

FRUITS

BANANA (*Musa* spp.)

Banana prefers tropical humid lowlands and is grown from the sea level to 1000 m above MSL. It can also be grown at elevations up to 1200 m, but at higher elevations growth is poor. Optimum temperature is 27°C. Soils with good fertility and assured supply of moisture are best suited.

Season

Rain fed crop : April-May

Irrigated crop : August-September

Adjust planting season depending upon local conditions. Avoid periods of heavy monsoon and severe summer for planting. Adjust the time of planting so as to avoid high temperature and drought at the time of emergence of bunches (7-8 months after planting).

Varieties

Nendran (Clones): Nedunendran, Chengalikodan, Manjeri Nendran, Zanzibar, Big Ebanga. Growth and yield characteristics of popular banana Nendran varieties are given in Table 32.

Table varieties: Monsmarie, Robusta, Giant Governor, Dwarf Cavendish, Chen-

kadali, Poovan, Palayankodan, Njalipoovan, Amritsagar, Gros michael, Karpooravally, Poomkalli, Koopillakannan, Chinali, Dudhsagar, BRS-1, BRS-2 and Yangambi.

Culinary varieties: Monthan, Batheesa, Kanchikela, Nendrapadathy

Njalipoovan, Robusta, BRS-1 and BRS-2 are particularly suitable for intercropping in coconut gardens both under rainfed and irrigated conditions. Dudhsagar is highly resistant to major pests and diseases. The variety Bodles Altafort is recommended for high range region (*ad hoc*).

Preparation of land

Prepare the field by ploughing or digging and dig pits for planting. Size of pits depends upon soil type, water table and variety. In general, pit size of 50 cm x 50 cm x 50 cm is recommended. In low-lying areas, take mounds for planting suckers.

Selection of suckers

Select 3-4 month old disease free sword suckers from healthy clumps. In the case of Nendran variety, cut back pseudostem to a length of 15-20 cm from corm and remove old roots. The rhizomes are to be smeared with cowdung solution and ash and dried in the sun

Table 32. Growth and yield characters of Nendran

Clonal name	Plant height (cm)	Pseudostem girth (cm)	No. of leaves	Crop duration (days)	Bunch weight (kg)	No. of hands	No. of fruits	Fruit weight (g)
Nedunendran	292.0	46.0	14.0	290.0	10.50	5.53	47.6	157.6
Chengalikodan	332.0	49.0	14.0	333.0	12.60	6.25	65.0	172.3
Zanzibar	351.0	56.0	15.0	331.0	11.75	2.30	23.0	390.0
Big Ebanga	346.0	53.0	15.0	335.0	12.70	7.00	45.0	250.0
Manjeri Nendran	327.0	52.0	16.0	336.0	14.00	6.86	65.0	180.5

for about 3-4 days and stored in shade upto 15 days before planting.

Spacing

Spacing may be provided as indicated below:

Variety	Spacing (m)	Suckers/ha
Poovan Chenkadali Palayankodan Monthan	2.1 x 2.1	2260
Nendran	2.0 x 2.0	2500
Gros michael	2.4 x 2.4	1730
Robusta, Monsmarie, Dwarf Cavandish	2.4 x 1.8	2310

Planting

Plant suckers upright in the centre of pits with 5 cm pseudostem remaining above soil level. Press soil around the sucker to avoid hollow air spaces.

Manuring

1. Apply compost, cattle manure or green leaves @ 10 kg/plant at the time of planting.

For double sucker planting at a spacing of 3 m x 2 m, 133 per cent of recommended dose for single sucker planting in six splits is needed when farm yard manure is used as the organic source. The recommended dose for single sucker itself is sufficient with vermicompost as organic source. This should be accompanied with *in situ* green manuring @ 15 g cowpea seeds per pit (25 kg ha⁻¹) at the time of planting. Incorporate the cowpea crop into soil 40 days after sowing.

Plant crop followed by two ratoon crops gives maximum yield. Two suckers per clump should be retained for ratooning.

2. Apply N:P₂O₅:K₂O at the following dose (g/plant/year).

Nendran (irrigated): 190:115:300

Other varieties depending upon soil fertility level: 160-200 : 160-200 : 320-400
Palayankodan (rainfed): 100:200:400
Palayankodan (reclaimed alluvial soils of Kuttanad)

Plant crop : 100:200:400

First ratoon : 150:200:800

Second ratoon : 150:200:800

Apply the fertilizer 60-75 cm around the plant in two equal split doses; the first, two months after planting and the second, four months after planting. For ratoon crop, the entire fertilizers have to be applied in a single dose immediately after the harvest of the preceding crop. Irrigate immediately after manuring.

Note: For Nendran, apply the fertilizers in six split doses as detailed below which will be beneficial to improve the finger size and bunch weight, provided the farmers can afford the cost of application.

