Participatory Research for Development of Sustainable Water Management Practices

Manual on Micro Irrigation for Capacity Building and Development for Andhra Pradesh and Karnataka Action sites

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1. Introduction

Agricultural research and development has traditionally focused on meeting the challenge of feeding the increasing population through the development of appropriate technologies and their support services for better adoption by the farming community. Central to this agenda is the need to increase agricultural production through the development of appropriate skills for better adoption for improving farm yield and income. Subsequently, newer challenges to agricultural research and development have emerged, such as: a) promoting more equitable distribution of benefits resulting from significant improvements in agricultural production; b) sustaining productivity gains through better management of natural resources; c) shifting the focus of research and development interventions to less favorable environments and low-input agricultural systems; d) strengthening the capacity of local farming communities to continuously learn and experiment ways of improving their agricultural production and livelihood opportunities; e)building better governance mechanisms for sustainable agricultural development.

In seeking to address these emerging challenges, among other things, technology development and transfers are important. However, the existing transfer-of-technology paradigm has proven inadequate for managing more complex second-generation issues such as: diverse biophysical environments, multiple livelihood goals, rapid changes in local and national policies, expanded range of stakeholders over agriculture and natural resources, and drastic decline in resource investment in agriculture sector. Keeping this in mind, it is considered important to develop needed based farmers guide for technology adoption by identifying the local specific issues relating to technology development and their better adoption. In this context, the present manual aims to highlight the key parameters of change in key technologies such as micro irrigation awareness, adoption and maintenance by the farming community. The manual brings out the crop production details for important crops cultivated in the state, irrigation and fertigation schedules under micro irrigation (drip and sprinkler) and the key questions and the answers to enhance the farmers' knowledge base on micro irrigation adoption and development.

Micro irrigation adoption is increasing in the country steadily. Though there is considerable area under different micro irrigation systems for different crops, yet based on field surveys it is evident that the farmers use more water and fertilizer than required through micro irrigation. The reason for the excess usage of these inputs is that the farmers do not have the knowledge and exact data on these. Further, the irrigation and fertigation scheduling depends upon the crop, variety, geometry, local evaporative demand, micro irrigation system design crop growth stage, nutrient uptake pattern etc.

Using the user friendly and interactive software developed by Dr Raman as part of the IWMI – Gok project, relevant data for selected crops and regions were collected and fed into the model. The relevant question and answers for irrigation and fertigation scheduling's are presented in the following section. Selected crop wise calendar of activities with irrigation

and fertigation schedules are also given for some selected districts of Andhra Pradesh and Karnataka.

2. An overview of Micro Irrigation: How and why farmers want it?

Fresh water resources for human use are becoming more and more scarce day by day. The present allocation of water to agriculture (90 per cent) expected to be reduced to 75 per cent in the coming decade. Due to increasing demand for water from other uses like domestic, power generation and industries coupled with increase in standard of living, there is tremendous pressure, which necessitates scientific management of all available water resources. This can be achieved by additional development of water resources, conservation and proper management of water resources. Increase in the water use efficiency is of foremost important and adoption of advanced irrigation methods like drip and sprinkler irrigation economises the use of irrigation water and double the irrigated area. Fertigation is a recent approach of applying fertilizers chiefly through micro irrigation. All the three major nutrients are applied in one solution directly to the plant root zone thereby water and fertilizer use efficiencies are increased. Therefore, fertigation is a sophisticated and convenient means of applying nutrients to crop plants that saves time, labour, energy etc. This section describes the practical know-how on drip irrigation and fertigation techniques, problems encountered and their solutions.

1. What is drip irrigation and its prime objective?

Drip irrigation is one of the micro irrigation methods. The others include, sprinkler, micro-sprinkler, mini-sprinkler etc. Drip is a precise and regulated application of irrigation water and plant nutrients at low pressure over a period of time at short intervals through emitters/drippers with close network of pipes is known as drip irrigation system.

In drip irrigation, water is conveyed only through pipe network from point to point (i.e.,) water source to plant rhizosphere unlike surface irrigation wherein water is conveyed in open channels leading to evaporation, percolation and seepage losses. In the surface irrigation we are irrigating the entire “land” but we are irrigating the crop/plant in drip irrigation. Irrigation efficiency is as high as 95 per cent under drip while it is 50 per cent under surface irrigation.

2. What are the advantages of drip irrigation system?

- Improvement in water use efficiency and thereby the savings in water
- Low application rate
- Uniformity of water application
- Efficient fertilizer and chemical application
- Better control of root zone environment
- Crop yield enhancement
- Improvement in crop quality

- Reduction in pest incidence including weed problem
- Savings in electrical energy
- Use of saline water
- Reduction in labour cost
- Suitable for irrigating difficult terrain and marginal lands
- Maintains soil health

3. Enlist the crops where drip irrigation can be employed?

Crop Group	Crops
Orchard and fruits	Banana, Grapes, Papaya, Pomegranate, Oranges and Lemons, Mango, Custard apple, Aonla, Sapota, Guava, Litchi, Melons, Coconut, Arecanut, Cashewnut etc
Vegetables	Tomato, Chillies, Capsicum, Cabbage, Cauliflower, Onion, Bhendi, Gourd crops, Peas etc.
Cash crops	Sugarcane, Cotton, Turmeric, Garlic, Cloves etc
Flowers	Rose, Carnation, Gerbera, Anthurium, Orchids, Jasmines, Dahlia, Marigold etc
Oilseeds	Sunflower, Oilpalm, Groundnut etc

4. For which crops mini sprinklers/micro sprinklers are used?

Micro sprinklers are designed for wide range of applications. It is best suited to short statured crops (less than a meter high), non-flowering crops, pulses, groundnut, greens, curry leaves, cabbage, cauliflower, beet root, leafy vegetables, lawn and nurseries and in green houses. It can also be used in intercropping systems in orchard crops

5. What is the extent of area irrigated by drip in India?

As on 2013, drip irrigation is adopted in about 2.85 million hectares in India (NCPAH,2013). Maharashtra was the leading state covering 0.83 million hectares followed by Andhra Pradesh with 0.73 million hectares. Gujarat and Karnataka followed this with 0.35 and 0.33 million hectares respectively. Raman (2010) estimated to be 45 million hectares in the country and the contribution of drip to this was estimated to be 15 million hectares. Based on this estimation the coverage under drip, till 2013 is estimated to be around 20 per cent.

6. Is it a myth under drip irrigation and the crops will be lodged?

Since there will be more of surface root development under drip, there is a possibility of lodging in crops like sugarcane. But, it can be overcome by adopting to subsurface irrigation technique.

7. How are the drippers designed for different types of soils?

In sandy soils higher discharge drippers are preferred. On the other hand, in heavy clay soils low discharge of 2 lph will be effective. But, on the whole under Indian soils 4 lph works well.

8. What are the different types of drippers?

Basically the drippers are classified as Laminar drippers, Turbulent drippers, orifice drippers, Typhoon drippers and bubblers. They are also classified into pressure compensating and non-pressure compensating drippers. They may be also either online or inline drippers based on their insertion on the laterals

9. What type of drip emitters are ideal for water scarce and power shortage areas?

In several regions of the state, water scarcity is acute besides limited power supply. Hence, drip system with micro-tubes would be the ideal solution, which would require lesser irrigation period at high discharge rate. This facilitates larger area coverage in short span of time. Thus, both limited water and power supply can be managed. But the micro-tubes have limitations. Unless it is properly designed for uniform discharge throughout the field with adjustment of the length of the micro-tube at head, mid and end portions of the field, the discharge will be highly variated.

Presently, there is tendency of designing the system with 2 lph drippers spaced at 40 cm. But, with 4 lph of 60 cm spacing, we can save 30% of energy without having any moisture stress to the plant.

10. How the drip system efficiency can be classified based on moisture distribution?

The efficiency of drip system can be classified based on the distribution uniformity % as shown below in table:

Table 1: classification of drip system based on distribution uniformity

Classification	Uniformity %
Excellent	More than 90
Good	81 -90
Fair	71-80
Poor	61-70
Unacceptable	Less than 60

11. What are the essential components of a typical drip irrigation system?

- Water source (Well with motor or water tank)
- By pass valve
- Non-return valve
- Filtration system
- Fertigation device (ventury or fertilizer tank or fertigation pump)
- Pressure regulators
- Pressure gauges
- Water meters or hydrometers
- Back wash valve
- Air valve

- Main pipe (75, 63 mm PVC pipe)
- Sub main pipe (50, 40 mm PVC pipe)
- Laterals (12 or 16 mm LLDPE)
- Emitters (drippers, micro tubes)/emitting tubes in case of drip line /inline drippers
- Flush valves at Sub main and laterals
- End cap

The main components with a typical layout is illustrated in Figure.1

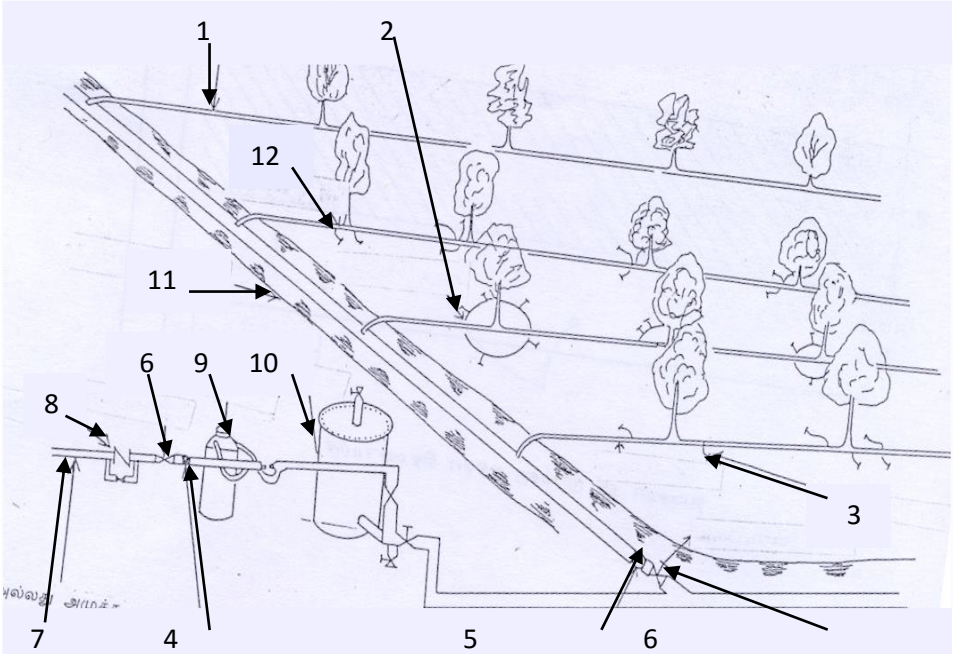


Fig. 1 Fertigation - Basic components

1. Flexible tube
2. Lateral tube
3. Distibutory tube
4. Pressure changer
5. Pressure preventing valve
6. Closure valve
7. Pressure distribution
8. Check valve
9. Fertilizer tank
10. Filter
11. Primary sub tube
12. Multi points irrigation tube

12. What are the essential considerations in designing a drip system?

- The water availability/ discharge of well
- Daily irrigation requirement of crops
- The HP of motor
- Deciding the size of main and sub main pipes
- Deciding size and length of laterals
- Selection of drippers based on soil and crop types
- The quality of irrigation water (EC, pH)
- The soil characteristics like salinity, alkalinity, acidity, infiltration rate etc.

