Package of Organic Practices from Assam, Manipur, Meghalaya and Nagaland for Arecanut, Ginger, Large Cardamom, Passion Fruit and Pineapple

North Eastern Region Community Resource Management Project for Upland Areas (NERCORMP) (IFAD & GOI/DoNER/NEC) Shillong
Package of Organic Practices from Assam, Manipur, Meghalaya and Nagaland

for

Areca nut, Ginger, Large Cardamom, Passion Fruit and Pineapple

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North Eastern Region Community Resource Management Project for Upland Areas (NERCORMP)
Package of Practices for Organic Cultivation of Areca nut, Ginger, Large Cardamom, Passion Fruit and Pineapple

Prepared by North Eastern Region Community Resource Management Project (NERCORMP) (September 2006)

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August 12, 2006

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The North Eastern Region Community Resource Management Project for Upland Areas (NERCORMP) is a joint initiative of the Government of India (GoI) and the International Fund for Agricultural Development (IFAD), a specialized agency of the United Nations based in Rome. The North Eastern Council (NEC) under the Ministry of Development of North Eastern Region (DoNER) represents the Government of India; the United Nations Office for Project Services (UNOPS) at Bangkok is the cooperating institution for this project.

The overall objective of the project is to improve the livelihood of the vulnerable groups in a sustainable manner through improved management of their resource base in a way that contributes to protecting and restoring the environment. The strategy is to foster synergies for optimum utilisation of the strengths of the government, an international organization, a dedicated project management and support team, local NGOs and the inherent potentials of the local communities.

NERCORMP was declared effective from February 1999. It operates in the three states of Assam, Manipur and Meghalaya, covering two districts in each state. These districts are Karbi Anglong and N.C. Hills in Assam; Senapati and Ukhrul in Manipur; West Khasi Hills and West Garo Hills in Meghalaya. The project adopts a holistic approach to development, encompassing the following broad focus areas:

- Social mobilization, community organization and capacity building to tap, realize and sharpen the great latent potential of communities employing time-tested traditional value systems of community participation and action; and

- Intervene with economic, social and village infrastructure activities with predominant thrust on Income Generating Activities (IGA) to achieve economic transformation.

Over the past seven years, as part of income generating activities as well as transformation processes of areas under shifting cultivation, the project has promoted and up scaled the cultivation of varieties of agro-horticultural crops, including arecanut, ginger, large cardamom, passion fruit, and pineapple, adopting the cluster-approach in production to reach commercial volumes. The farming practices were generally ‘organic’ following ‘good’ traditional farming conventions without use of
inorganic fertiliser and chemical pesticides. The project is also in the process of securing organic certification for many of these crops and farming practices.

Organic farming is the basis for producing healthy food crops for healthy living and it is the natural way of producing food. But due to increase in population, the use of chemical fertilisers increased manifold in India. Fortunately the use of chemical fertilisers in the hilly areas of the North Eastern Region remained negligible compared to the plains areas of this region.

There is now worldwide awareness about the ill effects of chemical farming and many farmers are now willing to convert from chemical to organic farming. With little modifications and improvements, along with appropriate packages of organic practices, the upland areas of the North Eastern Region can be utilised for organic farming.

Under the aegis of FAO India and in association with the Ministry of Agriculture, Government of India, NERCORMP is happy to present this humble volume, ‘Package of Organic Practices for Areca nut, Ginger, Large Cardamom, Passion Fruit and Pineapple.’ We have selected these crops as they are not only traditionally grown in the North Eastern Region, but also have great sustainable economic potential if up scaled with appropriate packages of good farming practices that could address the livelihood and food security needs of the people of the hilly regions.

This write-up provides information on the background, season, climate, ground preparation, seed selection, seed treatment, preparation of organic manures and their application, pest and diseases affecting the crops, the control of diseases with organic measures, harvesting, etc. It also gives information on post harvest management, biodiversity management, habitat management, etc., for better farming practice. Above all, the document reflects the rich traditional experiences and practices of the farming communities.

We would like to place on record the sincere and dedicated efforts of our study team led by Dr. Vincent Darlong, Natural Resource Management & Extension Coordinator, whose untiring efforts are the results in this compilation. The team has made their best efforts to record and document farmers’ experiences in farming practices both within and outside our project villages by directly interacting with the lead farmers themselves. The team also realized the fact that there are great variations of farming practices even within the region. Obviously, this could be just the beginning of the long processes of documentation of ‘organic package of practices’ from North Eastern Region for
different crops. The support and contribution of other members of the project both at the PSU and DST are also sincerely appreciated.

In particular, we would like to express our gratitude to Dr. R. K. Pathak for his excellent moderation of the study with valuable inputs. The initial encouragement, coordination and cooperation received from Mr. Ajay Rastogi of FAO India are also thankfully appreciated. The support and cooperation received from the various institutions, government departments and the local communities, which enabled this study to reach its present form is also gratefully acknowledged. In addition, the generous cooperation received from NEPED, Kohima for documentation of large cardamom on the experiences of Nagaland is gratefully acknowledged.

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Programme Coordinator & Development Strategist
AGROLOGY OF NORTH EASTERN REGION

The North Eastern Region (NER) comprises the states of Assam, Arunachal Pradesh, Manipur, Meghalaya, Nagaland, Mizoram, Sikkim and Tripura. This region, which has a total geographical area of about 2.6 lakh sq km, constituting approximately 8% of the total geographical area of India, holds just about 4% of India’s total population. The region is bestowed with rich resources of soil, agro-climate, agro-biodiversity, forest biodiversity, wetlands, rainfall, flora and fauna. The vast areas of hills interspersed with fertile valleys represent agro-climates of unique diversity. While almost about 98% of the region’s boundaries are shared with neighbouring countries, only 2% is with mainland India. Agriculture in the hilly areas remained predominantly in the form of shifting cultivation. However, for a number of reasons, the agriculture of the region has remained backward and underdeveloped.

The topography of the region represents a mixture of valleys, hills and mountains, with altitudes ranging from near zero (the plains of the Brahmaputra and Barak valleys in Assam and the plains of Tripura) to 5000 metres and above (the northern alpine ranges of Arunachal Pradesh and Sikkim). More than two-thirds of the region is mountainous and hilly. Consequently, the climate of the region is also a mix of warm, tropical and humid in the valleys and lower altitudes, while temperatures drop to sub-zero in the alpine region. Most hill areas enjoy cool, sub-tropical climate throughout the year, though winter months can be quite cold. Rainfall is generally distributed fairly well throughout the region, starting from April–May through October. The annual average rainfall in Cherrapunjee, (considered to be the wettest place on earth), and adjoining Mawsynram areas in Meghalaya is 11,000–12,000 mm. Most of the rainfall is drained through the Brahmaputra and the Barak river...
drainage systems in Assam, while the Teesta is the main drainage river in Sikkim.

The region is also endowed with rich biodiversity of forest vegetation, crop species and wildlife. About 40% of the total flora of the country is represented in this region. The heavy precipitation, soil conditions and climate of the region are ideally suited to produce and support a whole range of plantation crops, spices, fruits, vegetables, flowers and herbs. Therefore, the region is home to a large variety of economically useful medicinal and aromatic plants, fruit and food producing trees, oilseeds, fodder, bamboo and canes, dyes and spices, orchids and other flowering plants. Ethnographically, the region is also very rich, with more than 400 large and small tribes and communities living in the region, having diverse languages and culture as well as indigenous knowledge systems.

The land tenure system in northeast India is unique. Besides the government holdings, most other lands are broadly under various systems of community ownership. Such ownership may be categorized as (a) land owned by the villagers or communities collectively; (b) land owned by the clans; (c) land owned by the chiefs; and (d) land owned by individual families. The underdeveloped agriculture of the region is often attributed to this peculiar land tenure system. Due to it’s varied ecological and geo-physical features, the land use or land utilization patterns remain fairly uneven – large areas being forests or forested land or rugged and steep areas (not available for agriculture). In fact, only 7.5% of the NER is reported as net area sown. The NER accounts for only 1.5% of grain production of the country, though about 80% of the population of the region is dependent on agriculture. In terms of crops and cropping patterns, besides food grain production, the NER has been steadily promoting the cultivation of various
horticulture and cash crops such as ginger, turmeric, arecanut, pineapple, large cardamom, passion fruit, oranges, etc., which grow very well in the lower altitudes and mid-hill ranges of the region. Shifting cultivation (locally known as jhum or jhumming) involving slash-and-burn for food grain and other crop production remains a characteristic of the region in the hilly areas, except perhaps in Sikkim.

Several crops are grown in the NER, depending upon the system of farming, food habits and climatic conditions. Cereals form an overwhelming proportion of about 85% of total gross cropped area. Rice is the most important cereal, both in the valleys/plains and in the hill areas, covering about 70% of total cultivated area. Besides maize and millets, other important crops, although covering lesser area, are potato, oilseeds (mostly mustard, rapeseed and sesame), cotton, jute, pulses, chilies, sugarcane, sweet potato, etc. Wheat cultivation is also increasing gradually. Fruits and vegetables occupy about 5–6% of the cultivated area. It may however be mentioned that 90% of the cultivated area is still monocropped and rain-fed; only about 10% of the cultivated area in the plain areas of Tripura, Manipur and Assam is under irrigation.

In the mid-hills (up to 900 m altitude) and tilla (local terminology for hillock) areas of the region, along with food grain production, areas under cash crop and horticultural crops are also increasing steadily. These include ginger, turmeric, arecanut, pineapple, orange, litchis, large cardamom, passion fruit, papaya, banana, guava, black pepper, cashew nuts, jack fruit, etc. In the high hills and montane areas (altitudes ranging between 900–2000 m), the most common fruits are plums, pears, peaches, apricots, apples, etc. Potato, cabbage, cauliflower, radish, carrots, beans, broccoli, etc., are some of the commonly grown vegetables. In these altitudes, maize and millet are also popular, while cash crops like
large cardamom also grow well in these altitudes. Beyond 2000 m altitudes, the predominant crops are maize, millet, cabbage and potato.

However, in the hilly areas of NER, the predominant system of agriculture continues to be shifting cultivation or jhum or jhumming. The practice involves slash-and-burn followed by cultivation of a mixed crop (sown by dibbling) for one or two years, after which the land is allowed to lie fallow or recuperate for a period of 3–5 years (or more), after which, the cycle is again repeated. It is reported that at any given time about 5–7% of the land in the hill areas of NER is under shifting cultivation, and about 40% of the forested portions of the hill areas have been affected by shifting cultivation at one time or the other. Due to the shortening of the jhum cycle and decreasing jhum productivity, many of the farmers are now adopting permanent cultivation with horticulture or cash crops. The various on-going interventions from the Government of India, as well as the State Governments of the NER are also aimed at stoppage of shifting cultivation and at creation of opportunities for permanent cultivation. The terraced method of farming is also an old practice in many hilly areas of the region, particularly in the Mao-Maram areas of Manipur, Angami and Phek areas of Nagaland and parts of Sikkim. Terrace development and terraced cultivation is also gaining popularity in large parts of the NER, particularly where local irrigation can be developed.

**Agro-climatic zones**

Based on the data available on various aspects of climate, topography and soil, and also on the basis of diverse crops and livestock species being maintained in various zones of the region,
the NER can be described under the following six broad agro-climatic zones¹:

- Alpine zone
- Temperate and sub-alpine zone
- Sub-tropical hill zone
- Sub-tropical plain zone
- Mild tropical hill zone
- Mild tropical plain zone

The alpine zone – which covers a large part of the Eastern Himalayas – falls in Sikkim and Arunachal Pradesh at an altitude above 3500 m and with an average minimum temperature of 0–2 °C, but often going below −10 °C. The major part of the area in the higher elevation remains snow-covered throughout the year. Rocky outcrops are common features of the alpine zone. The soil is acidic. Depending upon the altitude, the forest types range from conifers in the higher elevation to temperate evergreen in the lower areas. Junipers, pine, ferns, rhododendrons and wild strawberries are common. Conifers may also be found mixed with broad-leaf species at relatively lower elevations. No crop is cultivated in this zone due to extreme climatic limitations. However, the zone abounds in pasture lands, signifying its importance for transboundary migratory animals like the yak, sheep and mules.

The temperate and sub-alpine zone falls within the altitudinal range of 1500–3500 m and extends over Sikkim, Arunachal Pradesh (Tawang, Bomdila and Dibang valley), Meghalaya (Shillong plateau), Manipur (Mao, Maram and Ukhrul), Mizoram (Blue Mountain and adjoining areas) and Nagaland (Tuensang, Zunheboto, Phek and the higher areas of Mokokchung and Kohima). This zone exhibits wide variations in climate,

physiography and agricultural practices and is best described under two sub-categories, viz., (i) areas with a temperate climate and (ii) areas with a sub-temperate climate.

The typical temperate areas (mostly in Sikkim and Arunachal Pradesh) are characterized by snowfall during winter, which does not persist for long on the ground, but stays on the mountain peaks. Soils have high humus but are also highly acidic. The common plants are devdar, pines, firs, rhododendrons, orchids and varieties of medicinal plants. The farmers of the temperate zone generally do not practise jhumming, but common field crops are millets, maize, barley, wheat, potato, etc. Common fruits are apple, plum, peaches, pears, walnut, etc. The temperate zone harbours rich livestock with its abundant grassland.

On the other hand, the sub-temperate zone does not receive any snowfall during winter but experiences ground frost. Soils in this zone are red loam (Shillong plateau) to lateritic (Manipur, Nagaland and Sikkim). Plant diversity in the lower altitude forests of this zone is fairly high. Among the field crops, paddy is dominant. Other crops are potato, maize and millet. Varieties of vegetables like cabbage, carrot, cauliflower, broccoli, beet root, radish, etc., are also grown here.

The sub-tropical hill zone falls within the altitude range of 1000–1500 m. The zone is well distributed throughout the NER covering almost all the states, except Tripura and has a mild temperature and well distributed rainfall. The soils are generally loamy silt containing low to moderate organic matter with pH values of 5.0–6.5. The zone has very rich forest species of trees, herbs and shrubs, and also ferns, orchids and epiphytes. Major crops grown here are rice, maize, wheat, mustard, castor, soybean, pulses, ginger, turmeric, beans, etc. The important fruits are citrus, pineapple, plums, pears, etc. All types of vegetables are also grown.
in this zone, including potato, cruciferous and cucurbitis. Both shifting cultivation and terrace cultivation are common.

The sub-tropical plain zone is confined to areas within the altitudinal range of 400–1000 m. Important examples are the Imphal valley of Manipur, the Bhagti valley of Nagaland and the Umkiang area of Meghalaya. The zone is characterized by highly intense agricultural practices. It has warm summers and cool winters. Paddy is the most important crop here with a fairly well-developed irrigation system (Imphal valley of Manipur). Other crops are pulses and oilseeds. Fruits grown here are mango, lemon, guava, banana, etc. Areacanut also grows well in this zone. Winter vegetables are also commonly grown.

The mild tropical hill zone falls within the altitudinal range of 200–800 m spread over Meghalaya (major part of the Garo hills, southern part of Jaintia hills and northern part of Khasi hills and Ri Bhoi district), Manipur (Jiribam area), Nagaland (Dimapur and Ghaspani), Assam (parts of N.C. hills and Karbi Anglong), Tripura (Jampui hills) and Sikkim (mostly southern parts). Summer is hot and humid here. Soils are sandy loam to clayey loam and acidic in reaction with high iron content. Most forest species are evergreen and deciduous. Bamboo and canes are common here, besides medicinal herbs and shrubs. Rice is the most important field crop, grown both in jhum under rain-fed conditions and in the valleys. Maize, millets, wheat, pulses, beans, etc., are also grown. Important fruits are mandarin orange, pineapple, banana, papaya, litchi, etc. Medicinal plants, tea, coffee, cashew nuts, arecanuts, etc., are commonly grown here. Shifting cultivation is the common land use system in this zone.

The mild tropical plain zone covers most of the remaining areas of the NER extending over the plains areas of Assam, Tripura, Arunachal Pradesh, Nagaland and Meghalaya within the altitudes of
200 m. Topographically, this zone has small hillocks called *tilla* interspersed with flat or valley lands called *lungas* as in Tripura. *Jhum* is also common here. Paddy is the main crop grown under both irrigated and rain-fed conditions. Other crops are oilseeds, sugarcane, fibre crop (jute), potato, sweet potato, etc.

Pineapple is one of most important horticultural crops. Other fruits are litchi, mango, banana, jackfruit, and lemon. Arecanut and betel leaf are also widely grown. Cashew nuts, tea, coffee, rubber, coconut and dates also grow widely.

The crops selected for the package of organic practices include arecanut, ginger, pineapple, large cardamom and passion fruit.

Of these, arecanut, ginger and pineapple can be considered traditional crops of the region, while large cardamom and passion fruit, although growing in abundance in the region, were not economically exploited until recently. Wild cardamom occurs naturally in the region; passion fruit grows in the hills of Mizoram, Nagaland and Manipur as home garden fruit.

However, introduction of large cardamom and economic exploitation of passion fruit chiefly occurs in Sikkim and Nagaland, while passion fruits have been growing as one of the home garden crops in the hills of Manipur and Mizoram.

These crops have been selected due to the following considerations:

a) These crops are generally considered the most common traditional crops in the hilly areas of the NER, of which farmers have good cultivation and farming knowledge. On the other hand, crops like passion fruit have been gaining popularity because of their high nutritional value together with good economic returns. Similarly, cultivation of large cardamom has been gaining popularity in the agro-forestry practices of the region as the crop grows well along with existing trees and also has good economic potential.
b) Women play a dominant role in the upland farming activities of the NER, especially in the cultivation of the crops selected for the present study. Therefore, the present study not only reflects the traditional knowledge of the farmers in general, but also the knowledge of women farmers in particular. The package is generally expected to consolidate the knowledge of the women farmers of NER, and also to facilitate the use of this knowledge to upscale their economic opportunities.

c) Since the past few decades, the Government of India, as well as the State Governments of the NER have been promoting the cultivation of these crops as priority activities in the rehabilitation and resettlement of shifting cultivators (locally known as jhumias) in the NER. This policy and patronage has helped to upscale the cultivation of these crops and therefore it is considered most appropriate that the cultivation package of practices of these crops, which continues to be ‘organic’ by tradition (meaning minimum or no application or use of chemical pesticides or fertilizers) in most upland areas of NER, is properly documented.

d) Two major externally funded projects in the region, viz., (a) NEPED in Nagaland (funded originally by the Canadian Government), and (b) NERCORMP (funded by IFAD and GoI) have also extensively promoted the cultivation of these crops through a bottom-up approach of the community resource management plan whereby the communities/farmers themselves prioritized these crops as preferred species for cultivation in areas under shifting cultivation. Hence, it is appropriate that these crops were selected for the packages of organic practices by which the knowledge of the farmers is consolidated and disseminated, and also new information is added from other parts of the country.

e) Since these crops have high potential for rural livelihoods and economic transformation, knowledge of the ‘package of organic
practices’ together with up-scaling of the ‘organic’ cultivation of these crops can further enhance farmers’ livelihoods and economy in the NER. Moreover, these commodities continue to have high market demand.
A living soil is the basis of organic farming. A live healthy soil with proper cropping patterns, crop residue management and effective crop rotation can sustain optimum productivity over the years without any loss of fertility. Organic farming envisages a comprehensive management approach to improve soil health, ecosystem of the region and quality of produce. It includes all agricultural systems that promote environmentally sound production of food and fibres. These systems take local soil fertility as a key to successful production by respecting the natural capacity of plants, animals and the landscape; they aim to optimize quality in all aspects of agriculture and environment.

A living soil can be maintained by continuous incorporation of crop and weed biomass, use of animal dung, urine-based manures (FYM, NADEP, Vermi, BD, MM composts), biofertilisers and bioenhancers *(amrut pani, cow pat pit, BD-500, beejamrut, jeevamrut, panchagavya)*, special liquid formulations (vermiwash, BD-501, BD-liquid manures) in crop duration.

In general, if the soil is fertile and appropriate varieties are sown, the plants usually do not suffer infection from pests or diseases. If these do occur, many options are available for their effective management. These include sprays of BD-501, BD liquid pesticides prepared from cow dung, cow urine mixed with certain organic materials and other formulations.

In phosphorus (P) deficient and acidic soils, some quantity of mineral grade rock phosphate and lime can also be used through compost or applied directly on the field.

The management of appropriate habitats for the sustenance of different life-forms is an essential component of organic farming. This can be achieved by maintaining crop diversity in the first place.
and by maintaining a wide variety of trees and bushes as per climatic suitability. In the plains, for a 10-acre farm, the suggested combination is at least 5–6 neem trees, 1–2 tamarind, 2 gular, 8–10 ber bushes, 1–2 aonla, 1–2 drumstick and 10–15 wild bushes. Major and minor plots should be separated by a bund, approximately 1.5 m wide, which should be planted with *Gliricidia*. Lops from these trees will provide adequate quantities of biologically fixed nitrogen. A 400 m long *Gliricidia* strip (1 ha boundary) can provide up to 22.5 kg N/ha from the third year onwards and up to 77 kg N/year by the seventh year. In the higher altitudes (above 800 m) of the NER, particularly in the states of Nagaland, Manipur, Arunachal Pradesh and Sikkim, many farmers grow alder trees (*Alnus nepalensis*) in the fields. This multipurpose tree is of great ecological and economic significance. It is not only nitrogen-fixing, but leaves can be used for fodder and mulching, while the branches can be used as fuelwood and construction material as the tree coppices very well.

These trees and bushes not only ensure nutrients from the air and from deep soil layers but also add diversity to the nutrients and provide shelter and food to a wide variety of birds, friendly insects, pollinators and pest predators. There may be some loss of productivity due to the shading effect, but that loss will be compensated with a reduced pest problem and the creation of a natural biological pest control system. Ecological diversity is an essential component of a successful organic farming system. It is also important to manage wildlife habitats as an integral part of organic farms. This includes areas such as banks, hedges, ponds, pasture areas and scrub land.

**Converting soil to organic:**

**Kharif season**

For effective results, the process of converting a field to organic should start with the *kharif* season. With the first monsoon showers, plough the field lightly and apply 4–5 quintals of
NADEP-vermi/BD compost with 50 kg rock phosphate and 5 kg each of azotobacter and PSB per ha and mix well with soil. Apply 500 litres of *amrut pani* or *jeevamrut* per hectare area. This can be accomplished by sprinkling the solution over the soil surface during mild showers. Select three types of leguminous crops of different durations for sowing in strips. They could be *moong* (60 days), cowpea, soybean (120 days) and pigeon pea (160 days). After every four rows of pigeon pea, sow one row of maize/millets/Job’s tears (*Coix lachryma-jobi*). Before sowing, seeds must be treated with 300 gm of appropriate *rhizobium* in the case of legumes and with *azotobacter* in the case of maize/millet/s/Job’s tears per 10 kg of seed.

After 20–25 days, apply a second dose of *jeevamrut* @ 500 l/ha along with irrigation or sprinkle over the wet surface after the rains. *Moong* will mature in 60 days. Harvest the pods and use *moong* residue as mulch around the pigeon pea plants. This mulching will conserve moisture and provide nutrients to pigeon pea at the grain formation stage.

*Cowpea*/*soybean* will mature in 120 days. Collect the pods and spread the residue in the empty spaces. This can provide about 12–15 quintals of green leaves. Allow the pigeon pea to shed all the leaves in the field and cut the bushes for harvesting. Spray sufficient quantity of *jeevamrut* over the crop residue and mix with the soil.

**Rabi season**

Take up any short to medium duration crop. Incorporate the residue in the soil by ploughing and apply 500 litres of *jeevamrut*. In case the farmer again intends to grow legumes (such as gram, green gram or lentil), there is no need to add any other manure, but if it is a cereal crop, then preferably intercrop it with wheat-mustard-gram or wheat-mustard-safflower. Add 4–5 quintals of compost plus 5 kg of PSB/ha and before sowing the seeds treat these with *beejamrut* and *azotobacter/rhizobium* biofertilisers.
Apply two doses of *jeevamrut* after 25 days and 50 days of sowing along with irrigation water (use a water pump if irrigation facilities are not available). After the harvest, remove only the grain and leave the residue in the field as mulch to protect the soil from the harsh summer. If irrigation is available, then grow one *moong* crop. In this way, by the next rainy season, the soil is ready for regular crops.

