Effects of different sources of silica and soil salinity (2, 5 and 10 dS m^{-1} of ECe) on dry matter accumulation of paddy, grain yield, straw yield, sodium uptake in grain and straw of paddy and potassium uptake in grain and straw of paddy terms of mean values are provided below Table 2.26.

Table 2.26 Effects of different sources of silica and soil salinity on dry matter, grain yield, straw yield, Na uptake and K uptake

Silica sources	Dry matter accumulation (g/plant)	Grain yield (g/plant)	Straw yield (g/pot)	Na uptake (mg/plant)		K uptake (mg/plant)	
				in grain	in straw	in grain	in straw
T_1- Control	13.06	10.9	12.05	53.42	161.8	55.45	264.4
T_2- Potassium silicate	24.06	15.03	20.98	30.89	87	76.47	591.1
T_3-Calcium silicate	22.26	13.63	20.58	31.76	120.3	75.11	512.2
T_4- Paddy straw	20.37	12.94	18.61	37.39	136.2	76.18	476.7
T_5-Paddy husk	19.8	12.33	17.91	34.35	155	62.58	360

In general, application of silica through different sources could reduce the impact of salinity on crop dry matter accumulation, grain and straw yield. It promoted K uptake and reduced Na uptake. The results also showed that incorporation of paddy straw and husk in soil may help to reduce adverse effects of salinity.

The K^+/Na^+ ratio observed in paddy crop revealed that, 2 dS m^{-1} soil salinity level recorded the highest potassium content to sodium content both in grain and straw of paddy crop (Table 2.27). In different sources of silica application, potassium silicate application recorded highest K/Na ratio followed by calcium silicate treatment.

Table 2.27 Potassium/Sodium ratio in plant affected by different sources of silica nutrient

Main treatments	K/Na ratio in grain	K/Na ratio in straw	Sub treatments	K/Na ratio in grain	K/Na ratio in straw
Salinity levels			T_1- Control	1.04	1.63
2 dS m^{-1} ECe	2.06	5.33	T_2- Potassium silicate	2.48	6.78
5 dS m^{-1} ECe	1.92	3.38	T_3-Calcium silicate	2.36	4.26
10 dS m^{-1} ECe	1.43	2.02	T_4- Paddy straw	2.04	3.5
			T_5-Paddy husk	1.82	2.31

Field evaluation of simulation models for prediction of long term salinity and watertable fluctuations using SWAP model (Bapatla)

Experiment was not implemented during 2014-15 as the data of closed sub-surface drainage system data is not available as the project APWAM has been terminated and hence the project is discontinued and concluded. The experiment was concluded with the existing results with the permission of the PC, CSSRI, Karnal during Annual review meeting held at CSSRI, Karnal.

Investigation, design, installation and evaluation of mole drainage systems in black soils of Andhra Pradesh for control of waterlogging (Bapatla)

The study was planned to take up in Bapatla, Kapileswarapuram and Kondapaturu areas. Accordingly, 24 years rainfall data (1991 to 2014) was used for determination of drainage co-efficient for Bapatla. The maximum annual rainfall was 1898.4 mm in the year 2010 and minimum annual rainfall was 666.6 mm in the 2009. The best fit probability distribution for 1 day to 10 day maximum rainfall are presented below through Table 2.28.

Table 2.28 Best fit probability distributions for the cumulative rainfall

Sl. No.	Cumulative Maximum Rainfall days	Best fit probability Distributions
1	1 day Maximum	LOG-PEARSON-3
2	2 day Maximum	LOG-NORMAL
3	3 day Maximum	LOG-NORMAL
4	4 day Maximum	LOG-PEARSON 3
5	5 day Maximum	LOG-PEARSON 3
6	6 day Maximum	LOG-PEARSON 3
7	7 day Maximum	GUMBEL MAX
8	8 day Maximum	GUMBEL MAX
9	9 day Maximum	GUMBEL MAX
10	10 day Maximum	GUMBEL MAX

The rainfall amounts at different return periods for 1 maximum to 10 day maximum rainfall are given Table 2.29This information can be useful for designing the structures.

Table 2.29 Cumulative daily maximum rainfall return periods from one day to ten days for different return periods.

Daily maximum rainfall, mm	Return Periods (Years)					
	2	5	10	15	20	25
1 day Maximum	110.1	170.4	216	242.6	261.5	276.2
2 day Maximum	148.7	224.1	281.1	314.4	338.1	356.4
3 day Maximum	166.7	264.6	338.6	381.9	412.6	436.4
4 day Maximum	177.3	272.9	345.2	387.6	417.6	440.9
5 day Maximum	188.4	286	359.9	403.1	433.7	457.5
6 day Maximum	194.5	296.8	374.2	419.5	451.6	476.6
7 day Maximum	205.9	311.4	391.1	437.8	470.9	496.6
8 day Maximum	206.5	314.4	396.1	443.8	477.7	504
9 day Maximum	215.3	330.2	417	467.9	503.9	531.9
10 day Maximum	222.7	336	421.8	472	507.6	535.2

Rainfall data analysis for 30 years has been completed for determining the appropriate drainage co-efficient for mole drains as given in Table 2.30. The site selection is under progress and the soil samples were collected and are subjected to soil chemical and physical analysis.

Table 2.30. Drainage Coefficient (DC) values for Bapatla region

Rainfall, mm	Maximum DC values	Average DC, mm/day
One day Maximum	4.1	4.1
Two days maximum	7.1	3.6
Three days maximum	9	3
Four days maximum	9.7	2.44
Five days maximum	10.7	2.14
Six days maximum	11.3	1.9
Seven days maximum	12.3	1.8
Eight days maximum	12.4	1.56
Nine days maximum	13.4	1.5
Ten days maximum	13.9	1.4

Effect of micro irrigation techniques and fertilizer levels on root yield and quality of sugar beet under saline soils of TBP area (Gangavati)

Sugar beet is considered to be a suitable crop for saline soils where sugarcane is not a viable crop due to its sensitivity to soil salinity. As no agronomic information was available for sugar beet in TBP command, initially research was conducted to identify the suitable dates of sowing and planting geometry. During 2013-14, experiment was initiated to study the effect of micro-irrigation and fertilizer levels on root yield and quality of sugar beet under saline Vertisol. Main irrigation treatments were I_1- Drip irrigation, I_2- Sprinkler irrigation and I_3- Furrow irrigation. Sub-treatments were F_1- 100: 50: 50 NPK kg/ha, F_2- 120: 60: 60 NPK kg/ha, F_3- 150: 75: 75 NPK kg/ha, F_4- 200: 100: 100 NPK kg/ha. There were 3 replications and design was split plot. Spacing was 60 cm x 30 cm. Date of sowing was 16-08-2013 and date of harvest 20-02-2014. The variety was Calixta hybrid (JK Seed Company). Experiment was conducted at ARS Farm, Gangavathi. This experiment was initiated during 2013-14 but only fertilizer treatments were implemented. Micro irrigation treatments were not implemented due to shortage of funds. During 2014-15, we could able to implements both micro irrigation and fertilizer levels. However, this experiment was not continued during 2015-16 due to non availability of seeds from the different seed companies. Hence, pooled data of 2013-14 and 2014-15 are presented here (Table 2.31). The results of the two years pooled data revealed that among micro irrigation techniques, drip method of irrigation recorded significantly higher root yield of sugar beet (39.04 t/ha), weight of ten beets (7.94 kg) and brix value (21.85) which was on par with sprinkler method of irrigation as compared to furrow method of irrigation. However, among fertilizer levels, significantly higher root yield (43.31 t/ha), weight of ten beets (8.83 kg) and brix (23.67%) was recorded with fertilizer level at the rate of 200:100:100 NPK kg/ha compared to 100:50:50 and 120:60:60 NPK kg/ha levels but was on par with fertilizer level at the rate of 175:75:75 kg NPK/ha. For all these parameters, the interaction effect was non-significant.

Table 2.31 Root yield (t/ha) of sugar beet as influenced by different irrigation techniques and fertilizer levels

Treatments	Root yield (t/ha)			Weight of ten beets (kg)			Brix value (%)		
	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled	2013-14	2014-15	Pooled
Irrigation Treatments									
I_1- Drip irrigation	36.92	41.17	39.04	7.42	8.46	7.94	21.25	22.46	21.85
I_2- Sprinkler irrigation	36.92	39.88	38.4	7.42	8.25	7.83	21.25	21.75	21.5
I_3- Furrow irrigation	36.92	34.54	35.73	7.42	7.75	7.58	21.25	20.67	20.96
S.Em	-	0.62	0.31	-	0.1	0.06	-	0.17	0.1
CD @ 5%	-	2.43	1.21	-	0.38	0.24	-	0.66	0.41
Fertilizer Treatments									
F_1-100:50:50 NPK kg/ha	30.67	34.39	32.53	6.33	7.22	6.78	18.83	19.83	19.33
F_2-120:60:60 NPK kg/ha	34	36.5	35.25	6.83	7.67	7.25	20.33	20.94	20.64
F_3-150:75:75 NPK kg/ha	39.33	40.28	39.81	7.67	8.33	8	21.17	21.28	21.22
F_4- 200:100:100 NPK kg/ha	43.67	42.94	43.31	8.33	8.89	8.51	22.67	22.44	22.56
S.Em	0.87	0.89	0.74	0.25	0.21	0.2	0.29	0.25	0.15
CD @ 5%	4.77	4.91	4.08	1.37	1.16	1.1	1.07	1.1	0.84
Interactions (IXF)									
S.Em	2.12	2.18	1.81	0.61	0.52	0.49	0.47	0.49	0.38
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

Large scale demonstration on response of sugar beet to dates of sowing under saline Vertisols of TBP area : A large scale demonstration (1 acre) on response of sugar beet to dates of sowing under saline Vertisols of TBP area was also conducted during 2014-15. The data on root yield, weight of ten beets and brix value was recorded at the harvest (Table 2.32). Results indicated that, the higher root yield (38.15 t/ha), weight of ten beets (7.57 kg) and brix (20.33%) was recorded with sowing during August 1st fortnight compared to other dates of sowing. Similarly, gross returns, net returns and B:C ratio were also higher with sowing during August 1st fortnight compared to other dates of sowing. Thus, 1st fortnight of August is more suitable for sowing of sugar beet in TBP command.

