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(A) Aspect wise recommendations

Canal Command and Ground water irrigation

a) Drip method of irrigation:

Reco# 1 : Irrigation and fertigation trails on hybrid castor (Var. GCH-4)

The farmers of South Gujarat heavy rain fall zone are advised to adopt drip irrigation for castor grown during rabi season for 38 % water saving and 32 % increased in yield over flood method. They should plant the crop in paired raw method at 60 x60 x 120 cm and use one lateral at 1.8 M grid with a dripper (8 lph) spacing of 1.2 M. The system should be operated for 50 minutes on alternate days up to January, 60 minutes in February and 75 minutes during March. The crop should be fertilized with a fertigation dose of 40 - 20 - 0 NPK kg/ha (40 % of R.D.) Nitrogen should be given in six splits and phosphorous in first two splits at an interval of 15 days.

Reco# 2 : Comparative study of different micro irrigation systems for vegetable crops clusterbean)

The farmers of South Gujarat heavy rainfall zone are advised to adopt typhoon method of micro irrigation for clusterbean. Typhoon irrigation method scheduled at 60 per cent fraction of pan evaporation gave about 25 per cent more yield with about 33 per cent saving of irrigation water over surface method of irrigation which would additional 0.5 ha area can be brought under irrigation. Further the net income can be mainly improved.

The system should be laid out as one lateral with 60 cm spacing of in line dripper between crop pair row of 45 cm distance and operated for 3 to 3.5 hr. during March to May on alternate day at a pressure of 1.2 kg/cm2 with 2 Lph discharge rate.

Reco# 3 : Performance evaluation of tube rose under drip irrigation system

The farmers of AES-III of South Gujarat heavy rainfall zone cultivating tuberose are advised to adopt drip irrigation (0.8 PEF) to get about 42 per cent more yield and 45 per cent more income. They should operate the system for about 50 minutes during October to February and 85 minutes subsequently till the onset of monsoon. Under irrigation water constraints, they should operate the system for about 35 minutes during October to February and 55 minutes subsequently to get about 30 per cent more yield, 24 per cent water saving and 27 per cent more income. They should install the system at 0.9 m x 1.20 m (plant x literal) and operate it at 1.75 kg/cm2 pressure.

Reco# 4 : Evaluation of drip with mulch in bitter gourd

The results have indicated that higher yield of bitter gourd can be obtained through use of black plastic mulch. Under constraints of irrigation water, drip can save 40% of irrigation water without affecting the yield and with the saved water more area can be brought under irrigated agriculture.

The farmers of AES-III of South Gujarat heavy rainfall zone growing bitter gourd (hy. Namdhari) as summer crop are advised to adopt the practice of mulching with black plastic (25 micron) for getting 18 % more yield and net return. Under constraints of irrigation water, they are advised to adopt drip along with they practice of mulching with black plastic to save 40 per cent water and bring about 0.67 additional hectarage under irrigation with this crop. In the paired row (50 x 50 x 150 cm) sown crop, the system should be laid out at a lateral distance of 200 cm (middle of paired row) with 8 LPH discharge dripper in the middle of 4 plants and operated at 1.2 kg/cm2 pressure for 100 minutes on alternate day.

Reco# 5 : Fertigation through minisprinkler in onion crop

The farmers of South Gujarat heavy rainfall zones (AES III) are advised to adopt minisprinkler system of irrigation along with fertigation for their onion crop to get about 23 per cent higher net income along with saving of about 20 per cent in fertilizer and 42 per cent in water over surface method. The 50 per cent N as urea should be applied at the time of planting and remaining 50 per cent in three equal splits at 30, 45 and 60 DATP through minisprinkler.

The minisprinkler should be laid out at the spacing of 2x2 m and system should be operated at 0.6 IW/CPE with a pressure of 1.5 kg/cm2 for 8 hrs for getting 50 mm depth of irrigation.

Reco# 6 : Effect of drip irrigation and fertigation on yield of brinjal (Cv. Surati ravaiya)

The farmers of AES-I of South Gujarat zone-II growing brinjal (Surati ravaiya) during rabi/summer are advised to adopt drip irrigation (0.6 PEF) and fertigate the crop with 80 kg N/ha. By doing so, farmers can get 11% higher yield and 5% higher net profit along with saving of 36 % water and 20% of fertilizer N.

The crop should be planted in paired row (60 x 60 x 120 cm). The lateral should be placed at a spacing of 1.8 m and dripper spacing of 0.6 m using dripper of 4 Lph capacity. The system should be operated at 1.2 kg/cm2 on alternate day for 1.5 hrs during December to February, 2.5 hrs during March and April and 3.0 hrs thereafter up to harvesting.

Reco# 7 : Irrigation management in smooth gourd

The farmers of AES-III of South Gujarat heavy rainfall zone growing smooth gourd as rabi-summer crop are advised to adopt the practice of mulching with sugarcane trash @ 2.5 t/ha for getting 23 and 18 per cent more yield and net return, respectively than un mulched control.

Under the constraint of irrigation water, they are advised to adopt drip along with sugarcane trash mulch (2.5 t/ha) to save 57 per cent water and bring about 1.30 ha additional area of this crop under irrigation. The system should be laid out at a lateral distance of 2.0 m and dripper (4 Lph) spacing of 1.0 m and be operated at 1.2 kg/cm2 pressure for 30 to 60 minutes during October to January and 60 to 120 minutes during February till harvest on alternate days.

Reco# 8 : Saline water management in brinjal (rabi)-paddy (kharif) sequence

The farmers of South Gujarat heavy rain fall zone (AES-III) growing garlic after kharif paddy are advised to adopt minisprinkler method of irrigation and apply N as urea @ 80% RD (80 kg /ha) in five equal split at an interval of 10-12 days starting from 15 days after sowing. They are further recommended to apply gypsum @ 2t/ha for improving soil physical conditions. By doing so, farmers can save 20% irrigation water and get 51% higher bulb yield with a BCR of 2.74 as compared to conventional method.

The system details are:

- Minisprinkler spacing = 2.5 x 2.5m
- Application rate = 12.8 mm/hr
- Operating pressure = 1.4 kg/cm2
- Operating time = 4 hr/irrigation
- Irrigation depth = 50mm
- Irrigation interval = November to January 10days
  = February harvest 8 days

Coefficient of uniformity = 76.4 %

Reco# 9 : Study on drip layout with different dripper discharge rates in onion grown on clay soil

The farmers of South Gujarat heavy rainfall zone growing onion after kharif paddy are advised to adopt drip method of irrigation which results in 36 and 39 per cent higher bulb yield and net profit, respectively over conventional method of irrigation. The system details are:

Lateral spacing (cm)	: 80	
Dripper spacing (cm)	: 80	
Dripper discharge (lph)	: 4	8
Operating pressure (kg/cm2)	: 1.25	1.25

Operating time:

Jan-Feb	: 40 minutes,	20 minutes,
March	: 50 minutes	25 minutes,
April	: 1 hrs 15 min.	40 minutes,
Operating frequency	: alternate days	alternate days

Reco# 10 : Irrigation management in spider lily

Farmers of AES III of South Gujarat heavy rainfall zone growing spider lily in canal command are advised to apply 20 irrigations (IW/CPC= 1.0) each of 60 mm depth at an interval of 13-15 days during winter (Nov. to Feb.) and 7 – 10 days during summer (March to June) for realizing higher bud yield and net profit as compared to farmers' method (standing water).

Alternatively, farmers growing lily using canal as well as ground water conjunctively are advised to adopt drip method of irrigation for saving irrigation water up to 40 per cent without any reduction in the bud yield as compared to surface method of irrigation.

The system details are:

Lateral spacing : 1.80 mm
Dripper spacing : 0.90 m
Dripper discharge : 8 lph
Operating pressure : 1.2 kg/cm2
Operating frequency : Alternate day
Operating time:
Winter : 75 – 100 min
Summer: 100 – 150 min

Reco# 11 : Evaluation of methods of irrigation in oil palm

The farmers of AES-III of South Gujarat heavy rainfall agroclimatic zone intended to grow oil palm are advised to adopt triangular method of planting (9 x 9 x 9 m) and drip method of irrigation. The drip system should be placed at 0.5 m away from trunk for first two years and third year onward 1.5 m away from the trunk. The system details and operation schedule are given below:

System detail:

Particulars		**Year-I**	**Year-II**	**Year-III onward**
Lateral spacing (cm)	**:**	9	Two laterals per row	
Lateral diameter (mm)	**:**	16		
Dripper discharge rate (lph)	**:**	8		
Number of dripper /tree	**:**	2	12	18
Operating pressure (kg/cm^2)	**:**	1.20		
Operation frequency	**:**	Alternate day		

Operation schedule:

Month	**Year**		
	I	**II**	**III and onward**
	(Hours)	(Hours)	(Hours)
Jan.-Feb.	3 to 3.5	1.5 to 2.0	3 to 3.75
March – April	5 to 5.5	2.5 to 3.15	5 to 5.30
May-June	5.5 to 6.0	2.5 to 3.5	5.15 to 6.0
Sept. – Oct.	3 to 3.4	1.5 to 2.0	2.5 to 3.0
Nov. – Dec.	4.3 to 4.6	2.2 to 2.5	1.75 to 2.25

Reco# 12 : Feasibility of using banana pseudostem sap as liquid fertilizer in onion under drip irrigation

The farmers of South Gujarat heavy rain fall zone (AES-III) growing white onion (Cv.GW-1) crop after kharif paddy are recommended to transplant onion on raised bed (top width 90 cm followed by 30 cm wide and 15-20 cm deep furrow) and be irrigated through drip and fertigated @ 60% RDF (75 : 30 kg NK/ha) along with banana pseudostem sap @ 2000 l/ha in five equal splits of N, K and sap at an interval of 10 days starting from 15 days after transplanting for getting 57 per cent higher bulb yield and double net income along with saving of 30 per cent of irrigation water as compared to conventional practice. Alternatively, they can also apply fertilizer @ 80% of RD + sap @ 1500 l/ha in a similar way for getting higher bulb yield and net profit.

System detail:

Lateral spacing (cm)	**:**	120
Lateral diameter (mm)	**:**	16
Dripper discharge rate (lph)	**:**	8
Dripper spacing (cm)	**:**	100
Operating pressure (kg/cm^2)	**:**	1.20
Operation frequency	**:**	Alternate day

Reco# 13 : Study on periodical water stress in castor under drip irrigation with and without mulch

The farmers of South Gujarat heavy rain fall agroclimatic zone (AES-III) growing castor (Cv. GCH-4), during rabi season under drip method of irrigation and operating the system on alternate day are advised to impose water stress by stopping drip irrigation for a period of 20 days in case of without mulch and 30 days with BPM starting from 50 per cent emergence of main spike stage. By adopting this no cost practice, farmer can get 6 to 7 per cent higher yield and 9 to 10 per cent higher net income along with saving of irrigation water by 12 to18 per cent as compared to normal operation of the drip system.

Reco# 14 : Planting geometry and mulching study in watermelon under drip irrigation

Recommendation for the farmers

The farmers of South Gujarat growing water melon during summer season are advised to follow paired row planting (1m x 0.8 m : 3.2 m) with drip irrigation and mulching using either black plastic or silver black plastic (50µ, 38 % area coverage) for getting 48 per cent higher fruit yield and 57 per cent more net profit along with 29 per cent water saving over conventional method of irrigation. Full dose of P and 10% each of N and K should be applied as basal and the remaining N and K should be applied through drip system in 8 equal splits at an interval of 8 days starting from 3-4 leaves stage.