However, these practices are suitable only in the plains areas of the region where cultivation is by means of ploughing and irrigation can also be provided. Hill agriculture is devoid of ploughing and depends on rain-fed cropping practices and hence these practices may not be suitable. Terrace fields with irrigation facilities may be brought under these practices with suitable local modifications for *kharif* or paddy cultivation; no *rabi* or winter crops are generally cultivated in terraces in the region. However, with improved science and technology along with enhancement of water availability, there may be opportunities for promoting winter crops in the lower altitude terraces in the near future.

**Selection of crops**

In organic farming, the following principles may be kept in mind for optimum output of this farming system:

a) Mono-cropping should be avoided and preferably 2–3 crops should be grown together. If for any reason it is not possible to grow mixed or intercrops, then grow different crops in adjacent plots to maintain diversity.

b) At any given time legumes must occupy at least 30% of total cropping area. The legumes are nitrogen-fixing and can also be a good source of mulching from the crop residue.

c) High yielding varieties require high nutrient inputs; they should be replaced with improved varieties suitable for organic management.
d) The same crop or same cropping sequence should not be repeated in the same field in two consecutive seasons/years (except for some legume crops such as moong or cowpea) and the field must be rotated every 2–3 years.

e) High nutrient demanding crops such as potato, radish, ginger, etc., must be preceded or followed by legumes or grown as intercrops in a three-year rotation.

Field preparation

Spread the crop residue over the soil and sprinkle 500 litres jeevamrut/ha. Mix the residue in the soil with a rotavator or with the aid of a bullock-drawn plough. While spreading crop residue ensure that one third of it is from a legume crop. Maintain optimum moisture in the field. After two weeks, apply 4–5 quintals of compost, 5 kg of PSB and 500 litres of jeevamrut. If required, 300–400 kg of rock phosphate can also be applied along with compost. In acidic soils, application of lime @ 100 kg/ha is also beneficial.

From the third year onwards, lops of Gliricidia will be available in plenty. These should be used as green leaf manure in compost or as mulch material. For nutrient demanding crops grown in the rabi season, a mixture of chicken manure and crushed oil cakes can be used @ 1,000–1,500 kg/ha in addition to the above treatment. In the plains and lower altitude areas of the NER, besides Gliricidia, other plants that can be grown are sajna or drum stick (Moringa oleifera), arhar shrub/pigeon pea (Cajanus cajan), tree bean (Parkia javanica or Parkia roxbyghii), mulberry (Morus alba) bohemia, Albizia procera, etc. In the higher altitudes, the most common multipurpose tree is the alder (Alnus nepalensis), which acts as a wonder tree for the upland farmers.

Seed treatment

Beejamrut or white anthill soil and cow urine in combination with rhizobium/azotobacter/biofertilisers are good seed treating agents.
In the case of root/foot rot and ‘damping-off’ disease-infested soils, use of *Trichoderma viride* inoculants and azotobacter in double dose has been found to be highly effective. The seed may also be soaked in diluted cow urine or cow urine plus *agnihotra*. In wilt-infested soils, use of azotobacter in double dose has been found to be highly effective. In upland areas, many of the communities traditionally treat the paddy and other seeds with a mixture of ash and mature forest soil before sowing in the *jhum* fields, which is reported to ensure better germination and also protection from both infestation as well as birds foraging on these seeds.

**Sowing**

Select a right combination of 2–4 crops and some random trap crop plants in order to maintain diversity and to check pest attacks. Some common combinations for the plains and lower altitudes of the region are:

**Kharif**

- Maize/millets, pigeon pea, moong/cowpea
- Pigeon pea, moong/cowpea, maize
- Pigeon pea, soybean, maize
- Maize, moong, soybean/cowpea

**Rabi**

- Wheat, mustard, gram
- Wheat, mustard, safflower
- Moong, tomato, mustard
- Vegetable crops (potato, cabbages, cauliflower, etc.) with moong or green pea in between.

In the higher altitudes of northeast India, such as Meghalaya (Khadi hills) and Arunachal Pradesh (Bomdilla and Tawang), the winter months are severe. Hence, most crops are grown during the summer or monsoon season. The most common combinations of cultivation in the higher and mid altitudes of the Khadi hills in Meghalaya are:
• Potato, cabbage, green pea/french bean
• Potato, cabbage, french bean/green pea
• Cabbage, cauliflower, french bean/green pea
• Tomato, cabbage/cauliflower, bean/pea
• Carrots, tomato, cabbage, beans/pea
• Cabbage, cauliflower, radish, bean/pea
• *Flemingia vestita* (locally called ‘sohphlang’ in the Khasi hills) rotated with maize or vegetables.

However, in practice, the farmers rotate these crops on the same plots or plant these crops in small plots in the same area rather than growing them as a mixture on the same plot. In the drier periods, the most common vegetable combination is mustard leaves.

In many parts of Nagaland and the hill areas of Manipur, besides the usual crop combinations in shifting cultivation areas, the popular combinations of crops in the alder-based farming systems are as follows:

• Paddy, maize, velvet bean, etc.
• Maize, Job’s tear, millet, velvet bean.
• Kollar bean (rajma), maize, soybean, etc.
• Potato, cabbage, soybean, french bean, etc.

**Contamination control**

The following measures can minimise contamination from outside and within the farm:

a) If neighboring fields are non-organic, a buffer zone should be maintained. The height of the buffer crop should be twice the height of the organic crop and the width of the buffer should be around 25–50 ft. When chili is grown as the organic crop, castor or agate (*Sesban*) can be grown as the buffer crop. The crops from the buffer zone should be sold as non-organic.

b) If the farm is under conversion, equipment used in these areas should be well cleaned before it is used for organic production.
c) Products based on polythene, polypropylene and other polycarbonates may be allowed to cover protected structures, insect netting, nursery, drying, etc., but these materials should not be burnt or buried in the soil after use.

**Processing**

Processing technologies like solar drying, freeze-drying, hot air chambers are permitted. Irradiation of agricultural produce is not permitted. No synthetic additives/dyes may be added during processing.

**Packaging**

For packing, recyclable and reusable materials like clean jute bags should be used. Use of biodegradable materials may also be encouraged. Unnecessary packaging material should be avoided. Organic and non-organic products should not be stored and transported together except when labelled.

**Certification process**

Certification of organic farms is required to satisfy consumers that the produce is totally organic. The certifying agency conducts an inspection and confirms that the minimum requirements prescribed for organic agriculture are being fully met by the farm and that the produce has been grown organically. Certification by any agency includes the following programmes:

1. Certification Attested by the certification manager
2. Inspection Done by an inspector
3. Adopting standards Attested by the quality control manager

Certification by an independent agency of a farm as ‘organic’ indicates transparency of operation and improves the image of organic farming. It also protects the interests of both producers and consumers.

Certification programmes vary from country-to-country or region-to-region and also among certifying agencies themselves. In India, APEDA, an apex organization under the Ministry of
Commerce, has formulated a National Programme for Organic Production (2001) and also developed a logo, 'India Organic'. APEDA has also accredited a number of organizations for certifying organic farms. In recent years, a number of Indian certifiers (a few of them supported by international certifiers) are also engaged in certification activity.

Certification being expensive, technical, time-consuming and probably beyond the reach of the common Indian farmer, other schemes such as Internal Control Systems (ICS), Participatory Guarantee Systems (PGS) and Producer Companies (PC) are being viewed as better options to be promoted in the country.

The present study

The present study is largely based on farmers’ practices and knowledge, gathered through field studies of leading/successful farmers in the NERCORMP and NEPED project areas, particularly covering the states of Assam (hill districts), Manipur, Meghalaya and Nagaland. Additional information has also been collected from ICAR and concerned state government departments of the region. Secondary information was obtained from relevant publications. The expert moderator of the study (appointed by the FAO) provided the final inputs as considered appropriate.
ARECANUT

BACKGROUND TO THE CROP

Arecanut or betel nut or supari (Areca catechu) is an important member of the family Araceae. It is chewed, both as raw nut and after processing. While ripe arecanut is favoured in Assam, Kerala and parts of West Bengal, dried arecanut (chali) is popular in the western and northern parts of India. Processed green nut (kalipak) is the choice of people living in Karnataka and Tamil Nadu. Owing to its medicinal properties, arecanut is used in treating leucoderma, cough, fits, worms, anemia and obesity. Arecanut is of utmost importance in many religious ceremonies, particularly among the Assamese (Assam) and Khasis (Meghalaya) in northeast India.

The tannins in arecanut are being used for dyeing clothes, ropes and for tanning leather. Plastic, hard board and craft paper of satisfactory strength can be made from its husk. The leaf sheath is a good material for making disposable cups and plates, polyboard, decorative veneer panels and picture mounds. The stem or trunk of arecanut is also good construction material in the rural areas. The hard dried endosperm of ripe and unripe seed called the ‘nut’ is chewed as a narcotic and indeed outrivals chewing gum in popularity on a world basis. Arecanut may be chewed alone, but the usual practice is to wrap small slices or pieces of the nut in a leaf of betel vine (Piper betel) to which a dab of slaked lime is added and chew the ‘pan’ slowly. The chewing causes continuous salivation and the saliva turns bright red, hence ‘the bloody gouts’ that spatter roads, pavements and corners of buildings in places where betel is chewed. The quid is not generally swallowed, but eventually spatted out; however, it is commonly swallowed among the Khasis of Meghalaya. Tobacco, cardamom, clove, dried coconut, ginger, etc., may sometimes be included in the quid.
The habit of chewing the betel quid has spread more slowly than smoking tobacco, possibly because several materials are used in its preparation. It has prominent place in local religious observance and mythology. It is believed to make the teeth strong and prevent their decay, but blackens them and eventually grinds them down. Arecanut is systematically cultivated only in India.

**Climate and area of distribution**

Areca nut is basically a tropical plant commonly found in most parts of the NER, which grows well up to 1000 m. Its quality is affected adversely at higher attitudes. The crop flourishes well at temperatures ranging from 14–36 °C. Extremes of temperature and wide diurnal variations are not conducive for desirable performance. Wet tropical and humid climate is considered to be most suitable for its successful cultivation and growth.

In northeast India, arecanut is extensively grown in Assam, Tripura and in the foothills of Meghalaya. It also grows well in the foothills of Mizoram, Nagaland, Manipur and Arunachal Pradesh. Areca nut is an important component of multi-storied cropping systems and considering its addictive properties, organic production of the crop will go a long way in improving the economy of the region. In other parts of India, arecanut is mostly grown in Kerala, Karnataka, West Bengal and Tamil Nadu.

**Growing season**

The best months for planting arecanut are during the pre-monsoon period of May–June with the onset of the monsoon. It can also be planted in September–October provided there would be some sources of water for irrigation.

**Soil**

In the foothills of northeast India, arecanut is planted in hilly loamy soil with well-drained slopes of gentle gradients. In plains areas, where it is planted on flat lands, water stagnation must be avoided.

**Crop duration**

Under the best conditions, arecanut palms will flower in four years. However, it starts bearing fruit on an economic scale only 7–8 years
after its planting. The economic viability of the crop is 15 years on an average, though in the foothills of Meghalaya, many of the plantations are as old as 30 years or more. The time taken from full bloom to maturity of the fruit ranges from 35–47 weeks. However, it depends on the prevailing temperature of the area. Being monocot, arecanut is always propagated by seeds. Seedlings are raised in nurseries.

**Biodiversity management**

*Areca catechu* is the only domesticated species in the genus. In northeast India, the arecanut is specially valued culturally by the Assamese and Khasis. The plant is considered to be as old as the history of the tribes or communities in this region. However, from the perspective of biodiversity management within the arecanut plantation, the general practice and experience in the region has been that fruit crops such as papaya, coconut, mango, citrus and also banana are intercropped with arecanut without losses in soil fertility and productivity. In fact, these fruit trees provide shade and enhance the moisture retention capacity of the soil. The fruit trees also attract insects which in turn act as pollinators for the arecanut palm.

**VARIETIES**

The only important variety grown in Meghalaya is *Kahikuchi*, which is also a common variety grown in Assam. However, another variety, which is most preferred by the locals in Meghalaya, is popularly known as ‘*Dawki Kwai*.’ This variety is extensively grown in the foothills of the east Khasi hills (Dawki and adjoining areas) and Jaintia hills (Ratcherrra and Umkiang area) of the state. In other parts of India, the main cultivars are known as *Mangala, Sumangala* and *Sreemangala*, though there are also known cultivars from the localities of their origin such as *Mohitnagar, Calit* and *Sasi*.

**Mangala**: It has a number of desirable characters, such as early fruiting, higher yield (10 kg ripe nuts/palm/year) and quicker
stabilization of production. The variety is semi-tall and bears nuts with good chewing and market quality.

**Sumangala (VTL-11):** This variety was introduced into India from Indonesia. The palm is tall and partially drooping. Under ideal conditions, the palm flowers in 4–5 years. The colour of the ripe nut is deep yellow to orange and oblong to round in shape. It gives an average yield of 17.25 kg of ripe nuts, per palm, per year, at the age of 10 years.

**Sreemangala (VTL-17):** This variety was introduced into India from Singapore. The palm is tall and partially drooping. It comes to flower in the fifth year. It is a high yielding variety, with an average yield of 15.63 kg per palm per year. The ripe nuts are oblong to round in shape and have a deep yellow colour.

**SEED**

**Sources of seed**

There are a few local varieties known by the name of the place where they are grown. For example, *Kahikuchi* is a local variety grown in Assam that is also suitable for the other NER. The Central Plantation Crops Research Institute, Regional Station, Vittal, Karnataka is also a reliable place for procuring seeds for plantation.

**Selection of mother palm**

The importance of genetically superior planting material in a perennial crop like arecanut needs no emphasis. One of the established methods of selecting genetically superior seeds is to select palms, which have a history of possessing good characteristics. Of the many mother palm characteristics studied, age at first bearing and percent nut-set have been found to correlate with yield and high heritability. Therefore, collection of seed nuts should be confined to palms which bear early, as well as to those which give high percentage of fruit-set.

**Selection**

From the selected mother palms, only fully ripe, medium-sized nuts should be selected from middle bunches. All nuts that are
undersized, malformed or from the tips of bunches should be avoided for seed purposes. About 25% of the nuts in a bunch are light in weight and they have less germination potential. So heavier seed nuts should be selected for better germination and vigorous seedlings. In practice, nuts which float vertically with calyx end pointing upwards when placed in water are preferred to those that float horizontally or in a slanting position.

**Treatment**

No formal treatment of seeds is done in NER prior to planting. It is also not necessary to dry nuts before planting to ensure good germination but dipping in cattle dung solution or water before planting produces better seedlings. Efficiency of nut treatment with *amrut pani/cow pat pit/jeevamrut/panchgavya* needs to be assessed.

**FIELD PREPARATION**

**Sowing methods**

Areca nut palms need adequate protection from exposure to the south-western sun as they are susceptible to sun scorch. Proper alignment of the palms in the plantation will minimise sun scorching of the stem. In the square system of planting at a spacing of 2.7 m x 2.7 m or 2.7 m x 1.8 m, nearly 1,370 and 2,080 seedlings per hectare, respectively, can be accommodated; the north-south line should be deflected at an angle of 35° towards the west. The outermost row of plants on the southern and south-western sides can be protected by covering the exposed stem with areca leaves or leaf sheaths or by growing tall and quick growing shade trees such as jackfruit, banana, etc. In other parts of India, intercropping with neem, casuarina or pongamia is most common.

**Nursery preparation technique**

**Primary nursery**

Nursery beds of 90 cm width and of convenient length are prepared for raising seedlings. The nursery soil should be a mixture of sand, garden soil, leaf mould and FYM (well decomposed). The selected seed nuts are sown immediately after harvest and up to 80 days after
harvest, 5 cm apart, in sand beds, under partial shade, with their stalk ends pointing upwards. Sand is spread over the nuts just to cover them. Also, it is a practice in some areas to sow the seeds in baskets mulched with straw or tied in banana leaf sheath or gunny bags. The beds may be watered daily. Germination commences about 30–40 days after sowing and the sprouts can be transplanted to the secondary nursery when they are about three months old. At this stage, the sprouts might have produced two to three leaves.

**Secondary nursery**

Secondary nursery beds of 150 cm width and of convenient length are prepared for transplanting the sprouts. The sprouts are transplanted at a spacing of 30 cm x 30 cm with the onset of the monsoon. Partial shade to the seedlings should be provided during summer through a *pandal* or by growing banana. In the Khasi Hills of Meghalaya, secondary nurseries are also raised in open areas. Care should be taken to drain the nursery beds during monsoons and to irrigate them during the dry months. Weeding and mulching should be done periodically. Seed nuts can also be sown in polythene bags (25 x 15 cm size, 150 gauge) after filling the bags with potting mixture containing seven parts of loam or top soil, three parts of dried and powdered FYM and two parts of sand.

**Selection of seedlings**

Seedlings are generally ready for transplanting when they are 12–18 months old. For planting, lanky and dwarf seedlings are rejected. Seedlings with maximum leaves (five or more) and with a minimum height are selected. The selected seedlings should be removed with the ball of earth carefully and without injuring the roots, to enable them to establish firmly when transplanted. If they are raised in polythene bags in the secondary nursery, they can be transferred without any difficulty.
**Main field preparation**

Before the onset of monsoon, pits of 90 x 90 x 90 cm are dug and the pits are filled with a mixture of topsoil, powdered cow dung and sand to a height of 50 to 60 cm from the bottom. The seedlings are planted in the centre of the pit, covered with soil to the collar level and pressed around. A shade crop of banana can be raised to give protection to the seedlings from sun scorch. Rural communities usually apply leaf-compost in place of cow dung.

**MANAGING SOIL FERTILITY**

Growing of green manure crops at the onset of monsoon will help suppress weed growth, prevent soil erosion and add large quantities of organic matter to the soil. Cover crops such as Munosa invisa, Stylosanthes gracilis, Pruraria gavanica and Calapogonium muconoides have been found to be suitable for arecanut gardens. The cover crops may be sown in the months of April and May and the green matter may be cut and applied to the arecanut palms. In most parts of the foothills of northeast India, arecanut is cultivated as one of the agroforestry species and the weeded vegetation is used as mulch.

**Nutrients**

Adequate supply of plant nutrients in the soil throughout the life of the crop is essential to get high yields. Hence an annual application of about 1–2 kg each of green leaf and compost or cattle manure per bearing palm is recommended. Green leaf and compost can be applied as a single dose in September–October. Irrespective of the age of the plant, a full dose of green leaf and compost or cattle manure should be applied from the first year of planting itself. The green leaf and compost or cattle manure may be broadcast around the base of each plant after weeding and mixed with the soil by light forking. Or it may be applied in basins around the palm, usually dug to a depth of 15 to 20 cm, and at 0.75 to 1 m radius. In acidic soils, the required quantity of lime may be forked in during the dry months.
Most of the arecanut plantation areas in the region are rain-fed. Irrigation of arecanut plantation, at least in northeast India, is uncommon. However, it is observed that in some pockets of the region, farmers occasionally carry out manual irrigation by connecting their fields with upstream or nearby perennial streams, for watering the plants during the dry season. The practice is more common when the plants are still small.

**Quality**

As the source of water is from seasonal rainfall and as well as perennial streams, the assessment of the quality may be carried out as per the norms and guidelines of permitted organic package of practices, if any.

Areca nut grows best in monsoon climate with a well-distributed rainfall pattern. It requires soils with fairly high moisture content throughout the year, but cannot tolerate stagnant water. Therefore, adequate drainage should be provided during the monsoon since the palms are unable to withstand water logging. Drainage channels should be 25 to 30 cm deeper than the bottom of the pits to drain excess water from the plot.

**Conservation technique**

Cover crops have been found to be most suitable for arecanut gardens. The crops that can be grown successfully in arecanut gardens without loss of arecanut yields are banana, cocoa, pepper, pineapple, betel vine, elephant foot yam, tapioca, dioscorea, sweet potato, ginger and turmeric. Nutmeg and clove can be also grown in between four palms on alternate rows. Common plants grown with arecanut in the NER are banana, papaya, pineapple, etc. Even jackfruit is planted occasionally.
**Crop protection**

**Weeds**
Weeding should be done periodically to keep the garden clean. Inter-cultivation is done regularly to remove weeds. Weeding is carried out almost twice in a year during the first 3–4 years of plantation in northeast India, and thereafter once in 6–7 months, usually in the months of July–August. The weeds/grasses so removed are spread in and around the arecanut tree as mulch.

**Animal grazing**
In most parts of northeast India, arecanut plantations that are near homesteads are provided with some sort of fencing to minimise damage from animals. Alternatively, strong ‘social fencings’ are created by way of strict enforcement of regulations to stall-feed animals or have them tied with a rope away from plantations.

**Fire**
In the foothills of northeast India, where accidental fire could be common during the dry season of March–April, communities have well-organized community-based fire management systems which are basically preventive and also punitive. Therefore, most arecanut growers prefer to grow arecanut along with other perennial horticulture species so that fire accidents are minimal.

<table>
<thead>
<tr>
<th><strong>DO’S AND DON’TS IN ARECANUT IPM</strong></th>
<th><strong>DO’S</strong></th>
<th><strong>DON’TS</strong></th>
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<tbody>
<tr>
<td>Cultivate recommended varieties only.</td>
<td>Do not grow varieties not suited to the region.</td>
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<tr>
<td>Sow seedlings in recommended width and depth (spacing) for better establishment.</td>
<td>Avoid too thick seedling placement or overcrowding.</td>
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<tr>
<td>Provide timely irrigation (if available).</td>
<td>Do not expose to water stress at critical stages of growth.</td>
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<td>Use biofertilisers as per soil test recommendations.</td>
<td>Avoid imbalanced use of fertilisers.</td>
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<tr>
<td>Release natural enemies only after noticing adult stage or as per field observation.</td>
<td>Do not use chemical pesticides.</td>
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<td>In case of nocturnal pests, it is that recommended organic biocides are sprayed when such pests appear.</td>
<td>Do not use pesticides/biocides unless absolutely required.</td>
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</tr>
</tbody>
</table>
PROBLEM INSECTS

Mites: Red mites (*Raoiella indica*) and White mites (*Oligonychus indicus*)

Mites are major pests in arecanut plantations and are commonly found in arecanut gardens all over the country. Mites are of two types – red and white – and they attack both seedlings and older plants. The under surface of the leaf infested by white mites looks as though it has been dusted with a fine white powder. This appearance is due to the leaf surface being covered by a fine white web in which the eggs are fastened. Red mites do not have such webs. The mites feed by sucking the sap of the leaf and gradually small areas of yellow patches appear on the leaf, which indicate the presence of these pests. These patches spread and finally the entire leaf dries up. Mites are most active in the dry season but their activity receives a setback immediately after the onset of the monsoon.

**Management**

- The heavily infested and dried leaves should be pruned, removed and burnt.
- The ladybird is an effective counter to the mites.

Spindle bug (*Carvalhoa arecae*)

This is another major pest that usually multiplies rapidly towards the close of the monsoon. Colonies of bugs consisting of pale yellowish green nymphs and reddish-brown or black and red adults live inside the top most leaf axil at the base of the spindle which fails to unfurl completely, often getting slightly twisted. The bug sucks the sap from the tender spindles. As a result, the spindle does not attain normal size. The affected leaves show numerous linear, dark-brown necrotic patches. Holes are formed. Severe infestation causes loss of vigour in the palms and subsequent death.

**Management**

- Maintain proper drainage in the plantation area.
- Uproot the heavily infested palm and burn it.
- Clean cultivation in and around the plantation area is also effective.
Inflorescence caterpillar (*Tirathaba mundella*)

This pest causes damage directly to the inflorescence. The adult moths lay eggs in the holes made on the spathe by slugs and earwigs. On hatching, the caterpillars get entry into the inflorescence through these holes and feed on the flowers inside, and clump the inflorescence into a wet mass of truss with the silky threads woven by them, and shelter therein. A trained eye can easily locate the inflorescence attacked by the pest. The affected spadices do not open and the punctures made by the slugs at their bases indicate the presence of caterpillars inside.

**Management**

- Affected spadices are to be forced open and slugs and snails have to be picked out and killed.
- Red ants act as a predator against this pest.

