RESEARCH PROGRAM ON
Dryland Systems

CGIAR

Report on

"Implementation of micro irrigation in dryland system"

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Introduction:

In rural areas of South Asia, one of the biggest challenges is to move people out of poverty. Climate change and variability further influence the development of the rural sector hindering the agriculture sector. This is obviously means an impact on the lives and livelihoods of millions of farmers and farm labour. The small and marginal farmers are more vulnerable to the climate change because of their limited adaptive capacity, socio-economic background and unfavourable policy environment. Nevertheless, there are many potential adaptation options available for exiting agricultural systems to meet the current climate risks (Palanisami et al 2015). It consists of the *in situ* soil and moisture conservation practices such as contour cultivation, contour bunding, border trenches, deep trenches in dryland orchards and ex situ practices such as development of check dams, percolation tanks, farm ponds on watershed basis.

Researchers reveal that farm pond technology is economically feasible with lost for providing critical irrigations (Gurava Reddy et al., 2014). Studies in Ananthapur and Kurnool districts of Andhra Pradesh show that water harvesting in a farm pond of size 271 m^3 is useful for supplemental irrigation and is economically viable with a cost benefit ratio of 1.7 (Goyal et al, 1995). The results of supplemental irrigation in medium black soils at Bijapur over a period of 5 years indicate that crop yields with one life saving irrigation could be enhanced by 40-90%. The harvested runoff in farm ponds is costly and scarce commodity in dryland agriculture for supplemental irrigations. Adding technical inventions, such as drip kit to the farm pond can have higher efficiency of resource use.

On the other hand, groundwater extraction for the supplemental source has become critical due to the frequent power cuts. Farmers in the Bijapur district has developed the system of water storage tanks by pumping groundwater and storing it for supplemental irrigations. The supplemental irrigations are provided through gravity or micro irrigation system. The economics of such double pumping are crucial for the policy making. However, cost benefits of such system depends on the crop selection, electricity charges, etc. which need to be sightseen. Hence, investments on different farm level investment options such as farm ponds, percolation ponds, open well irrigation with micro irrigation based accessories, and solar pumps has to be explored in detail. In Ananthapur district of Andhra Pradesh farmers have instigated the solar pump from the bore wells with the support of Rural Development Trust (RDT). But the economics of solar energy vs electricity and groundwater access in the long-run is not accessible for improving the intervention. Regional Agricultural Research Station, University of Dharwad, Bijapur is also testing the intervention of farm pond with solar energy and drip/sprinkler.

As a part of CRP dryland system program, Ananthapur, Kurnool districts from Andhra Pradesh and Bijapur from Karnataka were identified as action sites. Balaganur and Mannur villages from Sindagi taluk of Bijapur district were selected for the implementation of micro irrigation system management and capacity building program. Three farmers from the Balaganur and one farmer from Mannur were identified for the implementation purpose based on the water resources access. Farmers are growing vegetables (tomato, brinjal, onion) and orchard crop (Citrus, mango) in the villages. In Balganur, one farmer was identified for the solar pump with open well and drip irrigation (vegetables) flooding for sugarcane. The details of implementation plan in the district is presented in table 1.

Similarly, 7 farmers from Ananthapur and Kurnool districts were identified for the implementation. Micro irrigation in vegetables through groundwater and farm pond was taken up in the action sites. The details are presented in the table below.

Table 1: Implementation of micro irrigation in the action sites

	Description (total acreage, major crops grown by farmer and demo details)	Crop for piloting	Area under demonstration (ha)	Villages	District /State	Remarks
1	Timmaraju, – 6 acres, Demo: Drip irrigation with irrigation schedule, fertigation and system maintenance	castor	0.2	V.Bonthirala	Kurnool (AP)	Farmer has sown castor with drip due to the market demand
2	K.Madhava Raidu, 2 acres (chilly) Demo: Drip with irrigation schedule, fertigation and system maintenance	Chilli	0.2	V.Bonthirala	Kurnool (AP)	Dry Chilli crop was completed successfully
3	Giddaiah, 3 acres (Marigold, tomato, onion, groundnut) Demo: Farm pond with drip kit	Tomato	0.2	Yerraguntla	Kurnool (AP)	Delayed monsoons and Installation of drip kit was delayed for Kharif season. Piloting has to be continued in the next year
4	T.Nagarjuna, 5 acres (G.nut, sorghum, onion & carrot) Demo: Drip with irrigation schedule, fertigation and system maintenance	Onion	0.2	Yerraguntla	Kurnool (AP)	Onion crop was completed successfully
5	K.Ramanujamma, 4 acres (Mango, vegetables intercrop) Demo: Drip with irrigation schedule and fertigation	Tomato and chilli	0.2	Mallapuram	Ananthapur (AP)	
6	B.K.Govindarajulu, 5 acres (groundnut) Demo: High density mango plantation with drip, irrigation schedule and fertigation	Tomato	0.2	Mallapuram	Ananthapur (AP)	Farmer changed crop to tomato due to high cost of High density mango
7	K.Chiranjeevi, (Mango) Demo: Drip for vegetable crop as intercrop for mango	Tomato	0.2	Mallapuram	Ananthapur (AP)	Initiated Tomato in October due to the delayed monsoon and less discharge from borwell
8	Appanna Kolageri, 7ac (Tomato, Brinjal, Sugar cane) Demo: Solar system connected with open well source and integrated with drip and flood irrigation	Brinjal	7	Balaganur	Bijapur (Karnataka)	Brinjal crop was taken-up instead of chilli
9	Vimala Honnapa Pasodi, (Mango, lemon, sapota) Demo: Intercrop with drip vegetable	Tomato	0.4	Balaganur	Bijapur (Karnataka)	
10	Amruth Siddappa jetagi (onion, brinjal, Tomato) Demo: Drip with vegetables	Onion	0.4	Balaganur	Bijapur (Karnataka)	Onion crop
11	Bhimappa Basappa Pujari, 7 acres (citrus, rainfed crops) Demo: Drip with citrus (4 years old)	Lemon	0.4	Balaganur	Bijapur (Karnataka)	