Time of fertilizer application	N:P ₂ O ₅ :K ₂ O g/plant
One month after planting	40:65:60
Two months after planting	30:50:60
Three months after planting	30:00:60
Four months after planting	30:00:60
Five months after planting	30:00:60
Just after complete emergence of bunch	30:00:00
Total	190:115:300

In Onattukara, for Njalipoovan, apply N, P₂O₅ and K₂O @ 200:200:400g/plant/year in two equal split doses: the first, two months after planting and the second, four months after planting.

For Palayankodan (rainfed), planting may

be done in January and the suckers may be given pot irrigation @ 9 litres of water once in 15 days until April-May.

After planting banana, sow sun hemp / daincha / cowpea adopting a seed rate of 50 kg ha⁻¹. Incorporate the crop into the soil 40 days after sowing. Repeat sowing of green manure crop and incorporate into soil 40 days after sowing.

Incorporation of cowpea in the inter-spaces of banana cv. Nendran with 75 per cent recommended dose of fertilizer (143:85:225 g N: P₂O₅: K₂O /plant) can be done as INM practice for highest BC ratio.

Irrigation

1. During summer months, irrigate once in three days.
2. Ensure good drainage and prevent water logging.
3. About 6-10 irrigations per crop may be given depending upon soil conditions.
4. Banana var. Nendran (October planting) grown under deep water table conditions (below 2 m from ground level) needs 10 mm (40 l/plant) irrigation once in two days during summer season to ensure higher bunch yield and better water use efficiency. Mulching the basin with 3.5 kg paddy straw (waste quality) will considerably improve the bunch yield.

Weed control

During early stages, complete control of weeds could be obtained by raising cowpea in the interspaces. In gardens where this is not possible, pre-emergence application of diuron 1.5 kg ha⁻¹ or oxyfluorfen 0.2 kg ha⁻¹ is effective. Weeds emerging later could be controlled by the application of glyphosate 0.4 kg ha⁻¹. If hand weeding is resorted to, give 4-5 surface diggings depending on weed growth. Avoid deep digging. Do not disturb soil

after plants start producing bunches. If green manure crop is grown, weeding operations can be reduced to 1-2 diggings.

Desuckering

Remove side suckers produced till the emergence of bunch. Retain one or two suckers produced after the emergence of bunch.

Intercropping in Nendran variety

Cucumber and amaranth can be cultivated profitably with banana raised in September-October without affecting the bunch weight. For vegetable purpose, cucumber may be harvested within 95 days and for seed purpose the duration may be about 130 days. Greater yam and elephant foot yam can be profitably intercropped with Nendran.

Pre harvest bunch spray

Pre harvest bunch sprays of 3 per cent K₂SO₄ (3 g in 100 ml of distilled water) twice, the first two weeks after bunch emergence and the second four weeks after bunch emergence increases the fruit yield substantially and consumer preferences in Nendran banana.

Tissue culture Nendran banana

(Ad hoc recommendation)

Tissue culture offers a rapid method of multiplication of quality, uniform, pest and disease free production of planting materials in large quantities in banana. The productivity of banana can be increased by cultivation of tissue culture plants of selected elite ecotypes of different varieties.

Spacing

Give spacing of 2 m x 2 m (2500 plants/ha). Tissue culture plants can also be used for high density planting in Nendran banana to achieve higher returns. The spacing recommended for high density planting is as follows: (a) 2 m x 3 m with two plants / pit

(3332 plants in 1666 pits per ha) (b) 1.75 m x 1.75 m with one plant per pit (3265 plants / ha).

Pit size

50 cm x 50 cm x 50 cm

Method of planting

Prepare pits 15 days in advance of planting. Fill the pits with topsoil and FYM 15-20 kg per plant per pit. Plant the tissue culture plants on the top of the pit at ground level. Remove the polythene cover completely before planting without damaging the roots. Planting may be done preferably during evening hours. Provide partial shade to plants to protect against sun scorching for about two weeks. Irrigate the crop daily during initial days of establishment.

Plant protection

Adopt integrated plant protection measures to control major pests and diseases.

Manures and Fertilizers

Apply FYM @ 15-20 kg per plant and lime 1 kg per plant at the time of land preparation. Apply $N:P_2O_5:K_2O$ @ 300:115:450 g per plant in six split doses as shown below.

