

Banana

Soil



Soil

- Banana can grow from the poorest to the richest type of soil with varying success.
- The soil should be tested before banana cultivation
- The soil should have good drainage, adequate fertility and moisture.
- Deep, rich loamy and salty clay loam soil with pH between 6-7.5 is most preferred for banana cultivation.
- Ill drained, poorly aerated and nutritionally deficient soils are not suitable for banana.
- Extreme clayey, Sandy soil, Saline soil and Calcareous soil is not suitable for Banana cultivation.
- Avoided soil of low lying areas, very sandy & heavy black cotton with ill drainage.
- A soil that is not too acidic & not too alkaline, rich in organic material with high nitrogen content, adequate phosphorus level and plenty of potash are good for banana.

Field Preparation

- Wetlands: no preparatory cultivation is needed
- Garden lands: 2-4 ploughings are required
- Padugai : one deep spade digging is needed
- Hill Banana: Cleaning the jungle and construction of contour stone walls before planting is required.
- Prior to planting banana, grow the green manuring crop like daincha, cowpea plough insist in the field. The selected field must be ploughed 4-6 times and allowed to weather for two weeks.
- Rotovator or harrow is used to break the clod and bring the soil to a fine tilt. During soil preparation basal dose of FYM (about 50 tonnes/ha. before last harrowing) is added and thoroughly mixed into the soil.
- The field is leveled by passing a blade harrow or laser leveler.
- Land Leveling through Laser Leveler is one such proven technology that is highly useful in conservation of irrigation water. Laser land leveling is leveling the field within certain degree of desired slope using a guided laser beam throughout the field.
- By using laser leveler, the land looks leveled even when the wide topographic variation exists, wide variability in crop yields at field, better distribution of water, saving the water, improvement in nutrient use efficiencies, option for precision farming, achieve higher crop productivity.
- A pit size of 45cm x 45cm x 45cm is normally required. The pits are to be refilled with topsoil mixed with 10 kg of FYM (well decomposed), 250 gm of Neem cake and 20 gm of carbofuron.

- In areas where nematode problem is prevalent, nematicides and fumigants are also added to pits before planting.
- Prepared pits are left to solar radiation helps in killing the harmful insects, is effective against soil borne diseases and aids aeration.
- In saline alkali soil where PH is above 8 Pit mixture is to be modified to incorporate organic matter. Addition of organic matter helps in reducing salinity while addition of purlite improves, porosity and aeration.
- Alternative to planting in pits is planting in furrows. Depending on soil strata one can choose appropriate method as well as spacing and depth at which plant is required to be planted.
- In wetlands and hilly areas no land preparation is needed and pits are directly taken in the required spacing. For Hill Banana cultivation clean the jungle and construct contour stone walls before planting.
- Plough furrows may be formed length wise and breadth wise of the field at the required spacing and its intersection of the plough furrows pits of size 0.6m x 0.6m x 0.6m are dug sufficiently ahead at points fixed for planting.



**Mini Tractor Drawn
Rotavator**



Disk Plough



Rotavator

Ratoon Crop

Bananas are perennials which produce succeeding generations of crops. The first cycle after planting is called the plant crop. The ratoon is the sucker (also called the follower) succeeding the harvested plant. The second cycle is called the first ratoon crop. The third cycle is the second ratoon crop, and so on.

The growth cycle of Banana consists of two phases,

- **Vegetative phase**
- **Reproductive phase**
- The vegetative phase (or 'shooting') begins with the production of leaves by the planted tissue culture plant and ends when the inflorescence appearing at the top of the plant. The reproductive phase begins with the transition of the vegetative meristem into a floral shoot. The division of phases is arbitrary, and it takes normally about 7-8 months after planting before the inflorescence emerges at the top of the plant. The fruit filling period, that is, the time between flowering and harvest, completes the reproductive phase and the growth cycle.

During the growth cycle, plants develop essentially three major components

1. *an underground corm, producing suckers and roots.*
2. *a pseudo stem, consisting of encircling leaf sheaths and carrying the leaves.*
3. *an inflorescence, containing female flowers that develop into fruits.*
4. The length of the growth cycle depends on the cultivar. Under the best growing conditions, the yield of the second cycle is higher than the yield of the first cycle. The

mother plant and the ratoon are in competition for resources and ratooning is generally followed only in those areas where there is an assured source of irrigation. During the vegetative phase, most of the resources are directed to the growing mother plant. During flowering, ratoon development increases. Hence ratoon management or de-suckering becomes very important. As a rule, a follower is allowed only after the emergence of the inflorescence in the planted crop and the same package of practices are followed as that of the planted crop before allowing a follower for the second ratoon. Starting with a TC planting material that ensures uniform growth and early and uniform maturity, proper ratoon management (follower management) will result in yet another uniform ratoon crop. Thus it has been proved that in a span of 30 months (12 months for planted crop and 9 months each after harvest for the subsequent crops), three crops comprising of one planted crop and two ratoon crops can be harvested without reduction in yield.

Ratoon Management

- Keeping the field and neighborhood free of weeds generally is advised to avoid spread of infestations. Though the TC plants, which are supplied are healthy and virus free, field contamination can be avoided only by keeping the generally field free of weeds. Ratoon management is important for sustained income. In a place like Theni, three ratoons have been done in 24-25 months. Once the flowers emerge and all the fruits have fully opened, the bunches are covered using a skirting bag which prevents the tender fruits from insect attack, besides maintaining uniform temperature inside. This is important for colour and fruit development.