Pictures: Installation of drip and solar system


Filter and Fertigation tank installed for vegetables


Drip installed for lemon crop in Bijapur


Solar drip farmers at Balaganur village, Bijapur on 03-06-2015 and awareness meeting

Field demonstrations were initiated with the onset of monsoon during June-August 2015. The main objective of the piloting/demonstrations is to improve the crop water use efficiency with efficient irrigation and fertigation scheduling. Jain irrigation system Ltd (JISL) was involved on a public private partnership (PPP) mode for installation and training programs. Many of the farmers in the study regions are aware of the micro irrigation and benefits but do not schedule irrigation and fertigation for efficient resource management. Hence, initiatives were taken on the development of package of practices, irrigation scheduling with drip and fertigation. Crop-wise/demonstration details can be seen below:

Tomato:

Tomato (*Lycopersicon esculentum*) is the most popular and important protective vegetable crop in India. It is grown in 0.45 million hectares with 7.27 Mmt production and 15.9 mt/ha productivity. With the help of modern technologies (Micro irrigation, Polyhouse), it can be grown throughout the year. 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.

Nursery bed preparation: Tomato requires a well-drained loamy soils rich in organic matter with a pH range of 6.5-7.5. Application of FYM 10 kg, VAM 50gm, enriched superphosphate 100gm, and Furadon 10 gm per square meter before sowing is required

Seed rate:

Hybrid: 100-150 gm/ha

High yielding varieties: 300-350 gm/ha

Or 30,000 plants per hectare

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 slanting slope of 2 % 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
- Form raised beds of 1 m width and convenient length and place HDPV pipes at 2m interval for further protection with polythene sheets during rainy months.
- 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 the production of 23,334

seedlings, which 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.

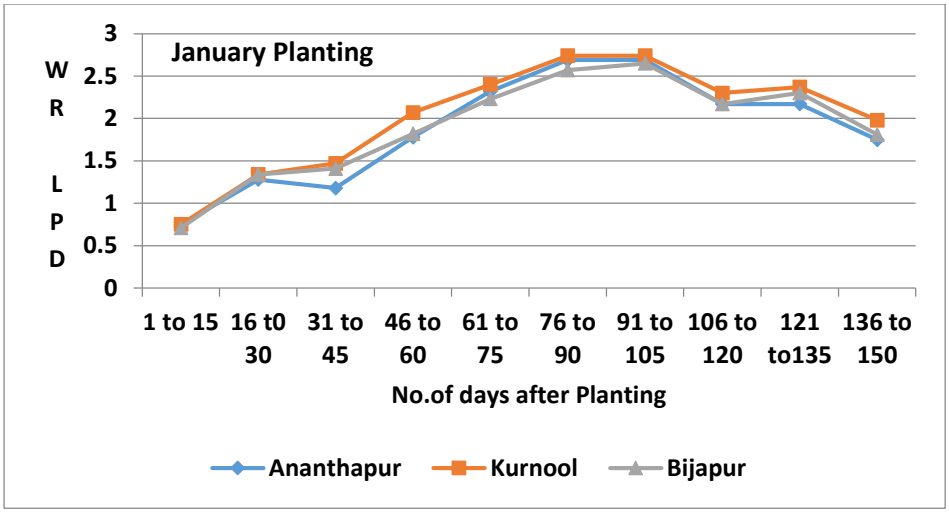
Installation of Drip:

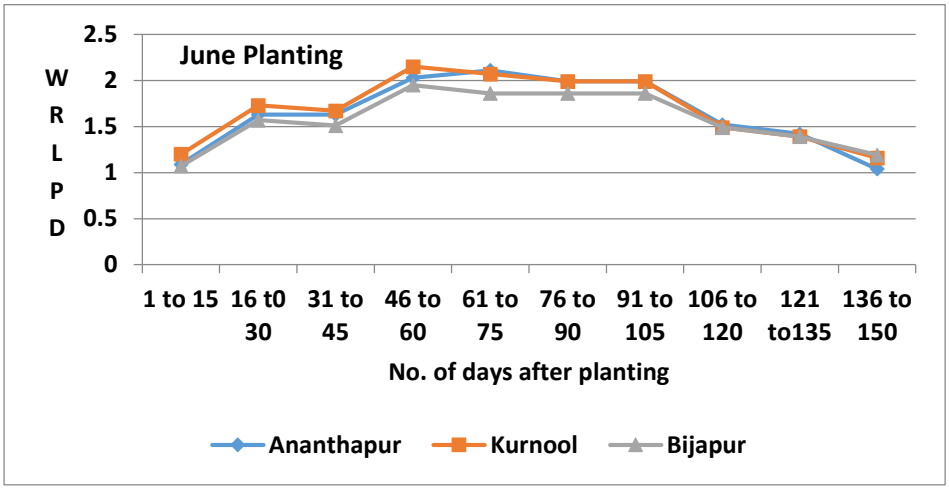
- Install the drip irrigation with main and sub main pipes and place lateral tubes at an interval of 1.5 m.
- Place the drippers in lateral tubes at an interval of 60 cm and 40 cm spacing with 4 LPH and 2 LPH capacities respectively.
- Form raised beds of 120 cm width at an interval of 30 cm and place the laterals at the centre of each bed.

