cowpea and bhindi when grown without mulch. The phosphorous content was found to be reduced in all treatments. phosphorous content was comparatively higher in treatments without mulch except in case of cauliflower with mulch which is in agreement with the results of previous crop season

Table 2.50 Changes in soil properties before and after harvest of vegetables at RRS, Vyttila (2015-16)

Soil Properties	Unit	Initial	Cauliflower		Cabbage		Cowpea		Bhindi	
			WM	WOM	WM	WOM	WM	WOM	WM	WOM
			After harvest							
pH		3.99	5.71	5.83	4.77	5.9	6	4.3	5.83	4.59
EC	dS m^{-1}	0.17	0.33	0.4	0.36	0.38	3	0.36	4	0.36
OC	%	0.36	1.46	1.66	1.11	1.48	1.37	1.17	1.48	1.07
P	kg ha^{-1}	149.8	71.33	49.78	57.55	66.98	52.89	65.11	43.55	53.77
K	kg ha^{-1}	572.3	829.2	406.56	772.8	717.92	776.16	779.52	700	613.6
Na	kg ha^{-1}	88.5	512.21	418.88	420.75	481.23	206.08	430.83	465.55	358.03
Ca	mg kg^{-1}	655.5	548.19	481.28	654.83	512	321.28	296.98	751.6	426.67
Mg	mg kg^{-1}	15.1	10.65	26.88	25.64	24.765	24.7	26.756	26.7	27.08
S	mg kg^{-1}	0.4	0.649	0.444	0.232	0.303	0.194	0.205	0.054	0.108
B	mg kg^{-1}	0.04	0.12	0.13	0.29	0.22	0.16	0.16	0.26	0.21
Fe	mg kg^{-1}	418.4	22.29	44.25	16.64	36.38	62.14	15.16	13.29	22.39
Zn	mg kg^{-1}	0.3	10.2	9.3	12.9	9.9	13.01	13.23	14.98	13.85
Cu	mg kg^{-1}	0.5	4.25	4.18	1.39	1.29	5.97	1.98	3.63	4.26
Mn	mg kg^{-1}	1	24.03	21.7	26	29.18	25.65	18.12	22.07	14.97

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 which is exactly the same trend as in previous cultivation. 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. The magnesium content was increased as compared to initial value in all treatments except in cauliflower with mulch. The sulphur content was increased as compared to initial value only in both the treatments of cauliflower. All the other three crops recorded reduced value in both the treatments. All micronutrients were found to be increased in comparison with the initial values of all treatments except in case of iron.

The crop performance was very good at RRS, Vyttila (Fig. 2.5), but, winter season vegetables like cauliflower and cabbage did not come up well in Kumbalangi (Fig. 2.6).

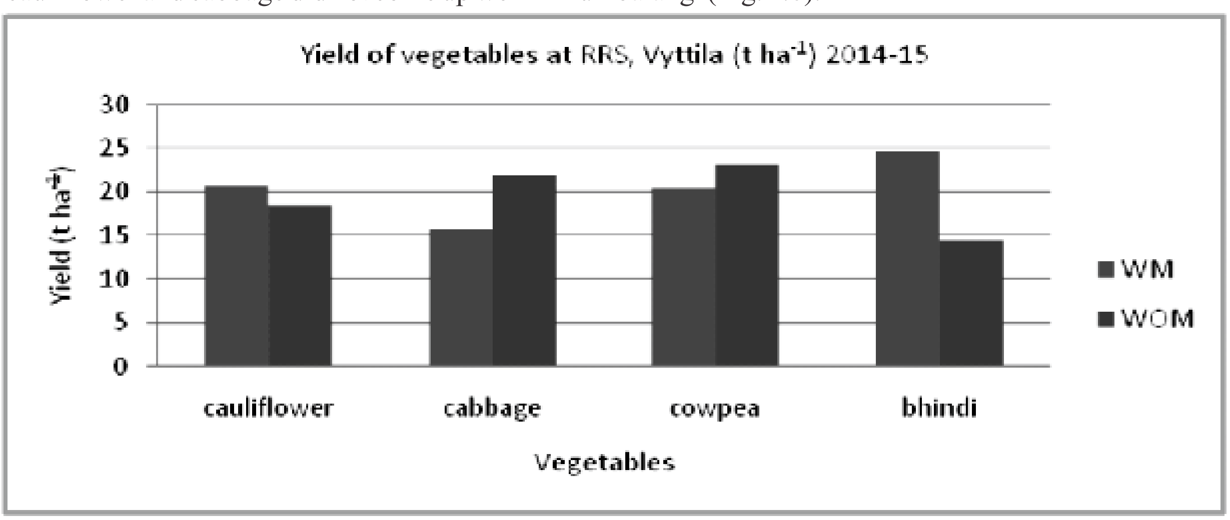

Fig. 2.5 Yield of vegetables at RRS, Vyttila

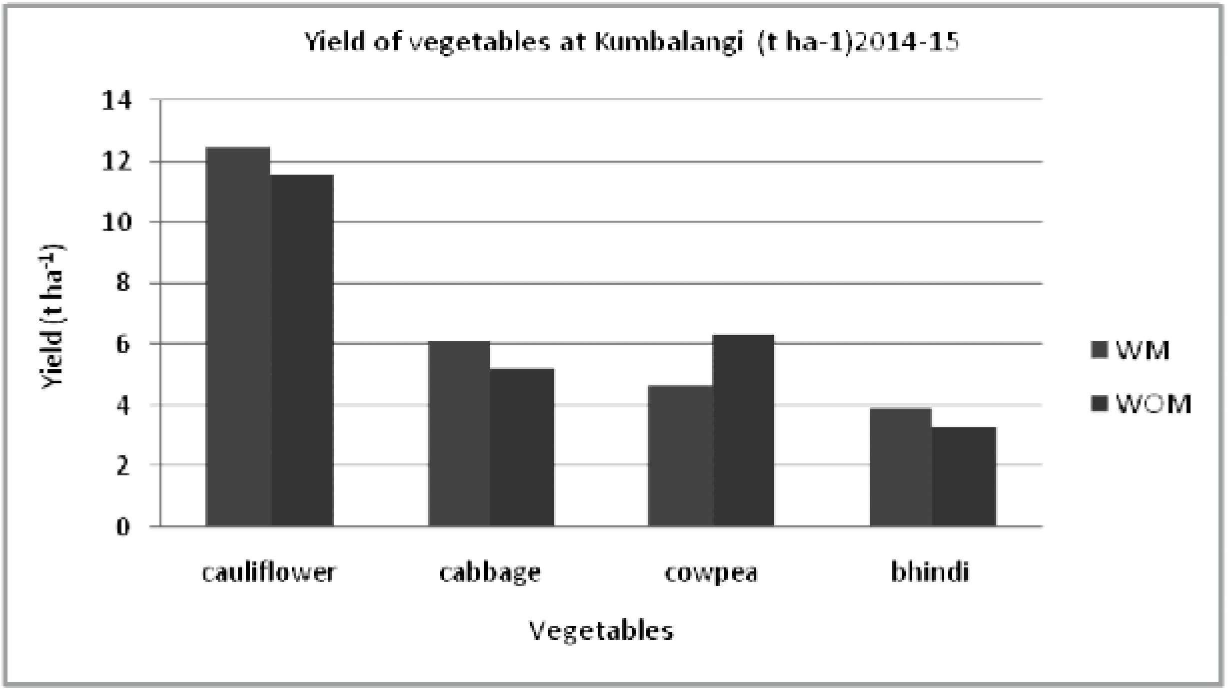

Fig.2.6 Yield of vegetables at Kumbalangi

It was seen that, mulching with polythene sheet is having a significant effect on crop growth and yield of vegetables viz. cauliflower and bhendi at RRS, Vyttila. The winter season vegetables did not come up well in typical *Pokkali* lands. As compared to growth performance and yield of cauliflower, growth of cabbage was very poor and more susceptible to salinity at farmer's field. There is a periodic increase in electrical conductivity of water due to brackish water intrusion. This may increase the salinity of soil and affect the crop growth and yield. By the adoption of proper management techniques to reduce this salinity, sustainable yield of crops can be achieved.

The second phase of the experiment was conducted in the research station only. The experiment was conducted in bunds of pokkali field 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 bhendi) were selected to know the adaptability of these vegetables in *Pokkali* lands and to find out the most suitable cool season and summer season vegetables for *Pokkali* fields. The bunds in between the ponds were selected for planting vegetables. After leveling of fields and preparation of ridges and furrows, drip fertigation was installed and 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, liming and fertilizers were applied. Fresh water was used for irrigation at Vyttila.

The highest yield was obtained in T_4C_4: Bhendi with mulch. It was found that the treatments with mulch produced more yield than without mulch except in cabbage. The crop performance of bhindi and cowpea was very good at RRS, Vyttila, but, the winter season vegetables like cauliflower and cabbage did not come up well due to the increase in temperature during the season. The cauliflower did not flower due to the increase in temperature.

It was seen that, mulching with polythene sheet is having a significant effect on crop growth and yield of vegetables viz. cowpea and bhendi at RRS, Vyttila. In case of cabbage and cauliflower, the general performance was found to be poor.

The experimental conditions (eg. fertigation) were modified to some extent during second year and hence first year's results are not comparable with second year's results. During first year cowpea performed better without mulch. However, cowpea performed better with mulch during second year. Similarly, there was decrease in soil pH during first year while increase in soil pH was observed during second year. This clearly indicated that water and salt dynamics of pokkali land is very complex and sensitive and to understand basic chemical processes in soil further investigation are required.

Rice – prawn integration in Pokkali (Vytilla)

The experiment was planned to evaluate the rice-fish/prawn integration in *Pokkali* lands for maximum productivity as well as benefits and to analyze the changes in soil properties. The site for experiment at *Pokkali* land at farmer's field, Kumbalangi, Ernakulam was selected. Field for rice cultivation was made ready. Rice variety Vyttila - 6 was cultivated during first season (Plate 2.5). The field was drained out followed by rice cultivation and prepared for prawn cultivation (Plate 2.6). Mahuva cake was applied @ 50 kg/acre into the field to make the land free from pests and pathogens. Then the plot was kept as such for two weeks to kill pest and pathogens. After that, fresh water was allowed to enter the field through a sluice. The sluice was made up of wire mesh with brush to stop the entry of weeds and foreign materials. The tiger prawn seedlings collected from MPEDA were released into one acre of pokkali land @ 15,000 seedlings/acre on 5th March 2015. Analytical data of soil samples before and after rice cultivation are given in Table 2.51.