Spacing and planting

Spacing

Spacing for Hybrids

Varieties	Spacing	No. of suckers/ha	No. of suckers per acre
CO 1	1.8x3.6	4600	1840
Udhayam	1.8x3.6	4600	1840
Grand Naine	1.5x1.5	4440	1785
BRS1	1.8x3.6	4600	1840
BRS 2	1.8x3.6	4600	1840
FIHA-01	3x2	1667	666
Saba	3x2.5	1333	533
Lacatan	3x3	1111	444

Planting

Planting can be done in May-June or in September - October. Single sucker is planted upright in small pits taken in the centre leaving 5 cm pseudostem above soil level. Soil is pressed around the sucker to avoid hollow air spaces. Tissue culture plants are planted on the top of the pit at ground level. Poly cover should be removed before planting without damaging the roots. Planting is followed by light irrigation. Partial shade should be provided immediately after planting.

- Banana can be planted throughout the year except in severe winter and during heavy rains when the soil remains very wet.

- The ideal time (October-November) of planting is after the monsoon season.
- With assured irrigation, the planting can also be done in February-March.
- Plant population depends on cultivars, topography and soil fertility.
- Apply 25 g *Pseudomonas fluorescences* / plant at the time of planting.

Pre-treatment of suckers

- Trim the roots and decayed portion of the corm, cut the pseudostem leaving 20 cm from the corm and grade the suckers to size.
- To avoid wilt disease in Rasthali, Monthan, Virupakshi and other wilt susceptible varieties, infected portions of the corm may be pared and dipped for 5 minutes in 0.1% Emisan solution (1 g in 1 lit of water).
- Pralinage is done with 40 g of Carbofuran 3 G granules per sucker. (Dip the corm in slurry solution containing 4 parts clay plus 5 parts water and sprinkle Carbofuran to control nematodes).
- Alternatively, dip the corm with 0.75% Monocrotophos, shade dry for atleast 24 hours and plant.
- Use tissue cultured banana plants with 5-6 leaves.

System of Planting

Single row system



- In single row planting, the distance within the row is close, whereas the distance between the row is wide.
- This system allows good aeration to plant canopy, allowing wet leaves to dry more rapidly, reducing fungal disease severity.
- In this, less number of trees occupied in the field and yield will automatically reduced .

Paired Row System



- In this method, the distance between the two lines is 0.90 to 1.20 m. while plant to plant distance is 1.2 to 2 m.
- Due to this spacing, intercultural operations can be carried out easily and cost of drip irrigation is decreased.

Square System



- This is the most commonly followed system and is very easy to layout.
- Banana is mostly cultivated by adopting 1.8x1.8m spacing
- In this system, trees are planted on each corner of a square whatever may be the planting distance.
- The central place between four trees may be advantageously used to raise short lived filler trees.
- This system permits inter cropping and cultivation in two directions.

Triangular System

- This system is best suited for tissue culture banana suckers.
- In this, adopt spacing in between rows was 1.5m and plant to plant was 1.8m in the row.
- The trees are planted as in square system but the difference being that those in the even numbered rows are midway between those in the odd rows instead of opposite to them.
- The distance between any two adjacent trees in a row is equal to the perpendicular distance between any two adjacent rows.
- When compared to square system, each tree occupies more area and hence it accommodates few trees per hectare than the square system.

System of Planting	Planting distance	Plant population per hectare
Paired row	1.2x1.2x2.0 m	5200
Square system	1.8x1.8 m	3025
Triangular system	1.5x1.8 m	3630
2- suckers/hill	1.8x3.6 m	3200
3- suckers/hill	1.8x3.6 m	4800

Method of planting

- **Pit Method**
- **Furrow Method**
- **Trench Planting**

Pit Method

- Pit planting is commonly followed in garden land system of cultivation. Pits of 60 cm x 60 cm x 60 cm size are dug, filled with a mixture of soil, sand and FYM (Farm Yard Manure) in a 1:1:1 ratio. Suckers are planted in the centre of the pit and soil around is compacted.
- Planting is done from February to May whereas in North India, it is done during July-August. In South-India, it can be done any time of year except summer. This is mostly followed in biennial plantations for Dwarf Cavendish, Rasthali, Robusta, Poovan and Karpuravalli banana.

- However this method is very laborious and expensive. The only advantage is that no earthing up is required as planting is done at the required depth. This practice is not very popular at present.



Pit Method



Pit Method



Pit Method

Furrow Method

- In Gujarat and Maharashtra, furrow planting is practised. After land preparation, 30-40 cm deep furrows are made, either manually or with a ridger.
- Suckers are placed at required spacing; FYM is applied around, mixed with soil and tightly packed round the suckers.
- Furrow planting is practised in annual panting system. In this method earthing up needs to be frequently done to cover the exposed rhizomes.



Furrow Method



Furrow Method



Furrow Method

Trench Planting

- Trench planting is practised in wet land cultivation of Cauvery delta region of Tamil Nadu. Land is prepared like paddy using plenty of water and gauge wheel.
- Water is drained from the field allowing setting for a day. Planting is done by simple pressing the suckers into the wet field.
- After a week 15 cm deep trenches are opened both ways maintaining 4 or 6 plants in each block.
- Deepening of trenches by 20-25 cm is taken up every month after planting till suckers put forth 1-3 leaves.
- During third month trenches are broadened and deepened to 60 cm. in rainy season some trenches are used as drainage channels. After about 2 months, trenches are cleaned; decayed manure is used for plants for organic cycling.



Trench Method



Trench Method



Trench Method

High Density Planting

- High Density Planting (HDP) is normally refers to planting at a spacing than the usual recommended spacing.
- Choosing the correct planting density is very important for bridging the gap between the actual yield and the potential yield of banana from a unit area.
- For the highest possible yields of good quality fruit, there is an optimum plant density, which should be maintained for sustaining the economic life of the plantation.
- This optimum varies with the location, cultivator, soil fertility, management level and economic considerations.
- These factors in turn influence more specific determinants of density choice such as prevailing climate, plantation vigour and its longevity.



