Research Achievements:

(A) Recommendations released for farmer:

1) Hard, grassy or dryland fields with stubbles of sugarcane, wheat, millet and sorghum can be prepaid for immediate sowing in next season by working ones with rotavator instead of working three or more times with plough, cultivator and straight blade harrow rotavator is the quickest and cheapest means for land preparation. This implement is recommended for farmers use. **(1982)**
2) Drilling attachment to multipurpose pipe framed implement is useful for automatic and uniform sowing without gaps and clusters. It helps in reducing cost of seeds and sowing and increased the yield of crops. This implement is recommended for farmers use. **(1983)**
3) Farmers are recommended to use adjustable yoke instead if three or more local yokes. **(1986)**
4) The bullock drawn multi crop seed-cum-fertilizer drilling attachment to "Samrat Santi" is useful for sowing groundnut, blackgram, Bengal gram, green gram, cotton, sorghum, wheat, pearl millet and sesamum etc. with uniform seed placement at controlled rates alongwith fertilizer drilling manually. Its use is economical as compared to the local seed drill, it is recommended for farmer's use. **(1996)**
5) Small and marginal farmers are recommended to replace their pair of bullocks by single bullock and use single bullock drawn multipurpose implement for harrowing, sowing and interculturing operation. **(1993)**
6) The tractor drawn drilling attachment to cultivator is useful for sowing groundnut blackgram, bengalgram, sorghum, sesamum, pearl millet and pigeonpea etc, with uniform seed placement and controlled seed rates. Its use is also economical as compared to tractor drawn manually metered seed drill (LOCAL). Hence, it is recommended for farmer's use. **(1996)**
7) The bullock drawn hoe-cum-Fertilizer drilling attachment is useful to place second dose of nitrogenous fertilizer (Urea) for cotton is moist soil zone near the plant roots alongwith the interculturing operation without plant damage. In comparison to traditional method crop yield is also increased by placing fertilizer with this equipment. Hence, its use is beneficial to the cotton grower. It is therefore, recommended for farmer's use. **(1996)**
8) The seed cum fertilizer drilling attachment to tractor drawn cultivator is useful for sowing of crops like groundnut, green gram, block gram, gram, wheat, sorghum, pearl millet and pigeon pea along with the fertilizer application with uniform placement and controlled seed and fertilizer rate. There fore, it is released for the farmers' use and its commercial exploitation. **(2000)**
9) The farmers are recommended to use semi automatic gap filler for filling the gaps in the field and for planting wide spaced crops like cotton, Castor and groundnut. Using this equipment work out put of the operator can be increased by two times. Therefore the equipment is released for farmers' use and its commercial exploitation. **(2000)**
10) A mango plucker has been devised and recommended for commercial use by farmers in order to mechanize the mango harvesting. It maintains fruit stack length of 1-2 cm. and doubles the work output. **(2001)**
11) Following matching equipments are recommended for farmers' use for increasing the usefulness of power tillers: **(2001)**
    1) 300 to 375 mm long twin straight blade with tool carrier for interculturing groundnut sown at 600 mm row spacing.
    2) Straight blade harrows of size 450 mm, 600 mm, 750 mm etc. as per spacing with two depth controlling wheels and tool carrier can be used for groundnut harvesting. (Curved blade is more effective in case of hard soil conditions)
    3) A drive mechanism designed and developed to operate locally available threshers and decorticators.
12) Farmers of South Saurashtra Agro-climatic Zone No. 7 growing castor and other raw crops like groundnut, cotton etc. are advised to use sweep blade (angle - 70° and working length

- 42 cm) for interculturing to reduce number of clogging and to increase weeding and field efficiency as compared to straight and curved blade. Use of sweep blade in interculturing also reduces human drudgery to operator. **(2005)**

13) Mango growers of South Saurashtra Agro-climatic Zone are advised to use positioner for mango harvesting with uniform stalk length (1-2 cm.), for maintaining white layer on the fruits and with choice of matured fruits as the operation is conducted at a close distance. Using this machine, one can get economical advantage over local picker. **(2006)**

