the soil up to a depth of 3.5 m and produce 5.6 kg casts by ingesting 90% soil and 10% organic waste.
2) Non- burrowing earthworms are red or purple and 10 to 15 cm long with life span of only 28 months (*Eisenia fetida* and *Eudrilus eugenae*) live in the upper layer of soil surface (Fig 1). Eat 10% soil and 90% organic waste materials and convert the organic waste into vermicompost faster than the burrowing earthworms. They can tolerate temperatures ranging from 0 to 40°C but the multiplication rate is more at 25 to 30°C and 40–45% moisture level in the pile.

Selection of earthworm species is one of the important criteria to produce good quality manures in specified time period. The red wiggler or tiger worm (*Eisenia fetida* or *Eisenia andrei*) are commonly used earthworm, but African Night crawlers (*Eudrilus eugeniae*) are another set of popular composters can be used for vermicomposting. The *E. fetida* earthworm species was a more efficient producer of vermicompost biomass than *E eugenae* (Singh *et al* 2008). But *E eugenae* is more efficient than other earthworm species like *Perionyx excavatus* and *Lampito mauritii* (Vizi and Neelanarrayan 2013).

- Important characteristics of most common red earthworm (*Eisenia foetida*): body length 3-10cm, body weight 0.4-0.6g, maturity 50-55d, conversion rate 2.0 q/1500worms/2 months, cocoon production 1 in every 3 days, incubation of cocoon 20-23days.One earthworm reaching reproductive age of about six weeks lays one egg capsule (containing 7 embryos) every 7-10 days. Three to seven worms emerge out of each capsule. Thus, the multiplication of worms under optimum growth conditions is very fast. The worm lives for about 2 years.
- For initial inoculation, farmers are advised to collect the earthworm cultures from reputed agencies or firms located in their region

***Methods of vermicomposting***:

1) *Pits below the ground*

   Pits made for vermicomposting are 1 m deep and 1.5 m wide. The length varies as required.

2) *Heaping above the ground*

   The waste material is spread on a polythene sheet placed on the ground and then covered with cattle dung. Earthworm population, biomass production and production of vermicompost are higher in heap method (51 kg) than in the pit method (40 kg).

3) *Tanks above the ground*

   Different materials such as normal bricks, hollow bricks, shabaz stones, asbestos sheets and locally available rocks can be used for preparation of tanks of dimensions suitable for operations

4) *Cement rings*

   Vermicompost can also be prepared above the ground by using cement rings of size 90 cm in diameter and 30 cm in height (Fig 1)

5) *Commercial models*

   Several commercials models have been developed by various organizations. The points to be consider for development of the permanent structure commercial model for vermicomposting is listed below (Fig 2, 3)

- A well-drained land with shades is preferred for construction of vermicomposting unit.
- A thatched roof shed preferably open from all sides is required for making vermi beds.
- The sheds should be erected in east-west direction length wise to protect the site from direct sunlight.
- To facilitate drainage, the base of the site should be raised at least 6 inches above the ground level.
- The size of the shed depends upon the quantity of waste to be treated and the availability of space.
- An area of 12 ft x12 ft would be enough for three 10ft x 3ft x 2ft (Length x Breadth x Height) vermibeds with 1 ft space in between the beds.
- The height of roof can be kept at 7-8 feet from the centre and 5-6 feet from the sides.

- Prepare the vermi beds by bricks and cement mortal keeping the bottom of the bed without plastering.
- A water channel should be made around the top of the brick wall to deter ants from entering the beds.
- Keep drainage outlet at lower side of bed to collect vermiwash.

***Portable Rhino vermi bed method***

- Low cost readymade portable vermicomposting beds of size 12ft x4ft x 2ft made up of Polyethylene net window with one netted outlet at the bottom of the bed (Fig 4).
- Rhino bed method is very easy to install and easy to carry/shift from one place to another.
- This method is superior than permanent brick wall methods in terms of moisture retention capacity and quality of final product produce.

***Materials for vermicomposting***

Crop residues like, sorghum straw and rice straw, dry leaves of crops and trees, pigeon pea stalks, groundnut husk, soybean residues, vegetable wastes, weeds before flowering, fiber from coconut trees and sugarcane trash can be converted into vermicompost. In addition, animal manures, dairy and poultry wastes, food industry wastes, municipal solid wastes, biogas sludge and bagasse from sugarcane factories also serve as good raw materials for vermicomposting.