High Density



High Density



High Density

Plant canopy and light intersection

- Unlike other fruits, the vegetative growth, flowering and fruit growth is not seasonal in banana and are largely influenced by time of planting, type and size of planting material and prevailing temperature.
- Planting density and their interception. Reduced light intensity at ground level with increase in size energy conversion efficiency was maximum in 1.2 x 1.2m spacing and minimum in 2.1 x 2.1m spacing.



Light intersection



Light intersection

Plant height and girth

- Height of pseudostem is invariably increased with reduction in spacing.
- Plant height is adversely influenced, depending upon cultivators.
- Stem girth is reduced with height on increase in density.
- Girth of Robusta banana was not influenced by varying plant density although tallest plants were produced under closer spacing of 1.2 x 1.2 m.
- In poovan cultivar, plant height was significantly increased and girth reduced when spacing was brought down from 2.1 x 2.2m to 1.5 x 1.8m.



Plant height and girth



Plant height and girth

Leaf number and leaf area index

- Canopy characteristics such as leaf area index (LAI) and transmission of photosynthetically Active radiation (PAR) can be used to correlate with optimum density.
- Leaf emergence is reduced under very close planting owing to lower temperature inside the canopy since temperature had significant influence on rate of leaf emergence.



Leaf number



Leaf number

Sucker production and root growth

- The number of suckers per plant was more in wider spacing compared to that in closer to that in closer spacing.
- The suckers per plant decreased with reduction in planting distance with reduction in planting distance in Robusta and Poovan.
- The length of fine roots increased with increase in plant density to shooting and declined thereafter.



Sucker production and root growth



Sucker production and root growth

Weed growth

- High planting density (4440 to 6950 plants/ha) coupled with initial check on weed population through intercropping of cowpea caused reduction in weed growth.
- Under high density planting, at all stages of plant growth, weed growth was minimized and cowpea intercrop also improved the soil fertility besides suppressing weed growth.



Weed Growth

Flowering and fruit maturity

- Dwarf Cavendish banana required a minimum of 3.24m², which can be achieved by spacing at 1.8 x 1.8m or 2.7 x 1.2m.
- With plant densities of 1600 to 10000 per hectare by spacing from 1.0 x 1.1 to 2.0x2.0m, significant delay in flowering and fruit maturity.



Flowering and fruit maturity



Flowering and fruit maturity

Bunch weight and quality

- Planting two plants per hole at spacing of 1.8 x 1.8m doubled the yield with little or no influence on bunch size and time of maturity on the plant crop in Dwarf Cavendish.
- In Robusta banana also, double planting increased returns.



Bunch weight quality

Fruit yield

- High density planting in banana enabled to achieve higher yields.
- High density planting coupled with practices like cowpea intercrop, timely irrigation and fertilization can bring phenomenal yield increase in Robusta banana without adverse effect on finger size and shape.
- Different planting densities fertilizer requirement under HDP system (Nalina, 1997) with planting of three and four suckers per pit at spacing of 1.8 x3.6 m.
- There were three NPK levels viz. 50,75 and 100% of the recommended doses.



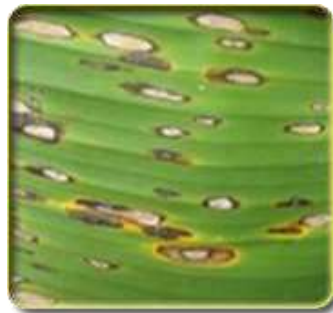
Fruit Yield



Fruit Yield

Diseases incidence

- Sigatoka leaf spot is increased under high density planting especially in high rainfall and coastal regions.
- Under North Karnataka conditions, wider spacing (2.4 x 2.4m) resulted in less disease incidence during the second ratoon of Rajapuri banana, under Trichy conditions (Tamil Nadu) Sigatoka leaf disease was lesser in dense planting (3 suckers per hill) than in wide plantings, due to the adoption of wider spacings between hills and thus resulting in less relative humidity.
- In paired row planting, higher plant densities increased the relative humidity, kept the leaf moisture longer and thus increased the incidence.



Disease Incidence



Disease Incidence

Cropping System

Introduction

- Farmers around the world produce banana and plantain in different production systems. These represent farmer ingenuity, experimentation and tradition under particular soil and climatic conditions, but also their response to market opportunities.
- Although export fruit crops are a major source of jobs and currency, they are now often barely viable, in agronomic, economic or social terms. Monocultures often cause pollution and impoverish the environment. The markets are increasingly competitive and consumers increasingly demanding. The only likely solution is to switch from the conventional intensive monoculture systems to sustainable cropping systems.

Homestead or backyard cultivation

- In traditional growing areas, homestead cultivation of banana is common. Homestead cultivation is traditional because of the ease in establishment, availability of area around farmhouse, minimum capital investment, ease monitoring and sharing of labour among family members. Homestead farming is characterized by improper spacing, inadequate use of fertilizer and pesticides, high productivity and longer crop duration. Homestead gardening is a traditional practice of multiple and mixed cropping in small holdings in Kerala.

- This farming system is a need based crop production system adjacent to adjacent homes of Keralites, which can be defined as the man made forest fitted to family needs. This is based on the subsistence need of his family, climate of the area, economic factors and dietary habits of the household. In general, perennial crops like coconut, jackfruit, timber yielding forest trees, arecanut, cashew etc. occupy the upper layer followed by mango, nutmeg, pepper, clove, cinnamon as the second layer.
- Banana, cassava, yam- like crops from the third layer in this man made forest while the ground layer is occupied by ginger, turmeric, pineapple and various types of vegetables. The home gardens of Kerala are often combined with livestock rearing which interact synergistically to sustain productivity. The common livestock like cows, goats, buffalo and poultry when added to homestead will provide additional income for the families.