- Before planting, wet the beds using drip system for 8-12 hrs.
- 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 after transplanting

Water budgeting:

The daily water requirement of the crop varies from season to season/time of sowings, and local climatic conditions. The water requirement for tomato crop planted during January, June and September at 90*60*60 cm in paired row system with 4 lph drippers for Ananthapur, Kurnool and Bijapur action sites are provided below.





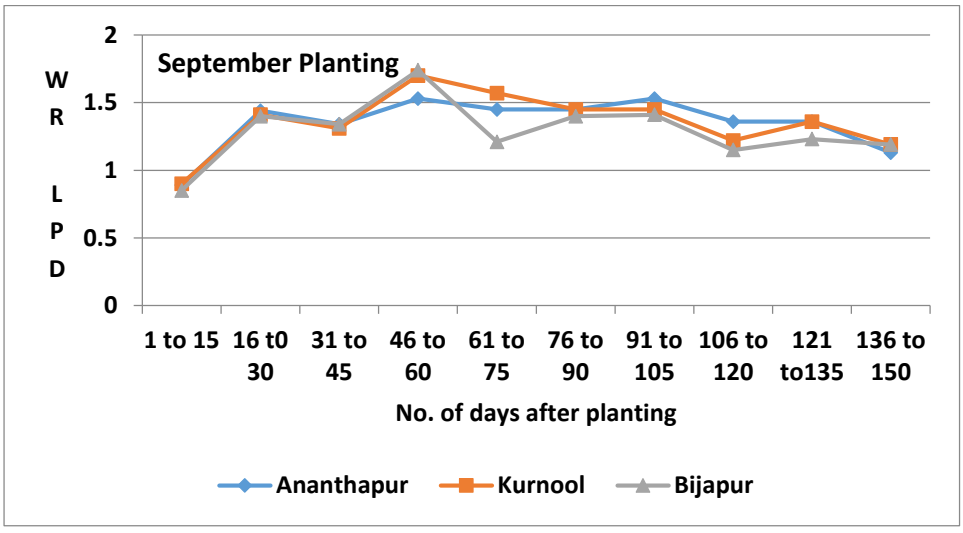


Figure 1: water requirement – litres per day (WR LPD) for Tomato crop for January, June and September Planting

The major factors that determine the operation time are, number of drippers per plant,dripper spacings and the discharge rates of the drippers. suggested operation time for suppling the required water for Ananthapur, Kurnool and Bijapur farmers are given below:

Table 2: Suggested operating time (min) at 90*60*60 geometry – January 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	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 3: Suggested operating time min) at 90*60*60 geometry – 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 4: Suggested operating time (min) at 90*60*60 geometry – 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.
Farmers were also suggested with the fertigation schedule as majority of the farmers apply fertilisers by hand on top of the soil. The recommended fertigation schedules for Ananthapur, Kurnool and Bijapur are as follows:

Table 5: Suggested fertigation schedule for Tomato (Kg/ha)

Stage	Days after planting	Basal	Fertigation	
		Super phosphate	Urea	Muriate of potash
Establisment 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: 30% savings through fertigation is considered; fertigation to be done at 3 days' interval

Table 6: High yielding varieties – Tomato (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	21	7
Upto flower initiation	11 to 40 (30 days)			100	25
Flowering to fruit set	41 to 70 (30 days)			100	35
Fruit development to harvesting	71 to 150 (80 days)			80	40

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

Table 7: Tomato cultivation with scheduled drip irrigation and fertigation in Andhra pradesh and Karnataka district (Rs/ha)

Particulars	Ramanujamma, Ananthapur	Vimala H. Pasodi, Bijapur	Chiranjeevi, Ananthapur	Govindarajulu, Ananthapur	Giddaiah, Kurnool
Intervention	Drip Irrigation scheduling and fertigation	Drip Irrigation scheduling and fertigation	Drip Irrigation scheduling and fertigation	Drip Irrigation scheduling and fertigation	Normal irrigation
Variety	Anirudh (Mahyco)	Mahyco	448	448	3140
land preparation	11000	4750	9375	17500	13500
Seed/seedling cost	19000	12000	21000	21000	12000
Nursery cost	0	2000	0	0	0
FYM	18000	5000	0	0	0
Cost of planting	4000	3000	3000	3000	1750
Weeding cost	19500	7800	9750	6000	3000
Fertiliser cost	11600	12200	10560	18000	8750
Pesticide cost	9000	6500	6700	9500	6250
Cost of picking	11500	8000	-	-	6000
Land rent*	12500	8000	12500	12500	10000
Total cost	116100	69250			64390
Yield (kg/ha)	33333	18750			16000
Total income	733333	375000			320000
Gross Margin	617233	305750			255610
Irrigation (m^3/ha)	6917	6232			7546
WUE (kg/m^3)	4.82	3.01			2.12
WUE (lt/kg)	208	332.37			471.65
Remarks	Followed scheduled irrigation and fertigation		Crop initiated in October due to late onset of monsoon and delayed drip installation		Proposed for farm pond drip irrigation. Delayed monsoon and installation

*land rent per crop /season was considered in all the crops

Duration: Total duration of the crop is 135-140

The details on cost of cultivation for Ananthapur, Kurnool and Bijapur disrticts are given below based on the field demonstarion (refer table 1) observations under dryland system

program. Returns for tomato is high with the scheduled irrigation and fertigation (Table 7). The water use efficiency (WUE) is about 4.8 kg/m^3,and 3.01 kg/m^3, where as for the normal irrigation the WUE is 2.12 kg/m^3. The market price for the tomato is also comparatively high during the season for acheiveing the higher return.