System details:

1	Lateral spacing	:	4 m
2	Dripper spacing	:	1m
3	Dripper discharge	:	8 lph
4	Operating pressure	:	1.2 kg/cm2
5	Operating frequency	:	Alternate days
6	Operating time	:	March:3.5-4.0 hr April : 4.0-4.5 hr May to June: 4.5-5.25 hr

Reco# 15 : Study on irrigation and fertilizer levels on yield and quality of sugar beet grown on clay soils

The farmers of South Gujarat heavy rainfall zone(AES III and IV) intending to grow sugar beet crop are advised to irrigate their crop by drip method @0.8 PEF and fertilize @ 120:60:60 kg N,P2O5 and K2O/ha. The full dose of P and 10 % of N and K dose should be applied as basal and remaining 90 % FD of N and K should be applied in 10 equal splits at an interval of 8-10 days starting from 15 DAS. By adopting these practices, higher beet yield and net return are realized as compared to surface method of irrigation.

System details:

System details:

1	Lateral spacing	:	1.6m
2	Dripper spacing	:	1m
3	Dripper discharge	:	8 lph
4	Operating pressure	:	1.2 kg/cm2
5	Operating frequency	:	Alternate days
6	Operating time	:	

Month	**Normal soil**	**Salt affected soil**
Nov. and Dec.	1.30 hr	1.40 hr

Jan. and Feb.	1.40hr	1.50 hr

Reco# 16 : Feasibility of drip irrigation in pigeon pea (rabi) with and without mulch

The farmers of South Gujarat heavy rainfall zone (AES III) growing pigeon pea (GT-102) during rabi season are advised to follow paired row sowing (60x20:120 cm) with drip irrigation at 0.6 PEF and mulching with black plastic (50µ and 56 % coverage) for getting higher net profit and water saving over surface method of irrigation.

The system details are:

Lateral spacing	:	1.80 m
Dripper spacing	:	0.60 m
Dripper discharge	:	3 lph
Operating pressure	:	1.2 kg/cm^2
Operating frequency	:	Alternate day
Operating time	:	
January	:	90-120 min
February	:	100-130 min
March-April	:	140-180 min

Reco# 17 : Standardization of low cost drip system

The farmers of hilly areas/ kitchen garden of South Gujarat are advised to irrigate brinjal crop through low cost drip system in about 25 to 35 m^2 area using 35 litre of water per day for realizing a net profit of about Rs. 300 to 350. The crop should be planted in paired rows (0.6 x 0.6 x 1.2 m) with row length of 4.8 m. Such 4 sets of pair rows can be made in the available area. The lateral should be placed in between two rows and micro tube should be placed at 60 cm apart *i.e*. each micro tube (dia.: 1.2mm, length: 7.2 cm) cover two plants. The system should be operated on alternate day.

Reco# 18 : Planting and irrigation management with and without mulching in *rabi* castor

The farmers of AES-III of South Gujarat heavy rainfall zone are advised to grown castor after *kharif* paddy as *rabi*-summer crop for getting Rs.20300/ha net profit.Under the constraint of irrigation water, they are also advised to plant their crop in pair and method (60 x 60 x 120 cm) and adopt drip method of irrigation to save 39 per cent water,40 per cent fertilizer and bring about 0.63 ha additional area of this crop under irrigation. The system should be laid out at a lateral distance of 1.8 m and dripper (8 Lph) spacing of 1.2 m and be operated at 1.2 kg/cm^2 pressure for 40 to 60 minutes during November to January and 60 to 100 minutes during February till harvest on alternate days.

Reco# 19 : Irrigation management in pointed gourd

The farmer of AES – III of South Gujarat heavy rainfall zone growing pointed gourd (local) as *rabi*-summer crop (spacing 1 x 2 m) are advised to adopt drip irrigation system along with black plastic mulch (50µ) with 50 per cent area coverage for getting 47, 37 and 42 per cent more yield, water saving and net return, respectively than un mulched control along with water saving up to 37 per cent. The system should be laid out at a lateral distance of 2.0 m, dripper (4lph) spacing of 1.0 m and be operated at 1.2 kg/cm^2 pressure for 70 to 80 minutes during winter and 80 to 155 minutes during summer on alternate days.

Reco# 20 : Optimization of raised bed size under different levels of fertigation in turmeric

The farmer of AES – III of South Gujarat heavy rainfall agroclimatic zone are recommended to plant three rows of turmeric(S*ugandhm*) (30x20 cm) on raised bed of 90 cm width followed by 45 cm wide and 25 – 30 deep furrow. They are advised to applied 80 % of recommended dose of fertilizers (60:60:60 N:P_2O_5:K_2O kg/ha).Full dose of P and half dose of N&K should be applied at the time of planting. The remaining 50 % of N and K should be applied in nine equal splits through drip system at an interval of 15 days starting after cessation of monsoon. By adoption of this technology farmer can realize 36 per cent higher net income and 25 per cent higher yield along with 32 per cent water and 20 per cent fertilizer saving as compared to farmer's practices.

System details are:

Lateral spacing: 1.35 m

Dripper spacing: 1.00 m

Dripper discharge: 8 lph

Operating pressure: 1.2 kg/cm2

Operating frequency: Alternate day

Operating time:

Sept-Dec : 45 – 60 min

Jan-March : 50 – 75 min

Reco#21 : Feasibility of drip irrigation in pigeon pea *(rabi)* with and without mulch

The farmers of South Gujarat heavy rainfall zone (AES III) growing pigeon pea during rabi season are advised to follow paired row sowing (60x20:120 cm) with drip irrigation at 0.6 PEF and mulching with black plastic (50µ and 56 % coverage) for getting higher net profit and water saving over surface method of irrigation.

The system details are:

Lateral spacing	:	1.80 m	**Operating time**		
Dripper spacing	:	0.60 m	January	:	90-120 min
Dripper discharge	:	3 lph	February	:	100-130 min
Operating	:	1.2 kg/cm2	March-April	:	140-180 min

pressure

Operating frequency : Alternate day

Reco# 22 : Title: Study on levels of nitrogen and intra-row spacing on yield of drip irrigated castor (rabi)

The farmers of South Gujarat heavy rainfall zone (AES III) growing drip irrigated hybrid castor during rabi season are advised to sow their crop with intra row spacing of 0.6 m and row spacing of 2.4 m. Further, they are advised to fertilize @ 160:40NP kg/ha. The full dose of P and 10 % N should be applied as basal and remaining 90 % N should applied through drip system in 10 equal spilt at an interval of 8-10 days starting from 15 DAS. By adoption of these practices, higher yield and net profit can be realized as compared to paired row (60x60:120 cm) sown castor.

The system details are:

Lateral spacing	:	2.40 m
No of dripper per plant	:	6
Drpper spacing	:	0.60 m
Dripper discharge	:	4 lph
Operating pressure	:	1.2 kg/cm2
Operating frequency	:	Alternate day
Operating time	:	
Nov-Dec	:	80-130 min
Jan-Feb	:	90-160 min
March onward	:	150-210 min

Reco#23: Comparative performance of water soluble and routinely used fertilizer in banana under drip irrigation

The banana growing farmers of South Gujarat are recommended to apply 80 per cent of recommended dose of fertilizers in the form of Urea (522 g/plant) + Orthophosphoric acid (85 ml/plant) + MOP (267 g/plant) through drip system (0.6 PEF) for getting higher income.

The operating frequency of drip system and fertigation schedule should be as follows

Drip system detail:

Lateral distance: 2.4 m Dripper distance: 0.6 m

Dripper discharge: 4 lph Operating pressure: 1.2 kg/cm2

Operating frequency: Alternate day

Operating period : 1.5 to 2.0 hrs during winter and 2.5 to 2.75 hrs during summer

Fertilizer schedule:

Frequency of fertigation: twice a week

- ✓ P application should be started 21 days after planting in 32 equal splits and completed within 4.5 month.
- ✓ N and K application should be started 35 days after planting in 44 equal splits and complete it within 6.5 month.

Recommended dose (300:90:200 g NPK/plant)	Splits requirement of Routinely used fertilizer			or	Splits requirement of Water Soluble fertilizer		
	Urea (g/plant)	Orthophosphoric acid (ml/plant)	MOP (g/plant)		Urea (g/plant)	12;61;00 (g/plant)	13;00;45 (g/plant)
80% RDF	11.86	2.65	6.06		8.85	3.69	8.08

Reco#24: Title: Study on pit method of planting in sugarcane under drip irrigation

The farmers of South Gujarat intended plant sugarcane through pit method are recommended to dig out pit of 60 cm diameter with a spacing of 1.75 x 1.75 m and 40 cm depth by using post hole pit digger. Sixteen sugarcane sets of two budded put in pit with filling of soil and FYM/bio-compost to a depth of 25 cm below and 15 cm upper side of sets. By adopting of this method, three ratoons can be taken with higher yield and net profit as compared to two ratoons with paired row planting (0.6 x1.2 m) under drip irrigation.

The system details are:

Lateral and dripper spacing : 3.5 m
Size of micro tube fitted on dripper: 4 mm
Dripper discharge : 8 lph
Operating pressure : 1.2 kg/cm2
Operating frequency : Alternate day
Operating time : October- December : 1 hr and 50 minutes
Jan.- Feb. : 2 hr and 37 minutes10-157 min.
March- June : 3 hr and 05 minutes and 6 hr and 08 minutes.

Reco#25: Effect of water application in different layers of soil on growth and yield of drip irrigated young mango plantation

The farmers of South Gujarat heavy rainfall zone having 8 to 9 year old mango plantation at a spacing of 5 m x 5 m are recommended to apply irrigation water after initiation of flowering directly in vertically inserting HDPE/PVC pipe (75 mm diameter) into the soil at 40 to 50 cm depth below ground level in four side 1.5 m away from mango trunk through spaghetti tube (4 mm diameter) fitted on online dripper through drip system for getting good quality mango fruit with higher yield, net profit and water use efficiency as compared to water applied through surface drip system.

System details
Lateral spacing : 5 m
Dripper discharge : 8 lph
No. of drippers per tree : 4
Operating pressure : 1.2 kg/cm2
Operating frequency : Alternate day
Operating time : Oct. – Nov. : 2 hr to 2 hr and 20 minutes
March – May : 2 hr and 26 minutes to 5 hr and 30 minutes

Reco#26: Feasibility of drip irrigation in summer rice

The farmers of South Gujarat heavy rainfall zone growing summer rice are recommended that the surface irrigation is more economical than drip irrigation due to higher yield and less cost, however, in scarcity of water and availability of drip irrigation system, they can adopt the drip system at 60 cm lateral spacing for getting higher water productivity and 41% saving of water as compared to surface irrigation even though 4 to 5 irrigation of 80 mm depth given by surface method during initially establishment of the crop.

The system details are as under:

Crop spacing: 20x20:40 cm (Paired row)
Lateral spacing: 60 cm
Dripper spacing: 60 cm
Dripper discharge: 8 lph
Operating pressure: 1.20 kg/cm^2
System operating period: twice in week
Operating time: March to May: 1 hr and 50 minutes to 2 hr and 05 minute

Reco#27: Comparative study of different sleeving materials in banana

The drip irrigated banana growing farmers of South Gujarat Heavy Rainfall Zone (AES III) are advised to cover their fully emerged fruit bunch with either 16 micron plastics (transparent or blue plastic) or PP non-woven film for getting better quality fruits (minimum load of bacteria and fungus) and premium price as well. By adopting this practice, higher net return is realized as compared to control

b) Surface technology:

Reco# 1 : Scheduling of irrigation to wheat crop based on crop water stress index(CWSI)

The farmers growing wheat in upland conditions of AES - III of South Gujarat heavy rain fall zone are advised to give 8 irrigations (0.2 CWSI, 60 mm depth). After the first irrigation at sowing, three irrigations should be given at 15 days interval followed by 2 irrigations at 12 days intervals and last two irrigations at 10 days intervals.

Reco#2 : Utilization of dugout pond for water storage and irrigation in tail end area

The farmers of AES-IV of South Gujarat heavy rainfall zone growing wheat crop are advised to give 4 irrigations each of 60 mm depth. The first irrigation should be at sowing, second at CRI, third at knee heigh and fourth at boot leaf stages.