Plate. 2.5 Rice cultivation during kharif season

Table 2.51 Changes in soil properties before and after rice cultivation (2014-15 and 2015-16)

		2014-15		2015-16	
Properties		Initial	Final	Initial	Final
pH		6.64	5.66	7.03	8.3
EC dSm-1		12.7	3.9	3.01	7.6
OC %		2.1	1.89	1.97	1.05
Na	kg ha-1	339.36	1317.15	1010.2	2611.8
K	kg ha^{-1}	327.04	259.36	672	664.2
P	kg ha^{-1}	148.6	22.66	19.3	37.1
Ca	mg kg-1	1315	1945.62	615	783
Mg	mg kg^{-1}	34.4	14.75	17.2	16.7
S	mg kg^{-1}	1.87	9.36	37	48.8
Fe	mg kg^{-1}	90.04	124.87	139.4	442.1
Zn	mg kg^{-1}	1.4	1.6	0.4	0.6
Cu	mg kg^{-1}	0.1	0.4	0.1	0.2
Mn	mg kg^{-1}	4.6	4.8	0.7	0.8

It was observed that:

- pH recorded an increase in the year 2015-16 compared to the previous 2014-15
- EC values before cultivation was more during second year than in the previous year. After cultivation, EC values decreased in both years
- Organic C content was high in 2014-15 than in 2015-16. Highest value was observed in the initial than in the final analysis

- Sodium and Phosphorous levels increased after crop than initial analysis in both years
- Potassium level decreased after the crop cultivation in both years
- Ca and Mg showed highest values in 2014-15 than in 2015-16 and the values were high after crop for Ca and for Mg the values were low.
- Sulphur recorded increase in values in both 2014-15 and 2015-16

Temporal changes in chemical properties in Pokkali rice field during 2015-16 with crop stages are given in Table 2.52.

Table 2.52 Chemical properties of soil samples of Pokkali rice field, during different stages of Rice (2015-16)

Crop stages	pH	EC	P	K	Na	Ca	Mg	S	Fe	Cu	Mn	Zn
		dS m^{-1}	kg ha^{-1}			mg kg^{-1}						
Transplanting	3.01	15.6	19.3	672	10100	615	17.2	37.0	139.4	0.1	0.7	0.4
Dismantling	2.93	5	16.0	726.9	2968	489	16.5	37.0	339.8	0.4	ND	ND
Active Tillering	3.15	1.7	30.4	1209.6	3599.7	536.5	16.9	48.8	339.0	0.4	ND	ND
Harvesting	6.4	4.1	37.1	664.2	2611.8	783	16.7	48.8	442.1	0.2	0.8	0.6

It was observed that:

- A decrease in pH value was observed in the water samples taken from rice field during initial growth stages and later it increased.
- Electrical conductivity of water samples also showed a same trend during rice growth
- Results of soil analysis showed that pH and EC decreased during initial stages of plant growth and then increased
- Grain yield recorded was 2.34 t ha^{-1}
- During January 2016, Rice fields were prepared for prawn cultivation
- Tiger prawn seedlings was released during February,
- Harvesting was conducted on last week of May
- 208 kg/ha prawn were harvested

The *Pokkali* field after release of prawn is shown in Plate 2.6. Analytical data of soil samples before and after prawn cultivation are given in Table 2.53. There was a change in chemical soil properties after the cultivation of prawn. There was an increase in all chemical parameters except sulphur content of the soil.

Plate 2.6. Pokkali field after release of prawn

Table 2.53 Changes in soil properties before and after prawn cultivation (2014-15 and 2015-16)

		2014-15		2015-16	
Properties		Initial	Final	Initial	Final
pH		5.72	6.92	6.66	7.05
EC	dSm^{-1}	2.8	8.95	2.3	8.2
OC	%	1.89	2.12	1.9	2.34
Na	$kg\ ha^{-1}$	1677.8	9023.84	1627.36	8078.72
K	$kg\ ha^{-1}$	390.9	937.8	286.2	1087.9
P	$kg\ ha^{-1}$	22.66	95.1	87.9	58.25
Ca	$mg\ kg^{-1}$	28.92	189.63	76.53	382.5
Mg	$mg\ kg^{-1}$	7.44	29.64	3.865	19.195
S	$mg\ kg^{-1}$	9.36	7.565	9.6	231.84
Fe	$mg\ kg^{-1}$	150.6	870.6	54.46	1871
Zn	$mg\ kg^{-1}$	-	1.12	1.3	1.95
Cu	$mg\ kg^{-1}$	-	0.225	0.29	0.798
Mn	$mg\ kg^{-1}$	-	0.89	0.77	0.944

It was observed that:

- pH and EC recorded the highest values in the final stages of both years and the highest values were recorded in the year 2015-16 than the previous.
- Organic Carbon % was recorded highest in 2015-16 and the highest value was observed in the final stage.
- Both the nutrients Potassium and Sulphur recorded the highest value after prawn and highest value was recorded in the year 2015-16.
- Highest value of Phosphorus content was observed in after prawn cultivation.
- When comparing micro nutrients Fe and Zn recorded the highest value in after prawn cultivation.
- Cu and Mn also recorded the highest level in after prawn analysis in 2015-16.

The B. C ratios for rice, prawn and rice-prawn integration system for 2014-15 and 2015-16 are provided in Table 2.54 and Table 2.55.

Table 2.54 Integrated BC Ratio for 2014-15 (3 acre system)

Crop	Cost of Cultivation (Rs)	Returns (Rs)	BC Ratio
Rice	37,700	50,000	1.32
Prawn	17,200	60,750	3.53

Benefit-Cost Ratio of Rice-Prawn integration = 2.02

Table 2.55 Integrated BC Ratio for 2015-16 (3 acre system)

Crop	Cost of Cultivation (Rs)	Returns (Rs)	BC Ratio
Rice	39,000	46,800	1.2
Prawn	20,500	87,500	4.26

Benefit-Cost Ratio of Rice-Prawn integration = 2.73

The rice-prawn integration was found to very beneficial and successful in *Pokkali* lands. As the left over's of prawn cultivation become manure for rice cultivation, there would not be any additional application of fertilizers. It may enhance the soil qualities as well as the growth and yield of following rice crop. In 2014-15 grain yield was 1000 kg/ ha, prawn yield was 150 kg and the Benefit-Cost Ratio of Rice-Prawn integration was 2.02, during the year 2015-16, grain yield recorded was 2.34 $t\ ha^{-1}$ and total of 250 kg prawn were harvested. The BC ratio of the rice prawn integration was 2.73.

3. MANAGEMENT OF POOR QUALITY WATERS

3.1 Management of Alkali water

Use of alkali well/tube well waters to supplement canal waters (Agra)

A field experiment was initiated during 2015-16 for assessing different modes of irrigation with canal and alkali waters (cyclic and mixing) in toria-chicori crop rotation. The alkali water having RSC 10 meq/l was used for irrigation. Crop yield data for grain, stover, biological yield and harvest index for different canal and alkali water use modes are presented in Table 3.1.The grain and stover yield did not differ significantly amongst the different mode of canal and alkali irrigations and also found at par with the single irrigation source either canal or alkali (RSC 10 meq/l). The biological yield of toria was recorded no significant difference in all the irrigation modes. The harvest index of toria crop was no significant difference but all the treatment at par. The maximum net profit and B: C ratio was observed in canal irrigated plots (Rs. 17,041) and 1.08.

Table 3.1 Effect alkali water irrigation to supplemental canal water irrigation on seed yield, Stover yield, net profit and benefit cost ratio of Toria

Treatments	Grain yield (q/ha)	Stover yield (q/ha)	Biological yield (q/ha)	Harvest index (%)	Net profit (Rs/ha)	B:C ratio
CW	8.53	19.37	27.90	30.58	17,041	1.08
1CW:1AW	8.10	18.82	26.92	30.09	15,385	0.97
2CW:2AW	8.33	18.61	26.94	30.92	16,271	1.03
2AW:2CW	8.10	18.16	26.26	30.66	15,385	0.97
Mix.(1:2)	8.03	18.07	26.17	30.68	15,115	0.96
Mix. (2:1)	8.10	18.28	26.17	30.70	15,385	0.97
AW	7.97	18.06	26.03	30.61	14,885	0.94
CD at 5%	NS	NS	NS	NS	-	-

After harvest of toria crop, the chikori crop was grown during *rabi* season with different alkali: canal irrigation modes. The chikori root yield data are presented in Table 3.2. The chikori root yield differ significantly amongst the different mode of canal and alkali irrigations . The maximum chikori root yield was found in cannel irrigation treatment (171.87 q/ha) and lowest in alkali water irrigated treatment (159.03 q/ha) and all other treatments between theses range. The maximum net profit and B: C ratio was found in canal irrigated treatment (Rs.43,980) and 1.56.

Table 3.2 Effect alkali water irrigation to supplemental canal water irrigation yield, net profit and benefit cost ratio of chikori

Treatments	Diameter of chikori root(cm)	Length of chikori root (cm)	Yield of chikori root (q/ha)	Net profit (Rs/ha)	B:C ratio
CW	12.17	22.37	171.87	43,980	1.56
1CW:1AW	11.17	21.57	167.27	42,048	1.49
2CW:2AW	11.37	20.50	166.63	41,760	1.49
2AW:2CW	10.33	19.90	162.33	40,058	1.42
Mix.(1:2)	11.07	20.70	161.07	39,444	1.40
Mix. (2:1)	11.43	21.77	167.30	42,061	1.49
AW	9.93	18.67	159.03	36,908	1.31
CD at 5%	0.92	1.60	5.33	-	-

The annually net profit for toria-chikori rotation is presented in Table 3.3.The maximum net profit for two crops grown in one year was Rs. 61,021 with canal irrigation and minimum profit was Rs. 51,793 with alkali irrigation. The maximum benefit cost ratio for this rotation was 2.64 for canal irrigation and minimum was 2.25 for alkali water irrigation.

Table 3.3 Effect alkali water irrigation as supplemental to canal water irrigation on net profit and benefit cost ratio of toria and chikori

Treatments	Net profit (Rs/ha)			B:C ratio		
	Toria	Chikori	Total	Toria	Chikori	Total
CW	17,041	43,980	61,021	1.08	1.56	2.64
1CW:1AW	15,385	42,048	57,433	0.97	1.49	2.46
2CW:2AW	16,271	41,360	57,631	1.03	1.47	2.50
2AW:2CW	15,385	40,058	55,443	0.97	4.42	2.39
Mix.(1:2)	15,115	39,444	54,559	0.96	1.40	2.36
Mix. (2:1)	15,385	42,061	57,446	0.97	1.49	2.46
AW	14,885	36,908	51,793	0.94	1.31	2.25

Soil profile wise ECe, SAR, pH and ESP were determined at sowing and harvest of toria crop and harvest of chikori crop for different irrigation treatments. In general the ECe, pH, SAR and ESP at sowing and harvest of toria crop was stable as number of irrigations was limited and also there was rainfall during crop period. However, these values increased slightly during chikori crop due use of alkali water in case of alkali water treatments.

Performance of wheat crop as influenced by different depth and frequency of irrigation under different methods of irrigation in Sodic Vertisols (Indore)

To avoid waterlogging after irrigation and to meet irrigation needs of crop, modifications in irrigation systems' operations were required in case of sodic Vertisols. Keeping this in mind, experiment on Border Strip Irrigation (BSI) and Sprinkler Irrigation (SI) were designed with following objectives of arriving at optimum depth and frequency of irrigation for growing wheat on sodic vertisols for prevalent methods of irrigation i.e. Border strip irrigation and sprinkler irrigation. The ESP of soil was 35 to 40. Irrigation treatments for wheat crop were as below.