Crop Rotation

- Crop rotation is the growing of two or more crops one after the other in the same piece of land.
- It is advantageous that the succeeding crop belongs to a family different from that of the previous crop.
- The period of crop rotation may be for two to three years or longer.
- Farm income significantly increased
- Better control of weeds
- Better control of pests and diseases
- It improves soil structure, soil fertility and organic matter content
- Banana may be rotated with paddy, sugarcane, pulses, vegetables etc

Mixed cropping

- Mixed cropping is growing of two or more crops simultaneously on the same piece of land. It is also known as multiple cropping. This type of cropping leads to an improvement in the fertility of the soil and hence, increase in crop yield because when the two crops are properly chosen the products and refuse from one crop plant help in the growth of the other crop plant and vice-versa.
- Mixed cropping is an insurance against crop failure due to abnormal weather conditions. Banana is cultivated predominantly as a commercial shade crop for coffee on Palney and Shevaroy hills, contributing to income in the initial years. In mixed farming systems, bananas are used as a ground shade and nurse-crop for a range of shade crops including cocoa, coffee black pepper and nutmeg.
- In coastal areas of Karnataka, Kerala and Andhra Pradesh, banana is grown in coconut and Arecanut plantations with tall varieties. Apart from these palm crops, banana plantations are intercropped with ginger, turmeric, elephant-foot yam, cotton, gourd and other vegetables to exploit maximum income/unit area.



Mixed Cropping



Mixed Cropping

Multistorey System

- It is commonly followed in Coastal plantation of Karnataka and Kerala where crops with different Canopy level are Planted. High Density Planting with Coconut And Arecanut forming the Upperstorey followed by banana, next with tapioca and lower – most storey with Colocasia , Turmeric , ginger and Garlic.High input management is its important feature.
- Semi – Tall Banana Poovan And Ney Poovan are preferred in this system.In India banana cultivation/plantation can be seen as multi-storied plantation such as with turmeric and ginger on ground floor, elephant foot as first floor, Dioscoria as second floor and banana as third story crop.
- The limited flat land available in the state may hardly be practicable of such as intensive cropping. However, it is very much feasible to take turmeric or ginger or onion in between the rows of banana plantation enabling at least two dimensional cropping systems in the state.



Multistorey System



Multistorey System

Intercropping System

- Intercropping is the cultivation of two or more crops at the same time at the same field.
- Intercropping of bananas with other crops is also a common soil fertility improvement effort, which when it occurs, is sometimes a secondary benefit to the primary purpose of the practice.
- Intercropping in banana gardens with annual crops can be remunerative. Farmers with limited resources have traditionally multicropped their lands to minimise risks associated with growing a single crop and to ensure more stable subsistence in terms of food nutrition and possible income.
- Bananas are mostly grown by small and marginal farmers. With holdings less than a hectare, they can hardly be expected to raise a pure crop of banana.



Intercropping



Intercropping



Intercropping

Intercultural Operations

-🌱 Desuckering
-🌱 Propping
-🌱 Mulching
-🌱 Removal of withered styles and Perianth
-🌱 Pruning of Leaves
-🌱 Mattacking
-🌱 Earthing up
-🌱 Bunch Covering
-🌱 Denavelling
-🌱 Bunch Thinning
-🌱 Peduncle Wrapping
-🌱 Tagging
-🌱 Wind Break

Desuckering

- Removal of surplus and unwanted suckers from banana plant is known as desuckering.
- Suckers are removed from the mother either by cutting the sucker at ground level or by destroying the heart of the suckers without detaching the sucker from the plant.
- Desuckering can also achieved by pouring kerosene oil into the heart of the sucker.
- Under garden land and wet land cultivation, desuckering is done at monthly intervals.
- In hill banana ,two bearing plants and two suckers per clump areconsidered as the optimum condition and the rest are desuckered.
- Only one sucker is retained per plant and set for ratooning.
- Set suckers are headed back once at 2 month stage to arrest the apical growth and allow to enlarge the rhizome.
- At the time of harvest of the first crop, the set sucker will become ready for the next ratoon crop.



Desuckering



Desuckering

Propping

- At the time of bunch emergence , pseudostem requires support from props.
- Tall varieties which produce heavy bunches need propping.
- Bamboo or casuarinas poles which have effective life of 3-4 years are commonly used for propping.

- Coir or polythene wire can also be used for propping.



Propping

Mulching

- Mulching is useful in conserving the soil moisture increasing the number of feeder roots and thereby improving the nutrient and water use efficiency suppression of weed growth and thereby enhances the banana yield by 30-40%.



Mulching



Mulching

Removal of withered styles and Perianth

- Removal of dead leaves is practiced to reduce disease spread, to prevent senescent leaves from hanging over suckers and reducing light and to prevent fruit scarring.
- There should be atleast six to eight healthy leaves remaining on the plant at flowering ensures maximum bunch development.
- Plants with severe leaf removal or damage have bunch weight.
- The green life of the harvested banana is also reduced by leaf loss



**Removal of withered styles
and Perianth**



**Removal of withered styles
and Perianth**

Pruning of Leaves

- In some varieties the styles are persistent and hence they remain in bunch till maturity.
- They can be easily removed by a light brushing movement of the hand a few days after flowering and if it is delayed, it is difficult to remove and later, they become brown and shriveled.
- This operation eliminates the removal of infection by saprophyte fungi especially to avoid the finger tip disease.



Pruning of Leaves



Pruning of Leaves

Mattacking

- After harvesting, the pseudostem should be cut leaving a stump of about 0.6m height.
- This practice is called attacking.
- The food material stored in the left out stump continues to nourish the daughter sucker till it withers and dries up.



