AGRO-ECOLOGICAL ZONES OF KERALA

Four parameters that together evolve distinct agronomic environments wherein a distinct cropping pattern flourishes are altitude, rainfall pattern, soil type and topography. The parameters and their levels used for delineating agro climatic zones are summarised in Table 27. The levels of each parameter are broadly determined to avoid complexity in the process of land evaluation. In reality, there can be several more levels for each parameter (For example, there are 38 soil associations identified in Kerala, at 1:250,000 scale).

Altitude

Altitudinal variations influence the temperature regime. High altitude generates temperate climatic conditions in a tropical area like Kerala. Sizeable areas in the high ranges of Idukki and Wayanad districts fall under this category, even though high altitude areas are found all along the Western Ghats. The low altitude region, endowed with humid tropical climate is spread over the entire length of the state.

Rainfall

The State is relatively rich in rainfall endowment; with an annual precipitation around 2600 mm. Ninety percent of this precipitation is during the two monsoons, June to August (southwest) and October to November (northeast). About 60% of annual rainfall is received during southwest monsoon period and about 30% during northeast monsoon. From December to March there is very little rainfall, but the occasional rainfall during this period is a very critical requirement for cultivation as we still depend upon rainfall for raising many of the crops.

The spread of rainfall is relatively better with 6-7 months having rainfall above or nearly around the monthly average. The quantum of
annual precipitation is concentrated around lesser periods towards the northern part of the state while it is spread over longer periods in the southern parts.

The co-efficient of variation of the annual rainfall is below 20% and hence, agriculture is expected to flourish under relatively stable

conditions. However coefficient of variation of monthly rainfall is high. As a result, stability in production can be ensured only with the support of irrigation at least for most of the major crops so as to increase their production and productivity.

The state was divided into two halves namely the areas south and north of IION latitude (approximately south and north of Thrissur) with rainfall pattern i and II respectively. The southern region is having relatively well distributed rainfall and June maxima for SW monsoon while the northern region has relatively ill distributed rainfall and July maxima for SW monsoon.

Soil Types

Soil type is the third factor for distinguishing specific zones. The major group under the soils of Kerala is laterite and its variations. In the traditional midland region the dominant soil type is typical laterite with the B-horizon present. The areas skirting the Western Ghat and the high ranges which together form the traditional highland region has lateritic soil where the B-horizon is absent. Red loam is found in the southern most tip of the state. All these variability constitute distinct homogeneous agro-ecological zones, though the rainfall pattern is the same. Distinct zones have been identified based on special soil types such as riverbank alluvium, peaty soil (kari) as In Kuttanad and 'sandy soils, though the rainfall pattern and topographic models are the same. In the coastal area, the texture of the soil- especially of the garden lands is considered as a distinguishing feature in identifying two separate zones one with sandy loam and the other with sandy soil. The soil characteristics of the paddy land such as peaty (kari) and saline soils (pokkali) have also been associated in delineating the zones.

Topography

Areas having similar rainfall pattern and soil type are further delineated into zones based on topographical features. For instances, the midland region north of II _ latitude has a common rainfall pattern and the soil is of typical

laterite with B-horizon. It is further delineated into two zones based on the differences in topography with one zone having topographic Model II-b and the other Model II-c. Similarly the midland region south of II °N has been delineated into two zones based on the differences in topographic features as models II-a and II-b.

Agro-ecological zones

Following the above approach and using a matrix built upon altitude, rainfall, soil and topography, the state has been delineated into thirteen agro-climatic zones. Block Panchayat has been taken as the unit for purposes of delineation. All the Blocks, Municipalities and Corporations have been grouped into appropriate agro-ecological zones. Whenever a Block or Municipality was found to fall in more than one agro-climatic zone, it was assigned to that zone which has the largest area. Though 13 agro-climatic zones have been identified, no Block was assigned to one zone viz. the Riverbank alluvium as it is found scattered in several blocks. This zone is found generally all along the banks of the major rivers. It is found relatively extensively in the lower basins of the Periyar and Pumpa river systems. Further, such alluvium deposits are generally found in the paddy fields that form the valley portions of the undulating landscape, which is interspersed with mildly sloping hills. The principal characteristics of each zone are summarised in Table 28. Each of the zones identified is assigned a popular name. Many of them are currently in vogue and are associated with areas having singular agro-climatic features and cropping patterns.

Table 27. *Parameters for identifying agro-ecological zones*

Parameter	*Level*	*Description*	
I. Altitude	Type I	Up to 500 m above MSL (Low altitude zone - hot humid tropics, spread over the entire state)	
	Type II	More than 500 m above M;SL	
II. Rainfall	Pattern I	Both the southwest and northeast monsoons are active and moderately distributed. Southwest monsoon with June maximum (South of I IoN latitude).	
	Pattern II	Poorly distributed rainfall; southwest mQnsoon with July maximum and concentrated in 3-4 months. Northeast monsoon relatively weak (North of lioN Latitude).	
III. Soil types	I	Alluvial soil (Spread over river banks)	-
	2	Sandy soil (Coastal areas)	.
	3	Sandy loam soil (Coastal areas)	
	4	Laterite soil with well defined B horizon (Natural midlands)	
	5	Laterite soil without B-horizon (Natural highlands).	
	6	Red soil (Southern-most Ketala)	
	7	Black soil (Chittur taluk of Palakkad district)	
	8	Peat (kari) soil (Kuttanad)	
	9	Acid-saline soil (Pokkali and Kaipad areas)	
		Valleys | *Hill tops*	*Sl.opes*
	Model-I	Extensive valleys with level but raised garden lands	
	Model-lla	Valleys less extensive — Hills with moderate gradients	Slopes having mild gradients

IV. Topography	Model-IIb	Valleys less extensive	Hills with moderate gradients and top with egg shaped hump	Steep slopes
	Model-IIc	Valleys less extensive	Hills with table tops	Steep slopes
	Model-III	Narrow valleys	Hills with steep gradients	Steep slopes

COMPOSTING VERMICOMPOST AND COIRPITH COMPOST

Composting is largely a biological process in which microorganisms of aerobic (which require air or oxygen for development) and anaerobic (which functions in absence of air or free oxygen) decompose organic matter and lower the carbon-nitrogen ratio of the substrate. Compost is prepared from vegetable and animal refuses collected in the farm or in towns or villages.

Method of composting

The available refuses in the farm are collected and stored till they form sufficient mass for compost making. A trench of suitable size, say, 4-6 m long, 2-3 m broad and 1-1.5 m deep is dug, the accumulated refuse is well mixed, and a layer 30 cm in thickness, is spread all along the length of the trench. This layer is well moistened by sprinkling cowdung slurry and water over it. A second layer (30 cm thick) of the mixed refuse is then spread. The process is repeated till the heap rises to a height of 45 cm to 60 cm above ground level. The top is then covered with a thin layer of earth. After three months of decomposition, the mass is taken out of the trench and formed into a conical heap above the ground, moistened with water, if necessary, and covered with earth. After another month or two, the manure will be ready for application to field.

Vermicompost

Vermi-technology is a process by which all types of biodegradable wastes such as farm wastes, kitchen wastes, market wastes, biowastes of agro-based industries, livestock wastes etc. are converted to nutrient rich vermicompost by using earthworms as biological agents. Vermicompost contains major and minor nutrients in plant-available forms, enzymes, vitamins and plant growth hormones.

Species suitable: *Eudrillus eugineae* has been identified as the best species of earth worm for vermi-technology under Kerala conditions.

Vermicomposting of farm wastes

Pits of size 2.5 m length, 1 m breadth and 0.3 m depth are taken in thatched sheds with sides left open. The bottom and sides of the pit are made hard by compacting with a wooden mallet. At the bottom of the pit, a layer of coconut husk is spread with the concave side upward to ensure drainage of excess water and for proper aeration. The husk is moistened and above this, biowaste mixed with cowdung in the ratio of 8:1 is spread **up** to a height of 30 cm above the ground level and water is sprinkled daily. After the partial decomposition of wastes for 7 to 10 days, the worms are introduced @ 500 to 1000 numbers per pit. The pit is covered with coconut fronds. Moisture is maintained at 40 to 50 per cent. When the'
compost is ready, it is removed from the pit along with the worms and- heaped in shade with ample light. The worms will move to bottom of the heap. After one or two days the compost from the top of the heap is removed. Put back the un-decomposed residues and worms to the pit for further composting as described above. The vermicompost produced has an average nutrient status of 1.5%, N, 0.4% P2Os and 1.8% K_2O with pH ranging from 7.0 to 8.0. The nutrient level will vary with the type of material used for composting.

Precautions

1. The composting area should be provided with sufficient shade to protect from direct sunlight.

2. Adequate moisture level should be maintained by sprinkling water whenever necessary.

3. Take preventive measures to ward off predatory birds, ants or rats.

Depending on the extent of weathering of leaves used for composting, 70 per cent of the material will be composted within a period of 60-75 days. At this stage, watering should be stopped to facilitate separation of worms from the compost. Compost can be collected from the top layers, which can be sieved and dried under shade. Earthworms aggregated at the bottom layers can be collected and used for further vermicomposting.

Vermicompostingfrom coconut leaves

Weathered coconut leaves can be converted into good quality vermicompost in a period of three months with help of earthworm, *Eudrillus* sp. On an average, 6-8 tonnes of leaves will be available from a wellmanaged coconut garden, which will yield 4-5 tonnes of vermicompost with about 1.2; 0.1 and 0.5% N, P_zO_5, K_2O respectively.

Vermicomposting of household wastes

Select a wooden box of 45 x 30 x 45 cm or an earthen/plastic container with broad base and drainage holes. Keep a plastic sheet with small holes at the bottom of the box. Add a layer of soil of 3 cm depth and a layer of coconut fibre of 5 cm depth above it for draining of excess moisture. Add a thin layer of compost and worms above it. About 250 worms are sufficient for the box. Spread daily vegetable wastes in layers. Cover the top of the box with a piece of sac to provide dim light inside the box. When the box is full, keep the box without disturbance for a week. When the compost is ready, keep the box outside in the open for 2-3 hours so that the worms come down to the lower fibre layer. Remove compost from the top, dry and sieve. The vermicompost produced has an average nutrient status of 1.8 % N, 1.9 % P_2O_5 and 1.6 % K_2O, but composition will vary with the substrate used.

Mass multiplication worms

Earthworms can be multiplied in 1:1 mixture of cow dung and decaying leaves taken in a cement tank or wooden box or plastic bucket with proper drainage facilities. The nucleus culture of earthworms is to be introduced into the above mixture at the rate of 50 numbers per 10 kg of organic wastes and properly mulched with dried grass, straw or wet gunny bag. The unit should be kept in shade. Sufficient moisture level should be maintained by occasional sprinkling of water. Within 1-2 months, the earthworms multiply 300 times, which can be used for large-scale vermicomposting.

Preparation of vermiwash

Method 1

The system consists of a plastic basin having a capacity of 20 litres, a plastic perforated waste-paper basket and a PVC pipe of 5 cm diameter and 30 cm length. The waste-paper basket is covered with a nylon net and placed at the centre of the basin upside down. A hole is made at the bottom of the waste paper basket so that a PVC pipe of 5 em diameter can be placed into the basin through the hole in such away that one end of it touches the basin. The PVC pipe is perforated so that the leachate from the basin seeps through the waste-paper basket and collects in the PVC pipe, which can .be siphoned out by a kerosene pump, In the basin outsid_ the waste-paper basket, a layer of brick pieces are placed and a layer of coconut fibre of 2-3 cm placed above it. After moistening this, 2 kg worms (about 2000) are introduced into it and 4 kg kitchen-waste is spread over it. After one week the kitchenwaste turns into a black well-decomposed compost. Two litres of water is sprinkled over the compost containing worms. After 24 hours, the leachate collected in the PVC pipe is removed by siphoning. The collected leachate is called vermiwash, which is actually an extract of compost containing worms. This is

used for soil application and foliar spray in different crops. Vermiwash is honey-brown in colour with a pH of 8.5 and N, P_2O_5 and K_2O content 200, 70 and 1000 ppm respectively. For large-scale collection of vermiwash, a cement tank of size 80 x 80 x 80 cm is constructed. A layer of small brick pieces or gravel is placed at the bottom of the tank. Above it a layer of fibre of 3-4 cm thickness in placed. A definite quantity of biowaste (4 kg) is added to the system along with 2 kg of earthwonns. After two weeks, the entire mass of biowaste will turn to brownish black compost. Then add 2 litre of water. Vermiwash is collected through the side tap after 24 hours. Again biowaste is added to the system and the process is repeated.