Table 2.32 Root yield, weight of ten beets, brix (%) and economic of sugar beet as influenced by different dates of sowing under saline soils of TBP area

Treatments	Root yield (t/ha)	Weight of ten beets (kg)	Brix (%)	COC (Rs./ha)	GR (Rs./ha)	NR (Rs./ha)	B:C
T_1	38.15	7.57	20.33	27,650	76,300	48,650	2.75
T_2	37.45	7.55	20.1	27,650	74,900	47,250	2.7
T_3	33.56	6.89	19.83	27,650	67,120	39,470	2.42

T_1: Sowing during August Ist fortnight. T_2: Sowing during August IInd fortnight. T_3: Sowing during September Ist fortnight

Evaluation of spacing and controlled sub surface drainage system on soil properties, water table, crop yield and nutrient losses in rice fields of TBP Command (Gangavati)

A field experiment was laid out at ARS, Gangavathi in an additional area of 6 ha block adjacent to the existing SSD experiment (50 m spacing) initiated during 2012-13 by taking four additional treatments i.e., conventional and controlled SSD with 40 m and 60 m spacing each with a lateral depth of 1.0 m.

At crop harvest during Kharif-2015, the soil salinity under 40 m spacing conventional SSD was reduced to 8.05 to 6.39 (0-15cm), 9.94 to 9.38 (15-30 cm), 9.7 to 7.63 (30-60 cm) and 8.66 to 7.61 dS/m (60-90 cm), respectively. In case of controlled drainage system, the average soil salinity reduced from 7.33 to 5.3 (0-15 cm), 9.18 to 7.53 (15-30 cm), 8.63 to 9.72 (30-60cm) and 8.16 to 9.92 dS/m (60-90 cm), respectively.

At crop harvest during Kharif-2015, the soil salinity under 50 m spacing conventional SSD was reduced to 4.3 to 2.56 (0-15cm), 5.1 to 3.36 (15-30 cm), 5.93 to 3.06 (30-60 cm) and 5.25 to 2.91 dS/m (60-90 cm) respectively. In case of controlled drainage system, the average soil salinity reduced from 6.28 to 4.87 (0-15 cm), 8.3 to 7.63 (15-30 cm), 12.01 to 9.28 (30-60 cm) and 13.85 to 6.86 dS/m, (60-90 cm) respectively.

At crop harvest during *kharif* 2015, the soil salinity under 60 m spacing conventional SSD was reduced to 7.69 to 6.51 (0-15cm), 10.25 to 8.15 (15-30 cm), 11.01 to 9.33 (30-60 cm) and 11.55 to 10.03 dS/m (60-90 cm) respectively. In case of controlled drainage system, the average soil salinity reduced from 5.99 to 5.34 (0-15 cm) and increased slightly from 6.29 to 6.48 (15-30 cm), 6.43 to 6.93 (30-60cm) and 6.10 to 6.75 dS/m (60-90 cm) respectively. Due to continuous flow in the conventional system removal of dissolved salts through drainage effluent could be at faster and deeper than controlled drainage system. Higher soil salinity at lower depth in controlled system (Table 2.33) may also be attributed to their higher levels of salinity observed initially.

Table 2.33 Soil salinity (ECe, dS/m) as influenced by spacing of SSD and controlled drainage systems

Season	40 m spacing							
	Conventional drainage				Controlled drainage			
	0-15	15-30	30-60	60-90	0-15	15-30	30-60	60-90
Initial	8.05	9.94	9.7	8.66	7.33	9.18	8.63	8.16
Rabi-2013-14	8.0	7.5	7.8	8.9	8.5	7.9	9.1	9.0
Kharif-2014	5.0	7.1	7.3	7.3	4.9	7.8	9.5	9.6
Rabi-2014-15	4.98	7.05	7.79	7.97	4.86	7.80	10.10	9.57
Kharif-2015	6.39	9.38	7.63	7.61	5.3	7.53	9.72	9.92
	50 m spacing							
Initial	4.3	5.1	5.93	5.25	6.28	8.3	12.01	13.85
Rabi -2013-14	7.79	7.79	8.03	7.95	3.72	6.22	8.33	10.91
Kharif-2014	2.5	1.97	3.7	5.32	1.86	4.52	6.94	6.62
Rabi -2014-15	2.20	2.03	3.73	4.42	4.14	5.26	8.64	9.01
Kharif-2015	2.56	3.36	3.06	2.91	4.87	7.63	9.28	6.86
	60 m spacing							
Initial	7.69	10.25	11.01	11.55	5.99	6.29	6.43	6.10
Rabi -2013-14	7.80	8.33	7.76	8.93	6.58	7.24	6.53	6.67
Kharif-2014	6.83	7.2	7.46	7.31	5.47	6.02	7.12	7.46
Rabi -2014-15	5.62	7.67	8.35	9.47	4.39	5.78	5.27	5.68
Kharif-2015	6.51	8.15	9.33	10.03	5.34	6.48	6.93	6.75

In conventional subsurface drainage system during Kharif-2015, the average drain discharge observed was 0.58, 2.61 and 0.86 mm/d for 40, 50 and 60 m spacing respectively. In case of controlled drainage system fitted with water table control PVC pipe set device, the average drain discharge observed was 0.18, 0.81 and 0.56 mm/d 40, 50 and 60 m spacing respectively. Thus, the drain discharge in conventional system at all the spacing was higher over the controlled system. In conventional system, the average salinity of the drainage effluent observed during *Kharif*-2015 was 3.16, 1.97 and 2.14 dS/m, for 40, 50 and 60 m spacing as against 3.23, 1.76 and 1.86 dS/m for 40, 50 and 60 m spacing in controlled sub surface drainage system, respectively. In *rabi* 2014-15 in conventional system, the average salinity of the drainage effluent was 2.87 dS/m as against 2.09 dS/m for 60 m spacing in controlled sub surface drainage system, respectively. In *rabi* 2014-15 in 40 and 50 m spacing, crop was not taken due to water shortage. This means that in case of conventional system, nearly 0.011, 0.031 and 0.011 t/ha of salts was removed through drainage effluent while in case of controlled system it was 0.004, 0.008 and 0.004 t/ha over the sample period in 40, 50 and 60 m spacing respectively. Similarly in 60 m spacing, conventional system 0.385 t/ha of salts removed as against 0.218 t/ha in controlled drainage system. It showed that drain discharge and salt removal, in all the three spacings, were faster over the controlled system in conventional system.

Loss of nitrogen over the sampling period in 40, 50 and 60 m spacing during *Kharif*-2015 was 0.62 vs. 0.18, 4.43 vs.1.05 and 1.5 vs. 0.81 kg/ha under conventional and controlled SSD system, respectively. It was also noted that the crop was not taken during *rabi* 2014-15 in 40 and 50m spacing due to shortage of water. However, in 60 m spacing conventional system 1.30 kg/ha of nitrogen loss was recorded as against 1.05 kg/ha in controlled drainage system in the rabi 2014-15 (Table 2.34).

Table 2.34 Nitrogen loss through drainage discharge as influenced by spacing of SSD and Controlled drainage systems

Spacing (m)	Conventional sub surface drainage (kg/ha)				Controlled sub surface drainage (kg/ha)			
	Rabi- 2013-14	Kharif-2014	Rabi-2014-15	Kharif-15	Rabi-2013-14	Kharif-2014	Rabi-2014-15	Kharif-2015
40	1.85	4.63	-	0.62	0.62	1.54		0.18
50	11.45	5.4	-	4.43	4.03	6.75		1.05
60	4.07	15.47	1.3	1.5	2.87	9.42	1.05	0.81

During *Kharif* 2015, grain yields were 38.2 vs. 34.2 q/ha, 54.3 vs. 49.12 and 49.2 vs. 46.3 q/ha under conventional and controlled drainage systems at 40, 50 and 60 m SSD spacing respectively. In rabi 2014-15, the grain yield was 46.3 vs 45.8 q/ha in under conventional and controlled drainage systems at 60 m spacing. In 50 m spacing at both conventional and controlled drainage system gave higher yield compared to 40 and 60 m spacing because SSD was installed 2 year before and it might have helped in leaching of salts.

Evaluation of mole drains on reclamation of Saline Vertisols in TBP Command (Gangavati)

This project work was initiated at A.R.S. Gangavati . A total of 68 soil samples to a depth of 90 cm with 15 cm increment were collected using GPS during May-2014 and analyzed for soil pH and ECe.The initial soil mean pH values of the experimental area were 8.3 and 8.4 at 0-15 and other lower depth. The initial mean soil salinity (ECe) values of the experimental area were 9.1, 10.1, 10.6 and 10.5 dS/m at 0-15, 15-30, 30-60 and 60-90 cm, respectively. The mean hydraulic conductivity (14 Nos) of the soils was in range from 0.014 to 0.0261 and 0.020 to 0.068 m/day at 0-30 and 30-60 sites, respectively. The initial nutritional parameters like nitrogen, phosphorus and potash information also collected from soil. The soil texture at 0 to 60 cm was found to be clay with clay content varying from 45 to 60% in the study area. It was possible to open mole drains in paddy field at 50 cm depth at 10 m spacing. Prior to land preparation for paddy and drain discharge was also seen. However, immediately after puddling operation all the mole drains were blocked and no drain discharge was observed. Now it is proposed to take up mole drains in cotton field to check the feasibility.

Evaluation of different depth (head) of controlled drainage system in saline vertisols of TBP command (Evaluation of variable lateral out let head of controlled drainage system in saline Vertisols of TBP command) (Gangavati)

An experiment was planned to study/ compare soil properties, water table and crop yield as influenced by variable depth of controlled drainage system; to assess discharge rate and quantify the nutrient losses through the different variable depth of controlled drainage system and to work out the economics of the controlled drainage system. Treatments were T_1 Controlled Drainage spacing of 50 m and upto root zone depth of paddy(control); T_2 Controlled Drainage spacing of 50 m and outlet depth of 0.3 m and T_3 Controlled Drainage spacing of 50 m and outlet depth of 0.6 m. A field experiment was conducted at Thimmapur village (Farmers field) in an area of 2 ha block by taking three treatments. Rice crop (BPT-5204) was transplanted in *Kharif* -2015

A total of 17 soil samples from 2.0 ha area to a depth of 90 cm were collected in the field for characterization. Based on the analysis the ECe of experimental area varied from 4.04 to 23.41 dS/m with an average value of 13.48 dS/m, 4.76 to 26.07 dS/m with mean of 14.40 dS/m, 4.39 to 22.88 dS/m with a mean of 12.29 dS/m and 3.06 to 23.41 dS/m with a mean of 11.67 dS/m at 0-15 cm, 15-30 cm, 30-60cm and 60-90 cm respectively. Further investigation are going on.