14) The farmer, entrepreneur and design engineer are advised to install the drip irrigation system as per the layout as given below for different crops for minimizing the cost of installation. **(2007)**

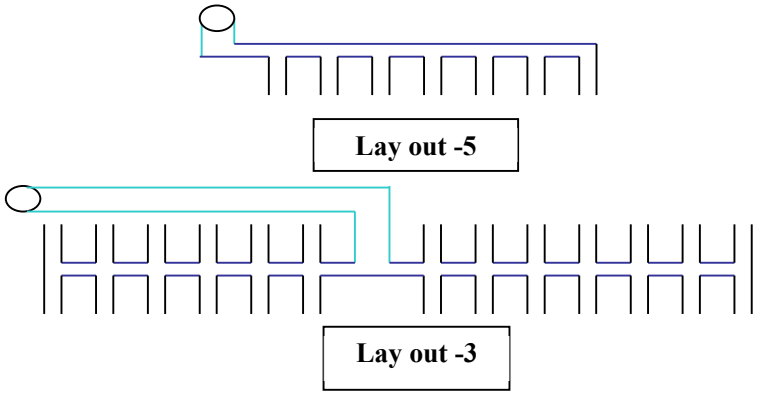
Cost of Drip irrigation in horticultural crops

Sr. No.	Name of Crop	Spacing (m x m)	Expenditure (Rs/ha)	Design Layout No.	Size of Different components				
					Screen Filter	Main Line	Sub main line	Lateral	Dripper Discharge
					m^3/h	mm	mm	mm	lph
1	Mango	10 x 10	25,376/-	5	10	-	50	16	8
2	Sapota	10 x 10	25,493/-	5	10	-	50	16	8
3	Coconut	6 x 6	33,855/-	5	10	-	50	16	8
4	Custard apple	6 x 6	34,123/-	5	10	-	50	16	4
5	Guava	6 x 6	33,372/-	3 or 5	10	50	40	12	8
6	Lemon	6 x 6	33,855/-	5	10	-	50	16	8
7	Pomegranate	6 x 6	35,131/-	5	10	-	50	16	4
8	Datepalm	8 x 8	30,255/-	5	10	-	50	16	8
9	Ber	6 x 6	32,209/-	3 or 5	10	50	40	12	8
10	Amla	8 x 8	29,476/-	4 or 5	10	40	32	12	8
11	Popaya	2 x 2	58,789/-	5	10	-	75	16	4
12	Cashew nut	5.4 x 5.4	36,124/-	5	10	-	50	16	8

Cost of Drip irrigation in field crops

Sr. No.	Name of Crop	Crop geometry (m x m) (R x P)	Lateral x Dripper Spacing (mx m)	Expen-diture (Rs/ha)	Design Layout No.	Size of Different components				
						Screen Filter	Main Line	Sub main line	Late-ral	Dripper Discharge
						m^3/h	mm	mm	mm	lph
1	Groundnut	0.45x0.1	0.9 x 0.6	1,23,986/-	3	20	90	75	12	2
2	Groundnut	0.9x0.1	0.9 x 0.6	1,19,971/-	3	20	75	63	12	2
3	Groundnut	0.6x0.1	1.2 x 0.6	94,586/-	3	20	75	63	12	2
4	Groundnut	0.75x0.1	0.75x0.6	1,42,174/-	3	25	90	75	12	2
5	Cotton	1.5x0.6	1.5 x 1.2	86,723/-	3	25	90	75	16	8
6	Cotton	1.2x0.6	1.2 x 1.2	78,612/-	3	20	75	63	12	4
7	Cotton	0.9x0.6	0.9 x 1.2	98,673/-	3	20	75	63	12	4
8	Castor	0.6x0.6x 1.2	1.8 x 0.6	68,619/-	3	10	63	50	12	2
9	Castor	0.9x0.6	0.9 x 1.2	98,673/-	3	20	75	63	12	4
10	Castor	0.9x0.6	0.9 x 0.6	1,48,711/-	4	40	75	63	16	4
11	Tomato/ Brinjal	0.6 x 0.6 x 0.9	1.5 x 1.2	68,301/-	3	20	75	63	12	4
12	Tomato/ Brinjal	0.75x0.6	0.75x1.2	1,16,618/-	3	25	90	75	12	4
13	Banana	1.5 x 1.5	1.5 x 1.5	62,290/-	3	10	63	50	12	4
14	Banana	1x1.2 x 2	3.2 x 1/2	45,101/-	5	10	-	50	16	2
15	Chilles	0.6 x 0.6	1.2 x 1.2	78,612/-	3	20	75	63	12	4
16	Lady's finger	0.6 x 0.3	1.2 x 0.6	94,586/-	3	20	75	63	12	2
17	Lady's finger	0.3x 0.3x 0.9	1.2 x 0.6	94,586/-	3	20	75	63	12	2
18	Cabbage/ Cauliflower	0.45 x 0.45	0.9 x 0.9	1,02,902/-	3	20	75	63	12	2