Method 2

This is a simple and economical technique to collect vermiwash. The system consists of an earthen pot of 10 kg capacity, which is filled, with pieces of stone up to 10 cm height from the bottom. Above this, a plastic net is placed and spread out. Then a thick layer of coir fibre along with humus containing 1500-2000 wonns of species *Eudrillus euginae* or *Isenia foetidae* is laid down. The hole situated at the bottom of the pot is fixed with a water tap through which vermiwash is collected. Every day, the kitchen waste is put into the container. Allow the composting process to continue for one week or more till brownish black mask of compost is obtained. Occasionally, two or three tablespoons of fresh cowdung slurry is poured on the humus as feed for the worms. After the fonnation of compost, soak the entire mask with two litres of water. After 24 hours, about 1.5 litre of vermiwash can be collected. This process can be continued for one or two weeks till the brown colour of wash disappears. The less enriched compost that remains in the pot can be collected and used as fertilizer. Later, the pot can be emptied and set up again to continue the process.

The potential of vermiwash as a biocide either simply or when mixed with botanical pesticides can be very well exploited for household vegetable cultivation.

Recommendation for crops

When vermicompost is applied as organic manure instead of FYM, the quantity of inorganic fertilizers can be reduced to about half the recommended dose. .

Coirpith composting

Coirpith, one of the agricultural wastes is produced and heaped in large quantities as waste material from the coir industry. Approximately 2.5 lakh tonnes of coirpith accumulate in Kerala as waste. Coirpith has wide C:N ratio and its lignin rich nature does not pennit natural composting process as in other agricultural wastes. *Pleurotus* spp. have the capacity to degrade part of the cellulose and lignin present in coirpith by production of enzymes viz., cellulases and lactases. The C:N ratio of coirpith is reduced from 112:1 to 24:1 as a result of composting. The lignin content also reduces considerably.

Method of composting

Materials required: Coirpith 1 tonne, urea 5 kg, mushroom *(Pleurotus)* spawn 1.5 kg.

Select a shaded place of 5 x 3 m dimension and level it after removing weeds. First spread 100 kg coirpith unifonnly. SPread 300 g (one bottle or cover) of *Pleurotus* spawn on this and cover this with a second layer of 100 kg coirpith. On the surface of the second layer, spread 1 kg urea unifonnly. Repeat this sandwiching process of one layer of coirpith with spawn followed by another layer of coirpith with urea up to 1 m height. Sprinkle water if necessary to keep the heap moist. Allow the heap to decompose for one month.

The coirpith is converted into good manure after 30-40 days and the lignin content is reduced

from 30% to 40%. Another significant change is the lowering down of C: N ratio from 112:1 to 24:1.

This coirpith compost contains macronutrients as well as micronutrients. It has the unique property of absorbing and retaining moisture to about 500-600 per cent. It improves the water infiltration rate and hydraulic conductivity of soil.

BIOFERTILIZERS

The use of biofertilizers is quite important while practising the concepts of integrated plant nutrient management and organic farming. Some of the commonly used biofertilizers in Kerala are as follows.

I. Rhizobium (Bradyrhizobium and *Azorhizobium)*

It induces better root nodulation and stem nodulation *(Azorhizobium)* in inoculated plants and thereby brings down the requirement of nitrogen fertilizer for the cultivation of pulses, oil seeds and legume green manures. Commercially it is available as carrier based inoculums. Method of application is seed treatment.

2. *Azotobacter*

Suitable only for upland crops like vegetables, tapioca, plantation and orchard crops. It is available as carrier-based inoculum. It fixes N about 15-20 kg/ha under ideal upland conditions and thereby reduces the requirement of nitrogen fertilizers by 10-20 per cent. Methods of application are seed treatment, seedling dip and direct soil application.

3. *Azospirillum*

It is suitable for both upland and wetland conditions and is available as carrier-based inoculum. It fixes N about 20-25 kg per ha under ideal conditions thereby effecting a reduction of 25 per cent in the quantity of N fertilizers required. Treatment with *Azospirillum* also induces better root formation in inoculated plants; Hence this biofertilizer is also recommended for root induction in polybag-raised seedlings of plantation and orchard crops and also for vegetable crops. The isolates of *Azospirillum brasilense* strains AZR 15 and AZR 37 from Kuttanad soils are highly effective for rice, vegetables and nursery plants. The strains AZ 1 and AZ 2 are effective in vegetable and nursery plants.

Method of application.

Seed treatment: For treating 5-10 kg seeds, 500 g culture is required. Moisten the seeds by sprinkling water or rice-gruel water. Take 500 g culture in a plastic tray/basin, add moistened seeds, mix well and dry in shade for 30 minutes. This may be sown immediately.

Seedling root dip (for transplanted crops): Slurry of the culture is prepared by mixing 500 g culture with 50 ml of water and the roots are dipped in the slurry for 15-20 minutes before transplanting.

Soil application: Mix the culture with FYM or compost in the ratio 1 :25 and apply directly in the soil.

Inoculation for paddy

Mix 2 kg of culture in 60 litres of water and soak the seeds required for 1 ha (60 kg) for 24 hours before sowing. At the time of transplanting, dip the roots of seedlings for 15-20 minutes in the culture slurry prepared by mixing 2 kg inoculum with 40 litres of water. This slurry can be used for treating seedlings required for 1 ha. Another 2 kg culture may be applied to the field along with FYM or compost.

4. *Blue green algae(BGA)*

Mainly recommended for wetland rice cultivation. However, the use of this biofertilizer is not feasible in acidic soils with pH below 6.0. It is available as carrier-based inoculum and it fixes N about 25-30 kg/ha under ideal conditions.

Method of application: Direct broadcasting in the rice fields @ 10 kg/ha one week after transplanting the seedlings.

5. *Azolla*

It is suitable for wetland rice cultivation. The required quantity of azolla will have to be raised in the farmers' field itself. Fixes N about 25 to 30 kg / ha.

Method of application: Apply fresh azolla @ 10 t/ha before transplanting the rice seedlings at the time of ploughing.

6. *Phosphate solubilising bacteria and fungi*

Recommended mainly for upland crops raised in neutral and slightly alkaline soils. Available as carrier-based inoculum. Enables the efficient utilization of cheaper sources of phosphatic fertilizers such as rock phosphate by crop plants in neutral and alkaline soils.

Method of application: Seed treatment and direct application.

7. *Vesicular / arbuscular mycorrhiza (VAM/ AM)*

Vesicular arbuscular mycorrhiza is mostly recommended for upland especially for raising container and tissue culture plantlets and transplanted crops. It mainly improves the uptake of available P by inoculated plants. There is also an enhanced absorption of water and other nutrients such as N and K and certain micronutrients. Mycorrhiza inoculation can improve the survival and establishment of tissue culture plantlets under field conditions. Also induces better resistance against certain soil borne plant pathogens. It is commercially available as granular inoculum consisting of infected roots and soil with mycorrhizal spores. It is given as soil application.

VAM fungus *Glomus microcarpum* var. *microcarpum* is suitable for tropical tuber crops. The inoculation can be done by placing inoculum (3-5 g/sett) beneath the. sett before planting. The rate of spore load in the inoculum should be to the tune of 50 to 400 spores per 100 g soil medium. Method of application is the rooted infected cutting technique.

Application techniques of biofertilizers

1. Seed treatment

Five hundred grams of commercially available inoculum will be required for treatment of seeds for one-hectare area. For this, thick slurry of the carrier-based inoculum is initially prepared by mixing 500 g of the inoculum in 1.25 litre of water. The stickiness of the biofertilizer on seed surface can be significantly improved by using 10% jagerry solution or 5% sugar solution supplemented with 40% boiled and cooled gum arabic solution or rice-gruel water. The required quantity of seed material is then gently mixed with this slurry by taking care not to damage the seed coat. The treated seeds are spread evenly over a gunny bag and dried in shade and sown immediately in moist soil. Under no circumstances, the treated seeds are exposed to direct

sunlight for a longer period of time since the UV rays of solar radiation will reduce significantly the population of inoculated bacteria on seed surface.

2. Seedling treatment

This method of application is mainly recommended for transplanted crops. In this procedure, the roots of seedlings to be transplanted are dipped in loose water slurry of the biofertilizer (500 g in 2.5 litre of water) for 20 minutes, prior to transplanting.

3. Soil application

Soil application is generally recommended for all types of biofertilizers except *Rhizobium. Bradyrhizobium* and *Azorhizobium.* The method is to apply the biofertilizer after mixing with dried FYM, compost or vermicompost @ 1: 25. For crops of six-month duration, the recommended dose is 1-2 kglha. This can be increased to 2-4 kglha for crops of more than six-month duration. For perennial crops, 10 to 25 g of the biofertilizer is to be applied in the root zone during the first year and 25 to 50 g during subsequent years. This can be done at the time of sowing, transplanting or during intercultivation.

Factors influencing the efficient use of biofertilizers in Kerala

1. Use adequate quantity of organic manure (as per the recommendation for each crop) along with biofertilizer application. This is essential to ensure better survival, growth and activity of the introduced microbial inoculum in acidic soils.

2. Liming is essential if the soil pH is below 6.0. In moderately acidic soils, the application of lime @ 250 kg/ha is recommended along with biofertilizer treatment.

3. Irrigation is essential during summer months after biofertilizer application to ensurethe survival of the introduced microbial inoculum in the soil.

4. Since N biofertilizers can supplement only a part of the nitrogen requirement of the inoculated plant, low dose of nitrogen and full doses of phosphorus and potassium as per the recommendation may be applied. This is essential to ensure better plant growth and yield. Similarly, in the case of P biofertilizers, the full doses of nitrogen and potassium should, he applied. However, there should be a gap of at least one week between biofertilizer and chemical fertilizer applications.

5. Use only biofertilizers, which are manufactured as per the quality parameters prescribed by the Bureau of Indian Standards. In the case of bacterial biofertilizers, the prescribed standard is that in the final product, the population of the desired bacterium should not be less than ten million per gram of the carrier material and there should not be any contamination with other microorganisms when examined at 1: 100000 dilution. Further, it should have a shelflife of at least six months.

6. The commercially available biofertilizer should always be used before the expiry date marked on the culture packet.

7. Topdressing with superphosphate 25 kg/ha 10 days after inoculation of BGA will enhance its growth under field conditions.

8. Since the occurrence of green algae in rice field can affect the normal growth and

proliferation of BGA, the population of green algae should be controlled initially by applying copper sulphate @ 4 kg/ha.

9. In moderately acidic soils of pH around 6.5, root nodulation by *Rhizobium* and *Bradyrhizobium* can be improved by pelleting with finely powdered calcium carbonate. (See recommendation under cowpea)

10. Application of P_2Os @ 1 kg/ha is recommended once in 4 days in P_2O_5 deficient soils to ensure good growth of azolla. The development of a reddish purple colour in azolla is a typical symptom of P_2O_5 deficiency.

11. Since a floating population of azolla can release its bound nutrients only during decay in the soil, it is essential to incorporate azolla in the soil prior to the transplanting of rice seedlings.

GUIDELINES FOR MAXIMIZING FERTILIZER USE EFFICIENCY

Choice of a fertilizer depends on unit cost of nutrient present in it and its agronomic efficiency under a given situation. Fertiliser is a valuable input and measures should be taken to reduce its losses and to increase its uptake and utilisation by the crop. Selecting a situation-specific fertilizer and choosingthe time and method of application according to crop demand would minimize losses and increase its efficiency.

Nitrogenous fertilizers

Most crop plants recover only 25-35% of the nitrogen applied as fertilizers. Losses occur by ammonia volatilisation, denitrification, immobilization to organic forms, leaching and run off. Utmost care should be bestowed in selecting the type of fertiliser as well as the timing and method of application.

