

Soil and Water Management Research Unit, NAU, Navsari

Plan Project:

SN			
1	Name of the scheme	:	Strengthening of Existing Department of Soil and Water Management
2	B.H.	:	12866
3	Objectives/Target of the Scheme	:	<ul style="list-style-type: none"> - To impart training at post graduate level in the fields of soil and water management (SWM) - To impart suitable short term in-service training and conduct refresher courses in the fields of SWM - To initiate and conduct fundamental research in the fields of soil-water-plant relationship, irrigation and drainage, soil water pollution <i>etc</i> and to give proper support to the applied research

SN			
1	Name of the scheme	:	Centre of excellence of soil and water management technology
2	B.H.	:	12908
3	Objectives/Target of the Scheme	:	<p>The broad objectives of the scheme :</p> <ol style="list-style-type: none"> 1. Intensification and expansion of existing soil and water management research to suit different AES of South Gujarat. 2. To initiate research on newer aspects of soil and water management in canal irrigated and rainfed areas 3. Testing improved technologies in farmer's fields.

SN			
1	Name of the scheme	:	Research on Land Use Planning at Navsari
2	B.H.	:	12937
3	Objectives/Target of the Scheme	:	<p>The broad objectives of the scheme :</p> <ul style="list-style-type: none"> • Characterisation of soil, water and crops resources • Trend analysis of productivity of existing crops • Identification of crop production related constraints • Technological interventions for enhancing the productivity of existing crops and suggest alternate land use options if any

SN			
1	Name of the scheme	:	Strengthening of soil and water management training centre
2	B.H.	:	12308
3	Objectives/Target of the Scheme	:	<ul style="list-style-type: none"> 1. To impart training to field level workers regarding new aspects of soil and water management 2. To conduct need based training for field functionaries 3. To conduct periodical training for contact farmers 4. To conduct periodical special training for sprinkler and drip users 5. To organize workshop for the master trainers on specific areas of soil and water management technologies 6. To organize group discussion with the farmers, field officers <i>etc.</i> 7. To get feedback information from the participants through survey 8. To publish relevant literature in vernacular language.

SN			
1	Name of the scheme	:	Maximization of the total factor productivity of banana production system through value addition and byproduct utilization
2	B.H.	:	12026
3	Objectives/Target of the Scheme	:	<ul style="list-style-type: none"> -Refine the production technologies to assess the relative superiority of different nutrient management practices -Standardize the technologies for production of organic manure and for its pelleting to facilitate easy and cheaper transport. -Pre and post harvest management of banana fruits to achieve uniform size, colour, ripening and maturity indices -Developed value added products from banana pseudostem, flower, leaves <i>etc.</i> -Processing and packaging of fruits to enhance shelf life -Expedite marketing linkages between banana growers and cooperatives for better price and export opportunities

SN			
1	Name of the scheme	:	Centre of Excellence on precision Farming
2	B.H.	:	12037
3	Objectives/Target of the Scheme	:	<ul style="list-style-type: none"> • Develop precision farming technologies for different crops of South Gujarat • Conduct basic studies related to precision farming • Demonstrate precision farming technologies in farmers' fields on large scale. • Human resource development • Training to the farmers, entrepreneurs, officers and village level workers of government and NGOs .

Non Plan :

Establishment of main irrigation research station (B.H. 5023)

1. Mandates and Objectives:

1. Studies on the water use by the crops.
2. To determine the irrigation requirement of different cereal crops, cash crops, oil seed crops, vegetable crops *etc.*
3. To fix the schedule to irrigation for above crops.
4. To study the different methods especially surface method of irrigation for different crops.
5. To reduce the percolation losses in paddy field, use of different implements for puddling *etc.*
6. To check and study the feasibility of drip and sprinkler irrigation system for cash crops like sugarcane, banana & orchard crops like mango, sapota, papaya *etc.*
7. To study the feasibilities of fertigation in drip & sprinkler irrigation system on different crops.
8. To study the different organic and plastic mulches on different crops.
9. To study the different cropping systems and crop rotations in irrigation farming.

Year of starting: Area irrigation programme letter No. IRR. 1069/15431-6, date 04-05-70.

2. Name of Scheme and B.H.:

National agricultural research project phase-II (9091-1)

Mandates and Objectives:

Strengthening of research in soil and water management with special emphasis on transfer of technology

Year of starting: National agricultural research project phase-2, San. No.GAU/ RES / NARP-2 / 16270-95, Date 18-09-89.

ICAR, Project:

AICRP on Irrigation Water management, Navsari Agricultural University

Year: 2010-11

Name of research Station/Centre : Soil and Water management Research unit, NAU, Navsari

Name of the Scheme/project with B.H.2027 : AICRP on Water management BH.2027

Year of commencement of the project : 1970

Brief Objectives:

1. Effect of various irrigation schedules on the growth and yield of important crops.
2. Efficacy of mulches in reduction of irrigation requirements of crops.
3. Studies on the water use by crops in pure and intercropping system.
4. Studies on the water and fertilizes use by different crops and their interaction.
5. Comparison of different criteria for scheduling irrigation.
6. Studies on crops sequences under constraints of irrigation water.
7. Studies on the contribution of ground water to evapo-transpiration.
8. Effect on different physical and chemical properties of the soils of this region under different levels of irrigation and fertilizers.
9. Long term effect of irrigation and fertilizers on soil properties.
10. Work out the moisture extraction pattern by different crops under different moisture regimes.
11. Study and develop the design criteria of various irrigation methods for efficient use of water.
12. Determination of different sources and their extent of contribution to rise in ground water table.
13. Conjunctive use of surface and underground waters.

Brief Achievement

- Under crop diversification horticultural crops slowly replacing cereals
- Drainage technology gaining popularity in UKC command and more and more affected farmers coming forward for installing CSSD under the technical guidance of this unit.
- Oil palm irrigated through drip at 1.0 PEF ratio recorded significantly higher FFB yield as compared to the remaining treatments.
- Pointed gourd, irrigated through drip @ 0.6 PEF along with black plastic mulching recorded 47 per cent higher fruit yield and 42 per cent more net income and 37 per cent water saving than the surface control without mulch.
- Spider lily do not need ponding of irrigation water. Adoption of drip method of irrigation is also a viable option under the situation of conjunctive use of surface and ground water sources.

- The bulb yield of onion grown on raised bed under drip irrigation was significantly differed due to different levels of fertigation. The treatment receiving sap @ 1500 l/ha along with RDF recorded significantly higher value of bulb yield as compared to no sap application
- Study of effect of rain water harvesting during the year under report, the average EC values were ranging between 1.5 to 2.5 dS/m. It tended to remain higher during February and March, but showed declining trend during monsoon months. While in case of SAR, there was no consistency; in general, it tended to decline with progress of year i.e., January to December. In view of higher EC values (>1.0 dS/m), it is necessary to take precautionary steps if at all this water is to be used for irrigation particularly in high clay containing soils.
- The seed yield of castor grown during rabi season, the drip irrigation can be held up to 40 days after emerging of main spike without adversely affecting the seed yield.

2011-12

- Large scale demonstration of water management technologies in field crops in a pilot area of the Astagam Piyat Mandali situated in Navsari branch command of left bank of UKC on crop diversification and drainage technologies was carried out. Awareness about the significance of OSSD/CSSD has been created among the farmers of the command area as well as line departments of the state.
- Adoption of drainage technologies by the farmers by bearing 100 per cent cost of the system in 110 ha. Sugar cooperatives and Govt. of Gujarat is planning to take up CSSD project on large scale (1000 ha) in waterlogged and salt affected areas of UKC. Along with these MIS demonstrations in hilly areas (tribal areas) of South Gujarat on farmers' fields has been initiated during 2011-12
- Evaluation of methods of irrigation in oil palm, Based on 6 years of experimentation it has been established that drip method of irrigation at 1.0 PEF was found most suitable for getting higher FFB yield as well as net return in oil palm.
- Fertigation with banana pseudostem sap as a liquid fertilizer in onion, Application of sap at the rate of 1500 l/ha or 2000 l/ha through drip along with only 60 or 80 per cent of RDF in onion is more remunerative
- Planting geometry and mulching in watermelon has been conducted. The results shows that the planting geometry (paired row and normal) had no significant effect on fruit yield of watermelon whereas mulching with SPM (silver black plastic mulch) and BPM had pronounced effect on fruit yield. Both these mulches showed positive response on fruit yield of watermelon
- Rain water /canal waste weir water harvesting activity in Navsari Agricultural University campus on quality of ground water and level of water table was monitored for 6 years. The quality of ground water improved due to water harvesting and the effect was more pronounced in the vicinity of pond.
- Hybrid castor when grown during rabi season under drip method of irrigation in South Gujarat condition attain higher vegetative growth. Therefore, it is necessary to impose water stress during the vegetative growth period. experiment results showed that the , water stress imposed for a period of 20 days without mulching and 30 days with mulching starting from 50 per cent emergence of main spike stage of castor crop found beneficial for getting higher

seed yield and net profit.

