ABC

Agrobiotechnology (P) Ltd.

Banana Scientific Agronomy

Disclaimer

Banana Agronomy

The banana plant is a large perennial herb with leaf sheaths that form trunk-like pseudo stems. The plant has 8 - 12 leaves that are up to 270 cm long and 60 cm wide. Root development may be extensive in loose soils, in some cases up to 9 m laterally. Plant height, bunch size and various other characteristics depend on the variety. Flower development is initiated from the underground true stem (corm) 8 - 9 months after planting. The inflorescence (flower stalk) grows through the center of the pseudo stem. Flowers develop in clusters ("hands") spirally around the main axis. In most cultivars, the female flowers are followed by a few "hands" of neuter flowers that have aborted ovaries and stamens. The neuter flowers are followed at the terminal ends by male flowers enclosed in bracts. The male flowers have functional stamens but aborted ovaries. Fruits mature in about 60 - 90 days after flowers appearance. Each bunch of fruits consists of variable numbers of "hands" along a central stem. Each "hand" consists of two transverse rows of fruits ("fingers").The fruit quality is determined by size (finger length and thickness), evenness of ripening, absence of blemishes and defects, and the arrangement of the clusters. Quality standards may differ in various markets.

Soil type

Bananas grow well over a wide range of soils. The ideal soil should be well drained but have good water retention capacity. Soil pH should be between 5.5 and 6.5. Soil must not be compact.

Field Preparation :
Plough the field 2- 4 times, prior to planting banana, grow the green manuring crop like daincha, cowpea, the green manuring plants should be ploughed in to the soil 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 levelled by passing a blade harrow or laser leveller. Land levelling through Laser Leveller is one such proven technology that is highly useful in conservation of irrigation water. Laser land levelling is levelling the field within certain degree of desired slope using a guided laser beam throughout the field. By using laser leveller, the land looks levelled 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 60cm x 60cm x 60 cm is normally required. The pits are to be refilled with top soil 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 and soil borne pathogens and also aid 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 perlite 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.

Varieties

The Cavendish group banana varieties are the most popular dessert banana in India, which includes 'Williams', 'Grand Naine' and many superior selections like ABC Jumbo, ABC Hanuman and ABC Vaman. Starchy cooking bananas, or plantains, are also grown in some places.

Climate

Bananas grow best in areas with 2,500 mm or more of well-distributed rainfall per year. Irrigation is needed if rainfall is inadequate or irregular. Average temperature of 27°C (81°F) and full sun are also beneficial for optimum plant development and yields. The optimum conditions for ripening bananas are at temperatures of 20-21°C (68-70°F) and 90% relative humidity. As the fruit ripens, internal starch gradually turns into sugar.

Irrigation

Water is probably the most limiting a-biotic factor in banana production. The stringent water requirements of this crop can be evenly satisfied by effective rainfall and by irrigation. The use of these two sources varies widely throughout the world. Banana is a plant with a rapid growth rate, high consumption of water, shallow and spreading roots distribution, roots with weak penetration strength into the soil, poor ability to draw water from drying soil, low resistance to drought, and rapid physiological response to soil water deficit. These factors indicate that banana is sensitive to even slight variations in soil water content and that irrigation scheduling is critical. The water holding capacity of the soil, effective rooting depth of the plant, and the depletion percentage of total available water allowed before irrigation, determine the amount of water to apply, while crop coefficient together with the evapotranspiration data determine the irrigation interval.

Water Requirement			
Month	**Water Req. Lit/Day/Plant**	**Month**	**Water req. Lit/Day/Plant**
June	**5-6**	**October**	**4-6**
July	**4-5**	**November**	**4-6**
August	**5-6**	**December**	**4-6**
September	**6-8**	**January**	**8-10**
October	**10-12**	**February**	**10-12**
November	**8-10**	**March**	**16-18**
December	**6-8**	**April**	**18-20**
January	**10-12**	**May**	**20-22**
February	**12-14**	**June**	**20-22**
March	**16-18**	**July**	**10-12**
April	**20-22**	**August**	**12-14**
May	**25-30**	**September**	**14-16**

Planting density and expected yield

Planting density depends on the banana varieties planted and the management practices. The number of suckers developing should be kept to a maximum of 4 or 5 per plant, depending on planting distance and other practices. Yields 60 – 90 ton/ha can normally be obtained for the 'Cavendish' varieties. Yields of 120 ton/ha have been reported under optimal conditions.

System of Planting	Planting Distance	Plant Population Per Acre
Paired Row	1.2 x 1.2 x 2.00 m	2080
Square System	1.8 x 1.8 m	1210
Triangular System	1.5 x 1.18 m	1452
2 Plants/Hill	1.8 x 3.6 m	1280
3 Plants/Hill	1.8 x 3.6 m	1920

Method of planting

-- **Pit Method**
-- **Furrow Method**

Pit Method

-- Pit planting is commonly followed in garden land system of cultivation. Pits of 60 cm x 60 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. Tissue Culture plants are planted in the center of the pit and soil around is compacted.
-- Planting is done during June -July-August.
-- However this method is very labourious and expensive. The only advantage is that no earthing up is required as planting is done at the required depth.

Furrow Method

-- 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 practice in annual panting system. In this method earthing up needs to be frequently done to cover the exposed rhizomes.

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.

Nutrient Management

Low soil fertility is one of the major constraints to optimum crop growth and yield. Soils fertility can be managed by fertilization, but the grower must be fully aware of his nutrient problem(s) in order to arrive at the right decisions regarding the kind and rates of fertilizers to be applied. Numerous diagnostic techniques used in evaluating soil nutrient status and determining fertilizer requirement of the crop viz. nutrient deficiency symptoms, field and pot experiments, soil testing, and plant analysis Banana yield and quality improvement due to balanced fertilization has been well documented. Information on improving fruit storage quality and the storage properties of banana fruit through proper nutrient use is also crucial since large quantities of fruit are sold in remote markets.

Plant Nutrition can be broadly classified in to Macro and Micro nutrients, both macro and micronutrients are essential for plant growth. Macronutrients are those elements needed in large amounts by the crop, and large quantities have to be applied if the soil is deficient in one or more of them. Nitrogen (N), Phosphorus (P) and Potassium (K) are the 'primary macronutrients' and these form the basis of NPK fertilizer compounds. The 'secondary macronutrients' are Calcium (Ca), Magnesium (Mg) and Sulphur (S).
Micronutrients are those elements required in very small quantities. Despite being needed in small quantities, micronutrients are essential for the overall performance and health of the crop. They include Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Molybdenum (Mo), and Boron (B).

Main functions of plant nutrients

Nutrient	Functions
Nitrogen (N)	Synthesis of proteins (growth and yield).
phosphorus (P)	Cellular division and formation of energetic structures.
Potassium (K)	Transport of sugars, stomata control, cofactor of many enzymes, reduces Susceptibility to plant diseases.
Calcium (Ca)	A major building block in cell walls, and reduces susceptibility to diseases.
Sulfur (S)	Synthesis of essential amino acids cystin and methionine.
Magnesium (Mg)	Central part of chlorophyll molecule.
Iron (Fe)	Chlorophyll synthesis.
Manganese (Mn)	Necessary in the photosynthesis process.
Boron (B)	Formation of cell wall. Germination and elongation of pollen tube. Participates in the metabolism and transport of sugars.
Zinc (Zn)	Auxins synthesis.
Copper (Cu)	Influences in the metabolism of nitrogen and carbohydrates.
Molybdenum (Mo)	Component of nitrate-reductase and nitrogenase enzymes.

Nitrogen (N)

Nitrogen is one of the primary nutrients absorbed by banana roots, preferably in form of the nitrate (NO_3^-) ion. Nitrogen is a constituent of amino acids, amides, proteins, nucleic acids, nucleotides and coenzymes, hexosamines, etc. This nutrient is equally essential for good cell division, growth and respiration.

-- Nitrogen is the chief promoter of growth. It induces the vegetative growth of the pseudostem and leaves giving them desirable healthy green color.
-- A healthy robust vegetative frame is an essential pre-requisite for high yields, and nitrogen is mainly responsible for such a vegetative frame. Banana plants, poorly nurtured with N, produce only seven leaves versus 17 leaves produced by banana plants supplied with adequate N.
-- If N is deficient in bananas the leaves take 23 days for unfolding versus 10 days for the leaves of banana supplied with adequate N.
-- Nitrogen deficiency causes slow growth and paler leaves with reduced leaf area and rate of leaf production. N positively influences the longitudinal growth of petioles.
-- It was observed that the greater the number of large, healthy leaves, produced during the first 4-6 months, the larger will be the size of the fruit bunch.
-- Nitrogen increases the bunch grade, and sucker production.
-- Lack of N produces thin, short and compressed leaf petioles, thin and profuse roots, and lesser number of suckers. Phosphorus uptake is higher due to N deficiency.

Deficiency	Poor vegetative growth
Optimal N Rate	High content of dry matter Larger bunches are produced at optimal N : K ratio
Excess	Bunch break before maturation

Deficiency Symptoms:

Typical symptoms of nitrogen deficiency in banana are general yellowing of leaves, rose colored tints on petioles and leaf sheaths, stunting, rosetting, slender pseudo stem, small petioles and leaves, and reduced life span of leaves. Banana is more sensitive to a lack of nitrogen than any other element and Nitrogen deficiency causes notable reduction in yield.

Nitrogen deficiency symptoms:
Petioles turn pink to violet, and distance between them becomes extremely short

Severe nitrogen deficiency symptom on banana petioles

Severe nitrogen deficiency
Symptoms in banana

Severe nitrogen deficiency
Symptoms in banana

Potassium (K)

Due to the very high K contents in the banana fruit and leaves K is considered the most important plant nutrient in banana production. The amount of K taken up from the soil and removed from the field in harvested bunches is very high. Estimated annual soil losses through fruit removal alone can be 400 kg of elemental K(equivalent to 480 kg of K2O) per ha with a production of 70 tons of fruit. For this reason, banana requires a good K supply, even in soils where K levels are considered high.