M_1-Border strip irrigation (BSI) (Size – 50 x 6 m) with 5 cm irrigation scheduled on various physiological growth stages with 65, 75 and 85 % cut off distance (COD).

M_2-Sprinkler irrigation (SI) (Size – 50 x 24 m) with 5 cm irrigation scheduled on the basis of IW/CPE ratio as 1.2 with depths of irrigation as 2, 3 and 5 cm.

Three borders each one of size 50 x 6m were irrigated up to COD 65, 75 and 85% respectively by BSI. Similarly, three plots each one of size 50 x 24m were irrigated to depth of 2, 3 and 5 cm respectively by SI. The details of the yield, total water expense and water productivity obtained were given in Table 3.4. The minimum water expense (WE) was obtained 27 and 36 cm in case of SI with irrigation depth 3 cm and maximum WE was 44 cm in case of BSI with COD 85% in the year 2014-15 and 46.08 cm in case of BSI with COD 65% in the year 2015-16. The highest yield of 2008 and 1631 kg ha^{-1} and the lowest yield of 1020 and 1188 kg ha^{-1} were obtained in case of SI with irrigation depth 3cm and BSI with COD 65% respectively. Similar trend was seen in case of water productivity with values 74.4 and 25.3 kg ha^{-1} cm^{-1}.

Table 3.4 Water expense, yield and water productivity under different irrigation system

Name of system	Nos. of irrigation	Depth of fee irrigation cm	Water expense	Yield kg/ha	Water productivity kg/ha-cm
2014-15					
BSI with COD 65%	7	5.76	40.32	1020	25.3
BSI with COD 75%	6	7.2	43.20	1160	26.9
BSI with COD 85%	5	8.8	44.00	1347	30.6
SI with irrigation depth 2cm	14	2	28.00	1317	47.0
SI with irrigation depth 3cm	9	3	27.00	2008	74.4
SI with irrigation depth 5cm	6	5	30.00	1680	56.0

2015-16					
BSI with COD 65%	8	5.76	46.08	1188	25.78
BSI with COD 75%	6	6.88	41.28	1305	31.61
BSI with COD 85%	5	8.16	40.80	1510	37.01
SI with irrigation depth 2cm	19	2.00	38.00	1540	40.53
SI with irrigation depth 3cm	12	3.00	36.00	1631	45.31
SI with irrigation depth 5cm	8	5.00	40.00	1422	35.55

Evaluating performance of drip irrigation under different discharge rate and schedules for growing vegetable crop in sodic black soils (Indore)

An experiment was planned during 2014-15 to arrive at suitable combination of disharge rate and schedule of drip irrigation for growing vegetable crops in sodic black soils as crop grown in sodic black soils require light and frequent irrigation. Drip irrigation may prove effective for providing light and frequent irrigation. Basic infiltration in sodic black soils decreases with increase in ESP. Therefore correct irrigation scheduling is important to meet out variable irrigation requirement of crops in these soils. The study was initiated during the year 2013-14 in sodic black soils of Salinity Research Station, Barwaha at ESP level 40. The Cauliflower crop (UX – 178) was sown on 6th of January 2015 and harvested on 21st of March 2015. Treatments were related to discharge rate of drip system (Q_1=1.3, Q_2=2.4 and Q_3=4 LPH) and irrigation schedule (S_1= daily, S_2=alternate day and S_3= after 3 days). Combinations of treatments were (i) Q_1S_1; (ii) Q_1S_2;(iii) Q_1S_3;(iv) Q_2S_1;(v) Q_2S_2; (vi) Q_2S_3;(vii) Q_3S_1;(viii) Q_3S_2 and (ix) Q_3S_3. Design was RBD with three replications and plot size was 5.4 x 4.5 m. The operation of system was such that for all treatments with daily schedule (S_1) applied 217 cm, alternate schedule applied (S_2) 109 cm and third day schedule (S_3) applied 72 cm of water.

The details of Nos. of irrigation, water expense yield and water productivity are given in Table 3.5. The total water expense was estimated 217, 109 and 72 cm in case of dripper discharge rate of 1.3 LPH of drip irrigation for daily, alternate and third day irrigation schedules respectively. The highest yield 19132 kg ha^{-1} was obtained in case of drip irrigation system scheduled daily with 1.3 LPH dripper discharge rate followed by the lowest 2196 kg ha^{-1} in case of drip irrigation system scheduled every third day with 4.0 LPH dripper discharge rate. However, the water productivity was observed highest 184.71 kg ha^{-1}-cm in case of drip irrigation system scheduled every third day with 1.3 LPH dripper discharge rate followed by 141.77 kg ha^{-1}-cm in case of drip irrigation system scheduled every alternate day with 1.3 LPH dripper discharge rate. The lowest WP was observed 23.11 kg ha^{-}1-cm in case of drip irrigation system scheduled daily with 4.0 LPH dripper discharge rate followed by 30.37 kg ha^{-1}-cm in case of drip irrigation system scheduled every alternate day with 4.0 LPH dripper discharge rate.

Table 3.5 Water expense, yield and water productivity under different drip irrigation system (2014-15)

Discharge rates LPH	Irrigation No.	Depth of fee irrigation cm	Water expense cm	Curd yield kg/plot	Curd yield kg ha^{-1}	Water Productivity kg ha^{-1}-cm
$Q_1 S_1$	94	2.31	217	57.40	19132	88.11
$Q_1 S_2$	47	2.31	109	46.18	15392	141.77
$Q_1 S_3$	31	2.31	72	39.68	13227	184.71
$Q_2 S_1$	94	2.31	217	40.04	13348	61.47
$Q_2 S_2$	47	2.31	109	32.99	10998	101.30
$Q_2 S_3$	31	2.31	72	27.53	9178	128.17
$Q_3 S_1$	94	2.31	217	15.06	5019	23.11
$Q_3 S_2$	47	2.31	109	9.89	3297	30.37
$Q_3 S_3$	31	2.31	72	6.59	2196	30.66

Details of experiment (2015-16)

The study was initiated during the year 2015-16 in sodic black soils of Salinity Research Station, Barwaha at ESP level 40±2. The Cauliflower crop (UX – 178) was sown on 17st of November 2015 and harvested on

16th of March 2016. Treatments were related to discharge rate of drip system (Q_1=1.3, Q_2=2.4 and Q_3=4 LPH) and irrigation schedule (S_1= daily, S_2=alternate day and S_3= after 3 days). Combinations of treatments were (i) Q_1S_1; (ii) Q_1S_2;(iii) Q_1S_3;(iv) Q_2S_1;(v) Q_2S_2; (vi) Q_2S_3;(vii) Q_3S_1;(viii) Q_3S_2 and (ix) Q_3S_3. Design was RBD with three replications and plot size was 6 x 5 m. The operation of system was such that for all treatments with daily schedule (S_1), alternate schedule applied (S_2) and third day schedule (S_3) applied same irrigation water. Thus, volume of irrigation water applied was kept uniform irrespective of the discharge rates of drippers as well as different schedules.

The details of Number of irrigation, water expense yield and water productivity are given in Table 3.6. The total water expense was estimated around 47.00 cm, 46.53 cm and 46.19 cm in case of daily, alternate and third day irrigation schedules respectively. The highest curd yield 22.92 t ha^{-1} was obtained in case of drip irrigation system scheduled daily with 1.3 LPH dripper discharge rate followed by the lowest 8.22 t ha^{-1} in case of drip irrigation system scheduled every third day with 4.0 LPH dripper discharge rate. However, the water productivity was observed highest 487.6 kg/ha-cm in case of drip irrigation system scheduled every day with 1.3 LPH dripper discharge rate followed by 455.1 kg/ha-cm in case of drip irrigation system scheduled every alternate day with 1.3 LPH dripper discharge rate. The lowest WP was observed 177.9 kg/ha-cm in case of drip irrigation system scheduled every third day with 4.0 LPH dripper discharge rate followed by 265.3 kg/ha-cm in case of drip irrigation system scheduled alternate day with 4.0 LPH dripper discharge rate.

Table 3.6 Water expense, yield and water productivity under different drip irrigation operational schedules

Treatments	Nos. of irrigation	Depth of fee irrigation, cm	Water expense, cm	Curd yield (t ha^{-1})	WP kg/ha-cm
Q1 S1	94	0.50	47.00	22.92	487.6
Q1 S2	47	0.99	46.53	21.18	455.1
Q1 S3	31	1.49	46.19	18.47	399.9
Q2 S1	94	0.50	47.00	19.81	421.5
Q2 S2	47	0.99	46.53	17.23	370.2
Q2 S3	31	1.49	46.19	14.73	319.0
Q3 S1	94	0.50	47.00	15.17	322.7
Q3 S2	47	0.99	46.53	12.34	265.3
Q3 S3	31	1.49	46.19	8.22	177.9

The EC was recorded after harvest of crop on various points viz. on dripper, between dripper, 15 cm side of the dripper and 30 cm side of the dripper around drippers in case of each treatment from depths 0-15 cm and 15-30 cm. The values of EC for depths 0-15 cm and 15-30 cm indicated safe salt concentration on all the points *i. e.* on dripper, between dripper, 15 cm side of the dripper and 30 cm side of the dripper around drippers in case of each treatment.

The pH was also recorded after harvest of crop on various points viz. on dripper, between dripper, 15 cm side of the dripper and 30 cm side of the dripper around drippers in case of each treatment from depths 0-15 cm and 15-30 cm. The values of pH for depths 0-15 cm and 15-30 cm indicated no trend except alkaline reaction on all the points *i. e.* on dripper, between dripper, 15 cm side of the dripper and 30 cm side of the dripper around drippers in case of each treatment.

Conjunctive use of high RSC water in different cropping systems under sodic soil (Kanpur)

The purpose of the experiment was to find out the suitable cyclic mode of irrigation water particularly under sodic groundwater areas and study crop response to such modes in terms of crop yield. The rice-wheat rotation and pearl millet –wheat, prevalent in the area, were considered during the experiment. Details of experiment are given in Table 3.7. Initially pH, ECe, ESP and Organic Carbon of soil were 9.10, 093 dS/m, 42.2 and 0.28%, respectively.

Table 3.7 Details of experiment

Irrigation Treatments	Other details	
Best Available Water (BAW)	Crop rotation:	Rice, wheat and pearl millet
RSC groundwater	Varieties:	CSR-36, KRL-211 and ICTP-8203
BAW followed by all irrigations by RSC water	Treatments	6
RSC water followed by all irrigation by BAW	Replications:	3
1 BAW and 1RSCW (Alternately)	Design:	Split plot
BAW + RSC water after mixing	Plot size:	20 m^2
	Year of start:	2014
	Location:	Crop Research Farm, Dalipnagar, Kanpur

Quality parameters of two irrigation waters, namely Best Available Water (BAW) and RSC water are provided in Table 3.8

Table 3.8 Chemical composition of irrigation waters

Composition	BAW	RSCW
pH	7.5	8.82
EC(dSm^{-1})	0.7	1.11
Anions (meq l^{-1})		
CO_3	Nil	NIL
HCO_3	4.11	8.42
Cl	3.31	1.88
SO_4	0.1	0.73
Cations (meq l^{-1})		
Ca+Mg	6.41	2.63
Na+K	1	8.49
RSC (meql^{-1})	Nil	5.79

Results indicated that average yield varied from 24.01 to 38.22 and from 17.29 to 33.84 q/ha for rice and wheat, respectively in rice- wheat cropping system (Table 3.9). Highest yield was obtained from best available water (BAW) followed by BAW + RSCW (mixing) and lowest yield was received from residual sodium carbonate water (RSC Water) treatment.