19	Cabbage/ Cauliflower	0.3 x 0.3 x 0.9	1.2 x 0.6	94,586/-	3	20	75	63	12	2
20	Bittergourd	1 x 1	1 x 1	99,647/-	3	20	90	75	12	4
21	Sugarcane	0.1 x 0.6 x 1.2	1.8 x 0.6	68,619/-	3	10	63	50	12	2



15) The farmers having Kagzilime orchards are advised to use the JAU-Lime harvester to reduce losses like spoilage and immature lemon fall-up**. (2010)**
16) Farmers of South Saurashtra Agro Climatic Zone having saline ground water (EC-3.15 dsm^{-1}) and medium black calcareous soil (EC-0.88 dsm^{-1}) conditions are advised to introduce horticulture plants like; Seemaruba, Sweet Tamarind, Aonla, Pomogranate, Sapota, Date palm, Ber, Carambola and Guava**. (2011)**
17) Farmers of South Saurashtra Agro Climatic Zone growing bunch type Groundnut under poor drainage field conditions are advised to sow by Broad Bed Furrow method (55 cm width and 15 cm depth of furrow and 100cm bed between two furrows) for getting higher yield and net return**. (2012)**
18) The farmers of South Saurashtra Agro climatic zone are advised to use the excess rainfall prevailing during 27-32nd standard weeks (2nd July to 12th August) judiciously and frugally towards supplemental to sustain crop productivity under rainfed agriculture. **(2013)**
19) Farmers of South Saurashtra Agro Climatic Zone growing bunch type Groundnut are advised to prefer Broad Bed Furrow (55cm width and 15cm depth of furrow and 100cm bed width between two furrows) land configuration for getting more moisture retention and higher return under rainfed agriculture. **(2013)**