Reco# 3 : Effect of irrigation and N levels in presence and absence of mulching on yield of summer bhindi

Under the coastal salt affected soil conditions (AES-IV) of South Gujarat heavy rainfall zone, growing of okra (Parbhani kranti) during summer season was

found highly remunerative. For realizing higher yield and net income they are recommended to irrigate their crop at 1.00 IW/CPE ratio, with depth of irrigation 60 mm and mulching with black plastic (50 micron) and fertilize @ 125 kg N/ha, respectively. The first irrigation should be given at the time of sowing, second and third at 18-20 days interval and remaining 4 irrigations at 10-12 days interval.

Reco# 4 : Irrigation management in marigold

The farmers of South Gujarat heavy rainfall zone (AES-III) growing summer marigold are advised to give 8 (1+7) irrigations for obtaining higher flower yield and net profit. The first irrigation should be given on the day of planting and the second and third at an interval of 20-22 days. The remaining 4 irrigations should be applied at an interval of 14-16 days.

They are further advised to mulch their crop with sugarcane trash @ 5 t/ha (100% coverage) for obtaining 25 and 29 per cent higher flower yield and net profit over unmulched control. In absence of trash, they can use black **plastic (25 µ,** 100% coverage) for achieving 27 and 14 per cent more flower yield and net profit than control.

Reco# 5 : Irrigation and mulching study in castor

The farmers of AES-III of South Gujarat heavy rainfall zone growing castor in rabi season are advised to irrigate their crop at 0.6 IW/CPE ratio which required six irrigations. The schedule of irrigations is, first at sowing, second at 8 to 10 days after sowing and remaining four at 22-25 days interval.

Crop should be mulched with sugarcane trash @ 5 t/ha for obtaining 18 per cent higher yield and 27 per cent more net income than control. At present level of plastic cost, it was not found economical.

Reco# 6 : Response of rabi niger to irrigation schedules and integrated nutrient management

The farmers of South Gujarat heavy rainfall zone (AES-III) intended to grow rabi nizer are advised to give 4 irrigations for getting higher seed yield and net profit. The first irrigation should be given at the time of sowing, second at 18-20 days after sowing and remaining 2 at an interval of 24-25 days. The crop should be fertilized with either RDF (40:20:00 NPK kg/ha) or FYM @ 5 t/ha + 50% RDF (20:10:00 NPK kg/ha) for obtaining higher seed yield and net profit.

They are further advised to grow summer green gram as succeeding crop without applying any fertilizer for obtaining higher net profit. Application of 50% RDF + FYM@ 5 t/ha to first crop of nizer also improves soil fertility.

Reco# 7 : Study on irrigation and N management in palmarosa grass

The farmers of AES-III of South Gujarat heavy rainfall zone are advised to grow palmarosa crop. For achieving higher oil yield and net profit, the crop should be irrigated at 0.6 IW/CPE ratio (14 irrigations) and fertilized with N @ 100 kg/ha (six splits) apart from basal doses of P2O5 @ 60 kg/ha, K2O @ 40kg/ha and ZnSo4 @ 10 kg/ha every year.

Reco# 8 : Effect of irrigation and fertigation levels on growth and yield of annatto (Bixa orllana)

The farmers of South Gujarat heavy rainfall zone (AES III) intended to plant Annatto crop are advised to follow the spacing of 5 m x 5 m, apply RDF (60:40:40 kg NPK/ha/year) and give total 18-22 irrigations by surface method with an interval of 9-12 days during summer and 13-17 days during winter for getting higher net profit.

In scarcity of water, they are advised to adopt drip irrigation method for saving 75 per cent of water and 20 per cent N and K fertilizer. Further, they are advised to apply 48:40:32 NPK kg/ha fertilizer. Phosphorus should be applied in ring with half dose before two months of monsoon and remaining half dose after cessation of monsoon. The N and K should be applied in 10 equal splits at 10 days interval, of which five splits is to be applied in two months before monsoon and remaining five splits after cessation of monsoon through fertigation.

The system details are:

Lateral spacing		:	5 m
No of dripper per plant		:	6
Dripper discharge		:	8 lph
Operating pressure		:	1.2 kg/cm^2
Operating frequency		:	Alternate day
Operating time		:	
	Oct-Dec	:	25-30 min
	Jan-March	:	30-40 min
	April-Jan	:	40-50 min

Reco # 9 : Effect of irrigation and sulphur levels on yields of cluster bean under South Gujarat condition

The farmers of South Gujarat heavy rainfall zone (AES- III) intended to grow cluster bean (GG 2) during summer season are advised to give six irrigations (60 mm depth) i.e., first irrigation just after sowing, second at 7 to 10 DAS and remaining 4 irrigations at an interval of 13 to 15 days. They are further advised to fertilize their crop at 20:40:00:30 kg NPKS/ha through urea and SSP or 20:40:00:40 kg NPKS/ha, through DAP, urea and gypsum (300 kg/ha) for getting higher yield and net return.

Reco# 10 : Evaluating effect of banana pseudostem enriched sap (Foliar Spray) on hirsutum cotton

The farmers of South Gujarat heavy rainfall zone-I and South Gujarat zone-II, growing cotton are advised to apply recommended dose of fertilizer (120:00:00 NPK kg/ha) along with foliar spray of 3 % KNO_3 or banana pseudostem based enriched sap at 1.0 % concentration for getting higher seed cotton yield and net returns. They should follow the following schedule of spray:

- First at peak squaring
- Second at 20 days after first spray (Flower opening)
- Third at 20 days after 2nd spray (at boll formation) stages,

C) Conjunctive Use of Irrigation Water:

Reco# 1 : Utilization of dugout pond for water storage and irrigation in tail end area

The farmers of AES-IV of South Gujarat heavy rainfall zone growing wheat crop are advised to give 4 irrigations each of 60 mm depth. The first irrigation should be at sowing, second at CRI, third at knee heigh and fourth at boot leaf stages.

Reco# 2 : Conjunctive use of wallowing pond and tube well water and fertilizer management in Oat crop

The farmers of AES III of South Gujarat heavy rainfall zone adopting mixed farming of agriculture with animal husbandry and following the practice of wallowing are advised to give alternate irrigation with wallowing pond and tube well water to save about 30 kg N/ha for oat crop (fodder).

Reco# 3 : Irrigation management in spider lily

Farmers of AES III of South Gujarat heavy rainfall zone growing spider lily in canal command are advised to apply 20 irrigations (IW/CPC= 1.0) each of 60 mm depth at an interval of 13-15 days during winter (Nov. to Feb.) and 7 – 10 days during summer (March to June) for realizing higher bud yield and net profit as compared to farmers' method (standing water).

Alternatively, farmers growing lily using canal as well as ground water conjunctively are advised to adopt drip method of irrigation for saving irrigation water up to 40 per cent without any reduction in the bud yield as compared to surface method of irrigation.

The system details are:

Lateral spacing	: 1.80 mm
Dripper spacing	: 0.90 m
Dripper discharge	: 8 lph
Operating pressure	: 1.2 kg/cm2

Operating frequency : Alternate day
Operating time:
Winter : 75 – 100 min
Summer: 100 – 150 min

D) Mini sprinkler Irrigation:

Reco# 1 : Comparative study of different micro irrigation systems for vegetable crops clusterbean)

The farmers of South Gujarat heavy rainfall zone are advised to adopt typhoon method of micro irrigation for clusterbean. Typhoon irrigation method scheduled at 60 per cent fraction of pan evaporation gave about 25 per cent more yield with about 33 per cent saving of irrigation water over surface method of irrigation which would additional 0.5 ha area can be brought under irrigation. Further the net income can be mainly improved.

The system should be laid out as one lateral with 60 cm spacing of in line dripper between crop pair row of 45 cm distance and operated for 3 to 3.5 hr. during March to May on alternate day at a pressure of 1.2 kg/cm^2 with 2 Lph discharge rate.

Reco# 2 : Fertigation through minisprinkler in onion crop

The farmers of South Gujarat heavy rainfall zones (AES III) are advised to adopt minisprinkler system of irrigation along with fertigation for their onion crop to get about 23 per cent higher net income along with saving of about 20 per cent in fertilizer and 42 per cent in water over surface method. The 50 per cent N as urea should be applied at the time of planting and remaining 50 per cent in three equal splits at 30, 45 and 60 DATP through minisprinkler.

The minisprinkler should be laid out at the spacing of 2x2 m and system should be operated at 0.6 IW/CPE with a pressure of 1.5 kg/cm2 for 8 hrs for getting 50 mm depth of irrigation.

Reco# 3 : Response to fertigation levels by garlic under mini sprinkler irrigation

The farmers of AES III of South Gujarat heavy rainfall zone growing brinjal in paired row during *rabi* seasons using saline water (up to 4 dS/m) for irrigation through drip are advised to mulch their crop either with sugarcane trash (11%) or black plastic mulch for getting higher fruit yield (17%) and net profit (10-11%) as compared to no mulch treatment. Irrigation with saline water should be started at 30 or 45 days after transplanting of brinjal. After brinjal, they should grow transplanted paddy during *kharif* for minimizing deleterious effect of saline water usage on soil salinity/sodicity parameters.

E) Fertigation in Canal as well GW:

Reco# 1 : Irrigation and fertigation trails on hybrid castor (Var. GCH-4)

The farmers of South Gujarat heavy rain fall zone are advised to adopt drip irrigation for castor grown during rabi season for 38 % water saving and 32 % increased in yield over flood method. They should plant the crop in paired raw method at 60 x60 x 120 cm and use one lateral at 1.8 M grid with a dripper (8 lph) spacing of 1.2 M. The system should be operated for 50 minutes on alternate days up to January, 60 minutes in February and 75 minutes during March. The crop should be fertilized with a fertigation dose of 40 - 20 - 0 NPK kg/ha (40 % of R.D.) Nitrogen should be given in six splits and phosphorous in first two splits at an interval of 15 days.

Reco# 2 : Fertigation studies in chillies

Farmers of AES III of South Gujarat heavy rainfall zone cultivating chillies with micro irrigation system are advised to apply only 80 per cent of the recommended dose of NPK as soluble fertilizer in six splits at an interval of 20 days. In the case of shortage of fertilizer they can save 40 per cent of the recommended dose of fertilizer without getting any significant reduction in the yield.

Reco# 3 : Fertigation through minisprinkler in onion crop

The farmers of South Gujarat heavy rainfall zones (AES III) are advised to adopt minisprinkler system of irrigation along with fertigation for their onion crop to get about 23 per cent higher net income along with saving of about 20 per cent in fertilizer and 42 per cent in water over surface method. The 50 per cent N as urea should be applied at the time of planting and remaining 50 per cent in three equal splits at 30, 45 and 60 DATP through minisprinkler.

The minisprinkler should be laid out at the spacing of 2x2 m and system should be operated at 0.6 IW/CPE with a pressure of 1.5 kg/cm2 for 8 hrs for getting 50 mm depth of irrigation.

Reco# 4 : Feasibility of using banana pseudostem sap as liquid fertilizer in onion under drip irrigation

The farmers of South Gujarat heavy rain fall zone (AES-III) growing white onion (Cv.GW-1) crop after kharif paddy are recommended to transplant onion on raised bed (top width 90 cm followed by 30 cm wide and 15-20 cm deep furrow) and be irrigated through drip and fertigated @ 60% RDF (75 : 30 kg NK/ha) along with banana pseudostem sap @ 2000 l/ha in five equal splits of N, K and sap at an interval of 10 days starting from 15 days after transplanting for getting 57 per cent higher bulb yield and double net income along with saving of 30 per cent of

irrigation water as compared to conventional practice. Alternatively, they can also apply fertilizer @ 80% of RD + sap @ 1500 l/ha in a similar way for getting higher bulb yield and net profit.