Table 3.9 Effect of treatments on grain yield of crops (q/ha)

Treatments	Rice-wheat					
	Rice			Wheat		
	2014	2015	Mean	2014-15	2015-16	Mean
Best Available Water (BAW)	37.18	39.25	38.22	32.73	34.95	33.84
RSC groundwater	24.25	23.77	24.01	17.45	17.12	17.29
BAW followed by all irrigations by RSC water	28.77	28.46	28.62	22.04	23.10	22.57
RSC water followed by all irrigation by BAW	33.26	34.43	33.85	27.14	28.88	28.01
1 BAW and 1RSCW (Alternately)	31.65	32.36	32.01	26.00	27.65	26.83
BAW + RSC water after mixing	34.61	36.11	35.36	28.11	29.46	28.79
CD = 0.05	1.57	1.64	--	1.23	1.46	--

Average yield varied from 08.27 to 15.04 and from 17.97 to 33.32 q/ha of pearl millet and wheat, respectively, in pearl millet-wheat cropping system, (Table 3.10). Highest yield was obtained from best available water (BAW) followed by BAW + RSCW (mixing) and lowest yield was received from residual sodium carbonate water (RSC water) treatment.

Table 3.10 Effect of treatments on grain yield of crops (q/ha)

Treatments	Pearl millet-wheat					
	Pearl-millet			Wheat		
	2014	2015	Mean	2014-15	2015-16	Mean
Best Available Water (BAW)	14.52	15.55	15.04	33.27	35.37	33.32
RSC groundwater	08.41	08.12	08.27	18.08	17.85	17.97
BAW followed by all irrigations by RSC water	10.58	10.05	10.32	20.55	20.82	20.65
RSC water followed by all irrigation by BAW	12.24	12.83	12.54	26.95	29.05	28.00
1 BAW and 1RSCW (Alternately)	10.98	11.27	11.13	26.78	28.00	27.39
BAW + RSC water after mixing	12.75	13.35	13.05	28.35	29.86	29.11
CD = 0.05	1.17	1.29	--	1.21	1.37	--

Changes in pH, electrical conductivity, exchangeable sodium percentage (ESP) and organic carbon (OC) indicate that although there has been overall improvement in soil properties in every treated plots excluding residual sodium carbonate water (RSCW). The soil pH, EC and ESP is decreased in BAW irrigated plot and increased with RSCW. There was noted improvement in organic carbon in all the treatments excluding RSCW. Related data are given in Table 3.11.

Table 3.11 Effect of treatments on physico-chemical properties of experimental soil after two years

Treatments	Rice-wheat				Pearl millet-wheat			
	pH	EC (dS/m)	ESP	OC (%)	pH	EC (dS/m)	ESP	OC (%)
Initial	9.10	0.93	42.2	0.28	9.10	0.93	42.2	0.28
Best Available Water (BAW)	8.7	0.88	38.7	0.32	8.7	0.89	39.2	0.31
RSC groundwater	9.2	0.94	43.5	0.26	9.3	0.93	43.9	0.27
BAW followed by all irrigations by RSC water	9.0	0.93	41.1	0.28	9.1	0.93	41.6	0.28
RSC water followed by all irrigation by BAW	8.9	0.91	40.0	0.30	8.8	0.92	40.1	0.30
1 BAW and 1RSCW (Alternately)	8.9	0.92	40.2	0.29	9.0	0.91	40.2	0.29
BAW + RSC water after mixing	8.8	0.89	40.2	0.30	8.8	0.90	39.7	0.30

Pressurized irrigation methods for vegetable crops in sodic soils (Tiruchirappalli)

The purpose of this experiment was to identify suitable pressurized irrigation methods for different crops and its effect in terms of growth, yield and economics under sodic soil with alkali water. Besides, soil moisture and salt dynamics under different pressurized irrigation methods in sodic soil with alkali water are to be understood. Treatment details are as below.

Main Plot (Irrigation methods)	Sub- plot (Crops)
I_1 : Drip irrigation	C_1 : Cluster bean (var: PUSA Naubahar)
I_2 : Sprinkler irrigation	C_2 : Bhendi (COBhH-4)
I_3 : Farmers method (Furrow irrigation)	C_3 : Vegetable cowpea (var: PKM 1)
	C_4 : Onion (CO-5)

The design was Split- plot and replications were three. The experiment was initiated during the second week of July 2015 with above mentioned treatments. Due to continuous heavy rain prevailed from the inception of the experiment, the vegetable crops failed to establish. Since continued heavy rain in the subsequent months flooded the entire experimental field, imposition of irrigation treatments were also got disturbed. Hence, the Rabi (2015-16) season experiment is abandoned. Thereafter, field experiment was initiated during second week of July 2016 at A3b farm of ADAC&RI, Trichirappalli for identifying suitable pressurized irrigation methods for vegetable crops under sodic environment. Initial soil samples were collected and the physico-chemical properties were analyzed using standard methods. The pH and EC of the initial experimental field soil is 9.0 and 0.87 dSm^{-1}, respectively. The N, P and K content of the initial soil is 237 kg/ha, 18.6 kg/ha and 254 kg/ha respectively (Table 3.12).

Table 3.12 Characteristics of initial experimental field soil

Sr. No.	Particulars	Value	Sr. No.	Particulars	Value
1	pH	9	7	ESP (%)	26.2
2	EC (dSm^{-1})	0.87	8	Exchangeable Ca (cmol (p+) kg^{-1})	8.6
3	Organic Carbon (%)	0.46	9	Exchangeable Mg (cmol (p+) kg^{-1})	4.5
4	Available N (kg ha^{-1})	237	10	Exchangeable Na (cmol (p+) kg^{-1})	4.8
5	Available P (kg ha^{-1})	18.6	11	Exchangeable K (cmol (p+) kg^{-1})	0.27
6	Available K (kg ha^{-1})	254			

As per the layout, drip irrigation system was installed and the laterals were laid in centre of each ridge. In line drippers of 4 lit hr^{-1} were used at a spacing of 60cm. After that vegetable seeds were sown in the ridges during second week of July 2016. Other management practices like gap filling, thinning, weeding and other plant protection measures were carried out according to the recommended package of practices. The drip and sprinkler irrigation system is being operated and the time and duration of drip irrigation is based on the daily rainfall, evaporation rate and stage of the crop.

Five plants were selected randomly in each plot and tagged for recording biometric observations. The biometric observations viz., plant height, number of leaves, leaf length and leaf breadth were recorded as per the standard methods on 30, 60 and 90 DAS. The results showed that the drip irrigation system exhibits significant difference in plant growth parameters of vegetables compared to sprinkler irrigation and farmers practice of flooded irrigation under sodic soil environment. Harvesting of vegetables is being under progress. To assess the salt load under different irrigation systems, soil samples also collected at various stages of crop growth period and the samples are being analyzed. The complete results of the study will be given after completion of the experiment.

Drip irrigation to cotton in alkali soils using ameliorated alkali water (Tiruchirappalli)

This experiment was planned to compare the efficacy of ameliorated alkali water using gypsum and distillery spent wash applied through drip irrigation to cotton with soil application of gypsum. Treatment details are as below.

Main Plot (Water treatments)	Sub- plot (Crops)
M_1:Drip irrigation with gypsum bed treated water	S_1: Soil application of gypsum @ 50% GR
M_2:Drip irrigation with spent wash treated water	S_2: One time application of DSW @ 5 lakh liters ha-1
M_3:Drip irrigation with untreated alkali water	S_3: No amendments

The design was Strip- plot and replications were four with crop as cotton (var. BG II hybrid RCH 20). Date of sowing was 28th Sept. 2016 and crop spacing was 90 x 60 cm. The pH, EC and ESP of the initial experimental field soil is 8.70, 0.44 dSm^{-1} and 23.4, respectively. The experimental soil was reclaimed through distillery spent wash and gypsum as per the treatment details. Then the experimental plot was thoroughly ploughed to bring optimum soil tilth and the layout was taken up forming ridges and furrows with a spacing of 90 cm. Drip irrigation system was installed and the laterals were laid in centre of each ridge. In line drippers of 4 lit hr^{-1} were used at a spacing of 60 cm. After that Cotton BG II hybrid RCH 20 seeds were sown along the ridges with a spacing of 90 cm between rows and 60 cm between plants during last week of September 2016. Other management practices like gap filling and weeding were carried out according to the recommended package of practices. The gypsum bed treatment structure was fabricated to a capacity of 1000 litre with RCC rings and a mild steel rod stand. The inlet of the irrigation water is provided below the stand and the irrigation water was treated during its upward movement though the gypsum bed kept within a gunny bag over the stand. This treated water is being collected in a storage tank from which the water is pumped into drip system through fertigation unit (ventury). Similarly, the distillery spent wash was mixed with irrigation water in a ratio of 1:250 through the fertigation unit to treat the alkali water. The drip irrigation is being operated and the duration of drip irrigation system is based on the daily rainfall, evaporation rate, stage of the crop. Seed germination was counted on seven days after sowing and expressed as percentage. Germination percentage and plant populations were not affected significantly by the application of ameliorated alkali water and soil reclamation through distillery spentwash and gypsum. The germination percentage varied from 87.5 to 92.5. Further observations in the experiment are under progress.

3.2 Management of Saline Water

Performance of groundnut with saline water through drip irrigation system (Bapatla)

The experiment was conducted on sandy loam soil at SWS fields, Agricultural College Farm, Bapatla during *rabi* 2014-15. The soil was neutral (pH of 7.0) and non saline (ECe 0.7 dS m^{-1}). The initial available soil nutrient status was 151 kg N ha^{-1},18.5 P_2O_5 $ha^{-1}$and 335 kg ha^{-1}.The results revealed that the maximum pod yield (Table 3.13) was recorded with Kadiri 6 (1459 kg ha^{-1}) variety which was on par with Kadiri 7 variety and both were significantly superior to Anantha variety (976 kg ha^{-1}). Among different salinity levels, pod yield was significantly influenced in all groundnut varieties. The highest pod yield of 1600 kg ha^{-1} was observed at a salinity level of 0.06 dS m^{-1} (BAW), which was significantly superior to the rest of salinity levels (4, 6 and 8 dS m^{-1}). The lowest pod yield of 940 kg $ha^{-1}$was observed at the maximum salinity level of 8 dS m^{-1}. There was no significant interaction affect of salinity levels and groundnut varieties on yield. The data pertaining to the stover yield revealed a significant influence of varieties, salinity levels and their interaction. Among the groundnut varieties, Kadiri 7 variety recorded the highest stover yield of 2253 kg ha^{-1}, and the lowest stover yield was recorded by Anantha variety (1606 kg ha^{-1}). The stover yield decreased with each increment in salinity level irrespective of groundnut varieties. Stover yield was maximum with BAW treatment (2290 kg ha^{-1}) and minimum (Table 3.13) with 8 dS m^{-1} treatment (1758 kg ha^{-1}).