Root grubs (*Leucophilis lepidophora*)

Grubs are major pests in nurseries and old plantations. They are the larvae of black beetles, which affect older palms and reduce their vitality and yield. Grubs are known to attack and feed on the roots of arecanut palms. They eat away all the young roots and the stem at the collar, causing the death of the seedlings. They also attack older trees due to which the leaves turn to a sickly pale yellow colour and the yield is reduced greatly. Grub infestation is severe in neglected gardens where there is no proper drainage, or where intercultivation is not attended to and the area is overgrown with weeds.

**Management**

- Application of leaf mould and non-decomposed farmyard manure helps grubs to breed and spread. Thus, keeping the gardens clean, well-drained and free of weeds will reduce grub attacks greatly.
- In addition, application of pongamia cake at the rate of 2000 kg per hectare also helps to reduce grub attacks.
After applying a top mulch to loosen the soil, drench the infected area either around the base of the older plants or the entire affected nursery area.

In recent years, the arecanut crop has been affected by an unknown malady, which causes tender nuts to droop. These nuts when carefully examined show one or more pinprick-like marks on their surface. When cut open, the tender edible kernel shows brown discolouration. It has been inferred that the Pentatomid bug, hitherto unknown as a pest of arecanut, causes the damage. The adults are bronze-coloured with brown spots and are about 1.75 cm long. At the young stage, they are black with white spots on the legs. Both the adult and young bugs suck the sap from the endosperm of tender nuts and cause premature shedding. Unlike other pests of arecanut, this bug is directly responsible for loss of yields.

Drooping is severe during June, July and August, the time of the southwest monsoon. Once the endosperm begins to harden, the insects migrate to other hosts such as cowpea and bitter gourd. Significantly, many arecanut farmers who grow cowpea in their kitchen gardens report that the bugs readily migrate to this crop when the tender arecanut is not available.

Management
Vegetables like cowpea and bitter gourd should be closely watched for detecting the bug at its young stage. When noticed, the insects should be mechanically removed and destroyed.

The infection and spread of this disease is related directly to the incidence of heavy rainfall. The disease first makes its appearance just after the first monsoon showers and extends its stay throughout the monsoon period. A warm damp interval is always very helpful for its rapid development. It attacks nuts of all ages and if

Pentatomid bug
(Halyomorpha marmorea)

DISEASES
Fruit rot or koleroga or mahali
(Phytophthora arecae):
unchecked will extend to the crown of the plant ultimately bringing about its death.

The first sign of the disease is the appearance of patches of water-soaked areas or rotting tissue at the base of the nuts. The nuts darken and the patches enlarge and they begin to drop in large numbers. These fallen nuts soon develop a whitish mass all over. If unchecked, the disease may later invade the crown causing the leaves and bunches to die within one or two seasons. The disease is carried forward in the remains of infected materials lying in the gardens from year to year.

**Management**

- Spray 1% bordeaux mixture in 10 litres of water as a prophylactic spray just before the onset of the monsoon.
- Covering the bunches with polythene sheets in the month of June will also control koleroga to a considerable extent.

**Foot rot or anabe** *(Ganoderma luciderm)*

This disease is a major problem in regions with less rainfall. It has a wide range of 44 host species belonging to 34 genera from 18 families. The first visible symptoms of the disease are the yellowing of the crown and the dropping of the older leaves. Within three to four months the entire crown dries up. The disease usually affects the roots and the base of the palm. The affected roots begin to rot and become soft or brittle. Brown patches appear all round the base of the palm, exuding a brownish liquid. The interior of the stem at the basal region becomes discoloured and rotten, emitting a foul odour. The crown turns yellow and dries up. The healthy palms with heavy bearing are affected. At a later stage, tough, bracket-like outgrowths that are fructifications of the fungus grow out all around the base of the trunk.

Since, by the time of perception of the visible symptoms of the disease, that is, yellowing and drying up of the crown, the disease is already in advanced stage, no cure is generally possible. Therefore,
only preventive measures to check its further spread to the
neighbouring plants are advocated for adoption.

Management

- Immediately on detection, all the affected palms should be
dug up along with roots and removed from the garden and
destroyed.
- Treatment of the pits caused by the excavation of the
infected area by a trench about 30 cm deep, 10–15 cm wide
and about 75 cm around the infected palm is also advisable.
- Preventive measures consist of digging up of shallow trenches
around the base of surrounding palms all over the infected
zone, about 1 m away from the base of the palms and
covering them with the soil.

Yellow leaf disease
(Mycoplasma-like
organism)

Yellowing of the leaves begins in the inner whorl, gradually
spreading to the outer parts of the crown. Chlorosis is finally
observed on almost all the leaves in the whorl from the edges of the
individual leaflet to the lamina. Withering of the tips starts and
gradually spreads to the older portions of the leaf. The freshly
formed young leaves grow shorter and their lamina show unequal
growth and flaccidity. In some cases, wilting and shredding of the
leaves are also observed. Naturally, the nuts are also reduced in size,
and have a shrivelled appearance, with their kernels turning black.
There is a severe reduction in total yield. The stem of the affected
palm becomes spongy and friable, the conducting strands getting
destroyed. In advanced stages, the stem breaks off at the top. Roots,
however, are found to be normal. Yellowing of the leaves is not
uniform and appears in patches, which later may expand and form
necrosis.

The diseased condition of the crop is primarily due to poor
cultivation practices, lack of proper drainage and heavy loss of soil
nutrients.
Management

- Irrigation should be provided in summer wherever possible and moisture conservation measures, as given below, should be adopted.
- Mulching should be practised for effective conservation of moisture.
- The top soil should be loosened and the ground should be covered with leaf litter and decomposed organic matter.
- The physical condition of the soil should be improved by deep digging and by the addition of sand/organic matter.
- Adequate drainage should be provided, especially during the monsoon season.
- Phytosanitary measures should be adopted to control Anabe. The dead trunk along with the root system should be removed and burnt.
- The palm should be protected against sun-scorching of the stem by having it covered with arecanut leaves or by painting the trunk with lime slurry.

Bud rot (Phytophthora palmivora)

The infection from this disease starts at the crown and on the leaves, and spreads gradually to the tissues ultimately killing the bud. It commences as brown patches on the leaves and the growing spindle, and spreads inwards. The tender central leaves are affected and begin to rot and the disease slowly spreads into the central core resulting in the rotting of the growing bud and death of the plant.

Management

- Cut and remove all infected leaves.
- Spray of 1% bordeaux mixture, if done early, will help in checking further spread of the disease.
Inflorescence die back or button shedding (*Colletotrichum gloeosporoides*)

Button shedding preceded by dieback of inflorescence is a severe problem in arecanut plantations. The first symptom appears on male flowers and then spreads to the entire rachis. The affected female flowers drop. Button shedding is most severe in dry periods.

**Management**

Wood ash application is found to be effective.

**Beneficial insects**

The two most beneficial insects in arecanut plantations are (a) coccinellid beetles, which are predators of mites (*Raoiella indica*), and (b) red ants, which are predators of the inflorescence caterpillar (*Tirathaba mundella*).

**Physiological Disorders**

Sun-scorch or stem breaking

Protection of the arecanut stem from the hot afternoon sun in summer is important. Otherwise, due to the scorching effect of the sun, cracks appear which gradually enlarge into large splits. These cracks and splits are always found on the exposed western side of the palms. Since these splits weaken the stem, it breaks at these points with the heavy winds associated with the south-west monsoon. Generally, the heavy bearing palms suffer the most. Planting quick-growing tall trees on the south-western side of the garden to provide adequate afternoon shade will prevent the formation of sun-scorch. Till such shade-giving trees grow up, tie split areca leaves or areca leaf sheaths over the exposed area of the palms during summer to prevent sun scorch.

Nut splitting

This is another physiological disorder of universal occurrence. In almost all gardens, at least one tree or two will exhibit ‘nut splitting’ in well-grown young and healthy palms. The growth of the pericarp does not keep pace with the development of the kernel inside and this causes the splitting up of the pericarp at the distal end. The split nuts drop. Infection by bacteria and fungus of the exposed kernel after splitting renders the nuts useless. This has been found to be due to excess flow of cell sap into the inflorescence in these
very healthy palms. Hence, checking excess flow either by making some deep wound at the base of the spadix with a sharp knife, or just jerking down the spadix and thus jamming the cells at the base when the nuts are half grown, prevents splitting. Excessive nutrition and a long stretch of dry period followed by a sudden flush of watering may also result in nut splitting.

POST HARVEST MANAGEMENT

Harvesting

The bunch is harvested when the nuts are fully ripe. The end use is _chali_ or _kotapak_ (dried ripe nuts), commonly known as _supari_ (in Assam), _kwai_ (in the Khasi hills) and _kuva_ (in Mizoram). About 6–7 months old nuts, which are dark green and soft, are harvested to produce _kalipak_. One climber – accustomed to climb on arecanut palms – can harvest up to 100 palms at a stretch (in areas where the palms are planted in close proximity to each other as a monoculture) before coming back to the ground.

The harvested bunches are dropped to the ground or lowered by using rope or gunny bags. Ladders are also used for harvesting individual palms.

Cleaning

Cleaning of harvested nuts is usually done manually. The dirt, stalk end and other unwanted materials are removed by hand and the nuts are then rinsed or washed with plain water, after which they are dried in the sun and stored.

Drying

The stage of harvesting depends on the type of produce to be prepared for the market. The most popular trade type of arecanut is the dried nut known as _chali_ or _kotapak_. Fully ripe nuts – about 8–9 months old fruits having yellow to orange red colour – are best suited for the above purpose. Ripe fruits are dried in the sun for 35 to 40 days on a dry levelled ground. For drying and dehusking, fruits are sometimes cut longitudinally into two halves and sun dried for about 10 days, after which the kernels are scooped out and given a final drying.
Grading
Grading is done according to the purpose and use. Nuts with a thin husk and with an average weight of above 35 gm are considered to be best grade and they fetch a good price. Good grade nuts are sorted out manually. Uniform, mature nuts, free from surface cracking, sticky husk and fungal or insect infestation, naturally command a good price.

Packaging
Another form of processing is making kalipak. Arecanuts of 6–7 months maturity, with a dark green colour, are dehusked, cut into pieces and boiled in water of dilute extract from a previous boiling; a kali coating is provided and the nut is again dried. Kali is a concentrate obtained after boiling three to four batches of kalipak. Many varieties of scented suparis are now prepared by blending the dried, broken bits of arecanut with flavoured mixtures and packed.

Storage insects
Storage pests can be avoided by good management practices. Pest control measures inside storage areas or transport containers generally include construction of physical barriers. No serious pest problems have been reported from northeast India in the arecanut storage areas. The general practice is to store the nuts in gunny bags or in open godowns with good ventilation to avoid excessive dampness.

PROCESSING OF ARECANUT
Fermentation process
In northeast India, particularly in Assam and in the Khasi-Jaintia hills of Meghalaya, the nuts of the areca palm are fermented as a form of processing and considered to be a value added product. Fermented nuts fetch a good market price and people prefer these nuts as fermentation increases the taste quality compared to that of fresh/raw ones.

The fermentation process is done in many ways but usually it is carried out in a tank or pond. A tank of convenient size and depth of 6–8 ft is constructed, sometimes with brick and cement. In addition, a bamboo basket of size 6–7 ft length and diameter of 4–
5 ft is also prepared. In the Khasi hills, fermentation is also done in an impounded stream or rivulet.

The fermentation process begins with filling up the tank/pond to the brim with a constant source of water. Nuts of good sizes, orange red colour and fully mature are selected and filled in a bamboo basket that is submerged in the tank/pond. Sometimes, heavy stones are used to provide weight so that the basket is well submerged in the tank/pond. Water is allowed to overflow constantly but slowly throughout the process (in Assam, fermentation is usually done in still ponds). The fermentation process takes place over three to four months. Only an expert can visually judge when the nuts are fully fermented. The complete fermentation of nuts is achieved when the nuts become soft after dissolving the pericarp and when the fibrous mesocarp is exposed. Finally, these nuts are again graded and packed in the gunny bags and then sent to the market.

**Dehusking**

In processing tender nuts, dehusking is the first operation attended to. Dehusking means separation of the inner kernel from its covering. A curved blade with a sharp pointed tip fixed at the other end to a wooden board is used for this operation. Dehusking of arecanut is traditionally done by skilled manual labour with the help of a tool, which has a small, sickle-shaped pointed blade fixed onto a wooden handle. A simple device for dehusking arecanut, developed by CPCRI, Kasargod can also be used. The main advantage of this device is that any unskilled person can operate it. The output is about 60 kg dehusked nuts in the case of dried nuts and 30 kg in the case of green nuts, if one person operates the device for an eight hour period.
**Drying of nuts**

The dehusked nuts are dried in various ways for further processing. The drying process in rural India is primarily using sunlight. Drying of nuts is carried out either whole or in split form (half-split is the most common one).

**Arecanut products**

*Chali or kotapak*

These are nuts that are dried for 35 to 40 days and then dehusked. The features of a good chali are: (a) There should not be any immature nut; (b) they should be free from any surface cracking; and (c) they should be free from fungal and insect attack.

*Kali or kalipak*

This is a processed arecanut, common in Kerala and Karnataka. Here 6–7 months old nuts are used for the preparation of kali. Soft, tender, green but mature nuts are harvested and dehusked. Then they are cut into pieces of different sizes and boiled in water. On boiling, the water turns into a reddish brown liquid called kali, which has a glossy appearance and has better storage life once it is dried. The reddish brown arecanut, so obtained, is also called kali.

*Scented supari*

Both kalipak and chali are used for this preparation. Dried arecanuts are broken into small pieces and blended with a flavouring mixture. The flavour of the supari varies with region and is considered a trade secret.

**The husk**

The husk consists of numerous short staple fibres embedded in a matrix of parenchymatous ground tissue. The chief constituents are hemicelluloses, cellulose and lignin. It is the presence of the latter that prevents easy rotting of the husk. The husk is chiefly used as a fuel. It also makes good mulch, conserves moisture and also increases the water retentive capacity of the soil. Experiments have revealed that the husk can be used in the manufacture of hard boards, fibreboards, wool insulation, packing material and cushions.
Spathe
The outer whorl of the spathe is used for packing purposes. Also, some other fancy items like caps, meal plates and cups are prepared out of it.

Trunk
The hardness of the stem and the golden colour it gives to the finished products make it possible for many utility articles to be made from it. They are very strong and long-lasting. Stationery articles like scales, rulers, paper cutters, bookshelves and waste paper baskets made out of the trunk of arecanut trees quickly find a ready market. From its strong wood, items like baton sticks, walking sticks, ladle handles and plough shafts, as well as stools and threshing benches are manufactured. If the pith of the stem is removed, durable drainage or irrigation pipes can be obtained. If used whole, they make good fence posts. Covered with a coating of tar, the arecanut stems last long and serve well.

ORGANIC ARECANUT CULTIVATION
Case study
Stone Rynniaw, aged about 38, from Upper Nongkyndang village in West Khasi district of Meghalaya, is a successful arecanut cultivator. He started arecanut cultivation about ten years ago in 1995–96, though he up scaled his plantation only about six years ago. Today he has about 5,000 palms with an annual income of about Rs.20,000 from the sale of arecanuts.

His arecanut garden is located on a gentle slope with black loamy soil, which appears to be rich in nutrients. Originally the land was cleared by slash and burn method, and he intercropped arecanut with banana, papaya and lemon. He obtained the seedlings (about 2–3 years old) from a local arecanut grower. The variety planted here is known as Garo kwai, as the original seedlings came from the adjoining Garo hill districts. He planted the saplings in the month of May–June, by digging pits of about 1 x 1 x 1 ft sizes, and followed a random planting system to enable him intercrop with banana, etc.
At the initial stage he applied rice husk and wood ash around the arecanut saplings. He has no irrigation system but is entirely dependent on rainfall. Even now he does weeding twice a year in the months of May–June and September–October. All the accumulated grass is used for mulching around the plants, which also suppresses growth of weeds for a while. He has applied no other manure in his garden. He has not encountered any serious pests and diseases in his arecanut plantations so far. Occasionally high speed wind during flowering and fruiting cause some damage. He harvests twice in a year (February–March for green nuts and May–June when the nut covers turn yellowish). Harvesting is done by traditional method (sickle tied on the tip of a long bamboo pole). Each arecanut tree gives a maximum of about 400–500 nuts and a minimum of 250–300. All his arecanuts are sold to local traders who come from the plains of Assam. Currently he is buying more saplings to expand his arecanut garden. Each mature sapling (about three years old) costs him about Rs. 7–10 locally.

**FURTHER READINGS**


INSTITUTIONS INVOLVED IN PROMOTING RESEARCH, TRAINING AND DOCUMENTATION FOR THE CROP

Central Plantation Crops Research Institute, Kasargod, Kerala, India.

Directorate of Cocoa, Arecanut and Spices Development, Kerala, India.

Regional Research Station of the Central Plantation Crops Research Institute, Vittal, Karnataka, India.
GINGER

BACKGROUND TO THE CROP

Ginger (Zingiber officinale Rosc.) is an important member of the Zingiberaceae family. It is one of the important cash crops and spices grown in India and in many other tropical and sub-tropical regions of the world. Due to its distinct flavour and pungency, it is used in culinary preparations, pharmaceutical preparations, as a flavourant in soft drinks, alcoholic and non-alcoholic beverages, and as a confectionary, pickle, etc. India is the largest producer and exporter of ginger. India exports ginger to more than 50 countries, particularly the Middle East. Ginger is grown in an area of 60,000 ha with a production of more than 2.00 lakhs tonnes. India also produces and exports value added ginger products like ginger oil and ginger oleoresin. Ginger is marketed in different forms such as raw ginger, dry ginger, bleached ginger, ginger powder, ginger oil, ginger oleoresin, ginger ale, candy, beer and wine, squash, ginger flakes, etc. The dried rhizome is preferred for commercial uses.

Kerala, Orissa, Andhra Pradesh, Himachal Pradesh, Meghalaya and West Bengal are important ginger growing states within the country. About 60% of the area under ginger cultivation is in Kerala, which accounts for 25% of the country's production. Northeast India is also considered an important ginger growing area. The agro-climatic conditions of northeast India, characterized by warm and humid summers with abundant rainfall, and cool winters, is favourable for ginger cultivation.

Ginger is cultivated as a cash crop, mainly in jhum fields spread over the hills and plains of tribal-dominated areas of the entire region. In northeast India, Meghalaya tops the list of ginger producing states; other states like Mizoram, Nagaland, Manipur and Assam also produce substantial amount of ginger. Since there is minimum use of agro chemicals in the NER, organic ginger and its
value added products have immense potential for economic exploitation.

Climate

Ginger is a tropical crop and is cultivated from sea level to altitudes of about 1500 m ASL. However, the optimum elevation for its successful cultivation is in the range of 300–900 m ASL. Moderate rainfall at sowing time till the rhizomes sprout, followed by fairly heavy and well-distributed showers during the growing period and dry weather about one month before harvesting are optimum requirements for its successful cultivation. Farmers of the northeastern region generally prefer to grow the ginger crop in moderate to high altitudes, where shifting cultivation or jhum has been carried out.

Growing season

The planting season for ginger is from March–April, with the onset of the monsoon.

Soil

A rich soil with good drainage and aeration is ideal for ginger cultivation. Ginger grows well in sandy or clayey loam, red loam and lateritic loam soils. Effective drainage is absolutely necessary for the prevention of disease. Ginger should not be grown on the same site, year after year.

Crop duration

The crop duration is generally around 9-10 months (March/April to December/January/February). Ginger starts flowering during the month of June–July along with the showers or rains.

Cropping system and pattern

Different types of cropping systems are followed for ginger cultivation in the region. Generally farmers prefer mono cropping of ginger. However, they also practise mixed cropping with maize, chili, brinjal, papaya, cucumber, pumpkin, yam, tree tomato, tapioca and different types of leguminous crops in jhum. Sometimes they intercrop ginger with maize and pineapple.
Cultivation of different types of vegetable crops, besides supporting a wide range of beneficial insects and soil micro-organisms, also helps in soil and water conservation, improves soil fertility and generates better income for farmers. Rather than monocropping, intercropping or mixed cropping of ginger in the hill areas of northeast India facilitates conservation and management of crop-biodiversity. The most common types of crops grown along with ginger in NER are both annuals and perennials, which include chili (Capsicum annum), brinjal (Solanum melongena), pumpkin (Citrullus lanatus), cucumber (Cucumis sativus), papaya (Carica papaya), maize (Zea mays), pineapple (Ananas cosmosus), banana (Musa spp), winter squash (Cucurbita maxima), pigeon pea (Cajanus cajan), castor (Ricinus commusis), tapioca (Manihot esculenta), kidney bean (Phaseolus aconitifolius), cluster bean (Cyamopsis psoraloides), french bean (Phaseolus vulgaris), etc.

In order to cultivate ginger organically, a buffer zone of 5–10 m should be left all around to separate the plot from conventional farms. The produce from this buffer zone should not be treated as organic. Being an annual crop, the conversion period required will be two years. Ginger can be cultivated organically as an inter crop or mixed crop provided all the other crops are grown following organic methods. It is desirable to include a leguminous crop in rotation with ginger. Ginger-banana-legume or ginger-vegetable-legume combinations are recommended as good cropping patterns.

Traditional varieties are more pungent and hence have a better market than other varieties. Since the majority of the population in the hilly areas of the northeastern region is non-vegetarian, ginger finds itself used in different culinary preparations. The farmers mostly prefer local varieties as these have less chance of being infected by pests and disease, and can be stored for a longer period.
(maximum for one week) as compared to high yielding varieties (maximum for 2–3 days). However, higher pungency status of the local varieties indicates higher oleoresin (gingerol) content, which is suitable for industrial extraction.

Varieties called Rio-de Janeiro and Nadia are popular among growers. Besides these, most of the states have their own local or traditional varieties. In the NER, different types of local and hybrid varieties are available, viz., Nadia, Moran, Thingpui, Thinglaidum, Karkai, Tura, Jate, Nadia, Rio-de-Janeiro, Suprabha, Poona, Varada, China, etc.

**SEED**

**Selection**

Carefully preserved seed rhizomes, free from pests and disease, collected from organically cultivated farms should be used for planting. However, to begin with, seed material from high yielding local varieties may be used in the absence of organically produced material. Seed rhizomes should not be treated with any chemicals. The seed quantity required varies from region to region and with the method of cultivation adopted. However, the average is 1500–2500 kg per ha. The weight of the seed rhizomes is approx. 25–30 gm and 4–5 cm length in size.

**Treatment**

Generally, no treatment of the seed is done. However, the farmers of Nagaland keep the seed rhizomes in the sun for a period of 20–30 days before planting, while in Meghalaya, they are kept in the sun for only a day. Rhizome sets should be treated with cow dung and urine preparation such as amrut pani/jeevamrut/panchagavya/cow pat pit, etc.

**CULTIVATION**

While preparing the land, minimum tillage operations may be adopted. Beds of 15 cm height, 1 m width and of convenient length may be prepared, giving 50 cm spacing between beds. Solarisation of beds is beneficial for checking the multiplication of pests and disease-causing organisms. Solarisation is a technique by which
Polythene sheets are spread over moist field beds, covering all sides and being thus exposed to the sun for a period of 20–30 days. The polythene sheets used for soil solarisation should be stored safely once the work is completed.

**Sowing methods (if directly sown)**

At the time of planting, apply 25 gm powdered neem cake and mix well with the soil in each pit at a spacing of 20–25 cm within and between rows. Seed rhizomes may be put in shallow pits and mixed well with decomposed cattle manure or compost mixed with *Trichoderma* (10 gm compost inoculated with *Trichoderma*).

However, in the northeastern region, ginger is planted directly in the main field. Seed rhizomes are planted randomly in shallow pits of 5 cm depth and at a plant-to-plant spacing of 15 cm (approximately) in the hill districts of Assam.

In Meghalaya and Nagaland, about 45 cm distance is maintained between the rhizomes that are covered with soil (1–1½ inches) and smoothed over by hand.

In mixed cropping, seeds of chili, brinjal, papaya, pumpkin, etc., are mixed and broadcast in the ginger planted field in Assam and Meghalaya; whereas in Nagaland, a nursery is prepared for chili, brinjal, tomato, papaya, etc., and these crops are transplanted in between the furrows of the ginger crop. The crops most commonly rotated with ginger in Kerala are tapioca, chili, rice, ragi, groundnut and maize. Ginger is also grown as a mixed crop and as an intercrop in coconut and arecanut gardens.

