Phase 1: Land Preparation (Weeks 1–6) (Month 1 - 2)

Week 1: Soil Testing and Analysis (Month 1)

- **Parameters:**
  - **Soil pH:** Ideal range 6.5–7.5.
  - **Nutrient Levels:** Test for N, P, K, organic matter, and micronutrients.
  - **Texture and Drainage:** Ensure loamy soil with good drainage.
- **Steps:**
  1. Collect soil samples from multiple locations at 15–20 cm depth.
  2. Send samples to an authorized lab or use a soil test kit.
  3. Apply amendments based on results (lime for acidic soils, gypsum for sodic soils).

Week 2–3: Field Clearing and Initial Plowing (Month 1)

- **Steps:**
  1. Clear weeds, stubble, and previous crop residues.
  2. Conduct deep plowing (30–40 cm) to break compact layers.
  3. Add **organic manure (10–12 tons/ha)** to enrich the soil.
  4. Level the field to facilitate uniform irrigation.

Week 4–5: Furrow Preparation (Month 1 - 2)

- **Parameters:**
  - **Row Spacing:** 90–150 cm (variety-dependent).
  - **Furrow Depth:** 10–12 cm.
- **Steps:**
  1. Use a furrow opener or tractor to prepare furrows at the required spacing.
  2. Add basal doses of fertilizers:
     - Nitrogen: 25 kg/ha (as urea or ammonium sulfate).
     - Phosphorus: 40 kg/ha (as DAP).
     - Potassium: 30 kg/ha (as MOP).
  3. Ensure uniform furrow alignment for easy irrigation.

Week 6: Seed Preparation (Month 2)

- **Parameters:**
  - Seed type: Healthy, disease-free, 3-budded setts.
  - **Seed Rate:** 35,000–40,000 two-budded setts/ha.
- **Steps:**
  1. Cut cane into setts (20–30 cm each).
  2. Treat setts with fungicide (carbendazim 0.1%) or hot water treatment (50°C for 2 hours).
  3. Keep setts moist in gunny bags for 24 hours before planting.

Phase 2: Planting and Germination (Weeks 7–12) (Month 3)

Week 7–8: Planting (Month 2)

- **Steps:**
    1. Lay setts horizontally in furrows with buds facing upward.
    2. Cover setts lightly with soil.
    3. Apply irrigation immediately after planting to ensure moisture.

Week 9–10: Germination Care (Month 3)

- **Temperature Requirements:**
    - Max temp: 32°C, Min temp: 20°C.
    - Relative humidity: 60–70%.
- **Steps:**
    1. Monitor germination (visible sprouts after 10–15 days).
    2. Apply pre-emergence herbicides like atrazine (1 kg/ha) to control weeds.
    3. Irrigate lightly every 7–10 days.

Week 11–12: Seedling Care (Month 3)

- **Steps:**
    1. Thin out weak seedlings if required to ensure uniform growth.
    2. Top-dress nitrogen (40–50 kg/ha) to promote healthy tillering.
    3. Perform light hoeing to break soil crust.

Phase 3: Tillering (Weeks 13–24) (Month 4 - 6)

Week 13–16: Early Tillering (Month 4)

- **Steps:**
    1. Perform inter-row cultivation to aerate the soil and control weeds.
    2. Apply post-emergence herbicides like 2,4-D (1 kg/ha) if weeds persist.
    3. Top-dress nitrogen (60 kg/ha) in split doses.

Week 17–20: Mid-Tillering (Month 5)

- **Steps:**
    1. Monitor crop for early signs of pests (e.g., borers) and diseases (e.g., red rot).
    2. Introduce **biological control agents** like Trichogramma for borers.
    3. Maintain soil moisture through irrigation every 10–12 days.

Week 21–24: Late Tillering (Month 6)

- **Steps:**
    1. Add micronutrients like zinc sulfate (25 kg/ha) and borax (10 kg/ha).
    2. Continue pest monitoring and implement IPM strategies.

Phase 4: Grand Growth Phase (Weeks 25–40) (Month 7 - 10)

Week 25–28: Stem Elongation Begins (Month 7)

- **Steps:**
    1. Irrigate every 12–15 days to avoid stress during critical growth.
    2. Intercrop harvest if any (e.g., pulses, vegetables).
    3. Apply remaining nitrogen (40 kg/ha) and potassium (30 kg/ha) for stem growth.

Week 29–32: Maximum Stem Elongation (Month 8)

- **Steps:**
    1. Ensure no water stress; this stage is critical for yield.
    2. Watch for diseases like smut and leaf scald; use fungicides if necessary.

Week 33–36: Canopy Development (Month 9)

- **Steps:**
    1. Apply green manure or additional organic matter for soil health.
    2. Conduct light hoeing to improve soil aeration.

Week 37–40: Early Maturity (Month 10)

- **Steps:**
    1. Stop nitrogen application to avoid lodging and delayed ripening.
    2. Focus on pest control to prevent damage to stalks.

Phase 5: Ripening and Harvesting (Weeks 41–52) (Month 11 - 12)

Week 41–46: Ripening (Month 11)

- **Steps:**
    1. Stop irrigation 3–4 weeks before harvest to enhance sucrose content.
    2. Use ripeners (e.g., Ethephon) if synchronized maturity is required.

Week 47–52: Harvesting (Month 12)

- **Steps:**
    1. Cut canes close to the ground with sharp tools.
    2. Remove dry leaves and transport to mills within 24 hours to prevent juice loss.

Key Considerations

1. **Water Management:**

    - Critical stages: Germination, tillering, and elongation.
    - Use drip irrigation to save water and enable fertigation.
2. **Weed Management:**
    - Use a mix of manual, chemical, and intercultural operations.
3. **Fertilizer Management:**
    - Split NPK applications based on crop stage.

This plan is adaptable for both **subtropical** and **tropical regions** in India, with slight modifications based on local conditions.

Key Strategies to Increase Production

1. **Adopt High-Yielding Varieties**: Based on regional recommendations.
2. **Integrated Nutrient Management**: Balance organic and inorganic sources.
3. **Integrated Pest Management (IPM)**: Minimize chemical use and adopt eco-friendly control methods.
4. **Mechanization**: Use sugarcane planters and harvesters to reduce labor costs.
5. **Intercropping**: Grow legumes, pulses, or vegetables to maximize land use efficiency.
6. **Water-Efficient Practices**: Drip irrigation with fertigation.

Expert System For Sugarcane

Irrigation Management

Categories

About Irrigation Management

- **Water requirement**
- **Irrigation Methods**
- **Drip irrigation**
- **Fertigation**
- **Drought management**

Water requirement

- Depending upon the agro climatic conditions, type of soil, methods of planting and use of manures and fertilizers and sugarcane yield the water requirement varies.The hot weather associated with dry winds and drought increases the water requirement of the crop.
- The crop sown in trenches needs relatively less water but sandy soils and application of more fertilizers increase the water uptake. On an average 1 ton cane needs about 60-70 tons of water or thin varieties of cane need 150 cm thick canes and need 200 cm water and Adsali planted canes 200 cm, in addition to 75 cm rainfall. The crop should be irrigated when available water reaches to 50% level.

- The soil must have sufficient moisture at the time of sowing. First irrigation should be done when about 20-25% plant have germinated or about 20 days after sowing and the irrigations are given at 10-15 days interval during summer, 25-30 days interval during winter and if there is drought the crop should be irrigated during rainy season also as and when needed. The crop needs maximum water at tillering stage and during elongation or grand growth phase.
- Under water logging conditions the root respiration becomes poor. Nutrients are leached down, activities of useful micro-organisms are reduced and the crop lodges down with an excessive branching. Thus the quality becomes poor along with very low crop yield. These all make it necessary to drain the excess water from the field.

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Average water requirement for sugarcane

- Average water requirement for sugarcane is 1800 to 2200 mm.

S.No.	Crops	Duration in days	Water requirement (mm)	No. of irrigations
1.	Sugarcane	365	2000	24

For 12 months sugarcane crop water requirement at each growth phase

Irrigation interval approach

Growth Phase	Duration of phase	Water Requirement
Germination	0-45 days	300mm
Tillering Phase	45-120 days	550mm
Grand Growth Phase	120-270 days	1000mm
Ripening Phase	270-360 days	650mm

Irrigation interval in different season and type of soil

Growth Phase	Irrigation Interval (days)		
	Coarse textured soil	Medium textured soil	Fine textured soil
Germination(0-45 days)	5-6	6-7	8-10
Tillering Phase(45-120days)	6-7	7-10	12-15
Grand Growth Phase(120-270days)	7	10	12-15

Ripening Phase(270-360 days)	10	12-15	15-20

Water Use Efficiency of Different irrigation systems

Irrigation system	Water applied (ha -cm)	Cane yield (mt/ha)	Water use efficiency	C. C.S. (mt/ha)
Rain gun sprinkler	175.26	126.56	0.72	17.87
Drip irrigation	132.14	128.64	0.97	18.29
Furrow irrigation	258.45	104.42	0.4	14.71

Poor irrigation leads to

- Decrease length of internodes
- Decrease amount of juice and increase percent of fiber
- Decrease rate of germination
- Decrease of sugar yield

Heavy irrigation leads to

- Death of buds,
- damage to roots,
- sugar content decreases,
- cane yield decreases
- plant can not adsorb elements from soil and becomes yellowish.

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Irrigation Methods

Flood irrigation:

- In Flood irrigation method, free flow of irrigation water is allowed in the fields in all directions.
- It is practiced in the flat planted cane, but water loss is high.