- Seasonal crop water requirement
- Computing frictional/head loss and designing drip system with 20 per cent allowable variation in flow and 10 per cent variation in discharge of emitters.

13. What is the operating pressure for desired discharge uniformity in drip system?

In drip irrigation, the operating pressure should be 1.2 to 1.5 kg/cm^2(including fertigation) for achieving a discharge uniformity of more than 90 percent.

14. What are the common problems encountered for adoption of drip system?

* High capital investment.
* Lack of technical skills on maintenance.
* High salinity in water
* Poor service after sale
* Time-lag for installation

15. what are the different field problems encounter in drip system

In field conditions the major problems encountered in maintenance and operation of drip system are clogging, displacement of laterals, rat and other animal bites, human damage due to inter-cultivation activities, harvesting in sugarcane etc.

16. What are the causes of clogging in drip system?

Irrigation water usually contains calcium and magnesium salts which precipitate along with carbonate and bicarbonates causing deposits in pipes and emitter points. Also when irrigation water is drawn from lakes or ponds contain bacterial slimes, algae, which get deposited along the pipe network and emitters. Thus, the discharge and flow rate in emitters and pipes are reduced.

17. How damages to drip system be avoided in field conditions?

The surface drip system usually get damaged at times of intercultural operations and by dogs, rats, squirrels etc. Hence, drip system can be installed under sub-surface method wherein narrow trenches would be formed 15 to 30 cm deep.

18. What are the remedial measures for clogging and salt encrustation?

When low flow rate is detected in pipes, diluted HCl of 35 per cent concentration can be injected into irrigation system through ventury or fertigation pumps. The salts in pipes and emitters are dissolved after few hours and flushed out step by step procedure, first the main flush valves are opened, then sub main flush valves and finally the lateral end caps are removed for flushing away all the wastes.

The quantity of acid to be used depends on the flow rate of irrigation system. For instance, if a pump discharge is 20 m3, 20 litres of acid would be needed at

1 litre /m3. The commercial HCl is available at Rs.6.00/litre and hence it would require Rs.120 for acid flushing.

19. How the clogging due to bacterial stains are cleaned in drip system?

If the drip system is clogged due to bacterial slimes and algae, sodium hypochlorite (10 per cent chlorine) is to be injected. This chlorination kills bacteria and other microbes and cleans the whole system. Depending upon the degree of clogging, chlorination can be done at 5 ppm to 500 ppm and then flushed out as described in acidification procedure.

20. What are the important aspects of drip system maintenance?

- Filters are to be cleaned periodically.
- All the dusts/ waste materials at the time of drip installation are to be first removed by flushing.
- Ensure that first dripper in each lateral are functioning properly
- If there is clogging due to salt, dilute HCl injection is to be done (as detailed earlier)
- If there is clogging due to algae, bacteria, chlorination is to be done (as detailed earlier)
- The drip laterals are to be wounded back at harvest after cleaning to enhance the life. Small wheels can be used for winding laterals.
- During fertigation recommended fertilizer (soluble) alone is to be used. After fertigation, system needs flushing to keep clean for next fertigation.
- The flow rate in main/sub main pipes and discharge of emitters should be checked periodically with pressure gauge and measurements. Maintaining minimum operating pressure would result in higher discharge uniformity.
- Open line ends once in a month to drain all the dirt accumulated

21. What is the importance of filtration system and what are the different types of filters and their uses?

Filtration is the heart of drip system. It prevents solids from clogging of valves or accumulating in water distribution piping system including emitters/drippers,

Basically there are four types of filters:

a) Screen filter/disc filter

b) Gravel/sand filter: Used mainly for waters containing organic matter and from open source

c) Hydrocyclone filter: Designed mainly to separate suspended solid particles, especially when the well water is used for irrigation.

While the screen or disc filter is a must any of the other is selected as per local situation

22. How fertigation is done?

Fertilizers can be efficiently applied along with irrigation water through drip irrigation system. This is called fertigation. Fertilizers which are completely soluble should be injected. Fertilizers like super phosphate, which are not soluble and create precipitation problems should not be used. The soluble fertilizers are injected into micro irrigation system through any one of the three devices viz., ventury, fertilizer tank and fertigation pump. The cost of ventury would be Rs.1200; a fertilizer tank at Rs.6000 (60 lts) and a fertigation pump would be Rs.12000.

23. How fertigation is useful in present day agriculture?

- Fertigation ensures uniform and regular flow of both water and nutrients,

  resulting in increased crop growth and yields.
- Through fertigation, the three major nutrients are supplied in one solution to the active root zone resulting in greater absorption.
- Small quantities of fertilizers can be applied at closer intervals.
- The system enables uniform distribution of nutrients in the root zone.
- Each irrigated plant receives the same proportion of nutrients
- When combined with proper management, fertigation can avoid fertilizer leaching beyond the root zone, resulting substantial saving in quantum of fertilizers (30-50 per cent)
- Considerable savings of labour and energy in the application of fertilizers.
- Micronutrients can be effectively applied through fertigation.

24. What are the fertilizers suitable for fertigation?

The fertilisers that are water soluble can be used for fertigation. So that clogging can be reduced. For nitrogen and potassium, the presently used fertilisers by farmers viz., urea and potassium chloride can be applied as water soluble fertilisers. For phosphorus, the presently used DAP or super phosphate are not water soluble. But recently the GSFC, Vadodara are manufacturing urea phosphate (17-44-0), which is water soluble and can be used by the farmers for fertigation. All other micro-nutrients like Zinc sulphate and Iron sulphate etc are also water soluble and can be used for fertigation.

25. What is the water requirement under drip system?

The water requirement of crops varies according to crop geometry and the climate especially evaporation rate. Approximate water requirement of crops under drip as well as surface irrigation system is furnished in Table 2.

Table 2. Water requirement of horticultural crops under drip and surface irrigation

Crops	Water requirement (lit/plant/day)	
	Drip irrigation	Surface irrigation
Coconut	75-100	200-300
Grapes	25-30	90-100
Mango	30-50	90-150
Guava	20-30	70-100
Sapota	20-30	70-100
Pomegranate	20-40	60-130
Banana	12-16	30-40
Citrus	10-20	25-65
Papaya	5-8	18-26
Vegetables	1-2	4-8

Source: Reddy et al, 2010

26. How the water requirement under drip system is computed?

Following are the chief considerations for computing water requirement through drip system

- Daily pan evaporation rate (Pe)
- Pan co-efficient (Kp)
- Crop co-efficient (Kc)
- Crop spacing (A)
- Percent wetted area (Pw)

For example, the water requirement computation for tomato is illustrated below.

Assume

1. Daily pan evaporation rate (Pe) : 7 mm
2. Pan co-efficient (Kp) : 0.8
3. Crop co-efficient (Kc) : 0.9 at flowering
4. Crop spacing (A) :75 x 60 cm
5. Percent wetted area (Pw) :80 per cent

Volume in litres = Pe xKp x Kc x A x Pw

= (7/1000) x 0.8 x0.9 x(75*60)/10000 x (80/100))

= 0.0018m3

1 m^3 =1000 lit

Volume in litres = 0.0018 x 1000

= 1.8 lit/day/plant

No. of tomato plants/acre = 8888

Water requirement for one acre/day = 8888 * 1.8 = 16000 litres

No. of drippers in one acre at one dripper for two plants = 4444

Irrigation period=16000/4444 = 3.6/4LPH * 60 min = 54 minutes

27. Does the government provide any financial help to the farmers for adopting drip irrigation?

Yes, the Government of India and state governments provide subsidy since 1990s. As per the recent guidelines of Government of India. The subsidy pattern is as below.

Table 3: cost of drip irrigation and norms of state government

S.No	Item	Practices	Cost norms & central Share	State Share
1	Micro irrigation	Drip Irrigation (wide Spaced crops)	35% of the total cost of installations for small & marginal farmers and 25% of actual cost installation for others in non-DPAP/DDP/ NE&H regions. 50% of the actual cost of installations for small & marginal farmers and 35% of cost of installation for others in DPAP/DDP areas and NE&H States Estimated cost of installation is Rs. 37200/ha (average). However, assistance to farmers will be as per norms of individual crop spacing. Maximum permissible assistance will be restricted to 5 ha per beneficiary/group.	Additional 110% assistance to be provided by state Government to all categories of farmers
		Drip Irrigation	35% of the total cost of installations for small &	Additional 10% assistance to be

		(closed Spaced crops with rows at less than 1.2 meter)	marginal farmers and 25% of actual cost of installation for others in non-DPAP/DDP/NE&H regions 50% of the actual cost of installations for small & marginal farmers and 35% of cost of installation for others in DPAP/DDP areas and NE&H States Estimated cost of installation is Rs. 90,000/ha (average). However, assistance to farmers will be as per norms for different land sizes. Maximum permissible assistance will be restricted to 5 ha per beneficiary/group.	provided by state Government to all categories of farmers

*DAPA: Drought Prone Area Program, DDP: Desert development program, NE&H States – North Eastern and Himalayan States

Source: NMSA, 2014

28. What is the unit cost for the drip system fixed by Government of India?

The Government of India has fixed the unit cost for different spacing as presented below

Table 4: Cost of drip system for different spacing and land size (Rs/ha)

Lateral Spacing	1 ha	2 ha	3 ha	4 ha	5 ha
Wide spacing					
8m & above	23500	38100	59000	74100	94200
4m to <8m	33900	58100	89300	131200	142400
2m to <4m	58400	108000	161800	220600	271500
Closed spacing					
1.2m to <2m	85400	161300	243400	332800	412800
<1.2m	100000	193500	292100	399400	495400

Source: NMSA, 2014

29. How the total drip system cost could be reduced?

The major cost of drip system goes towards laterals and drippers (40 per cent each) Hence, by suitable crop geometry, the number of drippers and laterals could be reduced by adopting paired row planting system wherein one lateral for two rows and one dripper/emitter for two plants. In this system, the plant population per unit area is maintained and hence there is no compromise in yield in spite of reducing the drip system costs.

30. Where the famers should seek support from, for trouble shooting?

Famers can contact Agri-engineers from nearby research station of the university, Supplier, micro-irrigation program field staff etc.

3. Crop production with drip irrigation management

In this section the package of practices to be followed by the farmers are discussed. The irrigation schedules are worked out for the normal crop geometry adopted by the famers. The irrigation schedule is done making use of the software SIWAAS developed by Dr.S.Raman. The software is based on climatological approach. It considers the historical weather data of 25-30 years for estimating the evaporation values for the study sites/districts. The crop-wise, planting time/date-wise, drip design wise daily water requirement per plant were calculated. The operating hours for drip irrigation system was calculated based on the lateral distance, dripping spacing and discharge rate. The soil type and mulched conditions for working out the time required for system operation can also be calculated by SIWASS.