After site selection, the jungle is cut and burnt during the months of November to January, followed by burning of the felled trees one month later (February–March). Then the unburned debris is removed from the field. The rhizomes are then planted after a few days. The planting techniques vary from state to state in the NER. In some districts of Meghalaya, terraces are constructed. In Assam, *khurpi* is used for digging shallow pits of 5 cm depth
with approximately 15 cm plant-to-plant spacing. In Meghalaya, bunds are constructed and the bund is broken into blocks in a zigzag manner in order to prevent soil erosion. In Nagaland, a *naga kur* (*spade*) is used for making furrows at a distance of 1–2 ft in monocropping and 2–3 ft for mixed cropping. The distance between the rhizomes is 20–25 cm and rhizomes are planted at a depth of 7–10 cm.

**MANAGING SOIL FERTILITY**

Mulching the ginger beds with green leaves is an essential operation to enhance germination of seed rhizomes and prevent the soil from washing off due to heavy rains. It also helps to add organic mater to the soil and conserve moisture during the later part of the cropping season.

The first mulching with green leaves @ 10–12 t/ha is at the time of planting. It is repeated @ 5 t/ha 40 and 90 days after planting. Use of *Lantana camara* and *Vitex negundo* as mulch may reduce the infection of shoot borer. Cow dung slurry or liquid manure may be poured on the bed after each mulching to enhance microbial activity and nutrient availability.

For the management of soil fertility, the farmers mostly incorporate leguminous crops like pigeon pea, black gram, cowpea, cluster bean and french bean as green manure crops. Besides improving soil fertility, these are income-generating crops and have a good market demand. Some farmers use wood ash in the field as this increases the potash content of the soil. In Meghalaya, compost or cattle manure is used to enrich soil fertility.

**Nutrients**

Ginger is a nutrient-exhausting crop but in general, inorganic fertilisers are not used. Therefore, intercropping of ginger with leguminous crops, crop rotation and use of cattle manure are practised in order to replace the nutrients exhausted by the previous crop. Application of well-decomposed cow dung or
compost @ 5–6 t/ha may be applied as a basal dose while planting the rhizomes in the pits. An additional application of neem cake @ 2 t/ha is desirable.

Generally in the northern region ginger cultivation is mostly on freshly prepared land, where adequate nutrients are already available. Addition of cattle manure before plantation is not very popular, though it is advisable in order to enhance the yield.

**WATER REQUIREMENTS**

Generally in the northeastern region the source of water is from seasonal rainfall, rivers and natural perennial streams.

Since the source of water is from seasonal rainfall and perennial streams, the assessment of water quality may be carried out as per the norms and guidelines of permitted organic package of practices.

**Requirement**

Moderate rainfall is required at the time of sowing till the rhizomes sprout; fairly heavy and well-distributed showers during the growing period; and dry weather for about a month before harvesting. A proper drainage channel in between the bunds to drain off stagnant water is advisable to ensure optimum drainage for better plant stand. Mulching of ginger beds helps in soil and water conservation. The first mulching is done at the time of planting with 12.5 tonnes of green leaves/ha and the second is done after 40 days with five tonnes of green leaves/ha.

**Conservation techniques**

Mulching conserves soil moisture by checking evaporation loss. Bunds are constructed to prevent soil erosion and to retain the topsoil and proper drainage channels are provided to drain off stagnant water. Seasonal legumes are also grown along with ginger to suppress weed growth, minimize soil erosion and enhance soil fertility.
Shoot borer, leaf roller and rhizome scales are the major pests that infest ginger. Soft rot, bacterial wilt and leaf spot are the major diseases affecting ginger. Regular field surveillance and adaptation of phyto-sanitary measures are necessary for pest management. Major pests and diseases found in ginger crop are:

**Shoot borer** *(Conogethes punctiferalis/Dictrhosis punctiferalis)*

*Shoot borer (Conogethes punctiferalis) in ginger plant*

**Life cycle description**

The moths lay eggs on leaves and other soft parts of the plant. The eggs hatch in about a week. The larvae pass through 4–5 instars and are full fledged in 2–3 weeks. Pupation takes place inside the seed or sometimes in the grass that collects after feeding. The pupal stage lasts about one week. The life cycle is completed in 4–5 weeks and three generations are completed in a year. The pest is most active from July to October.

**Marks of identification**

The full-grown caterpillar measures 25–30 mm in length and is reddish brown with black blotches all over the body and a pale stripe on the lateral side. The moths are orange yellow, with black markings on both wings.

The damage is caused by the caterpillar – which bores into the main stem of the young plants causing their death.

**Economic threshold level**

Management methods should be adopted at a stage when there is 1 egg mass per square meter.

**Management**

The shoots infested by the borer are cut open and the caterpillars are handpicked and destroyed. Some farmers grow neem trees along with ginger crops to repel the pest.
<table>
<thead>
<tr>
<th>DO’S AND DON'T’S IN GINGER IPM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>DO’S</strong></td>
</tr>
<tr>
<td>Grow only recommended/tested varieties.</td>
</tr>
<tr>
<td>Seed rhizomes should be free from any infection or infestation. Biocides like <em>Trichoderma</em> may be used while planting seed rhizome.</td>
</tr>
<tr>
<td>Remove weeds by hand weeding before each mulch and biofertiliser application.</td>
</tr>
<tr>
<td>Use biofertiliser as per soil test recommendation.</td>
</tr>
<tr>
<td>Proper drainage facilities must be provided to drain off stagnant water. Best choice of land should be with a gentle slope. Gently sloping land is best.</td>
</tr>
<tr>
<td>Visit the field periodically to check for pests or disease.</td>
</tr>
<tr>
<td>Install light traps for collecting and monitoring shoot borer adult moths, if such infestation is observed.</td>
</tr>
</tbody>
</table>

### Other insect pests

These include the rhizome fly (*Mimegralla coerulifrons*), white grub (*Holotrichia setticolis*), skipper (*Udaspis folus*) and scale (*Aspidiotus garlic*). Tilling of the soil during land preparation and solarisation are good practices that can reduce the chances of insect pests, particularly in controlling white grubs which get exposed at the time of tilling and are foraged by the birds. Light traps are helpful to control the adult population of insects. Mechanical collection of infected leaves and white grub adults is also practised. However, there is no intensity of insect pest attacks in the hill regions of NER. Suggested biological controls include application of *Trichodema sp.* At the time of planting, application of *Lantana camara* as mulch reduces infestation by shoot borer. Conservation of hedgerows around the ginger plantation also helps to maintain a population of ladybirds, spiders, etc., which are good natural bio-agents for control of many of the insect pests.
DISEASES

Soft rot or rhizome rot

Soft rot is caused by *Pythium aphanidermatum* and *Pythium myriotylum*.

Life cycle

Two species of *Pythium*, viz., *P. aphanidermatum* and *P. myriotylum* are chiefly responsible for rhizome rot in ginger. The fungus *Pythium* can survive in two ways: (a) in diseased rhizomes kept for seed, and (b) through resting structures like chlamydosores and oospores that reach the soil from infected rhizomes. Soft rot fungi are soil dwellers and can live with soil saprophytic allies in the absence of their host. A high temperature above 30°C and high soil moisture are the important predisposing factors favouring the disease. Hence, waterlogging in the field due to poor drainage increases the intensity of the disease. This disease mostly occurs during the months of June and July.

Symptoms and damage pattern

In the beginning, the leaves of the infected plants turn pale green. The top leaves become yellow. Gradually, yellowing of the leaf blade and leaf sheaths progresses downwards along the margin. Hence the leaf margins turn yellow while the centre remains green for a few days. After the leaves are completely yellowed, withered and dry, the dead area extends towards the leaf sheath. The dead leaves droop and hang down on the stem till the whole shoot dries. The junction of the plant and rhizomes on the soil surface turns pale translucent brown. Later, this junction becomes watery and soft. Such infected plants do not fall to the ground, but the shoot can be easily pulled out. Soft rot extends to the rhizomes from the collar region. Gradually the rhizomes decompose and form a decaying mass enclosed by the tough rind. Soft and rotten roots are found on the decayed rhizomes. The decayed rhizomes exhibit a very unpleasant odour.
Management

- Planting of disease-free seed rhizomes.
- Providing adequate drainage.
- Burning of diseased plants.
- Removing the affected clumps along with the soil.

Ginger growers in the hill districts of Assam believe that ginger is less prone to infection in bamboo growing areas and also give higher yields when grown in such areas.

Bacterial wilt

Bacterial wilt is caused by *Ralstonia solanacearum/Pseudomonas solanacearum*.

Life cycle

The bacteria are spread through soil, water, infected or contaminated rhizomes. The bacteria enter the plant through wounds made in the roots during transplanting, through cultivating equipment, nematodes and insects. They can also enter through the natural cracks from where secondary roots develop. The bacteria reach the xylem vessels and through them spread throughout the plant. Along the vessels they escape into the intercellular spaces of the parenchyma cells in the cortex and pith, damage the cell walls, and create cavities filled with slimy masses of bacteria.

Symptoms

Infected young plants die rapidly. In older plants there is leaf drooping and then discolouration. The plants exhibit one-sided wilting and stunting before they wilt permanently and die. Sometimes, development of adventitious roots increases. Vascular tissues of the stems and roots turn brown.

Damage pattern

The pathogen is soil-borne and it invades the root system and colonises most of the vascular elements, dramatically limiting the water uptake thereby resulting in rapid wilting and death of the plant.
**Management**

- Crop rotation with maize, cotton, soybean.
- Planting of disease-free seed rhizome.

**Other diseases**

Other diseases include leaf spot (*Phullosticta zingiberi*), sheath blight/leaf blight (*Rhizoctonia solani*), dry rot (*Fusarium oxysporium*), etc. A good drainage arrangement effectively reduces the occurrence of these diseases. Affected plants are generally removed mechanically by farmers and burned. However, in the case study areas, these diseases were reported to be uncommon.

**Animal and rodent pests**

In some areas, rodents damage the ginger crop by making holes in the ginger fields. Sometimes, monkeys, buffaloes, wild boar and other grazing animals also destroy the ginger cultivation by grazing or trampling over it.

**Management**

- Traps are used to catch and kill rodents.
- In the hill districts of Assam, ginger growers prefer to cultivate ginger in sloping and steep areas, as the crop will be protected from grazing animals and rodent pests.
- In the hills of Northeast India, the experience is that intercropping ginger with paddy or other crops reduces or lessens pest attacks.

**Beneficial insects**

Planting a variety of vegetable crops supports a wider range of beneficial insects, soil microorganisms and other factors that add to the overall healthy growth of the crop and result in higher yield. Natural predator insects and animals feed on the shoot borer, thus reducing the pest population. Birds are particularly beneficial as they feed on insect pests and grubs.

**POST HARVEST MANAGEMENT**

The crop is ready to harvest in about eight to ten months depending upon the maturity of the variety. When fully mature, the leaves turn yellow and start drying up gradually. Clumps are lifted...
carefully with a spade or digging fork and rhizomes are separated from dried leaves, roots and adhering soil. The harvested mother rhizomes are separated from the remaining clumps. In the hill districts of Assam, particularly in the North Cachar hill district, farmers keep ginger un-harvested for 2–3 years and the weight of ginger also increases (one bunch of ginger may weigh 300–400 gm after three years). During the dry season the weight of ginger is slightly less, but when harvested during off-season (April–May) with a small shower of rain, the weight increases. The average yield of fresh ginger varies from 20–30 t/ha depending upon the variety.

**Cleaning**

Cleaning of harvested ginger is usually done by hand. After the soil particles are removed and the mother rhizomes separated, the harvested ginger is kept in the sun for drying from a few hours to a day. The duration of drying varies from area to area depending upon the availability of sunlight.

**Drying**

Generally the farmers of the northeastern region keep the harvested rhizomes in the sun for 2–3 hours (hill districts of Assam) or for a day (Meghalaya) on an average. The harvested ginger is kept on raised wooden/bamboo platforms inside the shed, either for seed or for sale.

**Packaging**

Cleaned or dried ginger is kept in gunny bags. In hill areas, many of the farmers also carry the ginger in baskets or store the ginger in bamboo baskets lined with dried banana leaves for transportation.

**Storage**

No storage godown treatment is followed as the ginger is sold within a short span of time (one week). In Meghalaya and the hill district of Assam, the harvested ginger is kept in pits with layers of sand in between. Dry leaves or green leaves are used to protect the ginger from sunlight or rain. Thatched huts are also constructed to protect ginger from rain and sunlight.
The rhizomes to be used as seed material should be preserved carefully. The indigenous practice is to spread layers of leaves of *Glycosmis pentaphylla* with the seed material. In order to get good germination, the seed rhizomes are stored properly in pits in the shade. Healthy and disease-free clumps are marked in the field when the crop is 6–8 months old and still green. Seed rhizomes are stored in pits of convenient size made inside the shed and protected from the sun and rain. The walls of the pits may be coated with cow dung paste. Seed rhizomes are stored in layers along with well-dried sand/saw dust. Sufficient gap is to be left at the top of the pits for adequate aeration. The pits need inspection once in twenty days to remove shrivelled and disease affected rhizomes. In some areas, the rhizomes are loosely heaped over a layer of sand or paddy husk placed in a thatched shed and covered with dry leaves.

传统存储堆叠方法的生姜在梅加拉亚邦

**Storage pests**

Generally no pest management practices are adopted during the storage of ginger as storage periods are generally short. The only care taken is that the storage area should not be damp or wet.

**ORGANIC GINGER CULTIVATION**

**Case study**

Robin Naiding (37 years old) from Bagadima village, belonging to the Dimasa tribe, hails from a very poor family and has seven children. He was not in a position to send any of his children to school due to poverty. They could manage just one meal a day. In
2003, an NGO (Biate Cultural Organisation) entered his village for a baseline survey and his nightmare of poverty gradually disappeared. Under the Natural Resource Management Group (NaRMG) activities, he got Rs.2000 and invested the entire amount for purchasing ginger. He purchased 285 kg (@ Rs.7.00 per kg) of ginger and planted it on one acre of land. The site, selected during January, was a sloping *jhum* land with loamy soil. After the site was chosen, the shrubs and weeds were cleared and left for three weeks to dry. The dried weeds were burned during the same month. During the month of February, the burned debris was mixed with the soil by hoeing. Mulching was adopted for soil and water conservation. At the onset of the monsoon (March–April), he sowed the rhizomes (Nadia variety) along with *arhar*. At the border of the field, *sajana* was planted which acted as fencing plus for vegetables. (Traditionally the farmers grow ginger along with various other crops like cowpea, bean, maize, chilies, brinjal, cucumber, *solanum sp*, pumpkin, and papaya. The farmers believe that mixed cropping results in healthy growth of crops, better yields and also helps in controlling and reducing the pest population).

Total man-days required from land preparation to sowing were 14 days (for one acre of land). Ginger was harvested during the month of January–February. Once ginger was harvested, good healthy seed, free from pest and disease, was selected for seed purpose. The farmer did not practise any seed treatment. After harvesting, the seed was spread in the sun for removing soil particles. After a week of spreading in the sun, the ginger was stored in a thatched house. The farmer did not encounter any problems of pest or disease during storage. He was however aware of the use of tobacco liquid for shoot borer, leaf spot and soft rot of rhizome. In the first year, Robin Naiding harvested 2800 kg of ginger and sold 2500 kg @ Rs.12 per kg. He kept 300 kg for seed and earned a profit of
Rs. 30,000. The next year (2004), he was able to send two of his children to school at Umrangso, Assam. The same year he planted 300 kg of ginger and harvested 3000 kg and sold it for Rs. 13 per kg and earned a profit of Rs. 36,400. He was able to send two more children to school in the village itself. He also purchased 50 ducks for rearing and sold their eggs. He continues to cultivate ginger along with other farming activities. His dream is to begin commercial plantation within the next year.

There are five state-level primary markets that are selected by the Department of Agriculture in N. C. Hills, Assam. These are: Haflong, Mahur, Maibong, Langting and Harangajao. Besides these, Assam has a list of rural primary markets in N.C. hills (table 1) selected by the Autonomous District Council (North Cachar Hills Autonomous District Council, Assam) and regulated markets under the Assam State Agricultural Marketing Board (table 2).

**Table 1: Council selected rural primary markets in N.C. hills, Assam**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Dehangi</td>
<td>15. Thanalambra</td>
<td></td>
</tr>
<tr>
<td>8. Laisong</td>
<td>16. Longkhu</td>
<td></td>
</tr>
</tbody>
</table>
### Table 2: Regulated markets in Assam under the Assam State Agricultural Marketing Board

<table>
<thead>
<tr>
<th>Principal market</th>
<th>Sub-market</th>
<th>District</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gauripur</td>
<td>Gauripur Chapar. Mancachar</td>
<td>Dhubri</td>
</tr>
<tr>
<td>Dhing</td>
<td>Rupahi Ambagan Roha.</td>
<td>Naogaon</td>
</tr>
<tr>
<td>Howly</td>
<td>Barpet road Kalgachia Sorbhong</td>
<td>Barpeta</td>
</tr>
<tr>
<td>Bohorihat</td>
<td>Mandia</td>
<td>Barpeta</td>
</tr>
<tr>
<td>Golaghat</td>
<td>Dergaon Dakhinhegera. Borpathar Sarupathar</td>
<td>Golaghat</td>
</tr>
<tr>
<td>North Lakhimpur</td>
<td>-</td>
<td>North Lakhimpur</td>
</tr>
<tr>
<td>Goreswar</td>
<td>Rangia</td>
<td>Kamrup</td>
</tr>
<tr>
<td>Guwahati Sub-Division</td>
<td>-</td>
<td>Kamrup</td>
</tr>
<tr>
<td>Silapathar</td>
<td>-</td>
<td>Dhemaji</td>
</tr>
<tr>
<td>Lanka</td>
<td>-</td>
<td>Nagaon</td>
</tr>
<tr>
<td>Dhekiajuli</td>
<td>-</td>
<td>Sonitpur</td>
</tr>
<tr>
<td>Jorhat</td>
<td>-</td>
<td>Jorhat</td>
</tr>
<tr>
<td>Nalbari</td>
<td>-</td>
<td>Nalbari</td>
</tr>
<tr>
<td>Bongaigaon</td>
<td>-</td>
<td>Bongaigaon</td>
</tr>
<tr>
<td>Tinsukia</td>
<td>-</td>
<td>Tinsukia</td>
</tr>
<tr>
<td>Dibrugarh</td>
<td>-</td>
<td>Dibrugarh</td>
</tr>
<tr>
<td>Sivasagar</td>
<td>-</td>
<td>Sivasagar</td>
</tr>
<tr>
<td>Goalpara</td>
<td>-</td>
<td>Goalpara</td>
</tr>
<tr>
<td>Hailakandi</td>
<td>-</td>
<td>Hailakandi</td>
</tr>
<tr>
<td>Cachar</td>
<td>-</td>
<td>Cachar</td>
</tr>
<tr>
<td>Karimganj</td>
<td>-</td>
<td>Karimganj</td>
</tr>
<tr>
<td>Kokrajhar</td>
<td>-</td>
<td>Karimganj</td>
</tr>
<tr>
<td>Morigaon</td>
<td>-</td>
<td>Morigaon</td>
</tr>
</tbody>
</table>

### Constraints

The NER, as a whole, produces a large quantity of ginger, yet the utilisation of the produce within the region is quite poor. The reason may be due to poor internal market demand and to the undeveloped processing sector. As a result, the ginger of the NER is
generally transported to different parts of the country in fresh, unprocessed form. Calcutta is the main market for ginger produced from the NER, from where onward distribution takes place to different parts of India. Since ginger-growing pockets are predominantly located in the hilly tracts, the costs of transportation and marketing are unusually high. Again, due to poor or inappropriate post harvest management practices like proper cleaning, conditioning, grading and packaging, etc., the produce often fails to earn a high price at the terminal markets. Incorporation of decayed rhizomes (which cannot be easily seen externally) in the packs at times, imposition of excessive dead loads during transportation and the highly perishable nature of the green rhizome further add to quantitative as well as qualitative losses, especially when the consignments have to run over thousands of kilometers before reaching their destinations. Beside these factors, the fluctuating price at terminal markets, loss of commodity during transit and involvement of middlemen in the marketing channels adversely affect the grower’s price.

To overcome the problems associated with the ginger production of the northeastern region, particularly the problem of handling and transportation of raw ginger in huge quantities, industrial utilisation of green ginger within the region has been emphasised. Development of ginger-based processing plants to utilize the marketable surplus for manufacturing different kinds of value-added products as a strategy for better post harvest management has been given renewed thrust in recent years, which in turn could markedly reduce the cost of handling and transportation of ginger products.

Since the region is considered to be one of the important ginger growing areas in the country, there exists wide scope for manufacturing value-added export items, which is particularly
essential for overcoming the acute problems associated with ginger in the post-production stage.

**SUGGESTED READINGS**


**INSTITUTION INVOLVED IN RESEARCH AND EXTENSION**

Indian Institute of Spices Research, PB No. 1701, Marikunnu PO, Kozhikode-673012, Kerala.

ICAR Research Complex for NEH Region, Barapani-793103, Meghalaya.
**BACKGROUND TO THE CROP**

Large cardamom (*Amomum subulatum*) commonly known as 'bada elaichi' is one of the world’s very ancient spices. It belongs to the *Zingiberaceae* family under the order *Scitaminea*. It grows in the wild and is also domesticated in the sub-Himalayan region, at altitudes ranging from 1000 to 2000 m MSL. It is one of the main cash crops cultivated in Sikkim, Nagaland, Uttaranchal, Darjeeling and some other parts of the NER.

The plant is a perennial bush; it has a sheathed stem, reaching 2–5 m in height with a large tuberous rhizome and leaves that are 30–60 cm long and 5–15 cm wide. The trailing leafy stalk that grows from the plant base at ground level bears the seedpod. The flowers are green with a white-purple vein tip. The crop grows well in shaded areas. It is harvested before it ripens to avoid the capsules from splitting during the drying process.

Large cardamom is used as a spice and also in several Ayurvedic preparations. It contains 2–3% essential oils, possesses carminative, stomachic, diuretic and cardiac stimulant properties and is also a remedy for throat and respiratory trouble.

**Spice description**

Cardamom comes from the seed of a plant that is similar to ginger. The small, brown-black sticky seeds are contained in a pod in three double rows with 25–70 seeds in each row, depending on the cultivar. The pods are roughly triangular in cross section and oval or oblate. The dried surface is rough and furrowed with deep wrinkles. Pods are available whole or split, and the seeds are sold loose or ground. The natural presentation of a bouquet of large cardamom is described as pungent, warm and aromatic, while its flavour is eucalyptine, with camphorous and lemony undertones.
**Culinary uses**

Cardamom is used mainly in the Near and Far East. It features in curries, is essential in *pulao* (a rice dish) and gives a characteristic aroma to dishes made from pulses. It is often included in Indian sweet dishes, drinks and substantial meals. It is also seen as a ‘festive spice’ because of its high price. It is used in pickle herring, in punches and mulled wines, occasionally with meat, poultry and shellfish. It flavours custards and some Russian liqueurs. Cardamom is also chewed habitually (like nuts) where freely available, as in the East Indies, and with the Indian masticator, betel pan. It acts as a flavour for Arab and Turkish coffee, which is served with an elaborate ritual. The so-called Indian special tea is also generally flavoured with cardamom.

**Medicinal properties**

A stimulant and a carminative, cardamom is not used in Western medicine for its own properties, but functions as a flavouring agent and as a basis for medicinal preparations for indigestion and flatulence. The Arabs attribute aphrodisiacal qualities to cardamom and Indians regard it as a digestive and also as a cure for obesity. Macerating seeds of large cardamom in hot water makes a simple medicinal cordial, which is considered to be an aphrodisiac.

The best month for planting cardamom is during May–July, with the onset of the monsoon. Under best conditions, the crops will start bearing fruits in 36 months. Flowering starts from March–May and harvesting begins from September–October, and may extend up to November in higher altitudes.

