

Lecture No. 27

Water Management Practices in Rice

27.1 Introduction

Rice culture at present dominates irrigated agriculture (Fig. 27.1). About 64% of the irrigation water resources in Andhra Pradesh are used for cultivation of rice. An adequate water supply is one of the most important factors in rice production. In many parts of India including Andhra Pradesh rice plants suffer from either too much or too little water because of irregular rainfall and land topography.



Fig. 27.1. Irrigated rice crop

27.1.1 Percolation losses in rice fields

Percolation losses are a function of the local soil and topographic conditions. Therefore, at any time the amount of rainfall or irrigation water entering the soil becomes greater than its water holding capacity, losses by downward movement of free water (vertical percolation) will occur. Percolation is often defined as the movement of water through saturated soils due to gravity, hydrostatic pressure or both.

Thus where the soil is heavy and the water table is close to the soil surface, percolation losses are low, about 1 – 2 mm/day. On the other hand, where the soil is light and the water table is deep, percolation losses may be high, about 8 – 15 mm/day, or more. About 50 to 60% of applied water to rice is lost by deep percolation. The percolation losses can be reduced by adopting following agronomic practices:

1. Growing rice on clayey soils
2. Scrupulous land levelling
3. Thorough puddling

4. Shallow depth of submergence
5. Sub-soil compaction
6. Application of clay, silt, bentonite etc

Research has shown that a percolation rate of 5mm/day was favourable for supply of dissolved oxygen, the removal of harmful substances and the maintenance of root activity.

27.1.2 Submergence versus saturation

In most areas rice fields are submerged continuously throughout the crop-growing period, though not always essential. Studies have indicated that soil saturation is sufficient for *kharif* rice, while submergence not exceeding 5 cm seems to be essential and adequate for *rabi* rice (Fig. 27.2).



Fig. 27.2. Submerged rice field

27.1.2.1 Advantages of continuous submergence

- ◆ Less weed problem
- ◆ Fixation of nitrogen by Blue green algae
- ◆ Increased availability of nutrients such as P, Fe, Mn, Zn and silicon
- ◆ Regulation of soil temperature
- ◆ Reduction in labour cost

27.1.2.2 Disadvantages of continuous submergence

- ◆ Deep percolation losses of irrigation water
- ◆ Surface runoff losses of irrigation water
- ◆ Leaching of nutrients particularly nitrogen

- ◆ Sulphide injury
- ◆ Iron toxicity

27.1.3 Optimum depth of submergence

Optimum depth of land submergence at different growth stages of rice crop for saving irrigation water without reduction in crop yield is given below in Fig. 27.3 and Table 27.1:

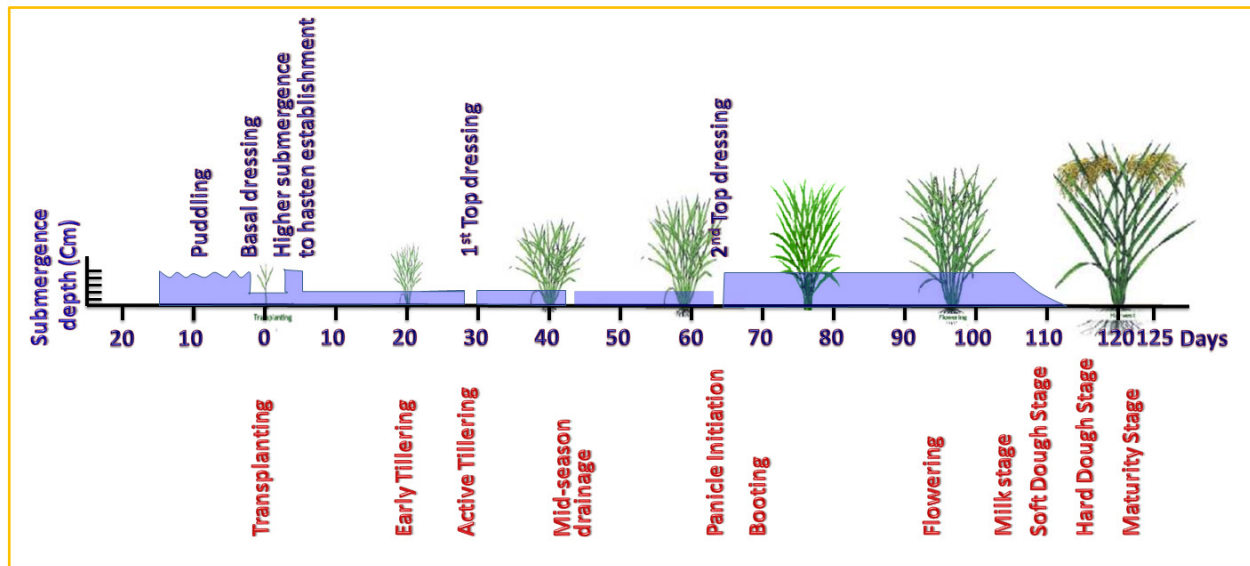


Fig. 27.3. Optimum depth of submergence in rice field

27.1. Optimum depth of submergence in rice field

Crop growth stage	Depth of submergence
At transplanting	2 cm
After transplanting for 3 days	5 cm
3 days after transplanting to maximum tillering	2cm
At maximum tillering (midseason drainage)	Drain water for 3 days
Maximum tillering to panicle initiation	2 cm
Panicle initiation to 21 days after flowering	5 cm
After 21 days after flowering	Drain out water gradually

- Shallow depth (2 cm) of submergence at transplanting seedling facilitates planting at correct depth, since more depth of water will lead to deep transplanting resulting in reduction of tillering
- After transplanting for 3 days adequate water is necessary to facilitate development of new roots and to hasten establishment of seedlings
- After 3 days of transplanting to maximum tillering again shallow depth is favoured by the rice crop because more water depth reduces tillering

- d) At maximum tillering in fertile soils i.e., 40 days after transplanting drain the field for three days till the soil shows fine cracks. This is known as mid-season drainage. This is essential because the respiratory function of the roots is highest during this stage and introduction of air into the soil by draining the field leads to vigorous growth of roots and checks the development of non-effective tillers thereby reducing the sterility percentage. It also helps in regulation of nitrogen supply thus controls the production of ineffective tillers.
- e) Reproductive growth starts when maximum tiller production is completed and includes the panicle primordia development, booting, heading and flowering stages. A large amount of water is consumed in the major part of the reproductive growth period. Drought at this stage causes severe damage leading to increased panicle sterility, caused by impeded panicle formation, heading, flowering or fertilization. Excessive water at booting stage causes decrease in culm strength and increases lodging.

27.1.4 Average water requirements

Total water requirement includes water needed to raise seedlings, preparation of land and to grow rice crop from transplanting to harvest, the amount is determined by many factors including soil type, topography, proximity to drains, depth of water table, area of contiguous rice fields, maintenance of bunds, fertility of both top and sub soil, field duration of the crop, land preparation method, and most of all the evaporative demand of the atmosphere during growing season. The daily evapotranspiration of rice varies from 4 – 5 mm /day during wet season and 7 – 8 mm/day during the dry season. The total water requirement was estimated to be 1240 mm under Andhra Pradesh agro-climatic conditions (Table 27.2).

Table 27.2. Water requirements of rice under Andhra Pradesh conditions

Crop growth stage	Water Requirement (mm)	Per cent of water requirement
Nursery	40	3.22
Main field preparation	200	16.12
Transplanting to panicle initiation	460	37.00
Panicle initiation to flowering	417	33.66
Flowering to maturity	123	10.00
Total	1240	100.00

Lecture No. 28

Water Management Practices in Wheat and Maize

28.1 Wheat

The dwarf wheat varieties were first introduced into India during 1963. In the very first year of their cultivation, it was realized that the irrigation practices developed for the tall wheat varieties did not suit the dwarf wheat varieties. Consequently studies to determine the optimum irrigation & water requirements of dwarf wheat were taken up at the Indian Agricultural Research Institute and other centers and the following recommendations were given by the ICAR for efficient use of irrigation water in cultivation of dwarf wheat.

28.1.1 Optimum time of first irrigation

The crown root initiation (CRI) stage is the optimum time for first irrigation in dwarf wheat – about 3 weeks after sowing. A delay of 2 – 3 weeks in this irrigation reduces the yield by 500 – 1000kg/ha. Crown roots of wheat generally develop within 2cm below the soil surface. If there is sufficient moisture at this depth, crown roots will develop normally and irrigation would not be necessary at this stage. But generally the top 5 – 6 cm of soil layer gets completely dry by the time the crown roots start developing. The water and nutrient supplies have then to be met only by the seminal roots, which are less vigorous and less efficient. Consequently, the growth of the plant, especially tillering, is much restricted, reducing the grain yield.