Choice of the nitrogen fertilizer

1. In submerged rice soil, ammoniacal and ammonia-producing fertilizers like urea are most suitable since ammonia is the most stable form of nitrogen under such conditions.

2. For acidic upland soils, ammoniacal fertilizers are most suitable during rainy season since ammonium is adsorbed on soil particles and hence leaching losses are reduced. Adsorbed ammonium is gradually released for nitrification and thus becomes available to crops for a longer period.

3. In highly acidic upland soils, urea is preferred to ammonium sulphate as the former is less acid forming.

4. In alkaline upland soils of low rainfall regions, nitrate fertilizers are preferred to ammoniacal fertilizers or urea since ammonia may be lost by volatilization under alkaline conditions.

Management of nitrogenous fertilizers

1. Almost all the nitrogenous fertilizers are highly amenable to losses and since most of the crops require nitrogen during the entire growth period, split application is necessary to ensure maximum utilization by crops.

2. More number of splits may be given for long duration crops as well as perennial crops.

3. Nitrogen losses from fertilizers are more in coarse textured soils with low cation exchange capacity (CEC) than in fine textured soils. Hence more number of splits is necessary to reduce loss of fertilizer nitrogen from sandy and other light soils.

4. For medium duration rice varieties, nitrogenous fertilizers should be given in three splits, as basal, at maximum tillering and at panicle initiation stage.

5. In coarse textured sandy or loamy soils, the entire dose of nitrogenous fertilizers may be applied in 3-4 splits at different stages of growth of rice crop.

6. In areas where split application of nitrogen is not feasible due to water stagnation after planting/sowing, full dose of nitrogen as basal may be given in the form of neem coated or coal tar coated urea.

7. In double-cropped wetlands, 50% of N requirement of the first crop may be applied in the organic form.

8. As far as possible, liming should be done one or two weeks prior to the application of ammoniacal or ammonia forming fertilizer like urea since ammonia is likely to be lost by volatilization if applied along with lime.

9. Almost 70% of N in urea applied by broadcast to flooded soil is lost by volatilization, immobilization and by denitrification

Measures to reduce the loss of N from applied urea

1. Urea super granules or urea briquettes may be used in places where soil is clayey and has cation exchange capacity more than 10 cmol (+) per kg of soil.

2. Sulphur or lac coated urea is suitable where soil is liable to intermittent flooding and in situations where water management is difficult. This is more suitable for direct sown crop.

3. Urea may be mixed with moist soil and kept for 24-48 hours before application to the field. Alternatively, urea may be mixed with moist soil, made into balls of about three inch diameter and dried under shade. The balls may be placed deep into subsoil.

4. Mixing urea with five times its weight of neem cake prolongs the period of nitrogen availability to the crop.

5. For submerged soils, coating urea with coal tar and kerosene (100 kg urea is mixed with 2 kg coal tar dissolved in one litre kerosene) before mixing with neem cake is preferred to simple mixing with neem cake.

6. Coating urea with neem extract (containing about 5% neem triterpenes) at 1% rate and shade-drying for 1 to 1.5 hours before applying in direct-seeded puddled lowland rice increases nitrogen use efficiency.

7. As far as possible, urea may be applied by deep placement or plough sole placement. Deep placement of prilled urea or super granules during the last ploughing followed by flooding and planting is beneficial in light soils. Urea briquettes or super granules may be placed between four hills of transplanted rice, whereas sulphur coated or lac coated urea may be broadcast on the surface.

8. Foliar spray of 5% urea solution can be practised in situations where quick response to applied nitrogen is required. If power sprayers are used, the concentration may be increased to 15%. Fresh urea should be used to avoid toxicity due to biuret.

Phosphatic fertilizers

Fertilizer phosphorus is an expensive input and its management poses serious problems due to

several complexities in its behaviour in different types of soil. This often results in its poor recovery from applied fertilizers.

Choice of phosphatic fertilizer

1. In slightly acid, neutral or mildly alkaline soils, water-soluble phosphatic fertilizers are more suitable.

2. In wetland rice soils, water-soluble phosphatic fertilizers are preferable as pH of most of the submerged soils is near neutral.

3. In strongly acidic soils whose pH does not rise above 5.5 to 6.0 even on submergence, phosphatic fertilizers containing citrate soluble form of P like basic slag, dicalcium phosphate, steamed bone meal etc. are suitable.

4. For highly acidic upland soils or submerged soils whose pH will not rise above 5.5 even on submergence, powdered rock phosphate is suitable. Soil acidity converts tricalcium phosphate in rock phosphate to plant available monocalcium form.

5. For short duration crops where quick response is required, water-soluble phosphatic fertilizers are most suitable.

6. For perennial crops like rubber, oil palm, coffee, tea, cardamom etc. phosphorus in the form of rock phosphate can be applied.

7. In black soil (Chittur taluk of Palakkad District) phosphatic fertilizers containing water-soluble phosphate like single superphosphate are most suitable.

Management of phosphatic fertilizers

1. Acid soils have to be amended with lime, dolomite or magnesium silicate and alkali soils with iron pyrite or sulphur before application of phosphatic fertilizers. This will help to reduce fixation and increase availability of P.

2. Surface application or broadcasting is preferred for shallow rooted crops whereas placement in the root zone is advantageous in deep rooted crops.

3. Rock phosphates can be used advantageously in rice grown in acid soils during the virippu seasbn. Powdered rock phosphate may be applied and mixed thoroughly with soil by ploughing. After two or three weeks, the field may be flooded, worked up and planted with rice. Under this situation, phosphorus in rock phosphate gets converted to iron phosphate, which on subsequent watedogging becomes available to the rice crop.

4. Rock phosphate can be used successfully as a phosphatic source for leguminous crop since its root system can extract phosphorous from rock phosphate.

5. In single crop wetlands where rice is grown in the virippu season, application of phosphatic fertilizers can be dispensed with for the rice crop, if the second crop (usually legume or green m_nure) is given phosphatic fertilizers.

6. In case of rice-legume cropping sequence in acid soils, application of rock phosphate to the pulse crop helps to skip phosphatic fertilizers in the succeeding rice crop.

7. Since phosphorus requirement of seasonal crops is confined to the early stages, phosphatic fertilizers are to be applied at the time of seeding or planting. Topdressing of phosphatic fertilizer leads to wastage of the fertilizer nutrient. Further, excessive phosphates may lead to deficiency ofmicronutrients such as zinc, boron etc.

8. Under adverse soil conditions and where quick result is required, spraying watersoluble phosphatic fertilizers like triple superphosphate or hot water extract of superphosphate can be resorted to.

Potassium fertilizers

For most crops potassium can be supplied as muriate of potash. But in crops like tobacco and potato, muriate of potash may cause chloride injury, reducing quality of the produce. In such cases, K may be applied as potassium sulphate.

Management of potassium fertilizer

1. In coarse textured soils and in heavy rainfall regions, potassium fertilizers should be applied in as many splits as possible, to reduce loss of potassium.

2. In fine textured soils, the entire dose of potassium fertilizers may be applied as basal

3. In acid soils, potassium fertilizers should be applied only after lime application to prevent loss of potassium by leaching.

Lime

Acid soils are characterised by high saturation of the exchange complex with hydrogen and aluminium. Crops grown in such soils suffer due to unavailability of most plant nutrients, especially calcium. Application of liming materials increases the availability of nutrients and alleviates Ca deficiency.

Liming materials

Burnt lime [CaO], slaked lime [$Ca(OH)_2$] powdered limestone [$CaCO_3$] and dolomite [$CaMg(CO_3)_2$] are some of the materials used as sources of calcium.

Management

1. In acidic submerged soils, flooding brings about rise in soil pH and hence response to lime is less marked.

2. Legumes are benefited most by liming.

3. For better results, liming materials should be incorporated into the soil.

4. For seasonal crops and in situations where immediate results are required, burnt lime or slaked lime may be used. For perennial crops, powdered lime stone or dolomite is sufficient.

5. Extreme care should be taken while broadcasting burnt lime and slaked lime as they can cause scorching of leaves.

6. In case of wetland rice, drain the field prior to lime application and re-flood after 24 hours. Flushing the soil by sequential flooding and draining will help to wash out the displaeed acid from the soil.

7. In extreme case of calcium deficiency, a 1 % solution of calcium chloride may be applied by foliar spraying.

BEEKEEPING (APICULTURE)

True honeybees belong to the family Apidae subfamily Apinae and genus *Apis.* They are social insects living in colonies. A colony consists of a queen, several thousand workers and a few hundred drones. There is division of labour and specialization in the performance of various functions. They build nests (combs) with wax, which is secreted from the wax glands of worker bees. The bees use their cells to rear thin brood and store food. Honey is stored in the upper part of the comb; beneath it are rows of pollen storage cells, worker brood cells and drone brood cells in that order. Some *Apis* species build single comb in open, while others build multiple combs on dark cavities.

Species of honeybees

There are four species of honeybees in India. They are:

Rock bees (Apis. dorsata): They are giant bees found all over India in sub-mountainous regions up to an altitude of 2700 ill. They build single comb nests with an area up to I m2 or more. They are good honey gathers with an average yield of 50-80 kg per colony.

Little bees (Apis jlorea): They are the smallest of the true honeybees found in plains of India up to the altitude of 500 m.They build single vertial combs. They are poor honey yielders and yield about 2009.00 g of *honey* per colony.

Indian bee (Apis cerana indica): They are the domesticated species, which construct multiple parallel combs with an average honey yield of 6-8 kg per colony per year,

European bees [Italian bees] (Apis mellifera): They are also similar in habits to Indian bees, which build parallel combs. They are bigger than all other honeybees except *Apis dorsata.* The average production per colony is 25-40 kg,

Stingless bees (Trigona iridipennis): In addition to the above, another species is also present in Kerala known as stingless bees. They are not truly stingless, but sting is poorly developed. They make nests in the ground, hollows of trees, bamboo, rocks or cracks of walls. Honey and brood cells are separate in the nest. They are efficient pollinators. They yield 300-400 g of honey per year.

Swarming

Swarming is the natural instinct of honeybees to reproduce its colonies. By swarming, strong colonies are divided naturally. It occurs mostly when the colony population is at its peak. Some of the several reasons for swarming are sudden honey flow, sudden failure of queen to lay eggs, congestion in the colony, want of breeding space, bad ventilation etc. Dividing the colonies or keeping young queen or preventing over crowding of bees or adding new combs can prevent swarming.

Absconding

Absconding is the total desertion of colony from its nest due to incidence of disease / pest attack, too much interference by human beings or robbing of honey by bees from other colonies. Proper hive management can prevent it.

Communication

The worker bees communicate with other bees about the exact location of nectar, pollen, water, next nesting site etc. by means of dances. Round dance is performed when the food is located within 100 m from hive and wagtail dance to communicate the location of food source when it is more than 100 m away from the hive.

Bee space

It is the space large enough to permit the free passage for worker bees but too small to encourage bees building a comb and too large for bees depositing propolis in it.

Indian bee *(Apis cerana indica)*

This is the domesticated hive bee in Kerala. A colony consists of a queen, 20,000 to 30,000 workers and a few drones. This species is with gentle temperament and responds to smoking. Lack of flora leads to absconding and also has a strong tendency for swarming. It yields 8-10 kg of honey per colony per year.

Bee-box

ISI Type-A box is recommended for the state of Kerala. A division board may be added to the bee box for adjusting the internal space depending on the strength of the colony. It can also be procured1Tom beekeepers. Wild feral colonies can be hived. Beekeepers in different regions use local hives made of low cost wood. The wood should not have a strong smell. Kail *(Pinus excelsa),* teak *(Tectona grandis),* toon *(Toond ciliata)* anjili *(Artocarpus hirsutus),* punna *(Calophyllum inophyllum)* are some of the suitable woods.

The hives should be preferably painted white on outside to protect the timber from weathenng.

Hiving wild colony

It is done during evening hours. Smoke the colony slightly, cut out the combs one by one and tie to the brood frames with plantain fibre. Arrange them in the box.

Location of beehives

The apiary must be located in well-drained open area, preferably near orchards, with profuse source of nectar, pollen and water. Windbreaks may be provided by planting shrubs, flowering plants and also creepers like antigonon. Shade must also be provided. Ant wells are fixed around the hive stand. The colonies must be directed towards east, with slight changes in the directions of the bee box as a protection from rain and sun. Keep the colonies away from the reach of cattle; other animal, busy roads and streetlights.