Pictures: Toamato with drip irrigation schedule and fertigation

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 is 0.794 million hectares with 1.3 MT production. In many areas chilli is grown with supplemental irrigation and improve the productivity. Drip irrigation to chilli was initiated due to the scarce water resources. The following package of practices are recommended for chilli drip irrigation.

Land preparation:

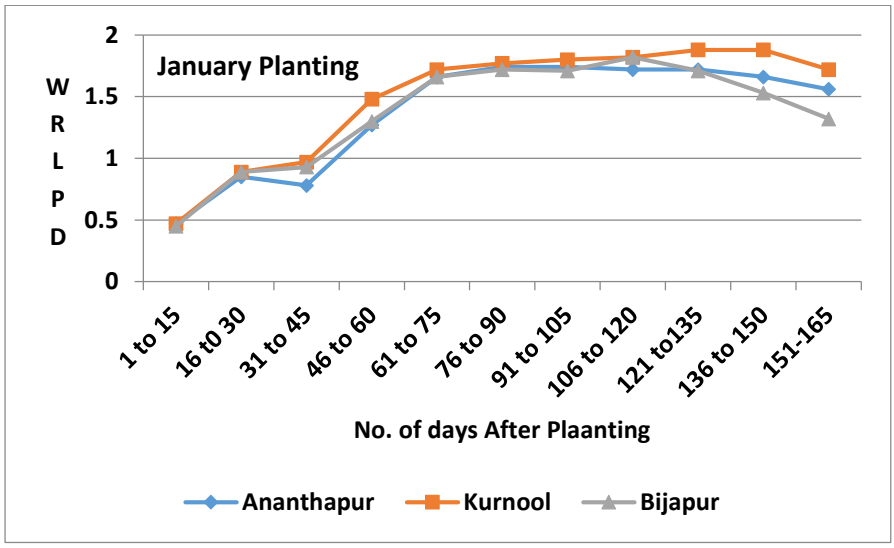
The land is thoroughly ploughed with the basal FYM and single super phosphate (refer Table 11 and 12).

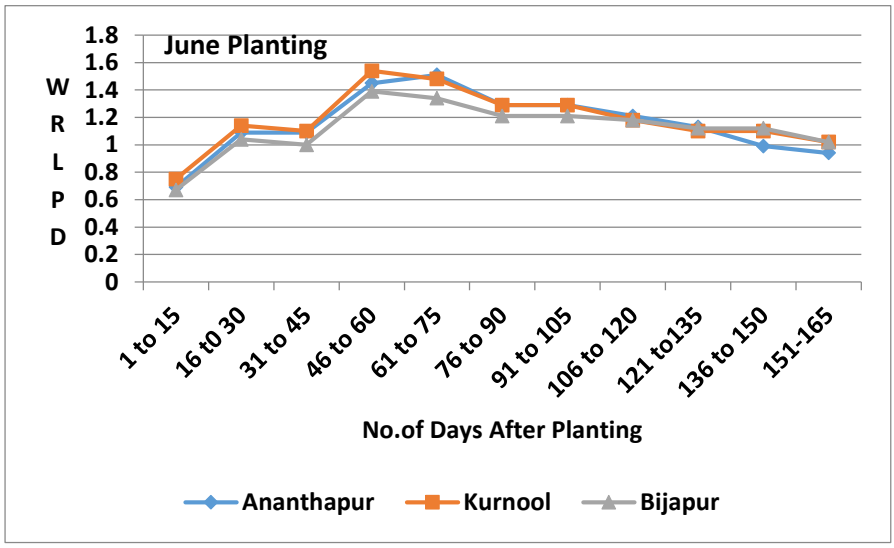
Layout and planting for drip irrigation:

- 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 120 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 90 x 60 x 45 cm in the paired row system, using ropes marked at 60 cm spacing.
- 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 management: The water requirement in the region varies with the season (figure 2). Farmers take-up plantation at different time periods (January, June and September) for green chilli. It is high for the January planting followed by June planting due to high evapotranspiration during the period.