***Process of vermicomposting***

- Chop the available crop residues, kitchen wastes, market wastes, bio-wastes of agro based industries, livestock wastes, weeds etc. into convenient size and shade dried for few days (10-15 days)
- Put 4-6 inch layers of the shade dried organic waste materials in to the bottom of the bed and sprinkle 1-inch layer of partially decomposed cow dung over it. Over this layer another layer of organic residues is spread followed by spraying of dung slurry uniformly. This process is repeated till the spread of the organic residues 6 inch above the top of the pit. Five percent dung slurry was uniformly distributed on the top of the organic residue sufficient to wet the surface
- After partial decomposition of organic residues (attained in 10-15 days) the earthworms are released @ 1 kg (around 1000 worms) per bed, consisting of 1 ton organic residues, by making holes at the top of the bed on four corners and centre of the pit.

- The bed can finally be covered with a jute bag or mat to protect earthworms from birds and insects.
- Sprinkled water daily on the vermi beds according to the requirement and season to keep them moist (50-90%).
- Sprinkling of water should be stopped when 90 % bio-wastes are decomposed.
- Normally after 45-60 days, organic refuse changes into a soft, spongy, sweet smelling; dark brown compost will be ready for collection.
- The appearance of black granular crumbly vermicompost on top of the vermi beds indicates maturity of the compost.
- The mature vermicompost is light in weight and does not emit any foul smell. The $P^H$ of the mature vermicompost remains in neutral range.
- Harvest the vermicompost by scrapping layer wise from the top of the pit and heap under shed.
- The harvested vermicompost has to be sieved. Sieving helps in the separation of the earthworms, cocoons and eggs from the compost.
- After sieving, the compost should be shade dried for a couple of hours, packed and stored in shade (Fig 6)
- As an alternate to sieving of whole amount, gather the compost in small heaps and leave under ambient conditions for a couple of hours when all the worms move down the heap in the bed. Separate upper portion of the manure and sieve the lower portion to separate the earthworms from the manure.
- The culture in the bed contains different stages of the earthworm's life cycle, namely, cocoons, juveniles and adults. Transfer this culture to fresh partially decomposed feed material. The excess as well as big earthworms can be used for feeding fish or poultry.
- Prepare another pile about 20 days before removing the compost and repeat the process by following the same procedure as described above

***Precautions during the process***

- The floor of the unit should be compact to prevent earthworms' migration into the soil.
- 15-20 day's old cow dung should be used to avoid excess heat.
- The organic wastes should be free from plastics, chemicals, pesticides and metals etc.

- Materials of animal origin such as eggshells, meat, bone, chicken droppings, etc are not suitable for preparing vermicompost.
- *Gliricidia* loppings and tobacco leaves are not suitable for rearing earthworms.
- A mixture of tobacco waste with rabbit manure in the ratio of 1:5 was found to be lethal to the earthworms.
- Aeration should be maintained for proper growth and multiplication of earthworms.
- Optimum moisture level (80-90 %) should be maintained.
- 18-25 $^{0}$C temperature should be maintained for proper decomposition.
- The earthworms should be protected against birds, termites, ants and rats.
- Adequate moisture should be maintained during the process. Either stagnant water or lack of moisture could kill the earthworms.
- After completion of the process, the vermicompost should be removed from the bed at regular intervals and replaced by fresh waste materials.

***Use of Vermi-compost***

- With increase in awareness of organic farming in rural and urban area, the demand for vermin-compost is increasing.
- Vermi-compost can be used as a component of integrated nutrient management to reduce the use of inorganic fertilizers in agriculture.
- It can be used as soil conditioner to maintain soil health and quality.
- Vermi-compost can be used for all crops: agricultural, horticultural, ornamental and vegetables at any stage of the crop.
- For general field crops: Around 2–3 tonnes per hactare vermi-compost is used by mixing with seed at the time of sowing or by row application when the seedlings are 12–15 cm in height. Normal irrigation is followed.
- For fruit trees: The amount of vermi-compost ranges from 5 to 10 kg per tree depending on the age of the plant. For efficient application, a ring (15–18 cm deep) is made around the plant. A thin layer of dry cow dung and bone meal is spread along with 2–5 kg of vermi-compost and water is sprayed on the surface after covering with soil.
- For vegetables: Application of vermi-compost @ 1t/ha in the nursery bed produces healthy and vigorous seedlings. Use vermi-compost 0.4 to .5 kg/plant at the time of

transplanting of seedlings as basal dose and subsequently apply at 45 days after planting (before irrigation).