Table 3.13 Pod and haulm yields of groundnut as influenced by saline irrigation water through drip system during 2014-15

Variety	Grain Yield (kg ha^{-1})	Stover Yield (kg ha^{-1})	Irrigation water quality	Grain Yield (kg ha^{-1})	Stover Yield (kg ha^{-1})
Main Treatment			Sub Treatment		
Anantha	976	1606	BAW	1600	2290
Kadiri6	1459	2194	2EC	1453	2114
Kadiri7	1413	2253	4EC	1336	1954
SEm+_	38	69	6EC	1084	1973
CD(0.05)	150	271	8EC	940	1758
CV (%)	8.2	9.4	SEm+_	53.4	110.7
			CD(0.05)	155	323
			CV (%)	8.8	11.6
Interaction					
SEm+_	65.4	135.6			
CD(0.05)	NS	396			
CV (%)	8.8	11.6			

The experiment also continued at Agricultural College Farm, Bapatla during *rabi* 2015-16 and the results were on similar to earlier results. During 2015-16, effect of saline water was studied on soil pH, ECe, plant growth and dry matter accumulation, sodium uptake and potassium uptake. The data pertaining to sodium uptake was significantly affected by different salinity levels. The sodium uptake was increased with increasing salt concentration. The maximum Na uptake (12.03 kg ha^{-1}) was recorded at higher salinity level of 8 dS m^{-1} whereas, the lowest Na uptake was recorded (5.75 kg ha^{-1}) at lower salinity level of 0.06 dS m^{-1} (BAW). No significant influence among varieties and interaction with salinity level was observed. The potassium uptake was also significantly affected by salinity levels. The highest potassium uptake was observed at 0.06 dS m^{-1}, which was significantly superior to remaining salinity levels. The influence of varieties on potassium uptake was found to be non-significant. The highest uptake was observed in Kadiri 6 variety (51.4 kg ha^{-1}) followed by Kadiri 7 and Anantha varieties. The maximum potassium uptake (84.4 kg ha^{-1}) was attained in the treatment combination of Kadiri 6 x BAW; where as the minimum (28.0 kg ha^{-1}) was attained in the combination of Kadiri 7 x 8 dS m^{-1}.

Micro (Drip) irrigation system with saline water for different vegetable crops in coastal sandy soils (Bapatla)

An experiment was laid out with five levels of irrigation water salinity i.e., 0.6 (BAW- Best available water)

2, 4, 6 and 8 dS m^{-1} imposed on Okra (bhendi), cluster bean and capsicum crops through drip irrigation. The soil was sandy loam in texture, neutral in reaction, non saline; medium in available nitrogen and phosphorous and high in potassium content. The highest crop yield was observed with BAW and with each increment of salinity of irrigation water, plant height and yield decreased significantly in all the three crops. The cluster bean crop was found to be highly tolerant when compared to okra and capsicum as 90% of the yield could be achieved at salinity level of 2.0 dS m^{-1}. The order of the salinity tolerance of the crops tested was found to be cluster bean> okra >capsicum (Table 3.14). The mathematical models, developed between the yields (t ha^{-1}) of the crops and irrigation water salinity (dS m^{-1}), are presented in Fig. 3.1.

Table 3.14 Plant height and yield of vegetables under drip

Vegetable	Plant height (cm)	Yield (kg ha-1)
Bhendi	80.66	6070
Clusterbean	93.60	7483
Capsicum	47.98	3023
SEM+	1.86	182.00
CD (P=0.05)	5.39	371.78
CV%	9.74	8.99

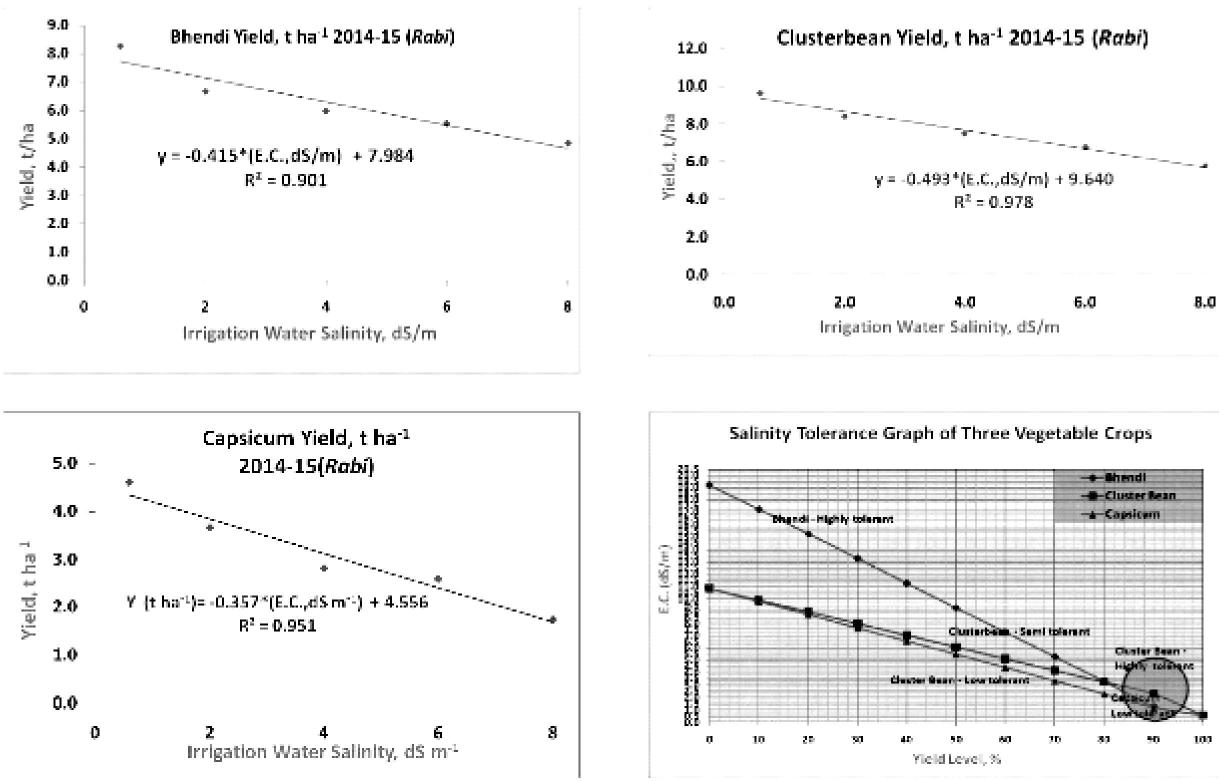

Fig. 3.1 Yield response of Okra, cluster bean and capsicum under different levels of irrigation water salinity (BAW, 2, 4, 6 and 8 dS/m) through drip system

Irrigation water salinity at 90, 75 and 50% yield level for different crops are provided in Table 3.15.

Table 3.15 Salinity tolerance levels (dS/m) of three vegetable crops at different yield levels

Crop	Yield levels (%)		
	90	75	50
	Irrigation Water salinity (dS/m)		
Bhendi	1.3	4.3	9.3
Cluster Bean	2.0	4.2	5.9
Capsicum	1.2	3.1	6.3

An experiment was laid out during rabi 2015-16 with five levels of irrigation water *viz.* best available water (BAW) i.e. pumped from bore well with EC as 0.6 dS m^{-1} and saline water with EC as 2, 4, 6 and 8 dS m^{-1} replicated 4 times in each plot of 62.50 m^2 with vegetable crops *viz*. capsicum, cluster bean and spinach (*palak*). The experimental soil was sandy loam in texture, neutral in reaction, non saline with medium levels of available nitrogen and phosphorous and high potassium. The results obtained are discussed here under.

Capsicum:

The mean yield of capsicum followed an inverse linear relation with salinity of irrigation water (with an intercept of 10.84 t/ha @ 0.6 dS m^{-1}) (Table 3.16)

Yield levels of 90, 75 and 50 per cent were realized with irrigation water having EC values of 1.2, 2.7 and 5.2 dS m-1, respectively.

The Capsicum is profitable till 3.15 dS m^{-1} (@ yield 7.81 t ha^{-1}) in open field cultivation and beyond, clusterbean and palak are found economically viable.

Cluster Bean:

The mean yield of clusterbean followed the inverse linear relation with the salinity of irrigation water (with an intercept of 8.34 t/ha) (Table 3.16)

Yield levels of 90, 75 and 50 per cent were realized at 1.5, 3.2 and 4.5 dS m^{-1} irrigation water salinity respectively.

Clusterbean is profitable till irrigation water salinity of 4.25 dS m^{-1} (@yield 5.35 t ha^{-1}) beyond 4.25 dS m^{-1}, better choose economically alternate crops.

Spinach:

The mean yield of Palak harvested is found to follow the inverse linear equation with the salinity of irrigation water (with an intercept of 9.90 t/ha) (Table 3.16)

Yield levels, 90per cent,75 per cent and 50per cent can be realized at 1.5, 2.9 and 5.3 dS m^{-1} irrigation water salinity respectively.

Palak is profitable till 4.50 dS m^{-1} (@yield 6.0 t/ha), if the salinity of irrigation water is beyond 4.0 dS m^{-1}, better choose economically alternate crops.

Table 3.16 Yield details of vegetables with different EC levels of irrigation water through drip irrigation system

Different salinity levels (dSm^{-1})	Capsicum	Cluster bean Yield (t ha^{-1})	Spinach
BAW(0.6)	11.02	8.49	10.24
2	8.83	6.97	8.8
4	6.54	5.76	6.16
6	4.61	3.94	4.3
8	2.7	2.16	2.32

The mean yields of capsicum, cluster bean and palak followed inverse linear relation with irrigation water salinity (Table 3.17).

Table 3.17 Mathematical models for yield under drip irrigation system with saline water

Sr. No.	Crop	Equation	R2 Value
1.	Capsicum	Y(kg ha-1) = -1103*EC (dS m-1) + 11286	$R^2 = 0.991$
2.	Clusterbean	Y(kg ha-1) = -832.8x*EC(dS m-1)+ 8894	$R^2 = 0.995$
3.	Palak	Y(kg ha-1)= -1080*E.C*(dS m-1) + 10817	$R^2 = 0.996$

Irrigation water salinity at 90, 75 and 50% yield level for different crops are provided in Table 3.18 Capsicum, Clusterbean and Palak are found economically viable upto 3.15, 4.25 and 4.50 dS/m irrigation water salinity in open field cultivation.

Table 3.18 Salinity tolerance levels (dS/m) of three vegetable crops at different yield levels

Crop	Yield levels (%)		
	90	75	50
	Irrigation Water salinity (dS/m)		
Capsicum	1.2	2.7	5.2
Cluster Bean	1.5	3.2	4.5
Palak	1.5	2.9	5.3

The relative economics were worked out and are presented through the following Fig. 3.2 It indicated that profitable returns are obtained only upto 4 dS m^{-1}.