Furrow irrigation:

- Furrow irrigation is most commonly used and is particularly effective for early plant crop.
- In later crop growth periods and during ratoon crops, the water distribution may become increasingly problematic because of deterioration of the furrows.
- Reduced furrow length is sometimes used to allow better distribution of water over the field in a later stage.

Alternate skip furrow method:

- In skip-furrow method, sugarcane is planted in flat beds as usual and after germination, 45 cm wide and 15 cm deep furrows were made in alternate inter row spaces.
- There is considerable saving of water in this method of irrigation.
- In Autumn planting, there are 7 irrigations in plains (5 before rain and 2 after rain)
- In spring planting, there are 6 irrigations (4 before rain and 2 after rain) - one irrigation at tillering is must.

Sprinkler irrigation:

- For sprinkler irrigation, increasing use is made of spray guns, hand and automatically moved, replacing the cumbersome boom and labour-intensive hand-moved sprinkler laterals Prevailing winds of more than 4 or 5 m/sec will limit their usefulness.

Drip irrigation:

- Drip irrigation is defined as the precise, slow and frequent application of water through point or line source emitters on or below the soil surface at a small operating pressure (20-200 kPa) and at a low discharge rate (0.6 to 20 LPH), resulting in partial wetting of the

soil surface.

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Drip Irrigation

Drip Irrigation

- Drip irrigation is defined as the precise, slow and frequent application of water through point or line source emitters on or below the soil surface at a small operating pressure (20-200 kPa) and at a low discharge rate (0.6 to 20 LPH), resulting in partial wetting of the soil surface.
- Drip irrigation in sugarcane is a relatively new innovative technology that can conserve water, energy and increase profits.
- Drip irrigation may help in solving three most important problems of irrigated sugarcane - water scarcity, rising pumping (energy) costs and depressed farm profits
- Drip will be successful depends on a host of agronomic, engineering and economic factors.
- 12 mm drip laterals have to be placed in the middle ridge of each furrow with the lateral spacing of 240 cm & 8 'Lph' clog free drippers should be placed with a spacing of 75 cm on the lateral lines. The lateral length should not exceed more than 30-40 m.
- Drip Irrigation is given once in three days based on the evapo-transpiration demand of the crop.

Surface Drip:

- The application of water to the soil surface as drops or a tiny stream through emitters placed at predetermined distance along the drip lateral is termed as surface drip irrigation.
- It can be of two types - online or integral type surface drip system. Integral dripline is recommended for sugarcane.

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Subsurface Drip (SDI):

- The application of water below the soil surface through emitters molded on the inner wall of the dripline, with discharge rates (1.0 - 3.0 LPH) generally in the same range as integral surface drip irrigation.
- The integral dripline (thin or thick-walled) is installed at some predetermined depth in the soil depending on the soil type and crop requirements.
- There are two main types of SDI - "one crop" and "multicrop".
- Subsurface irrigation saves water and improves yields by eliminating surface water evaporation and reducing the incidence of disease and weeds.

Advantages

- Save 25-50% of water
- Low requirement of water.
- Evaporation losses get reduce.
- Decrease the number of weeds.
- Period of irrigation is low (2-3 hours)
- The growth of plants is homogeneous.
- Little application of water but gives more yield.
- Decrease the infestation with pests (insects, diseases and weeds).
- Increasing the area of planting by saving the area of canals.
- Decreasing man infection by contacting the water (bilharzia or Schistosomiasis).
- Decreasing the pollution in canals.

There is considerable saving of water in this method of irrigation.

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Sugarcane Drip Design Guidelines

Planting pattern	Drip system	Distance (m)			Dripline installation depth (cm)	Emitter distance (m)	Discharge (LPH)
		Two rows of a pair	Two paired rows / two rows	Two driplines			
Single row	Surface	---	1.2 to 1.5	1.2 to 1.5	---	0.4 to 0.6	1.0 to 3.0
Paired row	Surface	0.4 to 1.0	1.4 to 2.0	1.8 to 2.5	---	0.4 to 0.6	1.0 to 3.0
Paired row	Sub surface	0.4 to 1.0	1.4 to 2.0	1.8 to 2.5	0.15 to 0.30	0.4 to 0.6	1.0 to 2.3

Major benefits of drip irrigation

Water

- Saving irrigation water 40 - 70 %
- Low Labour cost for irrigation
- Increased water use efficiency
- Uniformity in water distribution (90%)
- Suitable for inferior quality irrigation water
- Use of saline water is possible

Soil

- Suitable for any type of soil
- Suitable for marginal and undulating land
- Low tillage requirement

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Fertigation

Fertigation

- Sugarcane being a giant crop producing huge quantity of biomass generally demands higher amounts of nutrient elements.
- The cost of chemical fertilizers has also increased and there is a need to improve fertilizer use efficiency for more benefits. The best answer to this challenge is "Fertigation", where both water and fertilizers are delivered to crop simultaneously through a drip irrigation system.

- Fertigation ensures that essential nutrients are supplied precisely at the area of most intensive root activity according to the specific requirements of sugarcane crop and type of soil resulting in higher cane yields and sugar recovery.

Concept of fertigation

- Fertigation is the judicious application of fertilizers by combining with irrigation water.
- Fertigation can be achieved through fertilizer tank, venturi System, Injector Pump, Non-Electric Proportional Liquid Dispenser (NEPLD) and automated system.
- Recommended Nitrogen & Potassium @ of 275 and 112.5 kg/ha may be applied in 14 equal splits with 15 days interval from 15 DAP.
- 25 kg Nitrogen and 8 kg K2O per ha per split.
- Urea and MOP (white potash) fertilizers can be used as Nitrogen and Potassium sources respectively.
- Fertigation up to 210 DAP can also be recommended.

Requirement & Type of Water soluble fertilizers in Sugarcane

Recommended dose: 275: 62.5:112.5 kg NPK / ha
For Fertigation recommended: 275:15:112.5 NPK / ha

Fertigation Schedule

Crop stage	Duration in days	Fertilizer grade	No. of times	Quantity (kg/time)
First stage	From planting to 70 days(5,10…. 70th day)	12-61-00	14	0.9
		13-00-45	14	1.8
		Urea	14	12.1
Second stage	71 days to 120 days	12-61-00	10	1.2
		13-00-45	10	5.0

		Urea	10	20.9
Third stage	121 days to 160 days	12-61-00	8	3.1
		13-00-45	8	5.6
		Urea	8	14.1
Fourth stage	161 day to 210 days	12-61-00	10	2.5
		13-00-45	10	6.8
		Urea	10	8.3

Fertigation Schedule for Seasonal (12 months)/Ratoon Sugarcane

Days After Planting	Nutrients (kg/ha/day)		
	N	P2O5	K2O
1-30 Days	1.20	0.10	0.20
31-80 Days	1.50	0.40	0.24
81-110 Days	2.00	1.00	0.40
111-150 Days	0.75	0.30	0.75
151-190 Days	--		1.50

Fertigation Schedule for Preseasonal (14 to 16 months) Sugarcane

Days After Planting	Nutrients (kg/ha/day)		
	N	P2O5	K2O
1-30 Days	1.5	0.15	0.25
31-80 Days	2.0	0.60	0.30
81-110 Days	2.5	1.50	0.50
111-150 Days	0.75	0.50	1.0
151-190 Days	--		1.80

Advantages of fertigation

- Ensures a regular flow of water as well as nutrients resulting in increased growth rates for higher yields
- Offers greater versatility in the timing of the nutrient application to meet specific

crop demands

- Safer application method which eliminates the danger of burning the plant root system
- Offers simpler and more convenient application than soil application of fertilizer thus saving time, labour, equipment and energy
- Improves fertilizer use efficiency
- Reduction of soil compaction and mechanical damage to the crops
- Convenient use of compound and ready-mix nutrient solutions containing also small concentration of micronutrients.
- Free from chlorides and sodium
- No salt build up in the crop root zone
- Most of the fertilizers are blended with micronutrients.

Fertigation Offers Several Distinct Advantages in Comparison to Conventional Application Methods:

- Distribution of plant nutrients more evenly throughout the wetted root zone resulting in increased nutrient availability & uptake contributing to higher crop growth rates and cane yields
- Supply of nutrients incrementally according to the crop developmental phases throughout the season to meet the actual nutritional requirements of the crop
- Careful regulation and monitoring the supply of nutrients
- Application of nutrients to the soil when crop or soil conditions would otherwise prohibit entry into the field with conventional equipment
- Minimal nutrient losses through consumption by weeds, leaching and runoff
- No damage to the crop by root pruning, breakage of leaves, or bending of leaves, as occurs with conventional fertilizer application methods/equipment
- Less energy is expended in application of the fertilizer
- Usually less labour & equipment are required for application of the fertilizer and to supervise the application
- Soil compaction is avoided because heavy equipment never enters the field
- No salt injury to foliage
- Allows rising of crop on marginal lands, where accurate control of water and nutrient ion in the plant's root environment is critical.

Fertilizers Suitable for Fertigation Via Drip Irrigation System

Nutrient	Water soluble fertilizers	Nutrient content
Nitrogen	Urea Ammonium Nitrate Ammonium Sulphate Calcium Nitrate Magnesium Nitrate Urea Ammonium Nitrate Potassium Nitrate	46-0-0 34-0-0 21-0-0 16-0-0 11-0-0 32-0-0 13-0-46

	Monoammonium Phosphate	32-0-0
Phosphorus	Monoammonium Phosphate Monopotassium Phosphate Phosphoric Acid	12-61-0 0-54-32 0-82-0
Potassium	Potassium Chloride Potassium Sulphate Potassium Nitrate Potassium Thiosulphate Monopotassium Phosphate	0-0-60 0-0-50 13-0-46 0-0-25 0-52-34
NPK	Polyfeed	19-19-19 20-20-20
Micronutrients	Fe EDTA Fe DTPA Fe EDDHA Zn EDTA Ca EDTA Rexolin CXK (B+Cu+Fe+Mn+Mo+Zn+Mg)	13 12 6 15 9.7 ---

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Drought Management

Drought

Drought is a meteorological term and is defined as a period without a significant rainfall. Infact, when evapo-transpiration exceeds soil moisture supply i.e. water uptake, the water deficit/drought is resulted.