Function:

Potassium is required as a cofactor for over 40 enzymes. It has a role in stomatal movements by maintaining electro-neutrality in plant cells. It is required for many other physiological functions, such as formation of sugars and starch, synthesis of proteins, normal cell division and growth, neutralization of organic acids, involvement in enzymatic reactions, regulating carbon dioxide supply by control of stomatal opening and improving efficiency of sugar use, increasing plant resistance to biotic and abiotic stresses, such as frost tolerance by decreasing the osmotic potential of cell sap due to higher ratio of unsaturated/saturated fatty acid, drought tolerance, regulation of internal water balance and turgidity, regulating Na influx and/or efflux at the plasmalema of root cells, chloride exclusion through selectivity of fibrous roots for K over Na, and imparting salt tolerance to cells by increasing K holding capacity in the vacuole against leakage when Na incurred in external medium. Potassium does not play a direct role in the plant's cell structure, but it is fundamental because it catalyzes important reactions such as respiration, photosynthesis, chlorophyll formation, and water regulation. The role of K in the transport and accumulation of sugars inside the plant is particularly important since these processes allow fruit fill and, therefore, yield increase.

Potassium improves yield

K_2O rate (g/plant)	Bunch weight (kg)	Hands/Bunch	Fingers/Bunch
400	25.00	12.4	217
600	26.7	12.8	220
800	29	13.2	225
1000	29.4	13.9	226

The effect of K on yield** - (Cv. Grand Naine)

Dynamics of K Uptake:

-- Intensive K uptake in first vegetative phase
-- Overall decrease of K concentration in plant from sucker to fruit
-- High K in soil allows large uptake also at latter phase
-- K uptake is levelling off after bunch emergence
-- Low K supply, limits transfer of mineral nutrients (N, P, Ca, Mg, Cu, Zn) in xylem
-- Low K supply, limits transfer of carbohydrates

Deficiency Symptoms: Potassium deficiency symptoms in banana are quickly evident when it is not continuously applied under intensive banana cultivation. Classic symptoms of K deficiency are:

Leaves

-- Chlorosis of the leaves: The most characteristic symptom of plants lacking in K is the yellowing of the tip of the older leaves. Yellowing and necrosis spread rapidly towards the leaf base, until the whole leaf has withered standing in a normal position.

--- Rapid yellowing of oldest leaves, which then turn orange and dry-up; leaves may become tattered and fold downward, leaves are crumpled in appearance Splits develop parallel to the secondary veins and the lamina folds downwards, while the midrib bends and fractures, leaving the distal half of the leaf hanging.

Mild potassium deficiency:
Old leaves become yellow-orange

Moderate potassium deficiency:
Necrosis starts at leaf margins

Severe potassium deficiency:
Necrotic stripes reach leaf midrib

Extreme potassium deficiency: most of the leaf desiccates and typical curling starts. As time progresses, leaves curl inward and die soon after.

Phosphorus (P)

Function:

Phosphorus helps to produce healthy rhizome and a strong root system. It also influences flower setting and general vegetative growth. It is one of the three primary nutrients and is absorbed by banana roots mainly in the form of orthophosphate ($H_2PO_4^-$). It is a component of sugar-phosphates, nucleic acids, nucleotides, coenzymes, phospholipids, phytic acid, and more. It plays a key role in reactions involving ATP. This element is necessary for many life processes such as photosynthesis, metabolism of carbohydrates, and the transfer of energy within the plant. It helps plants store and use energy from photosynthesis, develop roots, speed-up the maturity, and resist stresses.

Deficiency Symptoms:

Phosphorus deficiency symptoms show on the old leaves as chlorosis of their margins. Purplish brown flecks develop there as well. With severe deficiency, the affected leaves curl, the petioles break, and the younger leaves have a deep green color. P deficiency causes complete cessation of elongation, at a height of about two feet rosetting of leaves with older leaves becoming increasingly irregularly necrotic, leaf production is reduced and marginal chlorosis and in severe cas es premature death follows.

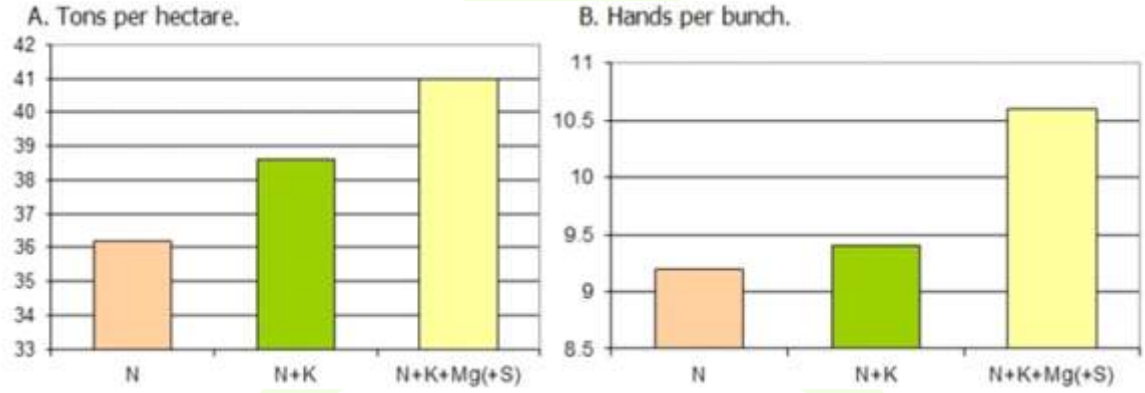
Severe phosphorus deficiency symptoms on banana laminae, Laminae edges become necrotic

Magnesium (Mg)

Function:

Magnesium is a secondary macronutrient absorbed as Mg_2^+. Magnesium is a crucial constituent of the chlorophyll molecule. It is required, nonspecifically by a large number of enzymes involved in phosphate transfer. It is involved in photosynthesis, carbohydrate metabolism, synthesis of nucleic acids, related to movement of carbohydrates from leaves to upper parts and stimulates P uptake and transport, in addition to being an activator of several enzymes.

The effect of magnesium on banana yield.



A. Tons per hectare. B. Hands per bunch.
N: 276 kg/ha, K2O: 585 kg/ha, MgO: 122 kg/ha (+ S: 96 kg/ha)

Deficiency Symptoms:

Magnesium deficiency is expressed by yellowish chlorosis of the central zone of the lamina while the margins and midrib area remain green, other symptoms are purple mottling of the petioles and separation of leaf sheaths from the pseudo stem.

Deficiency:

-- Common in bananas
-- Occurs in old plantations which have had little Mg applied or where excessive potassium is applied
-- Bluish - purple mottling of petioles ('blue sickness')
-- Separation of leaf sheath from stem

Result

- Lower yields
- Poor plant growth
- Poor uptake of potassium and calcium

Magnesium deficiency symptoms

Calcium (Ca)

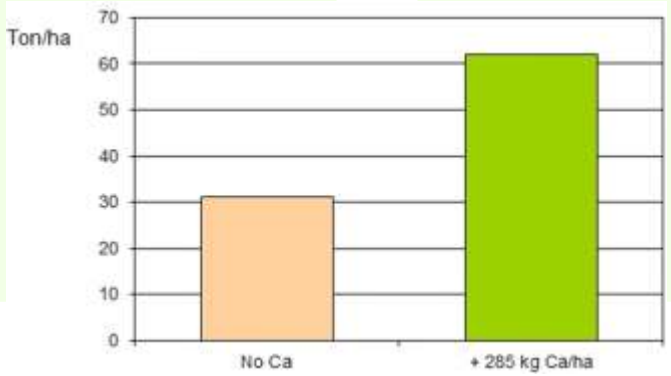
Function:

Calcium is another secondary plant nutrient, absorbed by plant roots as Ca_2^+. Calcium is a constituent of the middle lamella of cell walls as Ca-pectate. Calcium is required as a cofactor by some enzymes involved in the hydrolysis of ATP and phospholipids. It is an important element for root development and functioning; a constituent of cell walls, and is required for chromosome flexibility and cell division. Calcium deficiency is a widespread problem in banana crops and significantly reduces fruit quality. Moisture stress is the major cause of calcium deficiency as it interrupts the root uptake of calcium and leads to localized deficiencies in fruit. Boron is required for the maintenance of transpiration(water uptake) and therefore also calcium uptake. Over-use of nitrogen fertilizers and excessive plant vigour also compound calcium deficiencies. Calcium and boron are also essential for plant strength and therefore deficient plants are more likely to suffer from fungal diseases and environmental stresses. Calcium deficiencies are common in both acid and alkaline soils even when exchangeable soil calcium levels are high. This is largely due to the low mobility of soil calcium and competition with other nutrients such as ammonium nitrogen, potassium and magnesium.

Calcium deficiency caused by:

-- Low transpiration – e.g. at high humidity
-- Fruit has a low transpiration rate:
-- Reduced Ca uptake in maturating fruits may result in Ca deficiency
-- Maturity spots of banana (e.g. aggravated by plastic bags on bunch)
-- Rapid leaf growth may cause a Ca shortage
-- Cold winters in subtropics
-- Imbalances with K and Mg
-- High rates of K, Mg or NH4+ will reduce Ca availability
-- Optimum Ca uptake at soil Ca:(K+Ca+Mg) ratio of 0.7

The effect of calcium application on banana yield



N rate: 200 kg /ha, K rate: 498 kg/ha

Deficiency Symptoms

Typical symptoms indicating calcium deficiency in banana are general dwarfing, reduced leaf length, reduced rate of leaf emission; leaves are undulated; tissue near midrib thickens, may turn reddish-brown. In sub-tropical growing areas, calcium deficiency generally appears in early summer after spring flush. It reveals as typical chlorosis and necrosis and “Spike-Leaf’ in severe cases.