- Results indicated bed size of 75 cm top width followed by a 60 cm furrow with a 15 to 20 cm depth and three rows of turmeric with 135 cm lateral spacing is most suitable land configuration under South Gujarat conditions.
- Experiment on application of water in different layers of soil in drip irrigated mango orchard is in progress and the growth of mango tree in all the treatments is uniform and no significant difference was observed due to different depth of application.
- The experiment on irrigation and fertilizer levels on yield and quality of sugarbeet was sown in the month of November 2011 and periodical soil, plant sampling and other growth parameters recording is in progress.
- Annatto bixa has not responded to higher regimes of irrigation as well as fertigation of N and K.

2012-13:

- Adoption of drip irrigation and fertigation of (N and K in 8 equal splits at weekly interval) + mulching with black plastic or black/silver mulch) could enhance fruit yield of water melon (summer) by 47% and save water up to 34%.
- Planting of sugarcane (drip irrigation) by pit method (soil with hard pan by keeping spacing of 1.75 m x 1.75 m between two pits recorded significantly higher cane yield (151 t/ha) as compared to paired row planted control (128 t/ha).
- Scheduling of irrigation at 0.8 PEF and mulching with black plastic in pigeon pea (rabi) increased seed yield (1730 kg/ha) by 62 per cent and saved 15 per cent of irrigation water as compared to control.
- In drip irrigated banana, adoption of fertigation twice in a week @ 80% of recommended dose increased fruit yield by 43 per cent over surface irrigation control.
- The seed yield of castor (rabi) was increased by 11% due to fertigation @ 80% recommended dose of fertilizer and inter row spacing of 1.2m as compared to control (paired row planted).
- Installation of piped subsurface drainage in water logged and salt affected fields of the farmers increased sugarcane crop yield by 60 to 105 t/ha along with improvement in soil properties.
- Organized four demonstrations of micro irrigation system with mulching technology in vegetable crop grown by tribal farmers (eastern hilly tract).

2013-14

- **Planting geometry and mulching study in watermelon under drip irrigation**

Growing water melon during summer season in paired row planting (1m x 0.8 m : 3.2 m) and adopt drip irrigation and mulching either black plastic or silver black plastic (50 μ , 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. 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.

- **Study on pit method of planting in sugarcane under drip irrigation**

Adoption of pit method of planting in sugarcane and facilitate to take more number of ratoon crop and it will be more remunerative than paired row planted sugarcane.

2015-16

- **Comparative performance of water soluble and routinely used fertilizer in banana (cv. Grand Naine) under drip irrigation**

For getting higher banana fruit yield, the banana (Grand Naine) to apply 80 per cent of recommended used fertilizers in the form of Urea (522 g/plant) + Orthophosphoric acid (85 ml/plant) + MOP (267 g/plant) through drip system (0.6 PEF) and for getting higher income, also

- **Effect of irrigation and sulphur levels on yields of cluster bean under South Gujarat condition**

Cluster bean during summer season are apply 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.

2016-17

- **Natural resources characterization in relation to banana growing areas of South Constraint based technological interventions**

The soil, water and climate related banana production constraints under South Gujarat conditions are listed in below table. 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 mentioned below.

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	<ul style="list-style-type: none">➤ Deep ploughing once in three years➤ Addition of organic manures like FYM, biocompost, vermicompost <i>etc.</i>➤ Green manuring with dhaincha or sunn 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	<ul style="list-style-type: none">➤ Soil analysis based gypsum application in conjunction with organic manures, green manuring <i>etc.</i>➤ Provide drainage facility➤ Preference to sodicity tolerant variety of banana
3	Low in organic carbon, Fe and in some samples Zn deficient	Poor plant growth and low yield due to inadequate supply of element in question	<ul style="list-style-type: none">➤ Apply recommended doses of fertilizer as per soil test value➤ Soil test based 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	<ul style="list-style-type: none"> ➤ 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)	-----	<ul style="list-style-type: none"> ➤ Change date of planting in such a way that full growth stage of plant comes during monsoon season

- **Survey related to feed back of sub surface drainage (SSD) farmers**

Following important indications have emerged out from the study:

- Majority of farmers have experienced improve of soil productivity, which has reflected in terms of yield, net return
- Most of farmers have adopted for 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 (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.

2017-18

- **Study on pit method of planting in sugarcane under drip irrigation**

Adoption of pit method of planting in sugarcane treatment D₂S₂ (60 cm pit diameter with 1.75 x 1.75 m pit spacing) which was followed by D₁S₂ (45 cm pit diameter with 1.75 x 1.75 m pit spacing). Per cent increase in net profit over plant crop was positive up to three ratoon crops. Whereas it was positive only up to two ratoon crops in case of paired row planting.

- **Effect of water application in different layers of soil on growth and yield of drip irrigated young mango plantation**

For achieving higher net profit from 8 to 9 years old mango plantation, irrigation water can be applied through drip irrigation system directly in four vertically inserted HDPE/PVC pipe (75 mm diameter) into the soil at 40 cm depth below ground level on all the four sides around 1.5 m away from mango trunk through spaghetti tube (4 mm diameter) fitted on online dripper.

- **Feasibility of drip irrigation in summer rice**

The summer rice grain yield, total water applied and economics indicated, 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 system, it can adopt at 60 cm lateral spacing for getting higher water productivity and 41 % saving of water as compared to surface irrigation.

Staff position as on end of August-2018

SN	Sanctioned post	No. of posts	Name of incumbent	Field of specialization	Remarks
1	Chief Scientist	1	Dr. V. P. Usdadiya	Agronomy	In Charge, CS
2	Jr. Agronomist	1	Prof. R. B. Patel	Agronomy	-
3	Sr. Clerk	1	Mrs. B. M. Ahir	-	-
4	Lab Tech..	1	-	-	Vacant
5	Field Assist.	4	P. B. Patel	-	-
6	Field Assist.		M. R. Parmar	-	-
7	Messenger	1	R. M. Naika	-	-

Other Agency:**Title: Precision Farming Development Centre****PFDC mandates (B.H. 18009-84/85)**

Precision Farming Development Centre, NAU, Navsari was established during 1988-89.

- To undertake trials and experiments on plasticulture applications for the development of crop specific plasticulture technologies.
- To provide technical input to the State Govt. in implementation of Micro Irrigation and National Horticultural Mission & related schemes.
- To demonstrate proven plasticulture technologies at PFDC and farmers' fields.
- To transfer technologies through training & awareness programs, participation in agricultural related events and print & satellite media.
- To develop literatures on plasticulture applications & precision farming, package of practices and other extension material, etc.
- To establish display centre for depicting plasticulture technologies, system components, audio & visual units, literatures and related information.
- Survey of end users for impact evaluation and feedback.

Key achievements since inceptions of PFDC

SN	Aspect	No. of technologies
1	Drip	24
2	Fertigation	8
3	Drip + Mulch	15
4	Sprinkler	7
5	Minisprinkler	4
6	Mulch alone	15
7	Green house	7
8	Net house	2
8	Low tunnel	2
9	Drainage	1
10	Survey	10
	Total	95