- For flowers: Vermi-compost is applied at 750–1000 kg per hactare
- For vegetable and flower crops vermi-compost is applied around the base of the plant. It is then covered with soil and watered regularly.

***Other products and by-products of vermiculture***

- Vermiwash and worm meal are two major by-products of vermicomposting.
- Vermiwash is a liquid that is collected after the passage of water through a column of worm action and is very useful as a foliar spray. It is a collection of excretory products and mucus secretion of earthworms along with micronutrients from the soil organic molecules (Fig 5)
- The liquid byproduct can be used in agriculture as fertilizer and growth promoter.
- Fully grown worms could be separated and dried in an oven to make 'worm meal' which is a rich source of protein (70%) for use in animal feed such as poultry, fishery, pigs, pets etc. (Fig 6)

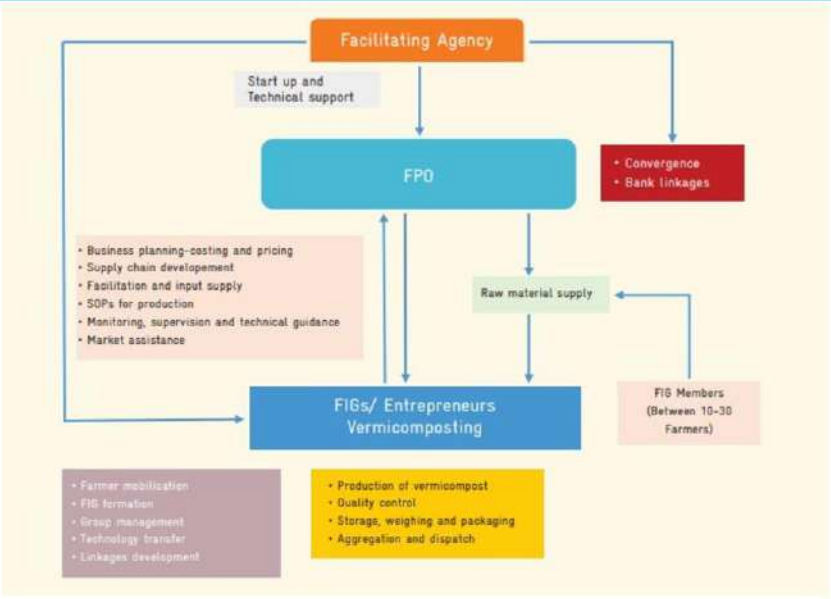
***Economics*:**

Cost of production, cost of cultivation and market price influences the profitability of vermiculture. It is observed that a farmer having one vermiculture unit having 3 Nos. of vermibeds (size 12 x4 x 2 foot) can produce about 3 tons of vermicompost in 45-60 days and can get net return of Rs18300 in 45-60 with B: C ratio of 2.10. The detail cost of production and return are computed in Table 2.

***Business models with flow chart representation of vermiculture***

The proposed business model for development of vermiculture units on large scale are depicted in below diagrams. The following flow chart represents the role of various institutions within the business model and also depicts the flow of inputs and outputs.

Diagrammatic representation of the proposed business model




***Basic entrepreneurial activities for commercial production of vermicompost***

- Collect information regarding demand and supply of produce in the market.
- Identify target customer and assess their needs such as amount required, purpose, quality etc.
- Ensure that the cost of production, transportation and marketing are included in costing and pricing.
- Collect information related to various subsidies/funds offered by the Government for promotion of the produce
- Comply with relevant regulations in marketing of the produce
- Track information related to wholesale and retail price of the produce
- Identify appropriate marketing channel
- Record keeping.

***Constrains and challenges in commercialization of vermiculture***

- Low awareness: There are several regions in India where awareness, regarding composting technology, has not been generated adequately.