20) Farmers' of South Saurashtra Agroclimatic Zone growing Bt. Cotton are advised to adopt drip irrigation (with 1.2m lateral spacing, 40cm dripper spacing and emitter discharge of 2 lph) in raised bed covered with silver black plastic mulch of 20 micron and irrigate every alternate day at 0.8ETc level (or to operate system for 2 to 3.5hrs, 2.25 to 3.25 hrs and 1.25 to 3hrs during September-October, November-December and January respectively) for acquiring higher yield (33%) water use efficiency (79%), higher water productivity (91%) and higher net return over no mulch. **(2015)**
21) Farmers of South Saurashtra Agroclimatic Zone growing Sapota (Kalippati) are advised to adopt drip irrigation (2 drippers per plant upto 2 years and after that 4 dripper per plant, dripper discharge of 4 lph) covered with black plastic mulch of 100 micron and irrigate every alternate day at 0.6 IW/ETc (or apply water 14, 34, 48, 34, 8, 11 and 9 liters per day per plant during January-February, March-April, May, June, July-August, September-October and November-December respectively) for acquiring higher yield and net return of Sapota over no mulch. **(2016)**
22) Farmers' of South Saurashtra Agroclimatic Zone growing cumin are advised to adopt drip irrigation with triangular geometry having 0.6m lateral spacing and 2 lph emitter discharge and to irrigate at 4 days interval with 0.8 IW/ETc (2 hours) for acquiring higher yield (38%), water use efficiency (60.95%), water productivity (61%) and net return (38.87%) compared to farmers' practices. **(2017)**
23) Tractor operated Farm Yard Manure applicator developed by Junagadh Agricultural University is recommended for farmers' use and for commercial exploitation to apply FYM at desired row spacing within furrow as per requirement. It saves time and economical as compared to manual FYM application. **(2017)**
24) Farmers' of South Saurashtra Agroclimatic Zone growing fennel are advised to adopt drip irrigation with 75 cm lateral spacing, 40 cm dripper spacing and 2 lps dripper discharge for acquiring higher yield (59%), water saving (69%) and higher net return over control. **(2018)**
25) The farmers' of South Saurashtra Agro climatic Zone growing wheat are advised to adopt drip irrigation with 67.5 cm lateral spacing, 60 cm dripper spacing, 4 lps dripper discharge and 1.2 kg/cm^2 operating pressure for acquiring higher yield (upto 29%), higher net return (upto 51%) and saving upto 18 % irrigation water over control. **(2021)**
26) Farmers of South Saurashtra Agro climatic Zone growing brinjal crop during rabi season are recommended to apply 100 % RDF of phosphorous and 25 % RDF of N and K (100:37.5:37.5 N: P2O5: K2O) as a basal dose and remaining 75 % RDF of N and K through drip irrigation in 7 equal splits after 25 days of transplanting at 12 days interval to obtain higher yield, net return, water use efficiency and save up to 42 % irrigation water compared to furrow irrigation. **(2022)**
27) Farmers of South Saurashtra Agro-climatic Zone growing wheat are recommended to apply 7.5 t/ha. FYM in furrow in addition to RDF, using Junagadh Agricultural University developed FYM applicator to obtain higher net return and save 25 % of FYM. **(2022)**
28) Farmers of Saurashtra region growing sweet corn during rabi season are recommended to apply 100% phosphorous of 75% RDF (90:45:45 N:P_2O_5:K_2O) and 25% N and K of 75 % RDF as a basal dose and rest N and K through sub surface drip irrigation (installed at 30cm depth) in 10 equal splits after 25 days of sowing at 6 days interval to obtain higher yield, fertilizer use efficiency, water use efficiency and net return. **(2023)**
29) Farmers of South Saurashtra Agroclimatic Zone are recommended to use the Solar Photovoltaic Pump for getting higher water horse power, discharge, array efficiency and overall efficiency during 10 am to 4 pm as the period is feasible to apply irrigation in field. **(2023)**
30) Farmers of South Saurashtra Agroclimatic zone are recommended to use solar photovoltaic pump (5 hp AC) operated rain pipe (32mm diameter, 300 micron wall thickness) irrigation system keeping operating pressure 0.5 kg/cm2, length of rain pipe 30m and 5m spacing between two rain pipe to irrigate the field during 10 am to 4 pm. **(2023)**

(b) Recommendations released for Scientific Community:-

1) Scientists, Policy makers and Irrigation planners of South Saurashtra Agroclimatic Zone are advised to plan their irrigation water schedules to the crop based on the following guidelines:
    1) Moderately dry and severe dry years appear once in seven years 7 years and 10 years from 2002
    2) Moderately dry July, August and September months appear once in 10 years, 9 years and 5 years respectively from 2002
    3) Severe dry July, August and September months and years appear once in 9 years, 18 years, and 13 years respectively from 2002
    4) Abnormal weeks appear once in six years from 2002
    5) Severe dry spell of 15 days occur once in 15 years during July and August
    6) A dry spell of 10 days occur once in 7 years in July (July 1-10) and once in 13 years in August (Aug 10-20) (10th AGRESCO JAU/RS(AE)/Tech-1/192-237, Date 21/02/2013)

2) **Planners, designers, NGO's field officers and Govt. Departments**

The following three models developed by JAU can be used to decide the lateral and emitter spacing in drip irrigation design for a particular emitter discharge in loamy soil.