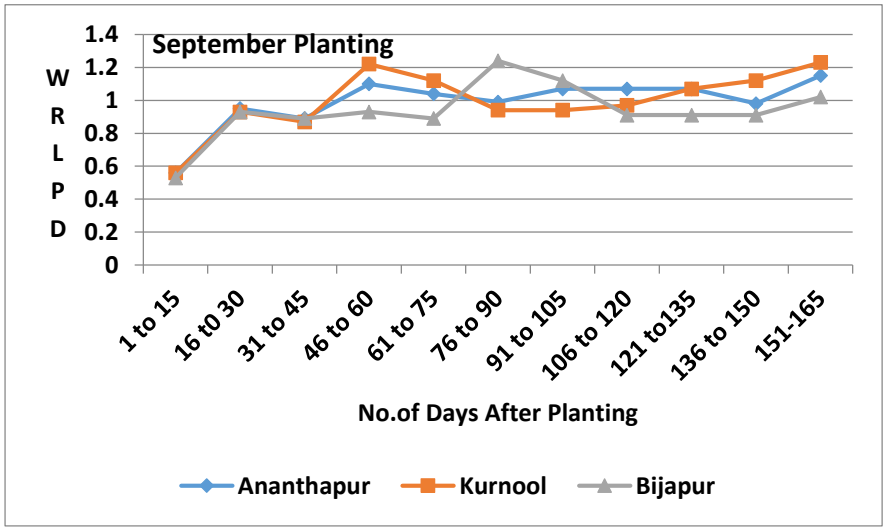


Figure 2: water requirement – litres per day (WR LPD) for Tomato crop for January, June and September Planting

The duration of each irrrigation according to the planting dates with the help of drip for chilli are given inTable 8, 9, 10. The duration of irrigation increases with the plant growth in all the seasons. The operation can be done in alternate days for the chilli crop

Table 8: Chilli opertaion time (Alternate days) for January Planting (Min)

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 9: Chilli opertaion time (Alternate days) for June Planting (Min)

Days after planting	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 10: Chilli opertaion time (Alternate days) for September planting (Min)

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

Fertigation schedule for the high yielding varieties and hybrid varieties are given in Table 11 and 12. The hybrid varieties need more than 50% of the fertilisers compared to the high yielding varieties

Table 11: Suggested fertigation schedule for HYV of chillies (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	14
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

Note: 70% of recommended dose from ANGRAU 2008

Table 12: Suggested fertigation schedule for hybrid varieties of chillies (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

Note: 70% of recommended dose from ANGRAU 2008

Table 13: Chilli cultivation with scheduled drip irrigation and fertigation in Andhra pradesh and Kurnool distrticst (Rs/ha)

Particulars	Ramanujamma, Ananthapur	Madhava Rayudu, Kurnool
Intervention	Drip Irrigation scheduling and fertigation	Drip Irrigation scheduling and fertigation
Variety	--	ANMOL (BSS-273)

Land preparation	11000	12500
Seed/seedling cost	19000	4000
Nursery cost	0	10000
FYM	18000	5000
Cost of planting	4000	2000
Weeding cost	19500	15000
Fertiliser cost	11600	11600
Pesticide cost	9000	14000
Cost of picking	11500	2500
Land rent	15277.78	10000
Total cost	118877.78	86600
Yield (kg/ha)	1388.89	7500
Total income	138888.89	75000
Gross Margin	20011.11	-11600
Irrigation (m^3/ha)	5472.6	50539
WUE (kg/m^3)	0.25	0.14
WUE (lt/kg)	3940.27	6738.54
Remarks		Yield loss due to virus attack and lack of rainfall during the year. Farmer gets 15 qt in normal year

Pictures: Chili drip irrigation field in Kurnool district followed by virus affected and harvested crop

Farmers in the action site has initiated chilli drip in July 2015 and was taken up for the first time in their farming experience. Farmers has initiated the crop for green chilli but converted into the red chilli due to lack of proper market price during the season. Adoption of chilli crop in the action site is also less due to the drought prevailing conditions. Less rainfall (60.3 mm from July-Dec 2015) in the action site has also increased the intensity of virus (farmers' perception and pictures) and reduced the yields (Table 13). In normal season farmers were

able to achieve 15-20 qt/ha. Hence, there is a need to continue the piloting in the following years to standardize the data base on irrigation scheduling and fertigation in the normal years.

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 such 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 gm for one hectare of land

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 14: 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

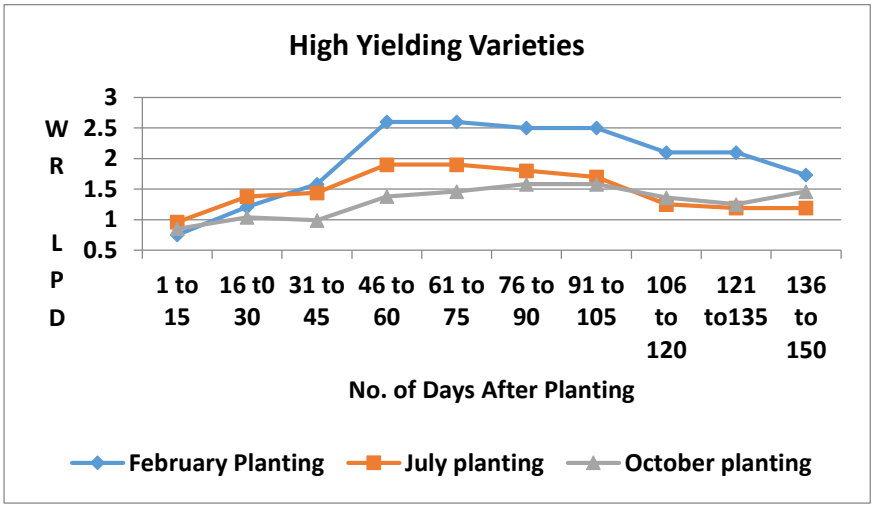
Table 15: Layout and planting for drip irrigation

Variety	Crop geometry (meter)	Lateral distance (meter)	Dripper distance (meter)	Dripper discharge rate (lph)	Remarks
High yielding	0.6*0.6	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 are given in figure 3.