The package of practices and calendar of activities for water and fertigation scheduling to different vegetable and fruit crops of Ananthapur, Kurnool and Bipaur districts are given below for medium textured soils with un-mulched conditions. The farmer with heavy soil should reduce operating time by 10% and for sandy soils it can be increased by 10%.

a. Tomato

Tomato (*Lycopersicon esculentum*) is the most popular and important vegetable crop in India. It is grown in 0.45 m. ha area with 7.27 M mt production and 15.9 mt/ha productivity. Tomato can be grown throughout the year with the help of water management technologies (micro irrigation, poly house). Tomato production is sensitive to temperature and can be grown with an optimal temperature of 23-27°c. The major tomato producing states are Bihar, Karnataka, Uttar Pradesh, Orissa, Andhra Pradesh, Maharashtra, Madhya Pradesh and West Bengal.

Soil: Tomato requires a well-drained loamy soils rich in organic matter with a pH range of 6.5-7.5.

Nursery bed preparation: Application of FYM 10 kg, VAM 50g, enriched superphosphate 100g, and Furadon 10 g per square meter before sowing

Seed rate:

Hybrid: 100-150 g/ha

High yielding varieties: 300-350 gm/ha

Seed Treatment:

Treat the seeds with Trichodermaviride 4 g or Pseudomonas fluorescens 10 g or Carbendazim 2 g per kg of seeds 24 hours before sowing. Just before sowing, treat the seeds with Azospirillum @ 40 g / 400 g of seeds. Sow in lines at 10 cm apart in raised nursery beds and cover with sand

Protected Nursery:

- Prepare the nursery area of 3 cents with a slight slanting slope of for the seedling production to cover 1 ha
- Cover the nursery area with 50 % shade net and cover the sides using 40/50 mesh insect proof nylon net
- Mix sterilized cocopeat @ 300 kg with 5 kg neem cake along with Azospirillum and Phosphobacteria each @ 1 kg. Approximately 1.2 kg of cocopeat is required for filling one protray. 238 protrays (98 cells) are required for one hectare adopting a spacing of 90 x 60 x 60 cm in paired row system
- Sow the treated seed in protrays @ one seed per cell
- Cover the seed with cocopeat and keep the trays one above the other and cover with a polythene sheet till germination starts
- After six days, place the protrays with germinated seeds individually on the raised beds inside the shade net
- Water with rose-can every day and drench with NPK 19:19:19 @0.5% (5 gm/lt) at 18 days after sowing

Field Preparation:

Plough the land to fine tilth. Thoroughly prepare the field with the addition of FYM @ 25 t/ ha as basal before last ploughing. Apply 2 kg/ha of Azospirillum and 2 kg/ha of Phosphobacteria by mixing with 50 kg of FYM.

Installation of Drip:

- Form raised beds of 90 cm width at an interval of 30 cm and place the laterals at the centre of each bedsuch that the distance between two laterals will be 150cm. But in the bed one lateral will feed two rows of plants which are planted at 60 cm
- Place the drippers in lateral tubes at an interval of 60 cm or 40 cm spacing with 4 LPH or 2 LPH capacities respectively.
- Before planting, wet the beds using drip system for 8-12 hrs.
- Spray Pendimethalin 1.0 kg a.i. / ha or Fluchloralin 1.0 kg a.i / ha as pre-emergence herbicide at 3rd day after planting
- Gap filling to be done at 7th day of transplanting

Irrigation and fertilizer application:

The water requirement of the crop planted at different months when irrigated through drip is presented through figure 2a-2c.

Figure 2a. District-wise water requirement of tomato planted during Jan. (litre/day/plant)

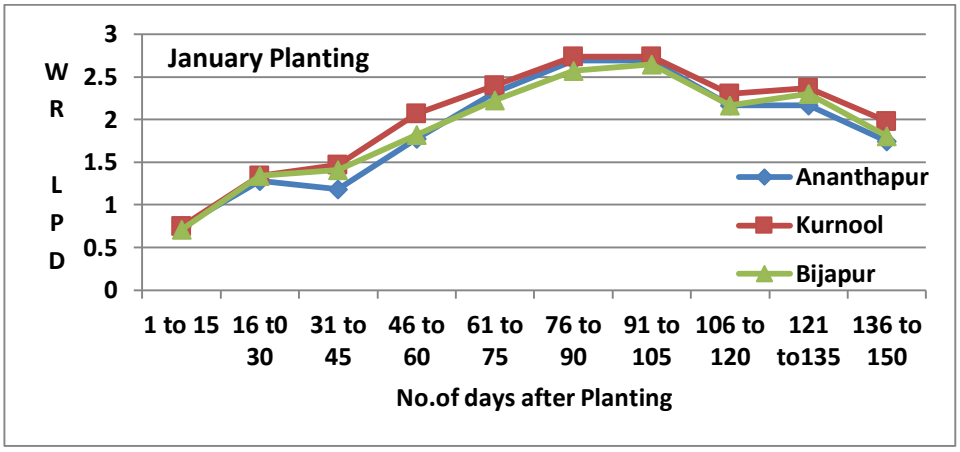


Figure 2b: District-wise water requirement of tomato planted during July (litre/day/plant)

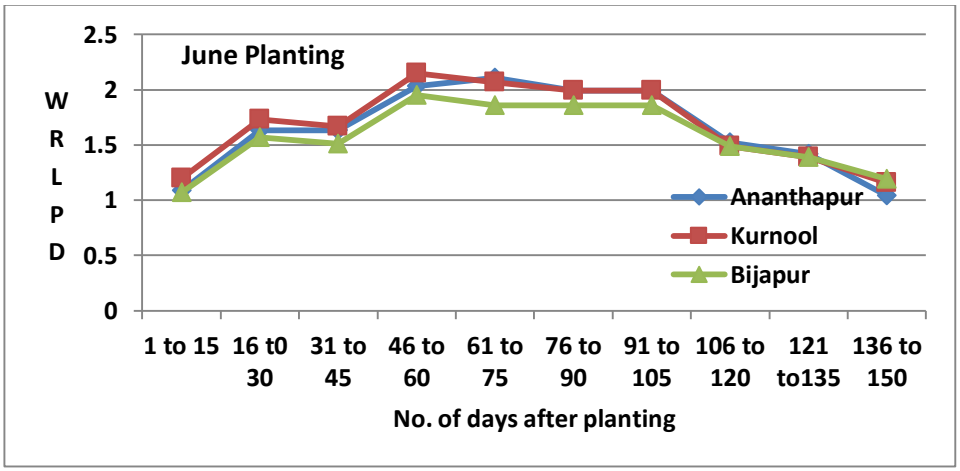
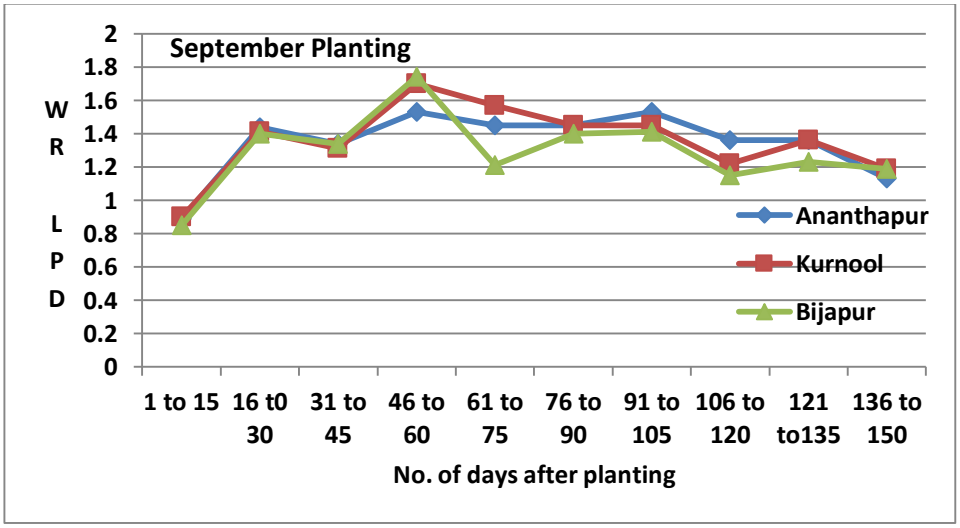


Figure 2c: District-wise water requirement of tomato planted during Sept. (litre/day/plant)



Operation time:

The daily operation time of the drip system depends upon the daily water requirement of the plant, and design of the system. The major system factors those determine the operation time are , number of drippers per plant,dripper spacings and the discharge rates of the drippers.

The suggested operation time for suppling the required water for tomato crop planted on a bed of 90 cm width at 60*60 cm geometry with lateral spacing of 1.5 m with 4 lph drippers is provided in tables 5-7.

Table 5: Suggested alternate day operating time (min) for January planting (1.5 m lateral, 0.6 m dripper of 4 lph)

Days after planting	Ananthapur	Kurnool	Bijapur
1 to 15	62	62	59
16 t0 30	106	111	111
31 to 45	98	122	117
46 to 60	148	172	151
61 to 75	193	199	185
76 to 90	223	227	213
91 to 105	223	227	220
106 to 120	180	191	180
121 to135	180	197	191
136 to 150	145	164	150

Table 6: Suggested alternate day operating time (min) for June planting (1.5 m lateral 0.6 m of 4 lph)

Days after planting	Ananthapur	Kurnool	Bijapur
1 to 15	90	100	89
16 t0 30	135	144	130
31 to 45	135	139	125
46 to 60	168	178	162
61 to 75	175	172	154
76 to 90	165	165	154
91 to 105	165	165	154
106 to 120	126	124	124
121 to135	118	115	115
136 to 150	86	96	99

Table 7: Suggested alternate day operating time (min) for September planting (1.5 m lateral 0.6 m of 4 lph)

Days after planting	Ananthapur	Kurnool	Bijapur
1 to 15	74	75	71
16 t0 30	120	117	116

31 to 45	111	109	111
46 to 60	127	141	144
61 to 75	120	130	100
76 to 90	120	120	116
91 to 105	127	120	117
106 to 120	113	101	95
121 to135	113	113	102
136 to 150	94	99	99

Note : For calculating the operation time for
40 cm dripper spacing of 4lph: multiply the above values by 0.67
40 cm dripper spacing of 2lph multiply the above figures by 1.33.

Fertilization:

The required quantity of FYM (25 t/ha) is applied at the time of ploughing and phosphorus as basal. The nitrogen and potassium need be given as fertigation through drip. The fertigation should be done at an interval of 3 days.

The suggested fertigation schedule is given in table 8 for hybrid varieties and table 9 for high yielding varieties.