Leaf:

-- The symptoms are found on the youngest leaves causes the spike leaf in which the lamina in new leaves is deformed
-- Inter veinal chlorosis near leaf margins
-- Creates ‘spike leaf’ appearance where lamina of new leaves is deformed or absent
-- Symptoms appear in after a flush of growth or where high levels of potassium are applied

Plant:

-- It causes heart rot to newly planted tissue culture plantlets.

Fruit:

-- Peel splits when fruit ripe
-- Fruit curls – scratching others in bunch
-- Fruit weight and diameter is reduced
-- The fruit quality is inferior and the peel splits during the ripening.

Early foliar symptoms (yellow stripes parallel to leaf midrib)

Severe Calcium deficiency

Sulfur (S)

Function:

Sulfur is also a secondary plant nutrient essential for protein formation as a constituent of the three amino-acids cystine, cysteine and methionine. Sulfur is required for the formation of chlorophyll and for the activity of ATP - sulfurylase. These essential functions permit the production of healthy and productive plants, which are a pre condition for high yields and superior quality.

Deficiency Symptoms:

Leaves are chlorotic and reduced in size, with a thickening of secondary veins; undulating leaf edges, necrosis along edge of lower leaves. Sulfur deficiency is rare, as sulfur is often supplied with fertilizers containing sulfur:$(NH_4)_2SO_4$, Super phosphate or $MgSO_4$

Leaf:

-- Symptoms appear in young leaves
-- Leaves become yellowish-white
-- If severe, necrotic patches appear in the leaf margins
-- Leaf veins are thickened

Fruit:

-- Bunches are small or 'choked'
-- Yields may be reduced

Sulfur deficiency -Yellowing of the entire lamina

Micro-nutrients

The availability of micro-nutrients is markedly influenced by soil pH

-- Above pH 7 there is a clear reduction in the uptake of Fe, Mn and Zn
-- Below pH 5 there is a clear reduction in the uptake of Mo and P and an increase in the uptake of Mn and Al
.-- High Na and Mg contents in soil reduce uptake of micro-nutrients

Boron (B)

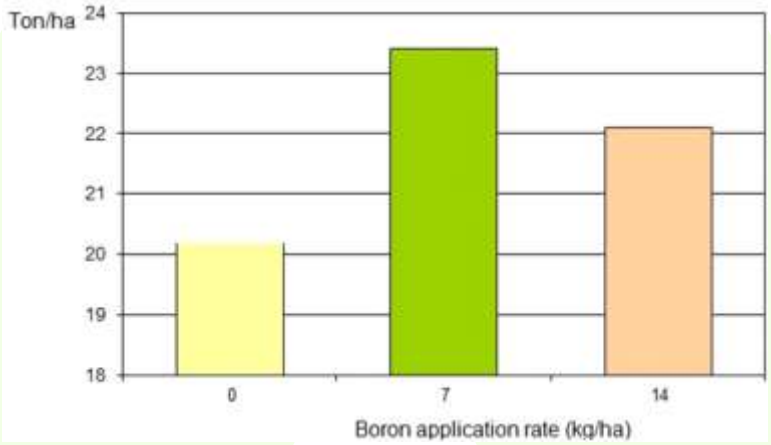
Function :

Boron deficiencies occur on a wide variety of soils, however, boron availability reduces as pH increases. Boron is essential for flowering, fruit set and the translocation of sugars. Boron is required for calcium uptake and movement, and calcium deficiencies can be significantly reduced by boron application. Boron plays a similar role to calcium in plant nutrition, which makes it essential for quality factors such as skin strength, fruit firmness and storage life. Because boron is required for root development and plant strength, deficiencies often increase the likelihood of fungal diseases and reduce the plant's tolerance to various environmental stresses.

Boron deficiency symptoms:

-- Curling and deformation of leaf
-- White strips perpendicular to veins on underside of lamina
-- Uptake rate in field is constant from sucker to harvest – 40 mg/plant/month

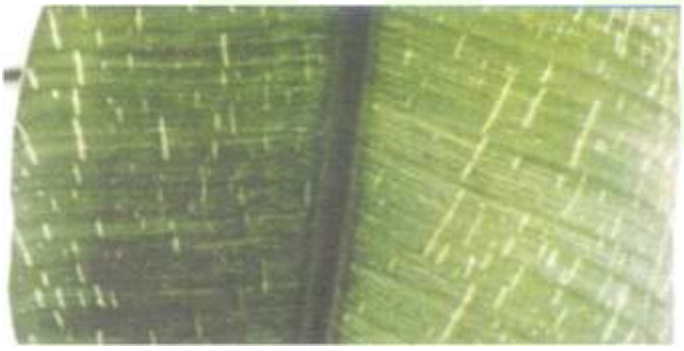
Effect of various Boron rates on yield



Planting density:3000 plants/ha
Fertilization [kg/ha]: N 224, P 35, K 336, Mg 62, Zn 24

Boron deficiency symptoms includes chlorotic streaking of leaves, oriented perpendicular to and crossing the primary veins , leaf malformation inter veinal chlorosis. This deficiency can develop slowly over time. Boron deficiency may results in reduction in weight and size of the bunch and in proper filling of the individual fruit units.

Boron deficiency - whitish parallel streaking of the entire width of central part of the leaf.



Boron deficiency – deformed foliage

Iron (Fe)

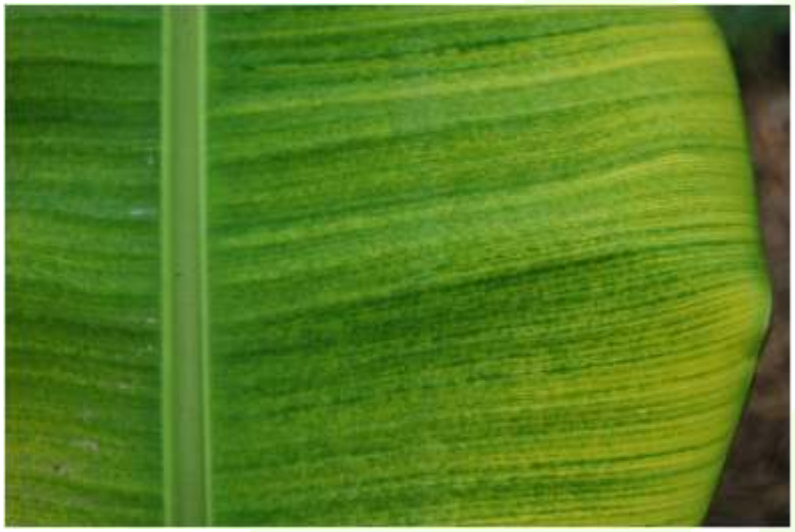
Function:

Iron is a constituent of cytochromes, non haeme iron proteins, it is involved in photosynthesis, and N_2 fixation and respiratory linked dehydrogenases. Iron is also involved in the reduction in nitrates and sulfates, and in reduction processes by peroxidase and adolase. Total amount of iron uptake by healthy plants is only about 1-3 g. 80% of this is absorbed during the first half of plant's life.

Deficiency Symptoms:

General chlorosis of entire lamina mainly of young leaves; retarded plant growth; small bunches. Leaf color becomes yellow-white.Iron deficiency is mainly observed on calcareous soils.

-- Soils with high water tables
-- Soils with high Manganese



Iron deficiency symptoms

Manganese (Mn)

Function:

Manganese is one of the micronutrients, absorbed by the plant roots in the form of Mn_2+.It is required for the activity of dehydrogenases, decarboxylases, kinases, oxidases, peroxidases, and non-specifically by other divalent cation activated enzymes. It is required for photosynthetic evolution of O_2, besides involvement in production of amino acid and proteins manganese has equally strong role in photosynthesis, chlorophyll formation and nitrate reduction. A metalloenzymeperoxidase concentration is considered to be the marker of Mn deficiency.

Deficiency Symptoms:

Manganese deficiency at its mild form is expressed as "comb-tooth"chlorosis, which starts on the leaf margins and spreads along the veins towards the midrib of the leaf with occasional narrow green edge. Chlorosis first appears on second or third youngest leaf.

Manganese deficiency symptoms.

Toxicity:
Manganese toxicity is a known problem in acid soils. In severe cases, leaf Mn levels may reach 6000 ppm. High Mn levels reduce calcium uptake by 30%, magnesium uptake by 40% and zinc uptake by 20%, and may enhance the occurrence of disorder known as 'mixed ripe'.

Zinc (Zn)

Function:
It is an essential constituent of alcohol dehydrogenase, glutamic dehydrogenase, lacticdehydrogenase, carbonic anhydrase (regulating carbon dioxide metabolism), alkaline phosphatase, carboxypeptidase, and other enzymes such as dehydropeptidase and glycylglycinedipeptidase active in protein metabolism. It also regulates water relations, enhances cell membrane integrity, and stabilizes sulflahydryl groups in membrane proteins involved in ion transport. Under low Zn availability bunch mass will quadruple in response to increasing Zn rate. At high concentration Zn features low mobility rate in the phloem from the leaves to the fruits.

Deficiency Symptoms:
Zinc deficiency is a very common problem in banana, observed in all growth regions. It is more common on young plants with no mother plant to act as a nutrient reservoir. Symptoms may appear in one year without affecting yield, but reduce fruit yield in second or third year. Zinc deficiency is found in banana when it grows in zinc-deficient soils, symptoms may be severe mainly in sandy soils and on high pH soils due to fixation, or on weathered, acidic soils, were Zinc content is low. Zinc may leach under acidic conditions. Also, zinc is inactivated at high concentrations of phosphorus in the soil.

In leaf:
-- Leaves become narrow
-- Yellow to white strips appear between the secondary veins
-- Oblong brown necrotic patches appear in the yellow stripes
-- It shows as narrow pointed and chlorotic young leaves, strap-shaped leaves, leaf chlorosis in strips or patches. A zinc deficient leaf is significantly smaller in size than a normal leaf and high concentration of anthocyanin pigmentation is developing on its lower side.