Case: a) If moisture data before irrigation is not monitored

Planners Designers, NGO's, Field officers and Govt. Departments are recommended to use the following expression for determining the wetting dimensions if moisture information is not available

$$W = 0.516\ V^{0.393}\ (K_s / q)^{0.062} \qquad (R^2 = 0.983)$$

$$Z = 0.069\ V^{0.303}\ (K_s / q)^{-0.060} \qquad (R^2 = 0.965)$$

Where W = Diameter of wetted spread on the ground surface, *m*; q= emitter discharge in lph; V = volume of water application, *l*, and K_s = saturated hydraulic conductivity, *m/sec*; and Z= depth of wetting front below the emitter, *m*.

Case: b) If moisture data before irrigation is monitored then

The Planners Designers, NGO's, Field officers and Govt. Departments are recommended to use the following expression for determining the wetting dimensions if moisture information is available

$$R = \Delta\theta^{-452.978}\ v^{0.393}\ q^{-0.062}\ K_s^{-17352.497} \qquad (R^2 = 0.983)$$

$$Z = \Delta\theta^{-439.643}\ v^{0.303}\ q^{0.060}\ K_s^{-16840.965} \qquad (R^2 = 0.965)$$

Where R = Radius of wetted spread on the ground surface, *cm*; q= emitter discharge in *ml/h*; V = volume of water application *ml*; and K_s = saturated hydraulic conductivity, *cm/h*; and Z = depth of wetting front below the emitter, *cm*.

(10th AGRESCO JAU/RS(AE)/Tech-1/1281-1313, Date 18/02/2014)

3) The Scientists of South Saurashtra agro-climatic zone are advised to keep the following suggestions while using the following developed equations by various scientists for predicting the wetting geometry in Loamy Soils
    1) Healy and Warrick (1981) model predicted wetting geometry (width (R^2 = 0.3141) and depth (R^2 = 0.1918) at lower discharges with poor accuracy and failed to predict at higher emitter discharges (> 8 lph)
    2) Philips (1984) model predicted wetting geometry (both width and depth) at lower and higher emitter discharges with good accuracy

3) Accuracy of original Debral (2012) dimensional analysis model is low in predicting wetting geometry (both depth below the emitter ($R^2 = 0.845$) and width at the surface ($R^2 = 0.895$)).
4) BEN-ASHER Hemi Spherical Model (1985) predicted both depth ($R^2 = 0.962$) and width ($R^2 = 0.9774$) with good accuracy
5) Steady state Wooding model (1968), Steady state Raats model and moment analysis approach predicted both steady width with low accuracy

(10th AGRESCO JAU/RS(AE)/Tech-1/1281-1313, Date 18/02/2014)

4) Root growth study of Brinjal crop under different irrigation methods

The drip designers/ Irrigation water managers/Scientific communities are advised to adopt the following root growth models of exponential model of either Rasmussen and Hanks or Hanks and Hill for Brinjal crop grown in loamy soil as a decision support tool for drip operational parameters to get wetted bulb matching with depth and spreading of root zone. Model efficiency was observed 99.79 %. The maximum number of lateral roots and length of the lateral roots found under drip irrigation with mulch resulted maximum moisture uptake (56.91 %) from first quarter of root zone (0-25 % from top) at all plant growth stages compared to other irrigation 167 methods.

(18th AGRESCO JAU/RS(AE)/Tech-1/390-391, Date 01/06/2022)

(c) The following technologies have been recommended for farmers:

1. Test data of 24 submersible pumps available in the market are released for the farmers to select the best for their requirements. (1980)
2. Use of power tiller for conducting three major farm operations like sowing, inter culturing and groundnut harvesting are found beneficial as compare to pair of bullocks. Hence, farmers having mechanical aptitude are recommended to use power tiller instead of bullock for groundnut farming. (1986)
3. The farmers having mechanical aptitude can successfully, replace the pair of bullocks by a power tiller (due to lower cost of field operations with higher speed, e.g. the total cost of the six operations for groundnut cultivation was found to be Rs. 1314 /ha using power tiller as compared to Rs. 2158 /ha with pair of bullocks. The area covered per unit time was also higher using power tiller in all the operations as compared to a pair of bullock.) (1994)
4. The farmers of South Saurashtra Agro Climatic zone growing summer groundnut (row spacing 45 cm) are recommended to use drip method (with laterals in alternate rows at 90 cm spacing and 4 lph drippers at 45 cm spacing) to irrigate the crop alternate day at IW/CPE : 0.8. The farmers are advised to operate drip system for 45 minutes to 1 hour during January to March months and 1 hour to 1 hour 45 minutes during April to June months at recommended pressure for securing maximum production at profit. (1994)
5. For the safe and prolonged use of recharging wells, it is recommended for the farmers of South Saurashtra Agro-climatic zone to use GAU filter for trapping sediment and other impurities from the runoff water after it passes through commonly adopted pre-filter with a good vegetative barrier.