Recommendations since inception of PFDC, NAU, Navsari

SN	Year	Title	Recommendation
A. Drip			
1	1993-1999	Study on drip irrigation in <i>ber</i>	<p>In the established <i>ber</i> orchard (3 to 4 years) of North Gujarat zone, the farmers should give 4 to 6 irrigations after cessation of monsoon (0.4 IW/CPE, 60 mm depth) for getting 14 % more yield and 7 % more net income over rainfed.</p> <p>Farmers who can afford drip technology should give 60 to 70 liters / tree on alternate days(0.4 PEF) to get 17 % more yield and 163 % additional income over the additional net income obtained under surface method.</p>
2	1994-2003	Study on drip irrigation system in mango	<p>The farmers of North Gujarat agro-climatic zone (AES-I), growing mango Rajapuri are advised to adopt drip system to irrigate their new mango plantation for better growth and earliness in fruiting.</p> <p>The system should be laid out with two drippers (8 lph) spaced at 30 cm from the trunk of tree during first two years, four drippers at 60 cm distance for 3 to 5 year and 5 dippers at 90 cm distance for 6 to 8 year.</p> <p>Under ample water availability conditions, the system should be operated as per the as per scheduled given below on alternate day with at 1.2 kg/cm² pressure.</p> <p>Under scarce water availability conditions farmers are advised to irrigate their crop through drip @ 0.6 PEF for getting similar fruit yield and net profit as that of surface irrigation with a saving of the water to the extent of 21 per cent. The system should be operated as per the schedule given below on alternate day at 1.2 kg.cm² pressure.</p>
3	1996-1999	Comparative study of different micro irrigation systems for vegetable	<p>The farmers of South Gujarat heavy rainfall zone are advised to adopt typhoon irrigation method of micro irrigation for cluster bean. Typhoon method should be scheduled at 60 % fraction of pan evaporation which gave</p>

		crops (cluster bean)	<p>about 25 % more yield with about 33 % saving of irrigation water over surface method of irrigation and with this, an additional 0.5 ha area can be brought under irrigation. Further, the net income can be increased by about 35%.</p> <p>The system should be laid out as one lateral with 60 cm spacing of inline dripper between crop pair row of 45 cm distance and operated for 3 to 3.5 hrs during March to May on alternate day at pressure of 1.2 kg/ cm² with a discharge rate of 2 LPH.</p>
4	1997-2000	Irrigation and intercrops management in banana	<p>The banana (Basarai) growing farmers of South Gujarat heavy rain fall zone are advised to adopt drip irrigation system for their banana planted at 1.5 x 1.5 m spacing along with bottle gourd as intercrop for water saving of 27 % and increase in net income by 35 % as compared to surface method of irrigation.</p> <p>The intercrop should be sown 50 cm away from banana plant on either side. The system should be laid out with 2 drippers (one on either side of the plant) of 4 LPH capacity placed 30 away from plant on either side and lateral should be placed at a spacing of 1.5 m.</p> <p>The system should be operated on alternate days for 1 hrs and 45 minutes during winter and 2 hrs and 45 minutes during summer season at 1.2 kg/ cm² pressure.</p>
5	1998-2000	Study on drip irrigation in banana	<p>The farmers of South Gujarat zone are advised to adopt drip system of irrigation with planting geometry of 1.5 x 1.5 m for banana crop. Drip method of irrigation gave 14 % more fruit yield than surface method with water saving of 48 %.</p> <p>The system should be laid out at 150 cm lateral spacing. Dripper having discharge of 4 LPH should placed at 45 cm away on either side of the plant and operated at a pressure of 1.2 kg/cm² on alternate day for 60 min. during October to January, 110 to 130 min. during February and March and 180 min. during April, May and June.</p>

6	1998-2000	Drip irrigation in okra	<p>The farmers of North Gujarat zone growing okra during summer are advised to give 16 irrigations (0.8 IW/CPE, D= 50 mm) at weekly interval.</p> <p>Under the constraint of irrigation water, they are advised to adopt drip irrigation to save 45 % water and bring about 0.8 additional hectare under irrigation with this crop.</p> <p>In the paired row (30 x 25 x 60 cm) sown crop, the system should be laid out at a lateral distance of 90 cm (middle of paired row) with dripper discharge of 4 LPH along with 50 cm dripper distance and operated at 1.2 kg/cm² pressure for 70 min. during February – March and 85 min. during April – May on alternate day.</p>
7	1999-2000	Performance evaluation of tuberose under drip irrigation system	<p>Farmers of South Gujarat heavy rain fall zone cultivating tune rose are advised to adopt drip irrigation (0.8 PEF) to get about 42 % more yield and 45 % more income.</p> <p>The system should be operated for about 50 min. during October to February and 85 min subsequently till the onset of monsoon.</p> <p>Under irrigation water constraint, they should operate the system for about 35 min. during October to February and 55 min. subsequently) to get about 30 % more yield, 24 % water saving and 27 % more income.</p>
8	2001-2002	Low cost drip technology for kitchen garden and hilly area	<p>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 m² area using 35 litre of water per day for realizing a net profit of about Rs. 300 to 350.</p> <p>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.</p> <p>The lateral should be placed in between two rows and micro tube should be placed at 60 cm apart <i>i.e.</i> each micro tube (1.2mm) cover two plants. The system should be operated on alternate day.</p>

9	2004-2006	Irrigation and planting management in <i>rabi</i> castor	<p>The farmers of AES-III of South Gujarat heavy rainfall zone are advised to grow castor after <i>kharif</i> paddy and apply 8 irrigations (60 mm). Of which the first 4 irrigations should be applied at 20-25 days interval and the remaining 4 at an interval of 12-18 days for getting higher net income.</p> <p>Under the constraint of irrigation water, they are advised to plant their crop in paired row (60 x 60 x 120 cm) and adopt drip method of irrigation to save 39 per cent water, 40 per cent fertilizer.</p> <p>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/cm² pressure for 40 to 60 minutes during November to January and 60 to 100 minutes during February till harvest on alternate days.</p>
10	2007-2008	Large scale testing of precision farming technologies for brinjal on research farm	<p>The farmers of South Gujarat growing brinjal (Variety: Surati ravaiya) are recommended to adopt following package of practices for higher yield (40%) and net profit (44%).</p> <ul style="list-style-type: none"> i) Paired row planting(0.6 x 0.6 x 1.2 m) ii) Drip irrigation schedule: Nov to Jan. 1.5 hr, Feb. to March 2.5 hr and April to June 3.0 hr on alternate days. iii) Fertigation schedule: 80:50:50 NPK kg/ha (<i>i.e.</i> 80% N of RD) of which 16:50:50 NPK kg/ha basal and 64 N kg/ha was applied in 4 equal splits at monthly interval from date of transplanting. iv) Black plastic mulch: 25 μ, 45 % coverage.
11	2014-2016	Intercropping studies in banana under drip irrigation	<p>The farmers of South Gujarat who have adopted drip irrigation in banana are recommended to take onion as intercrop for realizing higher net income. Four rows of onion (<i>i.e.</i> 40 cm) should be planted on both sides of banana row by leaving about 20 cm space on all the sides of stem + 8 rows (80 cm) in between two row of banana or 8 rows (80 cm) of onion only in between two rows of banana. This intercropping system also improves the land use</p>

			<p>efficiency.</p> <p>They are further advised to apply respective recommended doses of fertilizer to both the crops.</p>
12	2014-2016	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.
B. Fertigation			
1	1994-1996	Determination of frequency of application of NPK fertilizer dose for banana crop	<p>The farmers of South Gujarat heavy rainfall zone are advised to adopt fertigation in drip irrigated banana crop.</p> <p>They should apply a total dose of 108 : 54 : 108 g plant NPK / plant in equal seven splits at 20 days interval.</p> <p>They should apply either soluble or liquid fertilizers only. This will result in 40 % fertilizer saving and 35 % reduced irrigation water requirement without any adverse effect on crop growth, yield and quality.</p>
2	1994-1996	Study of nitrogen use efficiency under drip and surface method of irrigation in Potato	<p>The farmers of North Gujarat Agro-climatic zone having light textured soil and having drip irrigation system for irrigating potato crop are advised to apply 220 to 300 kg N/ha according to economical condition of farmers under drip irrigation system for higher potato tuber yield. Half dose of nitrogen should be applied as basal and remaining half dose in four equal splits at an interval of 7 days after 30 days of planting.</p> <p>The farmers are advised to operate drip system for 45 minutes during December to January and 68 minutes Feb to March at alternate days</p>
3	1994-1996	Fertigation and planting studies in tomato	<p>The farmers of South Gujarat heavy rainfall zone are advised to adopt drip fertigation in hy. Tomato (Cv. Avinash-2) grown during late <i>rabi</i> season for 23 % water saving and 33 % increase in yield over surface method of irrigation.</p> <p>Drip fertigated hybrid tomato should be planted in paired row pattern (50 x 50 x 150 cm) and fertigated with</p>