- Lack of standard operating procedure (SOP)in composting sector: SOPs need to be developed for educating the farmers on technical aspects for making compost, nurturing tiny earthworms and managing the vermicomposting enterprises.
- Training, capacity building and extension facilities: At the farmer entrepreneur level, there is a need for capacity building in vermicomposting technology. Intensive trainings and capacity buildings are required to be imparted to the entrepreneurs.
- Scalability of vermicomposting: The adoption of vermicomposting as an enterprise is still not been conceived as a viable business option.
- Market connectivity: The distribution and retail network of existing vermicompost units is weak and hence popularization of vermicomposting has not taken place.
- Financial constrains: Accessing finance from the formal financial institutions is still a challenge for vermicompost entrepreneurs in many place.
- Availability of suitable species of earthworm: Many times, even the trained farmers find it difficult, to start or to upscale the vermicomposting enterprises due to lack of availability of suitable species of earthworms.
- Quality testing facilities: There is a need to establish quality control and certification systems for vermicomposting. However, laboratory facilities for chemical analysis of compost are lacking in the rural areas and also there is no single window system to locate the vermicomposting activities in India.

***Conclusion***

Worm or vermiculture is a technique for recycling of biological wastes into a rich organic fertilizer, for producing high-protein feed for poultry and fishery. Vermicomposting is a highly environment friendly, economically viable and efficient biological process to convert partially decomposed organic matter into compost amenable for assimilation by plants. The technology is very useful for kitchen gardens, urban horticulture, integrated nutrient management and particularly in organic farming. Demand for vemicompost in present scenario of crop production and availability of sufficient raw materials for vermicomposting encourages unemployed youth and farmers to take vermicomposting as enterprise to meet their livelihood. The utilization of vermicompost results in several benefits to farmers, industries, environment and overall national economy.

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**Table 1: Nutrient content of some organic manures**

| | Nutrient content (%) | | |
|---|---|---|---|
| | N | P2O5 | K2O |
| Bulky organic manures | | | |
| Cattle dung and urine mixed | 0.6 | 0.15 | 0.45 |
| Poultry manure (fresh) | 1.0-1.8 | 1.4-1.8 | 0.8-0.9 |
| Sheep dung | 0.95 | 0.35 | 1.00 |
| Farm yard manure dry | 0.5-1.5 | 0.4-0.8 | 0.5-1.9 |
| Rural compost dry | 0.5-1.0 | 0.4-0.8 | 0.8-1.2 |
| Urban compost dry | 1.0-2.0 | 0.9-3.0 | 1.0-2.0 |
| Sewage sludge dry | 2.0-2.5 | 1.0-1.2 | 0.4-0.5 |
| Sewage sludge activated dry | 5.0-6.5 | 3.0-3.5 | 0.5-0.7 |
| Vermi compost | 0.51-1.61 | 0.19-1.02 | 0.15-0.73 |

**Table2: Economics of vermicomposting**

| Inputs | | | |
|---|---|---|---|
| Materials | Quantity | Rate (Rs.) | Amount (Rs.) |
| Depreciation cost of vermibed (5year lifespan) and shade | 3 Nos | 600.00 | 1800.00 |
| Cow dung | Two tractor load | 1000.00 | 2000.00 |
| Organic residues | Four tractor load | 500.00 | 2000.00 |
| Vermiworm | 3kg | 400.00 | 1200.00 |
| Miscellaneous items (gunny bag, packing materials etc.) | Ls | | 500.00 |
| Labour | | | |
| Filling of pits (4MDYS),watering(10 MDYS), harvesting (6 MDYS) and packing (4 MDYS) | 30 MDYs | 300.00 | 9000.00 |
| Total production cost | | | 16500.00 |
| Output | | | |
| Vermicompost | 3000kg | 10.00 | 30000.00 |
| Worms | 12kg | 400.00 | 4800.00 |
| Gross return | | | 34800.00 |
| Net return | | | 18300.00 |
| Rupee return per rupee invested | | | 1: 2.10 |


*Eisenia andrei*

Fig 1: Different species of earth worm


Cement ring covered with gunny bag

Processed vermicompost

Fig 2: Cement ring method

Fig 3: Tank above the ground method

Fig 4: Commercial model (Rhino vermicomposting bed)