Table 28.1 Irrigation scheduling under limited water supply situations

Water available for	Irrigation to be given at
I. Adequate water supply	
Four irrigations	Crown root initiation, Late tillering (tiller completion), Flowering and Milk stages
Five irrigations	Crown root initiation, Late tillering (tiller completion), Late jointing, Flowering and Milk stages
Six irrigations	Crown root initiation, Late tillering (tiller completion), Flowering, Milk and Dough stages
II. Restricted water supply	
One irrigation	Crown root initiation
Two irrigations	Crown root initiation and Boot (Late jointing)
Three irrigations	Crown root initiation, Boot and Milk

28.1.2 Optimum number of irrigations under adequate water supply

If the underground water table is well below the root zone and there is no rainfall during the growing season, 4 – 6 irrigations depending on the climatic conditions, soil type

and the variety may be needed for getting the highest yield from the dwarf wheat's. Irrigation at a soil moisture tension of 0.5 bars at a depth of 22.5 cm amounted to the same number of irrigations and resulted in similar grain yields. The schedule for adequate and restricted water supply is given in Table 28.1.

Based on soil water regime approach under south Indian condition irrigations at 25% DASM and 40 – 50% DASM under north Indian conditions were found to be optimum. Likewise irrigations at 0.75 to 1.0 IW/CPE ratio based on climatological approach were found to be optimum for many locations. An IW/CPE ratio of 1.0 was optimum at CRI stage. The critical growth stages for irrigation are crown root initiation, tillering, heading & grain formation. The seasonal crop water requirement varies between 350 to 500mm depending upon the agro-climatic zone. The recommended method of irrigation is check basin and border strip method of irrigation (Fig. 28.1).



Fig. 28.1. Surface basin irrigated wheat crop

28.2 Maize

The maize is one of nature's most amazing energy-storing plants. From a seed, which weighs little more than one-hundredth of an ounce, a plant of 7 – 10 feet tall develops in about nine weeks. Thus corn has a high water requirement but is one of the most efficient field crops in producing higher dry matter per unit amount of water used (Fig. 28.2).

The effective root zone depth of the maize crop varies from 0.9 to 1.5 m. For maximum production a medium duration grain crop of maize requires between 400 to 600 mm of water depending upon the soil-plant and climatic factors. The furrow method of irrigation is commonly practiced in India. For estimating crop evapotranspiration begin with 0.3 Kc of daily ETo in the initial period, raise it to 0.8 to 0.9 at vegetative stage, 1.2 at tasseling, silking & pollination stages, and decrease it to 0.5 at maturity of corn.

Frequency and depth of irrigation has a pronounced effect on grain yield. Maize appears relatively tolerant to water deficits during the vegetative and ripening periods. Greatest decrease in grain yield is caused by water deficits during the flowering period

including tasseling-silking and pollination, mainly due to a reduction in grain number per cob. Water deficits particularly at the time of silking & pollination may result in little or no grain yield due to silk drying. Water deficits during the ripening period have marginal effect on grain yield.



Fig. 28.2. Irrigated corn field

To obtain good stand and rapid root development, the root zone should be wetted at or soon after sowing. Taking into account the level of evaporative demand to meet full water requirement irrigations have to be scheduled at 40% DASM in the germination and seedling & establishment stages. Whereas during vegetative, tasseling, silking, pollen shed and kernel development stages irrigations have to be scheduled at 55 to 65% DASM and up to 80% DASM during ripening or maturation period. Likewise irrigation at an IW/CPE ratio of 1.0 at critical growth stages and 0.75 – 0.5 at other stages was found to be optimum. The threshold soil moisture tension levels for scheduling irrigations based on tensiometer readings vary between 30 to 60 centibars at different growth stages. Higher grain yields of maize were recorded when irrigations were scheduled between –14 to –20 bars leaf water potential depending on the crop growth stage using pressure bomb or pressure chamber apparatus. Water quality threshold electrical conductivity values 3.2 dS/m in sandy soil, 1.8 dS/m in loamy soil and 1.1 dS/m in clay soil, above which yield decreases.