Mattacking



Mattacking

Earthing up

- Earthing up is important which provides support to the base of the plant and also gives chances for the formation of a better root system.
- Earthing up should be done at rainy season for avoiding water logged conditions.
- It will also provide proper drainage facilities to the plant.



Earthing Up



Earthing Up

Bunch Covering

- Covering bunches with gunny cloth or polythene protects the fruit from sunburn, hot wind and dust.
- Covering of bunches is practiced in Cavendish group and nendran bananas to get attractive colour.
- Perforated / polythene bags when used for bunch covering increased yield by 15-20 %.
- Peduncle of the bunch may be covered with the flag to prevent main stalk rot.



Bunch Covering



Bunch Covering

Denavelling

- Removal of male bud after completion of female phase is known as denavelling.
- This checks the movement of photosynthates into the unwanted sink and promotes fruit development.



Denavelling



Denavelling

Bunch Thinning

- One to two small bottom hands should be removed from the bunch in order to facilitate uniform bunch development. Keep only 7 to 8 hands.



Bunch Thinning



Bunch Thinning

Peduncle Wrapping

- The peduncle is the main nutrient, photosynthate, water conducting bridge between the developing bunch and the plant.
- During bunch maturation period, due to bright sunshine, there are possibilities of scorching injury on peduncle.
- This will pave way for secondary infection by any fungi or bacteria.
- Once the peduncle gets affected, the nutrient, photosynthate and water flow from plant to developing bunch will be arrested and it will lead to immature ripening or immature falling of bunches.
- So during peak summer banana bunch peduncle exposed to scorching sun should be wrapped with flag leaf or banana leaf trashes.



Peduncle Wrapping



Peduncle Wrapping

Tagging

- Bunch should be tagged with respect to the week of bunch emergence & covering.



Tagging



Tagging

Wind Break

- Wind break like Shevri (*Sesbania egyptifolia*) can be raised along the border of field in East-West direction to avoid damage due to heavy & hot winds.



Wind Break

MAT System

- A farmer begins a new field of banana or plantain by planting either suckers from another banana field or young plants produced by tissue culture. Each new stem produces only one bunch, but numerous lateral shoots that become the next generation of bunches each from its own stem. In time the lateral shoots produce their own lateral shoots which produce bunches, each from its own stem. The stem bearing the bunch is cut down when the bunch is harvested. The parent plant and the successive lateral shoots are referred to as a **stool or mat**.
- The sucker must be uprooted from an existing mat to reproduce the variety and, because of its bulk, transports poorly. Once farmers have acquired a new type, they can propagate it themselves and maintain its yield advantages for many years if the material is kept free of pests and diseases.

How many leaves per stem?

- Each sucker or new plant has a growing point where the new leaves, flowers and fingers originate. This growing point can be found in the center of the corm just above ground level where the leaf sheaths are attached.
- The growing point produces between 30 to 50 leaves. Shorter cultivars are generally characterized by the production of fewer total leaves, while taller cultivars produce more total leaves before flowering. Within a cultivar, the total number of leaves is very similar from stem to stem and mat to mat. The first leaves are small and may even be hard to see. During early growth each leaf is bigger than the previous one. New leaves emerge from the center of older leaves. The leaf sheaths are tightly wrapped to form the trunk or pseudostem which becomes taller and taller during the first few months.

- New leaves develop above older leaves and a healthy plant may have between 10-15 active leaves at any one time. Once the plant has produced 30-50 leaves, the flower bud is formed. No more leaves can be produced after that. When the flower bud is formed, there are 11 leaves within the stem remaining to emerge.

How fast does a stem produce a bunch?

- Under optimal growing conditions (temperature, water, light, nutrients, soil), a new leaf emerges every 6-8 days. If the plant has optimum conditions, the time from the first leaf to the last leaf will be 245 to 320 days (8 to 11 months). However, when we plant a sucker or a tissue culture plant, they already have produced some leaves. Small suckers have produced fewer leaves up to the point of planting, while larger suckers have produced more leaves and therefore produce fewer leaves after planting until flowering.

Do all leaves emerge at the same interval?

Under optimum conditions, the very first leaves emerge every four days and interval becomes progressively long until the last leaves to emerge take seven to 10 days for each leaf.

Interval for leaf emergence under optimal conditions for

Leaves 1-10	=	43 days
Leaves 11-20	=	54 days
Leaves 21-30	=	65 days
Leaves 31-40	=	76 days
Total days	=	238 days (8 months)
Days per leaf	=	6 days

How long from one generations of bunches to the next?

This is an important factor in field productivity, since it strongly influences the time interval between the first generation of bunches and the next generation of bunches. In some types of Musa such as plantain, lateral buds are released for growth when the flower bud is initiated in the parent corm. Remember that we said that 11 leaves remain with the stem to emerge when the flower is initiated. Since this is the moment when lateral shoot growth begins, this means that overlap between the growth of the parent stem and the growth of the next generation, called the ratoon crop, is the time for the emergence of 11 leaves and the time for bunch formation. As a result, the interval from the harvest of the first bunch and the harvest of the second bunch may be as short as 180 days (6 months). In other cultivars, the production of new lateral shoots is not closely linked to flower initiation. Lateral shoots may be produced before flower initiation and continue afterwards. Lateral shoots are not usually produced on a parent after its bunch has emerged from the top of the pseudostem.

How do the roots grow?

The root system is equally important for productivity. Bananas and plantains have a root system made up of many, many roots arising from the corm. These cord roots emerge from interior layers of the corm. Secondary roots are much thinner than the primary cord roots. If the growing tip is damaged or cut, lateral root formation can compensate. However, if damage occurs more than 20 cm from the tip, growth ceases and the root even loses the potential to generate secondary roots.