Response of cotton to drip irrigation in saline soils under conservation agricultural practices. (Response of cotton to fertigation through drip irrigation in saline soils under conservation agriculture practices) (Gangavati)

The present study aimed to utilize the fertilizer more efficiently and to find out the best dose of fertilizer for

Bt. cotton under saline condition utilizing paddy straw as mulch which is abundantly available but often is burned by the farmers in the command area. The objectives of study are to study the response of cotton to different levels of fertigation under conservation agriculture practices on soil physico-chemical properties in saline Vertisols and to compare yield, fertilizer use efficiency and economics of fertigation in drip irrigation under conservation agriculture practices. Details of the experiment are as below.

The experiment was initiated on cotton during *Kharif* 2013-14 on response of cotton to fertigation in saline soils under conservation agriculture practices at Agricultural Research Station, Gangavati. The initial soil salinity of the experimental plot varied from 5.3 dS/m to 7.0 dS/m and 5.27 dS/m to 9.24 dS/m at 0-15 and 15-30 cm depths respectively and initial pH of the block varied from 8.38 to 8.62 and 8.15 to 8.44 at 0-15 and 15-30 cm depth, respectively. From the eight observation wells the water table depths of different treatment are being monitored. The Bt. Cotton variety viz, Ajit was sown in paired row (0.60x1.20x0.60 m) system with 0.4 m plant to plant distance. The 4 LPH emitters were punched for every two plants on 12 mm lateral and soluble fertilizers were supplied with venturi through drippers. The recommended dose of fertilizers for cotton was 120:60:60 (as per package of practice). Paddy straw @ 6.85 t/ha was used as mulch. Main treatment were i) with residue (M_1) and ii) without residue (M_2). Sub treatments were a) 50 % Recommended dose of fertilizer (S^1), b) 75% Recommended dose of fertilizer (S_2), c) 100 % Recommended dose of fertilizer (S_3) and d) 125 % Recommended dose of fertilizer (S_4).

From the pooled data of two years, the soil moisture content on dry weight basis at mid season and at harvest of cotton at different depth (0-15 and 15-30 cm) revealed that, significantly higher soil moisture was retained in mulch compared to no mulch treatments. Among fertilizer level, there was no significant difference was observed.

The pooled data on vegetative parameter such as germination percentage, plant height, number of monopodial and sympodial branches, bolls per plant and boll weight were analyzed. There was no significant difference between mulch and no mulch treatment and also in fertilizer level treatments with respect to germination percentage. In general, nearly 93 % germination was observed in all the plots. Significantly higher plant height was observed in mulch treatment (125.8 cm) compared to no mulch treatment (121.3 cm) under conservation practice treatments. Similarly, in case of fertilizer levels, significantly higher plant height (126.5 cm) was observed in 125 % RDF compared with 50 % RDF (119.6 cm). No significant difference in monopodial branches per plant was observed either due to mulch, fertilizer levels or interaction. Significantly higher sympodial branches were observed in mulch treatment as compared to no mulch treatment. In case of fertilizer levels, no significant difference was observed. Similarly, no significant difference was observed on sympodial branches due to interaction effects between mulch and fertigation levels. It was recorded that, among mulch and no mulch treatments, significantly more numbers of bolls per plant and higher single boll weight was obtained in case of mulch treatment (32.8 and 5.52 g/boll) respectively. In case of fertilizer level treatments, significantly more number of bolls per plant and higher single boll weight was recorded in 125 % RDF level (33.1 and 5.83 g/boll) which is on par with 100 % RDF (32.1 and 5.44 g/boll), followed by 75 % RDF (30.7 and 5.28 g/boll) and least in case of 50 % RDF (29.7 and 4.82 g/boll) treatment respectively.

The pooled data of three years revealed that, among conservation practice, significantly higher seed cotton yield was obtained in mulch (29.0 q/ha) and without mulch (24.4 q/ha) treatments (Table 2.35). Among fertilizer levels, 125% RDF (S_3) recorded significantly higher in (28.3 q/ha) seed cotton yield compared to S1 (50% RDF, 24.57 q/ha) but was on par with 100 % (27.13 q/ha) and 75 % RDF (26.78 q/ha). Irrespective of fertilizer levels, significantly lower seed cotton yields observed under without mulch treatments and could partly be attributed to intense weed infestation in these plots compared to mulched treatments. No significant difference was observed on seed cotton yield due to interaction effects between mulch and fertigation levels.

Table 2.35 Seed cotton yield as influenced by different fertigation levels and mulching (Pooled data of 3 years)

Fertilizer level	Cotton Yield (q/ha)		Mean
	Without mulch	With mulch	
	M_1	M_2	
S_1	22.5	26.7	24.57
S_2	24.2	29.4	26.78
S_3	24.6	29.7	27.13
S_4	26.3	30.3	28.3
Mean	24.4	29	
	SE m +	CD (0.05)	
M	0.94	4.04	
S	0.78	1.7	
M x S	1.11	NS	

Effect of laser land levelling, micro-irrigation technique and conservation agriculture practices in direct seeded rice under saline Vertisols of TBP command area (Gangavati).

In recent years, due to delay in canal water release coupled with short supply of water, farmers especially at tail-end, finding it difficult to take up second crop of paddy in rabi/summer. Hence, the concept of direct seeded rice (DSR) wherein the advantage of no land preparation, no nursery raising, no transplanting etc is gaining its importance in the command. Due to limited water usage under DSR can also prevent development of waterlogging and soil salinization. However, as such no information is available on DSR under saline soil conditions. Further, there is also need to develop suitable alternate crop(s) for DSR fallows in saline soils of the command. Therefore, experimental study to develop comprehensive understanding about laser land leveling and conservation agriculture practices in DSR area was proposed with 3 sub-experiments.

Sub experiment 1: To study the effect of laser land levelling and conservation agriculture practices in direct seeded rice under saline Vertisols of TBP command

The experiment was initiated during *Kharif* 2013-14 at Agricultural Research Station, Gangavati to know the effect of laser land leveling and conservation agriculture practices on direct seeded rice (DSR) under saline soils. Land was prepared with minimum tillage and leveled by laser leveller and continued during 2014 and 2015. The initial salinity of the experimental plot varied from 7.07-9.67 dS/m and 6.95-9.97 dS/m at 0-15 and 15-30 cm depth, respectively, in DSR plot and 3.85-7.1 dS/m and 4.5-7.5 dS/m at 0-15 and 15-30 cm depth, respectively, at puddled transplanted rice (PTR) plot. The salt tolerant variety viz, CSR-22 was used as a test crop. The soil salinity after harvest varied from 4.03-7.25 dS/m and 5.29-9.63 dS/m at 0-15 and 15-30 cm depth respectively in DSR plot and 4.37-7.45 dS/m and 3.6-5.93 dS/m at 0-15 and 15-30 cm depth respectively at PTR plot. Treatment details are as below.

Main plot:	Sub plot (Irrigation):
(Mulch)	
M_1: Laser levelling + Direct seeded rice +without residue;	S_1: 1.0 ET
M_2: Laser levelling + Direct seeded rice +with residue	S_2: 1.5 ET
M_3: Farmer's practice in saline soil (puddling & transplanting)	S_3: 2.0 ET

The pooled data of two years revealed that, among conservation practices plant height was found non-significant. Whereas, number of tillers per hill and number of panicles per square metre were significantly higher in transplanting method (14.1 and 216.5) as compared to laser leveling + DSR without mulch (8.5 and 176.2) and laser leveling + DSR with mulch (8.8, 190.1) treatments. Among irrigation levels, plant height and number of panicles per square meter were significantly higher at 2.0 ET compared to 1.0 ET. However, number of tillers per hill did not found significant with respect to irrigation levels. The interaction effect of conservation practices and irrigation levels were also non-significant. In case of number of grains per panicle, significantly higher grains were recorded in laser leveling + DSR with mulch treatment followed by laser leveling + DSR without mulch and least in case of transplanting method in conservation practices.

In case of paddy grain yield, the pooled data revealed that no significant difference was observed among laser leveling in DSR without mulch, laser leveling in DSR with mulch and transplanting methods under conservation practices. However, the paddy grain yield differed significantly due to irrigation level treatments (Table 2.36). Significantly higher grain yield was observed in 2.0 ETR (S3) (49.8 q/ha) followed by 1.5 ET (44.1 q/ha) and least in case of 1.0 ET (33.9 q/ha). Interaction effect of conservation practices and irrigation levels found non- significant. Significantly higher grain yields under 2.0 ET compared to 1.5 and 1.0 ET could be due to higher leaching of salts by applying higher level of irrigation.