**Climate**

Large cardamom is a shade-loving plant (seophytes). Its natural habitat is the humid, subtropical, semi-evergreen forests on the steep hills of the eastern sub-Himalayan region. The area receives well-distributed rainfall, spread around 200 days with a total of
about 3,000–3,500 mm/year. The weather remains mostly cloudy and foggy during the monsoon season. Large cardamom is best grown within an altitude of 600–2,350 m. It is normally cultivated at lower altitudes in cooler areas (near the snow lines) and at higher altitudes in warmer areas. During severe winter, its plants remain dormant and can withstand up to 2°C but frost and hailstorms are injurious. Continuous rain during flowering is detrimental, as it hampers the foraging activity of pollinating bees, thus affecting the flowers and resulting in poor capsule setting and barren spikes.

**Soil**

No formal soil testing is done in most large cardamom cultivation areas in northeast India.

**Type of soil**

Deep well drained soils with loamy texture, medium availability of phosphorus and potash, and with 4.5 to 6.0 pH are best suited. Usually the soil is rich in organic matter and nitrogen as the plants are cultivated under alder trees or other local varieties of trees.

**Biodiversity management**

The alder (*Alnus napalensis*) based cropping pattern is commonly practised. The tree is beneficial as it takes care of the nutrient requirements since alder is a nitrogen fixing plant. Growing wild varieties of large cardamom nearby (500 m apart) is found to be beneficial as the wild varieties act as a rodent repellant. There is no mechanical structure for water harvesting at the plantation site. However, as large cardamom is planted at the base of protected catchment areas, moisture is conserved in the ensuing dry season. Since cardamom is planted in good forested areas, it is observed that such plantation sites also become good habitats for wild animals and birds.

**Inter-cultural operations**

The calendar for inter-cultural operations for good and productive large cardamom plantations has been prepared as follows:
Table: Calendar for inter-cultural operations

<table>
<thead>
<tr>
<th>MONTH</th>
<th>ACTIVITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>Remove infected plants</td>
</tr>
<tr>
<td>February</td>
<td>Water at 15 days interval if dry conditions prevail; water can be sourced from upstream through natural gradient in hill. Provide mulch.</td>
</tr>
<tr>
<td>March–April</td>
<td>Clear leaf litter to facilitate flowering and fruiting. Do weeding</td>
</tr>
<tr>
<td>May–June</td>
<td>Plant healthy disease-free suckers and replace old plants</td>
</tr>
<tr>
<td>July</td>
<td>Complete planting of suckers; check for pest infestation; weeding</td>
</tr>
<tr>
<td>August</td>
<td>Remove diseased plants and destroy; best options are deep burial or burning. Adopt rodent control measures like clearing of the surroundings; weeding</td>
</tr>
<tr>
<td>September–October</td>
<td>Harvest the ripe fruits. Dry/cure cleaned capsules</td>
</tr>
<tr>
<td>November</td>
<td>Complete post harvest activities (drying and packing). Remove old stumps, infested plants and destroy.</td>
</tr>
<tr>
<td>December</td>
<td>Undertake activities like mulching and repairing of raisers.</td>
</tr>
</tbody>
</table>

Improved selection of cultivars

The regional station of the Indian Cardamom Research Institute under the Spices Board has conducted an exploratory survey of the large cardamom plantations in the North Eastern Region and identified a few high yielding selections. They are under evaluation in different locations. The following are the important ones:

<table>
<thead>
<tr>
<th>Selection</th>
<th>Cultivar</th>
<th>Altitudinal adaptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBLC 5</td>
<td>Sawney</td>
<td>Medium to high</td>
</tr>
<tr>
<td>SBLC 47</td>
<td>Varlangay</td>
<td>High</td>
</tr>
<tr>
<td>SBLC 42</td>
<td>Gosley (Dzongu)</td>
<td>Low</td>
</tr>
<tr>
<td>SBLC 44</td>
<td>Seremna</td>
<td>Low</td>
</tr>
<tr>
<td>SBLC 50</td>
<td>Sawney</td>
<td>Medium to high</td>
</tr>
<tr>
<td>SBLC 51</td>
<td>Green Golsey</td>
<td>Low</td>
</tr>
</tbody>
</table>

(N.B.: Low: Less than 975 m MSL; medium: 975-1515 m MSL; high: More than 1515 m MSL)
Organic production

Large cardamom is cultivated in forested areas that are thinned (4m x 4m) just sufficiently to give enough shade to the cardamom plant. *Alnus nepalensis* (evergreen nitrogen fixing coppice tree) is the most common and preferred shade tree for the crop in the higher altitudes of Nagaland and Sikkim. About 90% farmers in Nagaland follow an alder based cropping and 10% cultivate cardamom in mixed forestry. Very few farmers grow cardamom in orchards with plum, peach and tree tomato.

VARIETIES

The three main varieties of large cardamom cultivated are *Ramsey*, *Sawney* and *Golsey* (NEPED, 2002).

*Ramsey* is suitable for cultivation above 1500 m; its foliage is green to light green with leafy stem appearing maroon. Flowers are small and yellowish in colour, while the colour of the raw capsule is maroon.

*Sawney* grows best within the altitudes of 1000–1500 m. These varieties of plants are tall and robust with dark green leaves and greenish to purple stem. It usually flowers in May and has yellowish flowers and maroon coloured capsules.

*Golsey* grows best in altitudes slightly below 1000 m. It has deep green foliage and a greenish coloured stem. The fruits are oval in shape.

Other varieties also cultivated are *Bebo*, *Bharlangey* and *Ramla.* Besides these, there are several sub-varieties or strains, which are named in the local dialect of Lepchas, Bhutia and Nepalese in the cardamom growing areas of Sikkim and adjoining areas.

Propagation and seed collection

Propagation of large cardamom is done through seeds (seedlings raised in nurseries) or by the vegetative method (planting suckers). Propagation through seeds enables production of a large number of seedlings with the added advantage that viral diseases are not transmitted. Planting suckers, on the other hand, ensures true to
Large cardamom

Large cardamom is a type and high productivity, if the suckers are collected from high yielding plants. The plant grows best in forest loamy soil, with gentle to medium slopes. It is excellent if the soil is also moist but water logging is detrimental to the growth of the plant.

Seeds are collected from high yielding and well-maintained plantations that are free from viral diseases. Well-matured capsules from the bottom and middle portion of the spikes are selected for extraction of seeds. Certified seeds can be procured from the Horticulture Department or the Spice Board, NEPED-Nagaland, Large Cardamom Growers Association, Khonoma Village, Nagaland, and the Government of Sikkim (Forest and Horticulture Department).

Seed treatment

After de-husking, the seeds are mixed with sand and rubbed with the hand. Then they are washed in water to remove the mucilage completely. Once the water is completely drained, the seeds are mixed with wood ash for 30 minutes, dried in the shade and sown in the primary nursery. The seeds may be sown immediately after extraction, for maximum germination. However, farmers in Nagaland have reported a better germination rate from acclimatized seeds.

Seed treatment with a bioenhancer, viz., cow pat pit/amrut pani/jeevamrut/panchgavya is yet to be assessed.

Field preparation

Seeds are generally sown in January in nurseries and covered with fine soil and paddy straw mulch (10–15 cm thick).

Primary nursery

Seedbeds of 15–25 cm height, 1 m width and convenient length are prepared in a well-drained soil. The soil is tilled to a depth of about 30 cm and left for three to four weeks for weathering. Well-decomposed cattle manure is mixed with the soil and the surface of the bed is prepared to a fine tilt. About 80–100 gm of seed per
bed is sown in lines across the bed at a distance of 10 cm and the bed is mulched with local plant material. Watering (sprinkling) is done at regular intervals to keep the surface of the bed moist. The germination of seeds commences around 25–30 days after sowing. When average germination is noticed, the mulch materials are removed carefully. The inter space between the rows is then re-mulched with chopped paddy straw or finely graded leaves. Shades (pandals) are immediately erected, using bamboo mats or thatch grass or agro shade nets. When the seedlings attain 3–4 leaf stage, they are transplanted to secondary beds.

**Polythene bag nursery**

Polythene bags of 15 cm x 15 cm size are filled with a potting mixture of soil, sand and cow dung in the ratio of 4 : 1 : 1. Seedlings are then planted in April and May and watered regularly. They become ready for field planting in 10–12 months.

**Secondary nursery**

Nursery beds of 15 cm height, 100 cm width and any convenient length are prepared on contour terraces. Well decomposed cattle manure or vermicompost (if available) or leaf compost is mixed with the soil and smoothed out evenly. Seedlings with 3–4 leaves are transplanted into the beds in May–June with a spacing of about 15 cm between them. The interspace is mulched with chopped paddy straw or dried leaf. Overhead pandals (made of bamboo, thatch grass, etc.) are erected for providing shade. The soil is kept moist with regular sprinkling of water. Once the seedlings attain 45–60 cm height and have 2–3 tillers, they are planted in the main field during June–July of the subsequent year. Most farmers in Nagaland and Sikkim select moist areas where alder trees are grown, to get a natural shade for nursery beds, so that they need not erect shade pandals or water the beds.
**Sucker multiplication nursery**

Suckers should be generated only in sucker multiplication nurseries, where adequate precautions are taken to ensure that viral diseases are not transmitted through the suckers. The site for such a nursery should be located at least 500 m away from large cardamom plantations. Nurseries are established either under the shade of forest trees or under the shade of *pandals*. Trenches of 30 x 30 cm are prepared at convenient length with an inter space of 30 cm. Well decomposed cattle manure or compost is mixed with soil and the trenches are filled to the brim for planting the suckers from disease free, high yielding plantations. One grown up shoot and a vegetable bud are planted 30 cm apart from another, in the trenches during May–June. After planting, the plant base is mulched with dry leaves. The multiplication rate in this method is about 1 : 8 in a year. The grown up tillers each have an emerging bud and they are planted in the main field in June–July.

Treatment of seedlings and suckers with bioenchancers, viz., *amrut pani/jeevamrut/panchagavya*, etc., before transplanting, needs to be evaluated.

**Main field preparation**

The land selected for planting is cleared of all undergrowth for new plantations and if the land has been used earlier for large cardamom, all the old plants should be removed. Pits having a size of 30 x 30 x 30 cm are prepared on contour terraces, at a spacing of 1.5 m x 1.5 m (1.8 m x 1.8 m for robust cultivars) after the onset of monsoon showers. If the crops are planted too close, the leaves – instead of branching out – will stand erect and little space will be left for the capsule to develop to full size. The pits are left for weathering for a fortnight and thereafter filled with topsoil.

**MANAGING SOIL FERTILITY**

Application of manure in large cardamom farms is not done in the hilly regions of the NER as farmers generally select sites that are
rich in organic matter or cultivate under alder trees. The leaves that fall down retain moisture and decompose fast, ultimately becoming good manure.

**Nutrients**

It is good to apply farmyard manure @ of 2 kg per plant at least once in two years during April–May. However in practice, the farmers in Northeast India generally select sites that are rich in organic matter and no external manure is ever applied except for the nursery beds. No irrigation is provided, since the rainfall requirement (3000–3500 mm) is optimum in North East monsoon condition. The crop is grown entirely under rain fed condition. Further, plantation sites are mostly at the base of hills where the catchment areas are protected.

**Vermicomposting**

A source of nutrients, particularly in the nursery beds, which is becoming gradually popular is vermicomposting, primarily introduced through NGOs working in the NER. Many private entrepreneurs have also taken up vermicomposting activities.

**Weeds**

Generally, weeding is carried out thrice for effective control of weed growth in the initial three years. Weeding can be done either by hand or with a sickle, depending on the intensity of weed growth. From around the base, the weeds can be pulled out by hand and the weeds in the inter space need only be slashed with sickle.

Clean weeding may be avoided as the crop is found to be a good colonizer. While weeding, dried shoots and other thrashed materials can be used as mulch around the base of the plant which will help conserve moisture in the ensuing dry months, cover the exposed roots and prevent weed growth around the plant base. During flowering period, the thrashed materials should not cover the inflorescences. About 100–130 stems can crop up from a colony, but only 20–30 stems need to be retained, as too many
stems will interfere in the capsule size. The old stems can be removed and used for mulching.

**PROBLEM INSECTS**

Problems due to sporadic incidences of leaf eating caterpillars, leaf streak or rot diseases are found in isolated areas. Initially the caterpillar of the moth (*Artona chorista*) feeds on the leaf lamina from the under surface and finally defoliates the leaves completely leaving only the midribs. This can be controlled by hand picking the infested leaf and burning. The incidence of leaf eating caterpillars is reported more in mixed forestry based cultivation. This is because some trees harbor the pest which falls onto the leaf of the cardamom. Other animals like rodents, porcupine, and wild boar destroy the crops. In order to prevent rodents, wild varieties of cardamom can be planted near the plantation field.

| **DO’S AND DON’TS IN LARGE CARDAMOM IPM** |
|---|---|
| **Do’s** | **Don’ts** |
| Grow only recommended varieties for the particular altitude and area. | Don’t grow varieties, which are not suitable for the particular altitude. |
| Use only certified seeds. | Don’t collect seeds from unknown sources and disease-prone areas. |
| Treat the seeds with approved bioproducts for control of seed-borne disease. | Don’t use seeds without seed treatment with approved biocides. |
| Use NPK sources of biofertiliser as per soil test recommendations. | Avoid imbalanced use of biofertiliser. |
| Use only recommended bio-pesticides. | Do not use non-recommended bio-pesticides. |
| Apply bio-pesticides as a last resort when pest incidence is above the economic threshold level (ETL) | Do not apply bio-pesticides on calendar basis. |

**DISEASES**

**Chirke/Chirkey**

This disease is characterised by the appearance of a mosaic on the tender leaves with pale streaks that slowly turn brown, resulting in the plants withering away. Growth and yield of the affected plants gradually decline and the plants ultimately perish. The disease is transmitted by aphids.
It is also spread by planting infected suckers. Often the knife used for harvesting and cutting the suckers itself transmits the disease.

**Foorkey**

Numerous small tillers appear at the base of the affected plants, which become stunted and fail to give any yield. Inflorescence also fails to produce productive spikes.

Traditionally, smoking the area at certain periodic intervals is practised as a preventive measure. Being a viral disease, the affected plants cannot be cured, but by adopting appropriate management practices like keeping a constant vigil to detect the disease, remove and burn affected plants, the farmer can minimise losses.

**Fire**

Crop damage due to forest fire is rare, but since shifting cultivation is common in Northeast India, the probability of incidence of forest fire due to burning of jhum (shifting cultivation) is high. Therefore, most of the cardamom growing communities in Nagaland and other states of northeast India generally have community-based fire management strategies, which are basically in the form of preventive measures, and to some extent punitive too, i.e., the person(s) causing fire is fined heavily by the community.

**POST HARVEST MANAGEMENT**

Harvesting of large cardamom is carried out by cutting the spike with a special sickle that is sharpened at both sides of the end tip. The harvested spikes are heaped and the capsules separated and dried immediately after harvest. The dried capsules are rubbed on a wire mesh for cleaning and for removal of the tail. Traditionally, cardamom is dried on bamboo mats. The capsules are dried by direct heating with smoke or sunlight for 15 days. If smoke-dried, the cardamom capsule turns dark brown or black and has a smoky smell.
Modern drying methods have been introduced both in Sikkim and Nagaland where smoked or hot air is blown through fairly large pipes/channels made of fabricated tin/stainless steel over evenly spread cardamom kept on a wire mesh. Most farmers in the cardamom growing area of Nagaland do not, however, prefer this method of drying as it requires firewood and also experience to handle the drying chamber. Most farmers prefer the traditional method of sun drying the large cardamom especially since the harvesting period coincides with a good number of sunny days.

An improved curing technique called the ‘Bhatti (oven) system’ is available at ICRI Spice Board, where cardamom is dried by indirect heating at 45–50°C for 30 hours to give better quality and appearance. Other improved methods used are the ‘flue pipe’ system of curing, or use of gasifiers. These improved methods help the cardamom to retain its original colour, flavour and aroma, which is turn get the grower a better price.

Grading is done manually according to size, fullness and shape of capsules/pods. Properly dried capsules are allowed to cool and packed in moist-proof containers preferably polythene lined jute bags. The bags are stored on wooden platforms to avoid absorption of moisture. There is no incidence of storage pests till date. However, the dried cardamom should preferably be sold immediately to avoid degradation in quality.

REFERENCES AND SUGGESTED READING


INSTITUTION ENGAGED IN RESEARCH AND EXTENSION

ICAR Research Complex for NEH Region, Umiam, Barapani 793103, Meghalaya.

Spices Development Board, Kerala.
PASSION FRUIT

BACKGROUND TO THE CROP

The passion fruit (*Passiflora edulis*) is a perennial, herbaceous, tendril-bearing climber belonging to the family *Passifloraceae*. The evergreen leaves exhibit alternate phyllotaxy and divide into three large deep lobes when mature, having finely toothed margins. The foliage leaves are deep green and glossy above, paler and dull beneath. The fragrant solitary flowers exhibit a distinctive structure and are born at each node on the new growth, white in colour but often tinted with purple and are self-compatible. Just above the flower stalk are three large green leafy bracts called involucres. Each consists of five greenish-white sepals, five white petals and a fringe-like corona of straight, white-tipped rays. Each flower bears five stamens with large anthers. The multi-seeded berry fruit is nearly round or slightly oval, about the size of a hen’s egg. The shell is hard and smooth, green at first, ripening to deep purple and finally crinkling when fully mature. The tough rind is filled with a tart, but pleasantly flavoured, aromatic, juicy, orange-yellow pulp. The small, hard, dark-brown or black seeds are pitted, netted or transversely grooved and individually embedded in the fleshy aril.

Passion fruit self-pollinates and grows well in humid weather. It prefers tropical to subtropical climate with an average rainfall of 150–250 cm annually.

This fruit vine grows best in light sandy loams and sandy clay loam, with a pH of 6.5–7.5, rich in organic matter and low in salts. It grows luxuriantly in altitudes ranging from 750–1500 m above MSL.

Soil

No formal soil testing has been done for this crop in most northeastern states.
Passion fruit, however, grows well in most hill areas of the region which have rich forest loamy soil, good drainage and are within the altitudinal range of 750–1500 m.

**Crop duration**

Usually the seeds are sown in the nursery beds between January and March. When the seedlings attain 20 to 30 cm height, they are transplanted to the main field from April–May up to July–August. The average economic life-span of the crop is seven years and the first harvest starts approximately 18 months after sowing.

**Biodiversity management**

Mixed or intercropping with ginger, chili, soybean, beans, peas, etc., between rows of passion fruit plants in the first year when vines have not attained full growth is practised by some local growers. Most common crops grown are, however, the green leafy vegetables called ‘lai pata’, a kind of large mustard. Soybean, chilies, peas are also commonly cultivated along with passion fruit.

For best results in passion fruit cultivation, it is important that few sparsely distributed standing trees (but not with very thick crown) are also maintained, which can also act as wind breaks in hilly areas. In higher altitudes of Senapati and Ukhrul districts of Manipur, and also in Nagaland, the farmers prefer to maintain standing alder trees (*Alnus nepalensis*) which are native multipurpose trees that also fix nitrogen and provide additional nutrients through their fairly profuse growing leaves. Another very common feature of biodiversity management in passion fruit cultivation in the northeastern region is to maintain a few colonies of honey bees, which also act as pollinators for the passion fruit flowers. Bushes and hedgerows maintained near the passion fruit growing areas also act as habitats for insect pollinators, as well as predators.
There are two recognized varieties of passion fruit, viz., purple (*P. edulis* Sims) and yellow (*P. edulis var. flavicarpa*). The purple variety is grown in most parts of Northeast India particularly in the hilly areas of Nagaland, Manipur and Mizoram. The variety is known for best quality in terms of flavour and nutrient content.

The other popular variety is a yellow variety. *Kaveri*, a hybrid of ‘purple’ and ‘yellow’ is high yielding, tolerant to collar rot, wilt, brown leaf spot and nematodes. ‘Noel’s Special’ is a cultivar, tolerant to *Alternaria passiflorae*. It is precocious and can bear fruit starting at one year but it is self-incompatible and needs a pollinator for satisfactory fruiting.

**Local uses**

The leaf is used as a vegetable in the hills of Northeast India. The boiled extract of fresh tender leaves is prescribed as remedy for diabetes, hypertension, diarrhea, dysentery, gastritis, abdominal flatulence, etc., and as a liver tonic. The juice extracted from the fresh fruit is mixed with sugar and added to hot boiling water as a health drink. Value added products include juice, cordial, jam, etc. The fruit covers (shells) are either placed as manure at the base of the plants or they are locally cooked with other vegetables as pig meal.

**SEED**

**Selection and treatment**

The seeds collected from the healthy, fully mature fruits, borne from abundant yielding vines, are initially dipped in a solution of common salt. Those seeds that settle down in the solution are collected. About one kilo of these seeds is soaked in a mixture of one kilo of cow dung, one litre of cow urine, one litre of water and 100 gm of cow ghee for ten minutes. Thereafter, the seeds are dried in the shade for 6–10 hours. Seeds treated in this way are then sown directly in the nursery beds during February to July and exhibit the following advantages:
Source of seeds

Seeds that are collected from newly harvested fruits or from previously harvested seeds or different seed lots purchased from the market are used as the source of seeds for planting material. Currently, good quality seeds may be sourced from the Horticulture Departments of Nagaland, Manipur and Mizoram, and also from the Senapati District Community Resource Management Society (SEDCORM) and the Ukhrul District Community Resource Management Society (UDCRMS), both in Manipur.

Vegetative propagation

Passion fruit vines are usually grown from seeds. However, they can also be grown through vegetative cuttings. In this method, well matured vines with 3–4 nodes are cut into lengths of 20–30 cm. Cuttings should be well-rooted and ready for setting out in 90 days. However, in the NER, most farmers raise nurseries from the seeds and the vegetative means of nursery development is not popular as it is time consuming.

Grafting

Grafting is an important means of perpetuating hybrids and reducing damage from nematodes and other diseases. The resistant yellow passion fruit rootstock is generally utilised for this purpose. Healthy young plants are grafted on to seedlings either by cleft graft or whip graft or side-wedge graft.

Plantation

Seedlings are transplanted from the nursery bed to the main field when they attain a height of about 30 cm. Plant density of 884
plants per acre is considered to be optimum, at a distance of 7 ft plant to plant and row to row. Planting is done in the already well prepared pits. The vines are set out depending upon the topography or slope and contour of the field. Planting sites buffeted by high winds should be avoided as the wind not only damages the vines but makes it more difficult to train the vines on to the trellis. Spring season or early summer, i.e., March to June is considered ideal for transplantation. Passion fruit farming integrated with bee-keeping is also practised by some local farmers, which gives best results in terms of fruit as well as honey production. There are also farmers who intercrop leafy vegetables along with passion fruit cultivation. In Senapati district of Manipur, it is also common to see passion fruit cultivation along with plantations of *Alnus nepalensis* (the alder tree).

**Training**

Some temporary support at the base of each plant is necessary to train it to get a good hold of the wires of the trellis. A terminal branched portion of bamboo, inverted and hung over the trellis wire provides excellent support for the vines. About 4–6 laterals may be trained in the direction of the overhead wire and the sooner they come to a horizontal position on the trellis, the quicker will the vine flower and fruit.
Trellis

A standard trellis, 7 to 8 ft tall, is recommended for passion fruit cultivation as it has the advantages of giving the best spread of vines, early returns, greater yield, accessibility for pruning and harvesting. The trellis should run across the slope or in N-S direction so as to facilitate an even exposure to sunlight. Bamboos and tree branches are hung on the wires of the trellis and also erected along the trellis in between two posts. This gives support and provides better spread of the vines on the trellis.

Pruning

Pruning is necessary to keep the vines within bounds, to make harvest easier, to keep the plants productive by maintaining vigorous growth and to facilitate leader formation. Pruning is usually done after harvesting the crop in November–December. It is done by cutting back laterals to the nearest active bud.

Nursery preparation

The area where the nursery is to be raised should be ploughed at least thrice. About 5,000 kg of farmyard manure per acre should be spread before the final ploughing. Application of manure provides healthy and luxuriant growth of saplings. After levelling and final ploughing, raised beds of 1 to 1.5 metre width and of convenient length are to be made, leaving 30 to 35 cm channels/walking spaces in between two beds.