Suckers:
-- Become very thin
-- Bunches have small twisted fingers
-- Bananas have a characteristic light green tip
-- Plant growth shows stunting and rosetting.

Zinc Deficiency symptoms

Copper (Cu)

Function:

Copper plays an active role in enzyme performing key functions like respiration and photosynthesis, and Cu-proteins have been implicated in lignification, anaerobic metabolism, cellular defense mechanism, and hormonal metabolism. Known forms of Cu in the plants comprise cytochrome oxidase, diamine oxidase, ascorbateoxidate, phenolase, leccase, plastocyanin, proteinhaving ribulosebiphosphate carboxylase activity, ribulosebiophosphateoxygenase activity, superoxide, dismutase, plant acyanin, and quinol oxidase. Copper proteins exhibit electron transfer and oxidase activity. Copper is also a constituent of cytochrome oxidase and heme in equal proportions. It also acts as a terminal electron acceptor of the mitochondrial oxidative pathway.

Deficiency Symptoms :

Midrib and main veins bend backwards giving plant an umbrella appearance. Leaves turn a yellow bronze color. Cu toxicity is possible, in particular where Bordeaux mixture is still in use for plant protection.

Salt sensitivity

High salt levels in soil or water can cause stress. Salinity stress results in marginal leaf chlorosis, stunted growth and thin, deformed fruits. Dessert bananas of AAA type (e.g. Cavendish) are more sensitive than plantains(AAB/ABB types).100-500 ppm total soluble salts in soil is satisfactory with banana growth. At levels of 500-1000 ppm, plants and fruits are visibly affected. When total concentration of soluble salts exceeds 1000 ppm, plants are stunted or dead. Sodium and Chlorine are not considered essential nutrients for banana growth Bananas seem to be more sensitive to Na than to Cl. (E.g. bananas still grow at up to 600ppm Cl in irrigation water). At high Na levels, Na contents in roots can rise up to 1.5% (3 x normal value), especially when K is deficient. Excessive Na causes nutrient imbalances- Na (or Mg) present at high amounts in irrigation water, reduce K uptake, even if soils contain high K levels. High Na and Mg also reduce uptake of micronutrients. When Cl is excessive sucker growth is restricted and fruit will not fill.

Fertilization recommendations

Banana plants need fertile soil and an abundance of soil moisture for best growth and production. The development rate the plant makes in its first 3-4 months determines the weight of the bunch and the number of hands. Consequently, it is essential to provide the best care during this period.

Placement : Soluble potassium, phosphorus and nitrogen fertilizers can be made easily available to the roots after planting. Application can be done in various forms:
1) Soil application broadcast or localized- Since banana roots quickly ramify away from the pseudo stem, fertilizers should be rather broadcast than concentrated around the pseudo stem.
2) Fertigation - Fertigation (fertilizer placement via irrigation) is most efficient since nutrients are applied directly to the root zone.

Timing - Fertilizing schedule should coincide with climatic conditions and phenological stages of the crop.

Frequency- Frequent applications are especially important where the soil is light and lacking in fertility and when rainfall is heavy. Because of its limited mobility in the soil, P fertilizers should be applied once or twice annually. N, K fertilizers are normally applied at short intervals via the irrigation system. In humid tropics, intensive leaching due to extremely heavy showers dictates immediate fertilization via soil application in order to compensate for leaching losses. Application frequency can be reduced significantly when controlled-release fertilizers used. By using controlled-release fertilizers less leaching of plant nutrients, if any, will occur and less applications are required.

Nutrients uptake/removal

Uptake of macro nutrients is in the following mass order:
Potassium (K) > Nitrogen (N) > Calcium (Ca) > Magnesium (Mg) > Phosphorus (P)

Uptake of micronutrients is in the following mass order:
Manganese (Mn) > Iron (Fe) > Boron (B) > Zinc (Zn) > Copper (Cu).

N, P, K, Mg, and Cu have a high re-translocation rate compared to other nutrients.

Nutrient removal by banana plants (cv. Cavendish)*

Nutrients	Removal in Fruits (kg/ha)	Removal in pseudo stem (kg/ha)	Total (Kg/ha)	Share of Removal in Fruits %
N	189	199	388	49
P	29	23	52	56
K	778	660	1438	54
Ca	101	126	227	34
Mg	49	76	125	39

* 50 ton/ ha of fresh fruit @ 2000 plants / ha

N:K ratio

Critical leaf N:K ratio for optimum yields varies between 1:1 and 1:1.6, depending on method for leaf analysis.

Low N:K ratio results in:

-- "Finger Drop" (Dégrain) – a post-harvest problem of ripe banana bunches, called Finger Drop occurs during hot, wet seasons in tropics, if K supply is low, so that NH_4^+ accumulates.
-- Delay in bunch emergence
-- Widely spread hands, easily damaged during transport
-- Fruit pedicles are fragile and when ripe, fruit fall from the bunch
-- Reduced wind resistance

Nutrients demand

Nutrient management according to nutrient uptake and removal – general recommendation:
The nutrient uptake of the whole mats is a base for fertilizer application, only when fertilizing the first crop. For ratoon crops, crop residues of the previous crops, like leaf trash and cut pseudo stems supply additional nutrients – less fertilizer is needed. Nutrient losses from fertilizers and trash have to be considered for calculating fertilizer rates for plant and ratoon crops. Split application of fertilizers reduce nutrient losses, in particular, N and K losses can be high.

Removal of plant nutrients in the harvested banana fruit is one of the major considerations in formulating fertilizer recommendations. The quantities of plant nutrients contained in the whole plant and in the fresh fruit harvested and removed from the field, are the basis for scheduling the fertilization program. The large amounts of K reflect the high K content in the fruit. When the previous crop is being left in the field, the contribution of recycled plant nutrients should be taken.

Summary of Nutrient uptake – N, P, K

Nitrogen

-- Constant need for N throughout the growth period

Phosphorous

-- Constant need for small P amounts throughout the growth period

Potassium

-- Constant need for K throughout the growth period

80% of K application should be done before peak flowering, smaller K rates at early stages, increased K rates in month before and after flowering.

Magnesium

-- Constant need for small Mg amounts throughout the growth period.

Calcium

-- Main Ca uptake until shooting. No net Ca uptake into bunch after shooting
Ca application for fruit production should focus on periods before shooting.

Sulfur

-- The most rapid S uptake occurs from plants to shooting stage. After shooting the uptake rate is reduced.

Fertigation Schedule for Banana(Water Soluble Fertilizer) (Plants/Acre – 1249 – 1498)

Days After Planting	Fertilizer Grade	Qty./Kg/Day/Acre	Total Qty. (Kg)
35-60	19:19:19	1.00	25
	Urea	2.00	50
	Ammonium Sulphate	4.00	100
	Magnesium Sulphate ($MgSO_4$)	2.00	50
61- 135	12:61:00	0.750	50
	Urea	2.00	150
	13:00:45	0.25	20
	Muriate of Potash (MOP)	1.00	75
	Magnesium Sulphate ($MgSO_4$)	1.00	75
136 - 185	0: 52: 34	0.5	25
	Phosphoric Acid	0.250	13
	Urea	2.00	100
	13:00:45	0.5	25
	Magnesium Sulphate ($MgSO_4$)	1.00	50
186 - 285	13: 00: 45	2.00	200
	Muriate of Potash (MOP) (White)	1.00	100

Note:
Apply Boron 10 Gms/Plant at the time pit filling. Apply 12% of Zinc EDTA 500 Gms/Acre through Drip irrigation at 60 days of crop. If Iron deficiency noticed spray of 5 gm/L water of Ferrous sulphate should be done.

Fertigation Schedule (Conventional Fertilizers)
(Plants/Acre – 1249 – 1498)

Days After Planting	Fertilizer	Quantity/ Plant (Gms/Plant)	Quantity/Acre and Fertigation Rate
Basal Dose	Single Super Phosphate (SSP) Muriate of Potash (MOP)	125 105	181.5 152.5
30 Days **75 Days**	Urea Urea Single Super Phosphate (SSP)	62 62 125	90 (3 kgs/Day) 90 (3 kgs/Day) 181.5
125 Days	Urea Single Super Phosphate (SSP)	62 125	90 (3 kgs/Day) 181.5
165 Days	Urea Muriate of Potash (MOP)	62 105	90 (3 kgs/Day) 152.5 (5 kgs./Day)
210 Days	Urea	62	90 (3 kgs/Day)
255 Days	Urea Muriate of Potash (MOP)	62 105	90 (3 kgs/Day) 152.5 (5 kgs./Day)
300 Days	Urea Muriate of Potash (MOP)	62 105	90 (6 Kgs/Day) 152.5 (10 Kgs/day)

Note : The basal dose and SSP in the top dressing should be applied directly to the soil

Apply Boron 10 Gms/Plant at the time pit filling

Apply 12% of Zinc EDTA 500 Gms/Acre through Drip irrigation at 60 days of crop.

If Iron deficiency Noticed spray of 5 gm/L water of Ferrous sulphate should be done

Soil salinity area:

In an area that suffers from soil salinity, with plant density: 1249 – 1498 Plants/Acre and expected yield: 37 - 45 MT/ Acre, the fertilization practice is :

Fertilization recommendation in saline areas.