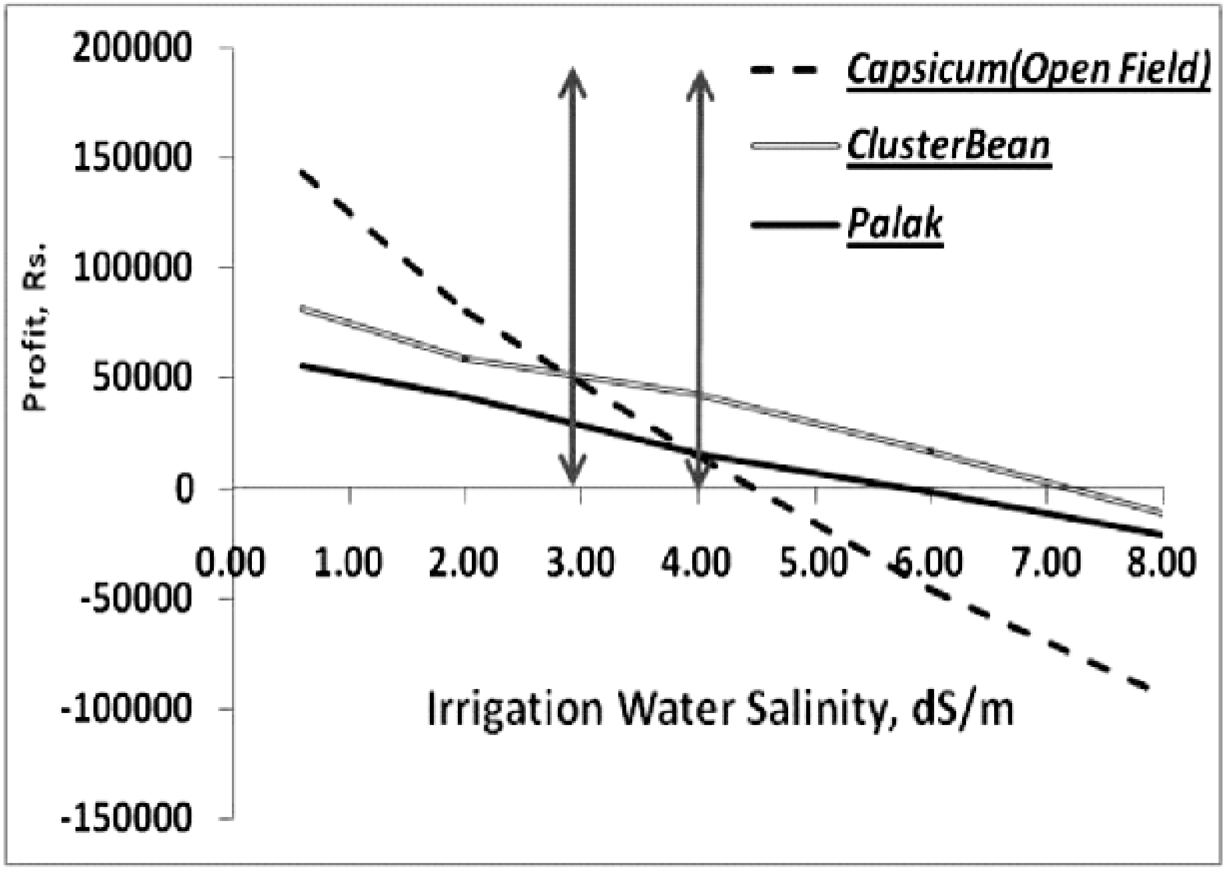

Fig. 3.2 Relative profit analysis of three vegetable crops under saline water irrigation through drip system

The salinity build up in the soil after the crop cultivation with different levels of salinity (EC) was found to increase from 40 per cent with 2 dS m^{-1} to 48.5 per cent with 4 dS m^{-1}, but the salinity build up was well below 1 ds m^{-1}. The nitrogen in the soil after experimentation was found to be reduced by 24.1 per cent and 25.7 per cent with 2 dS m^{-1} and 4 dS m^{-1} irrigation water salinity levels respectively, compared to the initial values. Similar trend was found with phosphorous, but inverse trend was observed with potassium content. The clogging of drip laterals was not found but salt deposition was observed outside the emitter on the periphery of the lateral with 6 and 8 dS m^{-1} irrigation water salinity.

Use of Saline water in shadenets for different vegetable crops in Krishna Western Delta (Bapatla)

An experiment was conducted during 2014-15 in the experimental beds of Bobbepalli shadenets to study the effect of irrigation water salinity (BAW, 2, 4, 6 and 8 dS m^{-1}) on capsicum. Capsicum crop was irrigated with different EC levels of water at an interval of 10 days. The growth and yield parameters of the capsicum are presented in Table 3.19. The statistical analysis revealed significant influence of irrigation water salinity on growth, yield attributes of the plant (except fruit circumference) and yield.

Table. 3.19 Yield and yield parameters of capsicum with different EC levels of irrigation water under shadenet during *rabi*, 2014-15

Irrigation water Salinity (dS m^{-1})	Plant height (cm)	Fruit Length (cm)	Fruit Dia. (cm)	Fruit Circumference (cm)	Fruit Weight (gm)	Yield (kg ha^{-1})	Yield (t ha^{-1})
BAW	115.42	9.88	9.23	1.08	190	11567	11.56
2EC	105.42	8.93	8.23	1.08	165	9741	9.74
4EC	100.45	8.21	7.50	1.10	115	8305	8.31
6EC	96.87	7.51	6.72	1.12	95	6789	6.78
8EC	91.30	6.36	6.13	1.05	50	5547	5.55
SEm+	4.99	0.31	0.32	0.07	5.47	407.66	0.41
CD (P=0.05)	15.37	0.94	0.98	NS	17	1256	1.25
CV %	9.8	7.5	8.5	12.9	8.9	9.7	9.7

The best fit regression equation developed between the yield response and salinity levels of irrigation water as Y=-0.846*(EC, dS m^{-1}) +12.02 with R^2=0.945 and between the yield levels (%) vs salinity levels fitted as YL (%)=-8.14448.01*EC(dS/m) + 109.4 with R^2=0.999. The crop under shadenet is shown in Plate 3.1


Plate 3.1 Capsicum grown under shadenet using different salinity waters

The experiment was conducted during 2013-14 and 2014-15 for the capsicum (Syngenta- Orebelle) transplanted in the engineered soil beds of Bobbepalli nursery irrigated with BAW (1.5), 2, 4, 6 and 8 dS m^{-1} water salinity. The average yield levels of 90, 75 and 50 per cent of capsicum were realized at 1.2, 3.0 and 5.9; 2.0, 3.5 and 5.3; 1.4, 2.8 and 5.2 and 1.3, 4.3 and 9.3 EC (dS m^{-1}) levels respectively. The initial soil sample analysis revealed that the beds contain high amounts of organic carbon. The plant and yield parameters of the capsicum with respect to different salinity levels of irrigation water are presented in Table 3.20.

Table. 3.20 Yield and yield parameters of capsicum with different EC levels of irrigation water under shadenet during *rabi*, 2015-16

Irrigation water Salinity (dS m^{-1})	Plant height (cm)	Fruit Length (cm)	Fruit Dia. (cm)	Fruit Circumference (cm)	Fruit Weight (gm)	Yield (kg ha^{-1})	Yield (t ha^{-1})
BAW	133.00	12.8	9.6	1.3	276	35550	35.55
2EC	115.00	11.9	8.5	1.5	223	31750	31.62
4EC	112.00	9.4	7.9	1.4	160	27500	27.44
6EC	83.00	8.6	6.9	1.1	118	19250	19.36
8EC	80.00	6.3	6.1	1.0	79	11750	11.57
SEm+	4.99	0.31	0.32	0.07	5.6	196.83	0.20
CD (P=0.05)	15.37	0.94	0.98	NS	16.95	715.48	0.72
CV %	9.8	7.5	8.5	12.9	8.9	0.627135	0.627135

The effect of irrigation water salinity on yield (t/ha) under shadenet is shown in Fig. 3.3

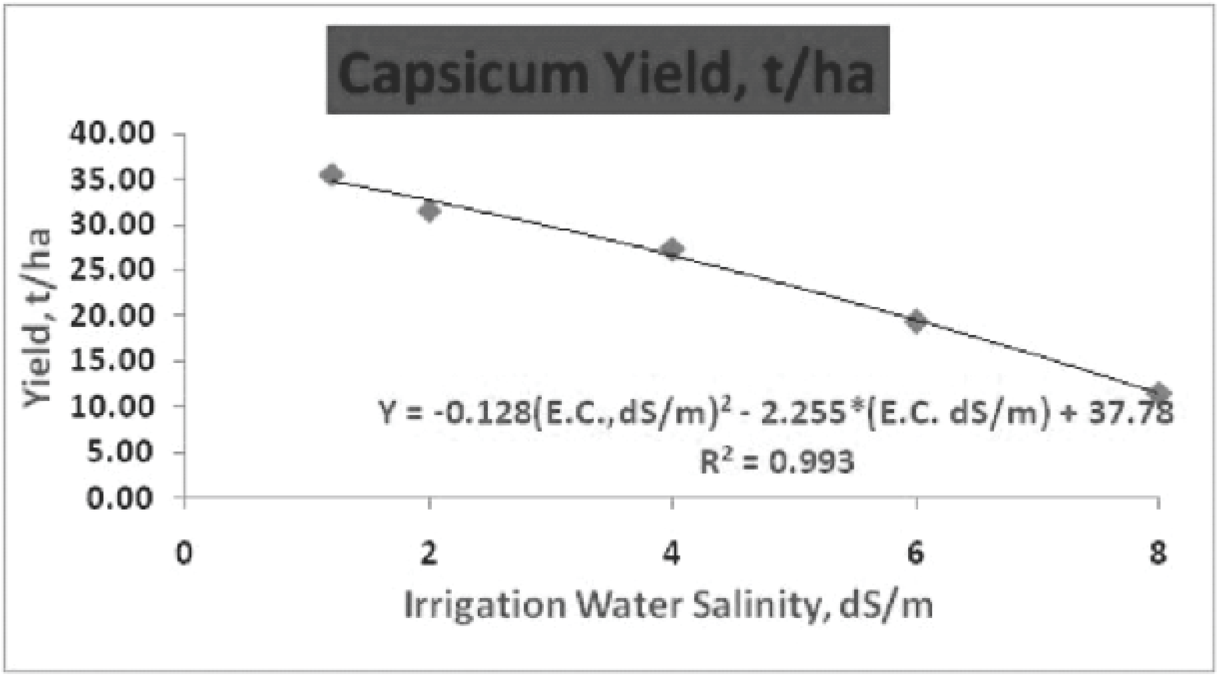

Fig. 3.3 Yield response of Capsicum under shadenets at different levels of irrigation water salinity

On the basis of two years experimentation, following important findings have been recorded.