When a sucker is planted, roots already initiated emerge in a first flush and may reach 40 cm before leaves begin to emerge. The next flush of roots is delayed for several weeks. A cord root grows up to 2 cm per day. Once flowering is initiated, new root emergence from the corm stops, although existing roots continue to function. The root system of the mat consists of the roots from the mother stem and the roots being formed by the lateral shoots. Most roots are concentrated in a zone 60 – 100 cm from the base, but often extend beyond 2 meters.

Are bigger bunches enough?

Of equal importance is the number of bunches produced in a given area of land over a given period of time. In addition, we need to know how many plants there are per land area. We also need to know the rate of production. The rate of production depends on the total leaves which a stem produces, the rate of leaf production and the point in the parent plant cycle when the lateral shoot is produced. Some of these factors depend on cultivar, while others are influenced by growing conditions.

Do's and Don'ts in banana cultivation

- In taking suckers from mother plants, gently separate the sucker from the other plant by using a spade or an iron bar to break the tissue that connects the sucker from the mother plant. This "tissue" is found at the sucker's corm. The sucker may survive this "separation" but make sure that the sucker already has its own root system. In some cases, the mother plant is planted deep and sucker separation is often difficult.
- Avoid over watering. Over watering will result in corm rotting and dying.
- When it comes to desuckering dwarf bananas, do not be confused. The very first or the second leaf of the emerging sucker should be narrow, not wide.
- Most bananas require at least 20 months without freezing producing fruit.
- Take care while transplanting/desuckering the mother plant. If this is done incorrectly, the mother or the sucker will die.
- The "Banana Bunchy Top Virus" is one of the most dangerous plant diseases.^[8] Once infected, even a single sucker, all the plants that are connected (including the mother plant and all its suckers) will be infected and all the plants are stunted. The virus is spread by a banana pest called "Banana Aphid" (*Pentalonia nigronervosa*). These pests are slow and live in colonies and they can transmit the disease in hours.
- If the newly planted banana is accidentally damaged (e.g. hit by ball) or if the plant is growing weak, but the plant is still alive, simply cut the plant in half. The banana plant will regrow.
- If you want your bananas to grow organically, don't add chemical fertilizer. Apply compost and/or any organic fertilizer.
- It is advisable to cut off the main flower as soon as the bananas start to sprout. This will lead to healthier and more bigger bananas, as the nutrients that would have been used for the main flower will now be utilized in nourishing the actual fruit.
- Wear old clothes before cutting any part of the banana plant because the sap causes black patches that are very hard to wash out.
- Avoid taking and planting diseased plants from diseased mother plants.
- In areas where Banana Bunchy Top exists, do not share banana suckers with friends. Only buy plants from retailers who can assure the plant is disease-free. It may not be obvious that a plant has Banana Bunchy Top so ensure you don't share plants.
- Irrigation of the plantation should be stopped well in time, preferably a week ahead of the harvest date in order to facilitate efficient movement of labour, harvesting, loading, etc.
- Erection of temporary shades near banana fields is highly recommended so as to store the goods properly. Application of fungicidal paste should be carried out under the shade in order to protect the produce from insects and other infections.
- Bunches selected should be green, three-fourths ripe, whole, free from rubbing, scratching, bruises, sunburns or other blemishes.
- Bunches having malformed fingers, octopus-shaped hands, broken, torn or split fingers, etc. should be rejected.
- The bunch should be cut in one stroke 20 cm to 25 cm above the first band or 7.5 cm to 10 cm from the tip of the fingers of the first hand.

- For carrying bunches to packing shed it is necessary that after 15 minutes of harvest, when the latex flow ceases, the bunches should be taken two at a time on stretchers and should not be allowed to come into contact with soil.

Do's and Don'ts in Tissue Culture Banana Cultivation

No	Parameters	Do's	Don'ts
1.	Study the cultivation practices pamphlet in detail for information and recommendations.		
2.	Soil testing	It's essential to understand the status of major and minor elements for their deficiency / excessiveness and presence of pathogenic fungi / bacteria / nematodes.	Don't cultivate Banana in nutrient deficient and nematode infested field.
3.	Soil type	Sandy loam soil organically rich with pH 6.0 – 7.5 and having good drainage.	Soils exceeding pH 7.5 are not suitable. Addition of decomposed press mud & organic manuring will reduce alkalinity.
4.	Field Manuring	Green manuring followed by dung manuring is very useful for soil conditioning.	Try to avoid planting of banana in the field devoid of organic matter.
5.	Wind shield	Always put a wind shield all around the field preferably of Sesbania (Dhaincha or crotalaria juncea (Sunhemp) plants for maintaining humidity and high velocity wind control.	Don't plant banana plants in the field without wind shield.
6.	Planting	Use Thimet, Furadon and neem cake powder in the pits before planting. Avoid planting during cold weather (below 15°C), extreme summer (above 40°C) or heavy rainy days.	Don't plant Banana plants in the field without application of insecticides and neem cake powder in the pits.
7.	Spacing	For Grand Nain 6 feet x 5 feet spacing has proved ideal. Even 6 feet x 6 feet, 7 feet x 5 feet could also be used considering climate & soil conditions.	Lesser spacing i.e 5 feet x 5 feet or still lower is not advisable for Grand Nain.
8.	Surrounding cultivation	Remove the cucurbitaceous plants such as Smoothguard, Riderguard, Ashguard, Cucumber, Pumpkin etc., Solanaceous plants such as Brinjal, Tomato, Chili etc. Legume crops such as Beans, Moong etc and virus susceptible weeds from the surrounding of the Banana field because these are hosts for viruses. Various aphids, mealy bugs and insects acts as vector in spreading viral diseases in Banana.	Don't cultivate plants of the said families and don't allow virus susceptible weeds to grow in the neighbourhood of Banana plot. Try to refrain Sugarcane and Citrus planted fields in the neighbourhood of Banana plot and also the planting of T.C Banana in Sugarcane fields (previous crop in the field)