Table 2.36 Paddy grain yield as influenced by irrigation levels and mulching (Pooleddata of two years)

Irrigation level	Paddy yield (q/ha)			Mean
	Laser leveling + DSR without mulch	Laser leveling +DSR with mulch	Transplanting	
	M_1	M_2	M_3	
S_1	28.84	28.79	43.93	33.9
S_2	40.06	42.01	50.21	44.1
S_3	48.4	51.64	49.24	49.8
Mean	39.1	40.8	47.8	
	SE-m +/	CD (0.05)		
M	2.75	NS		
S	2.41	7.43		
M x S	4.17	NS		

Sub experiment 2: Evaluation of different alternative crops under different tillage methods for rice (DSR) fallows in saline soils of TBP area

The experiment was initiated during rabi/ summer 2013-14 at Agricultural Research Station, Gangavathi in saline soil (6-8 dS/m) after the first crop of DSR in Kharif 2013. The same experiment was continued during 2014-15 and 2015-16. The experiment was conducted in split plot design with main plots (tillage) and sub-plot (crops) as detailed below:

Main plot: (Tillage)	Sub plot (Crop)	Other details
M_1- Zero tillage	T_1- Sweet sorghum	Design : Split plot; Treatments: 9,
M_2- Minimum tillage	T_2- Cluster bean	Replication: 3; Season : rabi/ summer, ECe
M_3- Conventional tillage	T_3- Sunflower	range : 6-8 dS/m

Evaluation of different alternative crops under different tillage methods for rice (DSR) fallows was initiated during rabi/summer 2013-14 and continued for the year 2014-15 and 2015-16. At this site, general DSR was taken up during *Kharif*. During rabi-summer the main treatments consisted of tillage (zero, minimum and conventional tillage) practices and sub-treatments consisted of sorghum, sunflower and cluster bean. These treatments were replicated thrice.

Pooled data of three years (2013-2016) as given in Table 2.37 revealed that, among the different tillage methods, zero tillage recorded significantly higher grain and straw yield in all the three crops (15.33 and 21.44 q/ha) compared to minimum (11.81 and 17.78 q/ha) and conventional tillage (10.66 and 15.89 q/ha). Among the crops (sub-plot), sorghum grain and straw yield was significantly higher (17.24 and 30.56 q/ha) than sunflower (11.63 and 14.00 q/ha) and cluster bean (8.92 and 10.56 q/ha). Interaction effect of tillage methods and crops were also found significant. Among the treatments, zero tillage with sorghum recorded significantly higher grain yield as compared to other tillage methods. Generally, sorghum and sunflower crops performed better under zero tillage. Cluster bean failed to establish properly under minimum and conventional tillage methods partly due to water stagnation. However, soil ECe and pH did not differ significantly due to different tillage methods and different crops. In general, slight decrease in soil ECe in zero tillage as compared to minimum and conventional tillage at harvest of the crop.

Table 2.37 Grain yield (q/ha) as influenced by different tillage methods and different crops (Pooled data of three years)

Treatments	Grain yield (q/ha)				Straw yield (q/ha)			
	Sorghum	Sun flower	Cluster bean	Mean	Sorghum	Sun-flower	Cluster bean	Mean
M_1	18.98	12.67	14.33	15.33	34	15	15.33	21.44
M_2	16.95	11.7	6.78	11.81	30.67	14	8.67	17.78
M_3	15.77	10.53	5.67	10.66	27	13	7.67	15.89
MEAN	17.24	11.63	8.92		30.56	14	10.56	
Comparisons		S.Em±	CD @ 5%		S.Em±		CD @ 5%	
Main		0.41	1.24		1.72		5.16	
Sub		0.44	1.63		0.87		3.2	
Main x Sub		0.66	2.99		1.31		5.88	

Sub experiment 3: Zinc and iron nutrition of dry direct seeded rice (DSR) in saline Vertisol of TBP irrigation command

The dry direct seeded rice (DSR) is known to save land, water, labour and most important one i.e., time compared to the TPR as there is no need of raising nursery, puddling and transplanting of seedlings. In TBP command more than 20,000 ha is already under DSR in the last two-three years and provided normal rainfall is received the area is expected to increase not only due to shortage of water but also because the yields and profit margins are acceptable by the farmers. Since direct seeding follows aerobic cultivation of paddy, it usually results in different nutrient dynamics than the transplanted puddle rice (TPR). In direct seeding, availability of several nutrients including N, P, S and micronutrients such as Zn and Fe, is likely to be a constraint. Restricted Zn movement towards plant roots due to reduced water contents may also occur under DSR. In addition, iron (Fe) deficiency is also an important abiotic factor limiting rice yields under DSR especially when cultivated on calcareous soils.

In view of above, it is imperative to study the effects of zinc and iron nutrition on crop yield and optimize the doses for enhanced crop yield. Treatments details are as below.

Main plot:	Sub plot	Other details
(Levels of Zn $ZnSO_4.7H_2O$)	(Levels of Fe as $FeSO_4.7H_2O$)	Design : Split plot;
Z_1- 0 kg ha^{-1}	F_1- 0 kg ha^{-1}	Replication: 3;
Z_2- 10 kg ha^{-1}	F_2- 10 kg ha^{-1}	Plot size: 5 x 4 m
Z_3- 20 kg ha^{-1}	F_3- 20 kg ha^{-1}	Crop & Variety: Paddy (CSR-36)
Z_4- 30 kg ha^{-1}	F_4- 30 kg ha^{-1}	Season: Kharif 2015

The mean initial surface soil pH and ECe of the experimental was 8.14 and 5.20 dS/m respectively. The organic carbon content was 0.57%. Available N, P and K contents were 173.8, 23.8 and 288.5 kg ha^{-1}, respectively. DTPA extractable Zn and Fe contents were 0.26 and 3.26 ppm, respectively. Paddy seeds were sown manually in lines in August 2014 and harvested at its physiological maturity. Data on plant height, number of tillers/hill, panicle length, test weight, grain and straw yields were recorded.

The results of the study revealed that (Table 2.38) among Zn levels applied, significantly higher paddy grain yield (3743 kg ha^{-1}) was observed with 20 kg ha^{-1} ($ZnSO_4$) over Z1 (3314 kg ha^{-1}) and Z2 (3519 kg ha^{-1}) but on par with Z4 (3724 kg ha^{-1}). Among Fe levels (0, 10, 20 and 30 kg ha^{-1}) applied, significantly higher paddy grain yield (3700 kg ha^{-1}) was observed with 20 kg ha^{-1} ($ZnSO_4$) over F1 (3380 kg ha^{-1}) and F2 (3547 kg ha^{-1})

but was on par with F_4 (3673 kg ha^{-1}). The interaction effects were non-significant. Straw yield also followed the similar trend. The Z_3 and F_3 levels also favoured plant height, No. of panicles/m^2, panicle length, grain filling percentage etc.

Table 2.38 Plant height, yield attributes and grain and straw yield of DSR as influenced by Zn and Fe levels.

Treatments		Plant ht (cm)	No of panicles/ m^2	Panicle length (cm)	Grain filling (%)	Grain yield (q/ha)	Straw yield (q/ha)
Zinc Level (Zn)	Z_1	84.2	327.0	20.8	89.8	3314	3944
	Z_2	86.7	371.7	21.1	90.8	3519	4285
	Z_3	96.0	411.3	22.3	93.5	3743	4741
	Z_4	93.1	399.7	22.0	92.9	3724	4698
	SE m	1.35	5.52	0.36	0.724	56.59	72.93
	CD	4.68	19.1	1.25	2.56	185.83	252.3
Iron Level (Fe)	F_1	87.0	360.3	21.2	90.4	3380	4056
	F_2	89.0	371.2	21.4	91.5	3547	4311
	F_3	92.7	396.9	21.8	92.9	3700	4692
	F_4	91.2	381.3	21.7	92.2	3673	4611
	SE m	1.04	5.59	0.20	0.465	49.0	66.62
	CD	3.05	16.3	0.60	1.36	143.2	194.46
Inter-action (Zn x Fe)	SE m	2.09	11.2	0.41	0.931	98.14	133.0
	CD (0.05)	NS	NS	NS	NS	NS	NS

Evaluation of subsurface drip irrigation on soil physico-chemical properties, growth and yield of salt tolerant sugarcane in saline Vertisols of Tungabhadra command area (Gangavati).

Sub-surface drip irrigation which is being practiced for sugarcane in non-saline soils can become complimentary for growing it under saline conditions as well. It is necessary to study the effect of subsurface drip irrigation vs conventional furrow irrigation method on soil physical and chemical properties in saline vertisols of command area. Information on yield, water use efficiency and economics of subsurface drip irrigation vs conventional furrow method of irrigation in saline soil is needed. The experiment on evaluation of subsurface drip irrigation on soil physico-chemical properties, growth and yield of salt tolerant sugarcane in saline Vertisols was initiated during summer 2013-14 at Agricultural Research Station, Gangavati and continued during 2015-16. Experimental details are given below.

S N	Particular	Details	S N	Particular	Details
1	Crop	Sugarcane	9	Date of harvest	23-01-2016, 23-02-016
2	Variety/ Hybrid	Co -91010 (Dhanush)	10	Sowing method	Paired row
3	No. of treatments	9	11	Row spacing	0.6 x 1.2 x 0.6 m
4	No. of replications	3	12	Plant spacing	30 cm
5	Design	Split	13	Dripper discharge	1.6 lph
6	Treatment size	5.4 m (w) x 9 m (L)	14	Dripper spacing	0.4 m
7	Fertilizer	250:75:190 kg NPK/ha	15	Drip line (Anti siphon)	DNPC 2016x0.4x1.6 lph
8	Date of sowing	5/2/2014			

The experiment was laid out in three replications with main treatments such as surface drip (M_1), subsurface drip (M_2) and furrow irrigation (control) (M_3) and sub treatments such as 0.8 (S_1), 1.0 (S_2) and 1.2 (S_3) ET treatments (Fig. 2.3). The sugarcane salt tolerant variety viz, Co-91010 (Dhanush) procured from Mudhol was sown during Feb-2014 in paired row system (0.6 x 1.20 x 0.6 m). The 16 mm inline Pressure Compensating (PC) anti siphon drippers (dripnet) with emitter spacing of 0.4 m and discharge 1.6 LPH were selected and installed. For subsurface drip treatment, the inline lateral was buried in soil at a depth of 0.15 m facing emitters upward and collecting sub mains for flushing of laterals were given with vacuum breakers. The nine observation wells were installed at each treatment to know the effect of different methods of irrigation technique on water table. The soil samples were collected before sowing to know the initial soil ECe, pH and N, P, K distribution. According to the fertigation schedule, the soluble fertilizers were given through venturi. The soil samples were collected at regular interval for soil moisture analysis.