Under conditions of marginal rainfall and limited irrigation water supply, the number of possible irrigation applications may vary between 2–5. A suggested schedule of these irrigation applications is given in Table 28.2. The recommended method of irrigation is furrow method of irrigation.

Table 28.2. Irrigation scheduling under limited water supply situations

Water available for	Irrigation to be given at
Two irrigations	Establishment and Flowering
Three irrigations	Establishment, Vegetative and Kernel development
Four irrigations	Establishment, Vegetative, Flowering and Kernel development
Five irrigations	Establishment, Vegetative, Flowering, Kernel development & Ripening

Lecture No. 29

Water Management Practices in Sugarcane and Groundnut

29.1 Sugarcane

Sugarcane being a long duration crop producing huge amounts of biomass is classed among those plants having a high water requirement and yet it is drought tolerant. Out of the total cropped area (0.4 million ha) of sugarcane in Andhra Pradesh nearly 97% is irrigated. The crop duration varies from 12 months in seasonal crop, 13 – 14 months in pre-seasonal and 16 – 18 months in adsali crop.

29.1.1 Physiological factors to be considered for efficient water management

- a) A liberal water supply reduces the cane yield and/or sugar yield, while mild water stress enhances the yield
- b) Excessive watering at tillering should be avoided since it coincides with active root development and hinders nutrient uptake due to poor O_2 diffusion
- c) Since there is no secondary thickening of the stem in sugarcane the length of the cane determines the sink available for sugar storage
- d) A 'drying off' or 'cut out' period of 4 – 6 weeks prior to harvest ensures an optimum sugar yield
- e) Restricted water application during the 'ripeness to flower' stage helps to control tassels or arrows
- f) Sugarcane has an intrinsic ability to circumvent water shortages and can more than make up for the potential yield loss.

29.1.2 Water requirements & Irrigation scheduling

During the initial germination, field emergence and establishment of young seedlings the crop requires less water, hence light and frequent irrigation water applications are preferred. Water deficits at this stage desiccate germinating buds leading to a lower and delayed germination. On the other hand over irrigation leads to bud rotting due to lack of aeration, fungal attack and low soil temperature. Thus both under and over irrigation is detrimental for germination, resulting in low stalk population per unit area.

During the early vegetative period (formative) the tillering is in direct proportion to the water application. An early flush of tillers is ideal because this furnishes shoots of approximately same age. Any water shortage during tillering phase would reduce tiller production, increase tiller mortality and ultimately the stalk population-an important yield component. However, excess irrigation during tillering phase is harmful particularly in heavy soils, since it coincides with active root development, which may be hampered by anaerobic condition. Scheduling of irrigations at 25% DASM or 0.75 to 1.0 IW/CPE ratio equivalent to an irrigation interval of 6 days was found to be optimum during formative stage.

The yield formation or grand growth period is the most critical period for moisture supply in sugarcane. This is because the actual cane yield build-up or stalk growth takes place in this period. The production and elongation of inter-nodes, leaf production on the stalk and its expansion, girth improvement, ultimately the stalk weight takes place in this period. It is also the period for production of sugar storage tissues. Therefore, crop reaches its peak water requirement in this stage. With adequate water supply to maintain a sheath moisture content of 84 – 85% in the leaf sheaths of 3,4,5 and 6th leaf from the top during this period of active growth produces longest inter-nodes with more girth (thick cane) and the total cane weight is greater. On the other hand water deficits in grand growth period reduce stalk elongation rate due to shortening of inter-nodes resulting in less cane weight and the effect is well marked on yield at harvest. Severe water deficits during the later part of the grand growth period forces the crop to ripen. However in the absence of sufficient rains during this period, scheduling of irrigations at 50% DASM or 0.75 IW/CPE ratio was found to be optimum.

In ripening period, a restricted water supply or mild water deficit (sheath moisture content of 74 – 76%) is necessary to bring the crop to maturity by reducing the rate of vegetative growth, dehydrating the cane and forcing the conversion of total sugars to recoverable sucrose. This can be achieved by scheduling irrigations at 75% DASM or 0.5 IW/CPE ratio equivalent to 21 days irrigation interval. With the check of vegetative growth, the ratio between dry matter stored as sucrose and that used for new growth increases. On the other hand, plentiful supply of water leads to continued vegetative growth thus affecting sugar accumulation process. An important consideration is that soil should not be allowed to crack, as it would cause root pruning and damage the root system.