Main field preparation

The vegetation cover (bushes/shrub/trees) at the selected site is slashed and burned. Some woody trees are allowed to remain in the field, as they serve as live posts for the trellis. Circular pits, each around 2.5 ft diameter and 1 ft depth, are dug in rows, keeping a distance of 8 ft between the pits, and 6 ft between the rows. The top soil of the dug pit is mixed with well decomposed cow dung or compost.
The whole operation should be planned well in advance (October to February) and completed before transplanting the seedlings into the main field.

**MANAGING SOIL FERTILITY**

**Cow urine and dung brew compost**

About 12.5 kg of fresh cow dung and 12.5 litres of cow urine are collected in an earthen pot. After 12.5 litres of water is added to the above mixture, it is stirred thoroughly. The pot is covered and the mixture is allowed to ferment. It is occasionally stirred with a stick. The mixture is filtered and 100 gm of lime is added to it. The mixture is then diluted with water in the ratio of 1:10 and is then sprayed on the crop. About 200 to 250 litres of the mixture are required for one hectare of land.

**Mulching**

Mulching should be done in between the rows for soil, water and weed management. Leaves of alder trees are used as mulch wherever passion fruit is cultivated along with alder plantations. This also prevents over-shading of the passion fruit by the growth of alder branches.

**Green manuring**

Green manuring by inter-cropping with nitrogen-fixing crops like beans, soybean, peas, etc., is another common practice among many farmers of the region.

**Compost**

Compost prepared from weeds and other organic waste like vermi/NADEP/BD can also be applied.

**WATER REQUIREMENTS**

Regular watering will keep the vine flowering and fruiting almost continuously, particularly during the dry season. Water requirement is high when fruits are approaching maturity, otherwise the fruits may shrivel and fall prematurely. However, the passion fruit growing areas of the NER as a whole are rain-fed,
with very good annual rainfall and hence irrigation is not practised by the local farmers.

Traditional techniques like laying of stone boulders, poles and logs across the slope of the hills, mulching, digging trenches, growing cover crops such as ginger, chili, soybean, peas, etc., are practised in order to conserve soil and water.

**Use of biocides**

Generally, no chemical or inorganic fertilisers and pesticides/insecticides are used by farmers on passion fruit farms. The nutrient requirement for the passion fruit vine is provided using well-decomposed cow dung or compost prepared in the pits dug out in the farm at the time of planting. Periodic mulching of the plant around the root zones also provides sufficient nutrients to the plant. Till date, no major disease outbreak has been reported in passion fruit cultivation in Northeast India. Mulching is extensively practiced by the farmers as a means of maintaining the fertility of the soil as cow dung and other biocompost are not easily available in the hill areas.

<table>
<thead>
<tr>
<th><strong>DO’S AND DON’T’S IN PASSION FRUIT IPM</strong></th>
<th><strong>DO’S</strong></th>
<th><strong>DON’T’S</strong></th>
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<tbody>
<tr>
<td>Grow recommended varieties such as Kaveri (hybrid between purple and yellow) as these are tolerant to collar rot, wilt, etc. (In the absence of this variety, farmers’ experience is that purple variety is superior to yellow variety).</td>
<td>Do not grow under-script materials; source and varieties of seedlings should be ascertained.</td>
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<tr>
<td>Select a gentle slope for passion fruit cultivation for proper maintenance of drainage.</td>
<td>Avoid flat land as drainage; maintenance is difficult and costly.</td>
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<tr>
<td>Follow healthy agronomic practices such as selection of healthy seedlings, timely sowing, maintaining good spacing, trellis, etc.</td>
<td>Poor agronomic practices lead to poor yield and unproductive plantation.</td>
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<tr>
<td>Encourage intercropping with annuals (soybean, etc.) and maintenance of good hedge plants to support predators.</td>
<td>Absence of intercrop and hedge plants may contribute to poor productivity of fruits.</td>
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</tbody>
</table>
Aphids are reported to be the major pests of passion fruits. The species of aphids that attack passion fruit plants are *Myzus persicae*, *Aphis spiraecola*, *A. gossypii* and *A. craccivora*. Reduced plant vigour, stunted growth and deformed plants are common manifestations of aphid infestations.

**Life cycle**

Though aphids belong to the group of insects with a simple life cycle, many species have very complex life histories that involve not only alternate generation between asexual parthenogenesis and sexual reproduction but also a switch in the host plant. The spring and summer asexual forms live on one host plant to lay fertilised eggs that will survive adverse winter conditions. In spring, the eggs hatch and the aphids migrate onto their summer host when it becomes available. The life cycle, i.e., the development to sexual maturity for most aphids is five to six days. Other important insect pests that attack passion fruit plants are mealy bugs, thrips, nematodes, etc.

**Management**

In most commercial plantations of passion fruit, application of pesticides or insecticides is carried out only when the population of the insect pests has reached the economic threshold level. For example, the economic threshold of aphids is 20 per 100 compound leaves. However, it is understood that such a stage has never been experienced in the NER in recent years. General mixtures that can be easily prepared and effectively used for
control of insect pest (aphid) infestations are as follows:

- **Oil spray**: mix one teaspoon of liquid soap with one cup of vegetable oil. Dilute as required using one or two teaspoons of the mixture to one cup of water.
- **Vinegar spray**: mix one part vinegar with three parts water and add 5 gm of soap flakes.
- **Garlic spray**: Soak one bulb of finely chopped garlic in paraffin for three days. Dissolve two cups of soap flakes in one litre of water, add to the garlic mixture, allow it to stand for two days and then strain the mixture through a fine cloth. Dilute half a cup of the garlic concentrate with four litres of water before application.
- **Soap spray**: mix soap with water and spray. It works as a natural contact insecticide by breaking down the insect’s exoskeleton causing it to dehydrate and die.

**Fruit fly (Bactrocera latifrons)**

Known as the Malaysian fly, this fruit fly is native to south Asia. *Bactrocera latifrons* is a group of insects that usually puncture the immature passion fruit while the rind is still tender, causing fruit distortion and shrivelling. Fruit flies are often present at low levels, without causing significant economic problems, so no management is required.

**Life cycle**

The fruit fly insect population is dependent on the temperature. Cool temperatures will slow its growth cycle. Warmer temperatures will increase its numbers. The life cycle of the *solanaceous* fruit fly is as follows:

One generation takes around 48 days. Egg to adult life cycle is completed in 21 days. Eggs hatch in about two days. Larvae develop in 8–9 days. Adults emerge in ten days. Pre-oviposition period is 10–11 days. Females lay an average of ten eggs at a time. The fruit fly generally has a low population level and patchy
distribution. There are reportedly 33 host plants mostly belonging to the family *solanaceae* (pepper, tomato, eggplant, and apple) and *cucurbitaceae*.

**Other pests**

Other pests include mealy bugs (*Panococcus* spp.) and mites (*Brevipapus* spp). Good management practices to control the pests of passion fruit include maintenance of adequate spacing at the time of planting, maintenance of adequate drainage, avoidance of overcrowding and excessive shading of vines, periodic removal and destruction of all infested leaves/twigs/fruits, etc. Maintenance of good hedgerows also supports varieties of predators like lady bird beetles, syrphids, wasps, spiders, etc., all of which feed on insect pests and mites. Farmers also report incidence of attacks from rodent pests (*Rattus* sp., *Bandicota* sp., etc.), squirrels and birds. Mechanical traps are used to control the population of rodents and squirrels. However, none of these pests are reported to be serious in the present case study areas of NER.

**Fungal diseases**

**Brown spot**

The disease is caused by the fungus *Alternaria passiflorae*. The symptoms are first seen on the leaves and are characterized by minute reddish-brown spots. As infection progresses, the spots enlarge forming a series of concentric rings resulting in premature leaf drop. Symptoms on the fruits are characterized by circular, sunken, reddish-brown necrotic areas.

**Root rot**

This disease is caused by *Pythium splendens*, *P. aphanidermatum* and species of the genus *Phytophthora*. The characteristic symptoms are a general decline in vigour as feeder roots are destroyed by the fungus.

**Fusarium wilt**

This is caused by a soil-borne fungus called *Fusarium oxyporium*. 
The disease starts with the wilting of the shoots followed by a total collapse of the plant. Water conducting tissues of the affected plants become brown or reddish-brown.

**Management of fungal diseases**

Species of *Pythium* and *Phytopthora* are causal agents for collar rot and root rot. These diseases are difficult to control because the pathogens survive saprophytically in the soil. However, their effects can be minimised by improving drainage and avoiding overcrowding of seedlings. Soil sterilisation by dry heat is another method for controlling these diseases. It is accomplished by burning wood at the sites where the seed beds are located. Major passion fruit diseases are yet to be reported from the NER.

**Post-harvest diseases**

Normally, post-harvest problems are minor. However the most common disease is 'brown spots' which is caused by *Alternaria passiflora*. Symptoms are circular, sunken, light-brown spots on ripening fruit. Septoria spot (*Septoria passiflora*) leads to uneven ripening of the skin. *Phytophthora* fruit rot (*Phytophthora* spp.) causes water-soaked, dark-green patches that dry up on the skin.

**Life cycle description**

Both the species of the genus *Phytophthora* and *Pythium* grow saprophytically and parasitically. Reproduction is asexual and sexual. In *Pythium*, asexual reproduction takes place by the formation of conidia and zoospores, whereas in the case of *Phytophthora* it takes place by means of conidia borne on branched conidiophores. Conidia, when grown in dry conditions, germinate directly to new mycelia. When species grow in moist conditions, each zoospore encysts and germinates by putting forth a germ tube. Sexual reproduction is by means of gametological contacts in both the species. Here the male gamete unites with the oosphere, i.e., the egg and forms the zygote which, after undergoing a rest period, germinates into a vegetative hyphae.
Viral diseases

Aphids act as the vectors of virus. Some common viral diseases that attack the passion fruit plants are:

**Passion fruit mottle virus**

Green and yellow mottle, leaf deformation and crinkling are the symptoms of this virus. The virus is transmitted through several species of aphids, contaminated pruning knives, etc.

**Cucumber mosaic virus**

Chlorotic mosaic and mottling are the most prominent symptoms. The mode of transmission is the same as passion fruit mottle virus.

**Passion fruit ring spot virus**

Chlorotic rings in mature and shaded leaves are the characteristic symptoms of this virus.

Physiological disorders

Shrivel, pulp, fermentation and fungal attacks are the major post-harvest physiological disorders or problems.

HARVESTING AND POST HARVEST TECHNOLOGY

Passion fruit ripens 9 to 12 weeks after pollination. On attaining maturity, the fruit turns deep purple in colour and then falls to the ground. The fruit can either be hand picked when it changes to purple colour or it can be collected from the ground. For storage, the fruits are washed and dried and placed in bags. The fruit can last for 2–3 weeks and it is sweetest when slightly shriveled. Fruits bound for the factory are packed in crates or boxes and transported within 2–5 days.

**Formally certified markets**

Exotic Juice Private Limited at Punanamei in Senapati district in Manipur is the formally certified market for passion fruit while informal markets exist at Mao Gate, Senapati, Kangpokpi, Motbung, etc. Dimapur and Kohima in Nagaland and Aizawl in Mizoram are also known for trade in passion fruit.
Successful initiatives of passion fruit cultivation in the NER

Recently, through the initiatives of the Small Farmer’s Agri-Business Consortium (SFAC), Agricultural and Processed Food Products Export Development Authority (APEDA) and an NGO named Good Samaritan Social Service Association (GSSSA), there is a systematic cultivation of passion fruit in the clean, pollution free environment of Manipur and Nagaland states of the NER. Prior to this, the Government of Nagaland, particularly the Department of Agriculture and the Department of Horticulture, was promoting passion fruit cultivation in Nagaland and providing appropriate extension services. Since 2003–04, IFAD-Government of India funded the NER Community Resource Management Project for Upland Areas (NERCORMP), through its two agencies, viz., the Ukhrul District Community Resource Management Society in the Ukhrul district of Manipur and the Senapati District Community Resource Management Society in the Senapati district of Manipur. In addition, the GSSSA has been promoting the processing of passion fruit to produce international quality, value-added products. The organisation has successfully installed one large scale (capacity 2 MT per hour) concentrate juice extraction unit at Punanamei in Senapati district of Manipur.

Lamak Kajung of Lairowching village of Senapati district of Manipur is from the Maram tribe and lives adjacent to the neighbouring Kohima district of Nagaland. Initially he learnt the art of passion fruit cultivation from the neighbouring farmers of Nagaland. He even brought the seedlings from Nagaland. He started passion fruit cultivation in 2001 and presently he has about 12 acres of land under passion fruit cultivation, which he up scaled after 2003 with the assistance and encouragement of the NERCORMP-IFAD project and GSSSA. In 2004, with a total
investment of Rs. 2.5 lakhs, including a Rs.50,000 loan from the State Bank of India, he earned a total of Rs.8.5 lakhs (Rs.2.5 lakhs by selling fresh fruits @ Rs.8 per kg and Rs.6 lakhs by selling saplings). Kajung received the ‘Award of Excellence as Best Horticulturist’ from SBI, Manipur during 2004–05 for his success in passion fruit cultivation.

Kajung has chosen gentle sloping land with good soil for his cultivation. Initially he slashes and burns the area for field preparation. He weeds the farm twice a year; the de-weeded plant materials are used as mulch. Initially he used local materials for trellis, but nowadays he has replaced this with a wire trellis. He inspects his farm very frequently for signs of any pest or disease. He says he is lucky that till date he has not come across or experienced any serious pest problem. He has also successfully developed nurseries to meet the high local demand for seedlings.

SUGGESTED READINGS


INSTITUTION ENGAGED ON RESEARCH AND EXTENSION

Indian Institute of Horticultural Research, Hassarghatta, Lake Post, Bangalore.

ICAR Research Complex for NEH Region, Barapani, 793103, Meghalaya.

Horticulture Departments of Government of Nagaland, Manipur and Mizoram.
PINEAPPLE

BACKGROUND TO THE CROP

The pineapple (*Ananas comosus Merr*) is a popular tropical fruit which belongs to the family *Bromeliaceae*. It originated in Brazil and subsequently spread to other parts of the tropical world. It can be grown as a pure crop on plantation scale or as an intercrop in coconut gardens or as an agro-forestry crop along with a variety of trees. In Tripura and in many parts of the Barak valley in Assam, pineapple is cultivated along with jackfruit trees. It is a fast growing fruit and is considered ideal for canning purposes. The fruit contains a special enzyme called bromelin which digests protein. Besides vitamin A, B and C, pineapple is a good source of minerals like iron, calcium and phosphorus. Pineapple juice and slices are famous as preserves and are exported to different countries. Fresh fruit is used for table purpose and also for making jams, jellies, etc. Because the climate in most parts of our country is favourable for pineapple cultivation, there is immense scope for increasing its area and production. Organic production of pineapple and its processing will go a long way in boosting the economy of the region. Pineapple cultivation is widespread in the states of Assam, Tripura, Tamil Nadu, Kerala, Karnataka, Meghalaya, West Bengal, Maharashtra, Andhra Pradesh and Goa.

Botany

The pineapple is a monocot, perennial, herbaceous plant, which attains a maximum size of 80–90 cm. Inflorescence emerges from the top portion of the stem. Fruit development in the first crop takes place from the main stem whereas in the second (ratoon) crop, it is from one or two branches from the main stem. The fruit is botanically known as *sorosis*. The same stem does not produce a second crop. Self-sterility is found in all the commercial varieties and fruits are parthenocarpic.
Climate

The pineapple is a crop of the humid tropics. The fruit grows well near the sea coast as well as in the interior, so long as the temperatures are not extreme. The optimum temperature for successful cultivation is 22–32 °C. Leaves and roots grow best at 32 °C and 25 °C respectively. Their growth ceases below 20 °C and above 36 °C. A high temperature at night is deleterious and a difference of at least 4 °C between day and night temperatures is desirable. Pineapple can be grown up to 1,100 m ASL, if the area is frost-free. Although the annual rainfall for its commercial cultivation is 100–150 cm, it grows remarkably well under a wide range of rainfall.

Growing season

The best planting season is at the onset of the monsoons. Planting during heavy rainfall should be avoided.

Soil

The plants grow well in most types of soil, except very heavy clay soil. Sandy loam soils are ideal. The soil should be 45–60 cm in depth without hard pan or stones. The pH should be 5.0–6.0.

Crop duration

The pineapple is a perennial crop with an economic life of 5–7 years, though many of the farmers in the northeastern region cultivate it beyond 12–15 years through crop manipulation and traditional agronomic practices. Even 20–25 year old plantations are common in many parts of north Tripura and in the Barak valley of Assam.

Cropping system and pattern

Pineapples are commonly grown as a monocrop in jhum-abandoned areas in the NER. They can also be grown along with different crops in mixed or intercropping patterns and as a mixed crop in home gardens with different vegetable crops like colocassia, yam, chilies, cabbage, cauliflower, sweet potato, pigeon pea, green gram, black gram, sesame, etc. Pineapple is also grown along with forest trees as part of the agro forestry cropping system; and in jhum areas, it is grown along with yam, pumpkin, sesame, sweet potato, chilies, etc. It is also found to be suitable
for intercropping with crops like orange, lemon, pigeon pea, banana, areca nut, etc. However, it is not suitable for intercropping with heavy nutrient feeder crops like rice, wheat, ginger, etc.

**VARIETIES**

There are five varieties of pineapple generally cultivated, each having distinct characteristics. They are as follows:

**Kew**

Also known as Smooth Cayenne because of the absence of thorns on the leaf margins. The average weight of the fruit is 2–3 kg and it is most suitable for canning.

**Queen**

The plants are smaller and the leaves possess thorns on the margins. The average weight of the fruit is 1–2 kg. Its keeping quality is better than the Kew. It is considered suitable as a table fruit. It is an early variety.

**Mauritius**

Smaller than the Kew and bigger than the Queen. The fruit contains more acidity and is less sweet. The average weight of the fruit is 1.5 to 2.5 kg. It is generally not used for canning and is a mid-season variety.

**Jaldhup and Lakhat**

Lakhat is markedly sour in taste, whereas Jaldhup has its sweetness well-blended with acidity. The fruits of Jaldhup have a characteristic alcoholic flavour.

**Giant Kew**

Synonymous with the Kew, except that the size of the plant and of the fruit is larger than the Kew.

**Propagation**

Pineapple is propagated vegetatively through suckers, slips, crowns and discs. Plants grown from suckers produce fruit in 15–18 months, whereas those from slips, crowns and discs take 20–22 months after planting.
Suckers and slips are cured by stripping off the lower leaves followed by drying in the sun or in partial shade for about a week before planting. This curing is done to avoid rotting of plants after they are planted.

Suckers can be treated by dipping them in a mixture of a cow pit/amrut pani/jeevamrut/panchgavya, etc., as per convenience. Then they are dried for 6–10 hours. When such treated suckers are used for planting, they will result in healthy plants and high yields.

**Preparation of land**

An area with 30–40% slope is generally selected for pineapple cultivation. In the NER, the most common method of initial clearing of the land for plantations is by way of slash-and-burn. No formal organic compost is added to the soil for planting. Only in cases where cow dung or other compost materials are available, they may be added to the pits dug for pineapple plantation. The land is generally prepared by hoeing, but in areas where the slope is not too steep, the land may be leveled by ploughing to facilitate uniform distribution of water and nutrients. Alternate crisscross rows are made using a bamboo across the slope, which helps in soil and water conservation. In most hill areas of the NER, the fields are not ploughed but uniform rows are demarcated either across the slopes or along the slopes where the suckers are planted at uniform spacing (in the case of mono-cultivation) or random spacing if planted along with other perennial crops such as banana, papaya, etc.

**Planting**

Planting is done either in flat beds where there is no danger of water logging, or in shallow trenches that are filled as the suckers grow and develop. Care should be taken to see that the bud or heart of the sucker does not get buried. A single or double row
system of planting is followed. The suckers are planted in about 8–10 cm deep holes with perfect alignment.

**Spacing**

In the single row system of planting, plants are spaced 30–60 cm apart with a spacing of 75 cm between rows. In the double row system, the spacing is 30 cm between plants, 60 cm between rows and 1–1.5 m between double rows from the centre.

**Planting time**

The best time for planting of pineapple suckers is during the rainy season i.e., between June to August. Suckers are planted directly in the main field. Most farmers in the region plant without giving any treatment to the suckers.
Crop-specific agronomic practices

An optimum planting density is important for obtaining fruits of good size and quality. For cultivation of pineapple in flat beds, a planting density of 43,000 plants per hectare is considered optimum, keeping a distance of 30 cm between plants, 60 cm between rows and 90 cm between beds. The interspaces are intercropped with seasonal pulses or vegetables of short duration.

In the double row system, planting is done with a spacing of 25 cm x 50 cm x 80 cm for a total plant population of 61,538 plants per hectare. A close spacing pattern is suitable for hill areas on terraces to prevent soil erosion. The plantation is allowed to remain on the same site for 4–5 years after which the old plants are removed and new ones are planted.

Incorporation of FYM or compost, viz., NADEP/vermi/biodynamic/mm, etc., as per their availability and application of microbial enhancers, viz., amrut pani/cow pat pit/BD-500/panchgavya/vermi-wash are effective in improving the physico-chemical and microbial properties of the soil.

MANAGING SOIL FERTILITY

Sufficient quantities of biodegradable material of microbial, plant or animal residue should be returned to the soil to increase or at least to maintain its fertility and the biological activity within it. A dose of 25 t/ha of compost/cattle manure can be applied as basal dressing. The green leaf and compost or cattle manure may be broadcast around the plant after weeding and mixed with soil by light hoeing or forking.

Weeds

Weeding is generally done twice a year; first, about a month or two after planting, in the month of August or September, and second, in the months of October to November. Periodic weeding keeps the area clean. The uprooted weeds are either used for making organic compost or as mulch to conserve water/moisture during winter/dry months.
Growing green manure crops/cover crops/green legume crops and mulching with weed slashings and leaf litter, etc., also suppress weed growth.

Pineapple is generally grown under rain-fed conditions in the NER. However, in extreme conditions, drip irrigation may be the ideal way of maintaining the soil moisture requirement for optimum growth of the plant, particularly during the dry summer season. During summer months, pineapple plants should be irrigated wherever possible: they may require five or six irrigations during the dry months at intervals of 20–25 days. However, no farmer has been observed to follow this practice in the NER.

**Conservation techniques**

Growing of green manure crops at the onset of monsoon in between two rows helps to suppress weed growth, prevent soil erosion and to add organic matter to the soil. Cover crops like sweet potato, etc., can also be grown to conserve soil moisture. Mulching with straw and other plant materials is the technique generally practised by the farmers.

**Problem insects**

**Mealy bugs**

The mealy bug is the most widely distributed and probably also one of the most damaging pests affecting pineapple crops. The rapid spread of this malady in fields is due to the feeding habits of these insects. Often, before the visual symptoms appear, mealy bugs have ahead left the infected plants and moved on to nearby healthy ones. Symptoms first appear on roots, and they are seldom observed because the roots are underground. The roots cease to grow, eventually leading to collapse of tissues. The predominant symptom is wilting of leaves, commencing from the leaf tips. Reddish-yellow colour manifests in the wilting areas.

**Other pests**

Other pests that appear sporadically in eastern India are the stem borer (*Metmasius ritchiei*) and the scale insect (*Diaspis bromeliae*). Minor pests include the fruit and stem borer (*Tecla*...
Nematodes

Reductions in crop yield, particularly in ratoon crops, are caused by root knot nematodes of the *Meloidogyne* genus. The other genera that cause root lesions or penetrate into roots of pineapple plants are *Pratylenchus* and *Rotylenchus*. Initially, when the nematode population is low, plants do not exhibit any symptoms. But later, with the increase in population, plant growth is restricted and finally chlorosis appears on the leaves. Plant material infested with nematodes should be destroyed and only healthy plant material should be used for fresh planting.

Animals

Common animals that are attracted to pineapples are rodents, monkeys, squirrels, wild boar, porcupines, and birds. Even cattle sometimes feed on the tender leaves of pineapple plants, though their trampling may cause more damage than their feeding.

Rodents

Rats attack mature or ripe pineapple fruits. Spreading pieces of colocassia in the field or in storage areas gives reasonable control.

Monkeys

In hilly areas, monkeys eat and destroy pineapple. Mechanical traps can control such attacks.