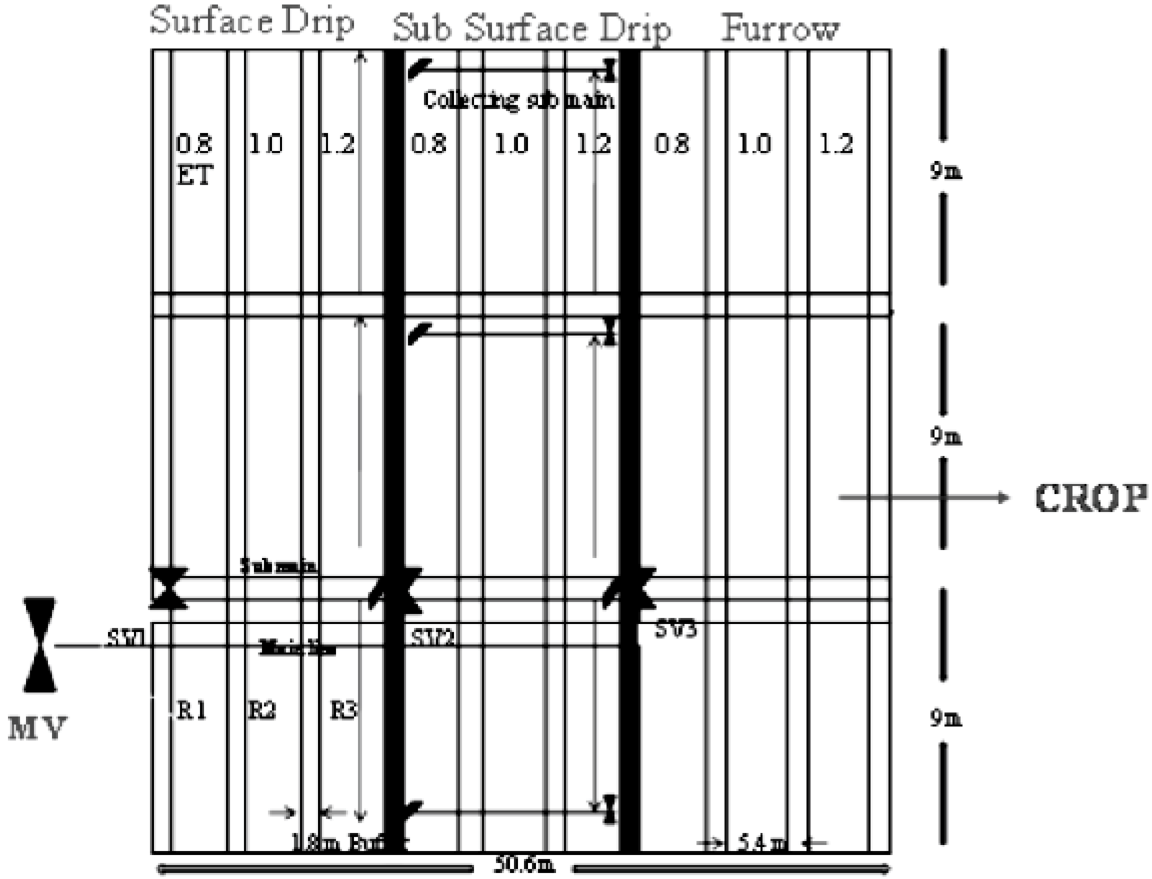


Fig. 2.3 Schematic diagram of sugarcane experimental plot

The initial surface (0-15 cm) soil pH and EC varied from 8.20 to 8.52 and 4.18 to 6.0 dS/m. The mean bulk density and soil porosity of the experimental site ranged between 1.46 to 1.61 gm/cc and 42.8% to 47.2% respectively. The average hydraulic conductivity of the experiment block was 0.23 m/day. The water table depth measured through observation wells weekly for twelve months in all the treatment blocks and the data revealed that, the mean depth of water below ground level (bgl) varied 1.02 (M_2S_2) to 0.73 m (M_3S_3) during summer season (March to July) i.e. in canal off period and the mean depth of water bgl varied from 0.95 (M_2S_1) to 0.48 m (M_3S_3) during the monsoon (August to December) i.e. in canal on period.

The pooled data of two years (2014-15 and 2015-16) revealed that, among surface, surface drip method, at the end of irrigation, the higher soil moisture content (28.5 %) was observed in surface drip with 1.2 ET at 0-15 cm depth at Z-direction (Vertical depth of soil) (Table 2.39). In case of 15-30, 30-45 and 45-60 cm depth of soil, the highest soil moisture content (35.5, 26.5 and 21.9 %) was observed in subsurface drip with 1.2 ET.

In case of X-direction (perpendicular to drip lateral) from 10 cm distance from emitter at 0-15 cm and 15-30 depths, the higher soil moisture content (40.9 and 43.4 %) was observed in subsurface drip at 1.2 ET respectively. In case of 20 cm distance from emitter at 0-15 cm and 15-30 depths, the higher soil moisture content (35.9 and 42.5 %) was observed in subsurface drip at 1.2 ET respectively.

In case of Y-direction (along the drip lateral) from 10 cm distance from emitter at 0-15 cm and 15-30 depths, the higher soil moisture content (55.7 and 57.7 %) was observed in subsurface drip with 1.2 ET respectively. In case of 20 cm distance from emitter at 0-15 cm and 15-30 depths, the higher soil moisture content (54.6 and 57.4 %) was observed in subsurface drip with 1.2 ET respectively. From the above data it can be summarized that, in case of 0-15 cm soil depth, more moisture was retained in surface drip irrigation method compared to subsurface drip irrigation. However, at 15-30, 30-45 and 45-60 cm depth of soil, more moisture was retained in subsurface drip compared to surface drip irrigation method. This is due to less evaporation. It was also observed that higher soil moisture content was observed in Y-direction compared to X-direction because of strip wetting pattern. In case of vertical (Z-direction) soil profiles, the lower moisture was observed compared to lateral directions (X & Y direction) in both the methods of drip irrigation.

Table 2.39 Percentage of moisture stored in soil profile at different depths and distances from emitter in surface and subsurface drip irrigation system (Pooled data of two years)

Distance from lateral emitter (cm)	Depth (cm)	Treatments					
		M_1S_1	M_1S_2	M_1S_3	M_2S_1	M_2S_2	M_2S_3
		Z-direction (vertical depth)					
0	0-15	25.7	28.1	28.5	24.2	25.0	26.6
	15-30	22.6	22.5	25.3	32.0	29.7	35.5
	30-45	17.9	18.7	21.7	24.6	24.8	26.5
	45-60	17.0	18.3	19.2	21.8	19.8	21.9
		X-direction (perpendicular to drip lateral)					
10	0-15	37.1	38.2	40.8	36.2	37.6	40.9
	15-30	34.1	33.8	36.9	41.6	42.4	43.4
20	0-15	30.7	31.9	34.0	32.0	33.0	35.9
	15-30	24.0	28.1	28.7	39.6	40.6	42.5
		Y-direction (along the drip lateral)					
10	0-15	47.9	51.3	52.5	49.8	53.9	55.7
	15-30	41.4	44.5	46.8	52.4	55.1	57.7
20	0-15	44.8	47.1	49.0	49.6	52.1	54.6
	15-30	35.1	39.2	42.0	51.1	54.8	57.4

The pooled of two years revealed that significantly higher cane weight was recorded in subsurface drip (1557 g) compared to furrow irrigation (1250 g) among irrigation methods and significantly higher weight was recorded at 1.2 ET (1463 g) compared to 0.8 ET (1340 g) in irrigation levels. Among irrigation methods, significantly higher cane yield (136.70 t/ha) was recorded in subsurface drip followed by surface drip (128.20 t/ha) and least in case of furrow irrigation (108.6 t/ha) method (Table 2.40). Among irrigation levels, significantly higher yield (130.4 t/ha) was recorded at 1.2 ET irrigation level compared to 0.8 ET (117.7 t/ha) but on par with 1.0 ET (125.5 t/ha) level of irrigation. The interaction effect between irrigation methods and levels was found non-significant.

From the pooled data of two years it was observed that, among irrigation methods, significantly higher water use efficiency (WUE) of 87.60 kg/ha/mm was recorded in subsurface drip irrigation followed by surface drip method (81.90 kg/ha/mm) and least in case of furrow irrigation (69.4 kg/ha/mm) method. Among irrigation levels, significantly higher WUE (85.8 kg/ha/mm) was recorded at 0.8 ET followed by 1.0 ET (79.7 kg/ha/mm) and least in case of 1.2 ET (73.4 kg/ha/mm). The interaction effect between irrigation methods and levels was found non-significant (Table 2.40).

The brix percentage did not affect by different irrigation methods and irrigation levels and interaction between irrigation methods and levels was found non-significant. Normally the brix percentage was ranging 20.1 to 20.7 in all the treatments. The sugar water use efficiency (S-WUE) was calculated based on brix percentage, yield and total water applied. In case of irrigation methods, significantly higher S-WUE was recorded in subsurface drip irrigation (1.81 kg/m^3) followed by surface drip irrigation (1.67 kg/m^3) and least in furrow irrigation (1.4 kg/m^3) method. Among irrigation levels, significantly higher S-WUE was recorded at 0.8 ET (1.72 kg/m^3) followed by 1.0 ET (1.65 kg/m^3) and least in case of 1.2 ET (1.51 kg/m^3) irrigation level (Table 2.40). The experiment will be continued for the 2016-17.