Table 8: Suggested fertigation schedule for hybrid variety (Kg/ha)

Stage	Days after planting	Basal	Fertigation	
		Super phosphate	Urea	Muriate of potash
Establishment to early growth	Upto 10 days	1563	30	30
Upto flower initiation	11 to 40		90	43
Flowering to fruit set	41 to 70		90	35
Fruit development to harvesting	71 to 150		90	116

Note: 70% of the recommended dose from ANGRAU, 2008; fertigation to be done at 3 days' interval

Table 9: Suggested fertigation schedule for High yielding varieties(kg/ha)

Stage	Days after planting	FYM	Basal	Fertigation	
			Super phosphate	Urea	Muriate of potash
Establishment to early growth	Upto 10 days	10-12 T/ha	375	15	5
Upto flower initiation	11 to 40 (30 days)			70	15
Flowering to fruit set	41 to 70 (30 days)			70	*20*
Fruit development to harvesting	71 to 150 (80 days)			55	30

Note: 70% of the recommended dose from ANGRAU, 2008; fertigation to be done at 3 days' interval

Growth regulator:

Spray 1.25 ppm (625 ml in 500 litres of water) Triacontanol at 15 days after transplanting and at full bloom stage to increase the yield

Pesticide and fungicide can be applied based on the requirement

b. Chilli:

Chilli (C*apsicum annuum*) commonly known as Mirchi and is one of the most valuable cash crop in India. It is reported to be native of South America and is widely grown in tropical and sub-tropical countries including India. The major chilli producing states in India are Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Orissa and West Bengal. The total area under chilli during 2012-13 was 0.794 million hectares with 1.3 MT production. In many areas chilli is grown with irrigation to improve the productivity. Drip irrigation to chilli was initiated due to the scarce water resources. The following package of practices should be followed in chilli for micro irrigation.

Soil: Well drained loamy soils

Season of sowing: January-February, June-July, September-October

Seed rate: HYV: 1 kg/ha, Hybrid: 200-250 g/ha

Nursery area: 100 sq.m / ha

Land preparation:

Thoroughly prepare the field with the addition of FYM @ 25 t/ ha as basal before last ploughing.

Apply 2 kg/ha of Azospirillum and 2 kg / ha of Phosphobacteria by mixing with 20 kg of FYM.

Apply recommended dose of superphosphate i.e. 375 kg / ha as basal

Layout and planting for drip irrigation:

- Install the drip irrigation with main and sub main pipes and place lateral tubes at an interval of 1.5 m.
- Place the drippers in lateral tubes at an interval of 60 cm and 40 cm spacing with 4 LPH and 2 LPH capacities respectively.
- Form raised beds of 90 cm width at an interval of 30 cm and place the laterals at the centre of each bed.
- Before planting wet the beds using drip system for 8-12 hrs.
- Planting to be done at a spacing of 60 x 45 cm.
- Gap filling to be done at 7th day after transplanting

Weed management: Spray Pendimethalin 1.0 kg *a.i.* / ha or Fluchloralin 1.0 kg *a.i* / ha as pre-emergence herbicide at 3rd day after planting or manual weeding as per the requirement

Irrigation and fertilizer application:

The water requirement of the crop planted at different months when irrigated through drip is presented through figure 3a to 3c.

Figure 3a: District-wise water requirement of Chilly planted during January (litre/day/plant)

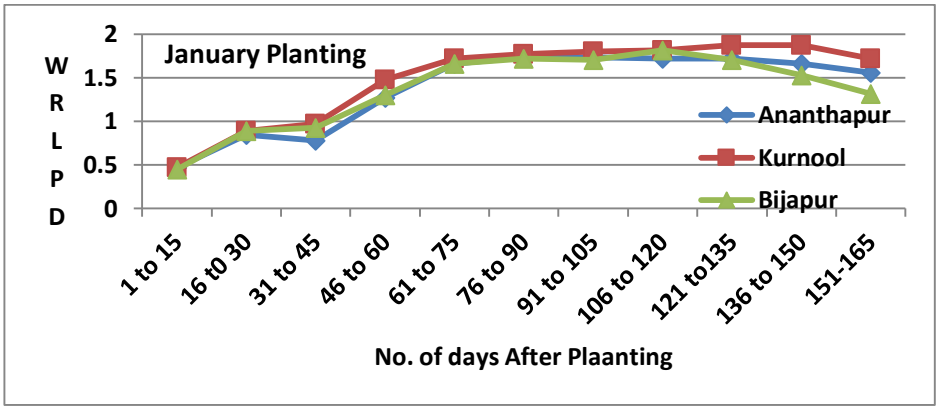


Figure 3b: District-wise water requirement of tomato planted during June (litre/day/plant)

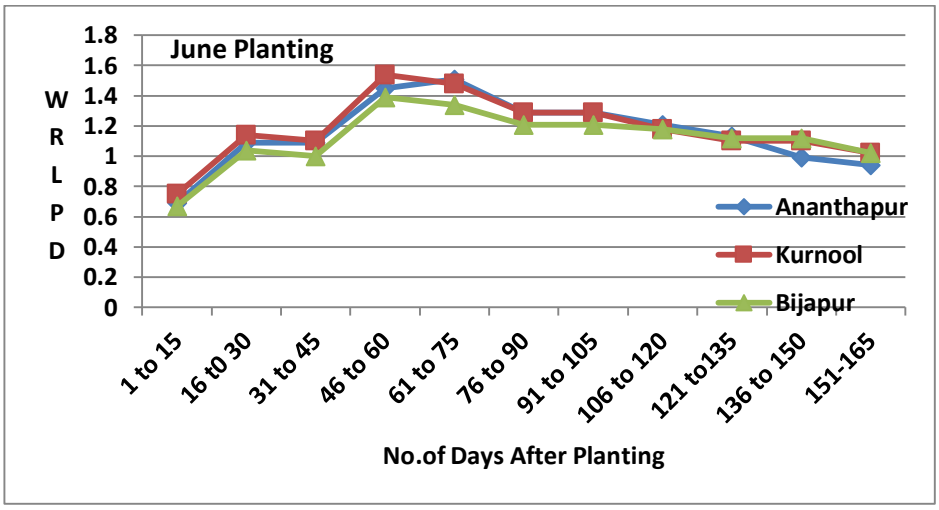
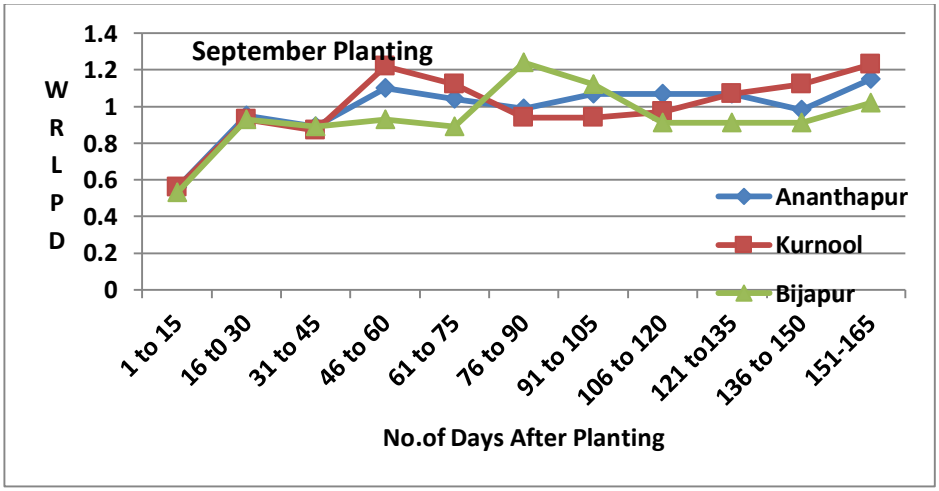


Figure 3c: District-wise water requirement of tomato planted during September (litre/day/plant)



System operating time: The suggested operation time for supplying the required water as per the requirement for chilly crop planted during January, June and September at 60*45 cm with 1.5 m lateral and 60 cm dripper spacing of 4 lph drippers is provided in tables (10-12) below

Table 10: District-wise suggested alternate day operating time (min) for January planting (1.5 m lateral 0.6 m of 4 lph)

Days after planting	Ananthapur	Kurnool	Bijapur
1 to 15	52	52	50
16 t0 30	94	99	99
31 to 45	87	108	103
46 to 60	141	164	144
61 to 75	184	191	184
76 to 90	193	196	191
91 to 105	193	200	190
106 to 120	191	202	202
121 to135	191	209	190
136 to 150	184	209	170
151-165	173	191	147

Table 11: District-wise suggested alternate day operating time (min) for June planting (1.5 m lateral 0.6 m of 4 lph))

	Ananthapur	Kurnool	Bijapur
1 to 15	77	83	74
16 t0 30	121	127	115
31 to 45	121	122	111
46 to 60	161	171	154
61 to 75	168	164	149
76 to 90	143	143	134
91 to 105	143	143	134
106 to 120	134	131	131
121 to135	125	122	124
136 to 150	110	122	124
151-165	104	113	113

Table 12: District-wise suggested alternate day operating time (min) for September planting (1.5 m lateral 0.6 m of 4 lph)

Days after planting	Ananthapur	Kurnool	Bijapur
1 to 15	62	62	59
16 t0 30	105	103	103
31 to 45	99	97	99
46 to 60	122	135	103
61 to 75	115	124	99

76 to 90	110	104	138
91 to 105	119	104	124
106 to 120	119	108	101
121 to135	119	119	101
136 to 150	109	124	101
151-165	128	137	113

Table 13: Suggested fertigation schedule for HYV of chilli (Kg /ha)

Stage	Days after planting	FYM	Basal	Fertigation*	
			Super phosphate	Urea	Muriate of potash
Establishment to early growth	Upto 15days	10-12 T/ha	375	45	15
Upto flower initiation	15 to 50 (35days)			165	35
Flowering to fruit set	51 to 85 (35 days)			145	35
Fruit development to harvesting	86 to 150 (65 days)			100	55

* 70 % of recommended dose from ANGRAU 2008; Fertigation to be done at 3 days' interval

Table 14: Suggested fertigation schedule for hybrid varieties of chilli (Kg /ha)

Stage	Days after planting	FYM	Basal	Fertigation*	
			Super phosphate	Urea	Muriate of potash
Establishment to early growth	Upto 15days	10-12 T/ha	375	70	15
Upto flower initiation	15 to 50 (35days)			275	35
Flowering to fruit set	51 to 85 (35 days)			240	35
Fruit development to harvesting	86 to 150 (65 days)			180	55

*70 % of ANGRAU 2008 recommendation

Harvesting/Picking can be initiated from 75 days after transplanting for green chilli

C. Brinjal:

Eggplant or Brinjal (*Solanummelongina*) is a hardy plant compared to other vegetables. Because of its hardiness, it can be successfully grown in very dry areas under rain-fed conditions or with minimum irrigation facilities. Brinjal is popular in Indian subcontinents and is derived from Arabic and Sanskrit. The brinjal is of much importance in the warm areas of Far East, being grown extensively in India, Bangladesh, Pakistan, Sri Lanka, China and the Philippines. It is a versatile crop adapted to different agro-climatic regions and can be grown throughout the year. It is a perennial but grown commercially as an annual crop. A number of cultivars are grown in India, consumer preference being dependent upon fruit colour, size and shape. The varieties of *Solanummelongena* L. display a wide range of fruit shapes and colours, ranging from oval or egg-shaped to long club-shaped; and from white, yellow, green through degrees of purple pigmentation to almost black.