The mean yield of capsicum grown in shadenets (50% shade) followed the inverse linear equation with the salinity of irrigation.

Under shadenets, capsicum yield levels of 90, 75 and 50% were realized at 2.3, 4.7, 8.7 dS m^{-1} irrigation water salinity, respectively.

Capsicum is profitable upto 6.0 dS m^{-1} (with a yield 17.25 t ha^{-1}) under shadenets with drip irrigation and humidifiers, on beds prepared with coco pit+FYM+ soil mix @ 1/3 each and decomposed for 3 months spraying bio-agents. Good surface drainage is a pre requisite for the bedding system.

Optimization of water requirement of groundnut-wheat cropping system under drip system using saline water (Bikaner)

Groundnut

An experiment was conducted during Kharif 2015 and 2016 to optimize water requirement of groundnut–wheat cropping sequence using saline water under drip irrigation. The treatments comprised of four levels of ECiw (BAW, 4 dS/m, 8 dS/m and 12 dS/m), two drip geometries (60 cm x 30 cm and 90 x 30 cm) and 3 levels of water requirement (0.6, 0.8 and 1.0 PE). Results of kharif component of experiment (Table 3.21) indicated that different treatments had significant effect on pod yield of groundnut. Increase in ECiw beyond 4 dS/m caused significant reduction in pod yield. As compared to BAW, ECiw of 8 dS/m and 12 dS/m caused significant reduction of 69.45 and 78.35 per cent, respectively on pooled basis. Drip laterals spaced at 60 cm resulted in 29.6 % higher pod yield as compared to laterals spaced at 90 cm. So far water requirement is concerned, in comparison to 1.0 PE and 0.8 PE, volume 0.6 PE showed significant reduction of 32.3 and 31.2 per cent, respectively, in pod yield, Volume 1.0 PE and 0.8 PE did not differ significantly to each other in this respect.

As far straw yield is concerned, non-significant improvement was noticed when ECiw increased to a level of 4 dS/m but further increase in ECiw i.e. 8 and 12 dS/m caused significant reduction of 31.58 and 46.6 per cent over ECiw of 4 dS/m, respectively (Table 3.21). Drip geometry of 60 cm x 30 cm proved significantly superior to 90 cm x 30 cm by a magnitude of 23.4 per cent in terms of straw yield. Volume 1.0 PE recorded the highest straw yield and differed significantly by a margin of 7.5 and 62.1 per cent to 0.8 and 0.6 PE, respectively.

Table 3.21 Effect of saline water, drip geometry and irrigations on pod yield and attributing characters of groundnut

Particular	Height (cm)			Number of pods per plant			Pod yield (q ha^{-1})			Straw yield (q ha^{-1})		
	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled	2014	2015	Pooled
ECiw (Irrigation water quality)												
BAW	27.25	20.11	23.68	25.55	20.52	23.03	35.34	26	30.67	56.02	45.33	50.67
4 dS/m	26.71	18.91	22.81	25.41	19.43	22.42	34.19	25.33	29.76	58.47	43.78	51.13
8 dS/m	21.27	14.87	18.07	19.57	15.25	17.41	10.39	8.34	9.37	46.65	23.31	34.98
12 dS/m	16.56	11.44	14	15.06	10.02	12.54	7.69	5.59	6.64	37.19	17.45	27.32
S.Em.±	0.36	0.45	0.3	0.36	0.39	0.28	0.63	0.25	0.35	3.93	0.61	2.01
C.D. (0.05)	1.05	1.32	0.87	1.05	1.13	0.8	1.86	0.73	1.01	11.57	1.81	5.73
Drip Geometry												
60 x 30	23.91	17.27	20.59	22.36	17.3	19.83	24.18	18.95	21.57	54.44	36.21	45.32
90 x 30	21.98	15.4	18.69	20.43	15.31	17.87	19.62	13.68	16.65	44.72	28.73	36.72
S.Em.±	0.25	0.32	0.22	0.25	0.27	0.2	0.45	0.17	0.25	2.78	0.43	1.42
C.D. (0.05)	0.74	0.93	0.61	0.74	0.8	0.56	1.32	0.51	0.71	8.18	1.28	4.05
PE												
0.6	21.97	15.36	18.67	20.42	15.57	18	16.7	12.48	14.59	35.07	24.53	29.8
0.8	23.24	16.48	19.86	21.69	16.56	19.13	24.36	18.03	21.19	54.04	35.88	44.96
1	23.63	17.16	20.39	22.08	16.78	19.43	24.64	18.43	21.54	59.64	36.99	48.31
S.Em.±	0.28	0.27	0.19	0.28	0.18	0.15	0.4	0.27	0.24	2.16	0.62	1.11
C.D. (0.05)	0.78	0.78	0.52	0.78	0.5	0.43	1.15	0.77	0.67	6.15	1.76	3.13

In respect of plant height at harvest, significant reduction was noticed with increase in ECiw beyond 4 dS/m. Drip geometry of 60 cm x 30 cm proved significantly superior to 90 cm x 30 cm by a magnitude of 10.2 per cent. Volume 1.0 PE slightly edged over 0.8 PE but as compared to 0.6 PE significant increase of 9.2 per cent in plant height was recorded.

It has been noticed that number of pods per plant was not affected significantly upto ECiw of 4 dS/m but as compared to BAW, ECiw of 8 and 12 dS/m caused significant reduction of 24.4 and 45.5 per cent, respectively. Drip geometry of 60 cm x 30 cm found significantly superior to 90 cm x 30 cm by a margin of 10.9 per cent. Volume 1.0 and 0.8 PE being at par with each other and found to bring about significant increase of 7.9 and 6.3 per cent, respectively over 0.6 PE.

Combined effect of treatments (lateral spacing x ECiw) was also found significant. Increase in the salinity of irrigation water beyond 4 dS/m significantly decreased the pod yield under both the drip geometries i.e. 60 cm x 30 cm and 90 cm x 30 cm (Table 3.22). It was also noted that when ECiw increased from BAW to 4 dS/m, significant reduction in pod yield was noted only at 1.0 PE volume. But further increase ECiw i.e. 8 and 12 dS/m, caused significant reduction in pod yield at all the levels of PE (Table 3.23). Under both the drip geometries tried, 0.6 PE resulted in significant reduction in pod yield, whereas 1.0 and 0.8 PE remained statistically at par in this respect (Table 3.24).

Table 3.22 Combined effect of treatments (lateral spacing x ECiw) on pod yield (q/ha) (pooled)

Drip geometry	BAW	4 dS/m	8 dS/m	12 dS/m
60 x 30 cm	35.34	33.85	9.93	7.14
90 x 30cm	25.99	25.67	8.80	6.13
S.Em.±	0.50			
C.D.	1.42			

Table 3.23 Combined effect of treatments (PE x ECiw) on pod yield (q/ha) (pooled)a

PE Level	BAW	4 dS/m	8 dS/m	12 dS/m
PE 0.6	23.21	23.03	7.28	4.84
PE 0.8	33.68	33.27	10.35	7.48
PE 1.0	35.10	32.98	10.48	7.59
S.Em.±	0.47			
C.D.	1.33			

Table 3.24 Combined effect of treatments (PE x lateral spacing) on pod yield (q/ha) (pooled)

PE Level	60 x 30 cm	90 x 30cm
PE 0.6	15.91	13.27
PE 0.8	23.86	18.53
PE 1.0	24.93	18.14
S.Em.±	0.34	
C.D.	0.94	

Wheat

During Rabi 2014-15 and 2015-16 experiment of optimize water requirement of groundnut – wheat cropping sequence using saline water under drip irrigation was conducted. The treatments comprised of four levels of ECiw (BAW, 4 dS/m, 8 dS/m and 12 dS/m), two drip geometries (60 cm x 30 cm and 90 x 30 cm) and 3 levels of water requirement (0.6, 0.8 and 1.0 PE). In 2015-16, however, wheat crop was badly damaged due to hail storm on 11th March 2016.

During 2014–15, it was noticed that different treatments had significant effect on seed yield of wheat (Table 3.25). Increase in ECiw beyond 8 dS/m caused significant reduction in seed yield. As compared to ECiw of 8 dS/m, 12 dS/m caused significant reduction of 58.2 per cent. Drip laterals spaced at 60 cm resulted in 29.5 % higher seed yield as compared to laterals spaced at 90 cm, a uniform distance of 30 cm, was, however, kept between emitter to emitter under both the drip geometries tested. So far irrigation volume (PE) requirement is concerned, in comparison to 1.0 PE and 0.8 PE, volume 0.6 PE showed significant reduction of 15.9 and 18.3 per cent, respectively, in seed yield, Volume 1.0 PE and 0.8 PE did not differ significantly to each other in this respect.

Table 3.25 Effect of saline water, drip geometry and irrigations on grain yield and attributing characters of wheat

Particular	Grain Yield (q/ha)	Straw Yield (q/ha)	Height (cm)	Tillers Per Sq.m.	Panicles per sq.m.	Grains/ panicle	Test wt. (g)
				ECiw			
BAW	25.77	31.75	71.87	296.6	282.3	25.3	29.22
4 dS/m	25.22	30.94	70.10	291.1	277.1	25.0	28.71
8 dS/m	24.49	30.02	59.45	254.6	233.2	21.5	27.09
12 dS/m	10.24	13.00	50.75	190.4	163.9	15.8	25.06
C.D. (0.05)	0.76	1.02	1.78	8.7	9.7	0.7	1.22

Drip Geometry							
60 x 30	24.18	29.15	68.21	284.4	265.7	23.6	30.73
90 x 30	18.67	23.71	57.87	232.0	212.5	20.1	24.31
C.D. (0.05)	0.54	0.72	1.26	6.2	6.9	0.5	0.87
P E							
0.6	18.83	23.99	59.53	236.8	218.2	20.3	24.66
0.8	22.41	27.53	64.08	265.9	246.2	22.5	28.53
1.0	23.04	27.76	65.52	271.9	252.9	22.9	29.38
C.D. (0.05)	0.87	1.04	2.22	10.4	10.6	0.8	1.32

Combined effects of treatments were also found significant. Increase in the salinity of irrigation water beyond 8 dS/m significantly decreased the seed yield under both the drip geometries i.e. 60 cm x 30 cm and 90 cm x 30 cm. As compared to BAW (Fig. 3.4), reduction in seed yield due to ECiw of 8 dS/m was statistically significant under both the drip geometries (60 cm x 30 cm and 90 cm x 30 cm). ECiw 4 dS/m and 8 dS/m were, however, at par in this respect. It is worth noting that as compared to BAW, ECiw of 8 dS/m caused significant reduction of only 3.9 and 6.3 per cent under drip geometry of 60 cm x 30 cm and 90 cm x 30 m, respectively, but with ECiw of 12 dS/m drastic reduction of the order of 58.7 and 62.2 per cent, respectively was noticed. Drip geometry of 90 cm x 30 cm proved to be inferior to 60 cm x 30 cm in this regard all the levels of ECiw.