Management of colonies

inspect the beehives at least once in a week during brood rearing / honey-flow seasons preferably during the morning hours. Bright, warm and calm days are suitable. If sunrays fall directly on the beehive spread cloth or a towel over the same. Look for freshly laid eggs to ensure that the colonies are healthy. Clean the hive in the following sequence, the roof, super/supers, brood chambers and floorboard. Observe the colonies regularly for the presence of healthy queen, brood development, storage of honey and pollen, presence of queen cells, bee strength and growth of drones. Look for the infestation by any of the following bee enemies.

Wax moth *(Galleria mellonella):* Remove all the larvae and silken webbings from the combs, comers and crevices of bee box.

Wax beetles *(Platybolium* sp.): Collect and destroy the adult beetles.

Mites: Clean the frame and floorboard with cotton swabs moistened with freshly made

potassium permanganate solution. Repeat until no mites are seen on the floorboard.

Diseases: The dead larvae due to Thai sac brood virus (TSBV) in the comb cells may be removed and destroyed.

Management during lean season

Remove the supers and arrange the available healthy broods compactly in the brood chamber. Provide division board, if necessary. Destroy queen cells and drone cells, if noted. Provide sugar syrup (1: 1) @ 200 g sugar per colony per week for Indian bees. Feed all the colonies in the apiary at the same time to avoid robbing..

Management during honey flow season

Keep the colony in sufficient strength before honey-flow season. Congestion in the hive must be avoided and surplus honeybees are drawn to supers. Provide maximum space between the first super and the brood chamber and not above the first super. Place queen excluder sheets in between brood and super chamber to confine the queen to brood chamber. Examine the colony once in a week and frames full of honey should be removed to the sides of the super and such frames can be raised from brood to super chamber. The frames, which are threefourth filled with honey or pollen and onefourth with sealed brood should be taken out of brood chamber and in its place empty combs or frames with foundation is added. The frame with comb foundation should be placed next to the brood nest. The combs, which are completely sealed, or two-third capped may be taken out for extraction of honey and returned to supers after honey extraction. This helps the colonies to activate the bees to collect and store more honey. Two or three such extraction_ are possible during a surplus flow. Extraction of uncapped honey will result in fermentation. Honey extraction, after the flow. is over, should be avoided to save the bee: colonies from robbing. Care should be taken to retain sufficient combs with honey in the brood chamber or reduce the lean period.

Migratory bee keeping

The moving of bee colonies from one place to another to capture increased nectar flow of a particular flora is called migratory beekeeping. Copious flow of extra floral nectar available on rubber trees during January-April is exploited by shifting bee colonies to these plantations during this period.

Similar practice is done in cashew plantations and in other orchards too. Maintaining bee colonies in orchards will increase the yields, since pollination is more efficient in such orchards.

Shifting of colonies is done after sun set. Colonies should be prepared as follows. Extract available honey and fasten all the weak combs to frames with plantain fibres. Secure the frames to the chamber with packing. Close the bee entrance with cotton. Then secure the bee-box (floorboard, brood chamber, supers and roof) firmly with strong threads. Do not tilt or topple' beehives while stacking them in the conveyance or during transit. Avoid strong jerks and shocks while transporting;

Set up the beehives as described above at the new site. Inspect the condition of combs and tighten loose threads, if any. 'This inspection should be done only in dim light. Next morning remove the/cotton plug at bee entrance. Later provide comb foundation sheets, if necessary and provide sufficient space for storage of honey.

Extraction of honey

Honey is extracted only from super combs using honey extractor. The sealing of cells on combs is removed with sharp knife before placing in the extractor. Extractor should be worked slowly at the beginning and at bout 150 rpm at the end for about 1 to 2 minutes. Then the sides of the frames are reversed and the extractor is again worked. Extracted honey is. filtered through muslin cloth. Providing a bee escape between the brood and super on the day prior to honey extraction keeps the bees away from the super. Remove the escape soon after honey extraction.

Processing of honey

Heat the honey to 45°C by keeping it in a water bath. Sieve it to remove wax particles, debris, dust and pollen. Again heat it to a temperature of 65°C in water bath and maintain it for 10 minutes. Then cool and filter it in 80- mesh muslin and store in glass, porcelain, earthenware, enamelware or stainless steel containers. Bulk storing can be made in mild steel containers lined with bee wax.

Italian bee *(Apis mellifera)*

It is a native of Europe introduced to Himachal Pradesh and Punjab during 1962-64 and introduced to Kerala on a trial basis from Haryana in November 1992. It maintains a prolific queen, swarms less, has gentle temperament and is a good honey-gatherer. It is known to be resistant to TSBV. A healthy colony may contain 60,000 to 80,000 worker bees. The following modifications are to be followed in beekeeping with Italian bees.

Bee-box

Langstroth beehive with ten frames each in brood and super chambers and a division brood chamber is recommended. The brood and super chambers are of the same size.

Procuring bee colonies

Colonies can be obtained either by dividing existing colonies or by buying from other agencies.

Location of beehives

Follow the practices as in Indian bees, but use a strong four-legged stand well protected from ants and other crawling insects by providing ant wells.

Management of colonies

Apart from the management practices followed for Indian bee, the practices as mentioned below may be followed.

Sources of pure water should be available near the apiary. Stagnant water or water in a container is not appropriate because it can spread nosema disease. Flowing water near the apiary should serve as a good source. As an alternative, water trickling from a container set on a stand and falling on a slanting wooden plank can be provided.

During the brood rearing season (growth period) from October to January, replacement of old queens by young healthy ones, uniting the weak colonies and giving supplementary feeding as

and when required should be done. Colonies should be provided with enough space for brood rearing and food storage, by giving comb foundation sheets one at a time.

In areas where queen mating is a problem, especially when only a few colonies are kept in isolated pockets, the colony with virgin queen is to be transferred to areas where more number of colonies are kept so as to ensure the availability of queen in sufficient numbers and afterwards returned to the former apiary.

During honey flow season (January-April), provide raised combs in the super and the number of combs to be added depends on the strength of the colony. Only ripe honey is harvested when two-third of the comb cells are capped so that honey contains less than 20 per cent moisture. Care should be taken to see that the bee colonies are not stripped of all the honey stores. Enough stores of honey should be ensured in the hive at the end of honey flow for use during the following lean period. For migratory bee keeping, follow the practices as adopted for Indian bees.

Extraction of honey

The sealing of comb is removed with a sharp knife and the extraction done in an extractor designed for langstroth size frames. Extracted honey is filtered through a coarse cloth to remove the impurities.

Processing of honey

To be done as described under Indian bees. During the lean season (May-September), remove the super chambers, arrange the available healthy brood combs in the brood chamber and use division' boards to restrict the space. Provide artificial feeding once in a week by way of 1: 1 sugar syrup in water. Each colony may require syrup prepared from 500-750 g sugar a week depending on the size of the colony and availability of stored food. When there is dearth of natural source, pollen substitutes may be provided in the colony.

Pests and diseases

Brood mite *(Tropilaelaps clareae):* Infests the brood and the infestation is severe during the major brood rearing season (October-January). These ectoparasites feed on the haemolymph of developing broods slowly killing them. Dusting sulphur on the topbars of the frames at the rate of 200 mg / frame at 7-14 days interval during brood rearing season is very effective in checking the infestation.

Yellow-banded wasp *(Vespa cineta):* These predatory wasps catch the bees from both the hive entrance and inside the hives. Locating and destroying their nests by burning or insecticidal usage is an effective control measure.

Wax moth *(Galleria mellonella):* Infests weak and unattended colonies. Proper cleaning of the hives periodically and keeping the hives without cracks and crevices can avoid infestation.

Black ants: Various species of black ants intrude beehives and take away honey and pollen and kill the brood and bees, which may lead to absconding of colony. The apiary should be kept clean and the ant nests destroyed by insecticidal applications. Ant wells should be provided for the beehive stands.

Red tree-ant (Oeeophyla smaragdina)

If not protected properly, the red tree-ants can cause considerable damage to the bees and the

brood. The bees that come in contact with the ground are attacked and killed by the ants and dragged to their nests by a number of ants. In the apiary, if the branch of a tree with these ants happens to come in contact with the hive, the entire colony is attacked and destroyed. Providing ant wells will keep away the ants. Care should be taken not to keep the colonies near or under the trees having ant nests.

Bee-eater bird (Merops orientalis)

These predatory birds do much harm in certain localities. They pick the bees on wings and 30-43 honeybees have been found in the stomach of a bird. Attack by these birds is mostly seen during December-January. These birds are also very useful in keeping down the insect population in a locality and hence no large-scale measures against them can be recommended. Scaring them away from apiaries is suggested.

Thai sac brood virus Symptoms

All the larval instars are susceptible to the disease, earlier instars being more susceptible. Affected larvae appear slightly plumby compared to healthy ones when examined on taking out of the comb cells. The infected larvae see stretched on their back in the cells with the head directed outwards and turned upwards like the prow of a boat. The dead larvae look like a sac filled with milky white fluid when lifted up and it ruptures even with the slight pressure releasing the milky fluid. The cadavers change their colour from white to pale yellow and sunk down to the floor of the cell and dry up in 10-15 days as brownish black boat shaped scales, which is easily removable from the cells.

The sequence of visible symptoms found in the fields are:

1. Presence of unsealed cells in brood area containing diseased larvae with their head directed outwards like the prow of a boat.

2. Dead larvae are seen lying stretched out on their back on the floor of brood cells and look like a sac filled with milky white fluid when lifted up.

3. Appearance of dead larvae strewn on the floorboards, hive entrance or on the floor near the hive.

4. Mottled appearance of brood combs with uncapped cells interspersed with capped cells or cells with perforated capping.

5. Appearance of more and more dead larvae left within the cells without being ejected by the worker bees.

6. Appearance of sac like remnants of dead larvae within the cells.

7. Lack of cleaning activity within the hive.

8. Decrease in egg laying rate and irregular placement of eggs.

9. Decrease in foraging activity and presence of idling workers inside the hive.

10. Dwindling of bee population of the colony.

11. Desertion of infected 4ives by the bees causing total loss to the apiary.

Control

Being a virus disease there is no known remedy for its cure. However, the following measures may help in minimizing the possibilities of further spread: a) Keeping colonies strong; b) avoid exchange of hive parts, combs etc. from infected colonies to healthy colonies; c) avoid procurement of colonies or swarms from infected areas.

SERICUL TURE (Ad hoc recommendation)

Moriculture

Mulberry can be grown under various climatic conditions ranging from temperate to tropical. Its growth depends on many climatic conditions such as temperature, humidity, rainfall etc. A temperature range of 24-28°C, humidity range 65-80% and 600-2500 mm rainfall are optimum for the good growth of mulberry. The soil should be deep, fertile, well drained, day loam to loam, with good moisture holding capacity. Slightly acidic (6.2-6.8 pH) soil free from injurious salts is ideal for good growth of mulberry.

Land preparation

The field is levelled and ploughed deeply before the onset of monsoon. FYM may be applied @ 1 O t/ha for the rainfed crop and 20 t/ha for the irrigated crop during land preparation.

Method of planting and spacing

(1) Pit system (rainfed crop): Spacing 75 x 75 cm (pit size 30 x 30 x 30 cm) .

(2) Row system (irrigated crop): Spacing 60 x 60 cm (ridges and furrows)

Planting material

The variety K2 gives higher yield and better quality leaves. Cuttings must be prepared from shoots of proper maturity (6-8 months) and thickness with well-developed buds. Cuttings of 7-10 cm length and pencil thickness with 3 or 4 active buds are ideal.

Planting

For irrigated crop, two cuttings should be planted at each spot along the margin of the ridge.

For rainfed crop, three cuttings are to be planted per pit in a triangular manner with a distance of 15 cm, keeping only one bud exposed.

Maintenance of the garden (1st year)

After 8 months of planting, 50 kg each of N, P_2O_5 and K_2O per ha should be applied after weeding. First harvest can be taken six months after planting by leaf picking. Second dose of 50 kg N per ha should be applied 8 weeks after the first leaf harvest. Two more crops can be taken at an interval of 3 months, by leaf picking.