Thus the critical stages for irrigation are formative (or tillering) stage and stem elongation (or grand growth period) stage. The effective root zone of the crop varies between 0.9 to 1.2 m. The recommended method of irrigation is either drip or furrow method of irrigation (Fig. 29.1). For predicting crop evapotranspiration begin with 0.4 Kc of daily ETo in the initial period, raise it to 0.7 to 1.05 at tillering & canopy establishment phase, 1.2 at grand growth period and decrease it to 1.15 to 0.95 to 0.7 at ripening & maturity period of sugarcane. Irrigate using tensiometer installed at 20 cm soil depth to maintain 15 – 40 centibars at different crop growth stages to maximize cane yields. Water salinity (ECw) threshold levels are 4.3 dS/m in sandy soil, 2.5 dS/m in loamy soil and 1.4 dS/m in clay soil, above which yield decreases.

Adequate soil moisture throughout the crop growing season is important for obtaining maximum yields because vegetative growth including cane growth is directly proportional to the water transpired. Depending on the agro-ecological conditions, cultivation practices adopted and crop cycle, seasonal water and irrigation requirements of sugarcane in different regions of Andhra Pradesh are given in Table 29.1.



Fig. 29.1. Furrow and surface drip irrigated sugarcane

Table 29.1. Water requirement of sugarcane in different regions of Andhra Pradesh

Crop growth phase	Period	Water requirement (mm)	Irrigation requirement (mm)
I. COASTAL ANDHRA			
Formative phase	February/March to June (120days)	73.66	50.80
Grand growth period	June/July to end of October / November (150 days)	69.85	6.35
Maturity phase	November/December to January / February / March (90 days)	26.67	17.78
Season Total		170.18	74.93
II. TELANGANA			
Formative phase	January to April (120days)	91.25	87.50
Grand growth period	May to September (150 days)	135.00	50.00
Maturity phase	October to December (90 days)	45.00	37.50
Season Total		271.25	175.00
III. RAYALASEEMA			
Formative phase	February to June (150days)	91.44	83.82
Grand growth period	July to end of October (120 days)	83.82	22.86
Maturity phase	November to January (90 days)	49.53	26.67
Season Total		224.79	133.35

29.2 Groundnut

Groundnut is an important oilseed crop of Andhra Pradesh and is cultivated in all the three agricultural seasons viz., *Kharif* (June to September), *rabi* (October to January)

and summer (January to May) seasons. Generally the rabi/summer groundnut is raised under irrigated conditions. However supplemental or protective irrigations during rainy season in the event of drought significantly improve the pod yield.

The effective root zone depth of the crops varies between 0.5 to 0.9 m. Depending upon the range of environment, variety and crop duration the seasonal water requirements vary from 400 to 650 mm. The irrigation schedule recommended for efficient use of irrigation water for Spanish bunch variety on a sandy loam soil in Andhra Pradesh is given in Table 29.2. The recommended methods of irrigation are check basin, border strip and sprinkler irrigation (Fig. 29.2).

Table 29.2. Irrigation schedule for rabi & summer groundnut

Crop growth stage	Duration (days)	Irrigation frequency	Crop ET (mm)	ET (mm/day)
RABI SEASON				
Sowing to pegging	0 - 30	2	125	4.16
Pegging to pod formation	30 - 55	3	150	6.00
Pod formation to maturity	55 - 90	2	100	2.85
Total season	90	7	375	---
SUMMER SEASON				
Sowing to pegging	0 - 35	3	135	4.00
Pegging to pod formation	35 - 65	6	270	9.00
Pod formation to maturity	65 - 100	4	135	4.00
Total season	100	13	540	---



Fig. 29.2. Surface basin and sprinkler irrigated groundnut

For estimating crop evapotranspiration begin with 0.4 Kc of daily ETo in the initial germination & establishment period, raise it to 0.7 to 0.8 at vegetative & flowering stage, 0.95 – 1.1 at pegging, pod initiation & pod addition stages, and decrease it to 0.7 – 0.8 at pod filling & maturity stages of groundnut.