			<p>60 % of RDF of fertilizer <i>i.e.</i> 150-75-75 N, P₂O₅ and K₂O kg/ha instead of the 250-125-125 N, P₂O₅ and K₂O kg/ha as soil application for maximization.</p> <p>But under constraints of fertilizer availability, a dose of 100-50-50 N, P₂O₅ and K₂O kg/ha can be adopted to get more yield than traditional fertilizer practices. The fertigation should be done at weekly interval. For P it was 4 splits and for N and K it was 12 splits.</p>
4	1998-2000	Study on fertigation in papaya	<p>For remunerative cultivation of papaya var. Madhubindu under South Saurashtra zone conditions, farmers are recommended to apply 160 g N + 160 g P₂O₅ + 200 g K₂O / plant in 8 equal splits starting from 45 days after transplanting and subsequently at 20 days interval through drip.</p> <p>The system should be operated for 3 hrs daily during October to February and 5 hrs from March onwards with 1 dripper of 8 LPH (1.2 kg/ cm²), keeping dripper 20 cm away from the base of papaya plant for getting maximum net income.</p>
5	1999-2000	Fertigation study in chillies	<p>Farmers of South Gujarat heavy rain fall zone cultivating chillies with micro irrigation are advised to apply only 80 % of recommended dose of NPK as soluble fertilizer in 6 splits at an interval of 20 days.</p> <p>In the case of shortage of fertilizer, they can save 40 % of the RDF without getting any significant reduction in the yield.</p>
6	2000-2003	Fertigation study in brinjal	<p>The farmers of North Gujarat agro climatic zone (AES-I) growing brinjal (BSR-1) in paired row (50 x 75 x 100 cm) are advised to irrigate their crop through drip at 0.8 PEF and apply fertilizers @ 100 kgN/ha as fertigation for obtaining higher fruit yield (27 %), net profit (25 %) and water saving (8 %) as compared to surface method. Recommended dose of P₂O₅ and K₂O (50 kg/ha) along with 20 % of N (20 kg N/ha) should be applied as basal and remaining 80 % N (80 kg/N/ha) should be applied in four equal splits at monthly interval through drip commencing from 30 days after</p>

			<p>transplanting.</p> <p>They should place lateral at 150 cm and dripper (4 LPH) at 75 cm apart. The system should be operated at 1.2 kg/cm² pressure for 180 minutes during September to October, 140 minutes November to February and 220 minutes till harvesting on alternate days. Under scarce waters availability conditions, they are advised to irrigate the crop through drip @ 0.4 PEF with 100 % RDN for getting more or less similar fruit yield and net profit as compared to control <i>i.e.</i> surface irrigation, with a water saving 45 per cent.</p>
7	2000-2003	Effect of fertigation in potato through drip irrigation system.	<p>The farmers growing potato in sandy loam soils of middle Gujarat agro climatic zone are advised to adopt drip system for getting 29 per cent higher tuber yield with a saving of 43.3 per cent of water. The crop should be fertilized @ 60 per cent (180 kg N / ha of recommended dose of nitrogen.</p> <p>They should apply 25 per cent of the total nitrogen as basal and remaining 75 per cent through fertigation in 4 equal splits at 10 days interval through drip.</p> <p>The fertigation should be started after days 40 of planting. The system should be laid out at a lateral spacing of 90 cm (middle of two crop rows) with 4 LPH discharge dripper placed at a distance of 45 cm(six plants per dripper) and operated at 1.2 kg / cm² pressure for about 50 minutes on alternate days.</p>
8	2001-2003	Effect of drip irrigation and fertigation on yield of brinjal (Cv. Surati ravaiya)	<p>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).</p> <p>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.</p> <p>The system should be operated at 1.2 kg/cm² on alternate day for 1.5 hrs during December to February, 2.5 hrs</p>

			during March and April and 3.0 hrs thereafter up to harvesting.
9	2009-2010	Lateral spacing and fertigation study in sweet corn	<p>The farmers of South Gujarat heavy rainfall zone (AES III) growing sweet corn at a row spacing of 60 cm. during <i>rabi</i> season are advised to adopt drip method of irrigation along with fertigation of N and K @ 100% RDF (120: 60: 60 NPK kg/ha) for getting higher yield and net profit. N and K fertigation should be done in 5 equal splits starting from 30 DAS. Full dose of P should be applied as basal.</p> <p>The system details are:</p> <ul style="list-style-type: none"> • Lateral spacing: 120 cm • Dripper spacing: 100 cm • Dripper discharge: 8 LHP • Operating pressure: 1.20 kg/cm² • Operating time: <ul style="list-style-type: none"> ◆ Dec-Jan 50 min ◆ Feb-March 65 min <p>Operation frequency: Alternate day</p>
10	2010-2011	Study on moisture regimes and fertigation in gladiolus	<p>The farmers of South Gujarat intending to grow gladiolus (cv. <i>Psittacinus Hybrid</i>) during <i>rabi</i> season are advised to adopt paired row planting (20 cm x 20 cm x 60 cm) on raised bed with drip irrigation (0.8 PEF) method (water saving 24 %) along with fertigation of N and K @ 200:100 kg/ha. Fertigation should be done in 10 equal splits at an interval of 7 days starting from 30 DAP. Full dose of P (100 kg/ha) should be applied as basal in addition to common dose of FYM @10 t/ha. By adopting these practices, farmers can get higher yield and net profit as compared to conventional method of irrigation.</p> <p><i>The system details are:</i></p> <p>Lateral spacing: 1.2 m Dripper spacing: 0.6 m Dripper discharge: 3 lph Operating pressure: 1.20 kg/cm² Operating frequency: Alternate day Operating time:</p> <p style="padding-left: 40px;">Nov.: 1.0 hr & 45 mins Dec.: 1.0 hr & 20 mins Jan.: 1.0 hr & 35 mins Feb.: 2.0 hr & 05 mins March: 2 hr & 25 mins</p>

C.		Drip + mulch / fertigation																						
1	1989-1992	Feasibility of drip irrigation for tomato crop with mulches	<p>The farmers of South Gujarat heavy rainfall zone who are growing tomato (Rupali) are advised to irrigate their crop with drip and mulch their crop with either sugarcane trash @ 10 t/ha or black plastic mulch to get 53 and 57 % increase in yield, respectively.</p> <p>With drip alone the yield could be increased by 42 %. Use of drip can result in a saving of water to the tune of 44 % and bring another 0.78 ha under irrigation with the same quantity of water used for surface method. The net income can be increased by 56 % using same quantity of water through drip and 41 % and 85 %, respectively, when they mulch the crop with either plastic (50 micron) or sugarcane trash mulches.</p> <p>The use of drip can reduce weed incidence by about 55 % while drip coupled with either of the mulches can reduce the weed intensity by more than 90 % and the fruit borer attack can be reduced by about 30 %. The drip system layout as one lateral for each dripper serving 2 plants and with the dripper capacity of 4 LPH, the farmers are advised to use the system with the following schedule.</p> <table border="1"> <thead> <tr> <th>Month</th> <th>Drip alone</th> <th>Drip with mulch</th> </tr> </thead> <tbody> <tr> <td>September</td> <td>6.00</td> <td>3.00</td> </tr> <tr> <td>October</td> <td>7.00</td> <td>3.50</td> </tr> <tr> <td>November</td> <td>6.00</td> <td>3.00</td> </tr> <tr> <td>December</td> <td>5.50</td> <td>2.75</td> </tr> <tr> <td>January</td> <td>7.00</td> <td>3.50</td> </tr> <tr> <td>February</td> <td>7.50</td> <td>3.75</td> </tr> </tbody> </table>	Month	Drip alone	Drip with mulch	September	6.00	3.00	October	7.00	3.50	November	6.00	3.00	December	5.50	2.75	January	7.00	3.50	February	7.50	3.75
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2	1990-1993	Nitrogen management in banana under drip method with mulching	<p>The banana growing farmers of South Gujarat heavy rainfall zone adopting drip irrigation alongwith sugarcane trash mulch need to apply only 72 g of N per plant instead of the recommended does of 180 g. Thus they can save 60 % of nitrogen fertilizer in addition to 30 % saving in water and 60 to 90 % reduction in weed infestation. By fertigating their crop with more than 72 g/tree, they can get additional return ranging from 10 to 19 % at different levels of recommended dose up to 180 g/ plant. (Yield 54.19 t/ha)</p>																					