Time of application	$N:P_2O_5:K_2O$ g/plant
1 month after planting	50:65:65
2 months after planting	50:00:65
3 months after planting	50:50:65
4 months after planting	50:00:65
5 months after planting	50:00:65
7 th month (i.e. after bunch emergence)	50:00:125

Organic production package for Banana var. Nendran

a. Sucker treatment

- Select healthy, disease and insect free suckers

- Dip suckers in cow dung + ash slurry containing neem oil 5% to control rhizome weevil

b. Manurial practices at planting

- Neem cake @ 1 kg/plant
- FYM @ 10 kg/plant + 10 g Azospirillum

c. Plant protection

- To control pseudostem weevil uniform spray of neem seed oil 5% + garlic to the leaf axils and pseudostem during third and fourth MAP
- Lime 500g/plant
- Sow green manure seeds around the banana sucker. *Pseudomonas fluorescens* spray @ 2% at two MAP

Nutrient recommendation

Any of the following combinations of organic manures can be applied as two splits (planting and 3 MAP)

- FYM 28 kg/plant + ash 4kg/plant - best treatment
- Poultry manure 14 kg/plant + ash 4 kg/plant
- Coir pith compost 10 kg/plant + ash 5 kg/plant
- Vermicompost 10 kg/plant + ash 4 kg/plant

Plant protection

Pests

Banana pseudostem weevil

The weevils resemble the rhizome weevil. Adult female weevil punctures and inserts eggs into the pseudostem. Grubs emerging out feed extensively on the pseudostem and thereby the entire plant collapses.

Management

1. Field sanitation is the most important factor in the prophylactic and curative control of this pest.

2. Remove affected plants along with the rhizome in full and destroy them by burning the life stages of the insect using kerosene or by burying the material in deep pits in soil.
3. Destroy the parts of rhizome and pseudostem of harvested plants in the field as described above.
4. Remove the dry outer sheaths of the pseudostem of all infested and un-infested plants in the endemic areas and spray any of the recommended insecticides. Drenching all the leaf axils, rhizome and surrounding soil and all round the entire pseudostem inserting the nozzle through the bore holes made by the larvae if any and also within the outer sheaths by slightly raising the same at different spots is also effective. Apply quinalphos 0.05 per cent or chlorpyrifos 0.03 per cent. Repeat the treatment after 3 weeks if the infestation persists.
5. Set traps using pseudostem of approximately 0.5 m length, which are split lengthwise and laid in the field. Adults attracted to it during nights may be collected and destroyed.
6. Application of Thiamethoxam 25 WG 0.2 g/l or 1g/5l or Fipronil 0.3 G 10 g formulation/plant at planting followed by two applications 2 and 5 months after planting.
7. Sucker treatment with *Pseudomonas fluorescens* @ 20 g/l + Sucker treatment with entomopathogenic nematode, *Heterorhabditis bacteriophora* @ 4 infected wax moth larvae/plant at planting followed by two applications 2 and 5 months after planting.

Aphid

Act as vector for the transmission of the dreadful bunchy top disease in banana.

Spindle leaf miner

Spray dimethoate 0.05 per cent on the spindle for controlling the leaf miner.

Nematodes

Major species are burrowing nematode, root knot nematode, root lesion nematode and cyst nematode.

In case of severe infestation there will be severe reduction in number of leaves, total bunch weight and number of fruits.

Management

Par the rhizomes and apply neem cake @ 1 kg/plant at the time of planting.

For managing nematodes paring+ banana sucker treatment with *Bacillus macerans*/*Paecilomyces lilacinus* @ 5g/sucker + pit application @ 10g/pit 45 days after planting can be recommended.

Diseases

Bunchy top disease

This is a virus disease transmitted by aphids.

Banana rhizome weevil

The attack by this pest is reported to be serious in all localities where banana is cultivated. Female adults puncture healthy rhizomes and insert eggs through it. Grubs tunnel into the rhizome and feed on it resulting in the stunting of rhizome. If the infestation occurs on a mature rhizome, damage symptoms such as reduction in leaf number, bunch size and the fruit number appear.

Management

1. Adopt strict field sanitation.
2. Select only healthy planting material.
3. Deep ploughing of the land so as to expose the inner soil layer to sun.
4. Cut and remove the outer layer of the rhizome and sundry for 3-4 days after smearing it with slurry of cowdung and ash.

Management

1. Eradicate disease affected plants.
2. Use disease free suckers for planting. Karpooravally, Kanchikela, Njalipoovan and Koopillakannan are less susceptible varieties.
3. Use of virus indexed tissue culture plants.

Panama wilt (*Fusarium wilt*) (*Fusarium oxysporum f. cubense*)

1. Dip suckers of susceptible varieties in 2 g l⁻¹ carbendazim solution to prevent spread of the disease.
2. Drench the soil around affected clumps with 2 g l⁻¹ carbendazim solution to prevent spread of disease.
3. Remove and destroy affected clumps along with corms.
4. Apply lime @ 1 kg pit⁻¹ and allow to weather. Varieties such as Palayankodan, Robusta and Nendran are resistant to the disease.

Sigatoka leaf spot (*Mycosphaerella* sp.)