Manuring

For rain fed crop apply FYM @ 10 t/ha as a basal dose and topdress every year at the time of annual pruning. Fertilizers are applied @ 130:65:65 kg/ha of $N:P_2O_5:K_2O$ in two split doses. For irrigated crop, FYM is given @ 20 t/ha as basal dose. Fertilizers are applied @ 300:120:120 kg/ha of $N: P_2O_5: K_2O$ in five split doses.

Pruning

For rainfed crop, bottom pruning is done in May-June. Two top clippings in August! September

and December/January are also practised. Middle pruning is done in October/November. For irrigated crop, bottom pruning at 15-30 cm height in-May, two top clippings in August and December and two middle pruning at 60 cm height in October and February/March are practised.

Pests

Tussock caterpillars *(Euproctis fraterna)*

Larvae eat the leaves of the mulberry plant. Their incidence is frequent during March to August. Collection and destruction of egg masses and spraying 1 % DDVP are effective. Waiting period is 3 days.

Jassids *(Empoasca flarescens)*

Greenish hoppers feed on the underside of the leaf, sucking sap causing hopper burn. Spraying 0.1 % dimethoate is effective. Waiting period is 10 days.

Thrips

These are frequent during summer season. Attack is severe in rainfed gardens. Spraying 0.02% DDVP is effective. Waiting period is 3 days.

Mealy bugs *(Maconelliococcus hirsutus)*

It causes 'tukra disease'. The affected leaves show curling and stunted growth at the growing point. Application of methyl demeton (0.05%) is effective. Waiting period is 15 days.

Scale insect

When attack is severe, branches dry and become yellow. Spraying lime sluphur solution is effective.

Leaf eating caterpillar *(Diacrisia obliqua)*

Appears frequently between November and January. Collection and destruction of egg masses, deep ploughing and flood irrigation to kill the pupae and application of 0.2% DDVP on the leaves can prevent the attack.

Root knot disease *(Meloidogyne incognita)*

Common in sandy loam type of soil under irrigated conditions. Controlled by applying neem oil cake @ of 400 kg per ha per year in four equal split doses.

Diseases

Powdery mildew *(Phyllactina corylea)*

It is more common during NovemberFebruary. White powdery patches appear on the lower side of the leaves. Can be controlled by spraying dinocap 0.2%.

Leaf rust *(Ceratelicum fici)*

The attacked portion of the leaves has whitish brown pustule on both sides and is deformed and also not nutritive. Infection is more in November-February. This can be controlled by spraying carbendazim 0.1 % or tridemorph 0.1 %

Leaf spot *(Cercospora moncola)*

Diseased leaves have a number of circular or irregular brownish black spots of varying size. Infection is more common in rainy season. This can be controlled by spraying 0.1 % of carbendazim.

Yield

Rainfed crop: 12000-15000 kg / ha / year
Irrigated crop: 25000-30000 kg / ha / year

Silkworm rearing

Requirements for silkworm rearing 1. Good quality mulberry leaves

2. Rearing house of approximately 20 m^2 for 100 dfls (disease free layings), with good ventilation, mild temperature (24-28°C) and humidity (65-85%).
3. Rearing equipments like chawki stand (one), wooden trays (10), rearing racks (5), chopping board (one) and knife, wooden / bamboo rearing trays (50), *chandrika* / *netrika* (mountage) (40), leaf chamber, feeding stands, ant wells, rocker sprayer, wet and dry bulb thermometer and materials like formaldehyde / bleaching powder, paraffin paper, cleaning nets, foam rubber strips, and RKO powder are required.

Rearing techniques

Disinfect the rearing house and equipments to prevent silkworm disease, two-three days before rearing.First, wash the rearing house and the equipments with 2% bleaching powder. Then spray the room and equipments with 5% bleaching powder' or 2% formaldehyde. Close the houses for 24 hours for the fumes to get diffused.

First incubate the dfls (egg card) at a temperature of 24-26°C and RH 75-80%, one day prior to hatching (blue egg stage); cover the eggs with black paper (black boxing). Next day morning, open it and expose to diffused sunlight. As the larvae emerge out, fresh tender leaves collected from the plant are chopped into 0.5 x 0.5 mm size and sprinkled over the hatched larvae. After half an hour, transfer the larvae to the paraffin paper spread in the chawky trays (wooden trays) using fine brush. Provide wet foam strips around and prepare a compact bed. Give another feeding in tIle bed. Cover with paraffm paper and stack the trays one over the other on the stand. Up to 20 laying can be brushed in a tray of90 x 60 cm.

Feeding schedule (for 100 laying)

Instar	Leaf position from the tip	Larval duration	Quantity ofleaf, kg,days
1	2nd and 3rd	2-2.5	3-4
2	3rd, 4th and 5th	6-7	2-3
3	5th, 6th and 7th	25-30	3-4
4	Lower leaves	75-80	4-6
5	Still lower leaves	600-650	6-7

At the end of each instar; larvae stop feeding and cast off old skin in 18-30 hours. When the worms set for moulting, paraffin paper should be removed and spread on the bed to dry up. If there are more feeding worms, a light and thin feeding may be given. All the worms settle in 6-8 hours. During moulting, worms should not be disturbed and full ventilation should be provided. Feeding is resumed when 90% of worms have moulted. RKO powder is dusted over the worms 30 minutes before feeding. After two consecutive feedings, the larvae with the net are transferred to a new tray. Mature larvae stop feeding and prepare themselves for spinning. Its body becomes translucent, shrinks in length and constrictions appear on fourth and fift4 segments. They move towards the periphery of the trays. Such worms are picked and transferred to Chandrika / Netrakae. About 1000' worms (400-450 larvae/m^2) can be mounted in a mountage. Mount the entire larvae within a maximum period of 48 hours and provide sufficient ventilation during spinning. Cocoon should be harvested on the fifth and sixth day

after mounting. In rainy and cold seasons, it should be delayed for one more day. The cocoons are collected from Chandrika and transported in light gunny bags to cocoon market. The cocoon should be marketed innnediately after harvest, so as to avoid adult emergence. Under average conditions, 100 dfls of bivoltine will yield 40-60 kg cocoons and cross breed will yield 30-50 kg cocoons.

Disease Pebrine

It is the most destructive disease caused by protozoa, *Nosema bombyscis.* The worms become very dull and they have poor appetite, irregular moulting and the skin becomes wrinkled.

Flacherie

Caused by bacteria, promoted by high temperature; high humidity and ventilation, bad leaf quality, over feeding and low alkalinity of the gut. Digestive and circulatory systems are damaged and the symptoms are loss of appetite and diarrhoea.

Grasserie

Mostly seen in riping larvae. Caused by *Borrlina* virus. Infection is induced by extreme low and high temperature. Swelling of the inter-segmental region, shining skin, rupture of body wall, oozing of body fluid and endless crawling are symptoms. Such worms do not moult and spin.
Mascardine

The fungi *Beauveria bassiana, Spicaria prasina* and *Isaria farinosa* are causal agents. The infected larvae loose appetite. Specks of oozing oily substance without any clear-cut margins appear on the skin. Body generally hardens and becomes stiff.

Prevention and control

1. Disinfect the rearing room and equipment before rearing.
2. Use only disease free layings from authorized agencies.
3. Dip the egg cards in 2% formalin solution for 20 minutes before incubation.
4. Collect undersized larvae and destroy regularly by burning or burrowing in soil.
5. Feed good quality leaves of correct stages.
6. Avoid over feeding and under feeding 7. Clean the bed every day and burn the infested litter.
8. Use RKO powder at every moulting before resumption of feeding.
9. Maintain humidity only to the des4"ed level.

Pests

Uzi-fly *(Trycholyga bombycis)*

It is a serious parasite of silkworm larvae and pupa causing heavy loss. Adult is a large fly with prominent black and gray stripes. The fly prefers later ins tars to the earlier ones for oviposition.

Control.

Prevent the entry of fly into the rearing room by providing wire mesh or nylon net on doors and ventilators. Burn the pest affected larvae. Apply chlorpyrifos on the ground and crevices of walls of rearing house. Other pests are ants, lizards, rats, squirrels, dermestid beetles and birds.

RODENTS AND THEIR CONTROL (Ad hoc recommendation)

The rats can be brought under two different groups as domestic rats and field rats.

Domestic rats

These are found near human dwellings.

1. House rats *(Rattus rattus):* There are two subspecies; one with white belly and the other with grey belly. Tail length is more than the length of head and body. They are found in houses and eat anything that man eats. They also cause qualitative damage due to deposits of faecal matter, urine and hairs. It damages gunny bags, plastic containers, clothes, electric wires etc. These house rats in the fields damage tender coconuts and cocoa pods. They also act as carriers of several human and animal diseases.

2. House mouse *(Mus musculus):* Fur is short without spines. Tail is almost naked and larger than head and body. The mouse is very active and is found in houses and gardens. It can climb up walls. It damages clothes, plastic containers and food materials.

3. Large bandicoot rat *(Bandicota indica):* This is the largest domestic rat. Fur is coarse. Tail length is almost equal to the body length. Body weight ranges from 750 to 1000 g. It damages all tuber crops. It also damages concrete buildings by making burrows under the basement.

Field rats

]

1. Large bandicoot rat *(B. indica):* Large bandicoot rats are also seen in the field. So this can be considered both as domestic and field rat.

2. Lesser bandicoot rat *(B. bengalensis):* It is a short tailed mole rat. Tail length is only 70% of the body length. Fur is short and coarse. It is seen making burrows in the paddy field bunds and also in areas where crops like tubers, vegetables, coconut and young rubber are cultivated.

3. Field mouse *(Mus booduga):* Fur is short.

and coarse and is mostly found in gardens and fields. They make small burrows for living. Tail is slender and nearly naked. Tail length is shorter than body and head. The burrows of this species are found in the paddy fields. They are found feeding on paddy grains in the mature crop as well as seeds sown in the nursery.

4. White rat *(Tatera indica):* More than one rat per burrow is common in this species. The tail is longer than the body and is provided with a terminal tuft of long hairs. The eyes are large. Tail is double coloured.

5. Long tailed tree mouse *(Vandeleuria 01eracea):* The fur is soft and tail is much longer than the body. They are found in most parts of India inhabiting trees and shrubs. They damage the inflorescence of arecanut and leafy vegetables by cutting its leaves.

6. Norway rat *(Rattus norvegicus):* These rats are found in waterlogged areas. This is a medium sized rat with tail more or less equal to the length of the head and body. These rats damage paddy crop. It cuts the plants at the base and chews the cut portion. Maximum attack is at the booting stage. The attack ceases after initiation of flowering. The damage is usually observed in patches away from the field bunds.

7. Soft furred field rat *(Millardia meltada):* These rats are found in cultivated field in pairs or small groups of 5 or 6. They are soft furred without spines. These rats cut the rice plants in the transplanted crop. The damage starts at the time of planting and continues up to harvest. The tillers are cut at the water level.

8. Bush rat *(Golunda elliotti):* These rats are seen in places near forest area. They live under bushes in nests. These rats are destructive to coffee plants. They feed on their buds and flowers. They damage paddy by cutting the plants in dryland paddy areas.

Integrated control of field rats

Rats cause considerable damage to agricultural practices and other human possessions in addition to acting as carriers of several human and animal diseases. Diseases like bubonic plague and weils disease (due to contamination of food by the urine of rats) are caused by rats. It is necessary that the importance of rat control be understood by all. An integrated approach to control rats involves the joint utilisation of all feasible control measures in a complementary manner to maintain the rat population at a very low level. Integrated control of field rats involves the following: (a) preventing their entry into a region or a building by putting up mechanical barriers or treating with repellents; (b) encouraging predators such as snakes, cats, dogs, mongooses etc.; (c) causing death by a variety of methods.

Methods of control *Environmental control*

In this method of control rats are rendered to a hostile environment in which they cannot survive. The mud walls in villages may be replaced by thorny hedges thereby preventing the rats from making burrows. Good house keeping is regarded as the most economical and effective way of. reducing rat population. Proper sanitation should be maintained by keeping food material inaccessible to rats in rat proof containers. The heap of garbage and sweepings in streets and towns should not be kept for a long period. Designing rat proof godowns and other buildings is another step to ensure environmental control.