3	1990-1993	Effect of plant spacing and mulches on banana yield under drip method with mulching	<p>The farmers of South Gujarat heavy rainfall zone growing banana are advised to adopt the geometry of 1.5 x 1.5 m with drip irrigation and mulch it with sugarcane trash @ 10 t/ha. This will result in 30 % saving in water. Further farmers can harvest about 60 % more yield and have 55 % more income than that obtained with 1.8 x 1.8 m spacing with surface irrigation or, 24 % more yield and 24 % more income as compared to 1.5 x 1.5 m spacing with surface method of irrigation.</p> <p>Where there is scarcity of sugarcane trash mulch, they can mulch with black plastic (50 micron) with 4 lph two drippers at 30 cm on either side of the plant.</p> <p>They should operate the system for 1.6 to 2.0 hours during winter and 2.5 to 2.75 hours during summer months on alternate days.</p>
4	1992-1995	Effect of mulching and microirrigation on chillies	<p>The farmers of South Gujarat heavy rainfall zone are advised to grow chillies under drip along with green plastic (50 micron) mulch to get about 15 % more yield and 16 % more income per hectare. But for the use of same quantity of water used as in surface method (660mm), the net extra income will be 58 %.</p> <p>In the case of non availability of green plastic, they should mulch the crop with sugarcane trash @ 10 t/ha.</p>
5	1994-1996	Economic feasibility of drip irrigation and plastic mulch in chillies	<p>The farmers of middle Gujarat zone are advised to grow chillies (Var. Jwala) in double paired row system (45 x 45 x 75 x 75) and adopt drip irrigation method with black plastic mulch (50 micron) and apply N @ 125 kg/ha as fertigation to get 47 % higher yield and 20,000 more net income over surface method.</p> <p>The nitrogen should be applied in 12 equal splits at forth nightly interval (P&K application as basal). The system should be laid at a lateral and dripper spacing of 1.2 m with dripper discharge of 4 LPH and operated at a pressure of 1.0 kg/cm² for 1.5 hrs on alternate day.</p>
6	1995-2000	Irrigation, fertigation and	The farmers of AES-III of South Gujarat heavy rainfall zone cultivating

		mulching studies in rose	<p>rose for cut flowers are advised to adopt paired row planting at 1m x 1m x 2m and irrigate their crop through drip (20% water saving) along with application of 60 : 20 : 20 g NPK/plant only through fertigation (10 days interval during April-May and Oct-Nov.) to increase the yield by 40%.</p> <p>Further, they are also advised to mulch their crop with 50 micron or 100 micron LLDPE BPM (70% coverage) to get about 40% more yield and reduce the weed infestation by 90%.</p> <p>The drip irrigation along with fertigation and BPM increase the net realization by about 70%.</p> <p>The system should be laid at 3.0 m lateral spacing and 1.0 m dripper spacing with 8 LPH dripper and it should be operated for about 2.5 to 3 hrs (9 to 11 l/plant) during winter and 3.5 to 4.5 hrs (13 to 17 l/plant) during summer on alternate days</p>
7	1998-2001	Saline water usage through drip with mulch in brinjal	<p>The farmers of South Gujarat heavy rainfall zone with poor quality under ground water, can grow brinjal with micro irrigation system. Saline water having EC up to 4.0 dS/m can be used through drip irrigation. They are also advised to mulch their crop with 25 micron LLDPE black plastic mulch (60 % coverage) to get about 21 % more yield and 15 % higher profit.</p> <p>The system should be operated for about 1.25 to 1.5 hrs during <i>rabi</i> and 1.5 to 2.0 hrs during summer on alternate days using 4LPH capacity dripper.</p> <p>The salinity built up during crop season gets washed away / diluted during the subsequent heavy monsoon.</p>
8	1998-2000	Effect of drip with mulch on yield of okra	<p>The farmers of South Gujarat heavy rain fall zone growing okra (GOH 1) are advised to adopt drip irrigation system to get 12 % increase in yield and 49 % saving in water over flood irrigation. The crop should be planted in paired row at 30 x 90 x 30 cm.</p> <p>The system should be laid out at the lateral spacing of 1.2 m with a dripper spacing of 60 cm with dripper discharge rate of 4 LPH and operated on alternate</p>

			<p>day for 26 minutes during crop growth period at 1.2 kg/cm² pressure.</p> <p>Mulching the crop with black plastic (50 micron) can result in 46 % increase in yield with drip and 25 % without drip which correspondingly results in 26 % and 17 % increase in additional net income.</p>
9	2000-2003	Study on drip with mulch in potato	<p>The farmers of North Gujarat agro-climatic zone (AES-I) adoption drip irrigation in potato are advised to follow paired row planting (30 x 60 cm) for securing 17 per cent higher yield and Rs..65922/ha net profit as compared to drip line in every row (45 cm). Use of black plastic mulch (50 micron) was not found beneficial in drip irrigated potato.</p> <p>The lateral should be placed at 90 cm by keeping dripper (8 LPH) at 50 cm spacing. The system should be operated at 1.2 kg/cm² for 25 to 30 minutes during November to February and 35 to 40 minutes during March onward on alternate days.</p>
10	2000-2001	Evaluation of drip and mulch for bitter gourd	<p>The farmers of South Gujarat heavy rain fall zone growing bitter gourd as summer crop are advised to adopt the practice of mulching with black plastic for getting 18 % more yield and net return.</p> <p>Under constraint of irrigation water, they are advised to adopt drip along with mulching for getting 40 % saving in 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 2.0 m (middle of pair row) with 8 LPH discharge dripper in the middle of 4 plants and operated at 1.2 kg/cm² pressure for 100 min. on alternate day.</p>

11	2000-2003	Effect of drip and mulching on yield of castor.	<p>Under the enough water availability situation, farmers of AES-I of North Gujarat agro-climatic zone growing castor crop are advised, to adopt paired row sowing (45 cm x 135 cm x 60 cm)and irrigate through drip at 1.2PEF.</p> <p>They should fertilize their crop @ 200 kg N/ ha for obtaining maximum yield and net profit. Full dose of P₂O₅ (50 kg ha⁻¹) and 30 kg N/ ha should be applied as basal and remaining 170 kg N/ ha should be applied in five equal splits at monthly interval starting from October through drip as fertigation.</p> <p>The system should be laid out at 180 cm lateral line distance and 60 cm dripper distance with dripper discharge of 8 lph. The system should be operated at 1.2 kg/cm² pressure for 125 minutes during October, 105 minutes during November and February, 80 minute during December-January, 160 minutes during March and 200 minutes till harvesting on alternate day.</p>
12	2003-2005	Irrigation management in smooth gourd	<p>The farmers of AES-III of South Gujarat heavy rainfall zone growing smooth gourd as <i>rabi</i>-summer crop are advised to mulch their crop with sugarcane trash @ 2.5 t/ha for getting 23 and 18 per cent more yield and net return, respectively than unmulched control.</p> <p>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.</p> <p>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.</p>
13	2009-2010	Drip and mulching studies in papaya under South Gujarat conditions	<p>The farmers of South Gujarat growing papaya are recommended to adopt following package of practices for higher fruit yield and net profit .</p> <ol style="list-style-type: none"> i. Planting (2.5 m x 2.5 m) ii. Drip irrigation schedule alternat

		farm	<p>day Winter:20-30lit/plant Summer:30-50lit/plant The system details are:</p> <ul style="list-style-type: none"> • Lateral spacing: 2.5 m • Dripper spacing: 30 cm away on either side of stem • Dripper discharge: 8 LPH • Operating pressure: 1.20 kg/cm² <p>iii. Fertigation schedule : (200:200:250 g/plant) N as urea and K as muriate of potash in 14 equal splits at an interval of 15 days starting from 30 days after planting. The whole amount of P should be applied in the form of single super phosphate as basal.</p> <p>iv. Black plastic mulch: 50 micron, 20 % coverage</p> <p>Adoption of this package of practices also saves 40 % water.</p>
14	2010-2011	Large scale testing of improved package of practices for sugarcane on research farm as well as on farmers' fields	<p>Adoption of improved practices (paired row, irrigation @ 0.6 PEF, fertigation of N & K) could enhance sugarcane productivity by 16 to 20 per cent along with saving in water as well as fertilizer to the tune of 40 %.</p> <p>Apart from increase in cane yield, improvement in quality parameters of sugarcane was also observed with improved practices over conventional practices.</p>
15	2010-2011	Pilot scale testing of improved package of practices for banana on research farm and farmers' fields	<p>Adoption of improved practices (irrigation @ 0.6 PEF, fertigation 60 % of RD N & K and mulching @ 42 – 67 %) in banana could enhance banana productivity by 13 to 21 per cent along with saving in water as well as fertilizer. This ultimately improves the net realization of banana cultivation by about 25 %.</p> <p>Banana fruit yield can be predicted precisely well in advance using lower girth at the age of six month or by using length of bunch, number of hands per bunch and number of fingers per bunch. This will help the farmers or co-operative in planning the sound marketing strategy well in advance.</p>
16	2015 - 2017	Study on combined effect of irrigation, fertigation and mulching levels on fruit yield and	<p>The farmers of South Gujarat heavy rainfall zone growing summer water melon are recommended to apply irrigation through drip system at 0.6 PEF, fertilize the crop at 150:75:75 kg NPK/ha and mulch with silver black plastic sheet (25 micron and 50 %</p>