1. Cut and burn all severely affected leaves.
2. Spray 1 per cent Bordeaux mixture with sticker soon after the appearance of the initial symptoms of the disease. The disease appears with the commencement of southwest monsoon. Five to six sprayings at fortnightly intervals are to be given depending upon the severity of the disease.
3. Petroleum based mineral oil 1 per cent emulsion is also effective in controlling the disease.
4. Spray carbendazim 1 g l⁻¹ or give alternate sprays of mancozeb (2 g l⁻¹) and carbendazim (1 g l⁻¹) soon after the appearance of initial symptoms of the disease. Three to four sprays at fortnightly intervals are to be given depending on the severity of disease.

5. Spraying of cow's urine (10%) / sucker treatment with *Pseudomonas fluorescens* 5% + Spraying 2% *Pseudomonas fluorescens* and vegetable oil (2.5 ml l⁻¹) + baking soda (2.5g l⁻¹).

Kokkan disease (Banana bract mosaic virus)

Kokkan disease was found to affect other varieties like Palayankodan, Kodappanilla-kunnan, Monthan, Kanchikela, Poovan (Rasthali), Karpooravally, Chenkadali and Nendran. Nendran is a highly susceptible variety.

During the young stage of Nendran banana plant (two months old), pinkish streaks can be seen on the pseudostem. All the kokkan affected plants may not show this symptom. Necrotic streaks are another important symptom of the disease. The streaks are initially brown, which later turn black. It occurs on all aerial parts of the affected plant except on lamina, the length being a few mm to 10 cm. All the kokkan-affected plants will exhibit the necrotic streaks from third month onwards at one stage or other. Some of the affected plants retain the necrotic streaks throughout the growth period. In certain cases it disappears with the senescence of the affected portion. Leaves of the infected plants also show travellers palm like leaf arrangements.

The affected plant produces only a small bunch. The fingers are small, curved and widely divergent with pale green to ashy green colour as compared to healthy ones. The abnormal colour and reduction in the size of bunch depend upon the severity of the disease.

Suckers should not be taken from affected plants, which show necrotic streaks or abnormal colour of the pseudostem. When the young plants show the symptom of pinkish streaks, they should be uprooted and destroyed.

Infectious chlorosis (Cucumber mosaic virus disease)

The disease is noticed in varieties such as Nendran, Palayankodan, Karpooravally, Kosthabontha, Peykunnan, Bhimkhel, Mottapooan, Dakshinsagar, Madhuraga, Rasthali and *Musa ornata*.

The most characteristic symptoms are the loss of leaf colour in patches, appearance of parallel chlorotic streaks on the younger leaves giving a striped appearance of the leaves. As the disease progresses, leaves emerge distorted, margins become irregularly wavy, often with blotches of necrotic tissues and the lamina is reduced in width. In severe cases, rotted areas are found throughout the leaf sheath and pseudostem. The affected plants produce only small bunches. This is a virus disease transmitted by aphids.

1. Use disease free suckers for planting.
2. Eradicate disease affected plants.
3. Avoid growing leguminous and cucurbitaceous vegetables as intercrop in banana in disease prone areas.

Banana streak disease

Banana streak disease is caused by Banana streak badna virus and transmitted by pineapple mealy bug (*Dysmicoccus brevipes* Cockerell) and striped mealy bug (*Ferrisia virgata* Cockerell). It is predominant on Palayankodan variety, also noticed on other varieties like Nendran, Chinali and Mottapooan. The symptoms appear on different parts of the plant such as leaf lamina, midrib, pseudostem and on bunches. Linear chlorotic streaks appear on leaf lamina which later turned brown streaks. Such dark brown

linear lesions appear on petiole, midrib, pseudostem and bunches. Under severe conditions, necrosis and death of cigar leaf is noticed and such plants fail to flower and lead to total yield loss.

For the control of the disease, eradicate diseased plants, do not select planting materials from infected clumps. Avoid growing colocasia as intercrop and control of mealy bug vectors.

Process Protocol for Banana flour production

The banana powder is prepared by drying banana slices at 70°C for 24 h, which was pre-treated with 0.5% citric acid for 10 min, in a convective dryer. An ethnic health mix was also developed out of *Nendran* banana flour and sugar (75:25). The best proportion of *Nendran* banana flour and sugar were selected based on the nutritional and sensory quality parameters. The new product could be stored for more than six months using suitable packaging technology.

RTE Snacks from starch based food products

An extruded Ready To Eat (RTE) snack food product was developed out of starch based food products such as rice, cassava and *Nendran* banana at optimized process parameters viz; temperature (180°C), screw speed (100 rpm) and moisture content (16%) using a single screw extruder. The best proportion of rice: banana and cassava (10:80:10) was selected based on the nutritional, engineering, textural and sensory quality parameters. The new RTE product could be stored for more than six months using suitable packaging technology.