Poisoning

Three types of poisoning are usually employed to control rats.

1. Acute poisons are those that can kill rats with a single dose; e.g. zinc phosphide.

2. Multiple dose or chronic poisons require repeated ingestion over several successive days; e.g. anticoagulants like warfarin.

3. Fumigants are gases and are usually pumped or released from pellets or tablets put in through burrow entrances; e.g. aluminium phosphide.

Acute poisons

Of the effective acute poisons used as solids, zinc phosphide is widely available. It is a dark grey powder and its toxic action is due to release of phosphine gas. When it is ingested, phosphine is released causing injury to the kidneys, liver and lungs followed by death after a few hours. In dry conditions zinc phosphide remains effective for 3 weeks. But in moist conditions there is faster deterioration. The dosage is 2%.

Zinc phosphide

This is used as a rat poison. Pre-baiting for 3-4 days in sequence is necessary to overcome the bait shyness. For pre-baiting and baiting, the same carrier material has to be used. Crushed wheat, maize, bajra, puffed rice, popcorn or rice mixed with a little jaggery and oil are excellent carriers. To prepare the carrier, 95 parts by weight of cereal ingredient is to be mixed with 5 parts ofjaggery.

For baiting, zinc phosphide is mixed with groundnut oil and carrier in the ratio 2:2:96 by weight. At each bait station, 30-40 g of the bait mixture will have to be exposed. The stations may be selected in areas where rats are frequent, such as areas around kitchen, store and in homesteads. Expose baits in the evening and collect them in the following morning. Conduct baiting for three successive days.

Chronic poisons / anticoagulants

They interfere with the mechanism of blood clotting. Even in the absence of external wounding, animals, which have ingested them, develop internal bleeding and die from this cause. The anticoagulants are not very dangerous to men and domestic animals; e.g. warfarin, rodfarin etc. Pre-bating is not essential for anticoagulants.

For preparing the poison bait, mix 90 g of bait carrier with 3 g of jaggery and 2 g groundnut oil. After mixing these ingredients (95g), add 5 g of 0.5% concentrate of warfarin. Expose 25 g of poison bait in each station and collect the leftover materials in the early morning hours. These can be re-exposed in the evenings. Continue for 3-4 days in succession.

The liquid bait is prepared by dissolving 25 g of water-soluble anticoagulant (0.5%) poison in 500 ml of water. In each station, place 150 ml of liquid bait in shallow containers.

Warfarin blocks

Ingredients required: Warfarin 5 parts; broken rice 63 parts; jaggery 2 parts; paraffin wax 30 parts. Mix broken wheat, jaggery and warfarin in the above proportion in a vial. Pour molten waxes into this mixture and mix thoroughly. Transfer this hot mixture immediately into a metanic tray of 2.5 cm depth. Spread evenly and press well with a spatula. Allow it to cool for sometime (about 20 minutes) and cut it into 5 x 2.5, 12.5 x 25 cm blocks with the help of a sharp knife. Keep it overnight. Next day remove the blocks from the tray one by one. The block is now ready for baiting.

Fumigants

Fumigants have been quite widely used against rodents. The most effective fumigant is aluminium phosphide, which is available both as tablets and pellets. Aluminium phosphide on contact with ambient moisture produces toxic vapour of phosphine. The tablets or pellets are to be introduced through openings of the live burrows, which are closed immediately thereafter.

Repellents

Chemical repellents include malathion and cyclohexamide which are repellents to house rats.

Biological control

Both field and domestic rats are subjected to attack by range of predators, parasites and pathogens. The predators include cats, dogs, snakes, owls, mongooses etc. The practice of rearing cats in house has been found to adversely affect rat population. The utilization of bacterial. and viral infections has not proved successful in any part of the world.

Trapping

Trapping is the oldest method of controlling rodents. Almost any trap will catch some rats, but the response varies with different species. The rats are easily caught in cage or .box, but a rat trapped in such trap will be exposed to other rats. So the rats develop trap shyness and they avoid such type of traps. The most effective rat taps are those, which can completely conceal the rats trapped in it; e.g. Moncompu trap. The rat traps can be grouped into a few categories.

Live traps (cage or box trap)

1. Automatic traps: These have counter balanced entrances. When an animal enters this type of traps, its weight makes it fall into a cage below. The counter balance on the trap door brings it back into place, leaving the rodent in the cage. These are intended to catch more than one rat;

e.g. wonder trap.

2. Remote triggered trap: These work by upsetting a delicate balance when the bait stick is disturbed or when the weight is put on a treadle. Common type of this is the box or cage trap that captures one rat at a setting. A box trap is a wooden or metal box open at one or both ends, having one or two doors. Some have one or both will have overhead trigger on which bait is fastened and the door is released when the rat works on the bait. Others have a treadle in the floor on which the rat steps to drop the door.

3. Glues: A form of trapping in which a sticky substance entangles the animal

4. Pot traps: These traps are extensively used for catching rice field rats. This trap consists of a wooden plank, a mud pot of 10 inch diameter, a metal strip which carry bait and a 'Y'shaped wooden peg to which needle is tied; e.g. Moncompu trap.

The trap is to be set up in rice fields, after placing the base plank above the canopy level on a specially erected platform, on poles. The rats attracted by the bait climb over to the base plank and try to snatch off the bait tied on to the metallic strip. Slight disturbance of the strip dislocates the wooden needle from the strip slot and causes the pot to fall down abruptly over the rat. The pot and the plank are tightly held and removed in that position and immersed in water after inversion for killing the trapped rat. Since the live rat does not see the captured ones, they do not develop shyness against this type of mechanical trap.

5. Snap traps: Most of the rat traps fall within this category and are widely used for trapping rats. These kill the rat instantly by snapping, when the rat nibbles the bait placed in the middle of the open trap. These are variously called as "break back traps', "guillotine", "spring traps", "saw toothed traps" and "bamboo traps" depending upon the materials used in making them.

6. Kerosene tin trap: It is made by cutting the top of the tin and filling it with water up to 15 cm from the top. Chaff is floated on the water surface so that the rat cannot see water. Attractive and strong smelling bait like dry fish, fried coconut etc. is pinned on to a piece of cork or lightwood and floated on the chaff. A plank is leaned against the side to enable the rat to climb to the top. Seeing no water and eager to get the bait the rat jumps on to the chaff and gets drowned.

Success or failure of trapping is dependent up on the following factors.

a. Placement: Traps must be placed where animals will regularly encounter them than places out of their normal activity.

b. Concealment: It is not advisable to use new shining traps against rats. To overcome trap shyness it may sometimes be necessary to cover the trap with a slight coating of paper or dry leaves that does not interfere with the trigger or action.

c. Size and design: Traps should be neither too small nor too large for the anticipated catch.

d. Mechanical conditions: Putting out traps that are in poor working conditions is a waste of time and effort.

e. Number of traps: Large number of traps relative to the expected size of the rodent population should be used.

f. Bait used: Fresh aromatic bait that is most attractive to the largest species should be used. Food grains in the houses should be properly covered so that the rat finds only the food in the trap.

Trapping is the preferred method of control in the houses and office building, because animals killed can be easily removed. Traps can be used profitably to deal with poisonshy and scattered survivors of poison campaign.

Control of important species of rats

Lesser bandicoot rat: These attacking tuber crops can be easily controlled by poison baiting in rodent burrows. Firstly, locate the burrows in the field. Open the burrows to a length of 30 to 45 cm. The rats will come and close the burrows with soil within 30 minutes. Then it can be again opened and poison bait can be inserted into the burrow.

From bait preference studies conducted at Entomology Division, College of Horticulture, Vellanikkara, prawn powder is found most effective. Dry prawn available in the market is heated and powdered. A few drops of vegetable oil are added and zinc phosphide 1-2% is mixed with the bait. This zinc phosphide bait can be put inside the burrow preferably on a dry leaf. No prebaiting is necessary for these rats in the garden lands since it has no bait shyness.

Norway rat: In the Rice Research station, Moncompu these species of rats were causing serious damage to paddy crop. The most effective method of control is using Moncompu trap. Firstly we have to locate fresh rat-damages in the field. These rats cut the paddy plants at the base above the water level in patches. The rats have a habit of coming to the same area on subsequent days. So the traps should be placed in such spots.

BIOCONTROL OF SALVINIA *(Salvinia molesta)*

Release of *Cyrtobagous salviniae* weevils is found effective for the control of salvinia. Even one pair of weevil is sufficient for establishment in a locality. But for practical consideration 50 to 100 weevils are recommended for release in a particular area. When collection of weevil is not possible, about one kg of infested salvinia can be used as the release material. Release may preferably be made whenever tender salvinia growth is available. If the plants are very old, they may be removed mechanically to promote regrowth and then weevils are to be released. Almost 100% control of the weed will be obtained in a span of 12-18 months.

The rate of natural dispersal of the weevil is rather slow and hence it is desirable that the infested weed mats are redistributed at periodic intervals. In canals used for navigation, the rate of spread of the weevil is found to be quite adequate.

BIOCONTROL AGENTS AGAINST PLANT PATHOGENS

V A mycorrhiza

Inoculation with V A mycorrhizal fungi at the time of planting in the nursery or main field improves the growth and tolerance of crop against root pathogens, particularly *Phytophthora, Pythium, Rhizoctonia* and root nematodes of black pepper, cardamom, ginger, turmeric, cowpea, rice and transplanted vegetables.

Trichoderma

Biocontrol of soil borne plant pathogens involves mass introduction of antagonistic microorganisms in the soil. *Trichoderma* spp. is a group of broad-spectrum antagonists subjected to detailed studies for their potential as biocontrol agents. They are effective against the quick wilt of pepper *(T. viride* T6, *T. longibrachiatum* T2), rhizome rot of cardomom *(T. longibrachiatum* T2, *T. virens* T9) and ginger *(T. viride* nO). A non-axenic system, viz. neemcake-cowdung mixture is used as food base for *Trichoderma* spp.

Dry neem cake and cowdung are to be powdered and mixed to get a coarse texture and then moistened by sprinkling water. Add the commercial preparation of *Trichoderma* spp. (available in polythene packets) @ 1-2 kg per 100 kg of neemcake-cowdung mixture. After thoroughly mixing, cover it with a perforated polythene sheet or ordinary newspaper and keep it in shade for 4-5 days for multiplication. Again mix well and keep for three more days for further multiplication. This preparation is ready for incorporation in the soil. Cowdung alone can also be

used as the food base; but, since neem cake is found to be a better substrate, the incorporation of neem cake to cow dung at the ratio of 1:10 (w/w) is better than using cowdung alone. If cow dung alone is used, mixing has to be done at 5 days interval and it will be ready for use only on the 15th day. This *Trichoderma* incorporated neerhcakecowdung mixture can be used in the potting mixture in nursery beds and in the field; i.e. wherever cow dung is used as a manure.

Fluorescent pseudomonas (ad hoc recommendation)

Fluorescent pseudomonas are a group of bac", teria very effective against disease incited by species of *Phytophthora, Pythium, Rhizoctonia, Fusarium, Colletotrichum, Ralstonia* and *Xanthomonas* in various crop plants in the nursery as well as in the main field.

Two isolates of *Pseudomonas jluorescens* (PI and P14) have been developed by the Kerala Agricultural University for the disease management and growth promotion of crop plants. This is found highly effective for the management of foot 'rot and fungal poIlu of black pepper, sheath blight and bacterial leaf blight of paddy, bacterial leaf spot and *Phytophthora* infestation in betel vine, bacterial wilt of solanaceous vegetables, bacterial leaf blight of anthurium and *Colletotrichum* and *Phytophthora* infestation in vanilla and rhizome rot of ginger. The organism significantly improves the growth and' biomass production of crop plants.

Method of application

The talc-based formulation at 1-2% level may be used for soil drenching and spraying. Seedlings/cuttings are treated with *Pseudomonas* culture by dipping the root/tip of cuttings in slurry of *Pseudomonas* (250. g in 750 ml for 20 minutes). For seed treatment in paddy use 109 talc-based *Pseudomonas* culture for I kg of seed; suspend *Pseudomonas* in water used for sprouting. This help in the control of fungal and bacterial diseases.