Table 2.40 Sugarcane yield, sugar percentage and water use efficiency as influenced by different irrigation methods and irrigation levels

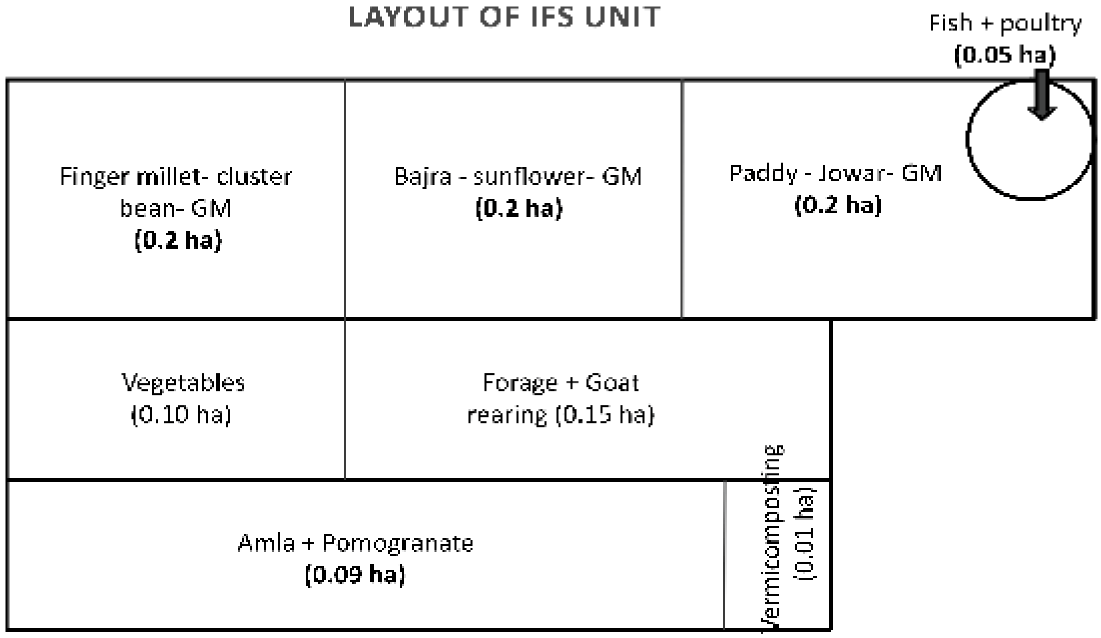
Treatments		Single Cane weight (g)	Cane Yield (t/ha)	WUE (kg/ha/mm)	Brix (%)	Sugar water use efficiency (kg/m^3)
Irrigation methods (IM)	Surface drip	1374	128.20	81.90	20.43	1.67
	Subsurface drip	1557	136.70	87.60	20.72	1.81
	Furrow	1250	108.6	69.4	20.17	1.4
	SE m +/-	21.68	1.42	0.90	0.13	0.007
	CD (0.05)	85.1	5.59	3.54	NS	0.03
Irrigation levels (IL)	0.8 ET	1340	117.7	85.8	20.08	1.72
	1.0 ET	1378	125.5	79.7	20.70	1.65
	1.2 ET	1463	130.4	73.4	20.50	1.51
	SE m +/-	23.61	1.60	0.96	0.21	0.019
	CD (0.05)	72.70	4.95	2.97	NS	0.058
Interaction (IM x IL)	SE m +/-	40.89	2.78	1.67	0.37	0.03
	CD (0.05)	NS	NS	NS	NS	NS

Development of profitable Integrated Farming System (IFS) module for saline Vertisols of Thunga Bhadra Project (TBP) command area of Karnataka (Gangavati)

Agriculture in Tungabhadra Project command area of Karnataka is dominated by rice-rice mono cropping system. Out of 3.62 lakh ha, rice occupies an area more than 2.5 lakh ha. Water logging and soil salinity problems are continuously affecting the productivity of the command due to violation of cropping pattern and unscientific irrigation practices. It is estimated that about 96,215 ha area which accounts for over 32 per cent of the total command area (3.62 lakh ha) is salt affected. It has become an uneconomical enterprise especially for the tail-end farmers of the command who lack adequate supply of water and or facing the problem of salinity/sodicity. There is a need for generating farm income through diversification of agriculture in saline soils where the present rice-rice mono-cropping system is subjected to high degree of uncertainty and thus uneconomical.

IFS Component	Area allotted (ha)
I. Cropping systems	
• Rice - Sorghum – Sunhemp0	0.30
• Bajra – Sunflower - Sunhemp	0.20
• Finger millet – Cluster bean – Vegetable cow pea	0.20
II. Fodder + Goat rearing (Jamnapari/Shirohi-5+1)	0.10
III. Fishery (six species of common carps) in pond	0.06
IV. Poultry (Giriraja-1 and Girirani-5)	
V. Vermi composting	0.01
VI. Vegetables (Okra, Beet root and cabbage)	0.05
VII. Horticulture (Pomegranate, Amla, drum stick)	0.08
Total	1.00
Conventional cropping system (control) (Rice- Rice - Fallow)	1.00 ha

IFS modules are being developed for normal soils. However little or no efforts are made to develop IFS module for salt affected soils in TBP command which is rather a more challenging. To augment farm income and create enterprise to make farmers especially of the tail-end to be self-reliant, this project was initiated to develop a suitable IFS module for salt affected soils in TBP command. Details of IFS components are provided below.



Among all the components of IFS, animal components and poultry on the pond were to be implemented in the ensuing years. With regard to yield obtained in different cropping systems followed, finger millet performed well in both the year of study as compared to other two cropping systems which have been recorded less yield which could be due to higher ECe (10-15 EC) in that area results in poor crop stand and stunted growth. However, though soil ECe was higher (15-20 ECe) in vegetable component, beet root performed well in both the year of study. Economics of each component have been worked out and it is compared with conventional cropping system of rice-rice-fallow. It indicated that mean B: C ratio of all components during 2014-15 and 2015-16 of study is higher (1.67 and 3.68, respectively) as compared to conventional cropping system (1.52 and 2.41). Further, it has to be compared after implementation of all the components of IFS in coming years.

Land shaping interventions for crop cultivation in water logged salt affected areas (Bathinda)

A survey was conducted to identify suitable sites (waterlogged) to demonstrate land shaping intervention. Out of different locations the field of Sh. Buta Singh S/o Sh. Malkeet Singh of Village Ghaga, Tehsil Gidderbaha, Shri Muktsar Sahib was approved for demonstration. Initial analysis of field soils (Table 2.41) showed that the soil is not suitable for crop cultivation.

Table 2.41 Initial soil properties at representative location for land shaping interventions

Soil Property	Soil Depth (cm)		
	0-15	15 -30	30-60
pH (1:2)	10.07	9.94	9.48
EC (1:2)	2.59	1.7	0.9
OC (%)	0.21	0.2	0.23
$CaCO_3$ (%)	5.94	5.37	3.72
K (kg/ha)	233	190.5	179.5
Na (kg/ha)	1902.5	1452.5	789.5

The scientists associated in the project at Bathinda centre visited ICAR-CSSRI, RRS, Lucknow during July, 2015 to acquaint with different land shaping models and a two tier design was adopted for the selected site for the region of Punjab after discussion with scientists working at CSSRI, Regional Research Station, Lucknow. Before execution of the work, estimate as well as financial sanction for the work was obtained from the competent authority of PAU, Ludhiana. Quotations from different contractors for above said work were invited and work order was issued to the contractor. But the work could not be started at the approved site due to some internal family issues/ circumstances of the farmer. After denial from first farmer, an another site (field of Sh. Harmeet Singh S/o Jagdev Singh of village Their Bhai Ke) in adjoining village having similar conditions of waterlogging and salinity was then identified and the contractor started the work after approval from competent authority. However, collapsing of side walls during excavation work was experienced due to quick sand condition as result of light texture of the soil and shallow water table at site. Consequently, contractor denied to execute remaining work with approved rates in estimate and started demanding additional charges for dewatering. Finally, work was stopped due to paucity of funds and no financial provision for dewatering work in original estimate. The OIC, Bathinda centre informed these facts to PC Unit at ICAR-CSSRI, Karnal and requested to visit PAU Regional Research Station, Bathinda to resolve problems arising during land shaping intervention. Finally, Dr. M.J. Kaledhonkar, Project Coordinator and Dr. R.L. Meena, Senior Scientist from PC unit visited the RRS, Bathinda to discuss the issue in details. During the visit, earlier sites as well as land taken on lease by PAU at village Ratta Khera in District Shri Muktsar Sahib were seen and inspected by the joint committee of ICAR- CSSRI, Karnal and AICRP on SAS&USW, RRS Bathinda. After visit to all sites, the joint committee felt that it would be better to demonstrate land modification technologies for waterlogged saline soils at land acquired by PAU, RRS Bathinda at Ratta Khera and necessary actions may be taken by RRS Bathinda for execution of work at earliest. The proceeding of joint committee, based on visit of sites in Shri Muktsar Sahib, Punjab was submitted for approval of competent authority at PAU, Ludhiana.

Isolation and characterization of microbes to enhance crop performance under saline environment (Port Blair)

Isolation and characterization of salinity tolerant effective microorganisms

Twenty microbes have been isolated from different saline environment across different islands and characterised. The results showed that all the isolates utilized a significant amount of iron in siderophore production, showing a yellow zone on the CAS agar medium plate and solubilized phosphorus in the plate-based assay as evidenced by the formation of a clear halo zone around the colony (Plate 2.4).

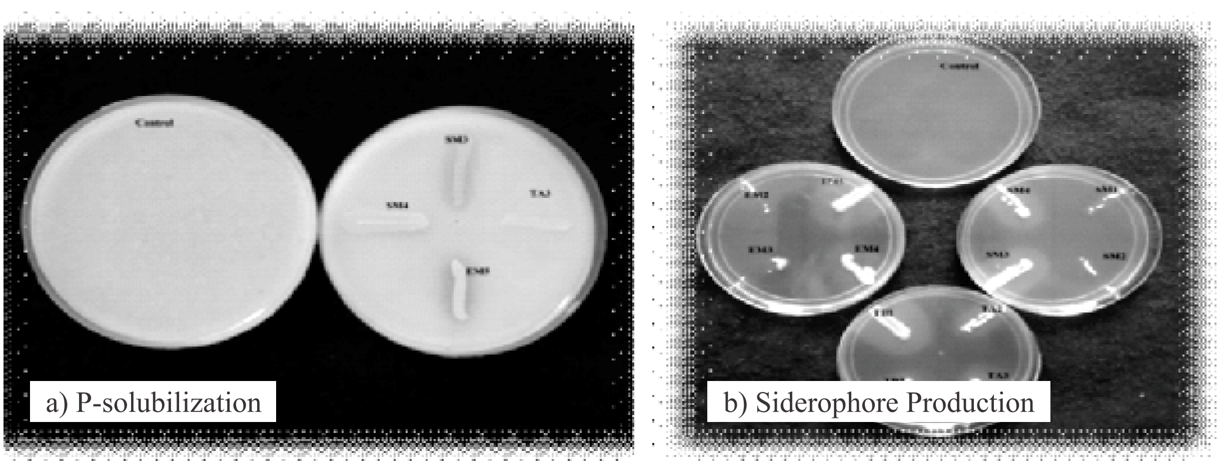


Plate 2.4 Invitro performance of bacterial isolates for selected properties

The study indicated that among the isolates *Bacillus subtilis* produced maximum IAA (34.9 $\mu g\ ml^{-1}$) and *B. cereus* solubilized maximum P (37.9 $\mu g\ ml^{-1}$), *L. sphaericus* produced maximum siderophore (Table 2.42). Similarly 12 fungal isolates mostly of *Trichoderma spp.* have been isolated from rhizosphere soil samples collected from saline and marshy areas which was evaluated for its growth promotion and plant protection properties.