System detail:

Lateral spacing (cm)	**:**	120
Lateral diameter (mm)	**:**	16
Dripper discharge rate (lph)	**:**	8
Dripper spacing (cm)	**:**	100
Operating pressure (kg/cm^2)	**:**	1.20
Operation lfrequency	**:**	Alternate day

Reco# 5 : Optimization of raised bed size under different levels of fertigation in turmeric

The farmer of AES – III of South Gujarat heavy rainfall agroclimatic zone are recommended to plant three rows of turmeric(Sugandhm) (30x20 cm) on raised bed of 90 cm width followed by 45 cm wide and 25 – 30 deep furrow. They are advised to applied 80 % of recommended dose of fertilizers (60:60:60 N:P2O5:K2O kg/ha).Full dose of P and half dose of N&K should be applied at the time of planting. The remaining 50 % of N and K should be applied in nine equal splits through drip system at an interval of 15 days starting after cessation of monsoon. By adoption of this technology farmer can realize 36 per cent higher net income and 25 per cent higher yield along with 32 per cent water and 20 per cent fertilizer saving as compared to farmer's practices.

System details are:

Lateral spacing: 1.35 m
Dripper spacing: 1.00 m
Dripper discharge: 8 lph
Operating pressure: 1.2 kg/cm2
Operating frequency: Alternate day
Operating time:

Sept-Dec : 45 – 60 min
Jan-March : 50 – 75 min

Reco# 6 : Study on irrigation and fertilizer levels on yield and quality of sugar beet grown on clay soils

The farmers of South Gujarat heavy rainfall zone(AES III and IV) intending to grow sugar beet crop are advised to irrigate their crop by drip method @0.8 PEF and fertilize @ 120:60:60 kg N,P2O5 and K2O/ha. The full dose of P and 10 % of N and K dose should be applied as basal and remaining 90 % FD of N and K should be applied in 10 equal splits at an interval of 8-10 days starting from 15 DAS. By adopting these practices, higher beet yield and net return are realized as

compared to surface method of irrigation.

System details:

1	Lateral spacing	:	1.6m
2	Dripper spacing	:	1m
3	Dripper discharge	:	8 lph
4	Operating pressure	:	1.2 kg/cm2
5	Operating frequency	:	Alternate days
6	Operating time	:	

Month	Normal soil	Salt affected soil
Nov. and Dec.	1.30 hr	1.40 hr
Jan. and Feb.	1.40hr	1.50 hr

Reco# 7 : Study on levels of nitrogen and intra-row spacing on yield of drip irrigated castor (rabi)

The farmers of South Gujarat heavy rainfall zone (AES III) growing drip irrigated castor (GCH-4) during rabi season are advised to sow their crop with intra row spacing of 0.6 m and row spacing of 2.4 m. Further, they are advised to fertilize @ 160:40NP kg/ha. The full dose of P and 10 % N should be applied as basal and remaining 90 % N should applied through drip system in 10 equal spilt at an interval of 8-10 days starting from 15 DAS. By adoption of these practices, higher yield and net profit can be realized as compared to paired row (60x60:120 cm) sown castor.

The system details are:

Lateral spacing	:	2.40 m
No of dripper per plant	:	6
Drpper spacing	:	0.60 m
Dripper discharge	:	4 lph
Operating pressure	:	1.2 kg/cm^2
Operating frequency	:	Alternate day
Operating time	:	
Nov-Dec	:	80-130 min
Jan-Feb	:	90-160 min
March onward	:	150-210 min

Reco# 8 : Effect of irrigation and fertigation levels on growth and yield of annatto (Bixa orllana)

The farmers of South Gujarat heavy rainfall zone (AES III) intended to plant Annatto crop are advised to follow the spacing of 5 m x 5 m, apply RDF (60:40:40 kg NPK/ha/year) and give total 18-22 irrigations by surface method with an interval of 9-12 days during summer and 13-17 days during winter for getting

higher net profit.

In scarcity of water, they are advised to adopt drip irrigation method for saving 75 per cent of water and 20 per cent N and K fertilizer. Further, they are advised to apply 48:40:32 NPK kg/ha fertilizer. Phosphorus should be applied in ring with half dose before two months of monsoon and remaining half dose after cessation of monsoon. The N and K should be applied in 10 equal splits at 10 days interval, of which five splits is to be applied in two months before monsoon and remaining five splits after cessation of monsoon through fertigation.

The system details are:

Lateral spacing		**:**	5 m
No of dripper per plant		**:**	6
Dripper discharge		**:**	8 lph
Operating pressure		**:**	1.2 kg/cm^2
Operating frequency		**:**	Alternate day
Operating time		**:**	
	Oct-Dec	**:**	25-30 min
	Jan-March	**:**	30-40 min
	April-Jan	**:**	40-50 min

F) Intercropping:

Reco# 1 : Crop geometry for intercropping with drip in Sugarcane

The sugarcane growing farmers of South Gujarat heavy rain zone (AES-III) adopting drip technology are advised to go for normal planting system, when they want to follow intercropping with onion or garlic or cabbage.

Reco# 2 : Management of inter cropping in drip irrigated sugarcane

The farmers of South Gujarat heavy rainfall zone growing sugarcane in paired row (60 x 120 cm) with drip irrigation are advised to take cucurbits as intercrop for achieving 46 per cent more net income than sole sugarcane. The cucurbits should be sown at either 10 or 20 cm away from the dripper

G) Hilly areas:

Reco# 1 : Standardization of low cost drip system

The farmers of hilly areas/ kitchen garden of South Gujarat are advised to irrigate brinjal crop through low cost drip system in about 25 to 35 m^2 area using 35 litre of water per day for realizing a net profit of about Rs. 300 to 350. The crop should be planted in paired rows (0.6 x 0.6 x 1.2 m) with row length of 4.8 m. Such 4 sets of pair rows can be made in the available area. The lateral should be placed in between two rows and micro tube should be placed at 60 cm apart *i.e.* each micro tube (dia.: 1.2mm, length: 7.2 cm) cover two plants. The system should be operated on alternate day.

H) For Policy makers and Scientific community:

Reco# 1 : Impact of drip irrigation in Gujarat State

From the results of survey on impact of drip on input usage and land use pattern is indicated that :

1. A sample survey adopting drip for various crops in different agroclimatic zones of Gujarat revealed that at present the levels of knowledge about drip as well as adoption by the farmers are of medium category. Frequent clogging of the emitter, lack of technical knowledge and guidance, high cost of spare parts, lack of after sales service by the companies, damage of rodent and other animals and insufficient year round water sources are the major problems encountered by the farmers for large scale adoption. They do not fell that difficulty in inter culturing operations under drip heavy initial investment for drip, theft of drip spare parts and clumsy procedure for getting the subsidy as major constraints.

2 Of the 150 drip owners, 43 per cent owners were of the opinion that adoption of drip method of irrigation could save more than 50 per cent of irrigation water. Similarly, among the farmers (47) employing fertigation practice, 85 per cent felt that more than 30 per cent fertilizer will could be curtailed.

3. From saving in plant protection expense point view, 53 per cent farmers opined about 16 to 30 per cent cost could be saved. Majority of them (57%) also opined about 51 to 75 per cent saving in weed control expenditure could be achieved. Similarly, they (59%), expressed that saving in labour cost to extent of 26 to 50 per cent could also be obtained.

4. Majority of the farmers (57%) indicated increase in yield to tune of 26 to 50 per cent and about 85 per cent of the farmers were of the view that along with increase in yield, improvement in quality of produce is also obtained. Subsequently, about 77 per cent have expressed their view that due to improved quality they are fetching more price.

5. On an average, about 41 per cent increase in area under fruit crop was observed due to adoption of drip method of irrigation. This was also substantiated by change in cropping pattern i.e. increase in area under fruit crop. Similarly, with the adoption of drip, an increase in cropping intensity to an extent of 11 per cent was also observed.

Reco# 2 : Drip survey - Gujarat

RECOMMENDATION DATA (BASE) FOR SCIENTIFIC COMMUNITY

A sample survey of 131 farmers adopting drip for various crops in different agroclimatic zones of Gujarat revealed that at present the levels of knowledge about drip as well as adoption by the farmers are of medium category. Frequent clogging of the emitters, lack of technical knowledge and guidance, high cost of spare parts, lack of after sales services by the companies, damage by rodent and

other animals, and insufficient year round water sources are the major problems encountered by the farmers for large scale adoption. They do not feel that difficulty in interculturing operations under drip, heavy initial investment for drip, theft of drip spare parts, and clumsy procedure for getting the subsidy as major constraints. (the impact of drip on crop production, water savings, ultimate economics as experienced by the farmers.

Reco# 3 : Estimation of Crop Water Requirement of Major Crops of South Gujarat (Using CRIWAR and CROPWAT Models)

From this study it could be recommended that both CRIWAR and CROPWAT models are the effective tool for quick estimation of crop water requirement, which could be used for planning the water management programme

Reco# 4 : Survey and transfer of technology

Out of the 27 farmers, 14 are following drip method of irrigation. Based on the average land holding, the farmers have put their 28 per cent of land under drip method of irrigation. In the farmers' opinion, there is increase in banana yield (42%) with drip method as compared to conventional method of irrigation. However, they feel that, still there is good scope in increasing the productivity of banana. This is because of the reason that the farmers are facing numerous problems in banana cultivation.

Reco# 5 : Survey related to banana cultivation in South Gujarat

Infrastructural problems:

Unassured power supply is ranking first and it is followed by inadequate availability of planting material, fluctuation in prices, high cost of fertilizer etc.

Soil and water management constraints:

Nutrient management seems to be a major problem for both the groups of farmers. In the case of drip irrigation, the farmers placed the poor know how and after sale service of system at second place.

Crop production problems:

Disease is at the top priority and next in order are stunted growth during winter, new high yielding variety, early flowering, scorching of fruit during summer and lodging of the plant.

In addition to these problems, farmers of both the groups have expressed the concern about higher cost of planting material and quality of water.

Reco# 6 : Soil and water resources analysis for appropriate technological interventions Sabarkantha district

During this year, resource analysis of Sabarkantha district (North Gujarat)

was done for identification of crop production related soil and water management constraints. The constraint based technological interventions have been suggested.

Reco# 7 : Rain water harvesting, recharging and monitoring

Based on 6 year study of monitoring ground water quality and water table fluctuation two major conclusions are drawn

- The quality of well water improved due to excavation / desilting of ponds and the effect was more pronounced near pond

Water table remain shallower near pond and it tended to decline as the distance from pond increases

Reco# 8 : Designing optimum drip system for sugarcane crop

The farmers of AES-III of South Gujarat heavy rainfall zone, adopting inline drip system for the sugarcane crop planted in paired row (1.2 x 0.6 m) can select 2 or 3 or 4 Lph dripper and place the system either as surface or sub surface (at 15 cm depth). Though, oozy pipe system as subsurface is technically viable, but it is not economical since the system in presently imported.

Reco# 9 : Closed subsurface drainage for combating water logging and salinity condition in canal command area

On account of concerted efforts made by this unit, farmers of command area have adopted drainage technology at their own cost. More numbers of farmers are still approaching this unit for installation of the system. However, there is need and to up scale this activity through Govt. and Sugar Co-Operative intervention.

Reco#10 : Survey related to feed back of sub surface drainage (SSD) farmers

Conclusions

Though, the sample size is small, following important indications have emerged out from the present study:

- Majority of farmers have experienced betterment of soil productivity, which has reflected in terms of yield, net return and increased in land value due to adoption of drainage technology in their field.
- Most of farmers have adopted previous recommendation (2003-04), installation of drain pipe at a spacing of 45 m and depth of 90 to 120 cm in their field.
- Due to soil improvement and increasing crop yield, farmers recovered total cost of drainage installation within period of 1-2 years which also supporting our earlier recommendation (Payback period of 2 year).
- Most of farmers are convinced that it is best technology for reclamation of

waterlogged and salt affected soils but there is a scope of research to reduce cost of drainage system.