Nursery bed preparation:

Brinjal seeds are sown on nursery beds to raise seedlings for transplanting in the field. Raised beds are necessary to avoid problem of water logging in heavy soils. In sandy soils, however, sowing can be taken up in flat beds. Raised beds of size 7.2 x 1.2 m and 10-15 cm in height are prepared. Thus, ten beds are sufficient to raise seedlings for planting 1 ha area. About 70cm distance is kept between two beds to carry out operations of watering, weeding, etc. The surface of beds should be smooth and well levelled. Well-decomposed FYM or leaf mould may be mixed with the soil at the time of bed preparation. To avoid mortality of seedlings due to damping off, drenching of the beds with Bavistin (15-20 g/10 litres of water) is effective.

Raising of seedlings:

Seed rate: 250 -300 g for one hectare of land

Seed treatment: treat with fungal culture of Trichodermaviride (4 g/ kg of seed) or Thiram (2g/ kg of seed) to avoid damage from damping-off disease

Nursery and Planting: Sowing should be done thinly in lines spaced at 5-7 cm distance. Seeds are sown at a depth of 2-3 cm and covered with a fine layer of soil followed by light watering by water can. The beds should then be covered with dry straw or grass or sugarcane leaves to maintain required temperature and moisture. The watering should be done by water can as per the need till germination is completed. The cover of dry straw or grass is removed immediately after germination is complete. During the last week in nursery, the seedlings may be hardened by slightly withholding water. The seedlings are ready for transplanting within 4-6 weeks of planting when they attain a height of 15 cm with 2-3 true leaves.

Table 15: sowing and transplanting can be done at different times as given below

Season	Time of sowing	Time of transplanting
Kharif	2nd week of June	July-August
Rabi	End of September	October – November
Summer	2nd week of January	February

Table 16: Drip irrigation design

Variety	Crop geometry (meter)	Lateral distance (meter)	Dripper distance (meter)	Dripper discharge rate (lph)	Remarks
High yielding	0.6*0.6 m	1.2	0.6	4	Normal
Hybrid	0.9*0.6	0.6	0.6	4	Normal

Land preparation:

- Apply FYM @ 25 t / ha as basal dose before last ploughing.
- Apply 2 kg/ha of Azospirillum and 2 kg/ha Phosphobacteria by mixing with 50 kg of FYM.
- Spray Pendimethalin 1.0 kg a.i./ha or Fluchloralin 1.0 kg a.i/ha as pre-emergence herbicide at 3rd day after planting.

Irrigation management: water requirement varies with varieties and month of planting. Brinjal irrigation requirement per plant during February, July and October Planting for Bijapur is given below.

Figure 4a: Planting month-wise water requirement of high yielding variety of chilli at Bijapur (litre/day/plant)

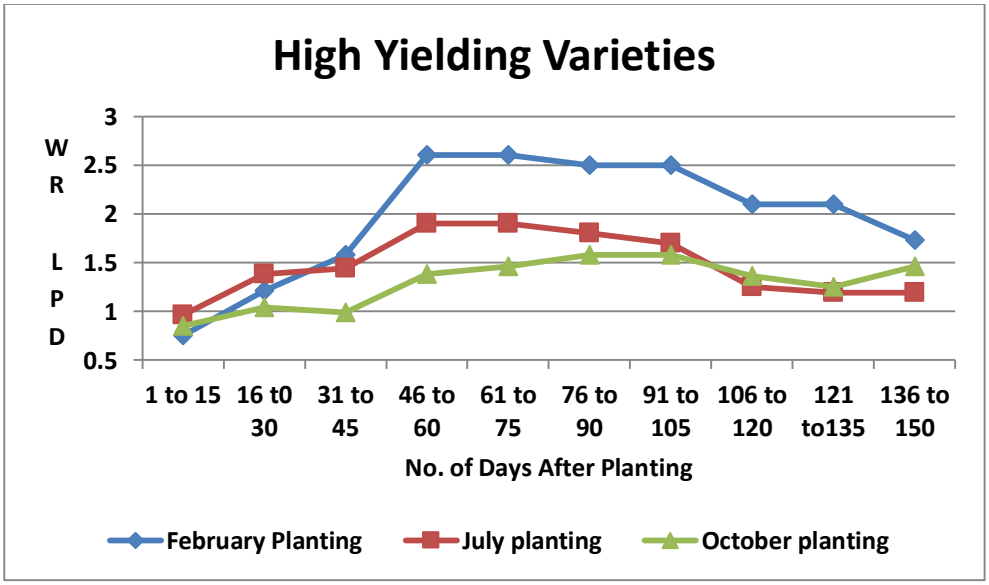
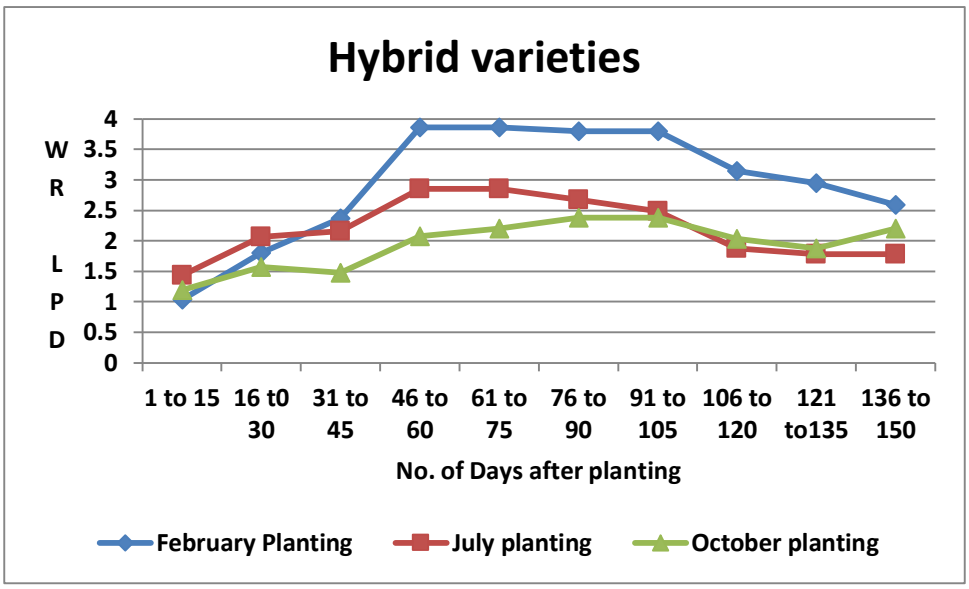


Figure 4b: Planting month-wise water requirement of hybrid variety of Chilli at Bijapur (litre/day/plant)



The duration of alternate day irrigation for the high yielding and hybrid varieties based on the month of planting are furnished in table 17

Table 17: Drip system alternate day operation time as per the crop geometry and system design

Days after planting	High yielding variety 0.6*0.6 at 1.2 m lateral			Hybrid variety 0.9*0.6 at 0.9 m lateral		
	February Planting	July planting	October planting	February Planting	July planting	October planting
1 to 15	50	64	57	35	48	40
16 t0 30	81	92	69	60	69	52
31 to 45	106	96	66	79	72	49
46 to 60	174	127	92	129	95	69
61 to 75	174	127	98	129	95	73
76 to 90	167	120	106	127	89	79
91 to 105	167	114	106	127	83	79
106 to 120	140	84	91	105	63	68
121 to135	140	79	84	99	59	63
136 to 150	116	79	98	87	59	73

In addition to irrigation, brinjal requires good amount of manures and fertilizers for high yield. The fertilizer dose depends upon the fertility of soil and amount of organic manure applied to the crop. The following fertigation schedules can be taken-up for effective nutrient management

Table 18: Suggested fertigation schedule for high yielding varieties of brinjal in Bijapur district (Kg /ha)

Stage	Days after planting	FYM	Basal	Fertigation *	
			Super phosphate	Urea	Muriate of potash
Establishment to early growth	Upto 15days	15 – 20 T/ha	375	30	5
Upto flower initiation	15 to 50 (35days)			40	20
Flowering to fruit set	51 to 85 (35 days)			40	35
Fruit development to harvesting	86 to 150 (65 days)			30	40

*70 per cent of recommended dose for traditional fertilizer application

Table 19: Suggested fertigation schedule for hybrid varieties of brinjal (Kg /ha)

Stage	Days after planting	FYM	Basal	Fertigation *	
			Super phosphate	Urea	Muriate of potash
Establishment to early growth	Upto 15days	10-12 T/ha	375	45	10
Upto flower initiation	15 to 50 (35days)			60	30
Flowering to fruit set	51 to 85 (35 days)			60	55
Fruit development to harvesting	86 to 150 (65 days)			45	60

*70 per cent of recommended dose for traditional fertilizer application

Pest and diseases: Epilachna betel, whitefly, ash weevil, aphid, red spider mite are commonly found pests in Brinjal. Leaf spot, little leaf and damping off are common diseases in brinjal. Pesticide and fungicide can be applied based on the requirement

Duration of the crop: Duration of the crop change based on the varieties. It takes about 150-160 days. Harvest/pickings can be initiated from 55-60 days after transplanting. Fruits can be harvest at tender stage at 4-5 days interval

d. Onion:

Onion (*Allium cepa*) is one of the most important commercial vegetable crops grown in India. The demand for onion is worldwide. It is used both in raw and mature bulb stage as vegetable and spices. The pungency in onion is due to a volatile oil known as ally-proopyldisulphide. The bulb of onion consists of swollen bases of green foliage leaves and fleshy scales. Maharashtra, Tamil Nadu, Andhra Pradesh, Bihar and Punjab are the important onion producing states. Onion is mostly grown in rabi season under a wide range of climatic condition.

Seed treatment and seed rate: 8-12kg of onion seeds are required to raise seedlings for one hectare of land. The seeds are treated with Pseudomonas fluorescens at 10 gm/kg of seeds

Field preparation:

- The field selected for planting should be ploughed thoroughly by using chisel plough, disc plough and cultivator.
- FYM @ 25t / ha and 75% of the total recommended dose of single superphosphate (285kg.) Azospirillum, phosphobacteria 2 kg / ha and Pseudomonos 2.5 kg / ha along with FYM 50 kg and neem cake @ 100g are applied before last ploughing.
- Along with biofetilizers 50kg each of zinc sulphate and ferrous sulphate are applied before last ploughing.
- Raised beds of 1.2 m width and 30 cm height are formed for transplanting.
- Drip irrigation is to be done @ 8-12 hours depending upon the soil condition to get field capacity.