Squirrels

Squirrels eat the ripe pineapple in the field. Mechanical traps can control such attacks as well.

Wild boar and porcupines

Wild boar and porcupines feed on the roots of the pineapple plant. Mechanical trappings are the traditional and effective ways of controlling this menace.
### Birds

A number of birds, especially crows and peacocks, feed on ripe pineapples. The farmers usually control the bird's population by mechanical trappings.

### DISEASES

#### Butt rot/leaf rot/base rot/fruit rot

The fungus *Ceratostomella paradoxa* causes rotting in planting material, fruits, stems and leaves under conditions of high moisture and high humidity. Base or butt rot of planting material occurs when the suckers are not dried properly and are tightly packed, with little aeration. Fungus also destroys older plants by entering through wounds caused in the collar region during weeding or other intercultural operations. Leaf rot, base rot and fruit rot are caused by *Ceratostomella paradoxa* throughout the pineapple growing areas. Treatment of suckers in BD liquid pesticides prepared from fermented cow dung, urine and leaves from local materials is yet to be evaluated.

#### Black rot or soft rot

This occurs in ripe fruit, mostly after harvesting, if there is a delay between harvesting and utilisation. The organism that causes black rot also causes butt rot. Occurrence of black rot is quite common. The fungus makes its entry through wounds caused during picking and packing. Infestation starts at the stalk end of the fruit, resulting in small, circular, water-soaked spots that are soft. Gradually, the fruit rots and emits a foul smell. Avoiding injury to the fruit during harvesting and transit will prevent the occurrence of this disease.

#### Heart rot or stem rot and root rot

The disease is caused by *Phytophthora cinnamoni* and *Phytophthora parasitica*. Infection due to *P. cinnamoni* is limited to warm and low rainfall areas. On the other hand, *P. parasitica* causes heart rot in warm and dry areas. This organism is commonly seen in India. Poor physical condition of the soil and inadequate drainage are responsible for spread of this disease which is frequently associated with alkaline soils but is not limited.
to them only. The green leaves turn yellowish green and tips turn brown. The central whorl of leaves when affected will come out with a gentle pull. The basal portion of the leaves shows signs of rotting and emits foul odour.

**Management**

- Provide adequate drainage in the field.
- Select healthy material for planting.

Treat the suckers with cow dung slurry or biodynamic preparations.

**Leaf spot**

Occurs most frequently in moist, warm, climates. Small, water-soaked areas first develop on the leaves and gradually enlarge. The affected portions become pale yellow in colour and gradually dry up. This disease is also caused by *Phytophthora spp*. Control measures are similar to those used for heart rot.

**Yellow spot**

Yellow spot disease affects both plants and fruits and is caused by a virus (tomato spotted wilt) which is transmitted through thrips from hosts such as *Emilia sanchifolia*, a well-known composite weed. Eradicating weed hosts may help in checking the spread of this disease.

**Management**

The majority of the pests and diseases can be effectively kept under check by judicious maintenance of the microclimate. The pests can be controlled by an integration of physical, cultural and biological methods including plant-based preparations.

**Following preparations are used for control**

- Dilute one litre of cow urine in ten litres of water and wet the whole plant at the rate of 200–300 l/ha at regular intervals.
- 12.5 kg of fresh cow dung and 12.5 litres of cow urine are collected in an earthen pot and mixed thoroughly with 12.5 litres of water. The pot is covered and the mixture is
allowed to ferment for a week. Occasionally it is stirred with a stick. After a week of fermentation, the mixture is filtered and 100 gm of lime is added. The concentration is diluted with water in a 1:10 ratio and sprayed on the crop @ 200–250 l/ha.

**Neem oil spray**

- 2% neem oil is mixed with any detergent powder @ 40–50 gm/100 l and used as a spray solution.

**Neem seed kernel extract (NSKE)**

- It can be used as a prophylactic before the onset of pests.

The method of preparation of NSKE is provided in the final chapter, *Current State of Inputs for Organic Agriculture*.

**Chili garlic soup**

Chili garlic soup is an effective insect repellent.

**Tobacco tea**

Tobacco tea is effective against most pests.

**Herbal mixture spray**

About 500 gm of tobacco leaves, 1 kg of neem kernel, 500 gm lime powder, 500 gm datura leaves and 500 gm pods and seeds of oleander (*Nerium oleander*) are powdered and mixed together, then soaked in 15 litres of water for 15 days. On alternate days, the mixture needs to be stirred with a stick. After 15 days, one litre of filtrate is mixed in 15 litres of water and sprayed on the crop. It is enough for 2.5 ha and is a multi-pest repellent.

**Cow dung spray**

A suspension of fresh cow dung (500 gm in ten litres of water) is prepared and strained through a muslin cloth. The suspension is sprayed on the infected crop twice at weekly interval. It reduces general incidence of disease.

**HARVESTING**

It takes about 15–20 months for the crop to mature. Usually flowering takes place from February to April and the fruit is ready...
between July to September. Sometimes off-season flowers appear and they produce fruit during winter, which is of poor quality. The fruit is harvested when it just becomes yellow, the angularities of eyes start reducing and the bracts wither. Average yield is 10–15 tonnes per hectare.

**Cleaning**

Pineapple fruits are cleaned by removing the leaves and stalk from both ends.

**Drying**

After harvesting, the pineapple fruits can be kept in the shade for a short duration.

**Grading**

The fruits can be separated and graded according to the size.

**Packaging and transportation**

Waste generating packaging material is to be avoided. The use of material for packaging should be eco-friendly. Clean bamboo baskets are used for packing pineapple both at the farm as well as at processing stage. For long distance transportation, the crown of the pineapple is usually cut half way in order to reduce damages during transportation.

**Storage godown treatment**

Adequate ventilation is required for short duration storage, whereas refrigerated system is suggested to slow down ripening during long storage. Care should be taken to prevent bruising during harvesting and packing. Fruits have to be adequately protected against fungal infection. The level of atmospheric oxygen in the transport container can be reduced to slow down respiration.

**Storage pests**

Rodents, squirrels, etc., destroy the pineapple fruits in the storage godown.
Storage pest management
Mechanical means and traps can control storage pests. Patchouli can be grown to ward off snakes.

Specific agro climatic requirements
Pineapple can be grown in a wide variety of soil and climatic conditions. However, slightly sloping land is most suitable for growing the fruit. The area should not, however, be too shaded, as the pineapple plant requires fairly good amount of sunlight in addition to some amount of shade.

Labour demand
Pineapple cultivation in the hill areas of Northeast India is fairly labour intensive. Maintenance of the garden and weed management are among the most important tasks as overgrowth of weed can markedly affect the quality of the fruit. Pineapple also suckers profusely, yielding at least 3–5 suckers on an average per plant. These have to be removed periodically or every year for healthy maintenance of the garden. Protection of pineapple gardens is also demanding, since unless fenced, the ripe pineapples can attract various kinds of animals. The best practice is to harvest mature raw pineapples before they ripen.

Organic pineapple cultivation
Khoya Teron is a farmer from the village of Kekangadong in the Deithor area of Bokajan sub-division in Karbi Anglong district of Assam who has been successfully growing pineapple organically for several years. His total cultivated area is a little over 1.00 ha. Originally this was jhum area which he converted into a pineapple garden. His annual income from selling the fruit and suckers is more than Rs 45,000.

Initially Teron spent a considerable time in weeding operations – at least thrice a year – during the first three years of cultivation. His garden is now mature and the spacing of the plants is such that weeds are almost naturally suppressed. He clears weeds only once a year now. However, he spends considerable time in
collecting suckers and clearing them periodically for proper
maintenance of the garden. ‘Overcrowding of the plants is not
good for pineapple,’ he says. He is fully occupied with his
plantation each year during the months of June through August to
early September. Fruiting seasons are particularly busy months as
he must collect the mature pineapple on alternate days to
minimise damage from animals. He also gets a winter crop of
pineapples, which he says does not have much demand but he is
able to sell them due to his proximity to the Bokajan market.

**FURTHER READINGS**


*Guidelines for production of organic pineapple in India*. APEDA,

Assam Agricultural University (1999). *Package and practices for
pineapple*. Department of Extension Education, Assam
Agriculture University, Jorhat.

**INSTITUTIONS ENGAGED ON RESEARCH AND EXTENSION**

Indian Institute of Horticultural Research, Hissarghatta Lake Post,
Bangalore-560089, Karnataka, http:www.kar.nic.in.iihr

ICAR Complex for NEH Region, Barapani, 793103, Meghalaya.
ORGANIC INPUTS

This chapter outlines various inputs for nutrient, pest and disease management commonly used in the organic farming of crops. The method of preparation and application is briefly described. For more detailed information, please consult the companion FAO publication, *Current State of Inputs for Organic Agriculture*.

**SEED/PLANTING MATERIAL**

*Trichoderma viride (TV)*

*Trichoderma viride* is a fungus prepared in laboratory which is used as a biological pesticide.

- It is useful against fungal attacks like wilt, rusting of leaves, root rot disease, food rot disease, etc.
- It helps in the germination of seed.
- It can enhance the growth of the plant and partly satisfies the nutrient requirements of the plant as well.
- It is not harmful to either plants or animals.

**Method by which TV is used**

**Seed treatment**

The seed has to be washed first to get rid of any chemical fertilisers and pesticides. *TV* culture @ 4 gm per kilo of seed is mixed with starch to make a sticky paste. The seed is mixed with the paste and then dried in the shade. The dried seed is sown immediately thereafter.

**Seedling treatment**

Twenty grams of *TV* is mixed in a litre of water. Seedlings of brinjal, chili, tomato, cabbage, etc., are immersed in the water for five minutes before they are transplanted to the main field.

**Nursery treatment**

About 50 gm of *TV* culture is mixed with 500 gm of vermicompost or compost and mixed with the soil for each 64.8m² of land.

**Main field treatment**

During preparation of the main field, 300 gm of *TV* mixed with compost or vermicompost is incorporated into the soil per bigha.
**TV spray on crops**

Ten grams of TV culture are mixed in a litre of water and sprayed on the leaves and shoots of the crop.

**Pseudomonas fluorescens**

*Pseudomonas fluorescens* is a plant commensal bacterium that lives near the roots of plants and produces secondary metabolites that suppress soil-borne plant pathogens.

*Pseudomonas spp.* are ubiquitous inhabitants of the soil, water and plants. The pseudomonas live in safe sites on the plant to avoid stress and get their nutrients from the plant surface. These species helps plants by suppressing pests, enhancing access of plants to key nutrients, altering physiological processes or degrading environmental pollutants. Pseudomonas have a capacity to produce a wide variety of chemicals, including antibiotics, that are toxic to plant pathogens.

**Nutrient management**

**High temperature compost**

Traditionally, farmers dig a shallow pit, approximately 120–130 cm wide, 170–180 cm long and 90–120 cm deep and dump all farm waste, household waste, animal manure, cattle urine, etc, into it. Some farmers also add thin layers of ash or soil from time to time.

This is farmyard manure although farmers often refer to it as compost. Such FYM or casual composting has certain problems. Moisture and oxygen levels are variable and so is the heat distribution within the pit. As a result, weed seeds and plant pathogens often survive inside the pit and get transmitted to the field when the FYM is applied. Second, a lot of nutrients leach out or evaporate. To avoid these problems, compost has to be made differently.
The method proposed is known as the ‘high temperature compost method’. In this method, the dimensions of the pit-cum-heap are as follows:

The width should be between 120–150 cm, the height can be 150–180 cm, of which roughly one-third will be below the soil surface and the rest above. The length should be at least 180 cm but that can be extended as required to utilise available wastes.

The compost site should be in a semi-shaded place and not too close to any large tree or in a spot where water tends to stagnate. Nor should it be close to any open well which is used as a source of drinking water.

**Procedure**

Dry matter, i.e., carbon-rich material, such as dry grass, straw, plant stalk from legumes and oilseeds, coconut coir, saw-dust, jute waste, etc., are thrown into the pit till it forms a 30 cm or 1 ft deep layer. In the dry season, it is preferable that before throwing in this material it is dipped briefly in a diluted (1 to 2 %) cow dung solution. Next, green matter – which can be leaves from nitrogen fixing trees, manure from cattle or birds, fish waste, oil seed cake, leaf or skin from fresh vegetables, etc., – and other nitrogen rich materials are added to the pit, upto a height of approximately 8” or 20 cm.

Immediately above this green layer, a 4-5 cm deep layer of soil is now added to retain moisture, nutrients and heat. Whenever similar kinds of materials are available, the same kind of layering is replicated. When there are four to five layers in the pit, the entire heap is soaked with water and a final 5–6 cm deep mud layer is used to plaster all the sides. In this kind of heap, the temperature rises up to 60–70 °C and because of the insulation, remains at that level for 5–7 days. This ensures that all weed seeds germinate and plant pathogens are destroyed.
For enriched compost, about 200–250 gm of azotobacter and phosphobacter as well as a handful of old compost or vermicompost are mixed with every soil layer. Sometimes special bio-activators are also utilised.

If surplus is available, then azolla, duckweed and the substrate of mushroom culture can also be added to the heap. Aquatic weeds like water hyacinth can also be added but after chopping their roots. Weed plants can be added before they start flowering. Leaves with lots of oil – for example, eucalyptus, mango leaf, pine-needles, etc. – are generally not added to compost.

Droppings from domestic carnivorous animals like dogs, cats, etc., are also not used.

This type of compost does not need any turning and is usually ready for use after 100–120 days.

**Importance of composting**

Composting improves the physical condition of the soil. It enhances the water-holding and heat-absorbing capacity of the soil and also its permeability. The general capacity of the soil to provide nutrition to the plant also vastly improves thus making the growth of the plant easier in such soils.

Compost acts as a buffer both for acidity and alkalinity and it improves the plant’s ability to tolerate salinity and, to some extent, other chemical residues in the soil. Compost also improves the cationic exchange capacity of the soil, though vermicompost is more effective for the purpose.

Compost is very rich in microorganisms, especially bacteria and fungi. When it is incorporated into the soil, various processes like ammonification, nitrification and nitrogen fixation are also accelerated. Compost activates those fungi which live in close association with the roots of plants and trees and which play an important role in transferring certain essential plant nutrients and
micronutrients from the soil to the plant. It also contains small amounts of growth promoting substances which are better known as hormones.

**Vermicompost**

Vermicomposting is a technique for recycling of non-toxic organic wastes. It refers to the organic manure produced by earthworms. Epigeics (worms which are surface living) do not process the soil but are efficient in composting of organic waste through biodegradation or mineralisation and nutrient mobilisation. When maintained in captivity under semi-natural conditions, they remain active, with high regeneration capacity, throughout the year. The key factors for bio-conservation process and maturity of vermicompost are population density of earthworms present in the substrate and also the quality of waste material used.

**Its importance**

Vermicompost is stable, fine, granular, organic matter which, when added to clay soil, loosens it and creates passages for the entry of air. The mucus associated with the vermicast absorbs water, prevents waterlogging, and thus improves the water-holding capacity of the soil.

Some of the secretions of worms and the associated microbes in vermicompost act as growth promoters along with other nutrients. Vermicompost improves the physical, chemical and biological properties of soil. The organic carbon in vermicompost releases the nutrients slowly and steadily into the system and enables the plant to absorb these nutrients. Soil enriched with vermicompost provides nutrients which influence the growth and yield of crops.

**How vermicompost is made**

Making vermicompost is very simple and easy. However, it needs careful, step-wise preparations.
1. Site selection

2. Collection or procurement of suitable worm species (generally local varieties)

**Basic characteristics of suitable species**

1. The worm should be tolerant to disease.

2. The worm should efficiently convert plant or animal biomass into body protein, so that its growth rate is high.

3. The worm should have high consumption, digestion and assimilation rate.

4. The culturing techniques should be simple enough to adopt.

5. The worm should have wide adaptability to environmental factors and it should also have feeding preference and adaptability for a wide range of organic material.

6. The worm should produce large numbers of cocoons that should not have a long hatching time, so that self-multiplication and conversion of organic matter are both rapid.

7. The growth rate and maturity from young ones to adult stage should be quick.

8. The worm should have compatibility with other worms.

9. The worm should feed near the surface of the organic matter.

**Materials required**

*Ingredients*

1. One portion of soil, two portions of raw organic matter (leaf, weed, water hyacinth without root, compost, waste material of animals and birds) and three portions of dry straw, husk (straw and husk of paddy, wheat, pulses).

2. Requisite amount of water for maintaining the mass at 40–50% moisture.

3. Leaf, dry straw.
Process

The organic matter is first mixed with water within a pit. The upper portion of the pit is next covered with mud.

After 4–5 weeks, when the whole mixture is semi-rotten, it is thoroughly mixed again and within one or two days, proper aeration is provided. In this way, semi-rotten compost is formed. The earthworms should now be introduced into this partially decomposed material. Approximately 100–150 earthworms are needed for every kilo of semi rotten compost. After four to five weeks, the total process of vermicomposting is complete.

Azolla

Azolla is a free-floating aquatic fern which, in symbiotic association with azolla anabaena algae in its root, assimilates atmospheric nitrogen and thereby enriches the rice field. Azolla is widely distributed in the rice-growing tracts of the tropics and temperate zones and grows in irrigated rice fields. There are six species of Azolla: *A. caroliana*, *A. nilotica*, *A. filiculoides*, *A. mexicana*, *A. microphylla*, *Azolla rubra* and *A. pinnata*. *A. pinnata* is the common species occurring in India. *A. microphylla*, a heat-tolerant species, was introduced into India from south America. Azolla has high nutritive value (4.0–4.5% N on dry weight basis) and grows rapidly.

This water fern is mainly propagated by vegetative means. It yields, on an average, about 1.5 kg per square metre, every week. Under normal conditions, the fern doubles itself in three days. Multiplying azolla through the sporocarp technique has been established in many research institutions in the world.

Multiplication of azolla

Azolla can be multiplied in clay pots, cement tanks or other shallow containers of convenient size. It can also be multiplied in the field.
Uses of azolla

Azolla can be used in two ways in the paddy field. First, it can be used as a biofertiliser. The field is inoculated with azolla 40 days before transplantation and the azolla incorporated into the soil during puddling. Second, azolla can be used to suppress weeds and at the same time act as a feed for ducks and fish when it is added to the paddy field 24–30 days after transplanting.

Cement cisterns

Azolla can be multiplied in cement cisterns of 2 x 1 x 0.3 m. A layer of 7.5–10.0 cm soil is provided at the bottom of the cistern and about 5.0–7.5 cm depth of water maintained in it. Vermicompost is added. About 200 gm of fresh azolla is then introduced into the cistern. In about 12-15 days, about 2.0–2.2 kg of azolla can be harvested. After each harvest, vermicompost is applied to facilitate quick multiplication. Each time, 200 gm of azolla is introduced for further multiplication.

Azospirillum

Azospirillum is a free-living organism in the soil. Unlike rhizobium, it does not need a symbiotic association with a plant root. It fixes atmospheric nitrogen and makes it available to plants. It can be used in all types of cereals, oilseeds and pulses. The amount of nitrogen attached depends upon the variety of azospirillum and the location, climate and soil of that site. It has been found that azospirillum attaches 3–4 kg of nitrogen per bigha and increases yields by 30% (approximately). Some useful varieties of azospirillum are:

i) A. Liproferum

ii) A. Brasilense

iii) A. Amazonense

Methods of using azospirillum

In half a litre of starch, at normal temperature, 300 gm of azospirillum is mixed and a paste is made. Seed adequate for one
bigha of land is mixed in it. The seed is then dried in the shade, after which it is sown as soon as possible.

In the case of seedlings that are to be transplanted, one kilo of azospirillum is mixed with ten litres of water and the seedlings are kept in that mixture for a period ranging from ten minutes to half an hour. Thereafter, the seedlings must be transplanted as soon as possible.

When azospirillum is directly applied to soil, it must first be mixed with compost. This compost must be mixed with the soil 24 hours before seed is sown or seedlings are transplanted. It is especially effective when rice fields are muddy but not waterlogged. Irrigation must be applied after 5–6 days.

**Phosphate solubilising bacteria (PSB)**

PSB are free-living bacteria found in the soil which secrete organic acids in their body – such as tartaric, fumaric and malic acids – that in turn convert the complex phosphates in the soil into simple soluble forms. This soluble mixture of phosphates is now available to the plants. Roughly, PSB can solubilise 20–30% of the existing phosphates present in the soil. This in turn increases crop yields by approximately 10–20%.

The commonly used varieties of PSB are:

- *Bacillus megaterium*
- *Bacillus polymyxa*
- *Pseudomonas striata*
- *Pseudomonas rathonis*

**Methods of using PSB**

About 300 gm of PSB is mixed in half a litre of starch – usually the water that is drained from cooked rice – at normal temperature and a paste is made. Seed adequate for a bigha of land is mixed in the paste. The seed is then dried in the shade after which it is sown as soon as possible.
In the case of seedlings that are to be transplanted, one kilo of PSB is mixed with ten litres of water and the seedlings are kept in that mixture for a period ranging from ten minutes to half an hour. Thereafter, the seedlings must be transplanted as soon as possible.

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Azotobacter is another free-living soil organism. Unlike *rhizobium*, it does not need any crops or trees to fix atmospheric nitrogen into the soil. This biofertiliser can be used in legumes and other crops. Azotobacter lives and reproduces in healthy soil containing a lot of microorganisms. It must always be mixed with compost or with other biofertilisers before being applied to the soil. It has been seen that after the application of azotobacter, rice yields increase by 22%, wheat by 30%, maize by 70%, brinjal by 60% and onion by 22%. Azotobacter has given favourable results after being added to cereals, vegetables and sugarcane, to mention a few. The germination rate and also the crop’s power to resist certain fungi attacks is also enhanced. A helpful variety of azotobacter is *Azotobacter chroococeum*.

**Methods for using azotobacter**

About 300 gm of azotobacter is mixed in half a litre of starch – usually the water that is drained from cooked rice – at normal temperature and a paste is made. Seed adequate for a bigha of land is mixed in the paste. The seed is then dried in the shade after which it is sown as soon as possible.

In the case of seedlings that are to be transplanted, one kilo of azotobacter is mixed with ten litres of water and the seedlings are
kept in that mixture for a period ranging from ten minutes to half an hour. Thereafter, the seedlings must be transplanted as soon as possible.

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**Foliar spray**

**Manure tea**

Compost tea or liquid manure is a mixture of different microorganisms. It provides a steady source of nutrients to vegetables, crops and trees. It can be manufactured in a cost effective way and within a short period of time.

**Material required**

- Litter of cattle or poultry (the smaller the animal, the better the litter).
- Leaves of plants like subabul or of any common local weed with deep roots (neem leaves, eucalyptus leaves or other oily leaves are not used).
- A pitcher with lid, a stick, a gunny bag, a small stone, water and a small string.

**Methods of preparation**

The litter is mixed with an equal volume of leaves. Both the materials are put into a small gunny bag. Now the pitcher is filled with water upto 20 times the volume of the litter or of the leaves. A small stone is put into the bag and tied with the string. Then it is immersed in the water which is then kept in the shade with the lid in place. The mixture must be stirred twice daily. The liquid manure will be ready within 3–4 weeks.

The colour of the manure will be blackish green and it will not contain any unfavourable odour. Manure tea can be strained and
mixed with water in the ratio of 1 : 4 or 5 and applied in rice field @ 150–200 litres/ha.

**Trichogramma**

*Trichogramma* are dark coloured, extremely tiny wasps that belong to the family *Trichogrammatidae*. The female wasp lays 20–40 eggs in its host's eggs. In 3–4 days, the parasitised host’s eggs turn uniformly black. Upon hatching, the *trichogramma* insects feed on the embryonic contents of their host’s eggs, coming out of the host eggs by chewing a circular hole in the eggshell. The entire cycle is completed within 8–12 days.

*Trichogramma* wasps occur naturally in almost every terrestrial habitat, and in some aquatic habitats as well.

Today, the *trichogramma* species is the most widely used natural enemy insect in the world, partly because it is easy to rear en masse and because it attacks many common insect pests. Nine species of *trichogramma* are reared in private or government owned insectaries around the world and released annually on an estimated 80 million acres of agricultural crops and forests in more than 30 countries.

*Trichogramma* are released to control some 28 different caterpillar pests attacking corn, rice, sugarcane, cotton, vegetables, sugar beets and fruit trees.