For transplanted crop dip the roots at the time of transplanting, and _me spray may be given at 30th day after transplanting. For black pepper, drenching the nursery plants immediately after planting followed by one or two sprays depending on the extent of disease. For managing foot rot of pepper in the main field, drench the base of the vine and spray the plant with *Pseudomonas jluorescens* @ 109/litre at the onset of monsoon. A second spray may be given, if necessary during the mid-monsoon period.

For all the crops, the time of application and the frequency of application may vary depending on the incidence and intensity of the infection. A combined application of *Trichoderma* and *Pseudomonas jluorescens* may be resorted to at the time of planting in the nursery and/or main field for the control of diseases of pepper, cardamom and ginger. The application may pe repeated based on the intensity of disease incidence.

Chemical fertilizers and plant protection chemicals should not be used along with biocontrol agents.

SOIL SOLARIZATION

Solarization is a method of hydrothermal disinfection. This is one by covering moist soil with transparent polythene sheet and exposing it to direct sunlight during the hottest period of the year.

Method of solarization

a. Nursery bed

The nursery bed for raising seedlings is to be levelled and pebbles present on the surface removed before solarization. Incorporate the required quantity of organic manure in the soil and irrigate @ 5 litres per m2. Cover the beds with 100-150 gauge transparent polythene sheets. Seal the edges of the sheet with soil to keep it in position in order to maintain the temperature and moisture inside the polythene mulch. Adequate care is also to be taken to see

that the sheet is in close contact with the surface of soil to prevent the formation of air pockets between the soil and polythene sheet. Keep the sheet in this way for 20-30 days. Protect it from stray animals and birds. After the period of solarization, remove the sheet and the bed is ready for sowing and transplanting.

b. Potting mixture

The required type of potting mixture is to be prepared as per the recommended practice. Spread this mixture on a levelled ground to a height of 15-20 cm. Moisten with water using a: rose-can and cover the soil with polythene sheet arid solarize for 20-30 days as described above. After solarization, the soil can be used' for sowing/planting. This method is found to be very effective to raise disease free pepper cuttings.

c. *Main field*

Solarization can also be effectively used for the control 'of soft rot of ginger and similar soil-born diseases in the field. The land used for planting ginger is initially prepared to a fine tilth and pebbles removed. Prepare raised beds as per the recommended practice. Apply organic manure before solarization. Irrigate the bed once ($511m^2$) and cover with polythene sheet. Leave the bed without any disturbance for 20-30 days. After this period, remove the sheet and plant rhizome bits. All the other agronomic practices are to be followed as per the' package of practices recommendations. Biopesticides and fertilizers can be incorporated in soil after removing the polythene sheet.

Hints for solarization

1. Solarization is to be done in open field without any shade.

2. Transparent thin polythene sheet (100 to 150 guage) is to be used, as it is both cheaper and more effective in heating due to better radiation transmittance than thicker sheets.

3. Summer months are more suitable for solarization.

4. Soil should be kept moist during solarization to increase the thermal sensitivity of resting structures of soil-borne plant pathogens and weeds, and to improve heat conduction.

5. Solarization period may be extended to one month or more to ensure pathogen control at deeper layers.

6. Summer showers will not affect solarization. However, excessive seepage of water into the bed during solarization should be avoided.

7. Potting mixture should never be heaped and solarized, as this will drastically reduce the efficiency of the technique.

8. Soil should be in good tilth allowing close contact between the plastic sheet and the soil to prevent the formation of air pockets, which reduces heat conduction.

Benefits of solarization

1. Control of fungal pathogens: Several soil borne pathogens tan be controlled by solarization. This includes fungi like *Pythium, Phytophthora, Fusarium, Rhizoctonia* etc.

2. C;ontrol of nematodes: Population reduction of nematodes like *Meloidogyne, Heterodera, Xiphinema,* etc. has been achieved by solarization.

3. Control of weeds: A number of commonly occurring weeds particularly annuals can be effectively controlled by solarization. These include, among monocots, *Cynodon dactylon,*

Cyperus rotundus and *Digitaria ciliaris* and among dicots, *Crotalaria muconata, Indigofera hersuita* and *Noxia* sp.

4. Plant growth response: Increased growth response is observed in plants cultivated in solarized soil. This is mainly evident as increase in plant height, number of leaves, better root formation, increased root nodulation in legumes and yield.

MUSHROOM

Species of *Pleuratus* commonly known as oyster mushrooms grow saprophytically under natural conditions on trees, dead wood, stumps and branches. Today several species of *Pleuratus* are commercially grown in many parts of the world. Kerala enjoying a typical tropical climate is found to be the most suitable place for mushroom cultivation. Species of *Pleuratus* and *Valvariella* can be successfully cultivated in the State all round the year on a variety of agro-wastes like saw dust, vegetable and paper wastes, oil palm pericarp waste and straw. But the best suitable substrate is found to be paddy straw.

Variety

Ananthan is a short duration variety released from KAU. It is an inter-stock hybrid of *Pleuratus petalaides;* tough fleshed, pure white in colour, pest and disease resistant; and yields about 100-120 g per harvest. It has good cooking quality and consumer acceptability and can be grown in wheat, paddy and sorghum straw. On an average, it takes eight days from spawning to harvest. Yield potential is 800 g per kg straw.

Method of cultivation

Polythene bags or tubes of 30 x 60 cm size with 150-200 gauge are taken for filling the substrate. If the tubes are used, the free-end is tied with a string. Seven to eight holes of 0.5-1.0 cm diameter are made all over the bag for aeration. One kg of well dried, oneyear-old paddy straw is cut into small bits of 5-8 cm in length and immersed in water for 18 hours. Then the soaked straw is taken out from water and kept inside the basket for 1-2 hours to drain away excess water. The soaked straw is kept under boiling water (100°C) for 30-40 minutes for surface sterilization or to achieve pasteurization and then taken out and kept inside the basket to drain excess water and allowed to cool down. The pasteurized straw is ready for filling the bags. Instead of straw bits, small round bundles of 20 cm diameter are also used for filling the bags. This method is followed to save time and labour. Now the perforated polythene bag is filled for about 5 cm height with the above processed straw and pressed with hand for making it even. Care should be taken to fill the bags as compactly as possible for the proper growth of mycelium. For getting maximum yield, 2-2.5% (125 g) of spawn is used, Spawn is taken out from packets and kept inside a clean container or paper. From this, one tablespoon full of spawn is sprinkled over the filled straw around the peripheral region. A second layer of processed straw is filled and spawned as above. Repeat the process as above until the soaked straw is finished. Every time before spawning, press the straw with hand for making it compact. If bundles are used for filling the bags care should be taken to keep the bundles inside the bag as compact as possible without leaving any space in between the bundle. Finally the bag is closed tightly with twine and beds are kept undisturbed for spawn running for about 15-20 days inside the rooms, thatched rodent-proof sheds or in verandas. The best temperature and humidity for spawn running ranges from 28-30°C and 80-85%, respectively. The beds can be arranged over a platform or in shelves. The spawn running can be judged from the whitish growth covering the straw completely. Periodicallyobserve the beds and discard the contaminated ones. After 15 days when the spawn running is complete, remove the polythene bag by cutting it with blade and keep the bed for sporocarp formation. The opened beds are

kept in well-ventilated rooms. Relative humidity of the room should be 80-85%. If temperature inside the room rises above 30°C, the room should be sprinkled with water to lower the temperature. Diffused light is essential for normal fruiting. Pinhead formation starts on 20th day and 2-3 days are required for the maturation of the fruiting body.

Cropping and yield

Matured and fully opened sporocarps are harvested by placing the thumb and forefinger near the base of the fruiting body and twisted in clockwise direction to get detached from the mycelium. An average yield 'of 500-700 g can be harvested from I kg of-straw. The spent straw can be used as enriched cattle feed.

Table 29. *Salient characters of common edible species of mushrooms of Kerala*

Characters	*Term;tomyces robustus*	*Termitomyces mammiformis*	*Term;tomyces m;crocarpus*	*Pleurotus cornucopiae*	*Pleurotus squarrosulus*	*Boletus edulis*
I. Pileus: Size	Large	Medium	Small	Medium	Medium	Large
Shape	Convex to planoconvex	Convex to flat	Convex	Flabelliform	Flabelliform	Globular
Colour	Pale cream	Whitish grey	White to cream	White	White to cream with scales	Pale green
Texture	Not very soft	Soft	Soft	Fleshy, turns fibrous when old	Fleshy, turns fibrous when old	Fleshy
Margin	Smooth, lacerate	Entire	Lacerate	Decutved, later expanded	Decurved	Involute
2. Gills	White, free with decurrent tooth	White, free	White, free	Creamy white to lilac decur-rent	White to creamy decur-rent	Absent; in-stead, tubes are present
3. Stipe	White, solid, taper to pseu-dorhiza which is also solid	White, solid, pseudorhiza hollow with blunt end	White slender; tendency to form pseu-dorhiza	Very short, often absent.	Stipitate	Tough, thick and solid
4. Annulus	Absent	Persistent	Absent	Absent	Absent	Absent
5. Spores	Pale-pink	White	Pink	Lilac	Creamy white	Olivaceous
6. Habit	Solitary or scattered	Gregarious	In groups	In clusters	In clusters	Scattered
7. Habitat	Associated with termite hills	Associated with termite hills	On soil	On wood logs and tree stems	Logs, wood stems, espe-ciallyon mango tree	Mycorrhizal, associated with trees like, jack, mango etc.
Remarks	Commonly known as up-pukoon,highly delicious	Common name perumkala	Common arikoon; very widely used in Kerala	Known as morakoon	Known as morakoon	Known as pannikoon

Cultivation of paddy-straw mushroom (Volvariella *volvacea)*

The paddy straw mushroom can be successfully cultivated in the plains of Kerala throughout the year where the temperature ranges between 28-32°c. The straw beds can be laid out in sheds, veranda of buildings and during summer under shades of trees. Beds should not be kept

under direct sunlight. Prepare a raised platform of I m long and 0.5 m broad with wooden planks or bricks. Ten to fifteen kg of well-dried and hand-threshed straw is required to raise a single standard bed. For spawning this bed, two bottles of spawn and about 100 to 150 g of red gram powder are needed. First the straw is made into twists of about.5 to 8 m long and 20-25 cm diameter. The twists are tied into small bundles and are kept immersed in clean water in tanks for about 6 to 12 hours. After this, the bundles are taken out and kept aside for some time to drain the excess water. The bundles are untied and the straightened twists are placed length-wise over the platform in a zigzag fashion. The twists are placed as close as possible. Keep another layer over the first layer crosswise. These two layers form the first layer to be spawned. Break open the spawn bottles and carefully divide. the spawn into small bits of 2-2.5 cm thick. Place these bits of spawn all along the periphery of the bed, about 5-8 cm away from the edge and 10 cm apart. Sprinkle a teaspoon full of coarsely powdered red gram powder before and after spawning the first layer. Build the next layer with one row of twist as done before and spawn it Make successive layers until the straw twists are finished. After placing the last of twists, press the bed thoroughly from the top in order to drain excess water. Make the bed as c9mpact as possible and cover with a transparent polythene sheet to maintain the temperature and relative humidity within the bed. Place another wooden plank over the bed and keep 4-5 bricks above the plank to get more compactness. Keep the bed undisturbed for 6-7 days. Slowly remove the sheet and observe the moisture level of the straw. If the moisture is excess remove the sheets for half an hour and then cover it again as before. Small white round pinheads appear all along the sides of the bed after 7 days and mature into button and egg stage on 9th day. Harvest the mature sporocarps in eggs stage. About 2-3 kg of mushrooms can be harvested from 10 kg of straw. Cropping lasts for 2-3 days. After the harvest, the spent straw can be sun-dried and used as cattle 'feed.

Instead of twists, the beds can be laid out using small bundles of straw each weighing about one kg. Place four such bundles of straw side by side over the platform with loose ends towards the same direction. Over this, place another four bundles, the loose ends towards the opposite direction. These eight bundles form one layer, which is to be spawned as in the case of twists.