Sugarcane being a long duration crop which requires more irrigation. In sugarcane, Germination and grand growth phase are the two important periods which requires more irrigation. In India this period comes on summer months and availability of water is poor. So the requirement of water is insufficient during those period which leads to drying of crop and yield loss.

Drought Management:

1. Planting of sugarcane in early season at the depth of 30 cm in furrow.
2. In drought area plant the setts with spacing of 60-75 cm instead of 90 cm.
3. Soak the setts in lime solution (80 kg Kiln lime in 400 lit water) for one hour.
4. Removal of dry trash at 5th month and leave it as mulch, in the field. This reduces the temperature upto 2ºC.
5. Spray potash and urea each at 25 gm in 1 litre of water during moisture stress period at 15 days interval.
6. Spray Kaolin (60 g in 1 ltr. of water) to alleviate the water stress.
7. Under water scarcity condition, alternate furrow and skip furrow irrigation method is beneficial.

8. Apply 125 kg of Muriate of Potash additionally at 120 day of planting.
9. Basal incorporation of coir waste @ 25 tonnes/ha at the time of last ploughing.
10. Use drought tolerant resistant varieties like Co 86032, Co 99004, Co 94008 and Co 86249

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Irrigation Management :: Sugarcane

Sugarcane

Water Management

Irrigate the crop depending upon the need during different phases of the crop.

Germination phase (0 - 35 days):

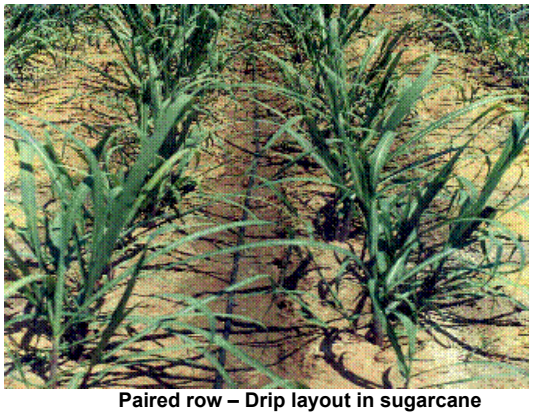
- Provide shallow wetting with 2 to 3 cm depth of water at shorter intervals especially for sandy soil for enhancing the germination.
- Sprinkler irrigation is the suitable method to satisfy the requirement, during initial stages.
- Later, irrigation can be provided at 0.75, 0.75 and 0.50 IW/CPE ratio during tillering, grandgrowth and maturity phases respectively.

The irrigation intervals in each phase are given below:

Stages	Days of irrigation interval	
	Sandy soil	Clay soil
Tillering phase (36 to 100 days)	8	10
Grand growth phase (101 - 270 days)	8	10
Maturity phase (271 - harvest)	10	14

Drip Irrigation:

- Planting setts obtained from 6-7 months old healthy nursery and planted in paired row planting system with the spacing of 30x30x30 / 150 cm.
- Nine setts per metre per row have to be planted on either sides of the ridge thus making it as four row planting system.
- 12 mm drip laterals have to be placed in the middle ridge of each furrow with the lateral spacing of 240 cm & 8 ‘Lph’ clog free drippers should be placed with a spacing of 75 cm on the lateral lines. The lateral length should not exceed more than 30-40 m.
- Phosphorus @ 62.5 kg ha-1 has to be applied as basal a the time of planting.
- Nitrogen and Potassium @ 275:112.5 kg ha-1 have to be injected into the system as urea and muriate of potash by using “Ventury” assembly in 10-12 equal splits starting from 15 to 150-180 days after planting.
- Low or medium in nutrient status soil to be given with 50 per cent additional dose of Nitrogen and Potassium.
- Irrigation is given once in three days based on the evapo-transpiration demand of the crop.



Paired row – Drip layout in sugarcane

Source:http://www.tnau.ac.in/tech/swc/fertigation.pdf

Concept of fertigation

- Fertigation is the judicious application of fertilizers by combining with irrigation water.
- Fertigation can be achieved through fertilizer tank, venturi System, Injector Pump, Non-Electric Proportional Liquid Dispenser (NEPLD) and Automated system
- .
- Recommended N & K @ of 275 and 112.5 kg. ha-1 may be applied in 14 equal splits with 15 days interval from 15 DAP.
- 25 kg N and 8 kg K2O per ha per split.
- Urea and MOP (white potash) fertilisers can be used as N and K sources respectively
- Fertigation up to 210 DAP can also be recommended

Advantages of Fertigation

- Ensures a regular flow of water as well as nutrients resulting in increased growth rates for higher yields
- Offers greater versatility in the timing of the nutrient application to meet specific crop demands
- Improves availability of nutrients and their uptake by the roots
- Safer application method which eliminates the danger of burning the plant root system
- Offers simpler and more convenient application than soil application of fertilizer thus saving time, labour, equipment and energy
- Improves fertilizer use efficiency
- Reduction of soil compaction and mechanical damage to the crops
- Potential reduction of environmental contamination
- Convenient use of compound and ready-mix nutrient solutions containing also small concentration of micronutrients.

Contingent plan

Gradual widening of furrow:

At the time of planting, form furrow at a width of 30 cm initially. After that, widen the furrow to 45 cm on 45th day during first light earthing up and subsequently deepen the furrow on 90th day to save 35% of water.

Subsurface irrigation in sugarcane

Pit method of sugarcane planting under drip fertigation system Technology

- Pit to pit spacing - 1.5 x 1.5 m
- Number of pits/ha - 4,444 pits
- Pit diameter - 0.9 m
- Pit depth - 0.38 m
- Number of budded setts / pit- 32 (single budded setts)
- Fill the pits to a depth of 15 cm with compost and native soil and mix it well. Place the healthy setts in circular fashion leaving 10 cm from the outer boundary of the pits with equal spacing between each setts and cover the setts with soil. On 50 to 60 days after planting give partial earthing up by sliding the soil from the outer boundary of the pit and full earthing up should be given leaving a depression of 2.5 cm from the ground level at 90 to 100 days after planting
- Fertilizer dose - 275:62.5:112.5kg NPK/ha
- The entire phosphorous dose can be applied as basal at the time of planting
- The nitrogen and potassium as urea and MOP (white potash) should be applied through fertigation system in 14 equal splits starting from 15 DAP upto 210 DAP
- Drip design -lateral to lateral spacing 3.0 m (alternate rows)
- 8 mm micro tubes on either side of the lateral to a length of 1.0 m with one 8 LPH drippers / pit
- Irrigation - daily or in alternative days

Benefits

- Higher cane yield
- Multi rationing is possible
- Suited in problem soils
- More water saving
- System maintenance is easy
- Less labour for after cultivation operations
- Higher net return

Economics

Pit planting of cane in 1.5 m x 1.5 m pit spacing registered the highest net return of Rs.1, 19,649 ha-1 and 1, 55,982 ha-1 with in BCR of 2.26 and 3.31 in plant and ratoon crops respectively compared to the net return of Rs.1,16,650 and 1,27,360 registered in conventional method of cane cultivation in plant and ratoon crops**.**

Source: TNAU, Coimbatore, 2006

Pit method of sugarcane planting under drip fertigation system

Expert System For Sugarcane

Crop Protection

About Crop Protection

- **Pest Management**
- **Disease Management**

Pest Management

Sugarcane crop is affected by more than 60 insects of which about 10 insects are rather more important as far as the yield loss is concerned. Among the major insects damaging sugarcane, borers, sucking pests, soil dwelling insects are more prevalent in Tamil Nadu and adjoining states which account 20% loss in cane yield 15% loss in sugar yield.

Sl.No	Common Name	Scientific Name	Family	Order
1	Early shoot borer	*Chilo infuscatellus*	Crambidae	Lepidoptera
2	Internode borer	*Chilo sacchariphagus indicus*	Crambidae	Lepidoptera
3	Top borer	*Scirphophaga excerptalis*	Pyralidae	Lepidoptera
4	Termites	*Odontotermes obesus*	Termitidae	Isoptera
5	White grubs	*Holotrichia Consanguinea*	Melolonthidae	COleoptera
6	Woolly aphid	*Ceratovacuna lanigera*	Phempigidae	Hemiptera
7	White fly	*Aleurolobus barodensis Neomaskellia bergii N . andropogonis*	Aleyrodidae	Hemiptera
8	Mealy bug	*Saccharicoccus sacchari*	Pseudococcidae	Hemiptera

Categories

9	Scale insects	*Melanaspis glomerata*	Diaspididae	Hemiptera
10	Nematode	*Reniform nematode* - *Rotylenchulus reniformis.* Root knot nematode – *Meloidogyne spp* Lance nematode – *Hoplolaimus indicus* Lesion nematode - *Pratylenchus coffeae*	Trichostrongylidae	Monhysterida
11	Grasshopper			

Early shoot borer, *Chilo infuscatellus snellen*

Discription:

Tamil Nadu, Andra Pradesh, U.P., Bihar, West Bengal, Maharastra, Madhya Pradesh, Punjab, Rajasthan. In Tamil Nadu, its occurance is noted in all sugarcane growing areas.