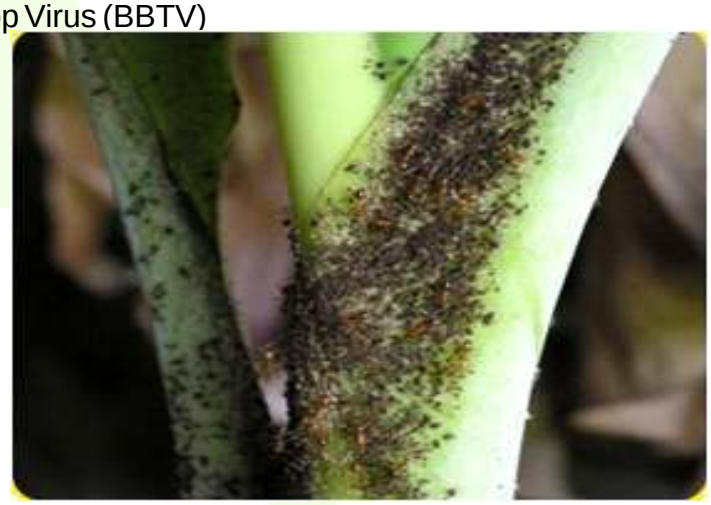
Nutrient Requirement (Kg/Acre)			Recommended Fertilizers (Kg/Acre)		
N	P_2O_5	K_2O	AN	MAP	13:00:46
250-450	70-100	450- 600	610 -110	120-160	850 - 1300

Crop Protection:

Aphids, Pentalonianigronervosa f. typica

Nature of Damage

-- The nymphs and adults congregate under the outer base of the pseudostem
-- Aphids always accompanied by ants, which act as dispersing agents of nymph
-- Honey dew secretion appears on the plants which attracts the ants
-- The aphids suck the sap of the plant and reduce the growth and vigour
-- They also act as a vector of Banana Bunchy Top Virus (BBTV)

Identification of Pest

Nymph : Oval or slightly elongated, reddish brown with six segmented antennae.
Adult : Small to medium sized aphids, shiny, reddish to dark brown or almost black. They have six segmented antennae and prominent dark veins.
Adults start producing young aphids one day after reaching maturity. They can give birth to 4 aphids per day with an average production of 14 offspring per female.


Adult


Nymph

Control Measures

Cultural Control

-- Ensure clean cultivation
-- Use healthy and pest free Tissue Culture Plants
-- Rogue out the affected plants
-- Immersing flowers and foliage in hot water at 49 degrees centigrade for 10 minutes kills banana aphids.
-- Destruction of weeds and alternate hosts.

Chemical Control

-- Spray soapy water or insecticidal soap on plants thoroughly on petioles, furled leaves, whorls or on young suckers
-- Spray Dimethoate (75ml/100lit) or Diazinon (1.5ml/lit) or Acephate (1.3g/lit) on infested plants.
-- Spray Methyl Demeton 25 EC 0.05% or Monocrotophos 36 SL 0.072%
-- Inject Monocrotophos 36 SL 1 ml/plant (1ml diluted in 4 ml of water). Avoid injection of Monocrotophos after flowering

Biological Control

-- Introduction braconid wasps, Lysiphlebiustestaceipes as parasitoid to parasitize the aphids
-- Release predators such as lady bird beetles and lace wings in the field which are very active aphid feeders

Lady bird beetles

Apply bio control agents like entomopathognic fungus, Beauveria bassiana in the banana fields.

Corm Weevil,Cosmopolites sordidus

Nature of damage

-- Newly planted banana fields are easily susceptible to infestation
-- Infestation begins at the base of the outer most leaf-sheath and in injured tissues at the lower part of the pseudo stem.
-- Initially the young grubs make several longitudinal tunnels in the surface tissue until they are able to penetrate to adjacent inner leaf-sheaths
-- Then they bore into the pseudo stem base and rhizome/corm, but also into the base of suckers and into roots.
-- Larval tunnels may run for the entire length of fallen pseudo stems.
-- Infested plant shows yellowing and withering of leaves, slowed plant growth, root destruction, reduced fruit production
-- Young infested suckers often wither and fail to develop.
-- Plants are easily blown down by mild to strong winds.
-- An economic threshold of 3 weevils per cut banana corm or pseudo stem placed in the field overnight will trigger control action

Reduced fruit

Production of Tunneling

Young suckers fail to develop and rotting of corms

Identification of Pest

Egg: Elongate-oval, about 2 to 3 mm long and white in colour. Eggs are laid singly in small cavities that are chewed out by the female in the base of the pseudostem just above ground level, in the upper part of the corm, in roots near the soil surface and at the end of cut stems (stumps). Egg period is 4 to 36 days depending on temperature conditions.

Grub: Creamy white legless grubs, stout and distinctly curved and swollen in the middle of the body. The head is reddish-brown with strong mouthparts. Fully-grown grubs are about 12 mm long. Grub period is 20 to 25 days.

Pupa: White and about 12 mm long. Pupation takes place in holes bored by the grubs. Pupal period is 5 to 7 days.

Larva

Pupa

Adult: 10 to 16 mm long weevils, hard-shelled, with a rather long curved snout. Newly emerged weevils are red brown, turning almost black after a few days. They are free living, they are most commonly found between leaf sheaths, in the soil at the base of the mat or associated with crop residues. Weevils may live for up to two years, and can live without food for six months, but are very sensitive to desiccation and will die within 48 hours if kept in a dry substrate. They are active at night.

Control Measures

Cultural Control

-- Field sanitation
-- Use clean planting material – This can be done by selecting vigorous healthy planting material
-- Trimming the suckers
-- Hot water treatment of corms at 52 to 55°C for 15 to 27 minutes
-- Suckers should be pruned periodically and infested pseudostems must be removed from the field and destroyed.
-- Banana stumps kept in the field after harvest must be removed and destroyed as they serve as weevil refuges and breeding sites
-- Crop rotation with non host crops like paddy and sugarcane
-- Use mechanical barriers in the field
-- Ensure proper fertilization and free from weeds at all times
-- Use mulch away from the banana stool leaving a clear ring about 60 cm from the base of the stool to keep the roots growing towards the surface and to avoid moist conditions near the stool, which will attract banana weevils
-- Do not take regular crop in the same field to avoid initial infestation
-- Removal of pseudo stems below ground level
-- Avoid growing Robusta, Karpooruvally, Malbhog, Champa and Adukkar
-- Grow less susceptible varieties like Poovan, Kadali, Kunnan, Poomkalli

Chemical Control

-- Cut the banana plant after harvest at the ground level and treat it with carbaryl (1g/liter) or chlorpyriphos (2.5 ml/lit) at the cut surface.
-- Application of Furadan 3G @ 20 gms or Phorate 10G @ 12 gms or Neem cake @ 1/2 Kg. per pit at planting.
-- Before planting, the suckers should be dipped in 0.1 per cent quinalphos emulsion.

-- Dip the suckers in Monocrotophos solution (14 ml in 1 lit water) for about 20 minutes to kill the eggs and grubs of the corm weevil .
-- Remove the pseudostem after harvest and treat it with Carboryl (1g/lit) or Chlorpyriphos (2.5ml/lit).
-- Fumigation of banana plants using Celphos (aluminium phosphide tablets), especially during the vegetative phase is phytotoxic and should be discouraged.
-- Apply castor cake 250g or carbaryl 50g dust or phorate 10g per pit before planting also prevents infestation.
-- Severe attack dimethoate, methyl demeton, or phosphamidon may be sprayed around the collar region.

Corm Injection in Banana

Biological Control

-- Natural enemies - Predatory ants such as the bigheaded ant (Pheidolem egacephala) and Tetramorium spp feed the eggs, grubs and pupae of weevils.
-- Apply biocontrol agents like Beauveria bassiana and Metarhizium anisopliae, anentomopathogenic fungus, in the banana fields and it causes more than 90% mortality of the weevils.
-- Steinerma and Heterorhabditis sp of nematodes attack both adult and grubs in the field.
-- Application of 60 to 100 g of neem seed powder or neem cake at planting and then at four months intervals significantly diminished pest damage and increased yields. Application of over 100 g or neem oil was phytotoxic (harmful to plants) and uneconomical.

Predatory ants

Mechanical Control

-- Use of pheromone trap @ 25 traps /ha to destroy the weevil populations.
-- Disc-on-stump traps can be used for trapping weevils. Disc-on-stump traps consist of corm slices placed on top of harvested plants cut at the rhizome. Adult weevils are attracted to the cut stems or corms for shelter, to feed and to lay eggs. The weevils can be collected by hand and destroyed. The efficiency of the traps depends on their numbers and frequency of trapping.
-- Keep the longitudinal split banana traps @ 100/ha.

Pheromone trap

Nematode

Nature of Damage:

-- Nematode causes reddish-brown to black, elongated lesions which are readily seen when the roots are split open. Roots eventually blacken and die.
-- Attacks by nematodes, combined with the effects of secondary rot organisms, destroy or weaken much of the root system.
-- Infested plants lack vigor and fruiting is poor.
-- Such plants are readily blown over and the roots are exposed.

Marginal yellowing of leaves

Affected plants topple over easily

Drying of boot leaf in advance stage

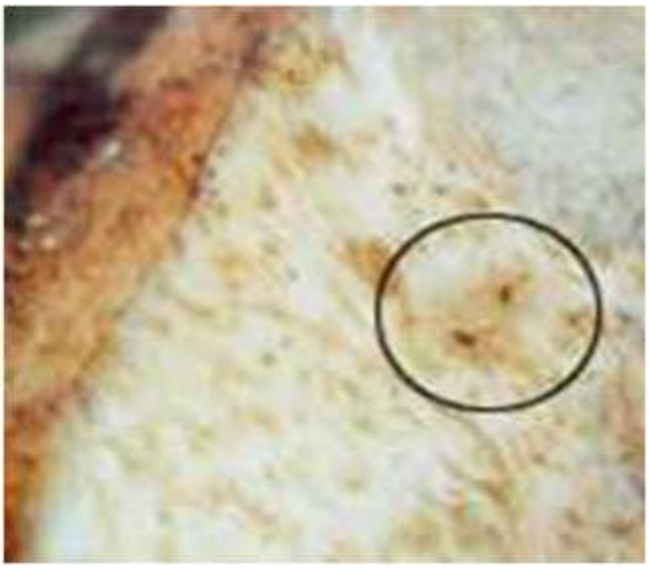
Identification of pathogen

The causal organism of nematode is Burrowing nematode (Radopholussimilis), Root lesion nematode (Pratylenchuscoffeae), Root knot nematode (Meloidogyne incognita), Sprial nematode (Helicotylenchusmulticinctus)

Meloidogyne spp. Are sedentary endoparasites. Second stage juveniles emerge from the eggs, move towards the roots and penetrate the roots either at the root tip or in regions of previous penetration or where minor wounds are present. The eggs are laid within a gelatinous matrix to form an external egg sac or egg mass. A single sac contains several hundred eggs. Complete life cycle within four to six weeks
Burrowing nematode – eggs are laid in the corms and roots.2 weeks are required for the life cycle to be completed. Female nematodes live 2 to 3 months and lay more than 100 eggs each. Nematode survive in the soil in the absence of suitable hosts.