Withholding of first irrigation (after germination) up to 25 – 30 days after sowing induces profuse flowering and fruiting. The critical growth stages for irrigation are Flowering, Peg penetration and early Pod development. In the case of limited water supply, water savings should be made during the periods other than flowering, pegging, pod initiation, pod setting and pod filling periods. Insufficient water in the pod zone can also depress calcium uptake of developing pods and cause more pops, fewer double loculed pods. Excessive soil water in heavy soils at harvest can cause the pods to be torn easily from the pegs with the pods remaining in the soil.

Scheduling of irrigations between 25% to 50% DASM or 0.75 to 1.0 IW/CPE ratio at different growth stages was found to be optimum for producing higher pod yields. Irrigate using tensiometers installed at 30 – 60 cm soil depth to maintain 40 centibars at germination, 60 centibars at early vegetative growth, 40 centibars at pod development and 60 centibars at maturity to maximize pod yields. Threshold water quality (ECw) was found to vary between 1.5 to 4.4 dS/m depending on the soil texture, above which pod yield decreases. Further water containing SAR >5 to 7, boron >0.75 ppm, chloride >400 ppm and sodium >400 ppm is not suitable for irrigating peanuts.

Lecture No. 30

Water Management Practices in Mango, Banana and Tomato

30.1 Mango

Most of the areas cultivated with mango are located in regions of short periods of rain, where water deficit takes place most of the year in the soil water balance. Irrigation scheduling from flowering to fruit ripening stage considering the following factors contributes to higher yield and improved fruit quality.

- a) Climatic conditions
- b) Crop age – Young and non-bearing orchards differ from the bearing orchards
- c) Root penetration and proliferation
- d) Fruit-bud differentiation takes place in terminal mature (8 to 10 months) shoots
- e) During fruit-bud differentiation and vegetative phase, requirements are antagonistic.
- f) Fruit quality depends upon moisture content in soil during fruit development and maturity.

Most of the feeding roots are found at distances from the plant of 0.9 m to 2.6 m and at depths from soil surface to 0.90 m though root penetration was noticed up to 2 m soil depth. The basin and drip method of irrigation are commonly practiced in India (Fig. 30.1). Critical stages for water supply are flowering, pollination and fruit development. Greatest decrease in fruit yield is caused by water deficits during the flowering and fruit development period, due mainly to a reduction in number of flowers, fruit number and fruit size. For estimating crop ET begin with a crop coefficient value of 0.4 during flowering, increase it up to 0.85 in the middle of fruit growth period and decrease it to 0.60 during fruit ripening stage.



Fig. 30.1. Irrigation scheduling in mango using tensiometer readings

Daily water use rates of mango planted at 8 m x 8 m distance were estimated to be 10 – 12 L/tree in the 1st year, 18 – 20 L/tree in the 2nd year, 45 – 50 L/tree in the 3rd year, 60 – 65 L/tree in the 4th year, 75 – 80 L/tree in the 5th year, 90 – 95 L/tree in the 6th year and 100 – 120 L/tree from 7th year onwards. The annual water requirement for a mature orchard of 8 – 10 years old was found to be 1100 – 1300 mm/year.

Taking into account the level of evaporative demand to meet full crop water requirements management allowable depletion level (DASM) during the reproductive phase of mango trees should be 0.35 and in other phases 0.65. Likewise irrigation at an IW/CPE ratio of 0.75 at critical growth stages and 0.5 at other stages was found to be optimum. The threshold soil water potentials for scheduling irrigations based on tensiometer readings for mango should be in the range of -15 centibars to -25 centibars for coarse textured soils and in the range of -30 centibars to -60 centibars for fine textured soils.