Symptom of damage:

Dead heart in 1-3 month old crop, which can be easily pulled out, rotten portion of the straw coloured dead – heart emites an offensive odour. A number of bore holes at the base of the shoot just above the ground level.

Life cycle:

- **Egg:** Flat – scale like eggs are laid in 3-5 rows on the lower surface of leaves in masses of 4-100. The masses are slightly overlapping like tiles. It hatches 4-6days.
- **Larva:** Larva is dirty white with five dark violet

longitudinal stripes and dark brown head. Duration 16-30days.

- **Pupa:** Pupation takes within the tunnel. Caterpillar before pupating makes a large exit hole in the stem and blocks the opening with silken discs.
- **Adult:** Pale greyish brown moth with black dots near the coastal margin of the forewings and with white hind wings.

Management:
Cultural method:

- Use resistant varities like CO 312, CO 421, CO 661, CO 917 and CO 853
- Early planting during December – January escapes the shoot borer incidence.
- Daincha intercropped sugarcane record the lowest early shoot borer incidence.
- Trash mulching along the ridges to a thickness of 10-15 cm 3 days after planting.
- Ensure adequate moisture to bring down the soil temperature and increase humidity (unfavourable condition for the multiplication of early shoots borer).

Physical method:

- Remove and destroy dead hearts.

Biological method:

- Apply granulosis virus 1.1 x 10 5 IBS / ml (750 diseased larvae / ha) twice on 35 and 50 DAP.
- Release 125 gravid females of sturmiopsis inferens a tachinid parasite per ac.

Chemical method

- Apply any one of the following insecticides if the pest crosses ETL.
- Carboryl +Lindane (Sevidol) 4% G 12.5 kg, lindane 10 G 12.5 kg, Carbofuron 3G 33 kg (Soil application). The granular application should be immediately followed by irrigation.
- Chlorpyriphos 1000 ml a sticker like Teepol (250 ml / 500 l of water) can also be added to make the solution stick on to the surface of the crop and it is preferable to use high volume sprayer to be most effective.

Internode Borer, *Chilo sacchariphagus indicus* (Kapur)

Distribution:

Major pest in tropical India

Symptom of damage:

Internodes constricted and shortened, with a number of boreholes and fresh excreta in the nodal region. Affected tissues reddened.

Nature of damage:

Caterpillars attack sugarcane plants after 3 months of planting. They bore into the canes near the nodes; entry holes are plugged with excreta. Entry is generally confined to the first five internodes.

Life cycle:

- **Egg:** Scale – like oval, flat, shiny and waxy white eggs are laid by female moths in batches of 9-11, near the midribs, on leaf sheaths or on stem.
- **Larva:** White larva with four violet longitudinal stripes and light brown head.
- **Pupa:** Pupation takes place in semi – dried sheath. Pupal period 7 - 10 days
- **Adult:** straw coloured with a dark spot on each of the forewings

Management:

Cultural method:

- Use resistant varities like CO 975,COJ 46 and CO 7304
- Select internode borer damage free setts for planting
- Detrashing & burying the trash during the 5th, 7th and 9th month

Physical method:

- Collect and destroy the eggs periodically.
- Detrash the crop on 150th and 210th day of planting. Detrashing dislodge the pupae that remain in the leaf sheath.

Biological method:

- Release egg parasite, Trichogramma chilonis at the rate of 2.5 cc / release / ha. Six release at fortnightly intervals starting from 4th month onwards.
- Setting pheromone traps at spindle level on 5th month of the crop at the rate of 6 traps per acre in a 15 metre grid. The pheromone septa need to be changed twice at 75

days interval.

Chemical method:

- Avoid the use of excessive nitrogenous fertilizers.

Top Borer, *Scirpophaa excerptalis (Fb.)*

Distribution:
Present in all states. In Tamil Nadu it is severe in Trichy, Tanjore and Cuddalore districts.

Symptom of damage:

- Dead heart arise on after sixth month grown up canes, which cannot be easily pulled.
- Parallel row of shot holes in the emerging leaves.
- Bore holes at the top of the shoot and shows bunchy top appearance.

Nature of damage:
Caterpillars are mainly found in the apical portion of the canes, boring through the growing point and down the upper joints until it reaches the sappy portion of the stem, there it feeds on the tissues and destroys the cane. They also bore into the unfolded leaves preferably into the midrib, mining its way to the base.

Life cycle:

- **Egg:** Eggs are laid on the lower surface of top leaves in clusters particularly near midribs. The clusters are covered with buff coloured hairs. : 10-80 eggs per egg mass
- **Larva:** Smooth, white or cream coloured with a red coloured mid – dorsal line and yellow head.
- **Pupa:** Pupation takes place within the larval tunnel in a chamber with an exit hole Constructed by the caterpillar. Pupal period 6 - 21 days
- **Adult:** White Coloured moth (with a buff Coloured anal tuft in the abdominal tip of female)

Management:

Cultural method:

- Use resistant variety CO 419, CO 745 and CO 6516 and tolerant varieties Co 859, Co 1158 and Co 7224.

Physical method:

- Collect and destroy the egg masses.

Biological method:

- Release Ichneumonid parasitized Gambroides (Isotima) javensis @ 100 pairs / ha as prepupal parasitoid.

Chemical method:

- Application of Carbofuran 3G 1 kg a.i/ha or Thimet 10G 3 kg a.i/ha

Termites, *Odontotermes obesus Rhamb*

Symptom of damage:

Poor germination of setts (after planting), characteristic semi – circular feeding marks on the margin of the leaves in the standing crop. Causes yellowing and drying of outer leaves first followed by the inner leaves Entire shoot dries up and can be pulled out. Setts hollow inside and may be filled with soil. Cane collapses if disturbed; rind filled with mud.

Life cycle:

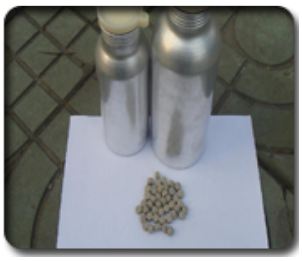
Eggs: Dull, kidney shaped and hatches in 30-90 days
Nymphs: Moult 8-9 times and are full grown in 6-12 months

Adult: Creamy coloured tiny insects resembling ants with dark coloured head

Management:

Cultural method:

- Flood irrigation at the time of planting.



Physical method:

- Locate and destroy the termite colony.
- Collect and destroy the termite affected setts from the field.

Chemical method:

- Fumigate the termite mounds with aluminium phosphate 2 tablets / 1 meter/Mounds.
- Dip the setts in imidacloprid 70WS 0.1% or chlopyriphos 20 EC 0.04% for 5min.
- Treat the soil with lindane 1.6 D @ 50 kg / ha or
- Apply 125 kg of heptachlor 3 % D per ha in the furrows at time of planting.

White Grub, Holotrichia consanguinea (Blanch)

Symptom of damage:

- Yellowing and wilting of leaves.
- Drying of entire crown.
- Affected canes come off easily when pulled.
- Cause extensive damage to roots and base of shoot.

Life cycle:

Egg: A female lays on an average of 27 eggs in the soil, which are pear like white enclosed in earthen cells.
Grub: Fleshy 'C' shaped, whitish yellow in colour found close to the base of the clump.
Pupa: Pupae are tan to brown, and occur deeper in the soil in earthen chambers.
Adult: Adult beetles are a rusty-red color just after emerging from the pupal stage, but turn nearly black.

Management:

Cultural method:

- Provide adequate irrigation.
- Deep ploughing immediately after harvesting.

Physical method:

- Set up light trap.
- Collect and destroy the adult beetles.

Chemical method:

- Apply lindane 1.6 D @ 50 kg/ha near the root zone.

Sugarcane Wooly Aphid, *Ceratovacuna lanigera*

Symptoms:

Adults and nymphs desap leaves by piercing styles through stomata. Whitish patches – coalesce to turn yellowish and drying from the tip along margins. Leaves become brittle and dries completely. Heavy secretion of honey dew – development of sooty mould. Deposition of wooly matter on ground / soil distinctly visible.

Life cycle:

Adult emerged after fourth moult and viviparous reproduction. Apterous (Wingless) female reproduce parthenogenetically. Each femal produced about 15 – 35 young ones within 24 hr after mating. Each female reproduces maximum of 217 nymphs during the period of 20 days. The female are more in the population, which leads to fast multiplication. Nymph takes 6 to 22 days to complete four instars and become adult.

The life cycle of female complete within one – month period. The longevity of adult is from 32 to 57 days. The life cycle may vary according to the climatic conditions and variety. In most of the affected fields at various locations all the nymphal instars and adults are noticed. In extreme cases, the winter is passed as eggs which are laid during the previous autumn by sexual females. In spring they hatch and give rise to apterous parthenogenetic viviparous females. The winged females appear in such swarms as to darken the sky and cover the vegetation. The non-migratory species, the whole life – cycle is spent on the same plant.

Management:

Cultural Method:

- Paired row system of planting.
- Avoid excessive use of nitrogenous fertilizers.
- Use of organic fertilizers.
- Rapping of canes all along the rows.
- Infested tops should not be transported.
- Infested canes should not be used as seed for planting.

Biological Method:

1. Encourage local predators like Diapha aphidivora Meyrick – Pyralidae
    a. Ishchiodon scutellaris
    b. Episyrphus baleatus – Syrphidae
    c. Chrysopa spp. – Chryospidae
    d. Schymnus sp.
    e. Cheilomeness sexmaculata, Coccinella

septempunctata, Synnonycha grandis

f. Brumus sp. and

g. Dideopsis aegrota – Coccinellidae

2. Pathogens like Cladosporium oxysporum, Metarhizium anisopliae, Verticillium lecanii and Beauveria bassiana

Chemical Method:
Dip the seed sets in Chlorpyripos 20 EC solution (2 ml / lit) before planting. Apply phorate 10 G @ 5kg / ac or Spray with acephate75 SP 1g / lit Chlorpyriphos 20 EC 2 ml / lit Malathion 50 EC 2 ml / lit Dimethoate 30 EC 1.7 ml / lit, Oxydemeton methyl 25 EC 1.3 ml / lit, Dusting with Malathion 5% dust @ 10 kg / ac.