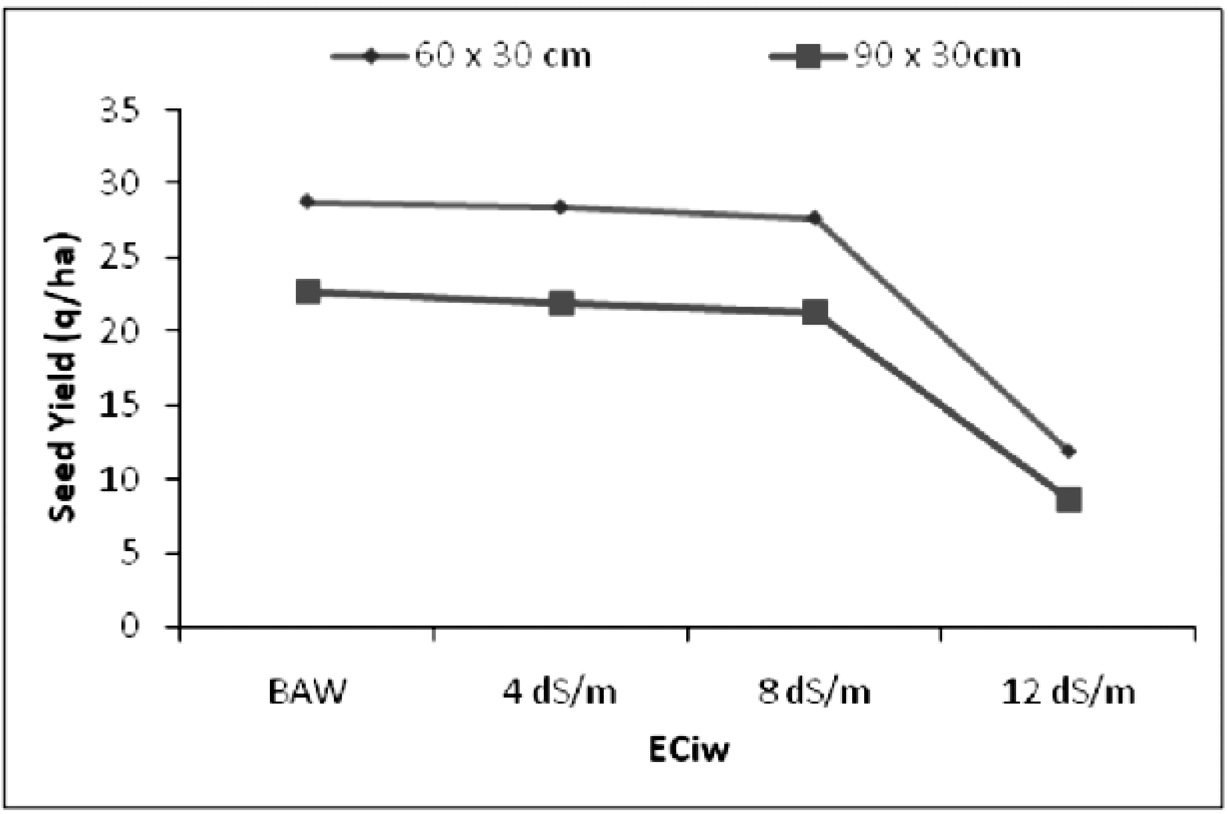

Fig. 3.4 Combined effect of treatments on seed yield (q/ha)

In terms of straw yield (Fig. 3.5) also, drip geometry of 90 cm x 30 cm resulted in significant reduction as compared drip geometry of 60 cm x 30 cm at all the levels of ECiw. At drip geometry of 60 cm x 30 cm, difference in straw yield recorded under BAW and ECiw of 4 dS/m was not significant. However, further increase in ECiw i.e. 8 and 12 dS/m caused significant reduction in straw yield. In case of drip geometry of 90 cm x 30 cm, reduction was not significant up to ECiw of 8 dS/m but further increase in ECiw i.e. 12 dS/m caused drastic reduction.

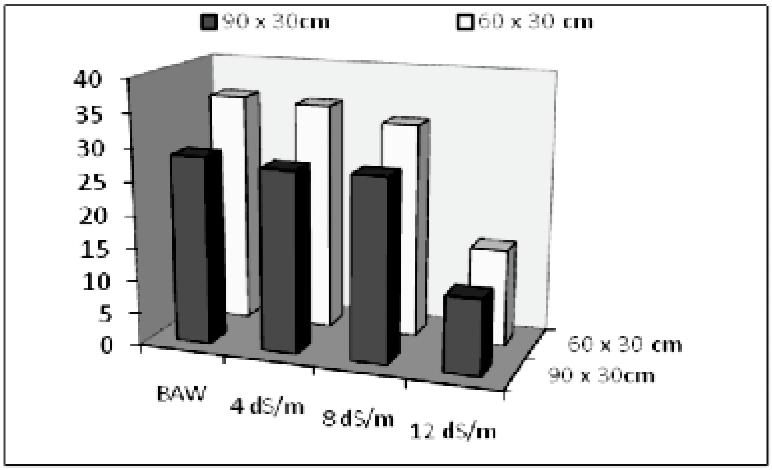

Fig. 3.5 Combined effect of treatments on straw yield (q/ha)

Plant height under both the drip geometries was not affected significantly up to 4 dS/m, but further increase in ECiw i.e. 8 and 12 dS/m resulted in significant reduction under both the drip geometries. As compared to drip laterals spaced at 60 cm, laterals spaced at 90 cm recorded leas height of wheat plants at all the levels of ECiw. So far various yield attributing characters (number of tillers/sq. m, panicles/sq. m, grains/panicle) is concerned, laterals spaced at 90 cm x 30 cm, resulted in significant reductions in all yield attributes at all the levels of ECiw. At lateral spacing of at 60 cm x 30 cm, differences in all these yield attributes due to varying ECiw were not significant up to 4 dS/m, however, further increase in ECiw caused significant reduction in the all these yield attributes.

Effect of fertility levels on isabgol - pearlmillet crop sequence under drip irrigation using saline water (Bikaner)

Isabgol

An experiment was conducted during Rabi 2014-15 and 2015-16 to optimize water requirement of pearl millet –isabgol cropping sequence using saline water under drip irrigation. The treatments comprised of three levels of ECiw (BAW, 4 dS/m and 8 dS/m), and 3 fertility levels (75% RD; 100% RD and 125% RD of NPK). The experiment was laid out but wind storms experienced during the season 2014-15 caused severe damage to the crop and left with no harvest, hence considered as failed. However, before the occurrence, observations on plant height and tillers per plant were recorded. Data (Table 3.26) indicated that increase in ECiw beyond 4 dS/m caused significant reduction in plant height and number tillers per plant, whereas, BAW and ECiw of 4 dS/m were statistically at par in respect of both the parameters. It was also noticed that application of 100% and 125% recommended dose of fertilizers recorded significantly higher values of both the parameters as compared to 75% recommended dose of fertilizers tested, however, both did not differ significantly with each other in these respects.

Table 3.26 Effect of different fertility levels on yield attributing characters of isabgol

Particular	Plant height (cm)	Tillers/plant
	Eciw	
BAW	21.56	11.08
4 dS/m	13.88	7.38
8 dS/m	0.37	0.33
C.D. (0.05)	1.09	0.97
	Fertility levels	
75 % RD	17.47	8.78
100 % RD	19.74	10.62
125 % RD	20.11	10.72
C.D. (0.05)	0.37	0.33

During rabi 2015-16 also, the experimental crop (Isabgol) was failed due to heavy hail storm observed in month of March, 2016.

Pearl-millet

An experiment was conducted during *Kharif* 2015 to optimize water requirement of pearl millet – isabgol cropping sequence using saline water under drip irrigation. The treatments comprised of three levels of ECiw (BAW, 4 dS/m and 8 dS/m), and 3 fertility levels (75 & RD; 100 % RD and 125 % RD of NPK). Results of kharif component of experiment (Table 3.27) indicated that different treatments had significant effect on grain yield of pearl millet. Increase in the ECiw beyond 4 dS/m caused significant reduction in the grain yield. As compared to BAW and ECiw of 4 dS/m, ECiw of 8 dS/m showed significant reduction of 20.0 and 16.8 per cent, respectively. In respect of fertility levels, it is noted that application of 100 % and 125 % recommended dose of NPK registered significant increase of 23.1 and 28.3 per cent in grain yield of pearl millet, respectively, over 75 % RD. In terms of straw yield also, similar trend was observed.

Different treatments had significant effect on straw yield of pearl millet. Increase in the ECiw beyond 4 dS/m caused significant reduction in the straw yield. As compared to BAW and ECiw of 4 dS/m, ECiw of 8 dS/m showed significant reduction of 18.2 and 13.5 per cent respectively. In respect of fertility levels, it is noted that application of 100 % and 125 % recommended dose of NPK registered significant increase of 17.9 and 23.9 per cent in straw yield of pearl millet, respectively, over 75 % RD.

Different treatments caused significant variations in various yield attributes viz., length of ear head, weight of ear head, girth of ear head and test weight. All attributes showed significant reduction when ECiw increased from 4 dS/m to 8 dS/m, however, BAW and ECiw of 4 dS/m were at par in respect of all these attributes. Application of 100% recommended dose of fertilizers found significantly superior to 75% RD in respect of all these yield attributes and remained at par with 125% RD of fertilizers. Plant height recorded at harvest showed similar trends.

Table 3.27 Effect of different treatments on yield and yield attributes of pearl millet

Treatments	Plant height (cm)	Ear head length (cm)	Ear head weight (g)	Ear head girth (cm)	Test weight (g)	Grain yield (q/ha)	Straw Yield (q/ha)
ECiw							
S_0 (BAW)	158.28	20.90	55.75	7.60	6.58	13.33	30.31
S_4 (4 dS/m)	153.58	19.70	53.75	7.41	6.41	12.82	28.66
S_8 (8 dS/m)	126.50	14.63	39.92	6.84	5.68	10.67	24.80
S.Em+	2.96	0.52	1.19	0.10	0.10	0.29	0.79
CD (0.05)	8.64	1.53	3.47	0.29	0.30	0.83	2.32
Fertility levels							
F_1 (75 % RD)	133.25	15.20	43.58	6.82	5.80	10.48	24.50
F_2 (100 % RD)	151.12	19.68	51.67	7.46	6.37	12.90	28.90
F_3 (125 % RD)	154.00	20.35	54.17	7.57	6.49	13.44	30.37
S.Em+	2.96	0.52	1.19	0.10	0.10	0.29	0.79
CD (0.05)	8.64	1.53	3.47	0.29	0.30	0.83	2.32

Combined effect of treatments of irrigation water and fertilizers (Table 3.28) showed that application of 100% RDF resulted in significant improvement the yield over 75% RDF at all the levels of ECiw but remained at par with that recorded 125% RDF. Application of 125% RDF at 4 dS/m recorded yield of 14.05 q/ha which was at par with that recorded with 100% RDF at same level of ECiw i.e. 4 dS/m and was also that recorded at BAW with the application of 100% and 125% of RDF. Increase in ECiw beyond 4 dS/m caused significant reduction with all the levels of fertilizer application.