- Due to the higher cost of PVC corrugated pipe, farmers demanding Government subsidy for this pipe.

Reco# 11 : Natural resources characterization in relation to banana growing areas of South Gujarat

Constraint based technological interventions

The soil, water and climate related banana production constraints under South Gujarat conditions are listed in table N4.5. For suggesting comprehensive remedial measure some of associated parameters like BD, organic carbon, hardness *etc*., have been clubbed together and then measures to be suggested. Apart from this, the deleterious effects of limiting factors or constraints are also mentioned in table 4.6.

Constraints based remedial measures for improving banana productivity

Sr. No	Constraints' for banana	Deleterious effect on root growth	Remedial measures
1	High bulk density, low organic carbon, hard consistency	Restricted root growth due to difficulty in penetration of roots	➢ Deep ploughing once in three years ➢ Addition of organic manures like FYM, biocompost, vermicompost *etc.* ➢ Green manuring with dhaincha or sun hemp ➢ Insitu incorporation of crop residues
2	High pH and ESP	Stunted growth of plant due to restricted soil air, moisture and nutrient movement , Apart from this, extremely high pH (>9), Nutrient availability decreased	➢ Soil analysis based gypsum application in conjunction with organic manures, green manuring *etc.* ➢ Provide drainage facility ➢ Preference to sodicity tolerant variety of banana
3	Low in orgainic carbon, Fe and in some samples Zn	Poor plant growth and low yield due to inadequate supply of element in question	➢ Apply recommended doses of fertilizer as per soil test value ➢ Soil test based

	deficient		application of Fe and Zn
4	Marginal or Poor quality of ground water	Stunted plant growth and poor yield of plant Mortality of plant in extreme cases Deterioration in soil health due to prolonged use of such water for irrigation purpose	➢ Adopt drip irrigation along with mulching for restricted upward movement of soluble salts ➢ Follow fertilization schedule using urea and MOP as source of N and K ➢ Use SSP as a source of P
5	Low rainfall (Unmanageable constraints)	--------	➢ Change date of planting in such a way that full growth stage of plant comes during monsoon season

(II) Promising Technology:

I : Management of water logged and salt affected soils

Presently, 15 per cent area of UKC has already gone out of cultivation due to twin problems of water logging and secondary salinization and another 25 per cent area of the command is critical (water table between 1.5 to 3.0 m bgl). In view of severity of the water logging and salinity problems in UKC, one pilot area study of 56 ha block situated in the jurisdiction of Chalthan Sugar Factory, Chalthan was carried out during 1984-85 to 1991-92. An increase in yield of paddy and sugarcane crop was observed under drainage block. Subsequently, in collaboration with ILRI, The Netherlands, one block each of open subsurface (169 ha) and closed sub surface drainage (CSSD) (188 ha) in operational research mode were taken up. Seeing the advantages of drainage, farmers having water logged and salt affected soils have approached this centre for guidance. As a result of this, about 75 ha area has been brought under CSSD under the guidance of Navsari center and the total cost of the system was born by the farmers themselves.

CSSD in sugarcane

Digging of open drain

Table : Economics of drainage systems

Parameters	Control	OSSD	Control	CSSD (Spacing 45 m)
Crop	Paddy	Paddy	Sugarcane	Sugarcane
Yield (t/ha)	2.2	3.8	78	105
Water table (bgl in m)	0.55	0.88	0.35	0.46
ECe (dS/m)	16.30	12.30	5.0	1.20
Cost of system installation (Rs/ha)	-	8000	-	20400*
Cost of cultivation (Rs/ha)	11000	16200	31286	41143*
Gross income (Rs/ha)	12980	22420	63555	85500
BCR	-	2.93	1.03	1.70
Internal rate of return (%)	-	114.5	-	58
Pay back period (years)	-	2	-	3

* The total cost of cultivation and gross income are converted from 14 month growing period of the sugarcane crop to a yearly basis.

OSSD: Open subsurface drainage

CSSD: Closed subsurface drainage

Considering an improvement in yield of sugarcane and paddy along with decrease in water table and soil salinity, farmers of UKC have adopted drainage technology even by bearing 100 per cent cost of drainage system under the technical guidance of Soil and Water Management Research Unit, NAU, Navsari.

Drainage technology for reclamation of water logged and salt affected soils

Drain spacing : 30 / 60 m
Cost of installation : Rs. 10,800 / 5,800/ ha
Cropping intensity : Pre : 46, Post: 102

Drain spacing : 45 m
Cost of installation : Rs. 20,000/ ha
IRR : 58
Payback period : 2 years

Field condition before SSD

Crop condition after SSD

II: Micro irrigation system:

Based on the availability of water, two extreme situations are prevailing in Gujarat. Because of misuse of amply available water in South and middle Gujarat, water logging and salinity problems are on rise. On the other hand, in Saurashtra and northern parts of the state, water table is receding and quality of groundwater has been deteriorated to such an extend that it is not fit for irrigation. Under both the circumstances, use of micro irrigation technology is highly appropriate option. South Gujarat is the orchard belt of Gujarat state. Apart from fruits, considerable areas are under vegetable and sugarcane crops also. Accordingly, about 140 MIS technologies covering 40 different crops across the state have been developed and recommended for the use of farmers. It is observed that for most of the crops, the water saving over recommended surface method is 20 to 60 per cent. The yield increase varied from negligible to 60 per cent. Looking to the benefits achieved through micro irrigation system, Government of Gujarat has established Gujarat Green Revolution Company in 2005. After establishment of the company, the area under MIS has increased considerably and presently it is around 1.1 lakh ha.

In view of the benefits realized from micro irrigation and government efforts, the Bardoli and Madhi sugar factories have installed drip system in sugarcane crop on 55 and 65 ha , respectively. Some fruit co-operative societies have also installed this system in banana in about 100 ha.

In order to reduce the cost of the system, research work conducted with sugarcane, banana, castor, cotton and some vegetable crops revealed that switching over to paired row method of planting from the conventional spacing could reduce the system cost by about 40-50 per cent. These technologies also have been demonstrated on farmers fields and now farmers are adopting it on wider scale.

a) Drip irrigation:

The drip technologies developed by this unit have become popular among the farmers owing to effective transfer of technology programme. This is evident from the increase in area under drip irrigation in horticultural crop from 1603 ha in 1990 to 13345 ha during the year 2003. Apart from this, based on the survey conducted by this unit, the farmers' opinion about the increase in yield and saving in water as well as fertilizer..

The drip method of irrigation facilitate application of nutrient in root zone and at higher frequency, which enhances efficiency of applied nutrient considerably. Because of this, fertilizer dose through drip can be reduced by 20 to 40 per cent in different crops. This technology is being effectively taken to the farmers through demonstration, training, audio-visual aids and news paper *etc*.

SN	Crop	System details			Yield increase (%)	Water saving(%)	Fertilizer saving(%)
		Lateral spacing (cm)	Dripper spacing (cm)	Dripper discharge (Lph)			
1	Sugarcane (Co. 91132)	180	60	4	23	38	50
2	Banana (Basrai)	320	100	4	28	40	-
3	Castor (GCH-4)	180	120	8	32	38	60% N saving
4	Smooth gourd (Hy.Chetak)	200	100	4	13	57	Drip+ trash mulch
5	Rabi Castor (GCH 4)	180	120	8	-	39	40% N saving
6	Maize (Sweet corn)	180	100	8	66	20	
7	Onion (pilipatti)	80	80	4/8	36	39	-


Drip in Sugacane


Drip in Onion

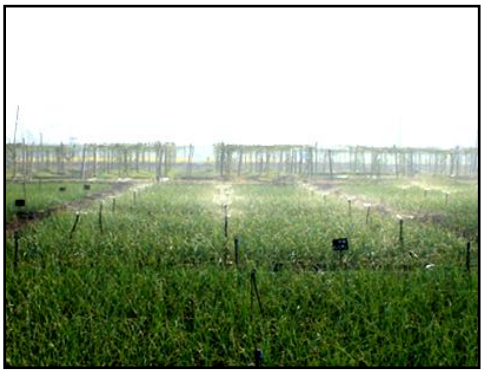

Drip in Banana


Drip in Maize

b) : Sprinkler technology

Techno-economic viability of this system was evaluated for different crops during the year which resulted in release of recommendations for agro climatic zones. The water saving through sprinkler ranged from 21 in garlic and 42 per cent in onion crop, while that of increase in yield was up to 37 percent in garlic and 23 per cent in onion.

SN	Crop	System details		Yield increase (%)	Water saving (%)	Remarks
		Sprinkler spacing (m)	No of irrigation (D: mm)			
1	Garlic (GAU G.1)	2.0 x 2.0	10 (50)	37	21	Herbigation for effective weed control
2	Onion (Guj. Red)	2.0 x 2.0	5 (50)	23	42	20 % N saving



Garlic

Onion

c) **Mulching technology:**

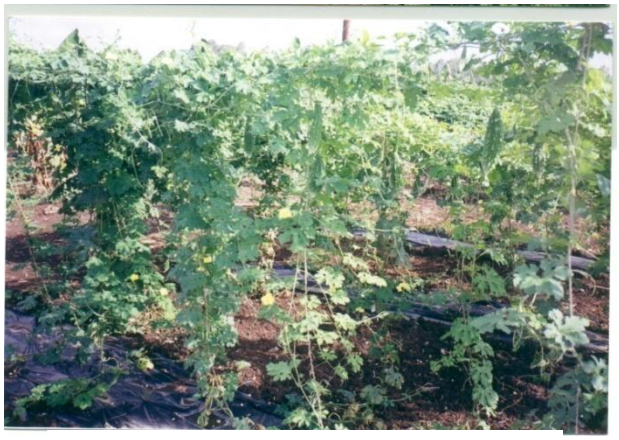
Mulching is an important technology useful under rainfed as well as irrigated situations. The mulch material tested are grass, crop resides, black plastic of different thickness *etc*. This centre has developed technologies for irrigated situation only. Mulching studies were conducted in surface as well as drip methods of irrigation. Mulching in surface method resulted in saving of water to the extent of 40 to 70 per cent along with increase in yield by 18 to 49 per cent. With drip method, mulching not only improved the yield and saved the water (17 to 57 %) as well as fertilizer (20-40 %), but also induces an early maturity in crop like banana by about 30-35 days. Similarly, drip + mulching also enable to use poor quality water without adversely affecting the soil health.

Table 4: Effect of mulching in surface and drip methods of irrigation on yield and water saving

Aspect	Crop	Recommended technology	Yield increase (%)	Water saving (%)	Remarks
Surface + mulch	Banana	STM	49	40	15 t/ha trash
	Okra	BP	25	-	90 % weed control
	Brinjal	BP	47	79	-
	Marigold	STM	29	-	-
	Castor	STM	18	-	5 t/ha trash
Drip + Mulch					
	Rose	BP	54	17	-
	Brinjal	STM/BP	17	-	-
	Smooth gourd	STM	-	57	-
	Banana	BP	43	17	-
	Bitter gourd	BP	18		25 micron plastic

Drip + BPM in banana

Drip + BPM in Sugarcane



Drip + Mulch in bitter gourd

Drip + Mulch in Castor

III : Identification of new crops

In order to mitigate the water logging problem in the command, it is essential to replace the high water consuming summer paddy crop by less water requiring but equally remunerative crop (s). In this direction, this center has already recommended castor (*rabi*), palmarosa, nizer (*rabi*)-green gram(s), garlic, marigold and Bixa crops. The work on crop like spider lily, turmeric, bixa *etc*., is in progress.