Table 2.42 Characterization of bacterial isolates for plant growth promoting traits

Properties	Isolate name			
	B. subtilis	L. sphaericus	B. pumilus	B. cereus
IAA production	+++	++	+	+++
IAA production (µg/ml)	34.9	31.6	21.4	33.1
P-Solubilization	++	++	++	+++
P-solubilization (µg/ml)	41.3	35.3	36.4	37.9
Siderophore production	+++	+++	++	++

Field evaluation of effective microorganisms

In-vitro study on germination and growth promotion ability of salinity tolerant bacteria (*Lysinibacillus* and *Bacillus cereus*) on Maize at 5 and 10 dS m^{-1} indicated significant effect. Among the isolates tested using brinjal as test crop, *Bacillus subtilis and B. cereus were identified as efficient* phosphorus solubilizers having growth promotion effect by production of IAA. All the isolates promoted root and shoot growth of brinjal seedlings and *B. subtilis* is highly significant in promoting seed germination.

After laboratory study, four native isolates of *Trichogramme harzianum* were evaluated for its growth support properties in a pot culture experiment. The effect of four native isolates of *Trichoderma harzianum* on salt stress of brinjal (0, 2, 4, 6 dSm^{-1}) was studied. Salt stress caused significant decrease in germination and seedling growth in untreated plants while seed treatment has significantly increased the germination, shoot and root growth during salinity stress (Fig. 2.4). Maximum shoot and root length were recorded in Th-5 (13.5 cm and 9.0 cm, respectively) followed by Th-7 (13.4 cm and 8.6 cm, respectively). The increase in growth was due to the production of cytokinin-like plant growth molecules by *Trichoderma* strains At higher salinity (6 dS m^{-1}) level proline and phenol concentration were higher in treated plants.

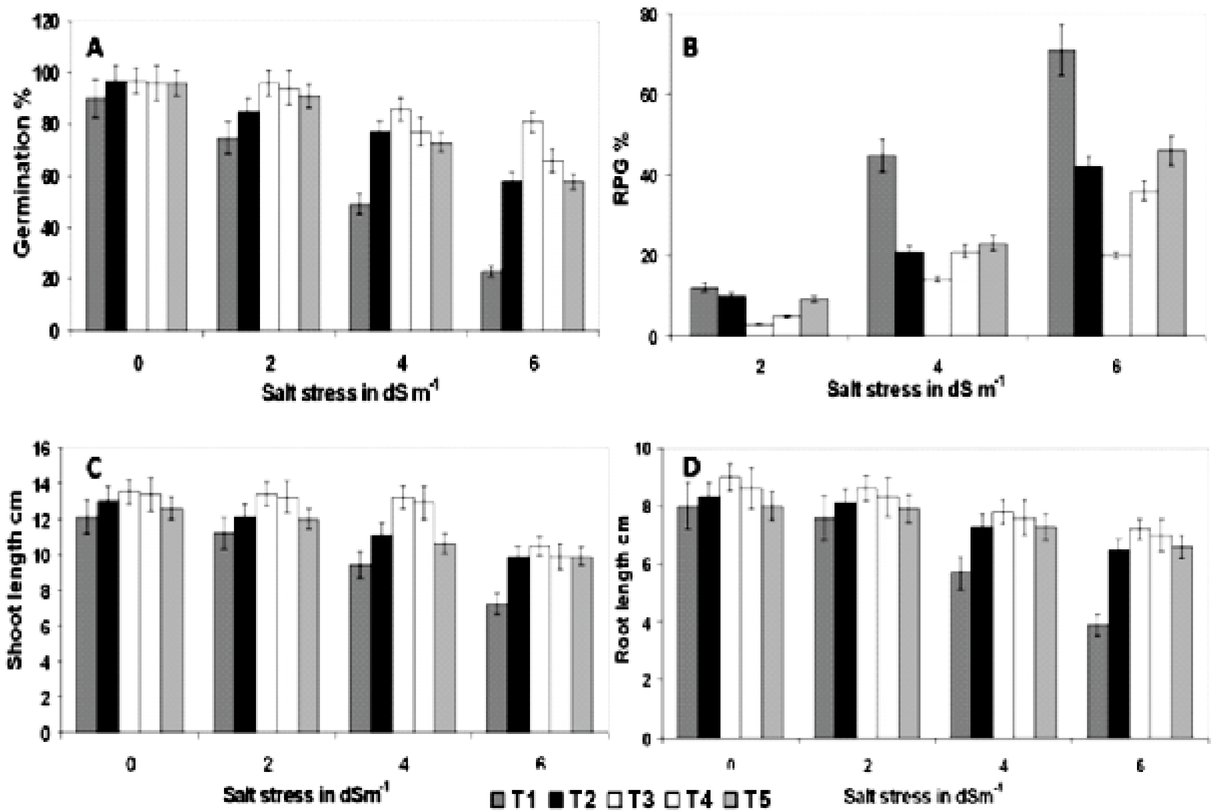


Fig. 2.4 Effect of seed treatment with salinity tolerant isolates of T. harzianumon on brinjal grown under different levels of salt stress A. Germination (%), B. RPG (%), C. Shoot length (cm), D. Root length (cm)

Effect of organics on plant growth and yield parameters of Brinjal

A field experiment was conducted at Field Crops Experimental Farm, Bloomsdale of Central Islands Agricultural Research Institute, Port Blair during January to May 2016 to study the effect of application of CIARI bioconsortia along with biogranules on the plant growth and yield parameters of brinjal (Var.VNR 218). The experiment was conducted in RBD with 4 treatments (T_1: control, T_2: Chemical fertilizer as per RDF), T_3 : Vermicompost (100% RDF N through VC) and T_4: Bioconsortia + biogranules @ 100g per plant) in 3 replications. The 45 days old seedlings were transplanted at a spacing of 60 x 60cm during January 2016 and all cultural practices were common except nutrient application. From each plot 5 plants were randomly tagged to record observations on plant height, no.of branches, no.of fruits, fruit weight per plant. The results are presented in Table 2.43 and showed that all the treatments have significantly increased the plant growth and yield parameters. Among the treatments bioconsortia significantly increased number of fruits, fruit weight and total yield which was on par with 100% RDF of chemical fertilizers under normal conditions.

Table 2.43 Effect of different treatments on growth and yield parameters of brinjal

Treatment	Mean observations per plant					Total yield ($t\ ha^{-1}$)
	Plant height (cm)	No. of branches	No. of leaves	No. of fruits	Fruit weight (g)	
Control	64	5	72	24	362.0	10.6
Chemical fertilizer (100% RDF)	75.2	11	91	30	856.8	23.8
Vermicompost	73	8	95	22	637.2	17.7
Bioconsortia + Biogranules	77	13	92	35	933.2	25.9

Exploring land and water management options for ensuring crop cultivation in low-lying coastal areas in case of sea water intrusion (Panvel)

The purpose of experiment was to develop an ideal and profitable model of Integrated Farming System for marginal (0.36 ha) and small (1.44 ha) farm house holds and to demonstrate it on farmer's field for efficient use of available farm resources. The details of two sites are provided in Table 2.44 and composition of models is provided in Table 2.45 and Table 2.46, respectively, for Vashi and Koproli with Benefit: Cost ratio as 1.99 and 1.67.

Table 2.44 Geographical information of the IFS Centre, Panvel

Sr. No.	Particulars	Information	
1	Geographical co-ordinates	1) Uran (Koproli village)	2) Pen (Village Vashi)
	i)Latitude	18.88 ^{0}N	18.40^{0}N
	ii)Longitude	72.94^{0}E	73.05^{0}E
2	Agro-Ecosystem (Av. Rainfall mm)	Coastal Hot and Humid (2800 mm)	
3	Agro-climate zone	12 West Coast Plains and Ghat Zone	
4	NARP Zone	North Konkan Coastal Zone (MH-2)	

Table 2.45 Composition of IFS model –Area-1.00ha (Vashi)

I. Seasonal crops					
Kharif season			*Rabi* Season		
Crop	Variety	Area (ha)	Crop	Variety	Area (ha)
Rice	PNL-1	0.25	Veg	-	0.02
Veg (Bhendi) (on bund)		0.02			
	Total	0.27		Total	0.02

II. Perennial crops:			
Sr.No.	Crop	Variety	Area (ha)
1	Coconut (on bund)	Banavali	0.20
2	Spices	Intercropped	0.01
3	Chiku	Kalipatti	0.03
Total			0.24
I. Livestock:			
Sr.No.			
A	Pond (Fish)		4035.75m^2
B	Poultry (50 birds)	Giriraj	35.75 m^2
		Total	4071.5 m^2
IV. Complementary enterprise :			
Sr.No.			
A	Vermi -compost unit	*Isaenia foetida*	8 m X 5 m(40 m^2)
B	Kitchen garden		8m X 4 m (32m^2)
C	Ornamental fishes		5mX3 m(15 m^2)
		Total	87m^2
V. Land for other uses:			
A	Store, threshing yard, operational area, roads, bunds, etc.		741.50 m^2
		Total	741.50 m^2
		Grand Total	1.00 ha

Benefit: Cost Ratio for IFS Model

Total cost	Gross Returns (Rs.) (Value of all the farm commodities produced at farm	Net Return (Rs.) (Gross returns - cost of production)	B:C
198720.5	396641.3	197920.7	1.99

Table 2.46 Composition of IFS model –Area-1.00ha (Village: Koproli, Tehsil Uran)