Fig 5: Vermiwash

Fig 6: Drying and storage of vermicompost at farmer's level

# Biocontrol Agents for Pest Management and Entrepreneurship Development

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## 1. Introduction

Pest problem is one of the major constraints for achieving higher production in agriculture crops. India loses about 30% of its crops due to pests and diseases each year. The damage due to these is estimated to be Rs. 60,000 crores annually. The use of pesticides in crop protection has certainly contributed for minimizing yield losses. The pesticides, which are needed to be applied carefully, only then the threshold limits of the pest population could be exceeded. However, quite often the indiscriminate and unscientific use of pesticides has led to many problems, such as pests developing resistance, resurgence of once minor pest into a major problem besides environmental and food safety hazards. In view of the several disadvantages associated with the unscientific use of pesticides in agriculture, there is an urgent need for minimizing the use of chemical pesticides in the management of insect pests. Growing public concern over potential health hazards of synthetic pesticides and also steep increase in cost of cultivation/low profit making by farmers has led to the exploration of eco-friendly pest management tactics such as Integrated Pest Management (IPM) "IPM is the right combination of cultural, biological and chemical measures which provides the most effective, environmentally sound and socially acceptable methods of managing diseases, pests and weeds". The success of IPM largely depends upon conservation of naturally occurring bio control agents.

## 2. Status of bio agents use in India

The popularity of bio agent has increased in recent years, as extensive and systematic research has greatly enhanced their effectiveness. Also, techniques for the mass production, storage, transport and application of bioagents have been improved in recent years. There are a number of instances where bio control agents have been successfully employed in India. Some examples of these are given below

- ✓ Growth of lantana weed was controlled by using the bug *Telonemia scrupulosa* .
- ✓ Sugarcane pyrilla has been successfully controlled in a number of States by the introduction of its natural enemy *Epiricania melanoleuca* and *Tetrastictus pyrillae*.

- ✓ *Trichogramma*, which feeds on the eggs of sugarcane borers, has been used against the borers in the states of Tamil Nadu, Rajasthan, UP, Bihar and Haryana.
- ✓ Similarly *Trichogramma* sp., *Bracon* sp., *Chelonus* sp. and *Chrysopa* sp. are being used for the control of cotton bollworms. *Trichogramma* sp. has also been used against rice stem borer and leaf folder.
- ✓ During 2003–04, the woolly aphid was observed in 3.13 lakh ha of sugarcane growing areas in Maharashtra and Karnataka. It was brought down to 0.82 lakh ha, only through the natural enemies, avoscutellum viz. *Dipha aphidivora, Micromus igorotus* and, *Eupeodes confrater*. An estimated benefit of approximately 398.23 crores was realised through this biocontrol intervention.
- ✓ Papaya mealy bug has been successfully controlled by parasitoid *Acerophagus papaya.* It is estimated that an annual saving of 1,623 crores has accrued to the farmers in Tamil Nadu, Karnataka and Maharashtra because of this biocontrol programme
- ✓ Tackling the Menace of Rugose white fly in Coconut by *Encarsia guadeloupae*

**3. Major advantages of using bioagents**

- ➢ No harmful residues;
- ➢ Target specific and safe to beneficial organisms like pollinators, predetors, parasites etc.;
- ➢ Growth of natural enemies of pests is not affected, thus reducing the pesticide application;
- ➢ Environmental friendly;
- ➢ Cost effective;
- ➢ Important component of IPM as 1st line and 2nd line of defence, chemicals being the last resort.

**4. Basic requirements for establishment of Bioagent unit**

**Land:** Land is required for construction of culture and rearing rooms, processing room, laboratory, office etc. Approximately 250 sq. mt. is required

**Building and civil works:** The civil structure may be designed to have separate room for diet preparation, host culture, egg production, etc. The host culture room should be kept at a distance with proper hygiene and entry may be restricted in such a way to prevent any contamination.

**Machinery and power:** There is no requirement of heavy machinery. UV chamber, incubator, mixer grinder and laminar airflow, autoclave etc some fabricated equipments for insect

collection and rearing may be required. All the machinery required are locally manufactured. Power supply is essential for bio-agents production units. Electricity charges under recurring cost are considered.

**Raw materials for food and the water requirement:** For rearing of insects, special diet is required which comprises of cereals, pulses, vitamins, antibiotics etc. All these materials are available locally. The water requirement is mainly for feed preparation, washing, cleaning, drinking etc. Water quality should be tested to establish the suitability

**Major equipment needed:** Equipments like semi-automatic *Corcyra* rearing cages, trays, iron racks, hot air oven, air conditioner, moth breeding tins, grinder, mating chambers, parasitization jars, refrigerator, wire mesh, netlon etc. are required for mass rearing of *Corcyra* and *Trichogramma* production. Depending on the bioagents, few of the equipments may be needed extra.