Planting:

- Transplanting is done in rows at the spacing of 15 cm between rows (of 6-7 rows within the bed) and 10 cm between plants.
- A total population of 4,70,000 seedlings are required to cover one hectare of land
- Drip design: The laterals need to be placed at 1.2 meter such that one lateral will serve for four rows. The drippers of 4 lph capacity can be placed at 60 cm

The estimated daily water requirement per plant is depicted in figure below

Figure 5: Water requirement litre per day (WR LPD) per plant for different regions

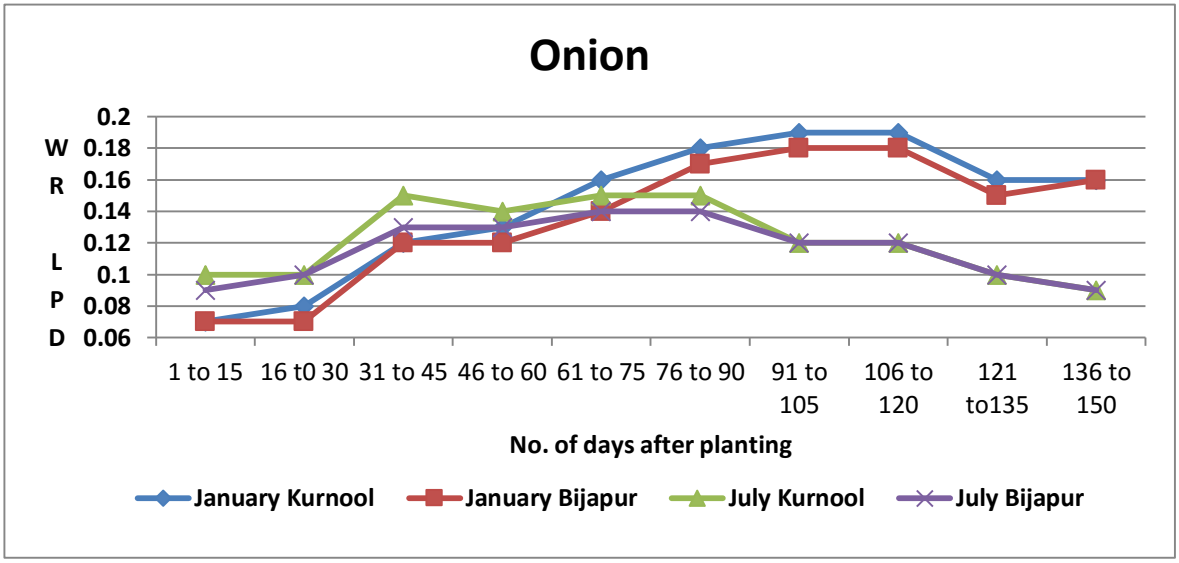


Table 20: Estimated alternate day operation time at different months of planting

	January planting		July planting	
	Kurnool	Bijapur	Kurnool	Bijapur
1 to 15	56	56	80	72
16 t0 30	64	56	80	80
31 to 45	96	96	120	104
46 to 60	104	96	112	104
61 to 75	128	112	120	112
76 to 90	144	136	120	112
91 to 105	152	144	96	96
106 to 120	152	144	96	96
121 to135	128	120	80	80
136 to 150	128	128	72	72

Table 21: Suggested fertigation schedule for onion in Bijapur district (Kg/ha)

Stage	Days after planting	FYM	Basal	Fertigation*	
			Super phosphate	Urea	Muriate of potash
Establishment	Upto 15days	25 T/ha	375	35	5
Grand growth	15 to 60 (45days)			55	20
Bulb formation	61 to 95 (35 days)			45	35
Bulb development	86 to 110 (25 days)			30	25
Maturity	111 to 135 (25 days)			10	20

*70 per cent of recommended dose for traditional fertilizer application

Crop *duration*: Harvest varies with the varieties. It takes about 150-160 days for complete harvest

e. Banana

Banana (Musa sps) is one of the major and economical fruit crop in India. It is grown in 7.7 m.ha with a production of 26.46 m.MT. In India it is highly produced in Tamil Nadu, Gujarat, Maharashtra, Andhra Pradesh, Karnataka, Bihar, Madhya Pradesh, West Bengal, Assam and Orissa states.

Planting: Majority (80%) of the farmers use suckers for planting where 20% use tissue culture. It can be planted at different spacing based on the variety grown. Rasthali, poovan, karpoorvalli, etc can be grown with 2.1x2.1 m spacing. Robusta and Nendran at 1.8x1.8 m spacing, Dwarf Cavendish at 1.5x1.5 m, Paired row at 1.2x1.2x2.0 m

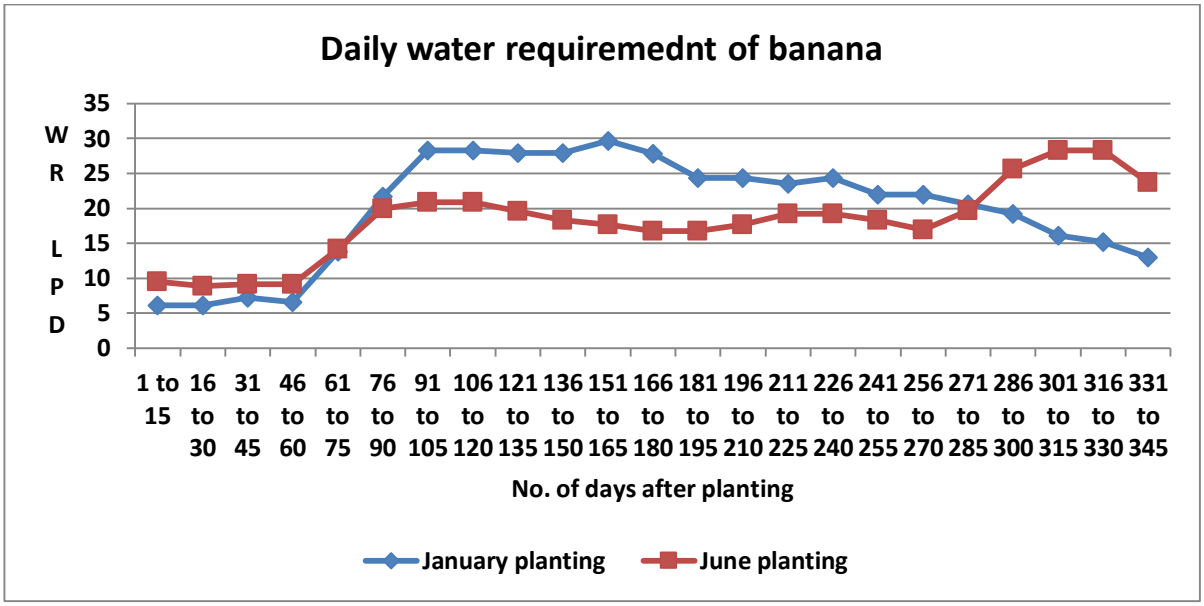
Soils: Well drained loamy soils are required for banana cultivation.

Table 22: Banana planting

Particulars	Particulars
Row to row spacing (m)	2.1
Plant to plant spacing (m)	2.1
Lateral spacing (m)	2.1
Dripper spacing (cm) and discharge rate (liter per hour, lph)	60 with 4lph or 40 with 2 lph

The total water requirement for banana crop is about 1200-1500 mm depending on the varieties and climatic conditions. However, it can be reduced with adoption of drip irrigation. Water requirement per plant for banana crop in Kurnool district is depicted in figure 6.

Figure 6: Estimated water Requirement (litre per day per plant) for January and June planted crops



System operating time: The required alternate day operating time for the system of 2.1 m lateral distance with 4lph dripper placed at 60 cm for a crop geometry of 2.1*2.1 m is given in table 23.

Table 23: Suggested alternate day drip operational time for banana in Kurnool

Days after planting	Planting month		Days after planting	Planting month	
	January	June		January	June
1 to 15	58	90	181 to 195	232	160
16 to 30	58	85	196 to 210	232	168
31 to 45	68	87	211 to 225	223	182
46 to 60	63	87	226 to 240	232	182
61 to 75	131	135	241 to 255	209	174
76 to 90	206	190	256 to 270	209	161
91 to 105	269	199	271 to 285	196	187
106 to 120	269	199	286 to 300	182	243
121 to 135	265	186	301 to 315	153	269
136 to 150	265	174	316 to 330	144	269
151 to 165	282	168	331 to 345	124	225
166 to 180	264	160	**Mean**	**188**	**173**

Table 24: Suggested fertigation schedule for banana (g/plant)

Days after planting	Basal	Fertigation*	
	Super phosphate (kg/ha)	Urea	Muriate of potash
Upto 70 days	3190	75	40
71 -125		125	70
71 to 250		225	170
251 to 335		65	95

*70 per cent of recommended dose for traditional fertilizer application

Banana fertigation schedule for Kurnool is given in Table 24. The basal does is provided upto 70 days of plating. Fertigation has to be scheduled at frequent intervals as suggested in table 24.

The pest and disease control operations can be followed as per the scientist recommendations in the sites

f. Mango

Mango (*Mangifera indica*) is the leading fruit crop and is the king of fruit crops in India. It is grown over an area of 1.23 million ha producing 10.9 million tonnes. It is highly grown in Uttar Pradesh, Andhra Pradesh, Bihar and Karnataka. India ranks first in the mango production with 52.6% of the total worlds production (19 million tonnes). Mango is well adopted to the tropical and subtropical climates. It grows well on wide variety of soils (eg. Laterite, alluvial, sandy loam) with a pH of 5.5 to 7.5

High density mango planting can be done at all those places where traditional mango is grown. Specifically, it well drained soil with pH between 6.5-7.5 having no hardpan layer till 1.5m depth.

The normal planting at a spacing of 10 x 10 m accommodates 100 plants/ha (40 plants/acre), the high density at a spacing of 5x5 m accommodates 400plants/ha (80 plants/acre) and ultra high density planting at a spacing of 3 x 2 meter accommodates 1666 plants/ha (666 plants/acre).

Mango grafts of commercial varieties can be planted at very close spacing of (3mx1m or 3mx2m) which allows attaining good growth during initial years and orchard attains commercial production from 3rd year onwards. Special techniques of training and pruning have to be used to develop sufficient number of branches and shoots since planting and tree growth and flowering are regulated through a combination of regular pruning and Pachlobutrazol application. Special care for nutrition management and pest control need to be followed.