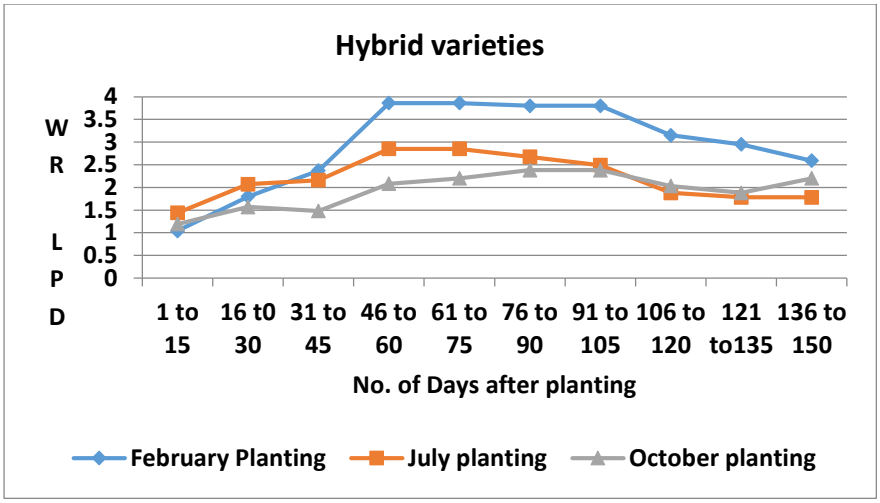


Figure 3: Daily water requirement of the high yielding and hybrid varieties

The duration of irrigation for the high yielding and hybrid varieties based on the month of planting can be seen in table 15

Table 15: Drip system 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 16 & 17).

Table 16: Suggested fertigation schedule for high yielding varieties of brinjal (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

Note: 70 % of fertiliser recommended dose from ANGRAU 2008

Table 17: 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

Note: 70 % of the recommended dose from ANGRAU 2008

The baseline information (2014) from the sample farmer show that diesel engine was used to irrigate the farm from an open well. Farmer was trained on the micro irrigation and encouraged with the solar pumps for the first time in the action site. Brinjal (0.4 ha), cotton (1.2 ha), sugarcane (0.8 ha) was taken up during the season under solar pump irrigation. Brinjal crop is equipped with drip system and recommend the above irrigation and fertigation schedules. As the focus of this report is mainly on the improvement of the WUE through scheduled irrigation. The variable costs related to the crop management is presented in the table 18.

Table 18: Brinjal cultivation with scheduled irrigation and fertigation in Bijapur district

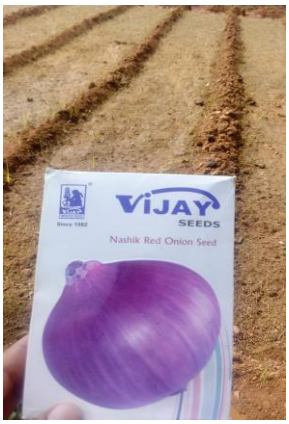
Particulars	Appanna Kolageri
Intervention	Drip Irrigation scheduling and fertigation – Solar Energy with MI
Variety	Mahyco
land preparation	3750
Seed/seedling cost	3000
Nursery cost	0
FYM	7000
Cost of planting	6250
Weeding cost	2500
Fertiliser cost	7250

Pesticide cost	5200
Cost of picking	8270
Land rent	8000
Total cost	51220
Yield (kg/ha)	25000
Total income	250000
Gross Margin	198780
Irrigation (m^3/ha)	8338.65
WUE (kg/m^3)	2.98
WUE (lt/kg)	335.54

The number of hours operated through drip irrigation is 226 hrs with 2 litres per hour discharge. The number of plants covered per hectare is 18518 with a spacing of 0.90*0.60 m. The total water discharged for the crop is 8388654 litres/ha. The analysis from these observations show that the WUE for brinjal drip irrigation is 2.98 kg/m^3.

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.

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 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;

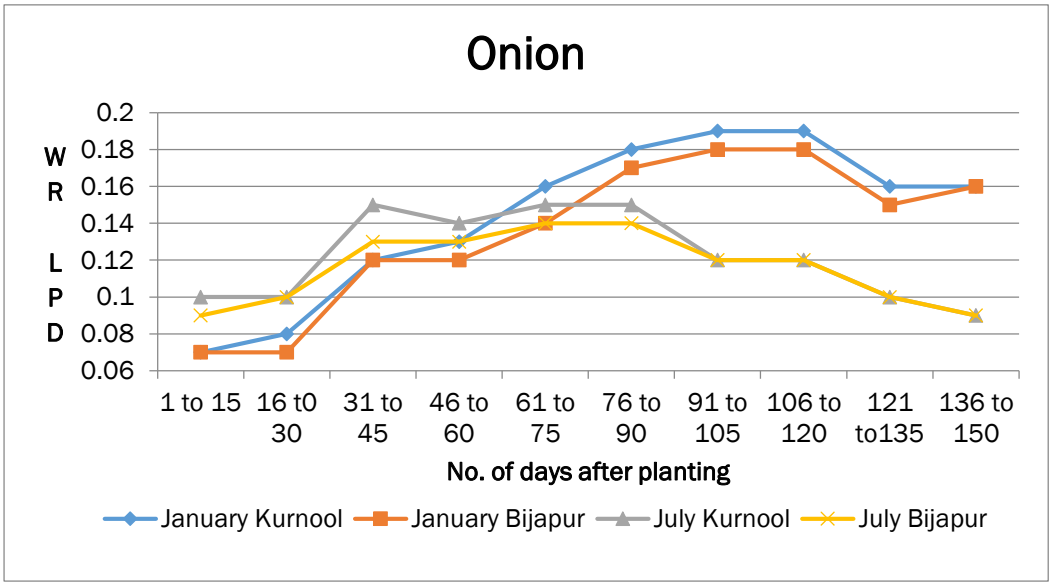


Figure 4: Water requirement litre per day (WR LPD) per plant for different regions