Table 5: Comparative water requirement and net income of some potential crops

Crop	Irrigation water requirement (mm)	Yield (t/ha)	Gross income (Rs/ha)	Net income (Rs/ha)	WUE (kg/ha-mm)
Paddy (Summer)	**1200-1400**	**4.0 – 5.0**	**25000**	**22000**	**3.46**
Castor	**320 - 380**	**2.5 – 3.0**	**50000**	**35000**	**7.14**
Marigold	**600 - 650**	**6.5 – 7.5**	**20000**	**36000**	**11.67**
Niger-Green gram sequence	**360 - 420**	**0.6 - 1.3**	**44000**	**28000**	**2.22**
Garlic	**620 - 680**	**6.0 – 7.0**	**180000**	**128000**	**10.48**
Palmarosa	**570-810**	**269 kg/ha oil yield**	**134550**	**87449**	**0.36**
Bixa	**570-600**	**1.12**	**56000**	**17000**	**1.97**

IV: Basic studies:

At beginning of the project, of the creation of data base and characterization of soils of command area and 62 research stations of the university with respect to water retention, water transmission, available water along with some physical and fertility parameters was done. This information was used for optimizing design criteria of surface and pressurized methods of irrigation through field experiments in different agroclimatic zones. Similarly, water balance studies of different agroclimatic zones of the state was attempted. This include climatic water balance (rainfall, PE, soil water balance), irrigation development and status, crop wise irrigated area and source wise irrigated area at district level. The crop water requirement of major crops of South Gujarat was estimated using CRIWAR and CROPWAT models. Apart from these, detail analysis of causes of water logging *viz.*, climate, ground water quality, water table fluctuation and trend of cropping pattern in head, mid and tail ends of the Surat branch command area (36000 ha) was done. Similarly, in lift command of North Gujarat, information related to the surface and ground water potential, ground water balance, extent of ground water pollution (F, NO_3), tube well intensity, irrigation status and domestic water requirement of Mehsana district was collected and appropriate management strategies were suggested.

Thrust areas:

- Mitigation of resources degradation due to irrigation including drainage research
- Efficient groundwater utilization
- Pressurized irrigation system
- Improvement in WUE at field level through surface irrigation method
- Watershed management
- Use of industrial effluent and wastes in agriculture
- Research on conjunctive use of water resources

IV: Castor a recently introduced low water requiring crop in canal command

In Ukai-Kakarapar command farmers have adopted high water consuming crops/cropping sequences like paddy(k)-paddy(s), paddy-sugarcane, sugarcane-sugarcane *etc*., by neglecting the suggested cropping pattern of the command. For instance, as against 10 per cent of the command area allotted to sugarcane, it is grown in more than 40 per cent of the command area. Similarly, not a single hectare area was earmarked for summer paddy which is occupying about 25,000 ha area of the command. Because of this, the water logging and secondary salinization problems are rising at an alarming rate *i.e.*, 15 per cent of the command area has already gone out of cultivation due to these problems. For mitigating these problems, Navsari centre is working towards introducing new crops with low water requirement but equally or better remunerative than that of summer paddy. Castor basically *kharif* crop can be grown during *rabi* season with good productivity after *kharif* paddy. Navsari centre have standardized the agro techniques for increasing the productivity of *rabi* castor and also popularized among the farmers. Because of these efforts, presently *rabi* castor is being grown in about 10,000 ha area in Ukai-Kakrapar command. The package of practices along with economics of *rabi* castor are given here.

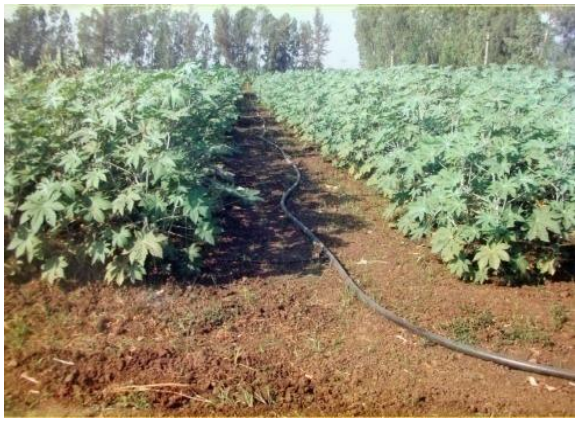
Standard package of practices for *rabi* castor grown after *kharif* paddy

SN	**Operations**	Details
1.	**Sowing time**	15th October to 15th November
2.	**Variety and Seed rate**	GCH-4 6.0 kg/ha
3.	**Land configuration**	Raised bed : Top width: 180cm, Furrow width: 25 cm, Furrow depth: 15-20 cm
4.	**Spacing**	Normal planting: 60 x 90 cm Paired row planting: 60 x 60 x 120 cm
5.	**Manuring**	Organics Bio compost: 6 t/ha FYM: 10 t/ha Fertilizer: Surface: 80 : 40 : 0 NPK kg/ha (50% basal and 50% 45 days after sowing) Drip: 60 : 40 : 0 NPK kg/ha (20% N as basal and remaining in 3 equal splits at 30 days intervals) (P as 100% basal application)
6.	**Irrigation**	**Surface:** at 0.8 IW/CPE, 60 mm depth First at sowing, second at 8 to 10 days after sowing and remaining four at 22-25 days interval. **Drip:** scheduled at 0.4 PEF **System detail:** 1.8 m lateral spacing, 1.2 dripper spacing and 8 lph dripper discharge rate (4 plants/dripper) **System operation time:** 40 to 60 minutes during November to January and 60 to 100 minutes during February till harvest.
7.	**Mulching**	Sugarcane trash mulch @ 5 t/ha (50% coverage) Black plastic mulch with drip 25 micron thick 50% area coverage.
8.	**Economics**	Conventional: 19000 Rs./ha Improved practice: 41725 Rs./ha

In view of the monetary return realized with castor (*rabi*), it is quite clear that castor (*rabi*) can replace summer paddy which require large volume of water. Growing of castor after *kharif* paddy will not only give monetary benefit to the farmers of the command, but also mitigate the problem of waterlogging and secondary salinization in the command area.

Sugarcane trash mulch

Normal planting



Drip with paired row planting

BPM with drip

V : Spider lily a recently introduced flower crop in canal command

Spider lily is the common name for a number of different plant species within the family *Amaryllidaceae* which is a tropical American plants of the genus *Hymenocallis,* having narrow leaves and umbels of white flowers propagated through bulbs. Spider lily an important perennial flower crop is recently spreading in South Gujarat at a very fast rate (2000 ha). This flower crop has best suitability in AES III of South Gujarat heavy rainfall zone of South Gujarat. Market of this flower is developed by the growers in nearby metropolitan cities. The buds before it opened up are harvested early in the morning and 50 bud bunches are prepared with the help of rubber bands and packed in empty fertilizer bags. Generally, this crop is irrigated by surface method. It is our observation that spider lily growing farmers are over irrigating this crop *i.e.,* the field is kept almost submerged. The drip treatment mean yield (54.34 lakh buds/ha) was conspicuously higher in comparison to farmers' method (43.29 lakh buds/ha). In terms of water saving, under farmer's method almost three times more water is required than drip as well as surface method of irrigation. This disproves the farmers' taboo that lily requires water just like transplanted paddy. With respect to net profit, the treatment receiving surface irrigation scheduled at 1.0 IW/CPE ratio ranked first by realizing net return of Rs.1,76,401 /ha and it was followed by drip irrigation @ 0.6 PEF (1,67,644 Rs/ha),0.8 PEF (1,67,960Rs/ha) and 1.0 PEF (1,67,350,Rs/ha).

Standard package of practices for *rabi* castor grown after *kharif* paddy

SN	Operations	Details
1.	**Sowing time**	In the month of June
2.	**Variety**	Local variety
3.	**Spacing**	Normal : 90 x 30cm
		Paired row: 60 x 30 x 120 cm
4.	**Manuring**	**FYM :** 10 t/ha , at the time of land preparation **Fertilizer :** 300:250 :00 NPK kg/ha **Surface :** Apply in four equal splits during June, September, December and March **Drip Method:** P should be apply at basal and Nitrogen through drip at monthly interval(Except monsoonic month)
5.	**Irrigation**	**Surface:** Farmers of AES III of South Gujarat heavy rainfall zone growing spider lily in canal command are advised to apply 20 irrigations (IW/CPE = 1.0) each of 60 mm depth at an interval of 13-15 days during winter (Nov. to Feb.) and 7 – 10 days during summer (March to June) for realizing higher bud yield and net profit

		Drip method: Alternatively, farmers growing lily using canal as well as ground water conjunctively are advised to plant spider lily in paired row (30 x 60 x 120 cm) and adopt drip method of irrigation. *The system details are:* Lateral spacing : 1.80 m Dripper spacing : 0.90 m Dripper discharge : 8 lph Operating pressure : 1.2 kg/cm^2 Operating frequency : Alternate day **Operating time:** Winter : 75 – 100 min Summer : 100 – 150 min
6.	**Water saving**	**Surface :** 56-74 **Drip :** 56-74 as compared to farmers practices(standing water)

Based on the results of three years experimentation following conclusions are emerged.

- Adoption of surface irrigation scheduled at 1.0 IW/CPE ratio proved to be more remunerative and also leading to saving in considerable amount of irrigation water than farmers' practice. In other words, lily does not need ponding of irrigation water.
- Adoption of drip method of irrigation was also seemed to be a viable option under the situation of conjunctive use of surface and ground water sources. In view of the lateral spacing 1.8 m, it can very well fit in the crops like sugarcane, castor, brinjal, tomato, chilli *etc*. being followed in South Gujarat.

Experimental filed

Flower buds ready for harvest

Opened flower

VI: Value added products from banana fruits and pseudostem:

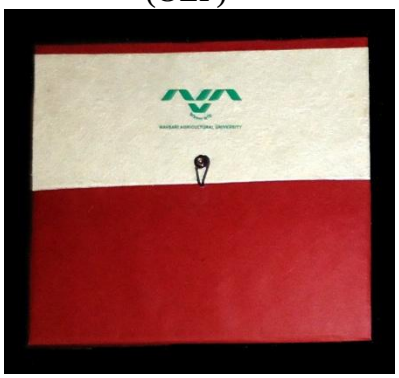
- Technologies develop for utilization of banana fruits; both ripe and unripe for preparation of various value added products like, Banana chips, Flour, Spray dried powder, Puree', Jam, Cheese, Ketchup, Powder, chwanapras, Paak, Bar *etc.* and recommendation given for processes.
- Waste to wealth: Technologies developed for utilization of banana pseudostem for making various products like paper, compost, fibre extraction, MCC, Handicrafts, Yarn and fabrics, non woven fabrics, hardboard, Fishfeed, organic liquid fertilizer, candy, pickles, ready to serve beverages, Jam *etc.* Successfully done technology transfer with more than 8 privet companies/ co-operatives for commercial production and marketing of various products.

Banana Fiber

Organic Liquid Fertilizer (OLF)

Vermicompost

Candy



File

Paper

Pickels

Jam

Soft-Drink

MIS a 'Key' to Success for economic crops production in Gujarat

Technology	Crops	Area coverage (ha)	Remarks
Micro irrigation system including fertigation and mulching	Sugarcane, Banana and Potato	In Gujarat about **13 lakh ha** area is covered under pressurized methods (drip and sprinkler) of irrigation.	This centre is actively associated *(technical back up, trainers' training, tribal youth training etc.)* with GGRC, Baroda which is main implementing agency for bringing more area under pressurized methods of irrigation in Gujarat.

MIS a 'Key' to Success for economic crops production in Gujarat

Preamble:

In a water scarce state like Gujarat micro irrigation system (MIS) has special significance. In order to bring more and more area under MIS, GoG has established special company *viz.*, Gujarat Green Revolution Company (GGRC). Because of the GGRC the area under MIS in Gujarat is steadily increasing (Fig. 1). The area under MIS up to March, 2016 in Gujarat has reached to 13.00 lakh ha. The success stories of drip, mulching, fertigation in banana and sugarcane as well as sprinkler irrigation in potato crops are presented here.