9.	Pesticides sprays	Continue intermittent foliar sprays of insecticides, fungicides and soil application of pesticides right from the initial establishment of plants in the field to keep the aphids and insects away.	Don't be irregular in spraying of insecticides otherwise the crop may be affected.
10.	Removal of infected plants	Uproot the diseased (Virus or other) plants along with the suckers and roots, burn them outside the field.	Don't leave any virus infected plant growing in the field otherwise that will serve as an inoculum for the spread of disease.
11.	Irrigation & Fertigation	Always prefer for drip irrigation system and apply liquid fertilizer for better growth of plants. Do optimum irrigation. Apply additional quantity of water during winters to avoid injury from chilled weather.	Don't go for flood irrigation and application of chemical fertilizers from above. Don't let the field dry in cold weather during weather.
12.	Cultural practices	Strictly follow the cultural practices recommended by the company because these have been developed after intensive trials	Do not follow cultural practices other than recommended by the company.
13.	Initial care of plants	Extreme care must be taken for initial three months of planting regarding irrigation, fertigation & pesticides sprays otherwise yield will be affected. Continue the fertigation schedule without fail.	Don't let shortage of fertilizers, pesticides and irrigation for at least initial three to four months of planting.
14.	Desuckering	Keep desuckering on, right from the establishment of plant till harvesting.	Don't allow clusters of baby shoots growing all around the mother plants. It will weaken them and reduce the yield to a high extent.
15.	Weeding	Make weeds removal as a routine practice and keep the field clean in and around.	Weeds should not be allowed to grow in and around the Banana field.
16.	Propping	Prop suitably the plants bearing heavy bunches.	Do not leave plants without prop bearing heavy bunches.
17.	Bunch Protection	Protect the bunches from heat by dry leaf cover and from insects & pests by skirting polybag.	Don't leave the bunches uncovered.
18.	Harvesting	Harvest the bunch and give a top cut to the plant leaving the Pseudostem as such so that the nutrients in it leach down and are available to young plant left for first ratoon (if to be taken).	Don't cut the Pseudostem from base as it is a common practice of the farmers.
19.	Agronomist help	In case of any problem please contact our authorized Agronomist or our dealer in your area.	Do not consult any other person for the hi-tech cultivation practices.

Calendar of Operations

During First month

- The soil around the plants should be pressed firmly for better and quick establishment of the plants.
- Wherever necessary, 'Gap Filling' should be done to replace the un-sprouted as well as rotten suckers. Seeds of green manure crops viz., cowpea or sunnhemp are sown.
- For additional income and also for effective land use efficiency, short duration crops such as onion, green gram, black gram, beans, radish, greens, marigold and short duration vegetables can be grown as intercrop.
- Tomato, chilly and cucurbits should not be grown as intercrop since these crops harbour nematodes and aphids, which act as vector of virus spread.

Second Month

- Green manures viz., cowpea or sunnhemp should be ploughed back in to the soil at flowering stage or about 40 days after sowing.
- Slight digging and earthing up to keep the weeds under control.
- For Fusarium wilt susceptible varieties like Rasthali, Karpuravalli, Ney Poovan, Monthan and Pachanadan, drench the soil around the plant with 0.2% Carbendazim as a prophylactic measure, or
- Apply 30g *Trichoderma viride* or *Pseudomonas fluorescense* along with FYM/compost 1 kg in the soil around the plant as a prophylactic measure for the control of wilt disease.

Third Month

- Application of 40g of Carbofuron to control nematodes.
- Digging and weeding.
- Application of first dose of fertilizers @ 100:300:100 g Urea, Super Phosphate and MOP per plant in basins made about 30 cm away from the plant.

Fourth Month

- Application of Azospirillum and phosphobacteria @ 30 g and *Trichoderma viride* @ 30g along with 5-10 kg FYM plant⁻¹.
- There should be a gap of minimum 2-3 weeks between the application of chemical fertilizers and biofertilizers.
- Periodical removal of side suckers by cutting them above the ground level and pouring 2 ml kerosene at the central core of the sucker.
- If any virus affected plants are noticed in the field, remove and destroy it immediately and spray with any systemic insecticide to kill the insect vectors which spread the virus.

Fifth Month

- Application of second dose of fertilizers @ 150:150 g Urea and MOP+ 300g neemcake per plant in the basins made about 45 cm away from the plant.
- Removal of dried leaves.
- Digging and weeding.
- To cater the micronutrient need of the plant and to correct their deficiency, apply 50g agricultural lime and 25g magnesium sulphate per plant.
- For Fusarium wilt susceptible varieties like Rasthali, Karpuravalli, Ney Poovan, Monthan and Pachanadan drench the soil around the plant with 0.2% Carbendazim as a prophylactic measure.
- To prevent the egg laying and further attack of stem weevil, spray 'Neemosol' @ 12.5ml/litre or Chlorpyrifos @ 2.5ml/litre on the stem especially in Nendran, Red Banana, Karpuravalli and Monthan varieties.

- To monitor the corm and stem weevil, 2 ft long longitudinal stem trap @40 traps/acre can be placed at different places. The collected weevils are to be killed using kerosene.
- Keep the Banana fields as well as surrounding areas weed free and spray systemic insecticides to control the insect vectors.