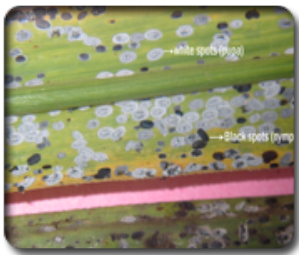
Whiteflies, *Aleurolobus barodensis*

Symptom of damage:

- Yellowing of leaves
- Leaf turns pinkish or purple and later gradually dry.
- Infested leaves look white and black dots.

Life cycle:

- **Egg:** Females lay eggs in a line near the midrib or any where on the lower surface of the leaves. Eggs are yellowish with a small curved stalk. Colour changes to black about two hours after the eggs are laid.
- **Nymph & Pupa:** Neonate nymphs are pale yellow in colour, flat and oval in shape, later turn shiny black. Its body is surrounded by fringes of wax.The fourth instar being the pupal stage, is flat, oval, grayish in colour and slightly bigger than the nymph. There is a 'T' shaped white marking on the thorax, which splits at the time of adult emergence.
- **Adult:** Pale yellow body with hyaline wings dusted with waxy bloom, exhibit brisk fluttering movements.



Management:

Cultural Method:
Avoid indiscriminate use of insecticides for control of other pests such as pyrilla, black bug, wooly aphids

Mechanical Method:
Detrashing the puparia bearing leaves and immediately disposing by burning or burying to prevent emergence of adult white flies

Chemical Method:
Spray fenitrothion 50 EC @ 2 lit / ha (1000 lit spray fluid)

Mealybug, *Saccharicoccus sacchari*

Symptom of damage:

Pinkish oval insects beneath leaf sheath on the nodes, with whitish mealy coating, main cane stunned also attack roots. Sooty mould develops on the honey dew giving blackish appearance on canes.

Life cycle:

Eggs: Eggs are retained in the female reproductive organs untils almost fully mature. Incubation period is short. The females may bring forth hundreds of young ones parthenogenetically. Egg is yellowish, smooth, cylindrical and rounded at both ends.
Nymph: Newly emerged nymphs are quite active with a pinkish transparent body.
Adult: White with mealy coating, sessile.

Management:

Cultural method:

- Use resistant varieties like CO 439, CO 443, CO 720, CO 730 and CO 7704
- Drain excess water from the field.

Physical method:

- Detrash the crop on 150 and 210 DAP

Chemical method:

- Apply any one of the following insecticides per ha and when the incidence is noticed spray on the stem only, methyl parathion 50 EC 1000 ml, malathion 50 EC 1000 ml.

Scale Insects, *Melanaspis glomerata* (Green)

Symptom of damage:

- The leaves of infested canes show signs of tip drying and unhealthy pale green colour and with continued infestation these turn yellow.
- Desapping leads to non-opening of leaves also, which also turn yellow and finally dry up.
- Nodal region is more infested than internodal region.
- Infested crop losses its vigour, canes shrivel, growth is stunted and the internodal length is reduced drastically.

- Ultimately cane dries up. Such canes when slit open appear brownish red.

Life cycle:

Nymph: Females multiply ovo-viviparously. The nymphs that hatch out from the eggs within the female's body come out through the genital aperture. They are called 'crawlers'. They settle after selecting suitable site for feeding.
Adult: Greyish black or brown circular scales, they cover the nodal region forming a thick encrustation.

Management:

Cultural method:

- Use resistant varieties like CO 439, CO 443, CO 453, CO 671, CO 691 and CO 692
- Select and plant the scale insect free setts.
- Keep the fields and bunds free from weeds.
- Avoid water stagnation in the field for the longer period.
- Avoid repeated ratoons.

Physical method:

- Detrash the crop at 150th and 210th day of planting.

Biological method:

- Release Chilocoris nigritus (or) Pharascymnus horni.

Chemical method:

- Presoak the setts in 0.1% solution malathion.
- Spray dimethoate 0.06% or 120th and 150th after detrashing.

Nematodes

Symptom:

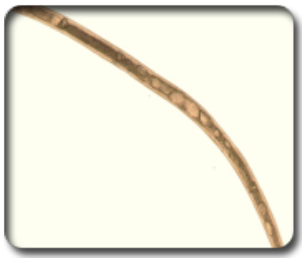
- Usually paling of leaves, first in the form of streaks, later complete yellowing-chlorosis, occurring in patches spread out all over the field. Chlorosis in severe cases, accompanied by drying up of margins and leaf tips is more common in ratoon and young crop.
- Stunting of crop, reduction in number and size of internodes.
- Roots are stubby and spares.
- Affected field shows pale green to whitish look.

Nematode types:

There are several nematodes present in the soil of which, four nematodes are mainly damaging the sugarcane crop. They are:

Lesion nematode - *Pratylenchus coffeae*

Root-lesion nematodes are migratory endoparasites Females of *P. penetrans* lay about 1 or 2 eggs/day for about 35 days, with a maximum of 68 eggs being laid by one female. Eggs are laid singly or in clusters in both soil and roots. Second stage juveniles hatch after eggs have incubated for 9 (30 C) to 25 (15 C) days. Males are required for reproduction by *P. penetrans* but not by *P. neglectus*.

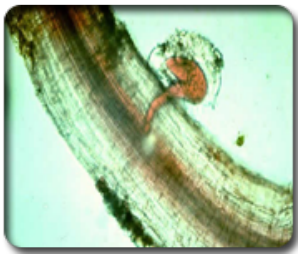


Lance nematode - *Hoplolaimus indicus*

Lance nematodes, Hoplolaimus spp., are ecto-parasites, sometimes semi-endo-parasites. Nematodes which are large and highly resistant to effects of temperature extremes and dry soil conditions. Larvae look similar to adults except that they are smaller.This group of nematodes is easily detected with soil sampling.

Root knot nematode - *Meloidogyne* spp.

Root knot nematodes are microscopic roundworms, obligate endo-parasites that complete most of their life cycle within their host roots. The nematodes survive in soil as eggs and also second stage larvae.



Reniform nematode - Rotylenchulus reniformis.

The term 'reniform' refers to the kidney-shaped body of the mature female. They are semi-endoparasitic (partially inside roots) species in which the females penetrate the root cortex, establish a permanent-feeding site in the stele region of the root and become sedentary or immobile.

Management:

Cultural method:

- Deep ploughing, solarisation, flooding, crop rotation and apply organic manure.
- Under wetland conditions, intercropping with sunnhemp or marigold or daincha
- Apply pressmud at 15 t/ha or poultry manure @ 2 t/ha or neem cake 2 t/ha or poultry manure @ 1 t/ha before last ploughing in garden lands.

Biological method:

- Application of biocontrol agents like *Pochonia chlamydosporia, Paecilomyces lilacinus* or *Trichoderma viride or Pseudomonas fluorescence* @ 20 kg/ha at the time of planting mixed with moist FYM or cured pressmud and distributed uniformly will help in suppressing the plant parasitic nematode.

Chemical method:

- Apply carbofuran 3G @ 33 kg/ha at the time of planting or 2 months after planting or Cartap 3 kg/ha (1.5 kg a.i./ha)

Grasshoppers, *Hieroglyphus banyan*

Symptom of damage:

- Adult and nymph grasshoppers feed on leaves from the margins of the leaf blades creating cutout areas during the solitary stage.
- finally it leaves only the leaf midrib.

Identification of pest:

Egg: Eggs in the form of egg pods, usually more than ten, either in the sand or among leaf litters. Each egg pod consists of about 10-300 eggs that are rice shaped.

Nymph:
Nymphs are miniature versions of adult grasshoppers, except that they are light in colour and do not possess wings. The nymphal stage may last for a period of 5-10 days.

Adult:
After about a month, a nymph becomes an adult. An adult grasshopper lives for 1-2 months.

Management:

Cultural method:

Tillage - Tillage controls grasshoppers primarily by eliminating the green plants on which grasshoppers feed.

Biological method:

Baits containing the protozoan *Nosema locustae* is a biological control option that may be considered for treating grasshopper breeding sites. This is sold under the trade names Nolobait or Semaspore and can produce infection of many species of grasshoppers. Because it is selective in effects, only affecting grasshoppers.

Sugarcane Diseases

Red rot

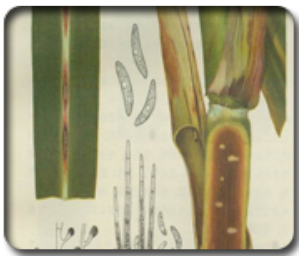
Symptoms

The affected canes exhibit leaf colour change, from green to

orange and then to yellow in the third or fourth leaf. Then the leaves start drying from bottom to top. The cane loses its normal colour and longitudinal discoloration spots / ribs are seen. The internode region shrinks with rupture of tissue in the root eye region and the spores are ejected from these spots. If the fungal spores enter the leaf sheath through the leaf midrib, then reddish spots can be seen on the backside of the leaf midrib also. The external symptoms appear only after16 - 21 days after infection and drying of entire cane takes another 10 days time. When the affected cane is split opened, the inner region is reddish in colour with intermittent white tinges across the cane length. If the variety is highly susceptible or disease incidence is severe, ash colour fungal growth is seen inside the cane. Sometimes, the pith inside the cane is filled with blackish brown liquid and exhibited alchohol odour.