		quality of water melon	<p>covering) for achieving higher yield and net return. By adopting these practices, saving of 38 % water, 80 % weed control and obtain good quality fruits.</p> <p>Drip detail:</p> <p>Lateral spacing: 2 m Dripper spacing: 1 m Dripper discharge: 8 lph Operating pressure: 1.20 kg/cm² System operating schedule: Alternate day Stages wise water application and system operating time:</p> <table border="1"> <thead> <tr> <th>Plant growth stage</th> <th>Water application (l/ plant)</th> <th>System operating time</th> </tr> </thead> <tbody> <tr> <td>Vegetative</td> <td>2.25</td> <td>20 min.</td> </tr> <tr> <td>Flowering</td> <td>2.25 - 8.25</td> <td>20 min.to 2 hrs</td> </tr> <tr> <td>Fruit setting</td> <td>8.25 - 18.00</td> <td>1 hr to 2 hts 15 min.</td> </tr> <tr> <td>Maturity</td> <td>18.00 - 15.50</td> <td>1 hr 55 min. to 2 hts 15 min.</td> </tr> </tbody> </table> <p>Fertigation schedule:</p> <p>Full dose of P₂O₅ and 10 % of N and K₂O applied as basal and remaining N and K through drip system in eight equal splits at weekly interval starting from 15 days after germination.</p>	Plant growth stage	Water application (l/ plant)	System operating time	Vegetative	2.25	20 min.	Flowering	2.25 - 8.25	20 min.to 2 hrs	Fruit setting	8.25 - 18.00	1 hr to 2 hts 15 min.	Maturity	18.00 - 15.50	1 hr 55 min. to 2 hts 15 min.
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D. Sprinkler																		
1	1988-1990	Studies on sprinkler vs surface in fenugreek	<p>The farmers of North Gujarat zone are advised to irrigate their fenugreek through sprinkler instead of surface method to have about 200 to 240 % more returns.</p> <p>When water is most limiting and land is not limiting, they are advised to irrigate their crop through sprinkler on the day of sowing and subsequently 22nd, 49th, 65th and 95th days after sowing. This will result in about 60 % saving in irrigation water.</p> <p>The system should be laid out at 12 m x 12 m grid and operated at 2.75 kg/cm² with an application rate of 17 mm/hr.</p> <p>Under the conditions where water is not very much limiting, they are advised to irrigate their crop on the day of sowing and subsequently on 22nd, 29th, 54th, 70th, 83rd and 96th days after sowing. This will result in about 29 % saving in irrigation water and 35 % increases in yield.</p>															

2	1988-1991	Studies on sprinkler vs surface method of irrigation in potato	<p>The farmers of North Gujarat zone are advised to adopt sprinkler method instead of surface method for their potato crop. By this, they will get an additional return of about 6 thousand rupees per hectare and also save about 46 % of irrigation water. With the use of saved water for the same crop through sprinkler an additional area of about 0.86 ha can be brought under irrigation which will result in about 23 thousand rupees additional income over surface method for the same quantity of water used.</p> <p>The crop should be irrigated on the day of planting and 8 days later, subsequently the crop need irrigation at 12 – 14 days interval till February and weekly interval during March. The system should be laid out at 12 m x 12 m grid and operated at 2.75 kg/cm² with an application rate of 17 mm/hr.</p>
3	1988-1991	Study on sprinkler method of irrigation for cabbage	<p>The farmers of South Gujarat heavy rainfall zone are advised to irrigate the cabbage crops through sprinkler method. When irrigation water is not a problem they may irrigate their crop with sprinkler at an interval of 11-14 days to supply 5 cm of water at each irrigation. This will result in about 7300 Rs. Extra income over surface method of irrigation. In the years constraint of irrigation water, they may irrigate their crop through sprinkler about 15-20 days interval so that they can bring almost one more hectare under irrigation and get about 40,000 rupees more income than surface method of irrigation.</p> <p>The sprinkler and laterals may be laid at 12 x 12 m grid and operated at 2.75 kg/cm² with an application rate about 1.7 cm/hr</p>
4	1990-1992	Study on sprinkler method of irrigation in cowpea.	<p>The farmers of South Gujarat Heavy Rainfall Zone who are cultivating summer cowpea are advised to irrigate their crop through sprinkler instead of surface method to get about Rs. 1300 more income from one hectare and save about 19 % irrigation water.</p> <p>They should operate the sprinkler at 9 to 10 days interval up to March and 7 to 8 days interval during April and</p>

			<p>May. Every time they should operate the sprinkler of 1.67 cm/Hr capacity for about 3 hours. The system should be laid out at 12 m x 12 m grid.</p>
5	1992-1995	Study on sprinkler vs surface method of irrigation for cauliflower.	<p>The farmers of South Gujarat heavy rainfall zone cultivating cauliflower are advised to adopt sprinkler method of irrigation to save about 34 % water and get about 5600 rupees more income per hectare.</p> <p>They should operate the system at 2.5 kg/cm² pressure for 3 hrs to apply 50 mm water. The irrigation should be given at 11-14 days interval.</p>
6	1994-1995	Comparative study of sprinkler vs surface method of irrigation for summer okra	<p>The farmers of South Gujarat heavy rainfall zone growing summer okra are advised to adopt sprinkler irrigation method.</p> <p>Under enough water availability, they should operate the system for 10 hours at 10 days interval to get about 26 % more income per hectare.</p> <p>Under limited water availability condition, the system should be operated for 3 hours at 18 days interval to get about 70 % increase in net return by doubling the area under irrigation over surface method for the same quantity of water used as in surface method.</p> <p>The sprinkler should be spaced at 12 x 12 m and operated at 2.75 kg/cm² pressure to get 17 mm/hr depth of water application.</p>
7	1999-2002	Study on sprinkler vs surface method of irrigation for cabbage	<p>The farmers of middle Gujarat zone growing cabbage (Var. Golden acre) are advised to give 7 irrigations (6+1) through sprinkler (1.0 IW/CPE ratio) to save about 17% of irrigation water and get 10% higher yield .One irrigation of 60 mm depth should be given on the day of planting and the rest of 40 mm depth at 10-12 days interval.</p> <p>The sprinkler system should be laid at 12.0 x 12.0 m spacing and should be operated at 2.75 kg/cm² pressure to achieve 1.67 cm/ha application rate. The set should be operated for about two and half hours per irrigation for achieving a depth of 40 mm.</p>

E.	Minisprinkler		
1	1990-1992	Comparative study of mini sprinkler and surface method of irrigation in onion crop	<p>The farmers of South Gujarat heavy rainfall zone are advised to adopt minisprinkler system of irrigation for their onion crop to get Rs. 6000 more income than surface method of irrigation.</p> <p>The schedule of irrigation should be (1) First at transplanting (ii) three irrigations at 10 to 12 days intervals till middle of February and rest 6 to 7 irrigation at weekly interval.</p> <p>During the years of low water availability and in areas of where irrigation water is a constraint they should apply the rest of the irrigation after transplanting at two weeks interval to save about 31 % water and bring more area under cultivation with the limited water available. (Yield 25 t/ha)</p>
2	1994-1997	Studies on minisprinkler v/s surface method of irrigation for potato crop	<p>The farmers growing potato on the loamy sand soil of North Gujarat zone are advised to adopt minisprinkler method of irrigation to obtained 17 % higher tuber yield and 35 % saving of water over recommended surface method.</p> <p>They should give about 12 irrigations each of 40 mm depth at 8 days interval. The minisprinkler system should be laid out at 3 m x 3 m grid and should be operated at 175 kg/cm (about 5.6 mm/hr application rate) pressure for 7 hrs to apply 40 mm depth of irrigation at every 8 days interval. Under constraints of irrigation water they should operate the system at an irrigation interval of 10-12 days to save about 50 % irrigation water and to get almost equal returns as in the case of surface method.</p>
3	1998-2000	Feasibility of inter cropping in banana under minisprinkler	<p>The farmers of South Gujarat heavy rain fall zone cultivating banana under micro irrigation system with a spacing of 1.5 x 1.5 m are advised not to use minisprinkler system of 3 m spread</p>