Table 25: Comparison of the planting types in Mango

Particular	High Density	Ultra high density
Gestation Period (years)	4-5	3-4
Duration to reach full potential (years)	7-8	4-5
Yield Potential	High	Very High
Orchard Management Activities		
Pruning	Manageable	Easy
Spray operation	Manageable	Easy
Spray efficiency	Fairly Good	Good
Harvest	Possible	Very Easy
Control of Fruit Quality	Possible	Easy

Benefits of high density planting:

a. Very low gestation period allows farmer to reduce cost burden and early income generation.
b. b. Suitable for small, medium and semi-large farmers as it is management intensive and yields good quality fruits which can get better market price.

c. It makes sensible bankable project to offer financial support due to assured high early returns

Water requirement:

The water requirement depends upon the monthly evaporation, crop spacing and age of the tree. The estimated water requirement of mango of different age groups are presented in figures 7a – 7e

Figure 7a: Planting density-wise estimated water requirement of new plantation of < 1yr at Ananathapur

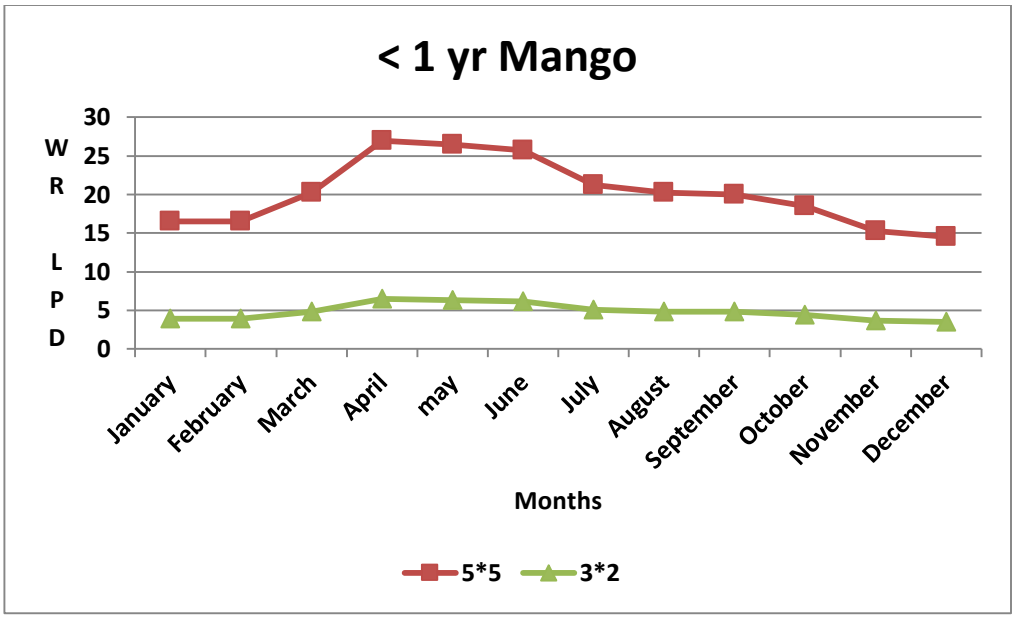


Figure 7b: Planting density-wise estimated water requirement of young plantation of 1 to 3 years at Ananathapur

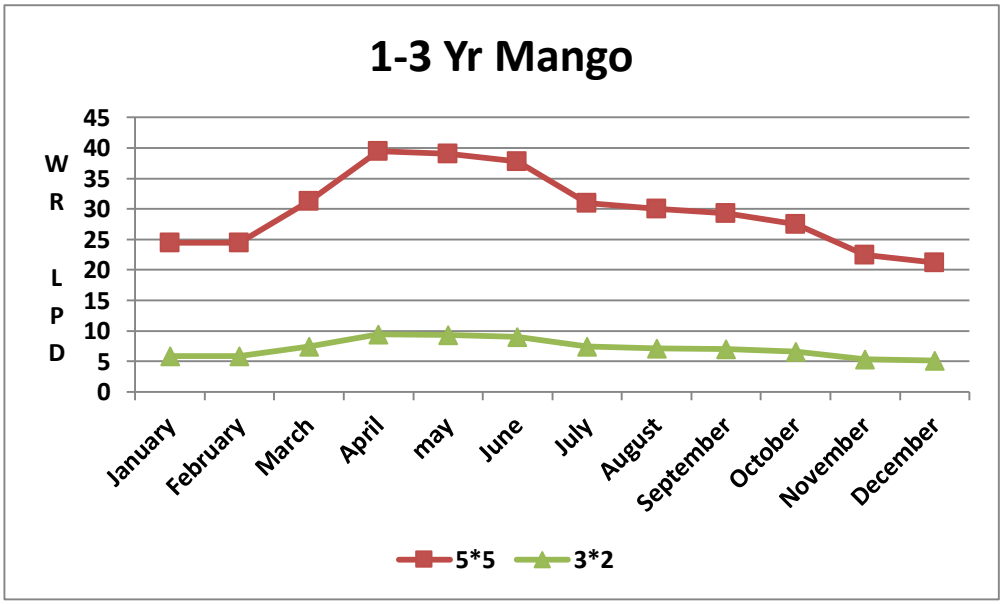


Figure 7c: Planting density-wise estimated water requirement of 3 to 6 years old plantation at Ananathapur

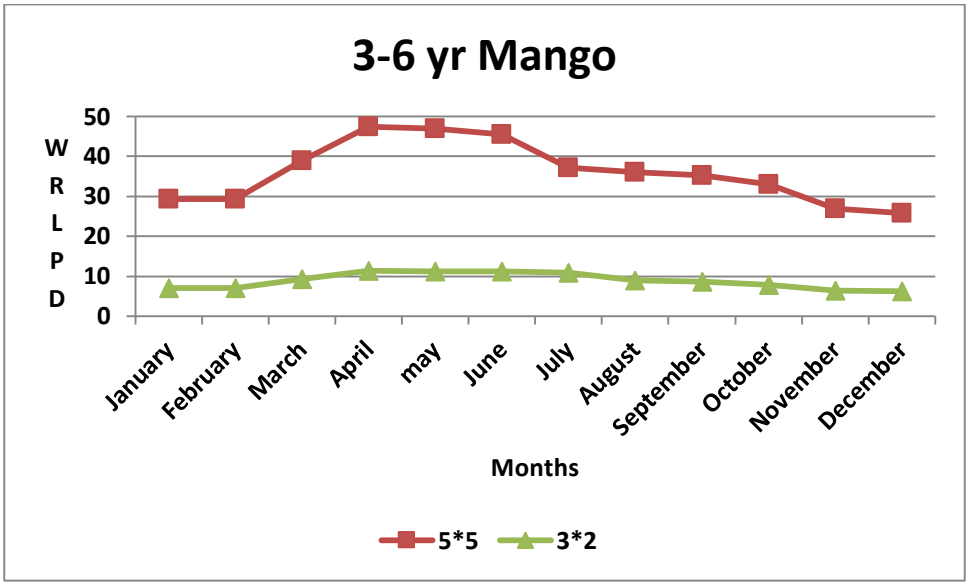


Figure 7d: Planting density-wise estimated water requirement of 6 to 9 years old plantation at Ananathapur

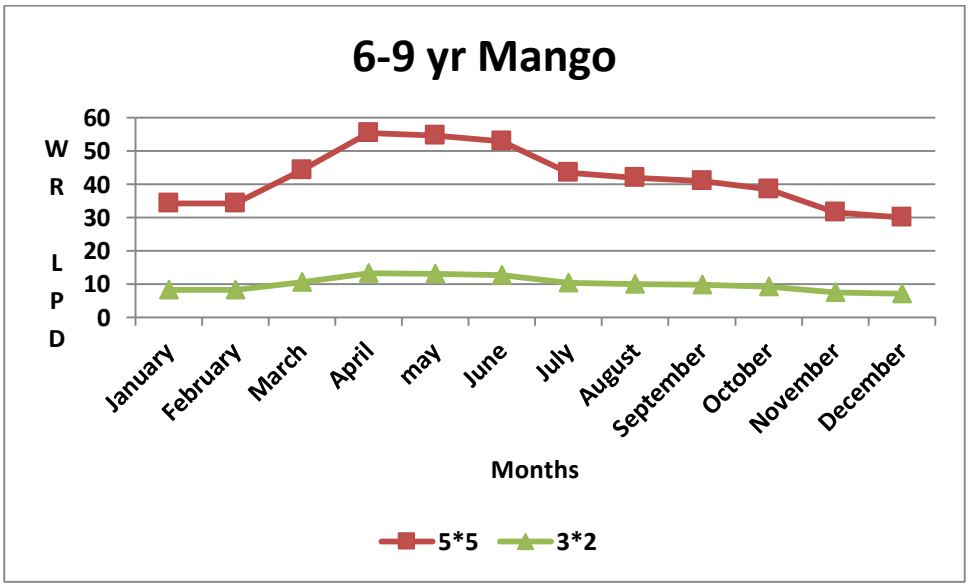
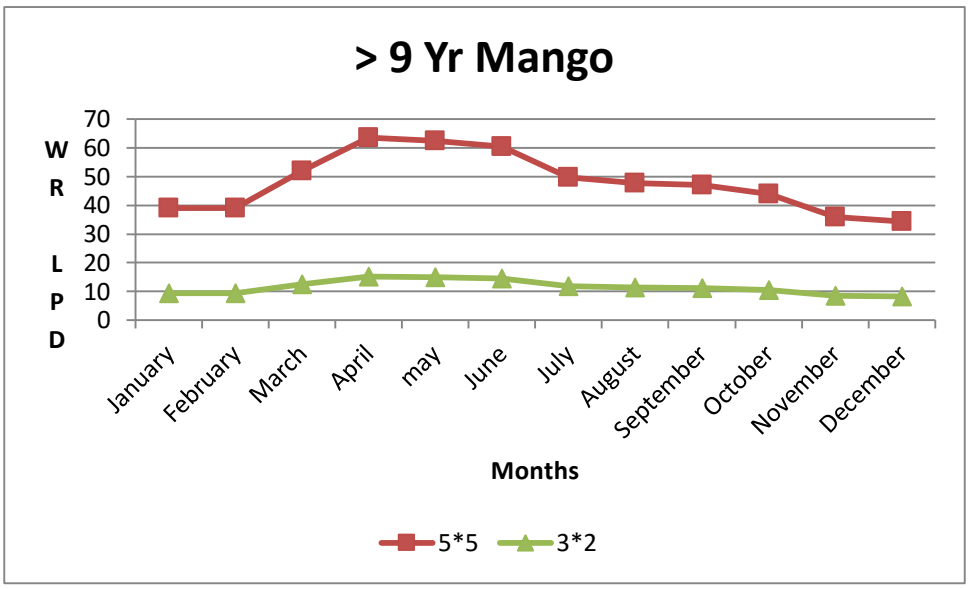


Figure 7e: Planting density-wise estimated water requirement of > 9 years old plantation at Ananathapur



Drip system operating time:

The drip system operating time depends upon the daily water requirement of the tree, as per its age, number of drippers per tree and the dripper rate. The operation time have been estimated for both the densities

Table 26: Age-wise estimated operational time (alternate days) for mango at high and ultra-high density plantation for Ananthapur