Lesion nematode – Their life cycle takes less than 20 days when temperatures range from 25°C – 30°C.

Spiral Nematodes are robust with strong stylets. They live partially or completely within roots, feeding on the outer cortical cells.



Control Measures:

Cultural Control

-- The use of nematode-free planting material on uninfested land
-- Trim the corm tissue until all black or discolored spots have been removed, leaving only clean white tissues
-- Wash corms in running water, and allow them to dry before planting
-- Submerge trimmed suckers for 20-25 minutes in hot water at 53-54°C.
-- Grow nematode resistant varieties
-- The planting tools should be cleaned before being used in the field
-- Well decomposed manure should be used
-- Crop rotation with non host crops
-- Grow marigold in the inter space which serves as repellent and trap crop
-- Covering the field for 6 to 8 weeks with plastic after tilling and watering raises the soil temperature.

Chemical Control

-- Application of Furadan 3G @ 20 gms or Phorate 10g @ 12 gms or neem cake @ 1/2 Kg. per pit at planting.

Trichoderma viride Nimbicidine Intercrop with Sun hemp

Pseudostem Weevil (Odoiporuslongicollis)

Nature of Damage

-- Infestation of the weevil normally starts in 5 month old plants.
-- Early symptoms of the infestation are the presence of small pinhead-sized holes on the stem
-- Fibrous extrusions from bases of leaf petioles.
-- Adult weevils and exudation of a gummy substance from the holes on the pseudostem.
-- During the advanced stages of infestation, when split open the stem, exhibits extensive tunnelling both in the leaf sheath and in the pseudostem.
-- Rotting occurs due to secondary infection of pathogens and a foul odour is emitted.
– When the true stem and peduncle are tunnelled after flowering, the fruits do not develop properly, presenting a dehydrated condition with premature ripening of the bunch itself.

Small pin holes in pseudo stem

Blackened mass coming out of Gummy exudation

Pseudo stem

Identification of Pest

Egg: Eggs are cream in colour and cylindrical in shape with rounded ends. The incubation period ranges from 3 to 8 days.

Grub: The emerging larvae are fleshy, yellowish white and apodous. The larvae feed on tissues of the succulent sheath by tunnelling extensively and may reach as far as the true stem

Pupa: Pupate in cocoon by winding short pieces of fibrous materials of the sheath around its body. The pupa is exarate and present inside the cocoon.

Adult: The adult weevils are black-coloured and measure 23-39 mm. They often confine themselves within the pseudostem and in the decomposing tissues of harvested pseudostems. It has a long life span and many adults live for a year.

Control Measures

Cultural Control

-- Uproot and burn infested plants.
-- Planting material should be trimmed to reduce the number of eggs and grubs.
-- After harvesting the bunch, remove and destroy the pseudostem from ground level so as to avoid it serving as a breeding site for the pest.
-- Avoid mattacking (leaving the plant after bunch harvest for recycling of nutrients) in weevil endemic areas.
-- Prune the side suckers every month
-- Use healthy and pest free Tissue Culture Plants to check the incidence
-- Do not dump infested materials into manure pit
-- Apply mud slurry mixed with neem oil 5% on the pseudostem five month after planting in heavily infested areas to prevent oviposition.Closely monitor the plants for the detection of oviposition punctures.

Chemical Control

-- Stem injection with Monocrotophos solution (150 ml in 350 ml water) using stem injector at 2 and 4 feet above ground level at 30 degree angle on either side of the plant. Injection should not be given after flowering. Injection needle should reach only 2 or 3 leaf sheaths and without touching the centre core.
-- Application of Furadan 3G @ 20 gms or Phorate 10g @ 12 gms or neem cake @ 1/2 Kg. per pit at planting.
-- Treat the cut end of the leaf petiole with Chlorpyriphos (2.5ml/lit) + 1 ml sticking agent
-- After harvesting of banana bunch cut the tree at base and treat it with 100ml Carbaryl (2g/lit) or apply 10g Beauveria bassiana

Biological Control

-- Swab the cut surface of the longitudinal split traps with 20g of Beauveria bassiana fungus or Heterorhabditis indica nematode and the weevils die on their own due to infection
-- Predatory ants such as big headed any and Tetramonrium spp. are important predators of the banana weevil.
-- Dipping the suckers in 20% neem seed solution at planting
-- Steinerma and Heterohabditis spp. attack both adults and grubs in the field.

Mechanical Control



-- Use Longitudinal Split Pseudostem Traps (LPST) – This traps (45cm long) are made from the pseudostem pieces cut longitudinally in two halves. Such traps are laid randomly in the field @ 25 traps per acre.
-- Disc -on-stump traps and old pseudostems can be used for trapping weevils. Disc-on-stump traps consist of corn slices placed on top of harvested plants cut at the rhizome.

Disease Management

Anthracnose

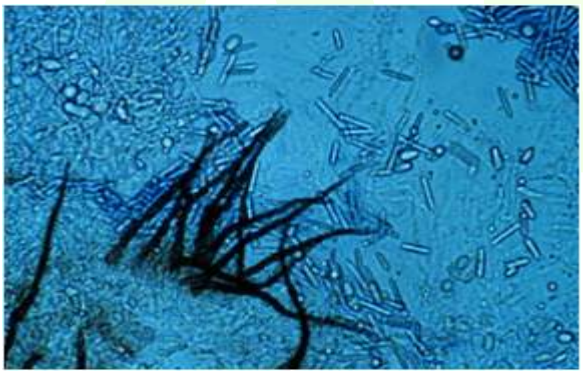
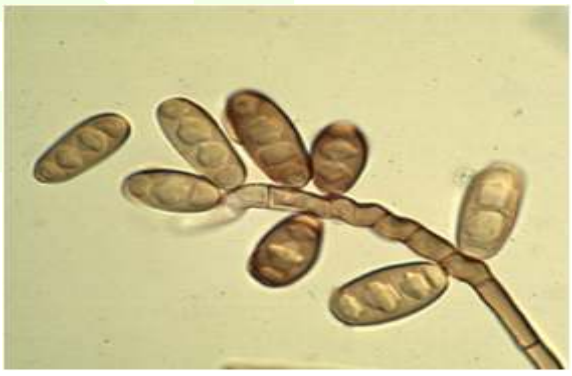


Nature of damage

-- The fungus attacks the young banana fruits usually at the distal end.
-- At the initial stage, small, circular, black spots develop on the affected fruits. Then these spots enlarge in size, turn to brown color.
-- The skin of the fruit turns black and shrivels and becomes covered with characteristic pink acervuli. Finally the whole finger is affected. Later the disease spreads and affects the whole bunch.
-- The disease results in premature ripening and shrivelling of the fruits which are covered with pink spore masses.
-- Occurrence if black lesions on the pedicel causes withering of the pedicel and dropping of the fingers from the hands.
-- Become black and rotten.

Identification of pathogen

-- Acervuli are usually rounded or sometimes elongated, erumpent.
-- Conidiophores are cylindrical, tapered towards the apex, hyaline, septate, branched and sub-hyaline towards the base, each with a single terminal phialidic aperture.
-- Conidia are hyaline, aseptate, oval to elliptical or straight cylindrical, obtuse apices or flattened at base and obtuse at the apex, guttulate.
-- The spread of the disease is by air-borne conidia and numerous insects which frequently visit banana flowers also spread the disease.
-- The disease is favored by high atmospheric temperature and humidity, wounds and bruises caused in the fruit and susceptibility of the variety.

Control Measures

Cultural Control

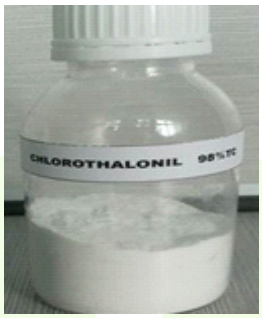
-- Burn the infected materials
-- Proper field sanitation
-- Practice crop rotation with paddy or sugarcane
-- Keep the field free of weeds and provide good drainage
-- Fruit should be free from infection and as possible before it is transported, stored and ripened
-- Banana bunches should be harvested at correct stage of maturity.
-- Proper fertilization prevents the infection

Chemical Control

-- Protective spraying when the fruit is still young with Bordeaux mixture 1%
-- Pre-harvest spray with Prochloroz 0.2% or Carbendazim 0.1% or Chlorothalonil 0.2% four times at fortnightly interval is highly effective
-- Post harvest dipping of fruits in mycostatin 440 ppm or Aureofunginsol 100 ppm or Carbendazim 400 ppm or Benomyl 1000 ppm.

Mechanical Control

-- The distal bud should be removed when all the hands opened to prevent infection
-- After harvest, the bunches should be transported to the store house without causing any bruises to them. The transported bunches should be stored carefully at 7 to 10°C
-- Avoid contamination in collecting places, during transport and in ripening rooms



Banana Bract Mosaic

Nature of damage

-- The disease is characterized by the presence of spindle shaped pinkish to reddish streaks on pseudostem, midrib and peduncle.
-- Typical mosaic and spindle shaped mild mosaic streaks on bracts, peduncle and fingers also observed.
-- Suckers exhibit unusual reddish brown streaks at emergence and separation of leaf sheath from central axis
-- Clustering of leaves at crown with a travelers palm appearance, elongated peduncle and half filled hands are its characteristic symptom.