Table 19: 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 20: 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

Table 21: Onion cultivation in Kurnool and Bijapur districts – DS action sites

Particulars	T. Nagaraju, Kurnool		Amrutha Siddappa, Bijapur
Intervention	Drip Irrigation scheduling and fertigation	Surface irrigation	Drip Irrigation scheduling and fertigation
Variety	Nasik Red	Nasik Red	
land preparation	11250	11250	3750
Seed/seedling cost	5625	5625	3750
Nursery cost	5000	5000	2000
FYM	0	0	5000
Cost of planting	24000	24000	6700
Weeding cost	19500	19500	3000
Fertiliser cost	6925	6925	3600
Pesticide cost	6525	6525	5500
Cost of picking	25000	25000	3000
Land rent	10000	10000	3000
Total cost	113825	113825	39300
Yield (kg/ha)	17500	14000	2000
Total income	136500	109200	16000
Gross Margin	22675	4850	-23300
Irrigation (m^3/ha)	50539.1	94000	
WUE (kg/m^3)	0.35	0.15	
WUE (lt/kg)	2887.95	6714	
Remarks			Monsoon failure and lack of electricity supply for irrigation has stunted the crop growth

The field results with drip and without drip has shown there is an increase of 25% yield in Kurnool district. The WUE has also increased by two folds with the drip irrigation scheduling and fertigation. In case of Bijapur, delayed monsoon and drought situation with continuous

power cuts has stunted the crop growth. Hence, there is a need to continue the piloting under normal conditions in the coming years/seasons.

Picture: Onion crop in Bijapur district dried due to lack of electricity and rainfall

Castor

Castor (*Ricinus Communis*) is one of the ancient oilseed crops in the world. Castor oil is used as industrial oil. India is largest producer of castor ranking first among the major producing countries such as China and Brazil. Castor yield 350-650 kg of oil per hectare in arid and semi-arid regions without any maintenance. Castor is grown as rainfed crop in most of the regions in the country. The normal sowing time of castor is June-July with flowering October-November, which may be effected with North-east monsoon. Nonetheless, castor bean price is increasing over the years due to the good export potential. The oil extracted from castor bean already has a growing international market, assured by more than 700 uses, ranging from medicines and cosmetics to substituting petroleum in the manufacturing of Biodiesel, plastics and lubricants

Highest yields of castor are produced under irrigation on fine or medium textured soils, and where low relative humidity prevails. The castor productivity can be increased to 3500 kg/ha with drip irrigation and fertigation compared to the national average of 1209 kg/ha.

Water requirement for castor is very low (500 mm) compared to maize and cotton, with 800 and 900 mm respectively.

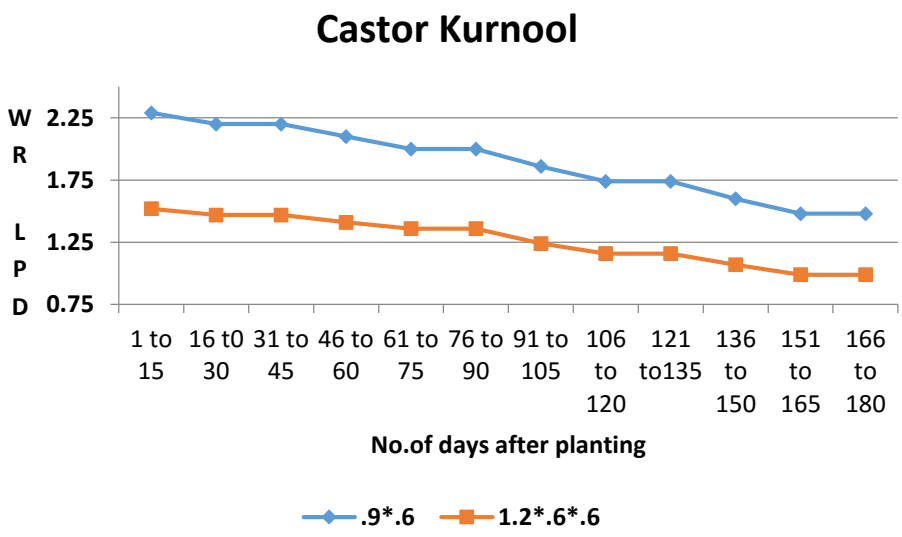


Figure 5: water requirement in liter per day for castor at different spacing's

Drip layout was designed at a lateral spacing of 120 cm and Dripper spacing 60 cm. Water requirement for the castor crop according to the spacing is given in Figure 5. The operational time for irrigation is given in Table 22. The dripper discharge of 4 lph was installed for the purpose. The cost of installation of drip for 0.2 ha is Rs. 42,000.