TISSUE CULTURE PROPAGATION OF CROPS (Ad hoc recommendation)

Plant tissue culture is the in *vitro* culture of plant cells, tissues and organs under aseptic condition in defined or semi-defined media. Tissue culture techniques are increasingly being used for the rapid vegetative propagation of plants. It helps in the mass clonal propagation of crop plants. It is useful for plants, which do not set seeds or where the viability of the seeds is poor. Even when conventional methods of vegetative propagation are commercially acceptable, tissue culture propagation can be adopted as it has definite advantages. It offers an extremely rapid rate of multiplication. The geometric progression of tissue culture propagation makes it possible to produce millions of plants from an initial explant in a few months. It can speed up the process of establishing new varieties.

Only a limited quantity of plant tissue is Tequiredas the initial explant Tissue culture propagation ensures the availability of plants throughout the year. It helps in the production of uniform progeny from crosspollinated plants. Disease-free planting materials can be made available to the farmers. Special laboratory facilities and teehnical skill are essential for adopting this technique for mass, multiplication of crop plants. Training in tissue culture is offered by various research organizations in Kerala.

Procedure

Pipette the required volume of stock solutions of chemicals into a one-litre glass beaker. Add components like sucrose and myo-inositol as solid and allow them to dissolve." Make up the volume to approximately 950 ml with distilled water. Adjust the pH to the required value (5.6 to 5.8 for Murashige and Skoog basal medium) with a few drops of either alkali or acid, using a pH meter. Add the required quantity of agar and make up the volume to 1.0 litre.

Pour the solution into a glass beaker and heat, while stirring, until the agar is dissolved. Dispense the medium (5 to 15 ml) in test tubes or flasks and plug with cotton. Plastic. lids or aluminum foil may also be used for the purpose. Culture jars may be plugged with plastic lids. Autoclave the vessels containing culture medium for IS minutes at 1.06 kglcm2 pressure (121°C). While using a pressure cooker, wait for the continuous flow of pure steam, put the weight and sterilize for 20 minutes. Explants collected from field grown plants will have to be disinfected before inoculating in the culture medium. The explants are washed in running tap-water first and then in soap solution. They are then surface sterilized and trimmed using sterile knives. The commonly used surface disinfectants are sodium hypochlorite (0.1 to 2.0 per cent for 15 to 30 minutes) and mercuric chloride (0.05 to 0.1 per cent for 3 to 20 minutes). The efficiency of the surface sterilant can be increased, by adding a few "drops of surfactants. After surface sterilization, the explants should be washed with sterile distilled water four to five times to remove the residues. The explants are then transferred to the sterile culture media in vessels. This process is called inoculation. Surface disinfection and inoculation must be carried out in a laminar airflow chamber. This equipment can filters the air through a high efficiency particulate air (HEP A) filter of very small mesh size. This will remove bacteria and fungal spores. The steady outward flow of filtered air will ensure a sterile zone in the equipment, suitable for aseptic manipulations. The needles, forceps, blades and petri-dishes used for the manipulation of explants should be presterilized.

The tools used in the airflow cabinet may be kept dipped in 70 per cent ethanol in a beaker and periodically flamed over a spirit lamp. After inoculating the explants in suitable culture media, the cultures are incubated in rooms under controlled conditions of temperature (26 +/- 2°C), light (200 lux, 18 hours) and humidity (60-80%). Response of an explant largely depends on the composition of the culture medium. There are several basal media, which can be used for various needs with necessary modifications. The basal medium is selected to suit the plant species and the method Qf *in vitro* culture. In general, culture medium consists of salts of major and minor nutrient elements, vitamins, and amino acids, plant growth substances and a source of carbon. The established cultures are sub-cultured to fresh media at intervals of 3 to 5 weeks. The media provided at each subculture decide the response of the tissue. Hardening the plantlets to make them adapt to the outside environment is a critical process, essentially due to the- anatomical and physiological peculiarities of the plantlets. A period of humidity acclimatization is necessary for the newly transferred plantlets to adapt to the outside environment, during which the plantlets undergo morphological and physiological adaptations, enabling them to develop typical terrestrial plant-water control mechanism.

Tissue culture techniques for mass multiplication have been standardized for crops like banana, pineapple, papaya, black pepper, cardamom, vanilla, orchids, anthurium, gladiolus and several medicinal plants. The commercial adoption of tissue culture clonal propagation is feasible only when the rate of 91ultiplication is satisfactory and the cost of plantlets is acceptable to the farmers. Protocols for the tissue culture propagation of a number of crops like red banana, Nendran, pineapple, orchid and anthurium, black pepper, vanilla, medicinal plants etc. have been developed at the Kerala Agricultural University and are available for commercial adoption.

KEEPING QUALITY OF FRUITS AND VEGETABLES (Ad hoc recommendation)

About 30 to 40% of the harvested fruits and vegetables are estimated to be lost due to improper harvesting, handling, storage and transportation in India. If proper care is taken during these operations, the loss to some extent can be minimized. Some of the techniques, which can be adopted, are as follows.

Harvesting

a) Harvesting must be done at the appropriate maturity depending up on the marketing distances and purpose.

b) Harvesting must be done preferably in the morning hours or late evening to avoid exposure of the produce to excessive heat, which will otherwise hasten spoilage.

c) Harvesting must be done preferably with suitable harvesting devices to suit the commodity and reachability e.g. mango harvesters with cutting edges and plastic net can prevent the damage during harvest and collection.

d) A void impact shock while harvesting fruits from tall tree; e.g. jackfruit, mango, etc. which will cause bruising leading to infection.

e) Avoid loose or too tight packing in gunny bags while transporting harvested produces to avoid bruising.

At packing

a) Wash the harvested produce in plain water or in chlorinated water to clean the adhering mud, dirt and residual pesticides.

b) Remove the infested, rotten and spoiled ones. .

c) Grading the produce can improve market acceptability. This can be done at farmers' level or at the co-operative sector to suit the standards established by individuals, industry or government. Grading will also increase farmers' bargaining power, as they are likely to get quality premiums for better-graded product. Similarly buyers can choose the grades they wish to buy. Possible grading can be based on colour, shape, size, weight etc. of the commodity

During storage

a) Pre-cool the commodity immediately after harvest to reduce the field heat.

b) Pre-packaging the commodity into unit packs can reduce the handling losses.

Some of the packaging techniques are (I)

Packing of banana hands at 0.2 to 0.4% ventilation with polyethylene cover of ISO gauge was found to increase the keeping quality up *to* 10 to 12 days under ambient conditions. (2) Packing of fresh mushroom *(Pleuratus* sp.) with 100 gauge polypropylene pouches without any ventilation can extend the storage life up to 36 hours in room temperature and up to 7 days under refrigerated conditions. (3) Fresh tomato can be stored up to 25 days under ambient conditions when packed with 35 to 40 per cent moistened saw dust in a ratio of 1 : 0.5 (tomato : saw dust). (4) Fresh mature and ripe sapota can be stored up to 6 days under ambient conditions when individually wrapped with cling film.

General storage methods practised to extend the keeping quality are:

1. By storing the commodity under optimum low temperature and humidity.

2. By skin coating using wax emulsion corttaining 'pennitted fungicides at optimum concentrations.

3. By controlled/modified atmospheric storage modifying the oxygen/carbon-dioxide ratio within the package.

4. By sub-atmospheric pressure storage.
5. By ventilated storage using ventilated films/bags.
6. Using evaporative cool chamber constructed to store temporarily the harvested produce at the field before marketing.

LOW COST TECHNOLOGY FOR IRRIGATION (Indigenous auto irrigator for irrigating potted plants)

Indigenous auto irrigator can be fabricated by fitting certain low cost accessories in or Dinary garden pot. Plug the holes of the garden pot with corks provided with holes.

Insert hospital drips through these holes. Garden pots designed in the manner can serve as auto irrigator. One auto irrigator can serve as water source for maximum six pots. Place the irrigator at a level above plant height and arrange the potted plant around this auto irrigator. Plants are irrigated by exploiting gravitational force. Adjusting the regulator attached to the hospital drips can regulate the flow of water. Irrigate the pots to bring it to field capacity. Daily loss of water from the, pots can be computed. The flow rate can -be adjusted according to water requirement of the plant.

FARM MACHINERY SUIT ABLE FOR KERALA

Manually operated paddy transplanter

The improved IRRI six-row paddy transplanter is simple in construction and easy to operate. Six numbers of seedling mats having size 20 x 50 cm are placed in the transplanter tray, which is operated by a single person. It weighs only 20 kg.

It is operated in puddled and leveled fields with a thin layer of water. Row spacing is 20 cm and hill spacing is adjustable. It covers approximately 0.1 ha/h and has a saving of 75% labour and 70% cost in transplanting. Approximately, this costs Rs 3000.

Yanji Shakti 8-row rice transplanter

Rated speed: 2600 rpm; row number: 8; row spacing: 238 mm; distance between hills:

120-140 mm; number of seedling per hill: 3-8; suitable width of seedling mat: 2-20 mm; planting depth: 0.60 mm.

5 HP self-propelled paddy reaper

The 5 HP engine-operated improved IRRI reaper harvests paddy in 1 m width both in dry and wet fields of Kerala, except in sticky kole fields. A person operates it by walking behind the reaper. Maximum recovery of grain and straw is achieved.

It harvests broadcasted or transplanted nonlodged paddy. It is suitable for owp. use as well as for custom hiring. It covers approximately 0.18 ha/h and has saving of 85% labour and 65% cost in harvesting paddy. Approximately, this costs Rs 40,000 including diesel engine.

Tractor operated paddy reaper

The tractor front mounted paddy reaper harvests at 2.2 m width. Power is taken from PTO for cutting and conveying the crop and the hydraulic system is used for controlling the height of cutterbar. It is suitable to any make of tractor. Cage wheels and pneumatic wheels are used for wet and dry fields. Broadcasted or transplanted nonlodged paddy can be harvested. Maximum. recovery of straw and grain is achieved. It is suitable for tractor owners for custom hiring. It covers approximately 0.4 ha/h and has a saving of 85 % labour and 65% cost in harvesting. Approximate cost is Rs. 25,000.

Portable power-operated rasp-bar paddy thresher-cum- winnower

The crop is fed in the thresher with modified concave powered by an 8 HP engine. After threshing and winnowing it delivers straw, chaff, stone and clean paddy in separate outlets. It has good threshing and winnowing efficiency. Transportation is made easier by its pneumatic wheels by a pair of bullocks, power tiller, jeep or tractor. It is suitable for paddy crops even with high moisture and long straw. Suitable for custom hiring.
Straw is not cut and damaged. It threshes crop from approximately 0.3 ha/h (100 kg/h) and has saving of 85% labour and 60% cost in threshing paddy. Approximate cost is Rs 30,000 without engine.

KAU jack-fruit harvester

This consists of two sub-units as adjustable telescopic long handle with a hood knife at the outer end and a basket suspended from a nylon rope. The basket can be located just

around the fruit by a handle and rope and then harvested into it for safe lowering. It can be used for normal and medium tall trees.
With two people, a fruit can be harvested in , 4-5 minutes. Weight is 4-5 kg (if made of aluminium). Approximate cost is Rs 500.

Petti and para

The petti and para is used very widely to dewater the low-lying kole lands and Kuttanad padasekharams. These are not operated at optimum speeds, and hence incur loss of energy. The optimum speed for high level of efficiency at relatively higher head (100-200 cm) has been found to be 330-340 rpm for a 15 HP pump. Beyond 340 rpttl, the pump gets overloaded.

Coconut husking tool

This consists of a stationary wedge, a movable wedge, a lever and a pedestal having a base. The stationary wedge is mounted upright on top of the pedestal at a convenient height. Bottom of the movable wedge is hinged to the bottom of the stationary wedge facilitating its opening and closing. The lever fixed to the movable wedge provides the necessary mechanical advantage needed in husking Self-weight of the lever forces the wedges to remain together forming a large wedge. Holding the coconut with both hands, it is thrust onto the wedge piercing the husk at its pedicle end and parallel to its longitudinal axis. On pulling the lever upwards, a sector of the husk is loosened off. The operation is repeated for the other two or three sectors and the nut is then separated from the husk by pulling with the hands, which is easier. The trade name is Keramithra and approximate cost is Rs 180.