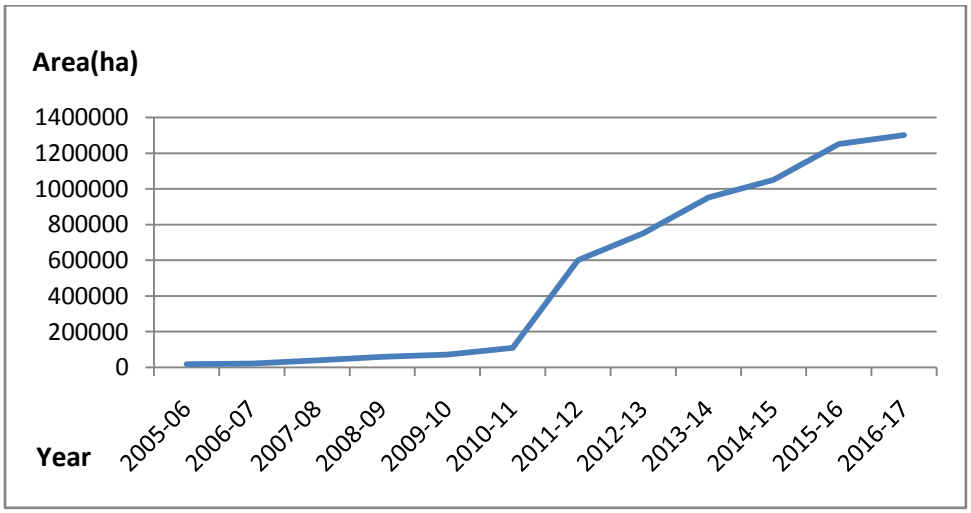


Fig. 1: Trend of area under MIS in Gujarat (Source: GGRC, 2016)

Drip, fertigation and mulching in banana and sugarcane

In Gujarat, banana (62,000 ha) and sugarcane (2,30,000 ha) are the two major cash crops predominantly grown in South Gujarat due to favourable agroclimatic conditions, presence of perennial irrigation facility and well established marketing network of farmers on co-operative basis. In both these crops, farmers were adopting conventional methods of irrigation and fertilizer application. Because of this, the productivity of both these crops was quite low *i.e.*, 35 t/ha of banana and 65 t/ha of sugarcane during 2002-03. For enhancing the productivity of both the crops, at state and national level concerted efforts were made to develop / standardize technologies like drip irrigation, fertigation, mulching *etc.*

Drip irrigation in Banana

Drip + Mulch in Banana

As a result of these efforts, Soil and Water Management Research Unit, NAU, Navsari have developed/ standardized the technologies *viz.*, tissue culture plantlets, drip irrigation, fertigation schedule and black plastic mulching for banana and paired row planting, drip irrigation and fertigation schedule for sugarcane crop. The significance of these technologies in enhancing productivity of both the crops was demonstrated to the banana and sugarcane growers through arranging package demonstrations (each of 0.4 ha) on farmers' fields along with training, farmers' days, *krishimahotsav*, TV and Radio talk *etc*. The results of demonstrations on farmers' fields reported in fig.1 clearly indicate that with adoption of mulching technologies, farmers could save 35 and 28 per cent of irrigation water and fertilizer along with an increase in yield by about 22.5 to 18 per cent, respectively in Banana and Sugarcane. The average additional net income per hectare realized by the farmers was ranging from Rs 70000/ha with banana and Rs. 30000 with sugarcane crop. If only area under drip irrigation in banana (10000 ha) and sugarcane (11000 ha) in Gujarat is considered, then the additional income generated per year by the farmers is about Rs 100 crores.

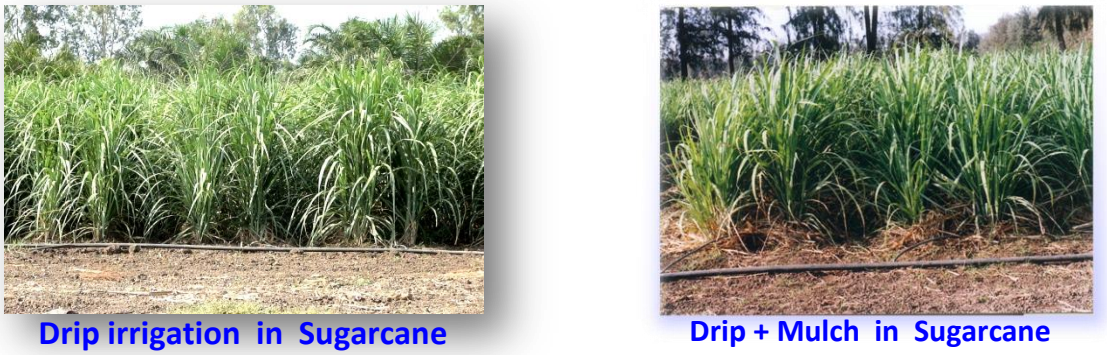
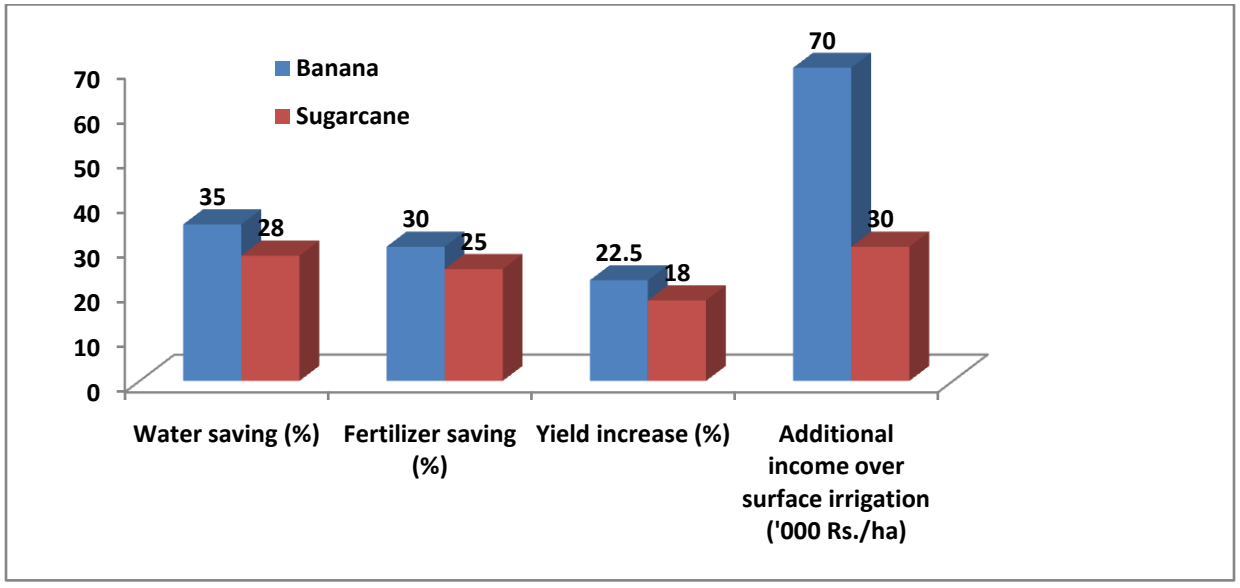
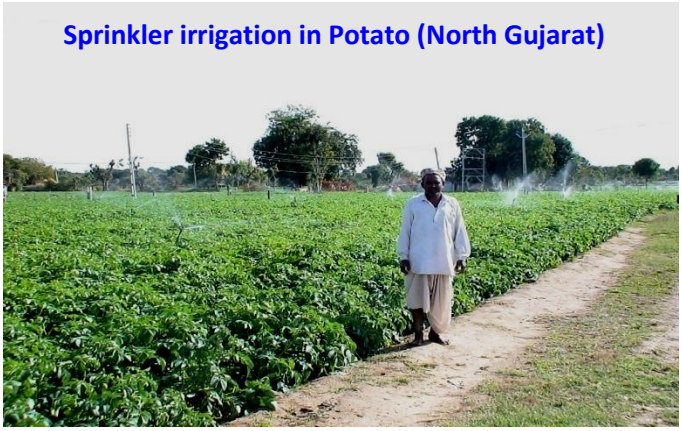


Fig. 1: The results of demonstrations on farmers' fields



Drip and sprinkler irrigation in potato

Gujarat is one of the major potato producing states in the country. Potato crop is grown predominantly on light textured soils of North and Central regions of the state. This crop occupies around 40,000 ha area in the state with total production of 978 t and an average productivity of about 25 t/ha. Though, farmers have started adopting drip and sprinkler methods of irrigation in potato, yet the potential benefits are not fully realized by them. This is because of the reasons that they are over irrigating the crop and in most of the cases fertigation is not adopted. On account of this, the main purpose of water saving through use of either drip or sprinkler is defeated. Not only is this, but the logic behind providing subsidy for drip and sprinkler also lost. For realizing the full benefits of these systems, it is necessary to get feedback from the farmers about MIS. The adoption of drip/sprinkler on such a large scale (800 ha) in particular pocket that too in single crop of potato is not a common phenomenon. In order to get feedback from the farmers, a survey of farmers who adopted MIS in potato was done. In this area, that the major source of irrigation water is personal tube wells (83%) followed by participatory tube wells (9%) and wells (6%).



The basic motive behind this is to save irrigation water (100%), improve quality of produce (83%), increase yield (79%) and reduce labour cost (48%). Some of the farmers were of the opinion that adoption of drip/sprinkler will mitigate the problem of receding water table also (Table 1).

Table 1: Distribution of farmers based on the motive behind adopting drip/sprinkler

N=42*

SN	Motive	No. of farmers	%	Rank
1.	**Efficient use of water**	42	100	I
2.	**Improving quality of produce**	35	83	II
3.	**Increasing yield**	33	79	III
4.	**Reducing labour cost**	20	48	IV
5.	**Mitigate receding water table problem**	16	38	V
6.	**Protecting soil deterioration due to use of poor quality water**	2	5	VI
7.	**Save crop during drought**	1	2	VII

* One farmer did not reply.

For procurement of the irrigation system, 67 per cent farmers availed the benefit of subsidy. Among the respondents, about 53 per cent of them procured the system through bank

loan. This is interesting to note that about 33 to 47 per cent farmers have installed the system without taking advantage of either subsidy or bank loan (Table 2).

Table 2: Distribution of farmers based on availing subsidy and bank loan

N=43

SN	Parameters	Category	No. of farmers	%
1.	**Subsidy**	Yes	29	67
		No	14	33
2.	**Bank loan**	Yes	23	53
		No	20	47

In order to understand the benefits of the system, farmers were specifically asked about improvement in quality of produce, early maturity and getting premium prices. The response in this regard by the farmers was positive as 44, 5 and 44 per cent of them realized the benefit of improvement in quality, early maturity and premium price, respectively, due to adoption of drip/sprinkler system (Table 3).

Table 3: Distribution of farmers based on the quality improvement, maturity and premium price realized by the farmers

N=43

SN	Parameters	Category	No. of farmers	%
1.	**Quality improvement**	Yes	19	44
		No	2	5
		Not replied	22	51
2.	**Early maturity**	Yes	2	5
		No	15	35
		Not replied	26	60
3.	**Premium price**	Yes	19	44
		No	1	2
		Not replied	23	53

It is apparent from the above information that majority of the drip and sprinkler owners felt that saving in water was 50 -75 %. While 67 per cent farmers said that labour saving was in between 50 and 75 % in drip. In sprinkler, 38 per cent of the farmers were of the opinion that labour saving was less than 50 % (Table 4).