Identification of pathogen

- Red rot disease is caused by the fungus *Glomerella tucumanensis*. An older name, *Colletotrichum falcatum*, is still preferred by some pathologists.
- Pathogen present on leaf sheaths and blades, solitary or aggregated, often forming short lines between vascular bundles, globose, immersed, dark brown to black 65-250 µm diam.; wall up to 8 cells thick, sclerotia on outside, pseudoparenchymatous within, ostiole slightly papillate, circular.



Management

Cultural method:

- The red rot affected field must be rotated with rice for one season and other crops for two seasons.
- Growing of recommended resistant and moderately resistant varieties *viz*., Co 86249, CoSi 95071, CoG 93076, CoC 22, CoSi 6 and CoG 5

Physical method:

- Removal of the affected clumps at an early stage and soil drenching with Carbandazim 50 WP (1 gm in 1 litre of water)

Chemical method:

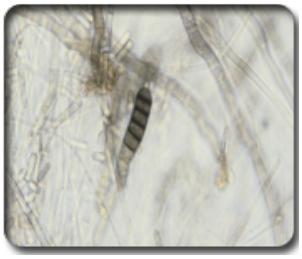
- Adopt sett treatment with Carbendazim before planting (Carbendazim 50 WP (0.5 gm in 1 litre of water) or Carbendazim 25 DS (1gm in 1 litre of water) along with Urea (10 gm in 1 litre of water) for 5 minutes)

Sett Rot

- When diseased setts are planted they may rot before germination, or the shoots may die after reaching a height of about 6-12 inches.
- As the setts get dried up, the reddish colour becomes black with lots of black coloured fungal spores adhering to it.
- If infected shoots survive, they are very much stunted and chlorotic.
- Eventually the leaves may wither and the shoots wilt.
- If the affected shoots and setts are examined the central portion of the shoots will be seen discoloured red and the contents of the sett rotting.
- When split opened, the affected setts exhibit pineapple odour.

Identification of pathogen:

Ceratocytis paradoxa were initially whitish, measuring about 5 mm in diameter. The colonies were turned black due to the production of chlamydospores, which are heavily pigmented, when mature.



Management

Cultural method:

- Proper drainage and planting of setts in 1-2 cm depth.

Chemical method:

- Sett treatment with Carbendazim or bavistin before planting (Bavistin @ 1per cent or Carbendazim 50 WP @0.5 gm in 1 litre of water or Carbendazim 25 DS @ 1gm in 1 litre of water along with Urea @10 gm in 1 litre of water for 5 minutes)

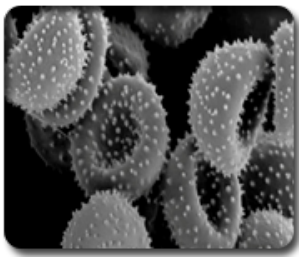
- Pre treatment the setts with hot water has been found to stimulate germination of buds and hasten growth soa s to help the young plants to overcome the competition with the pathogen.

Smut

Symptoms

- Production of whip like structure of 25 – 150 cm. from the growing point of the canes.
- Whip covered by translucent silvery membrane enclosing mass of black powdery spores.
- Initial thin canes with elongated internodes later become reduced in length.
- Profuse sprouting of lateral buds with narrow, erect leaves especially in ratoon crop.

Identification of pathogen



Ustilago scitaminea

The fungal mycelium spores are echinulate, light brown and spherical, measuring 6.5 – 8.5 µ in diameter.

- They germinate readily in water, producing 2-3 celled promycelia.
- sporidia arise terminally or laterally and they are hyaline, thin walled, single celled and elliptical to linear.

Management

Cultural method:

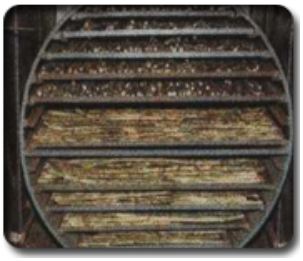
- Growing of resistant and moderately resistant varieties viz., Co 86249, CoG 93076, CoC 22, CoSi 6 and CoG 5
- Discourage ratooning of the diseased crops having more than 10 per cent infection
- *Cajanus cajan* is grown as a companion crop between rows of sugarcane, the secondary spread of the disease is substantially reduced.

Physical method:

- Treating the seed setts with Areated Steam Therapy (AST) at 50 ºC for 1 hour or in hot water at 50 ºC for 30 minutes or at 52 ºC for 18 minutes
- Roguing of smut whips with gunny bags/polythene bag and dipped in boiling water for 1 hour, and diseased clums must be uprooted and burnt

Chemical method:

- Sett treatment with fungicides *viz*., Triadimefon @ 1gm in 1 litre of water or Carbendazim @ 1gm in 1 litre of water for 10 minutes.



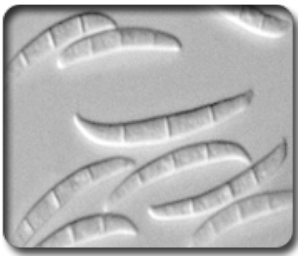
Wilt

Symptoms:

External: Gradual yellowing and drying of foliage, shrinkage/withering of canes.

Internal: Light to dark purplish or brown discolouration of ground tissue, pithiness and boat shaped cavities in the middle of the internodes.

Identification of Pathogen



Conidiosphores usually erect and branched. Macroconidia abundant, falcate to rather straight, 3-5-septate, with a distinct foot-cell, 27-73 × 3.4-5.2 mm. Blastoconidia straight or slightly curved, 2-3-septate, fusiform to lanceolate, with a somewhat pointed, often slightly asymmetrical apical cell and a truncate basal cell, 16-43 × 3.0-4.5 mm.

Management

Cultural method:

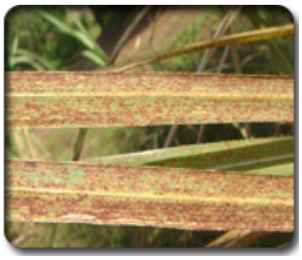
- Healthy seed, sett treatment with fungicides, resistant varieties, crop rotation, managing root borer, avoiding prolonged drought and water logging and hygienic practices.

Chemical Method:

- Dipping the setts in 40 ppm of boron or manganese, or spraying the plants with either of these minor elements reduces the disease intensity.

Rust

Sugarcane rust is mainly a disease of the leaf. The earliest symptoms are small, elongated yellowish spots that are visible on both leaf surfaces. The spots increase in length, turn brown to orange brown or red brown in color. Pustules, which produce spores, usually develop on the lower leaf surface.



Identification of pathogen

Puccinia erianthi

- Uredinia were elongate, reddish-brown, with capitate, hyaline to light brown paraphyses.
- Urediniospores were thick-walled, orange-brown, obovoid, measuring 26-34 x 16-20 µm. The urediniospore surface was echinulate with 4-5 equatorial pores.
- Teliospores were dark brown and measured 30-43 x 17-23 µm, clavate, two-celled and slightly constricted at the septum.

Management

Cultural method:

- Use resistant varieties like Co 91010 (Dhanush), Co 87025 (Kalyani)

Chemical method:

- Spray Tridemorph 1.0 litres or Mancozeb 2.0 kg/ha.

Grassy Shoot Disease

Symptoms

Initial symptom appears in the young crop of 3 – 4 months age as thin papery white young leaves at the top of the cane. Later, white or yellow tillers appear in large number below these leaves (profuse tillering). The cane becomes stunted with reduced internodal length. There is no millable cane formation. At times, one or two canes grow well in the affected tillers with greenish leaves. When these seemingly good canes are used for setts, the following crop produces only whitish leaves; these leaves dry early and gaps in the field.

Mode of spread

- The disease is spread by the use of affected setts for planting.
- Also, the black hopper (*Browtista moesta*) acts as a carrying agent of this disease.

Management

Cultural method:

- Growing resistant varieties viz., Co 86249, CoG 93076 and CoC 22
- Avoid ratooning if GSD incidence is more than 15 % in the plant crop

Physical method:

- Rogue out infected plants in the secondary and commercial seed nursery.
- Treat setts with aerated steam at 50°C for 1 hour to control primary infection.
- Treating them with hot air at 540C for 8 hours and spraying twice a month with aphidicides.

Chemical method

- Spray dimethoate @ 1ml in 1 litre of water to control insect vector

Yellow Leaf Disease

Symptom of Damage:

Yellowing of midrib and adjacent laminar region and subsequent leaf drying along the mid rib in 3 to 5 leaves from top. In some cases reddish discolouration is also seen and in severe cases drying of spindle along with leaves.

Pathogen:

- The virus is transmitted by aphids, *Melanaphis sacchari* and *Rhopalosiphum maidis,* in a semi-persistent manner.
- SCYLV is a member of the Luteoviridae family. The virus is localized within the phloem cells of the plant.

Management

Cultural method:

- Use healthy seed cane
- Field should be maintain with proper hygiene
- Application proper nutritional management and use resistant varieties.

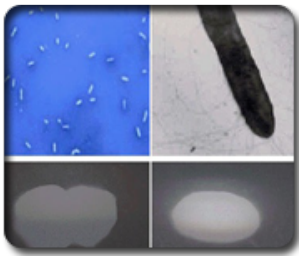
Chemical method:
Secondary transmission of the disease by insect vectors can be controlled by application of Malathion(0.1%) or Dimecron(0.2%).