Sixth Month

- Digging and earthing up of soil around the plant.
- Removal of the dried and diseased leaves and spraying of 0.1% Propiconazol (TILT) by thoroughly covering both the surfaces adding wetting agent with the spray fluid especially during winter and cool months for control of Sigatoka leaf spot diseases.
- Yellowing of leaves which is a symptom of iron deficiency, spray 0.5% ferrous sulphate + 1.0% urea added with wetting agent on the leaves especially in high pH >8.5 and Calcareous soils.
- To correct the deficiency of zinc, spray 0.5% zinc sulphate solution along with wetting agent.
- Foliar application of 0.5 Borax is recommended to correct the deficiency.
- Apply 30g *Trichoderma viride* or *Pseudomonas fluorescense* in the soil around the plant as a prophylactic measure to control the wilt disease.
- For controlling the stem weevil attack, using 'Banana Injector', inject 2ml of Monocrotophos (150 ml Monocrotophos mixed in 350 ml of water) at 2 and 4 feet height on opposite direction.

Seventh Month

- Application of third dose of fertilizers @ 150:150 g Urea and MOP per plant in the basins made about 60 cm away from the plant.
- Removal of the dried and diseased leaves and spraying of 0.1% Carbendazim or Calixin by thoroughly covering both the surfaces along with wetting agent.
- Periodical removal of side suckers by cutting them above the ground level, scoop the core and pour 2 ml kerosene in the core.
- Injection of 2ml of Monocrotophos using 'Banana Injector' at 2 and 4 feet height for the control of stem weevil.

Eighth Month

- After flowering, only one healthy side sucker should be allowed for first ratoon and the remaining suckers should be killed using kerosene or uprooted.
- Spraying of 0.1% Indofil by thoroughly covering both the surfaces.
- After the emergence of the last hand, the male bud has to be removed leaving about 15 cm stalk from the last hand.
- To prevent 'cigar end rot' disease, remove the pistil and perianth carefully from the fully emerged fingers and spray the bunch with Indofil M-45 @ 2.5 ml/litre.
- Spray 2% Potassium Sulphate (20g/litre of water) solution with surfactant by thoroughly drenching the bunch and cover the bunch with 100 gauge thick white or blue polythene sleeves having 6%ventilation.

Ninth Month:

- Thirty days after the first spray, give a second spray of 2% Potassium Sulphate (20g/litre of water) solution with surfactant by thoroughly drenching the bunch.
- Provide casuarina pole or bamboo support to the plants for tall and heavy bearing bunches.

Contingency Problems

Overcoming soil sodicity problem in Banana

- Due to salinity and sodicity of soil, the Banana plants may suffer from marginal chlorosis and necrosis of older leaves, lesser proliferation of roots and an yield reduction by about 30%. This problem may be rectified by applying 0.5 kg of gypsum + 15 kg of FYM along with 120 % recommended potassium per plant. The water drainage facility of the land should be improved to leach down the excess sodium and salts.

Overcoming flood damage in Banana

- Open deep trenches between the plant rows for improving the drainage condition of the land.
- Give foliar spray of 2% potassium sulphate. After 15 days, give another foliar spray of 1% potassium nitrate.
- At the bunch development stage, give 2% potassium sulphate spray on bunch, two times with 15 day interval.
- During flood, the possibility of outbreak of Sigatoka leaf spot is more. As a prophylactic measure, give 0.1 per cent Propiconazole, 0.2 per cent Carbendazim and 0.25 per cent Mancozeb foliar sprays with 15 day intervals between each spray.

Overcoming wind damage in Banana

Banana crop cannot tolerate the wind speed of even 30 km/hr. Banana being a shallow rooted crop requires proper propping with bamboo or casurina poles to avoid lodging during windy seasons. The supporting poles should be tied against the peduncle of developing bunches, so that it protects the plant from lodging during windy seasons and bears whole weight of developing bunch.

Overcoming the stem weevil problem

- The appearance of small holes and oozing out of gummy substances and fecal matter reveals the presence of stem weevil damage in Banana.
- Give Monochrotophos (150ml monochrotophos + 350ml water) injection.
- If ratooning is adopted, remove and destroy the mother plants after bunch harvest.

Overcoming the chilling injury during winter

- Banana growing regions, where the night temperature is below 5°C during winter, protection of bunches with 100 gauge polythene sleeves of 6% ventilation is very essential.

Overcoming the Erwinia rot

- During summer, high soil temperature injures the pseudostem tissues, which are in touch with soil. Through these injuries, Erwinia bacteria may enter the plant and cause rotting.
- To avoid this, drench the soil around the plant with 2% bleaching powder solution.

Overcoming the Wilt disease

- The varieties like Karpuravalli, Rasthali, Ney Poovan and Monthan are susceptible to Panama Wilt.
- The soil around the wilt-affected plant should be drenched with 2% carbendazim solution. Or cabendazim filled gelatin capsule should be applied into the corm.
- The affected plant should be uprooted and destroyed out of the field. After uprooting, about 3kg of lime should be applied to the soil.
- The implements used in affected plants should be disinfected by spirit before using them in healthy plants.

Contingency plan against natural calamities - Drought

- The water scarcity situation during summer months could be overcome by adopting drip irrigation.
- Use of plant waste mulches viz., Banana leaf mulches, sugarcane trashes, paddy straw

mulches around the plants conserves soil moisture and also promotes production of more feeder roots.

Protecting the peduncle from sun scorching

The fruit peduncle on exposure to sunlight suffers from sun scorching, which subsequently makes entry for pathogens that leads to rotting, poor uneven finger filling and ultimately breaking of the peduncle along with the bunch. Hence, the peduncle should be fully covered using the 'boot leaf' that emerges just before the bunch.

Propping / giving mechanical support to the plants against the wind

By giving 'Double pole support' using bamboo or casuarina poles, the plants can be protected from uprooting by heavy winds during the hot months (April/May) or during summer showers locally called as 'Chiththirai chuli' and during monsoon winds.

Pesticides and fertilizers

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Video link:

https://www.youtube.com/watch?v=m_iZAIJG13A