Table 4: Water and labour saving experienced by the potato growers of North Gujarat

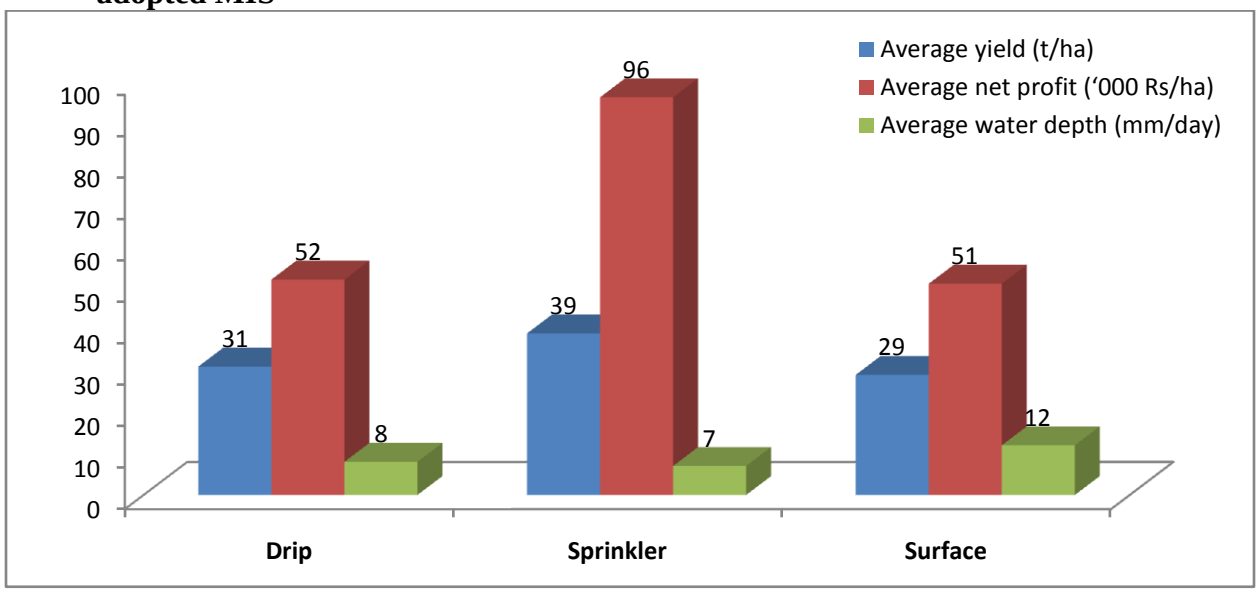
N = 43

SN	Parameters	Category	Drip (N = 6)		Sprinkler (N = 37)	
			No. of farmers	%	No. of farmers	%
1.	**Water saving**	75 %	0	0	0	0
		50 – 75 %	6	100	27	73
		< 50 %	0	0	7	19
		Not replied	0	0	3	8
2.	**Labour saving**	75 %	0	0	1	3

		50 – 75 %	4	67	5	13
		< 50 %	2	33	14	38
		Not replied	0	0	17	46

At the time of survey, majority of the farmers have adopted sprinkler in this area since 2006-07. Most of the sprinkler owners were growing potato with sprinkler first time indicate that farmers are not fully aware about the use of MIS. The data presented in Fig. 3 were collected from few selected farmers growing potato. These values clearly indicate the increase in yield with drip and more so with sprinkler method of irrigation as compared to control. Though, farmers have adopted MIS, yet the volume of water applied is on higher side (20-30 %). These suggest there is a need to educate farmers about schedule of MIS so as to derive desired benefits of the system.

Fig. 3: Average yield, net profit and water applied by potato growers of North Gujarat adopted MIS



Suggestions and opinion of the farmers:

Some of the important suggestions/indications given by the farmers' which may be considered before taking any policy decision(s) are given below.

- Sprinkler system is cheaper than drip system.
- Wilt problem in later stage of the crop is less under drip than sprinkler and flood methods of irrigation.
- Sprinkler system is more suitable than drip system for farmers following potato–groundnut cropping sequence.
- Drip system is tedious in handling as compared to sprinkler system.

Overall Impact:

Navsari centre has developed/ standardized crop specific drip and sprinkler method of irrigation along with fertigation schedule and mulching in some crops. In crops like sugarcane, banana, vegetable crops, castor *(rabi) etc;* the system cost was reduced by changing the planting

geometry from normal to paired row planting. The results of drip alone or drip + mulch or mulch alone in major crops of the state have shown that water saving to the tune of 9 to 54 per cent can be achieved along with increase in yield by about 17 to 60 per cent. The beneficial effects of drip alone are further magnified in presence of mulch and more so if fertigation is also adopted. Similar beneficial effects of these technologies in different crops were also achieved on farmers' fields as evident from the results of large scale demonstrations.

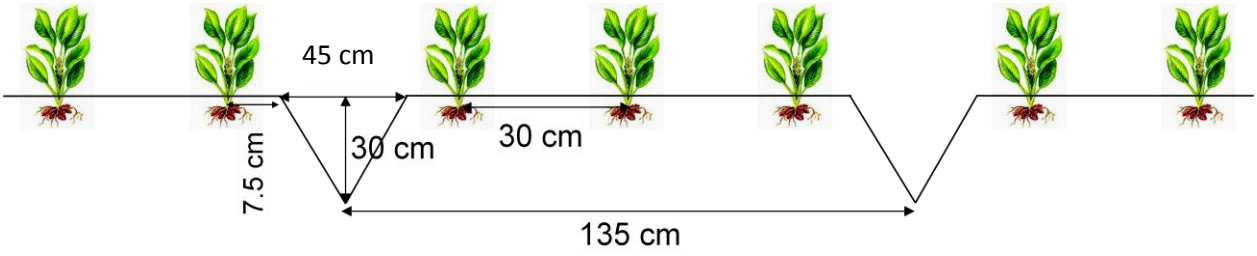
Technology	**Crops covered**	**Area coverage(ha)**	**Remarks**
Micro irrigation system including fertigation and mulching	Sugarcane, papaya, vegetable and flower crops, mango, castor(*rabi*) *etc.*	In Gujarat about **13 lakh ha** area is covered under pressurized methods (drip and sprinkler) of irrigation.	This centre is actively associated *(technical back up, trainers' training, tribal youth training etc.)* with GGRC, Baroda which is main implementing agency for bringing more area under pressurized methods of irrigation.
Pressurized methods of irrigation in canal command	Sugarcane, banana, papaya *etc.*	By - Mohini *piyat mandali :* 152 ha (Surat district)	The canal water is stored in common pond (6 – 8 acre) and used jointly through drip system by the farmers. Fisheries activity is also initiated for multiple uses of water.

Technology for Enhancing the Productivity of Turmeric (*Curcuma longa L.*) in South Gujarat

Turmeric being a high value crop, the area under this crop is increasing gradually in Gujarat. The high clay containing soils coupled with high rainfall in South Gujarat required appropriate land configuration to remove excess rain water during monsoon. Similarly, turmeric being rhizome crop there is need to precise application of irrigation water. So far our irrigation project, AICRP on Irrigation Water management, Navsari centre has developed technologies on soil and water management aspect for achieving quality and higher turmeric rhizome yield.

Soil Management:

In black clay soils of South Gujarat the crop should be sown (three rows: 30 x 20 cm spacing) on raised bed- prepared by opening 90 cm top width followed by 45 cm wide and 30 cm deep furrow as follows.



Schematic of raised bed

The crop should be applied Bio-compost @ 25 t/ha(in addition to RDF) as soil conditioner at the time of land preparation and plant three (3) rows of turmeric on raised bed.

Irrigation and fertilizer management:

Irrigation:

The turmeric crop should be irrigated at 0.6 PEF through drip irrigation system laying one lateral per three rows (i.e. one lateral on each bed). The detail of drip system given below:

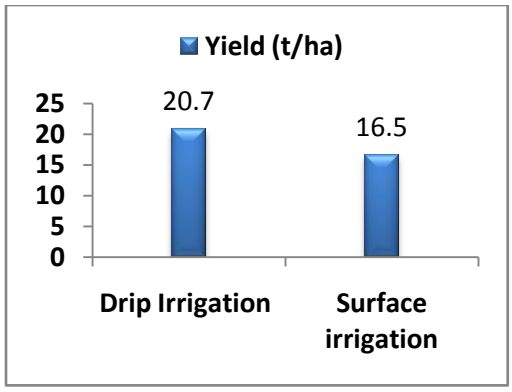
System Details:

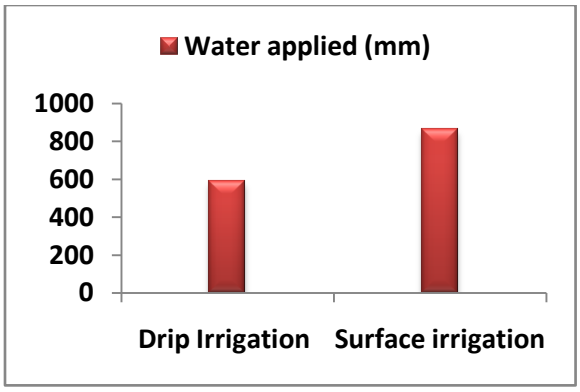
SN	Particulrs		
1	Lateral spacing	:	1.35 m
2	Dripper spacing	:	1.00 m
3	Dripper discharge	:	8 lph
4	Operating pressure	:	1.2 kg/cm^2
5	Operating frequency	:	Alternate days
6	Operating time	:	September to December: 45 to 60 minutes
			January to march: 50 to 75 minutes

Fertilizer:

Apply only 80 per cent of recommended fertilizer dose (60:60:60 NPK kg/ha). Among them full dose of phosphorus and half dose of Nitrogen and potash should be applied at the time of planting. The remaining 50 per cent of Nitrogen and potash is in nine (9) equal splits through drip fertigation system at an interval of 15 days, starting after cessation of monsoon.

Drip system layout in Turmeric crop





Turmeric Rhizomes and Plant

By adopting of such technology farmers can realize 36 per cent higher net income and 25 per cent higher yield along with 32 per cent water and 20 per cent fertilizer saving.

Shadow crop:

Initially crop required shadow for the germination of rhizomes, for this purpose sun hemp should be sown as nurse crop to prevent heat injury during initial growth stage. After attaining proper plant stand of turmeric (40 to 45 days after sowing), the nurse crop should be uprooted and mulch between the rows of turmeric.

Irrigation Water Use Efficiency and Economics:

Irrigation Water Use Efficiency and Economics (IWUE) recorded during field experiments under drip irrigation system was 35.2 kg/ha-mm and was 19.2 kg/ha-mm under flood method of irrigation. The fixed and variable cost of turmeric production under drip irrigation is about Rs.1.47 lakh/ha and Rs.1.33 lakh/ha under flood method. The net income of Rs.2.66 and 1.91 lakh/ha can be realized by following drip and flood methods of irrigation in turmeric, respectively. This suggests the investment on drip system can be recovered at the end of first year. Looking to the higher IWUE and highly remunerative crop, area under turmeric is increasing that to under drip system of irrigation in Gujarat.

Turmeric cultivation is normally preferred in medium to light texture soil as it is congenial for its rhizome development in soil. In Gujarat, area under turmeric cultivation has

increased from 1936 hectares in 2009-10 to 2975 hectares in 2013-14. Accordingly, turmeric production in Gujarat is almost double to 50,493 tonnes in 2013-14 as against 28,468 tonnes in 2009-10. In Gujarat, the major turmeric producing districts are Bhavnagar, Rajkot, Amreli, Junagadh, Navsari, Valsad and Jamnagar contributing about 84 per cent of the total area in the state. The state average productivity of turmeric is 12.20 t/ha as compared to productivity of 15.11 t/ha at national level.

In South Gujarat, heavy clay soils are encountered, where paddy (kharif) -paddy (summer), paddy – sugarcane and sugarcane - sugarcane sequences are generally followed. Due to puddling in paddy, the physical conditions of soil are adversely affected. Turmeric crop is well adapted to climate of South Gujarat the only limitations are the stagnation of water during heavy rain. Under such condition, growing of turmeric crop can only be possible by adopting land configuration. Whereas, adoption of drip method of irrigation, also resulted into saving of irrigation water and fertilizer.