Ratoon Stunting

The affected plants are stunted, the stunting being most severe in stubble and ratoon crops. Infected stocks is the presence of pin head like orange coloured dots of bacteria on the internal soft tissue in the nodal region The setts taken from diseased plants germinate poorly and the few shoots that are emerge grow very slowly. It is sap-transmissible and no insect vector has been found.

Pathogen

The organism that causes RSD is, *Leifsonia xyli* subsp. *xyli,* a small aerobic bacterium. The genus ofthe pathogen was previously called *Clavibacter.*



Management

Cultural method:

- Select healthy setts for planting.

Mechanical method:

Treat setts with hot water at 50°C for about 2 hours give 100 per cent control.

Sugarcane Farming Process (Step by Step Farming Process) Agriculture

Sugarcane plant is a coarse grass which is quite tall about 10-20 feet. A single plant bears many stems in a tuft. It is a rhizomatous, perennial plant with thick solid, aerial stem. The stem colour is variable from white, yellow, black, dark green, purple, and red or violet.

It is jointed and inter nodes are smaller at the base and increase in length, until it terminates in inflorescence. There are present prop or shit roots at the lower nodes to give mechanical strength to the stem on the nodes axial buds are present. Stem contains colored tissues in which many fibro vascular bundles lie. The inflorescence called an arrow or tarsal.

Soil Required for Sugarcane Cultivation:

Sugarcane grows best on the medium heavy soils, but can also be raised on the lighter soil sand heavy clay, provided there is adequate irrigation available in the former type of soils and drainage is good in the latter type of soils. In northern India, it is cultivated largely on the loams and clay loams of the gangetic and other alluviums, whereas in Peninsular India, it is grown on brown or reddish loams, laterites and black cotton soils.

In many places, dark rich clay loams, 120 to 150 cm deep and lying on a previous substratum of murum (disintegrated traprock) are used for this crop. The pH of the soil must be within 6.0-8.0.Sugarcane production is affected by unfavorable soil reaction (pH).The soil should be reclaimed according to acidity, alkalinity and other problems hindering the production of sugarcane.

The main characteristics of the soils suitable for sugarcane cultivation are that it must possess high contents of organic matter and is well drained. Therefore, heavy clay soil with proper drainage or light soils with irrigation facilities are also favorable for this crop.

Atmospheric Condition Required for Sugarcane Cultivation:

Sugarcane grows as well at a temperature of 21° to 26.2°C. A temperature of 20-23.7°C is ideal for good germination. Temperature above 32.2°C and below 18.3°C arrests the growth of the plant.

Sunlight is another key element which influences the yield and quality of cane. Sugarcane loves warmth and sunshine. Sugarcane requires long day for its vegetative growth and short day for its reproductive growth. Day length considerably influences

tillering. Short day length decreases number of tillers per plant and ultimately the tonnage.

Day length determines the flowering of the crop. Plant grows under long day conditions produces more dry matter. About 8-10hr of bright sunshine is conducive for yield and sugar output.
Shorter days favour tasselling or flowering. Bright sunshine is required the development stages of this crop. Under this condition, sugar content of this crop increases.
The physiological studies show that under good or bright sunshine, stems are thicker, shorter and leaves are broader and greener. Under less sunshine as is the case of cane grown as lower storey in coconut gardens, stems are slender, and taller having thinner and narrower leaves.

Rainfall:

Sugarcane does best in tropical and sub-tropical regions having rainfall of 75-100cm per annum. It requires heavy rainfall (150 cm) during its vegetative growth period. It grows well in an area receiving 100-175cm rainfall per annum.

In high rainfall areas (125-200 cm), this crop is grown without irrigation and thrives on the moisture conserved in the soil. Too heavy rainfall and prolong drought affects the crop adversely. Heavy rain lowers the sugar content and dry condition makes the cane fibrous.

Relative Humidity (RH):

High humidities (85 to 90%) are conducive for growth and development. But 45-65% RH is desired for sugar build up in cane stalks. In coastal areas high humidities and high temperature favour good growth and high yields. But sugar recoveries are low.

Atmospheric CO_2 Concentration:

Sugarcane benefits from increased atmospheric CO_2 concentration.
Generally photosynthetic rate increases as CO_2 concentration increases from 0.01 to 0.07% but becomes saturated at 0.06%. Varietal differences have also been observed. A strong and positive interaction is found between CO_2 and light. With increased sunlight, CO_2 fixation is also increased.

Frost:

Sugarcane experiences frost, which seriously reduces yield and quality. A temperature of -1 to -2 °C kills the plants. Severe cold conditions adversely affect ratoon sprouting and tiller formation. Irrigation just prior to frost and trash/polythene mulching mitigate frost to a great extent.

Effect of Climate on Ripening:

Ripening is influenced by rainfall, humidity, sunshine, night length, altitude, temperature and cultivar. For effective ripening, distinct cooler nights, and dry frost free sunny days are essential. High diurnal variation in temperature is not conducive for sugar accumulation. Ripening and maturity are influenced by the soil moisture.

Better drying-off strategy maximises the sugar output. Cane yield cannot increase after the Readily Available Water (RAW) has been extracted, but sugar yield can increase substantially while the remaining soil water is extracted. A mean dry temperature of 12-14 °C is desirable for proper ripening. At higher temperature during ripening, inversion takes place with considerably reduced sugar recoveries.

Preparation of Land for Sugarcane Cultivation:
The land is brought to fine tilt by ploughing with tractor or power tiller followed by planking after each ploughing. Plough the land thrice length wise and breadth wise and level properly. Prepare furrows 25 cm deep and 75 cm apart for short duration and 90 cm apart for medium duration varieties.

In hills tracts prepare pits in rows along the contour at spacing of 30 cm in the row and 75 cm between the rows. For mid late varieties, an inter row spacing of 75 cm is recommended.
Compost or F.Y.M @ 15-20 tonnes per hectare should be applied about 30 days before planting and thoroughly mixed with soil during land

preparation. The soil should be made free from stubbles, weeds and clods.

Sowing:

Efficient care and precautions should be taken while selecting the cuttings, treating it with chemicals at the time of planting.

Selection of Setts:

Stem cuttings or sections of the stalks are called “setts” or seed pieces. Each sett contains one or more buds.
Sugarcane crop is propagated by stem- cutting. The sugarcane sett should be taken from well matured, erect and healthy crop of not more than 10-12 months of age. The upper-half-portion of the plant bears buds of high viability and is best for raising new crop.

The top portion contains less sucrose and bud remains young and active due to which it germinates well. Cane setts of two or three nodes, bearing 3 or 4 vegetative buds are made from the healthy, free from insect pests and diseases, top portions of the plants after hand peeling. The sugarcane sett having red spot on the cut end should not be used for planting.

The implement used for cutting the sett

should be treated with spirit or solution of seed treatment chemical. Generally, three bud setts are used for planting throughout the world, while in some areas two-bud setts are also used. About 35,000 sets is required for one hectare.

Sett Treatment:

Cane-seed-setts are wet and sugary, therefore, while in soil, before sprouting into new plant, these are mostly damaged by insects (termites) and fungus. To avoid these losses, the sets, before planting, are treated before planting by different ways depending upon the condition of planting material.

(i) 1% Fish Oil Rosin Soap Treatment:

The sets are treated with 1 % fish oil rosin shop solution to stop spread of mealy bugs and scale insects.

(ii) 6% Mercurial Fungicide Treatment:

The sets are dipped for 2 to 3 minutes in a solution of 6 % mercurial fungicide like agallol or cerasan @ 500 gm. in 100 liter water. This treatment helps to prevent set borne diseases like smut

and to improve germination.

(iii) Hot Water Treatment:

The sets are kept in hot water at 50°C temperature for two hours to control red-rot, grassy shoots and other virus diseases.

(iv) Azotobacter Treatment:

Just before planting sets are dipped in azotobacter inoculant solution which is prepared by mixing 5 kg. azotobacter inoculants in 100 liter water for 2 to 3 minutes. This treatment helps in good germination and save nitrogenous fertilizers.

(v) Lime Water Treatment:

Sets are soaked in lime water solution prepared by dissolving 500 g lime in 200 liter water for 24 hrs to improve germination. This treatment is given only when dry scaled bud sets and staled cane sets are used for planting.

Time of Planting:

The best time of planting the sugarcane setts for spring crop is the period when the atmospheric temperature records an average of 25°C. Therefore, the time of sowing in Tamil Nadu, Andhra

Pradesh, Maharashtra and Karnataka is earlier (i.e. December – January) than the time of sowing in Punjab, Haryana, Uttar Pradesh (February – March).

The crop can be sown round the year. Crop planted before winter season gives less sprouting and tillers due to cold weather, during early sprouting stage. The duration of sugarcane crop in India ranges from 10-18 months. A 12 months crop is most common. Time of planting is governed by weather conditions. Sugarcane requires about 25-320 C temperature for good germination. Spring and autumn plantings are two important planting seasons.

Spring Planting:

In Northern India spring planting is done in February-March while in Peninsular India it is done in January- February. Spring planted crop is known as suru in Maharashtra and eksali in Gujarat and Andhra Pradesh.

Autumn Planting:

This planting is very popular in Northern India. This planting is done in September-October while in Bihar and Peninsular India it is done in

October – November. Autumn planting is also known as pre-seasonal planting in Maharashtra and Gujarat. The pre- seasonal crop matures in 13-15 months and supplies sugarcane in early crushing period.

Adsali Planting:

In Maharashtra and Karnataka, adsali planting is done in July-August and the crop matures in 16-18 months. Because of extended growing season, there is increase in yield as well as sugar recovery. Biggest advantage of adsali is that it passes through only one summer season. In the present scenario, area under adsali planting is declining because of less availability of irrigation water.