Reddish streaks on pseudostem

Mosaic streak on bracts

Dark streaks on midrib of leaf

Identification of pathogen

-- The disease is caused by a virus belonging to potyvirus group. The virions are flexuous filamentous.
-- The virus is transmitted through aphid vectors such as Aphis goosypii, Pentolonianigronervasa and Rhopalosiphummaidis. In field the disease spread mainly through suckers.


Aphis gossypi Potyvirus

Control measures

Cultural Control

-- The diseased plants should be removed as and when noticed to avoid the spread of the disease.
-- Disease free Tissue Culture planting materials should be used for new planting.
-- The banana gardens should be kept free from weeds
-- Weeds in the nearby areas should be removed as the virus survives in them in off-season
-- Early detection by regular inspection of planting and eradication of diseased plants from the field as soon as they are noticed.

Chemical Control

-- Control of insect vector by spraying Phosphomidon at 1 ml per litre or Methyl Demeton at 2 ml per litre or Monocrotophos at 1ml per litre .

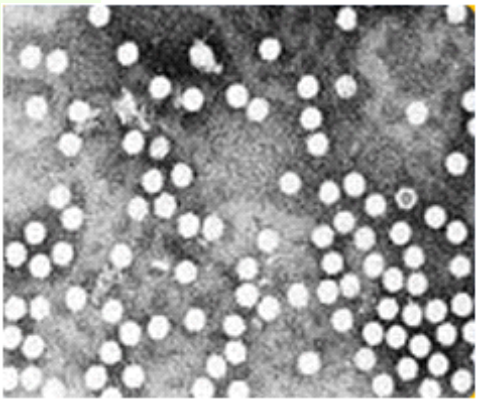
Bunchy Top


Nature of Damage

-- Initially, dark green streaks appears in the veins of lower portion of the leaf midrib and the leaf.
-- Dark green, hook-like extensions of the leaf lamina veins can be seen in the narrow, light-green zone between the midrib and the lamina.
-- On mature plants infected with BBTV, new leaves emerge with difficulty, are narrower than normal, are wavy rather than flat, and have yellow (chlorotic) leaf margins.
-- They appear to be “bunched” at the top of the plant, the symptom for which this disease is named.
-- Severely infected banana plants usually will not fruit, but if fruit is produced, the banana hands and fingers are likely to be distorted and twisted.

Identification of Pathogen

-- The virus is an isometric particle measure 20 nm in diameter.
-- It is ssDNA virus belonging to Nanoviridae family and babu virus genus.
-- The virus has multi component genome
-- There are six circular single stranded genomes known to be established.
-- The virus concentration is more present in phloem.
-- It is transmitted by infected suckers and banana aphid.



Control Measures

Cultural Control

-- Use virus free Tissue Culture planting materials.
-- Remove and rouging of infected banana plants.
-- Chop, dry and bury the infected plants.
-- Maintain clean, weed free field.
-- Avoid banana cultivation in sugarcane and cucurbitaceous areas as sugarcane mosaic virus or cucurbit mosaic virus can easily spread to banana.

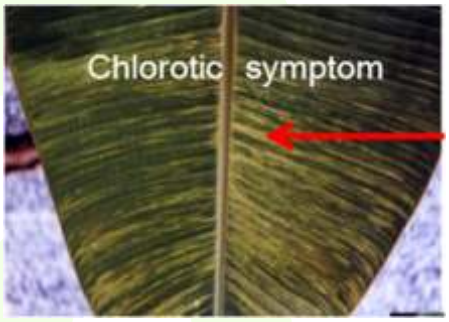
Chemical Control

-- The diseased trees should be injected with 4 ml of Fernoxone solution(50g in 400 ml of water)
-- Insertion of Fernoxone capsules (containing 200 to 400 mg of chemical per capsule) into the pseudostem by using the banana injector or capsule applicator.

Mosaic Virus

Nature of damage

-- The disease is characterized by the presence of typical mosaic-like or discontinuous linear streaking in bands extending from margin to midrib.
-- Rolling of leaf margins, twisting and bunching of leaves at the crown and a rigid erectness in newly emerged leaves
-- The presence of dead or drying suckers is noticed in advanced cases referred as heart rot resulting from rotting of heart leaf and central portion of pseudostem.
-- Primarily infected banana plants develop severe mosaic symptoms in young growth showing broadly streaked chlorotic or yellowish green bands and patches or chlorotic mottling distributed in patches over the leaf lamina.
-- The leaves are narrower and smaller than normal and the infected plants are dwarf and lag behind in growth. Such plants do not produce bunches but as a virus reservoir.



Identification of pathogen

-- The casual agent of this disease is Cucumber mosaic virus(CMV). The virus is isometric, linear positive sense and single stranded RNA. The RNA is surrounded by a protein coat consisting of 32 copies of single structural protein which form isometric particles
-- The primary transmission is through use of infected daughter suckers from diseased plants and the secondary spread of the disease is through melon aphid, Aphis gossypii and Aphids maidis.

Control Measures

Cultural Control

-- The banana gardens should be kept free from weeds.
-- Weeds in the nearby areas should be removed as the virus survives in them in off-season
-- Growing pumpkin, cucumber and other cucurbits between the rows of banana crop should be avoided.
-- Use virus free Tissue culture Planting Material
-- Early detection by regular inspection of planting and eradication of diseased plants from the field as soon as they are noticed.
-- Use of high input crop management of system comprising of 10 kg farm yard manure at the time of planting and subsequently at an interval of 3 months. 1 kg neem cake, 4 weeding at 2 months interval up to 8 months stage.

Chemical Control

-- Spraying Methyl Demeton 0.03 per cent (0.3 ml/lit of water) at 3 to 4 weeks interval controls the vector and reduces the spread of the disease
-- Foliar spray of micronutrient (0.2% CuSo4(2ml/lit), 0.2% FeSo4(2ml/lit), 0.5% ZnSo4(5 ml/lit) and 0.1% $H3BO_3$ (1 ml/lit of water) at 3,5 and 7th month after planting and spraying Glyphosate 2Kg per hectare to control weeds
-- Control of insect vector by spraying Phosphomidon at 1 ml per litre or Methyl Demeton at 2 ml per litre or Monocrtophos at 1ml per litre.

Erwinia Rot

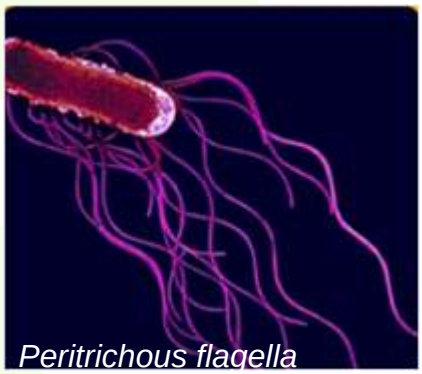
Nature of Damage

-- This disease is more pronounced on young suckers leading to rotting and emitting of foul odour.
-- Rotting of collar region is a commonest symptom followed by epinasty of leaves, which dry out suddenly.
-- If affected plants are pulled out it comes out from the collar region leaving the corm with their roots in the soil.
-- Splitting of pseudo stem is common in late stage of infection in cultivars Robusta, Grand Naine.
-- When affected plants are cut open at collar region yellowish to reddish ooze is seen
-- In early stage of infection dark brown or yellow water soaked areas are more in the cortex area.
-- In advance stage the interior lesions may decay to such extent that cavities surrounded by dark spongy tissues are formed.
-- This soft rotting may spread radially towards growing point through the cortical tissues. The rotten corm emits foul smell.



Identification of Pathogen

-- The pathogen is a Gram-negative bacterium with peritrichous flagella and it is a rod shaped bacterium that lives alone or aggregates into pairs and chains.
-- The pathogen is soil borne and enters through wounds and also through leaf sheath of suckers.
-- The disease can be spread by infected plant debris, plant wounds and injuries. Hot and damp weather with plenty of rainfall trigger the disease to occur. Water is required for the bacteria to invade into the plant.


Peritrichous flagella

Control Measures

Cultural Control

-- Good drainage and soil conditioning can control the disease to some extent.
-- Plant disease freeTissue Culture Plants.
-- Remove infected plants immediately.
-- Remove plant residues after harvest.
-- Practice crop rotation by using crops that are not susceptible to the bacterial rot disease like soybean, forage legumes and small grains. Banana should not be grown along with onion and other vegetables.
-- Control nematodes and other insect pests that serve as vectors of the bacteria to invade the plant tissues.
-- Avoid planting during rainy season and use of bigger Plants.

Chemical Control

-- Drench with Methoxy Ethyl Mercuric Chloride (Emisan-6) 0.1 / or Sodium hypochlorite 10% or Bleaching powder 20g /litre/tree.
-- Drench with 2% bleaching powder after three months of planting to control the disease in the field.

Panama Wilt

Nature of Damage

-- Externally, the first obvious signs of disease in most varieties are wilting and a light yellow coloring of the lower leaves, most prominent around the margins. They eventually turn a bright yellow color with dead leaf margins.
-- In the advanced stages of disease, affected plants may have a spiky appearance due to prominent upright apical leaves in contrast to the skirt of dead lower leaves.
-- Internally, symptoms first become obvious in the xylem (water conducting) vessels of the roots and the rhizome. These turn a reddish-brown to maroon color as the fungus grows through the tissues.
-- When a cross-section is cut, the discoloration appears in a circular pattern around the center of the rhizome where the infection concentrates due to the arrangement of the vessels. As symptoms progress into the pseudo-stem, continuous lines of discoloration are evident when the plant is cut longitudinally.