**Manpower:** Production of bio-pesticides required skilled manpower. There is need for a number of labourers at each stage of production. The project is labour intensive. The manpower required are Technical assistant (1), Skilled labour (3), Accountant / supervisor (1)

**Market Potential:** The Indian bioagent market stands at over US$127 million (7-8% of the global market) and is expected to triple by following year 2020.Considering the negative effects of indiscriminate case of chemical pesticides, importance for organic farming and promotion of sustainable farming practices possess better safety features are key drivers for the biopesticide market.

Example: The National Integrated Pest Management Workshop, 1992 estimated the gross demand for a trichogramma bioagent was 690 million cards.

**Regulatory measures:** As the bio-control agents are living organisms, it is very important to have effective regulatory measures. The quality control of commercial bioagents must be strictly enforced by the Government. In this connection, the Directorate of Plant Protection Quarantine and Storage, Department of Agriculture and Cooperation, Ministry of Agriculture, GOI have issued guidelines/data requirements for registration of bio-pesticides in the country. As per this, all the units have to meet the Indian standards and technical specifications to be eligible for registration under the Insecticides Act, 1968.

**Registration:** At present, Bacillus thuringensis, neem based formulations,microbial pesticides like fungi, NPV etc., are included in the schedule of Insecticides Act, 1968. This ensures the

quality of bio-pesticides at farmer's level. The standard parameters, protocols for data generation, guidelines for registration are prepared and circulated to prospective entrepreneurs by MoA. Now as such, any person dealing with biopesticides without registration is ill-legal.

❖ **Scope for entrepreneurship using NRRI technologies**

**1. 'Tricho-card' of *Trichogramma japonicum* and *T. chilonis***

The parasitisation of *Trichogramma* spp., in laboratory condition on one cc (18000-20000) eggs of *Corcyra cephalonica*, which are uniformly spread and pasted on a card measuring 10 cm x 8 cm, total size of the card is 13 cm (height)* 10 cm (Width), remaining area of the card other than eggs contains some relevant information. This card is called as Tricho card. The card has 10 demarcations (stamps).

One of the major constraints in utilizing these parasitoids are poor quality of mass reared *Trichogramma* can result in control failures. Hence, to avoid this, we are producing the quality assured parasitoids and mentioning the quality parameters as per (International Organization of Biological Control) IOBC standards on the card. If standards are not met, cards are distributed or sold to farmers.

**Recommendation**

*Trichogramma japonicum*- target insect pest is yellow stem borer

*T. chilonis*- target insect pest is leaf folder

**Method of usage**

***** Three tricho cards (60000 eggs/ha), five such releases are made at every ten days interval or till egg masses/moth activity is not seen whichever is earlier.

***** Card should be placed in the field before expected emergence date.

* Take out each strip and staple on the lower surface of the leaf, if weather conditions are normal or else each strip has been provided with hole at one end and they have been tied to a stick through inverted plastic cup to avoid heavy rains.

* Card should be stapled in morning hours and just before emergence to avoid predation.

* Farmers should refrain from using pesticides in the field where Trichogramma are released. Pesticides are to be avoided at least 15 days before or after release of *Trichogramma*

**2. 'Bracon-card' of *Bracon hebetor***

*Bracon hebetor* card is prepared in the form of pupa on *Corcyra cephalonica* larvae in the laboratory. Larvae containing pupae *Bracon hebetor* are uniformly spread and pasted on a card

measuring 11 cm x 11 cm, total size of the card is 13 cm (height)* 12 cm (Width), remaining area of the card other than pupae contains some relevant information. This card is called as Bracon card. The card has 10 demarcations (stamps).

One of the major constraints in utilizing these parasitoids are poor quality of mass reared parasitoids can result in control failures. Hence, to avoid this, we are producing the quality assured parasitoids and mentioning the quality parameters.

**Recommendation**

*T. chilonis*- target insect pest is leaf folder

**Method of usage**

***** 8-10 Bracon cards (4000-4500 pupae/ha) on appearance of pest. Depending upon the need weekly releases need to be made

***** Card should be placed in the field before expected emergence date.

* Take out each strip and staple on the lower surface of the leaf, if weather conditions are normal or else each strip has been provided with hole at one end and they have been tied to a stick through inverted plastic cup to avoid heavy rains.

* Card should be stapled in morning hours and just before emergence to avoid predation.

* Farmers should refrain from using pesticides in the field where *Bracon* are released. Pesticides are to be avoided at least 15 days before or after release of *Bracon*

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