   The filter comprises of three layer of 30 to 40 mm gravel, 8 to 12 mm pebbles and 2 to 3 mm coarse sand each of 15 cm thick from bottom followed by a 20 cm thick layer of 0.5 to 1.0 mm fine sand. A pipe of appropriate size from filter bottom to the well be laid at a slope of 5 par cent with suitable arrangement of bigger stones around the entrance end of it. A runoff by-pass arrangement 20 cm. Further, for an inflow rate of 1 liter per second, a filter size of 3 sq.m. is enough to function efficiently for a period of atleast 80 minutes. (1998)

6. The farmers of South Saurashtra Agro Climatic Zone growing papaya crop are recommended to use 200 gauge LDPE plastic mulch in drip irrigation with the 8 LPH drippers placed 20 cm away from plant stem. The system be operated daily for 3 hrs. at 1.1 Kg/cm^2 pressure in October to February and for 5 hrs. from March to April to gain maximum yield and profit. Under water scarcity situation, it is advised to irrigate daily for 1.75 hrs. during October to February and for 3 hrs. from March to April for bringing more area under cultivation with the limited available of water for maximum earning.(1999)
7. Adoption of Broad Bed Furrow method (55 cm width and 15 cm depth of furrow and 100cm bed between two furrows) for bunch type Groundnut under poor drainage field conditions for getting higher yield and net return.(2011)
8. The farmers of South Saurashtra Agro climatic zone are advised to use the excess rainfall prevailing during 27-32nd standard weeks (2nd July to 12th August) judiciously and frugally towards supplemental to sustain crop productivity under rainfed agriculture.(2013)
9. For getting more moisture retention and higher return from bunch type groundnut, Broad Bed Furrow (55cm width and 15cm depth of furrow and 100cm bed width between two furrows) land configuration advised. (2013)
10. Adoption of drip irrigation (with 1.2m lateral spacing, 40cm dripper spacing and emitter discharge of 2 lph) in raised bed covered with silver black plastic mulch of 20 micron and should irrigate every alternate day at 0.8ETc level, for getting higher yield, water use efficiency, higher water productivity and higher return of Bt. cotton **(2015)**
11. Adoption of drip irrigation (2 drippers per plant upto 2 years and after that 4 dripper per plant, dripper discharge of 4 lph) covered with black plastic mulch of 100 micron and irrigate every alternate day at 0.6 IW/ET_c for higher yield and net return of Sapota **(2016)**
12. Adoption of drip irrigation with triangular geometry having 0.6m lateral spacing and 2 lph emitter discharge and to irrigate at 4 days interval with 0.8 IW/ETc (2 hours) for higher yield, water use efficiency, water productivity and net return of Cumin. **(2017)**
13. Drip irrigation scheduling suggested for Fennel crop for getting higher yield and net returns. **(2018)**
14. Irrigation Scheduling suggested for wheat under different land configuration. **(2020)**
15. Drip irrigation scheduling suggested for wheat with different lateral geometry. **(2020)**
16. Drip irrigation and fertigaton scheduling suggested for brinjal crop for getting higher yield and net returns. **(2021)**
17. Root growth study of depth and spread of root zone under different irrigation methods were suggested to scientists for Brinjal crop grown in loamy soil. **(2021)**
18. Recommended the dose of FYM application to the farmers of South Saurashtra Agroclimatic Zone growing wheat using FYM applicator to obtain higher net return and save of FYM. **(2022)**
19. Saurashtra sweet corn farmers: Apply 100% phosphorus (75% RDF), 25% N and K as basal dose, rest via sub-surface drip in 10 splits from 25 days after sowing at 6-day intervals for enhanced yield, fertilizer efficiency, water efficiency, and net returns. **(2023)**
20. South Saurashtra farmers, use Solar Photovoltaic Pumps for efficient irrigation between 10 am to 4 pm; they offer higher efficiency, lower operating costs, and eco-friendliness compared to electric and diesel pumps**. (2023)**
21. South Saurashtra farmers, use a 5 hp AC solar pump for rain pipe irrigation (32mm diameter, 300 microns). Operate at 0.5 kg/cm2 pressure, with 30m pipe length and 5m spacing, ideal for field irrigation from 10 am to 4 pm. **(2023)**