Table 22. Drip operational time for castor crop in Kurnool (min)

Days after planting	Operating time normal and paired row design	
	Normal (0.9*0.6)	Paired row (1.2*0.6*0.6)
1 to 15	76	102
16 t0 30	73	98
31 to 45	73	98
46 to 60	69	94
61 to 75	66	91
76 to 90	66	91
91 to 105	61	83
106 to 120	57	78
121 to135	57	78
136 to 150	53	72
151 to 165	49	66
166 to 180	49	66

Table 23: Castor cultivation with drip and flood irrigation (Rs/ha)

Particulars	T. Nagaraju, Kurnool	
Intervention	Drip Irrigation scheduling and fertigation	Flood irrigation
land preparation	6500	6500
Seed/seedling cost	1750	1750
Nursery cost	0	0

FYM	2500	2500
Cost of planting	1000	1000
Weeding cost	8750	8750
Fertiliser cost	5800	5800
Pesticide cost	4500	4500
Cost of picking	7500	7500
Land rent	5000	5000
Total cost	43300	43300
Yield (kg/ha)	3000	2000
Total income	99000	66000
Gross Margin	55700	22700
Irrigation (m^3/ha)	4953	6498.3
WUE (kg/m^3)	0.60	0.30
WUE (lt/kg)	1651	3249.16

Pictures: Castor crop with drip and without drip irrigation in Kurnool district

The operational cost didn't vary with the scheduled irrigation. There is significant difference in the vegetative growth and yield of the crop with drip irrigation. Farmer didn't completely follow the scheduled fertigation as recommended due to the awareness gap and climatic factors. These are some of the challenges/risks encountered in the implementation of activities.

Lemon

Lemon/ Acid lime (*Citrus aurantifolia*) requires tropical and dry 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.

Table 24: 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

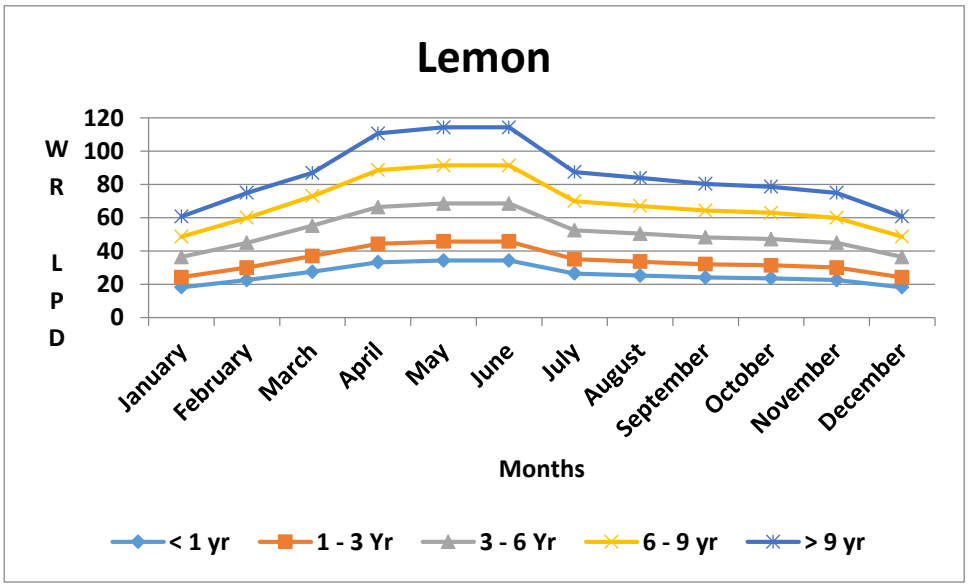


Figure 6: Water requirement in litres/day according to the age of the lemon crop – Bijapur district

Table 25: Irrigation duration according to the month and age of the plant (minutes)

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

Lemon orchard is 4 years old while planning the irrigation schedule and fertigation. Crop growth is less than the expected (farmer perception). The total number of plants recommended with the given spacing is 245 plants. As per the evapotranspiration rate lemon crop requires 50 lts/day on average. The total water required for the lemon crop is 4496.73 m^3/ha. Harvest/picking is initiated during the year and further analysis is required for estimating the WUE. Nonetheless, drip irrigation can save about 60% of the water.

Conclusions:

The micro irrigation system was well encouraged in a program mode in the arid and semi-arid regions of India from 2003. Initially, fruit crops are promoted on a subsidy basis for promoting the micro irrigation. In the recent years, adoption of micro irrigation was well received for the vegetable crops also. However, scheduling of irrigation and fertigation are not followed by the farmers due to lack of awareness. Hence, initiative was taken on the implementation of micro irrigation through capacity building in south India. The results show that the irrigation scheduling and fertigation with drip for the vegetable crops has decreased the water usage and improved the water use efficiency. The Water use efficiency has increased by 127% for tomato, 133% for onion and 100% for castor compared with normal/surface irrigation. The drought situation in the cropping season has affected the chilli crop in Kurnool and onion crop in Bijapur. To standardize the data base for science based evidences there is a need to continue the piloting in the following seasons under different climatic conditions.

Challenges:

The following challenges/risks are encountered in the implementation of the activities.

- Failure of monsoon during the year has delayed the cropping activities.

- Establishment of PPP with Jain irrigation system limited (JISL) for installation of energy efficient and new intervention such as farm pond equipped with micro irrigation
- Irregular/no power supply to the agriculture due to less rainfall and water in the states.
- Availability of control plot information as farmers keep changing crop due to the drought condition
- Complete adoption (100%) of recommended crop, fertigation and irrigation schedules by farmers.

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