*Trichogramma* wasps primarily parasitize eggs of moths and butterflies (Lepidoptera). However, certain species of *trichogramma* also parasitise eggs of beetles (Coleoptera), flies (Diptera), true bugs (Heteroptera), other wasps (Hymenoptera), and lacewings and their relatives (Neuroptera). *Trichogramma* sp., is the most widely used bio-control agent in the world and is effective against all fruit borers of vegetables.

Two species, i.e., *T. chilonis* and *T. japonicum* are predominantly used in India. *Corcera cephalonica*, a storage grain
pest, has also been used for mass multiplication of targeted species in India.

**Tricho cards**

The parasitisation of *Trichogramma* sp., in laboratory conditions on one cc eggs of *Corcyra cephalonica*, which are uniformly spread and pasted on a card measuring 15 cm x 10 cm, is called a tricho-card. The card has 12 demarcations. About 12,000 *trichogramma* adults emerge out of this card 7–8 days after parasitisation. The ratio of host egg and parasite adult should be maintained at 1 : 5.

**Methods of using a tricho-card**

The cards are to be used before the emergence of the adult parasite. Each tricho-card is torn into small pieces and distributed all over the field. Care is taken to release the parasites either in the morning or evening i.e., during the cooler hours, in the windward direction and in the total absence of any pesticide spray. The tricho-card is cost effective and its application in the field is simple. It also does not pollute the environment.

The following precautions are required to be taken while using tricho-cards: they should be packed in such a way that the parasitised surface is on the inner side and they must not be exposed to direct sunlight. The date of emergence from the eggs should be specified.

**Insect predators**

Predators (*Chrysopids* and *Coccinellids*) may voraciously feed on aphids, mealybugs and other insects that attack cotton, groundnut, mustard, etc. A predator feeds on several types of prey during its lifetime. *Chrysoperla carnea* is the most important insect predator for target pests like the aphid, white fly, mite, bollworm, caterpillar, etc.
**Pheromones**

**Sex pheromones**

Adult females of target insect pests that are ready for mating emit species-specific chemical odours to attract males. The method of utilising pheromones produced by insects for their procreation as tools for their destruction is known as the pheromone trap. The mass trapping of males using this type of sex pheromone lure ensures that the majority of females present in cropped fields remain unmated, and as a result, lay infertile eggs. In this way, the insect pest population is checked.

There are also other types of pheromones called ‘aggregation pheromones’ that insects produce to beckon others to a location, for example, wherever a food source is located. These pheromones can be effectively used to trap both males and females since both sexes respond to the chemical signal.

Installation of traps with suitable pheromone lures @ 2–3 per acre can provide information on pest incidence and their intensity in agricultural fields.

**Types of traps**

The funnel trap is one type of trap which is mostly used against larger moths. Another trap comes in a reusable sun-board casing with replaceable sticky liners. It is recommended for use against smaller moths, fruit flies, etc. For mass trapping of field crop pests such as sugarcane borers, still another trap that consists of an adapter, a basin to hold water (mixed with kerosene/detergent) and a lure holder with a canopy is in vogue.

**Biopesticides/bioagents**

**Bacillus thuringiensis (Bt)**

Bt is a crystalliferous spore-farmer that has been extensively studied in insect control experiments, and was first regarded as a potential microbial control agent by Steinhaus (1956). The first commercial preparation of the bacillus was available in the USA in 1958.
*Bacillus thuringiensis* produces toxins which are poisonous to mostly the lepidopterous larvae. As many as nineteen varieties or serotypes are known, with varying capacities, to produce various toxins, of which serotypes 3A and B have been approved by the Indian government.

The variable pathogenicity of this bacterium to different lepidopterous species is attributable to different varieties/serotypes.

For instance, *var. thuringiensis* is more toxic to cabbageworm (*Pieris brassicae*) than *var. sotto*, which happens to be more toxic to *Bombyx mori*. Being crystalliferous, Bt produces a toxic protein (delta-endoprotein) crystal or parasporal body in its cell when sporulation is to occur. On being ingested by a susceptible host, the endospore germinates in its gut, producing bacterial cells. The pH of the mid-gut of an insect is an important factor in determining its susceptibility to crystalliferous bacteria. The susceptible species of insects in general have a high mid-gut pH value. The bacteria are sprayed on the pest. It has harmful effects on humans. It must be stored below 25 °C to have maximum effect.

### Botanicals

#### Neem-based products

Neem has been used from time immemorial as a biopesticide. Various parts of the neem tree are used in making commonly used botanical preparations, such as:

**Neem seed kernel extract (NSKE)**

Good quality neem seed should be collected and pounded to remove the outer seed coat. It should be ground in water (50 gm of kernel in one litre of water). After 12 hours, the solution should be filtered through a fine cloth and sufficient water added to make a solution of one litre. This can be used for direct spraying. About 350–450 litres of the solution are required for
one hectare. Khadi soap solution @ 10 ml/litre (100 ml/tank) should be added before spraying to help the extract stick well on leaf surfaces. The concentration of the extract can be increased or decreased, depending upon the intensity of the pest attack.

The extract can be stored for a period of one month. The seed used for preparing the extract should be at least three months old.

When it is less than three or more than eight months old, the *azadirachtin* content in the seeds will be low and hence the pest control properties will also be less effective. The prepared extract should be milky white in colour. If it is prepared from aged seeds, the extract will be brownish in colour.

**Neem leaf extract**

One kilo of neem leaves is crushed and soaked overnight in five litres of water. Before spraying, the solution is strained and one ml of soft soap solution is mixed, per litre of extract.

This solution is effective as a foliar spray against sucking and chewing insects. It can also be applied directly to the soil to control nematodes, especially in *solanaceous* crops. However, in this case, the concentration of the solution has to be doubled, i.e., 2–2.5 litres of crushed leaves will have to be soaked per litre of solution.

**Neem cake (deoiled) extract**

A hundred grams of deoiled neem cake is taken to make one litre of aqueous solution. The cake should be kept in a cloth bag and hot water poured over it. The solution should be kept overnight in a covered container.

This is very effective against all boring insects.

**Neem oil**

About 25 to 30 ml of neem oil is mixed with soap water to make an emulsion that should be sprayed as soon as possible to control fungal disease such as downy mildew. Neem oil solution is also
effective against a wide range of pests such as beetles, plant hoppers, caterpillars, etc., but it can also harm some beneficial insects.

Neem oil is mainly used to protect seeds during storage. About 5–10 ml of oil is mixed well with 500 ml of seeds, before placing them in airtight containers.

**Various preparations to control fungal and bacterial disease**

One large tablespoonful (roughly 20 ml) of baking soda should be mixed with 15 ml of sesame or castor oil and dissolved in 3.5 litres of water. Twenty grams of molasses should also be added to the solution before spraying it on plants affected by powdery mildew, brown patch and other fungal diseases.

The African marigold plant can control insects, diseases and soil nematodes. About 200 gm of crushed leaves and roots should be added to one litre of hot water and kept overnight. Before spraying, the solution should be filtered and soft soap added @ 1 ml per litre of water. The concoction is applied as a foliar spray.

Garlic is an insecticidal, fungicidal, nematicidal, bacterial control agent and pest repellant. Some 2–3 cloves of garlic should be crushed and soaked in one litre of water for one or two days. After straining, the garlic extract should be mixed with soft soap and sprayed on any crop infested with sucking or chewing insects or affected by fungal or bacterial disease.

**Preparation of tobacco decoction**

Collect (cheaply available) *beedi* or *natu* tobacco dust. Boil 2.5 kg of dust in 25 litres of water for 30 minutes, stirring it regularly. Cool the decoction after it turns coffee red in colour, and filter the decoction using a thick cloth. Add soap, dilute the mixture with water to make 200–250 litres of solution and spray per hectare.
It may be noted that tobacco liquor is not permitted under India's national standards for organic farming.

**Preparation of chili-garlic solution**

Take 7.5 kg of green chilies, remove the pedicels and grind thoroughly. Soak the paste thus obtained in 25 litres of water overnight. Take 1.25 kg garlic, grind thoroughly and soak overnight in 625 ml of kerosene. Prepare two extracts separately by filtering through a cloth. Prepare a third solution by dissolving soap @ 75 gm in one litre. Mix the three solutions in a container and keep for four hours. Filter the mixture using a cloth, dilute to 200 litres and spray per acre.

**Pusa bins**

Developed by the Indian Agricultural Research Institute (IARI), these storage bins are made of earth or sun-dried bricks. They are rectangular in shape and have a capacity of storing one to three tonnes.

A typical ‘Pusa’ bin has a foundation of bricks, compacted earth, or stabilised earth. A polyethylene sheet is laid on this, followed by a concrete slab floor 10 cm thick. An internal wall of the desired height (usually 1.5 to 2 metres) is constructed of brick or compacted earth, with a sheet of polyethylene wrapped around it. This sheet is heat-sealed to the basal sheet, and the external wall is then erected. During the construction of the wall, an outlet pipe is built into its base.

The concrete slab roof is supported by a wooden frame and, like the floor, is constructed of two layers separated by a polyethylene sheet. During its construction, a man-hole measuring 60 x 60 cm is built in one corner.

The Pusa bin is widely adopted in India. It gives good results when loaded with well dried grain.
SEED/PLANTING MATERIAL

Trichoderma viride (TV)

Trichoderma viride is a fungus prepared in laboratory which is used as a biological pesticide.

- It is useful against fungal attacks like wilt, rusting of leaves, root rot disease, food rot disease, etc.
- It helps in the germination of seed.
- It can enhance the growth of the plant and partly satisfies the nutrient requirements of the plant as well.
- It is not harmful to either plants or animals.

Method by which TV is used

Seed treatment

The seed has to be washed first to get rid of any chemical fertilisers and pesticides. TV culture @ 4 gm per kilo of seed is mixed with starch to make a sticky paste. The seed is mixed with the paste and then dried in the shade. The dried seed is sown immediately thereafter.

Seedling treatment

Twenty grams of TV is mixed in a litre of water. Seedlings of brinjal, chili, tomato, cabbage, etc., are immersed in the water for five minutes before they are transplanted to the main field.

Nursery treatment

About 50 gm of TV culture is mixed with 500 gm of vermicompost or compost and mixed with the soil for each 64.8m² of land.

Main field treatment

During preparation of the main field, 300 gm of TV mixed with compost or vermicompost is incorporated into the soil for every bigha of land.

TV spray on crops

Ten grams of TV culture are mixed in a litre of water and sprayed on the leaves and shoots of the crop.
**Pseudomonas fluorescens**

*Pseudomonas fluorescens* is a plant commensal bacterium that lives near the roots of plants and produces secondary metabolites that suppress soil-borne plant pathogens.

*Pseudomonas spp.* are ubiquitous inhabitants of the soil, water and plants. The pseudomonas live in safe sites on the plant to avoid stress and get their nutrients from the plant surface. These species help plants by suppressing pests, enhancing access of plants to key nutrients, altering physiological processes or degrading environmental pollutants. Pseudomonas have a capacity to produce a wide variety of chemicals, including antibiotics, that are toxic to plant pathogens.

**MANAGING SOIL FERTILITY**

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Process

The organic matter is first mixed with water within a pit. The upper portion of the pit is next covered with mud. After 4–5 weeks, when the whole mixture is semi-rotten, it is thoroughly mixed again and within one or two days, proper aeration is provided. In this way, semi-rotten compost is formed. The earthworms should now be introduced into this partially decomposed material. Approximately 100–150 earthworms are needed for every kilo of semi rotten compost. After four to five weeks, the total process of vermicomposting is complete.

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temperature and a paste is made. Seed adequate for a bigha of land is mixed in the paste. The seed is then dried in the shade after which it is sown as soon as possible.

In the case of seedlings that are to be transplanted, one kilo of PSB is mixed with ten litres of water and the seedlings are kept in that mixture for a period ranging from ten minutes to half an hour. Thereafter, the seedlings must be transplanted as soon as possible.

When PSB is directly applied to soil, it must first be mixed with compost. This compost must be mixed with the soil 24 hours before seed is sown or seedlings are transplanted. It is especially effective when rice fields are muddy but not waterlogged. Irrigation must be applied after 5–6 days.

Azotobacter is another free-living soil organism. Unlike rhizobium, it does not need any crops or trees to fix atmospheric nitrogen into the soil. This biofertiliser can be used in legumes and other crops. Azotobacter lives and reproduces in healthy soil containing a lot of microorganisms. It must always be mixed with compost or with other biofertilisers before being applied to the soil. It has been seen that after the application of azotobacter, rice yields increase by 22%, wheat by 30%, maize by 70%, brinjal by 60% and onion by 22%. Azotobacter has given favourable results after being added to cereals, vegetables and sugarcane, to mention a few. The germination rate and also the crop’s power to resist certain fungi attacks is also enhanced. A helpful variety of azotobacter is Azotobacter chroococeum.

Methods for using azotobacter

About 300 gm of azotobacter is mixed in half a litre of starch – usually the water that is drained from cooked rice – at normal temperature and a paste is made.
Seed adequate for a bigha of land is mixed in the paste. The seed is then dried in the shade after which it is sown as soon as possible.

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**Foliar spray**

**Manure tea**

Compost tea or liquid manure is a mixture of different microorganisms. It provides a steady source of nutrients to vegetables, crops and trees. It can be manufactured in a cost effective way and within a short period of time.

**Material required**

- Litter of cattle or poultry (the smaller the animal, the better the litter).
- Leaves of plants like subabul or of any common local weed with deep roots (neem leaves, eucalyptus leaves or other oily leaves are not used).
- A pitcher with lid, a stick, a gunny bag, a small stone, water and a small string.

**Methods of preparation**

The litter is mixed with an equal volume of leaves. Both the materials are put into a small gunny bag. Now the pitcher is filled with water upto 20 times the volume of the litter or of the leaves. A small stone is put into the bag and tied with the string. Then it
is immersed in the water which is then kept in the shade with the lid in place. The mixture must be stirred twice daily. The liquid manure will be ready within 3–4 weeks.

The colour of the manure will be blackish green and it will not contain any unfavourable odour. Manure tea can be strained and mixed with water in the ratio of 1 : 4 or 5 and applied in rice field @ 150–200 litres/ha.

**PEST AND DISEASE MANAGEMENT**

**Predators**

**Trichogramma**

*Trichogramma* are dark coloured, extremely tiny wasps that belong to the family *Trichogrammatidae*. The female wasp lays 20–40 eggs in its host’s eggs. In 3–4 days, the parasitised host’s eggs turn uniformly black. Upon hatching, the *trichogramma* insects feed on the embryonic contents of their host’s eggs, coming out of the host eggs by chewing a circular hole in the eggshell. The entire cycle is completed within 8–12 days.

*Trichogramma* wasps occur naturally in almost every terrestrial habitat, and in some aquatic habitats as well.

Today, the *trichogramma* species is the most widely used natural enemy insect in the world, partly because it is easy to rear *en masse* and because it attacks many common insect pests. Nine species of *trichogramma* are reared in private or government owned insectaries around the world and released annually on an estimated 80 million acres of agricultural crops and forests in more than 30 countries.

*Trichogramma* are released to control some 28 different caterpillar pests attacking corn, rice, sugarcane, cotton, vegetables, sugar beets and fruit trees.

*Trichogramma* wasps primarily parasitize eggs of moths and butterflies (*Lepidoptera*). However, certain species of *trichogramma* also parasitise eggs of beetles (*Coleoptera*), flies (*Diptera*), true bugs (*Heteroptera*), other wasps (*Hymenoptera*),
and lacewings and their relatives (Neuroptera). *Trichogramma* sp., is the most widely used bio-control agent in the world and is effective against all fruit borers of vegetables. Two species, i.e., *T. chilonis* and *T. japonicum* are predominantly used in India. *Corcera cephalonica*, a storage grain pest, has also been used for mass multiplication of targeted species in India.

**Tricho cards**

The parasitisation of *Trichogramma* sp., in laboratory conditions on one cc eggs of *Corcyra cephalonica*, which are uniformly spread and pasted on a card measuring 15 cm x 10 cm, is called a tricho-card. The card has 12 demarcations. About 12,000 *trichogramma* adults emerge out of this card 7–8 days after parasitisation. The ratio of host egg and parasite adult should be maintained at 1 : 5.

**Methods of using a tricho-card**

The cards are to be used before the emergence of the adult parasite. Each tricho-card is torn into small pieces and distributed all over the field. Care is taken to release the parasites either in the morning or evening i.e., during the cooler hours, in the windward direction and in the total absence of any pesticide spray. The tricho-card is cost effective and its application in the field is simple. It also does not pollute the environment.

The following precautions are required to be taken while using tricho-cards: they should be packed in such a way that the parasitised surface is on the inner side and they must not be exposed to direct sunlight. The date of emergence from the eggs should be specified.

**Predators**

Predators (*Chrysopids* and *Coccinellids*) may voraciously feed on aphids, mealybugs and other insects that attack cotton, groundnut, mustard, etc. A predator feeds on several types of prey during its lifetime.
*Chrysoperla carnea* is the most important insect predator for target pests like the aphid, white fly, mite, bollworm, caterpillar, etc.

### Pheromones

**Sex pheromones**

Adult females of target insect pests that are ready for mating emit species-specific chemical odours to attract males. The method of utilising pheromones produced by insects for their procreation as tools for their destruction is known as the pheromone trap. The mass trapping of males using this type of sex pheromone lure ensures that the majority of females present in cropped fields remain unmated, and as a result, lay infertile eggs. In this way, the insect pest population is checked.

There are also other types of pheromones called ‘aggregation pheromones’ that insects produce to beckon others to a location, for example, wherever a food source is located. These pheromones can be effectively used to trap both males and females since both sexes respond to the chemical signal.

Installation of traps with suitable pheromone lures @ 2–3 per acre can provide information on pest incidence and their intensity in agricultural fields.

### Types of traps

The funnel trap is one type of trap which is mostly used against larger moths. Another trap comes in a reusable sun-board casing with replaceable sticky liners. It is recommended for use against smaller moths, fruit flies, etc. For mass trapping of field crop pests such as sugarcane borers, still another trap that consists of an adapter, a basin to hold water (mixed with kerosene/detergent) and a lure holder with a canopy is in vogue.
**Biopesticides/bioagents**

*Bacillus thuringiensis (Bt)*

Bt is a crystalliferous spore-farmer that has been extensively studied in insect control experiments, and was first regarded as a potential microbial control agent by Steinhaus (1956). The first commercial preparation of the bacillus was available in the USA in 1958.

*Bacillus thuringiensis* produces toxins which are poisonous to mostly the lepidopterous larvae. As many as nineteen varieties or serotypes are known, with varying capacities, to produce various toxins, of which serotypes 3A and B have been approved by the Indian government.

The variable pathogenicity of this bacterium to different lepidopterous species is attributable to different varieties/serotypes.

For instance, *var. thuringiensis* is more toxic to cabbageworm (*Pieris brassicae*) than *var. sotto*, which happens to be more toxic to *Bombyx mori*. Being crystalliferous, Bt produces a toxic protein (delta-endoprotein) crystal or parasporal body in its cell when sporulation is to occur. On being ingested by a susceptible host, the endospore germinates in its gut, producing bacterial cells. The pH of the mid-gut of an insect is an important factor in determining its susceptibility to crystalliferous bacteria. The susceptible species of insects in general have a high mid-gut pH value. The bacteria are sprayed on the pest. It has harmful effects on humans. It must be stored below 25 °C to have maximum effect.

**Botanicals**

*Neem-based products*

Neem has been used from time immemorial as a biopesticide. Various parts of the neem tree are used in making commonly used botanical preparations, such as:
Neem seed kernel extract (NSKE)

Good quality neem seed should be collected and pounded to remove the outer seed coat. It should be ground in water (50 gm of kernel in one litre of water). After 12 hours, the solution should be filtered through a fine cloth and sufficient water added to make a solution of one litre. This can be used for direct spraying. About 350–450 litres of the solution are required for one hectare. Khadi soap solution @ 10 ml/litre (100 ml/tank) should be added before spraying to help the extract stick well on leaf surfaces. The concentration of the extract can be increased or decreased, depending upon the intensity of the pest attack.

The extract can be stored for a period of one month. The seed used for preparing the extract should be at least three months old.

When it is less than three or more than eight months old, the azadirachtin content in the seeds will be low and hence the pest control properties will also be less effective. The prepared extract should be milky white in colour. If it is prepared from aged seeds, the extract will be brownish in colour.

Neem leaf extract

One kilo of neem leaves is crushed and soaked overnight in five litres of water. Before spraying, the solution is strained and one ml of soft soap solution is mixed, per litre of extract.

This solution is effective as a foliar spray against sucking and chewing insects. It can also be applied directly to the soil to control nematodes, especially in solanaceous crops. However, in this case, the concentration of the solution has to be doubled, i.e., 2–2.5 litres of crushed leaves will have to be soaked per litre of solution.

Neem cake (deoiled) extract

A hundred grams of deoiled neem cake is taken to make one litre of aqueous solution. The cake should be kept in a cloth bag and
hot water poured over it. The solution should be kept overnight in a covered container.

This is very effective against all boring insects.

**Neem oil**

About 25 to 30 ml of neem oil is mixed with soap water to make an emulsion that should be sprayed as soon as possible to control fungal disease such as downy mildew. Neem oil solution is also effective against a wide range of pests such as beetles, plant hoppers, caterpillars, etc., but it can also harm some beneficial insects.

Neem oil is mainly used to protect seeds during storage. About 5–10 ml of oil is mixed well with 500 ml of seeds, before placing them in airtight containers.

**Various preparations to control fungal and bacterial disease**

One large tablespoonful (roughly 20 ml) of baking soda should be mixed with 15 ml of sesame or castor oil and dissolved in 3.5 litres of water. Twenty grams of molasses should also be added to the solution before spraying it on plants affected by powdery mildew, brown patch and other fungal diseases.

The African marigold plant can control insects, diseases and soil nematodes. About 200 gm of crushed leaves and roots should be added to one litre of hot water and kept overnight. Before spraying, the solution should be filtered and soft soap added @ 1 ml per litre of water. The concoction is applied as a foliar spray.

Garlic is an insecticidal, fungicidal, nematicidal, bacterial control agent and pest repellant. Some 2–3 cloves of garlic should be crushed and soaked in one litre of water for one or two days. After straining, the garlic extract should be mixed with soft soap and sprayed on any crop infested with sucking or chewing insects or affected by fungal or bacterial disease.
**Preparation of tobacco decoction**

Collect (cheaply available) *beedi* or *natu* tobacco dust. Boil 2.5 kg of dust in 25 litres of water for 30 minutes, stirring it regularly. Cool the decoction after it turns coffee red in colour, and filter the decoction using a thick cloth. Add soap, dilute the mixture with water to make 200–250 litres of solution and spray per hectare. It may be noted that tobacco liquor is not permitted under India's national standards for organic farming.

**Preparation of chili-garlic solution**

Take 7.5 kg of green chilies, remove the pedicels and grind thoroughly. Soak the paste thus obtained in 25 litres of water overnight. Take 1.25 kg garlic, grind thoroughly and soak overnight in 625 ml of kerosene. Prepare two extracts separately by filtering through a cloth. Prepare a third solution by dissolving soap @ 75 gm in one litre. Mix the three solutions in a container and keep for four hours. Filter the mixture using a cloth, dilute to 200 litres and spray per acre.

**Pusa bins**

Developed by the Indian Agricultural Research Institute (IARI), these storage bins are made of earth or sun-dried bricks. They are rectangular in shape and have a capacity of storing one to three tonnes.

A typical 'Pusa' bin has a foundation of bricks, compacted earth, or stabilised earth. A polyethylene sheet is laid on this, followed by a concrete slab floor 10 cm thick. An internal wall of the desired height (usually 1.5 to 2 metres) is constructed of brick or compacted earth, with a sheet of polyethylene wrapped around it. This sheet is heat-sealed to the basal sheet, and the external wall is then erected. During the construction of the wall, an outlet pipe is built into its base.

The concrete slab roof is supported by a wooden frame and, like the floor, is constructed of two layers separated by a
polyethylene sheet. During its construction, a man-hole measuring 60 x 60 cm is built in one corner.

The Pusa bin is widely adopted in India. It gives good results when loaded with well dried grain.