I. Seasonal crops					
Kharif season			*Rabi* Season		
Crop	Variety	Area (ha)	Crop	Variety	Area (ha)
Rice	PNL-1	0.50	Field bean	Konkan wall	0.25
Vegetables (Okra on bund)		0.02			
	Total	0.52		Total	0.25

II. Perennial crops:			
Sr.No.	Crop	Variety	Area (ha)
1	Coconut (on bund)	Banavali	0.15
2	Spices	Intercropped	0.01
3	Chiku	Kalipatti	0.03
	Total		0.19

III.	Livestock:		
Sr.No.	Particulars	Variety	Area (ha)
A	Pond (Fish)		2035.75 m^2
B	Poultry (50 Birds)	Giriraj	35.75 m^2
		Total	2071.5 m^2
IV. Complementary enterprise			
Sr.No.	Particulars	Variety	Area (ha)
A	Vermi-compost unit	*Isaenia foetida*	8 m X 5 m(40 m^2)
B	Kitchen garden		7m X 4 m (28 m^2)
	Total		68 m^2
V. Land for other uses:			
	Store, threshing yard, operational area, roads, bunds, etc.		760.5 m^2
	Total		760.5 m^2
	Grand Total		1.0 Ha

Benefit : Cost Ratio

Total cost	Gross Returns (Rs.) (Value of all the farm commodities produced at farm	Net Return (Rs.) (Gross returns – cost of production)	B:C
173998.9	291984.5	117985.6	1.67

2.3 Management of Saline–acidic soils

Integrated farming system for sustainable land use in Pokkali lands – vegetable cultivation (Vytilla)

In this experiment was planned to study the effect of plastic mulch on reducing salinity in *Pokkali* lands and to find out best vegetable crop suitable for *Pokkali* lands during summer. To execute the experiment under field condition different activities such as site selection (i.e. bunds of *Pokkali* lands of farmer's field at Kumbalangi, Ernakulam and upland in *Pokkali* lands of Rice Research Station, Vyttila), levelling and laying out of the fields, preparation of ridges and furrows in the prepared fields, laying out drip irrigation at RRS Vyttila during 2015, spreading of polythene mulches in the fields, supply of inputs viz. seed, seedling and fertilizers as and when required to the farmer, spacing according to Package of Practices recommendation of Kerala Agricultural University, application of fertilizers and manures as per Package of Practices recommendation of Kerala Agricultural University, regular irrigation with fresh water, harvesting of rain water on mulch in between two ridges of crops and use of this rain water for irrigation in farmer's field at Kumbalangi and application of need based use of ecofriendly insecticides to control pests were completed. The experimental details are provided in Table 2.47.

Table 2.47 Experimental details

Sl. No.	Treatments	Crops	Use of mulch	Other details
1	T_1C_1	Cauliflower	With mulch (WM)	• Number of treatments: 8
2	T_2C_2	Cabbage		• Design: RBD
3	T_3C_3	Cowpea		• No. of replications: 3
4	T_4C_4	Bhindi		• Plot Size: 3m X 2m
5	T_5C_1	Cauliflower	Without mulch (WOM)	• Vegetables: Caulifower, cabbage, cowpea and bhindi
6	T_6C_2	Cabbage		
7	T_7C_3	Cowpea		
8	T_8C_4	Bhindi		

The experiment was conducted at two locations (in farmer's field and research station). The field of Sri. C. K. Mathew, a *Pokkali* farmer was selected to study the effect of mulch on salinity and yield of vegetables in typical *Pokkali* lands at Kumbalangi in Ernakulam district. He is a well experienced farmer in cultivating *Pokkali* land in the traditional way. The same experiment was conducted in upland of Rice Research Station, Vyttila to compare the effect of salinity on yield of vegetables. Both winter season vegetables (cauliflower and cabbage) and summer season vegetables (cowpea and bhindi) were selected to find out the adaptability of these vegetables in *Pokkali* lands and to find out the most suitable winter season and summer season vegetables for *Pokkali* fields. The farmer' field at Kumbalangi is typical *Pokkali* lands, where *Pokkali* rice varieties were cultivated during *Kharif* followed by prawn during remaining period of time. In between these *Pokkali* lands, bunds of 1 m height and 3 m width were raised for planting coconut palms. These bunds were prepared and coconut palms were planted during 1991- 1992. These raised bunds were selected for planting vegetables. After leveling of fields and preparation of ridges and furrows, polythene mulches were spread over the fields. The planting was done on ridges according to spacing of KAU POP for each crop. Recommended doses (KAU POP) of manures and fertilizers were applied. Fresh water was used for irrigation at Vyttila and fresh water along with rain water was used for irrigation at farmer's field.

Analytical data showed that, the pH of soil samples of both at Kumbalangi (Table 2.48) and RRS, Vyttila (Table 2.49), after harvest of vegetables was reduced. The reduction in pH of the soil samples was more in treatments with mulch as compared to without mulch in case of all vegetables at both places. The electrical conductivity of soil samples in all treatments were found to be increased at both places. The organic carbon content of the soil samples after harvest of vegetable in all treatments were higher except in treatment where cowpea was grown without mulch. The phosphorous content was higher in treatments without mulch in both places except in case of cabbage and cowpea with mulch at Kumbalangi and RRS, Vyttila respectively. The potassium content of the soil samples of RRS, Vyttila was found to be consistently higher in treatment with mulch rather than treatment without mulch. The sodium content increased in all treatments compared to initial value except in treatment with mulch of cowpea. The calcium content was decreased in all treatments compared to initial value at RRS, Vyttila. In case of Kumbalangi, the calcium content was found to be reduced in treatment with mulch of cabbage and cowpea. The magnesium content was reduced as compared to initial value in all treatments at both places. The sulphur content was increased as compared to initial value in all treatments at both places. All micronutrients were found to be increased in comparison with the initial values of all treatments. The highest is seen in the case of iron in the cowpea cultivation with mulching.

Table 2.48 Changes in soil properties before and after harvest of vegetables at Kumbalangi (2014-15)

Soil Properties	Unit	Initial	Cauliflower		Cabbage		Cowpea		Bhendi	
			WM	WOM	WM	WOM	WM	WOM	WM	WOM
			After harvest							
pH		4.65	4.06	4.57	4.10	4.42	4.12	4.11	4.11	4.44
EC	dS m^{-1}	0.34	0.98	0.74	1.61	1.16	1.74	1.50	0.81	1.34
OC	%	2.53	2.70	2.83	2.64	2.53	2.67	2.38	2.52	2.56
P	kg ha^{-1}	23.62	21.67	53.18	45.93	41.22	19.70	32.15	17.26	43.96
K	kg ha^{-1}	452.48	764.21	567.09	798.93	583.15	509.97	561.12	543.95	625.71
Na	kg ha^{-1}	467.04	821.33	894.88	1429.87	1617.65	1366.40	1324.96	833.65	1773.71
Ca	mg kg^{-1}	655.75	484.62	777.17	660.53	650.83	709.37	677.87	533.13	731.00
Mg	mg kg^{-1}	38.84	28.85	19.42	28.75	29.20	29.28	28.50	28.32	28.73
S	mg kg^{-1}	1.29	5.80	4.06	6.83	5.53	7.04	8.99	3.85	5.53
B	mg kg^{-1}	0.03	0.16	0.17	0.18	0.18	0.19	0.23	0.16	0.18
Fe	mg kg^{-1}	250.07	910.10	639.43	654.20	479.83	808.97	618.90	800.60	686.47
Zn	mg kg^{-1}	0.61	5.23	11.60	7.43	7.80	6.67	6.87	4.50	8.93
Cu	mg kg^{-1}	0.01	0.67	0.67	0.80	0.53	0.57	0.53	0.80	0.57
Mn	mg kg^{-1}	0.49	7.20	13.87	9.23	8.67	8.47	8.30	5.90	10.30

Table 2.49 Changes in soil properties before and after harvest of vegetables at RRS, Vyttila (2014-15)

Soil Properties	Unit	Intial	Cauliflower		Cabbage		Cowpea		Bhendi	
			WM	WOM	WM	WOM	WM	WOM	WM	WOM
			After harvest							
pH		6.64	5.72	6.29	6.08	6.23	5.98	6.43	6.20	5.85
EC	dS m^{-1}	0.41	1.50	0.96	1.38	1.37	0.57	0.53	0.91	0.59
OC	%	0.36	1.50	1.72	1.53	1.25	1.36	1.17	1.56	1.12
P	kg ha^{-1}	148.6	93.44	112.67	97.96	100.04	113.81	105.00	60.78	96.63
K	kg ha^{-1}	327.04	436.80	298.67	377.81	323.68	311.73	280.75	376.32	173.97
Na	kg ha^{-1}	339.36	512.21	418.88	420.75	481.23	206.08	430.83	465.55	358.03
Ca	mg kg^{-1}	1315	698.17	641.88	775.83	653.00	658.28	865.98	758.67	526.67
Mg	mg kg^{-1}	34.4	26.70	17.85	27.15	26.25	27.97	25.68	25.73	26.87
S	mg kg^{-1}	1.87	18.09	9.59	17.66	16.20	9.48	3.41	9.10	5.42
B	mg kg^{-1}	0.04	0.66	0.19	0.35	0.19	0.39	0.14	0.27	0.15
Fe	mg kg^{-1}	216.8	476.57	382.27	471.73	506.83	371.27	396.60	443.23	501.73
Zn	mg kg^{-1}	1.4	12.20	11.33	13.90	11.63	12.30	8.23	11.63	7.73
Cu	mg kg^{-1}	0.1	1.17	1.17	1.10	1.10	1.10	1.00	1.23	1.03
Mn	mg kg^{-1}	4.68	28.03	28.73	28.00	26.37	27.63	19.87	26.07	17.37

Analytical data (Table 2.50) showed that the pH of soil samples of RRS, Vyttila before and after harvest of vegetables were found to be increased during 2015-16. The increase in pH of the soil samples was more in treatments with mulch as compared to without mulch in case of all vegetables. The electrical conductivity of soil samples in all treatments was found to be greater in treatments with mulch. The organic carbon content of the soil samples after harvest of vegetable in all treatments were higher except in treatment where