Month/ Geometry	< 1 Yr		1 – 3 Yr		3 – 6 Yr	
	5*5 m	3*2 m	5*5 m	3*2 m	5*5 m	3*2 m
January	69	17	103	25	123	30
February	69	17	103	25	123	29
March	85	20	131	31	164	39
April	113	27	166	40	200	48
may	111	27	164	39	197	47
June	108	26	159	38	191	47
July	89	21	130	31	156	46
August	85	20	126	30	151	37
September	84	20	123	29	148	36
October	78	19	116	28	139	33
November	64	15	95	23	113	27
December	61	15	89	21	108	26

Month/ Geometry	6 – 9 yr		>9 yr	
	5*5 m	3*2 m	5*5 m	3*2 m
January	144	34	164	39
February	144	34	164	39
March	186	45	218	52
April	233	56	267	64
may	230	55	263	63
June	223	53	254	61
July	183	44	209	50
August	176	42	201	48
September	172	41	197	47
October	162	39	185	44
November	132	32	151	36
December	126	30	144	34

Fertilizer application:

The nutrients requirement of trees increases with the age of the trees. The recommended nutrient requirement for mango is furnished below:

Table 27: Age-wise recommended NPK application rates (g/tree)

Age of the tree	Nutrient application rate in g/tree		
	Nitrogen	Phosphorus	Potassium
First year	100	100	100
Second Year	200	200	200
Third Year	300	300	300
Forth Year	400	400	400
Fifth Year	500	500	500
Sixth Year	600	600	600
Seventh Year	700	700	700
Eighth Year	800	800	800
Ninth Year	900	900	900
Tenth Year	1000	1000	1000

- Fertilizers should be applied through placement in circular trenches around the trunk. For the 10 years' age and above trees the fertilizer should be applied at 1.5 m away from the trunk
- Manures and fertilizers should be generally done in the beginning of monsoon. Irrigation should be given after the application of fertilizers. Wherever irrigation is available it is advantageous to apply half of the recommended dose of fertilizers after fruit set.

- For the correction of micronutrient deficiency, spraying of $ZnSO_4$ 5 g, Boran 2 g and 10 g urea per litre of water is recommended at the onset of monsoon.
- Spraying of KNO_3 @ 10 g/l during November helps in opening of the flower bud and uniform flowering.

Canopy management:

Remove root stock sprouts and low lying branches nearer to ground to facilitate easy cultural operations. Remove overlapping, inter-crossing, diseased, dried and weak branches in old trees to get good sunlight and aeration. Carry out judicious pruning of the internal branches during August – September, once in three years. Do not allow flowering upto three years by removing the inflorescences as and when they appear. Retain two healthy shoots by trimming away the weak shoots among the crowded terminal shoots during August-September annually. Prune back 20 cm of annual growth of the terminals immediately after harvest

g. Lemon:

Lemon/ Acid lime (*Citrus aurantifolia*) requires tropical and sub-tropical climate. It is widely grown in Andhra Pradesh, Maharashtra, Tamil Nadu, Gujarat, Rajasthan, Karnataka etc. citrus can be grown in wide range of soils and deep well drained loamy soils is best suited for cultivation. Plating can be done in December-February and June-September.

Planting:
Healthy seedlings should be planted during June to December at 5 to 6 m spacing in 75 cm x 75 cm x 75 cm pits. The suggested drip irrigation design is presented below in table

Table 28: Plating lemon

Particulars	Values
Row to row spacing (m)	6.4
Plant to plant spacing (m)	6.4
Lateral spacing (m)	6.4
Number of drippers per tree and discharge rate (liter per hour)	4 with 8 lph

Water requirement:

The estimated water requirement of lemon of different age groups are presented in figures

Figure 8: Age-wise estimated daily water requirement for lemon at Bijapur

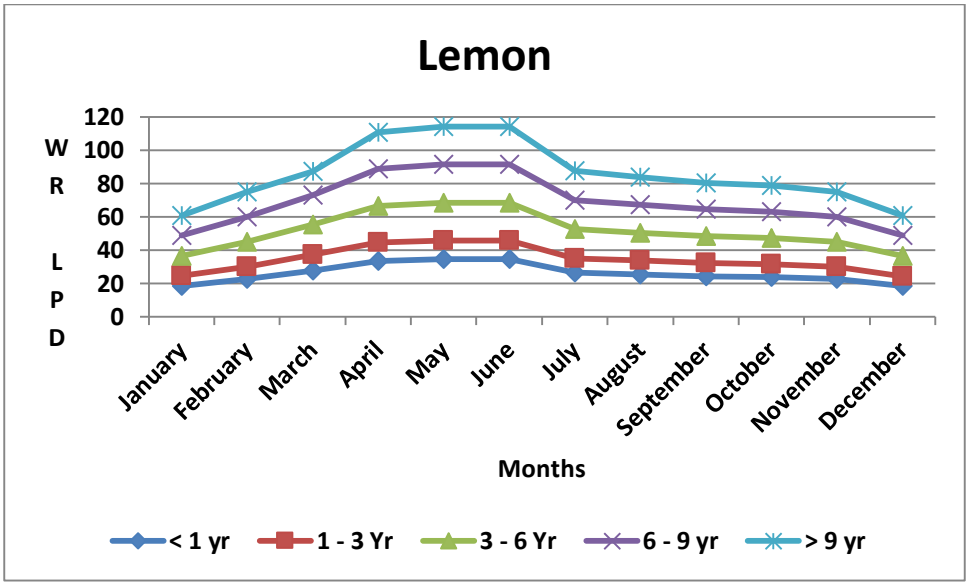


Table 29: Estimated alternate day drip operational time for lemon according to the age of the tree- Bijapur

Month	< 1 yr	1 – 3 yr	3 – 6 yr	6 – 9 yr	>9 yr
January	76	102	153	204	255
February	95	126	189	252	315
March	116	155	232	307	365
April	139	186	279	372	465
May	144	192	288	384	480
June	144	192	288	384	480
July	111	147	221	294	368
August	106	141	212	282	352
September	101	135	202	270	338
October	99	132	198	264	330
November	95	126	189	252	315
December	76	102	153	204	255

Table 30: Recommended fertiliser dose for lemon g/tree

	Nitrogen	Phosphorus	Potassium
> 1 year	375	150	200
1 – 3 years	750	300	400
3 - 6 years	1125	450	600
6 – 9 years	1500	600	600
> 9 years	1500	600	800

Pests and disease:

Lemon is mostly affected with leaf miner, leaf caterpillar, sucking pests (white fly, black fly, aphids, rust mite), twig blight, scab, canker etc. Management aspects can be followed as per the requirement and recommendations by the scientists.

Harvest:
The crop starts bearing from 3rd year after planting.

Post-harvest treatment
Treating the fruits with 4% wax emulsion followed by pre-packing in 200 gauge polythene bags with 1 % ventilation improves the shelf life for more than 10 days.

h. Pomegranate:

Pomegranate (*Punica granatum*) is grown in tropical and sub-tropical regions. In India, pomegranate is cultivated in 107 thousand ha (2010-11) with a total production of 743 thousand tons. Pomegranate production is mainly concentrated in the western Maharashtra, Karnataka, Gujarat, Andhra Pradesh, Tamil Nadu and Rajasthan states of India.

Soil: Pomegranate grows well in semi-arid conditions with deep loam and sandy loam soils. It is also suitable in light soils but with assured irrigations.

Planting:

Pomegranate should be planted in square system at a distance of 5 x 5 m or 4 x 4 m in 1m deep pits. The best time for plating it is December-January. The drip irrigation design for pomegranate is presented below in table 31

Table 31: Planting of pomegranate:

Particulars	Values
Row to row spacing (m)	4
Plant to plant spacing (m)	4
Lateral spacing (m)	4
Number of drippers per tree and discharge rate (liter per hour)	4 with 8 lph

Water requirement:

The estimated water requirement of pomegranate of different age groups are presented in figure 9.

Figure 9: Age-wise estimated daily water requirement of pomegranate at Bijapur

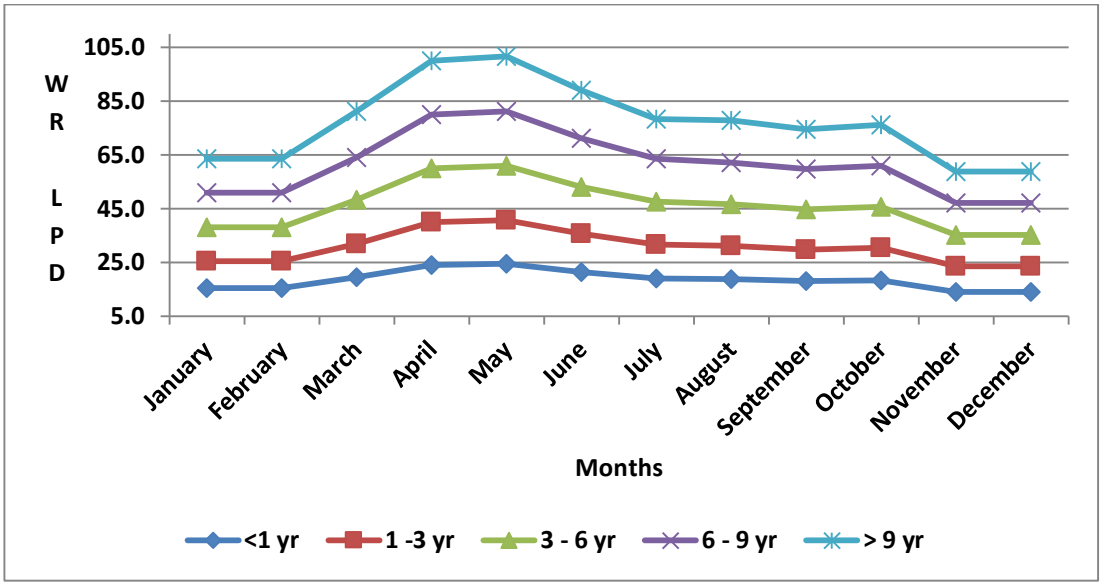


Table 32: Age-wise alternate day operating time for pomegranate under drip irrigation

Month	Operating time (min) on Alternate days				
	Age of the crop (years)				
	<1	1 to 3	3 to 6	6 to 9	>9
January	64	107	160	214	267
February	64	107	160	214	267
March	81	134	203	269	341
April	101	168	252	336	420
May	102	170	256	341	427
June	90	149	223	299	373
July	80	133	200	267	328
August	79	131	196	261	326
September	75	125	188	250	313
October	77	128	192	256	320
November	59	98	148	197	246
December	59	98	148	197	246

Fertiliser doses are given based on the soil condition and regions. The fertilizer need be applied as 50 % before onset of monsoon and rest immediately after cessation of monsoon

Table 33: Manures and Fertilizers/ tree for pomegranate

Age (Years)	FYM (kg)	Nitrogen (g)	Phosphorous (g)	Potassium (g)
1	10	250	125	125
2	20	250	125	125
3	30	500	125	125
4	40	500	125	250
5 and above	50	625	250	250

Weeding: weeding should be done manually by hoeing as inter-cultivation by tractors is not desirable.

Pruning: remove criss-cross and dried branches and no special pruning is required.

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