4	2002-2004	Fertigation through minisprinkler in onion crop	<p>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.</p> <p>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.</p> <p>The minisprinkler should be laid out at the spacing of 2.5 x 2.5 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.</p>
F	Mulching		
1	1991-1995	Effect of mulching on yield of banana	<p>The farmers of South Gujarat heavy rainfall zone growing banana are advised to mulch their crop with sugarcane trash @ 15 t/ha to save about 40 % irrigation water, get about 49 % more yield and increase their net income per hectare by 86 %.</p> <p>In absence of sugarcane trash, they can follow mulching with black plastic (50 micron) with 50 % coverage and get around 10 % more income in addition to 35 % water saving.</p>
2	1992-1994	Effect of moisture regimes and mulches on growth and yield of rabi brinjal	<p>The farmers of North Gujarat zone growing <i>rabi</i> brinjal crop are advised mulch their crop with castor shell and irrigate it with about 14 irrigations each of about 30 mm depth to get about 33 % more income. Due to high temperature of the film especially (black plastic, 50 micron) in summer the plants get damaged. (Yield 14 t/ha %)</p>
3	1992-1995	Effect of different mulches and methods of planting on yield of Brinjal under rain fed condition	<p>The farmers of South Gujarat zone cultivating brinjal as Kharif crop are advised to follow mulching practice with either grass (5 t/ha) or black plastic film (50 micron, 80 % coverage) to get about 50 and 36 % more returns, respectively. The mulching should be done within a week after cessation of monsoon.</p>
4	1992-1995	Effect of IW/CPE ratios	<p>The farmers of South Gujarat heavy rainfall zone transplanting chilies</p>

		and mulches on the yield of chillies	<p>in rabbi season are advised to give 12 irrigations to their crop (IW/CPE=0.9) each of 80 mm depth. The first irrigation should be given at the time of transplanting, second at 25-30 days after transplanting. Remaining irrigations should be given at 20-25 days interval during January –February and 12-15 days interval during March to May.</p> <p>The farmers are also advised to mulch their crop with black plastic to get about 63 % more yield and more income.</p>
5	1992-1996	Effect of different types of mulching on growth and yield of coconut. (Copus nucifera) Cv. Dwarf orange	The farmers of South Saurashtra zone are informed that mulching was not found beneficial in the fully grown (40-50 Yr. old) Coconut (Var. Dwarf orange) orchard.
6	1992-1999	Effect of different types of mulches on yield of coconut	For getting higher nut yield (25 %) and net return, the farmers of South Saurashtra are advised to apply wheat straw as mulch in the 4.1 x 4.1 m basin area of coconut tree. Under the circumstances of unavailability of wheat straw, the use of black plastic (3.8 x 3.8 m) (50 micron) was also found beneficial.
7	1993-1996	Effect of mulch and irrigation on coconut Cv. W.C.T.	Coconut growers of South Saurashtra region are advised to apply 10 to 11 irrigations each of 50 mm depth of irrigation. During winter the irrigation should be given at 22 days interval and during summer 15 days intervals to 40 to 50 years old coconut orchard (Var. W.C.T.) having basin size 4 x 4 m ² . The mulching was not found beneficial in this type of old plantation.
8	1993-1996	Irrigation management in brinjal through mulching	<p>The farmers of the middle Gujarat zone growing brinjal in deep black soil of Narmada command are advised to apply 12 irrigation each of 80 mm depth.</p> <p>The first irrigation should be given at the time of transplanting. The next three irrigations should at an interval of 10 to 12 days, fifth irrigation at 15 to 17 days and last three at 10 days</p>

			<p>interval.</p> <p>They can also mulch their crop with black plastic (50 micron, 80 % coverage) to get about 27 % more yield and 12 % more income as compared to no mulch treatment. In absence of plastic mulch, the mulching can be done with wheat straw (@ 10 t/ha) to get about 15 % more yield and 11 % more income. The mulching should be done one month after transplanting.</p>
9	1994-1997	Effect of IW/CPE ratio and different mulches on yield of chillies.	<p>The Chillies growing farmers of South Gujarat Zone are advised to give 4 irrigations to their <i>kharif</i> crop after cessation of monsoon.</p> <p>They are also advised to mulch their crop with dry grass @ 6 t/ha to get about 18.1 more yield and 21 % more income. Under constraint of non availability of dry grass, they can mulch with black plastic (50 micron) to get about 19 % more yield and 7% more income.</p>
10	1995-1996	Effect of growth regulator and different mulches on okra	<p>The farmers of south Gujarat heavy rainfall zone are advised to spray the summer okra crop with 50 mg/1NAA twice at 25 and 45 days after sowing (DAS) to get higher yield and more economic benefits. In addition to NAA spray, mulching the crop at 25 DAS with black plastic (50 micron 90 % coverage) is also advised to obtain additional yield (25%) and economic benefits.</p>
11	1995-1998	Irrigation and mulching studies in cauliflower	<p>The farmer of South Gujarat heavy rainfall zone transplanting cauliflower during November are advised to give 7 irrigations to their crop (IW/CPE ratio-0.75) each of 60mm depth.</p> <p>The first irrigation should be given at the time of transplanting, second at 9 and third at 20-25 days after transplanting. Remaining irrigations should be given at 18-20 days interval. The farmers are also advised to mulch their crop with black plastic to get about 33 % more yield and 27 % more income.</p>

12	1996-1999	Mulching study in brinjal	<p>The farmers of South Gujarat heavy rainfall zone planting brinjal during December – January months are advised to give 7 irrigations (0.4 IW/CPE) along with black plastic (50 micron, 100 % coverage) as mulch.</p> <p>The interval between two irrigations during winter should be 45 to 50 days while during summer it should be 30 to 35 days. Use of plastic mulch will increase the net return by 57 % over unmulched conditions.</p>
13	1999-2002	Irrigation and mulching studies in summer okra	<p>The farmers of middle Gujarat zone growing summer okra var. GOH-1 are advised to give 10 irrigations each of 60 mm depth (0.8 IW:CPE).</p> <p>The first irrigation should be on the day of sowing and at 12-13 days interval till March and weekly interval thereafter. They should also mulch the crop with sugarcane trash @ 5 t/ha to get about 10 % more yield and more income.</p>
14	1999-2002	Agrotechnique for ber cultivation in coastal salt affected soils of South Gujarat	<p>The farmers of Coastal areas of South Gujarat heavy rainfall zone who are growing <i>ber</i> in the un reclaimed coastal salt affected soils are advised to mulch their trees right from the first year to get 97 % more yield and 84 % more income even during the initial growth period.</p> <p>The 100 micron thick black poly ethylene film should be kept around the trees 1m x 1 m in the first year and 2 m x 2 m from second to fourth year) immediately after the cessation of the monsoon.</p>
15	2003-2004	Irrigation and mulching study in marigold	<p>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.</p> <p>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.</p> <p>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</p>

			profit, respectively, over un-mulched 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.
G	Green house		
1	1995-1998	Green house technology for rose (Gladiator) cultivation	<p>The farmers of South Gujarat heavy rainfall zone are advised to grow rose (Gladiator) in medium cost greenhouse for more production and better quality of the flower.</p> <p>They should keep the plant geometry as 0.5m x 0.33m .By this, they can get about 914% more net income compared to the planting in open field with the same spacing</p>
2	1996-2000	Green house technology for growing leafy vegetables	<p>The farmers of South Gujarat heavy rainfall zone are advised to grow leafy vegetables such as palak, tandeliya bhajee and green coriander leaves in low cost green house for more production and better quality.</p> <p>The cultivation practices inside the green house are similar to that of open field cultivation. By this they can get about 60% more net income compared to open field cultivation.</p>
3	1996-2000	Green house technology for raising of vegetable nursery	<p>The farmers of South Gujarat heavy rainfall zone are advised to grow vegetable nursery in low cost and medium cost green houses and rain shelter economically. By this they can get more net return of about 150 %, 90 % and 122 % with deshi seedlings and 160 %, 86 % and 115 % with hybrid seeds in MGH,LGH & rain shelter, respectively, as compared to open field planting. However, for better economy, low cost greenhouse or rain shelter should be preferred.</p>
4	1999-2001	Green house technology for growing tomato	<p>The farmers of South Gujarat heavy rain fall zone are advised to grow tomato (Hy. NS 5130) in low cost green house for more production as well as net income per unit area with 125 % recommended fertilizer dose. By this they can get about 143 % more yield and about 385 % more income to open field cultivation.</p>

5	2002-2006	Nutrient management in tomato grown in LCGH, MCGH and open field conditions	The farmers of South Gujarat growing hybrid tomato at high density (50 x 60 cm) under green house conditions are advised to apply fertilizer @ 125 % of recommended dose for getting optimum yield. However, the high production causes micronutrients depletion.										
6	2010-2011	Effect of NAA and GA ₃ on yield of capsicum grown under polyhouse conditions	The farmers of South Gujarat are advised to grow capsicum (Yellow Orbella) preferably in naturally ventilated poly house instead of fan and pad cooling system poly house and open field conditions. For achieving higher fruit yield and net profit, two spray of GA ₃ @ 100 mg/l at flower initiation and 10 days after first spray are recommended.										
H	Net house												
1	2010-2012	Influence of different growing conditions on yield of leafy vegetables during summer season	<p>Farmers of South Gujarat having different shade (%) net house are advised to prefer the following leafy vegetables to be grown during summer season for getting higher yield and net income.</p> <table border="1"> <thead> <tr> <th>Crops</th> <th>Ideal shade net house (Summer season)</th> </tr> </thead> <tbody> <tr> <td>Fenugreek</td> <td>75 %</td> </tr> <tr> <td>Coriander</td> <td>75 %</td> </tr> <tr> <td>Spinach</td> <td>30 %</td> </tr> <tr> <td>Amranthus</td> <td>30 % or open field</td> </tr> </tbody> </table>	Crops	Ideal shade net house (Summer season)	Fenugreek	75 %	Coriander	75 %	Spinach	30 %	Amranthus	30 % or open field
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F	Low tunnel												
1	1996-1998	Low tunnel technology for leafy vegetables	<p>The farmers of South Gujarat heavy rain fall zone are advised to grow palak and green coriander in low tunnels for production and profit per unit area in winter season. The details of tunnel construction material and dimensions are as follow: They can use geotextile and / or transparent white plastic sheet as the cover material for palak cultivation in tunnel.</p> <p>They can use geotextile and / or yellow plastic sheet as the cover material for coriander cultivation in tunnel. The tunnel can be made of iron rodes and angles having the dimensions of 2 m x 1.1 m x 0.6 m (L X B X H).</p>										