(d) Farm equipment's have been recommended and released for farmers' use:-

(i) Tractor drawn Rotavator (1982)

(ii) Drilling attachment to multipurpose pipe frame implement (1983).

(iii) Adjustable yoke (1986).

(iv) Single bullock drawn implement (1993).

(v) Seed-cum-fertilizer drilling attachment to pipe frame implement (1996).

(vi) Drilling attachment to the tractor drawn cultivator (1996).

(vii) Bullock drawn hoe-cum-fertilizer drill (1996).

(viii) Seed-cum-fertilizer drilling attachment to tractor drawn cultivator (2000)

(ix) Semi automatic gap filler (2000).

(x) Mango harvesting device (2001)

(xi) Power tiller matching equipment for interculturing / harvesting and threshing of groundnut. (2001)

(xii) Use of sweep blade for interculturing (2005)

(xiii) Tractor operated positioner for mango harvesting. (2006)

(xiv) Standardization of drip irrigation system (2008)

(xv) Kagzilime harvester (2010)

(xvi) Farm Yard Manure Applicator (2017)

The following technologies have been recommended for farmers:

(i) Submersible pump test data for the selection of pumps (1980).

(ii) Use of power tiller in place of a pair of bullocks for groundnut cultivation for the farmers having mechanical aptitude (1986)

(iii) Use of power tiller for farming (1994).

(iv) Use of drip irrigation for summer groundnut (1994).

(v) Use of sand filter for artificial ground water recharging through dug wells (1998).

(vi) Use of drip irrigation with mulching in papaya crop (1999).

(vii) Standardization of design drip irrigated system (2008)

(viii) Introduction of horticultural plants for coastal belt area (2011)

(ix) Broad bed furrow for groundnut under poor drainage condition (2012)

(x) Drought investigation using SPI index for Junagadh (2012)

(xi) Broad bed furrow land configuration for bunch type groundnut (2013)

(xii) Geometry of wetting pattern under trickle irrigation (2013)

(xiii) Use of drip irrigation with mulching for Bt. Cotton (2015)

(xiv) Use of drip irrigation with mulching for Sapota (2016)

(xv) Dripper geometry and lateral configuration in Cumin (2017)

(xvi) Drip irrigation scheduling for fennel crop is advised to increase yield and net profits. **(2018)**

(xvii) Irrigation Wheat scheduling under various land configurations is suggested. **(2020)**

(xviii) Drip irrigation scheduling suggested for wheat with different lateral geometry. **(2020)**

(xix) Drip irrigation and fertigation scheduling suggested for brinjal crop for getting higher yield and net returns. **(2021)**

(xx) Root growth study of depth and spread of root zone under different irrigation methods were suggested to scientists for Brinjal crop grown in loamy soil. **(2021)**

(xxi) To increase net returns and conserve FYM, it was advised to South Saurashtra Agroclimatic Zone farmers to apply the recommended dose of FYM. **(2022)**

(xxii) Response of fertigation under different irrigation systems on Sweet corn. **(2023)**

(xxiii) Techno-economic performance of solar pump. **(2023)**

(xxiv) Hydraulic study of rain pipe irrigation system under solar photovoltaic pump. **(2023)**