30.2 Banana

Banana (*Musa spp.*) is one of the most important tropical fruit of India including Andhra Pradesh. Banana is a tropical herbaceous evergreen plant which has no natural dormant phase and hence has a high water demand throughout the year, especially during high temperatures. With respect to water management the important characteristics of the banana plant are:

- a) A high transpiration potential due to the large broad leaves and high LAI
- b) A shallow root system compared with most tree fruit crops
- c) A poor quality to withdraw water from soil beneath field capacity
- d) A rapid physiological response to soil water deficit

These factors make banana plants extremely sensitive to even slight variations in soil water content, emphasizing the importance of correct irrigation scheduling. Banana requires an ample and frequent supply of water; water deficits adversely affect crop growth and yields. The establishment period and the early phase of the vegetative period determine the potential for growth and fruiting and adequate water and sufficient nutrient supply is essential during this period. Water deficits in the vegetative period affect the rate of leaf development, which in turn can influence the number of flowers in addition to the number of hands and bunch production. The flowering period starts at flower differentiation, although vegetative development can still continue. Water deficits in this period limit leaf growth and number of fruits. Water deficits in the yield formation period affect both the fruit size and quality (poorly filled fingers). A reduced leaf area will reduce the rate of fruit filling; this leads, at harvest time, to bunch being older than they appear to be and consequently the fruits are liable to premature ripening during storage. Thus the critical growth stages for irrigation in banana are vegetative growth, flowering and fruit development.

The banana plant has a sparse, shallow root system. Most feeding roots are spread laterally near the surface. Rooting depth will generally not exceed 0.9 m. For estimating crop evapotranspiration begin with 0.5 Kc of daily ETo in the initial period , raise it to 0.7 to 0.85 at vegetative development, 1.1 at grand growth period (bunch emergence, flowering & fruit filling period) and decrease it 0.9 to 0.80 at ripening & maturity stages of banana Daily water requirements vary in the range of 3 – 7 mm/day depending on the combination of LAI, temperature, humidity, radiation & wind. The annual water requirements vary between 1200 to 1500 mm depending on climatic conditions and crop duration.

Basin and furrow method of irrigation are commonly used in commercial plantations (Fig. 30.2). However, due to water scarcity conditions and higher yield realization farmers are also using drip irrigation in banana.



Fig. 30.2. Drip irrigated banana

Irrigation scheduling for bananas involves accurate calculations of the amount of water to be applied at each irrigation, and the interval between irrigations, for each soil-plant-climate combination. Scheduling of irrigations between 25% to 50% DASM or 0.75 to 1.0 IW/CPE ratio at different growth stages was found to be optimum for producing higher fruit yields. Irrigate using tensiometers installed at 30 cm soil depth to maintain 30 – 40 centibars at different growth stages to maximize fruit yields.

30.3 Tomato

Tomato is the second most important vegetable crop next to potato in India. It is rapidly growing crop with a growing period of 120 – 150 days.

The crop has a fairly deep root system and in uniform deep soils roots penetrate up to 1.2m. Over 80% of the total water uptake occurs in the first 50 cm. The crop is most sensitive to water deficit during and immediately after transplanting and during, flowering

and fruit development stages. Water deficit during the flowering period causes flower drop. Moderate water deficit during the vegetative period enhances root growth. Excessive watering during the flowering period has been shown to increase flower drop and reduce fruit set. Also this may cause excessive vegetative growth and a delay in ripening. Water supply during and after fruit set must be limited to a rate which will prevent stimulation of new growth at the expense of fruit development. Frequent light irrigations improve size, shape, juiciness and colour of the fruit, but total solids (dry matter content) and acid content will be reduced.

Surface irrigation by furrow is commonly practiced. Under sprinkler irrigation the occurrence of fungal diseases and possibly bacterial canker may become a major problem. Further, under sprinkler, fruit set may be reduced with an increase in fruit rotting. Due to the crops specific demands for a high soil water content achieved without leaf wetting, trickle or drip irrigation has been successfully applied (Fig. 30.3).



Fig. 30.3. A good crop of tomato

Crop coefficients related to reference evapotranspiration (E_{To}) at different crop development stages are - during the establishment stage 0.4 – 0.5, the vegetative stage 0.7 – 0.8, the flowering & fruit development stage 1.05 – 1.25, the fruit ripening stage 0.6 – 0.65. Seasonal water requirements after transplanting, of a tomato crop grown in an open field for a 150 day crop are 400 – 600mm depending on the climate.

Scheduling of irrigations between 25% to 50% DASM or 0.75 to 1.0 IW/CPE ratio at different growth stages was found to be optimum for producing higher fruit yields. Irrigate using tensiometers' installed at 30cm soil depth to maintain 20 – 30 centibars at establishment phase, 60 centibars at early vegetative growth, 30 – 40 centibars at flowering & fruit development periods to maximize fruit yields.