J.	Drainage		
1	2003-2004	Drainage technology for combating water logging and salinity conditions in South Gujarat	<p>For combating water logging and salinity problems in canal command areas of south Gujarat, farmers are advised to adopt drainage technology for getting economically viable crop production by maintaining average water table at about 60 cm bgl and reducing salinity by about 65 per cent.</p> <p>1) The close sub surface drainage using corrugated PVC pipe should be laid out at a spacing of 45 m and depth of about 0.9 to 1.2 m. Considering the internal rate of return (58 %), benefit cost ratio (1:1.7) and pay back period of 2 years with sugarcane crop, this system is economically viable.</p> <p>2) Similarly, resource poor farmers can adopt subsurface drainage system at spacing of 60 m and average depth of 80 cm. With paddy crop this system is economically viable as evident from internal rate of return (114 %), benefit cost ratio (1:2.93) and pay back period of 2 years</p>
K.	Survey		
1	2007-2008	Green house cultivation in South Gujarat- A survey	<p>1. Green house cultivation of gerbera, rose, carnation and capsicum crops is economically viable under South Gujarat. Among the crops, floriculture crops were found more remunerative than capsicum.</p> <p>2. The major problems encountered by the farmers are:</p> <ul style="list-style-type: none"> - No erection company in Gujarat - No information available from Govt. - No training centre in Gujarat. - Planting material not available locally - Pest and diseases - High summer temperature - High power charge - High cost of fertilizer - High cost of plants material.
2	2007-2008	Patchouli cultivation in	1. Patchouli cultivation is economically viable under South

		South Gujarat-A survey	<p>Gujarat conditions.</p> <p>2. Problems experienced by the growers</p> <ul style="list-style-type: none"> - Water stagnation during monsoonic months - Pests and disease - Weed control - Absence of improved varieties (high oil content) - Water and nutrient management <ul style="list-style-type: none"> - Poor awareness about cultivation practices among the farmers <p>3. Other problems</p> <ul style="list-style-type: none"> - Unavailability of quality planting material - High cost of planting material - Inadequate extraction unit - Lack of marketing net work
3	2008-2009	Economics of drip irrigation in sugarcane and banana - a survey	<ul style="list-style-type: none"> • The magnitude of net profit realized by the sugarcane and banana farmers empathetically proves the economic viability of DIS under farmers' fields situation. • Some of the important suggestions given by the farmers based on their experiences may form basis for taking policy decisions by GoG as well as GoI. • For enhancing know – how of the DIS, there is need to train the farmers.
4	2008-2009	Adoption of drip/sprinkler in potato – a survey	<ul style="list-style-type: none"> • In potato, sprinkler system is preferred over drip system in North Gujarat • There is need to maintain recommended plant population • There is need to train the farmers • This survey needs to be repeated after 2/3 years
5	2008-2009	Impact of feed back analysis of trainees of SWMRU, Navsari	<ul style="list-style-type: none"> • There is need to train the farmers in depth about improved technologies to be adopted by them • In order to cover large number of farmers, there is need to do Human Resource Development minimum at district level • The pattern of adoption of technology is drip > drainage >

			<p>sprinkler > green house = mulching</p> <ul style="list-style-type: none"> • The extent of adoption of technology in different zone is South Gujarat > Kutch > North Gujarat > Saurashtra > middle Gujarat
6	2009-2010	Impact assessment of "Yuva Tribal Juth" training (1 month duration) organized by GGRC in collaboration with PFDC.	<p>Based on the present survey, following conclusions are emerged.</p> <ul style="list-style-type: none"> • Considering the education level of the trainees (>SSC), receptivity of knowledge and extent of adoption is good. • MIS training helped in securing job to 20 % of the trainees.
7	2009-2010	Impact of trainers' training program on knowledge level of trainees.	<p>From the present study, following conclusions are emerged.</p> <ul style="list-style-type: none"> • Initial knowledge level of trainees was relatively more with drip and fertigation than sprinkler, mulch and green house technology. • There is considerable increase in knowledge level after training and the technologywise increase in level of knowledge was in order of green house > sprinkler > mulch > drip > fertigation.
8	2010-2011	Knowledge and adoption level of drip irrigation in sugarcane in collaboration with different sugar factories	<ul style="list-style-type: none"> ❖ Sugarcane growers are not having adequate knowledge about proper use of drip system in sugarcane. There is need to train the sugarcane growers about improved technologies related to MIS. ❖ Special strategy needs to be formulated for sugarcane grown in canal command area. ❖ The sugar factory officers should be trained in depth about technical aspects of drip irrigation and fertigation.
9	2010-2011	Indicative survey on quality of irrigation water in relation to clogging of drippers	<ul style="list-style-type: none"> • The risk of emitter clogging is considerably high when saline water is used through drip system having low discharge rate dripper. • The uniformity coefficient of drip system is distorted when saline water is used in drip system with low discharge rate dripper. • Use of saline water for irrigation through drip deteriorates the chemical properties viz., pH, EC and ESP of soil. • There is need to train the farmers about

			operation and maintenances of drip system thoroughly.
10	2013-2014	Adaptability and problems in adoption of fertigation by the farmers	<ul style="list-style-type: none"> • Fertigation technology helped farmers in saving about 20-40 per cent of fertilizers as well as the labour cost for application of fertilizers. Thus, because of fertigation, farmers were able to reduce cost of production and thereby increase in their profit • Because of fertigation, farmers could also harvest quality of produce and there by realized premium prices in some cases • Most of the farmers are using water soluble fertilizers for fertigation. Farmers feel that the cost of commercially available water soluble fertilizers is too high. So there is need to produce low costly liquid fertilizer by govt. agencies
11	2015-2016	Adaptability and problems in plastic mulching adopted farmers	<p>Beneficiaries' perception about the technology</p> <ul style="list-style-type: none"> ➤ Impressed by the plastic and organic mulching technology ➤ Paired row planting was selected by the farmers for reducing the cost of plastic mulching ➤ Good quality production <p>Feedbacks of farmers with respects to drawbacks/bottlenecks/constraints for adopting the technology</p> <ul style="list-style-type: none"> ➤ There is also need to train farmers about irrigation schedule for their crops after plastic mulching. ➤ In some farmer opinion plastic mulching cost, compensate by only saving in fertilizer as well as weeding. ➤ Problems observed during monsoon period than control conditions. <p>Feedbacks of farmers on Govt. of India schemes for its adoptions</p> <ul style="list-style-type: none"> ➤ The damage is more due cattle, pigs, boar etc. Therefore, farmers opined that there is need to extend subsidy benefit in mulching. This will help in expanding area under MIS.

12	2017-2018	Adaptability and problems in net house adopted farmers	<p>Beneficiaries' perception about the technology</p> <ul style="list-style-type: none"> ➤ Impressed most of the farmers' by the net house technology adopt during summer ➤ Get good quality with high production ➤ Get higher price due of their produce due to off season production <p>Feedbacks of farmers with respects to drawbacks/bottlenecks/constraints for adopting the technology</p> <ul style="list-style-type: none"> ➤ There is need to train farmers for cropping schedule in net house for round the year production ➤ In some farmer opinion, without crop rotation they suffer from soil born disease ➤ In some crops, problems observed during monsoon period <p>Feedbacks of farmers on Govt. of India schemes for its adoptions</p> <ul style="list-style-type: none"> ➤ All farmers' taken benefits of subsidy, some farmers' face problems in this ➤ The damage is more due to cattle, pigs, boar, dogs, squirrel etc. Therefore, farmers opined that there is need more subsidies for fencing / protected wall around their field. This will help in expanding area of net house.
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