Identification of Pathogen

-- The casual organism is Fusarium oxysporumf.sp.cubense.
-- This pathogen contains colonies of white to purple pigmented mycelium. Hyphae are septate and hyaline. Conidiaphores are short and simple and having macroconidia and microconidia.
-- Macroconidia usually produced abundantly, slightly sickle-shaped, thin-walled, with an attenuated apical cell and a foot-shaped basal cell. They are three to 5-septate measuring 23-54 x 3-4.5 µm.
-- Microconidia are abundant, mostly non-septate, ellipsoidal to cylindrical, slightly curved or straight, 5-12 x 2.3-3.5 µm occurring in false heads from short monophialides.
-- The disease is soil borne and the fungus enters the roots through the fine laterals. The disease incidence is high in acid alluvial soils.
-- The pathogen is easily spread by infected rhizomes or suckers, farm implements or vehicles, irrigation water.

Control Measures

Cultural Control

-- Practice proper crop rotation with paddy/sugarcane once or twice followed by banana for 2-3 cycles.
-- Plant wilt resistant cultivars such as Poovan and Nendran in endemic areas.
-- Remove and destroy infested plant material after harvest
-- When only 1-3 plants are infected, kill and chop up the diseased plants and stew all the material in water at a temperature of at least 70°C for 30 minutes.
-- Grow healthy Tissue culture plants with proper fertilization, irrigation, weed control.
-- Provide good drainage especially during rainy season
-- Soil application of rice chaffy grain or dried banana leaf formulation or well decomposed compost around the plants

Chemical Control

-- Application of 2 % of Carbendazim as injection of Carbendazim 50 ml capsule application.
-- Soil drenching of Carbendazim 0.2 % solution alternated with Propiconozole 0.1% around the pseudo stem at bimonthly intervals starting from five months after planting
-- Application of urea + sugarcane trash (250g/pit) followed by lime (1Kg/pit) and neem cake (1-2Kg/pit)
-- Application of neem cake @ 250 Kg/ha was most effective in controlling Fusarium wilt.

Biological Control

-- Application Pseudomonas fluorescens, a bactericide can also be applied along with farmyard manure and neem cake.
-- About 60 mg of Pseudomonas (in a capsule) can be applied in a 10 cm deep hole made in the corm.
-- Application of bio control agents like Trichoderma viride @ 25 g for 4 times once at the time of planting in the planting pit and remaining doses at third, fifth and seventh month after planting.
-- Application of T.harzianum Th-10, as dried banana leaf formulation @ 10g/plats in basal + top dressing on 2,4,and 6 months after planting.
-- Dipping the planting materials in spore suspension of P.fluorescens at 10g per plant at 3,5 and 7 months after planting.

Mechanical Control

-- Machinery and equipment should be treated with a sanitary solution such as Farmcleanse®
-- Footwear, which may have contacted banana plants or soil around banana plants elsewhere, should not be worn on the farm.
-- No agricultural vehicles, tools (including shovels, knives and ladders) or equipment should be removed from, or brought on to, the farm without prior approval from management.
-- Provide mechanical barriers in and around the infected plants.

Yellow and Black Sigotoka

Nature of Damage

-- Initially, appearance of pale yellow or greenish streaks parallel to the veins on the upper surface of the leaves.
-- Then these streaks darken and become more or less elliptical brown spots.
-- Later on, the centre of these spots turns to light grey color surrounded by yellow halo.
-- The spots often coalesce to form large irregular patches of dried tissue.
-- Rapid drying and defoliation of leaves are the characteristic feature of this disease.
-- Normally 15-18 leaves are necessary at the time of shooting for bunch development, but due to Sigatoka leaf spot it is difficult to maintain 15 leaves.
-- In severe cases, immature bunches fail to fill out.
-- The fingers of bunch in affected plants tend to remain undersized and angular but pulp starts ripening.

Identification of Pathogen

-- This disease is caused by Mycospharella musicola fungus by the characteristics of the conidia and conidiophores.
-- The conidiophores are bottle shaped and bear conidia. Conidia are narrow and multi septate.
-- Perithecia are dark brown to black, amphiceous, erumpent, ostiolate
-- Asci are oblong, clavate. Ascopores are one septate, hyaline, obtuse-ellipsoid with upper cell slightly broader
-- The conidia of the fungus are carried by wind, rain water and old dried infected leaves and they help to spread the disease.

Control Measures

Cultural Control

-- Removal and destruction of affected leaves.
-- Keep the banana field as weed free and remove the suckers timely.
-- Avoid planting at close spacing.
-- Provide proper drainage and avoid water logging in the fields which favors infection.

Chemical Control

-- Spray Bordeaux mixture 1 per cent + linseed oil 2 per cent on the plants.
-- Spray Copper oxychloride or Zineb with gas oil or mobile oil or white oil.
-- Spray 3 times with Carbendazim 0.1 per cent or Propicanozole 0.1 % or Mancozeb 0.25% or Calixin 0.1% and teepol (sticking agent) at 10-15 days interval, as the disease starting from initial appearance of leaf specks in lower side of the leaf.

Inter culturing Operations:

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. Only one sucker is retained per plant and set for ratooning.

Propping

-- At the time of bunch emergence, pseudo stem 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.

Removal of withered styles and Perianth

-- 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 shrivelled. This operation eliminates the removal of infection by saprophyte fungi especially to avoid the finger tip disease.

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.


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 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.

Denavelling


-- Removal of male bud after completion of female denavelling. This checks the movement of the unwanted sink and promotes fruit development.

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.

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.

Calender 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 plants. Seeds of green manure crops viz., cowpea or sun hemp 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 varietiesdrench the soil around the plant with 0.2% Carbendazim as a prophylactic measure, or Apply 30g Trichodermaviride or Pseudomonas flourescense 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

-- 30 g along with 5-10 kg FYM per plant.
-- There should 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 neem cake 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 50 g agricultural lime and 25 g magnesium sulphate per plant.
-- For Fusarium wilt susceptible varieties 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' @12.5 ml/litre or Chlorpyriphos @ 2.5 ml/litre on the stem.
-- 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 30 g Trichoderma viride or Pseudomonas fluorescence 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.

Post Harvest Technology:

Harvest

-- The dwarf bananas are ready for harvest within 11-14 months after planting, while tall cultivars take about 14-16 months to harvest.
-- A bunch usually takes 90-120 days to mature after shooting.
-- The maturity of banana is indicated by drying of top leaves, change in colour of fruits from dark green to light green and tendency of the floral end of the fruit to fall by slightest touch by hand.
-- The mature fruit becomes plumpy and all the angles are filled in completely. When tapped the fruit gives metallic sound.

Methods

-- Low growing varieties are harvested by cutting through the bunch stalk about 30-35 cm above the top hand.
-- With taller varieties, the stem of the plant will be partly cut through to bring the bunch down within the harvester's reach.

Dehandling

-- After harvest, dehandling should be carried out with a sharp, clean Banana knife, making a smooth cut as close as possible to the stem.
-- After dehandling, the fruits are placed with the crown facing downwards onto a layer of leaves to allow for latex drainage.
-- In order to restrict crown disease development, the hands should be dipped in a solution of 0.1% Benlate or Thiabendazole.

Stoving

-- After harvest banana bunches are arranged in rows with the cut ends of pedicel upward, called stowing
-- Stowing is required at two stages. Soon after harvest, the bunches are stowed in the field usually over a bed of banana leaves.
-- Before a carriage arrives, harvested bunches continue to remain stowed in this condition which pave way to spread of inoculums to healthy sites.
-- During transport and at the wholesalers godown the bunches are again stowed before sending them to ripening room.
-- During stowing the fruits are invariably subjected to mechanical or insect injury in addition to the spread of pathogens carried from field in latent condition or prevalent under local condition of storage.

Packaging

-- The arrangement of fruits in box has to be horizontal in two rows keeping crown end towards box side and fruit tips towards the center of the box.
-- While packing in single layer, the hands should be placed in the vertical positions by keeping their tips up and crown downside.
-- Cushioning pads or kraft paper should be placed at the bottom of the box and fruit may be covered in LDPE liner of 100 gauges inside the box to create modified atmosphere.

Pre-cooling

-- The fruit destined for the distant and export market should be precooled considerably for extending the storage life.
-- Pre cooling of the produce should be done within 10 - 12 hrs. of bunch harvesting.
-- The fruit packed in boxes should be pre cooled by forced air cooling at 13° C and 85 - 90% RH.
-- It may take 6 to 8 hrs to bring the fruit pulp temperature to 13° C from field temperature of 30° C to 35° C.
-- The boxes should be immediately moved to cold rooms for storage purpose.

Storage

-- Bananas can be exported successfully by sea-shipment if the guidelines related to harvest maturity are strictly followed.
-- Storage conditions of 13° C and 85% to 95% relative humidity are required.
-- Storage temperature below 13° C would cause chilling injury to fruits resulting in surface discoloration, dull color, failure to ripen and browning of flesh.
-- The storage life at 13° C depends on the cultivar and varies from 3 to 4 weeks.
-- A combination of low temperature with controlled atmosphere storage can further extend the storage life.
-- Banana (Robusta cvr.) fruits could be stored in green unripe condition for 8 weeks under controlled atmosphere storage condition of 5% O2 + 5% CO_2 at 12° C to 13° C with post storage ripening period of 4 to 5 days under ambient conditions.

Ripening

-- Green bananas in boxes and or cushioned plastic crates should be loaded into the ripening room (lower temperatures can damage the fruit)
-- The room should be closed, insulated and airtight and be maintained at 16 to 18 °C and 85-90 % RH. Temperature is controlled and maintained by thermostat.
-- Supply ethylene into the room at a concentration of around 100 ppm (0.01%)
-- The ethylene act as a catalyst initiating the hormonal process of ripening.
-- The room is kept closed for 24 hours. At the end of 24 hrs, room should be ventilated to clear the ethylene gas and the carbon dioxide released during the initial ripening phase and maintain at 18° C reducing to 15°C over three to four days.