Late Planting:

Because of wheat crop is taken on large area in rabi season in Northern and Central India, planting of sugarcane is delayed until harvesting of wheat in March-April. Research data has been proved conclusively that delay in planting causes considerable yield reduction.

Method of Sowing:

Sugarcane crop is sown by various

methods, depending upon the field problems.

Common methods of planting are described here:

(i) Flat Planting:

Flat planting method is mostly common in intensive sugarcane growing areas where soil-moisture is available in plenty. Sets are kept in shallow (8-10 cm) deep furrows at 75 cm apart. On an average, one viable bud per ten centimeter length in each furrow is planted (i.e. one sett/feet). The field is heavily planked. This method of sowing is popular in North India.

(ii) Furrow Planting:

Furrow planting method is mostly common under low soil moisture condition. In this method the ridges and furrows are opened with the help of ridge by keeping 120 cm distance between furrows in heavy soil and 105 cm distance in light to medium soil. After sowing irrigation is given immediately. First sets are laid on the top ridges end to end and later planted in furrows by two ways known as wet method and dry method of planting.

a. Wet Method:

This method is followed in light to medium soil. Irrigation is given to the field before planting. Sets are planted by pressing 2.5 to 5 cm deep in furrows with feet or hand. The sets are placed end to end by facing buds on sides.

b. Dry Method:

This method is followed in heavy soil to avoid the pressing as sets deep into the soil. Sets are placed in the furrow end to end by facing eye buds on sides and covered by giving a layer of soil. After completion of planting irrigation is given to the field.

(iii) Trench Method:

In some coastal areas as well as in other areas where the crop grows very tall and the strong winds during rainy season cause lodging of cane, trench method is adopted to save the crop from lodging. Trenches at a distance of 75-90 cm are dug with the help of ridger or by manual labour. Trenches should be about 20-25 cm deep. After this already prepared mixture of fertilizers (NPK) should be spread uniformly in the trenches and mixed thoroughly in the soil.

The setts are planted end to end in trenches. Gamma BHC 20 EC at the rate of 5 liters in 800-1000 liters of water per hectare is sprayed over planted setts in trenches to control termites and shoot and root borers. Immediately after this, trenches are filled up with loose soil as in case of flat sowing. The tractor-drawn sugarcane planter is a very suitable device for planting cane in trenches.

After Care:

After sowing, the sugarcane field requires some immediate cares like hoeing and protection from insects and farm animals. The fields are irrigated within a few days after sowing to get required soil conditions for hoeing.

Hoeing assists in the emergence of sprouts and increases the plant population in the field. The new emerging shoots are tender and palatable for animals to eat. Therefore, a number of insects and farm animals are attracted towards it and they require due protection measures.

Manures and Fertilizers:

Sugarcane is a heavy feeder and it occupied the land for about twelve months. Sugarcane depletes large

quantity of plant nutrients and makes the soil infertile. In this condition, the growth of the plant as well as yield of sugarcane reduces considerably. So adequate manuring is essential for getting higher yield of sugarcane. The nutrient requirements have been found more important in three stages of growth except ripening phase.

The nutrient requirement of sugarcane varies accordingly to the growing region, variety and fertility status of the soil as follows:

(i) Manures:

Farmyard manure is added one month before planting at the rate of 10-12 tonnes of well decomposed manure, to improve the soil texture and water holding capacity. Mustard oilcake or Neem cake (Qty.: 300kg/ha), if possible should be applied. Organic manures are good for sugarcane crops the same provides nutrient throughout the growing period of this crop.

(ii) Fertilizers:

Fertilizers are applied based on the recommendation of the soil test. For general purpose 300 kg nitrogen, 80 kg phosphorus, 80 kg potash and 80 kg

calcium per hectare are applied. Half dose of nitrogen and full dose of other fertilizers are placed in furrows below or on the side of cane-sets, at the time of sowing as a basal dose.

The rest of the nitrogen is applied in two split doses as topdressing during plant growth period. The application of fertilizer at the early stage of plant growth is advantageous, and increases the sucrose contents in the juice.

Water Management:

Sugarcane needs optimum moisture during all stages of growth. The vegetative growth period of the sugarcane crop can be looked upon in four stages i.e. (i) Sprouting stage, (ii) Formative stage, (iii) Grand growth stage and (iv) Maturity stage.

The water requirement of sugarcane varies from 200- 300 depending upon the soil type and weather conditions, method of planting, timely irrigations result in more juice with high sucrose contents. After the monsoon, mostly 6- 7 irrigations are required for successful crop production.

Irrigation:

In the case of sugarcane, the

maintenance of optimum soil moisture during all stages of growth is one of the essential requisites for obtaining high yields. The crop should, therefore, be grown in areas of well-distributed rainfall or under an assured and adequate irrigation.

In tropical India, depending on the type of the soil, the seasonal conditions, the variety grown, the method of planting and the rate of manuring, the total water requirement of the crop for optimum growth varies from 200 to 300 cm, inclusive of rainfall.

The requirement of an adsali crop is proportionately higher. Where the soil is not retentive of moisture, and where there are no reserves of subsoil moisture, cane requires to be irrigated frequently. In tropical India, usually one or two waterings are given at intervals of three or four days after planting to help the setts to germinate and the seedlings to establish themselves.

Thereafter, in the absence of rains, cane is irrigated every 10 to 12 days during its growing period. In dry areas and in sandy-loams soils, irrigations may be needed at intervals as short as

eight days. In deep clay loams, irrigation can be withheld for longer periods, say, up to two or three weeks.

Frequent light irrigations, each 40 to 50 mm, adjusted to suit the growing period of the crop and the prevalent weather conditions, are very useful. Towards the time of harvesting, irrigation frequency is reduced, and just before harvest, irrigation is withheld for about a month.

In Northern India the summer being drier and hotter the crop needs water more frequently than in southern India, but actually, adequate water for frequent irrigation is not available and irrigations are, therefore, usually given at comparatively long intervals. In canal irrigated areas, the frequency of irrigation depends entirely on the running of the canals.

The severity of these conditions is slightly mitigated by the high water- holding capacity of the alluvial loam soil. In the Punjab State because of the lower rainfall, drier climate, and slightly coarser soils, the crop gets 8 to 10 irrigations during summer. In Central and Western Uttar Pradesh three to five irrigations are usually given, and they help the crop to tide

over the summer.

In the eastern Gangetic areas, cane subsists almost entirely on subsoil moisture and rainfall, and receives no irrigation at all. In the post-monsoon season the crop receives only one or two irrigations or none at all, however these post monsoon irrigations only help to keep the crop in good condition, for cane does not make growth in winter.

In areas where frost occurs, irrigations are applied to save the crop from them. Sugarcane responds to irrigation in northern India as it does in the south and it is profitable to apply frequent light irrigations to the crop during the hot weather. Where irrigation facilities are scarce in summer, trash-mulching in the interspaces of the cane rows is done for conserving the soil moisture.

Interculture:

As the crop remains in the field for a long period, intercultural operation such as hoeing, weeding, earthing up, wrapping and trashing needs to be done.

i. Hoeing:

Hoeing is done first by a week or so

after planting in order to break the surface crust, else light irrigation is followed by the same period in order to help emergence of sprouts.

ii. Weeding:

Weeds are undesirable plants growing within a crop and they compete for resources such as nutrients, water and light. Germination of crop completes in 20-30 days. As area is irrigated, it grows variety of weeds during the period.

Weed poses a serious problem in sugarcane cultivation as its lowers the productivity of land robbing it of available nutrients and moisture.
Weeds often serve as host for some virus and vectors and increase the incidence of insects, pests and diseases. Without weed control, crop yields can be significantly reduced. Weed control in sugarcane is done by adopting mechanical method or chemical method.

(i) Mechanical Method:

Fields are given a hoeing with help of kurpi or spade, after a month of sowing and the process is repeated frequently. This method not only removes the weeds but also increases the sprouting

and tillers and destroys insects and enhances aeration in the soil. Some growers make best use of this laborious operation by cultivation of second crop in between the sugarcane crop as a mixed crop.

(ii) Chemical Method:

Chemical method is most effective for controlling weed during pre – monsoon period. Weeds can be effectively controlled by the application of herbicides or weedicides. Herbicides are of particular value in keeping down weeds early in the season when weed competition can do the greatest damage to the young growing crop and when no interculture can be performed. Herbicides are applied at different times depending on their mode of action.

iii. Earthing Up:

Soil between the furrows of canes, is taken with the help of spade and applied to the sides of the plants.

This earthing up is advantageous in many ways (i) Acts as hoeing, (ii) Mixes the top dress fertilizers well in the soil, (iii) Support the plant, to save them from lodging, (iv) Help the bud to sprout profusely and (v) Makes

watering and drainage easy. This operation is done when the crop is 5 to

5.5 months old and 2 to 3 internodes are visible.

iv. Trashing:

Removal of loosely adhering dried and drying leaves from the sugarcane known as trashing. It is generally done to clean the sugarcane.

v. Propping:

The tying of cane plants to prevent lodging is known as propping. Some canes of two adjacent rows are brought together and tied by sugarcane leaves rope. It also helps in applying irrigation in a better way.

Maturity and Harvesting of Sugarcane:
Cane should be harvested only when it is mature.

Practical tests to judge maturity are-
(a) General yellowish colour of whole crop, (b) Cessation of growth, (c) Swelling of eye buds, (d) Metallic sound of cane, (e) Breaking of cane at the nodes and (f) Brix saccharometer reading between 21 and 24.

Irrigation should be held for about 10 to 15 days prior to harvesting. Harvesting should be done with sharp cane cutting knife and very close to ground. The cane should be crushed within 24 hours to get high recovery.