Table 5.19 Effect of saline irrigation water on growth, yield attributes and yield of mustard genotypes (IVT-I + II saline conditions)

Mustard genotype	Days to flowering	Days to maturity	Plant height (cm)	No. of primary branches per plant	No. of secondary branches	No. of siliqua per plant	No. of siliqua on main stem	Seed yield per plant
CSCN-15-1	52.67	150.00	138.33	3.67	15.78	152.00	29.33	14.72
CSCN-15-2	54.33	152.33	145.33	3.89	16.78	121.99	34.00	14.50
CSCN-15-3	50.67	144.00	165.78	5.00	19.22	175.00	41.89	17.64
CSCN-15-4	51.67	147.00	169.22	4.44	18.33	186.67	42.34	17.56
CSCN-15-5	48.00	143.00	169.78	4.55	20.22	166.22	40.11	17.44
CSCN-15-6	48.67	143.33	155.33	4.55	19.11	169.00	41.44	17.72
CSCN-15-7	50.33	150.33	141.33	4.11	15.44	145.00	32.33	13.94
CSCN-15-8	51.67	148.00	148.56	4.78	17.00	149.00	28.89	15.28
CSCN-15-9	49.00	142.67	190.00	5.22	20.67	209.23	45.56	20.33
CSCN-15-10	52.67	149.33	141.67	3.89	15.67	140.03	34.78	10.50
S.Em.±	1.24	1.30	5.28	0.17	0.64	6.12	2.51	0.60
CD (P=0.05)	3.69	3.86	15.69	0.51	1.86	17.95	7.35	1.77

16) to 187.67 cm (CSCN-15-19). The highest plant height was recorded in genotype CSCN-15-19 followed by CSCN-15-12 and CSCN-15-13 and these genotypes were significantly superior to rest of the genotypes. The highest number of primary and secondary branches per plant was obtained in CSCN-15-19 followed by CSCN-15-12 and CSCN-15-13 and found significantly superior to rest of the other genotypes.

The highest number of siliqua per plant was found in genotype CSCN-15-19 followed by CSCN-15-14 and CSCN-15-13 and these genotypes were significantly superior to rest of the genotypes. Similarly, maximum siliqua on main stem was recorded in genotype CSCN-15-19 followed by CSCN-15-12 and CSCN-15-13.

Table 5.20 Effect of saline irrigation water on growth, yield attributes and yield of mustard genotypes (AVT-I + II saline conditions)

Mustard genotype	Days to flower-ing	Days to matur-ity	Plant height (cm)	No. of primary branches per plant	No. of secondary branches	Number of siliqua per plant	Number of siliqua on main stem	Seed yield per plant
CSCN-15-11	52.67	156.67	155.00	3.33	16.33	178.44	28.00	16.58
CSCN-15-12	52.00	152.33	178.67	5.00	17.67	174.22	31.32	19.17
CSCN-15-13	53.67	150.00	178.33	4.78	17.44	210.11	31.56	19.83
CSCN-15-14	49.00	148.67	162.67	3.66	15.89	216.67	25.94	14.50
CSCN-15-15	52.67	155.67	154.00	3.78	14.00	168.11	28.33	16.25
CSCN-15-16	55.00	153.33	151.22	3.66	13.78	162.00	28.78	15.42
CSCN-15-17	56.33	156.33	161.44	3.83	14.28	156.00	27.11	15.75
CSCN-15-18	56.33	154.67	154.33	4.11	15.44	181.89	25.22	14.00
CSCN-15-19	50.00	150.67	187.67	5.22	18.66	230.33	32.89	22.42
CSCN-15-20	57.00	164.33	152.78	3.78	13.89	172.33	29.67	18.67
S.Em.±	0.88	1.94	5.07	0.18	0.66	7.02	0.87	0.84
CD (P=0.05)	2.60	5.77	15.07	0.54	1.94	20.58	2.55	2.47

It is noted that all the entries so tested in these trials were heavily damaged due hail storm at maturity during March 2016 (Plate 5.3). However, growth and yield parameters and seed yield were recorded on the basis of selected plants only.


Healthy mustard crop before hail storm


Mustard crop failed due to hail storm

Plate 5.3 Failure of mustard crop due to hail storm

Screening of elite varieties of crops irrigated with poor quality waters (Hisar)

Screening activity is pursued by the centre to evaluate the performance of different varieties of crops under saline water irrigations and to study the effects of different qualities of saline water on the salt build up in the soil profile. Varieties of cotton, wheat, pearl millet and mustard are being screened. Four irrigation water qualities such as canal water (0.3 2.5 dS/m), saline water of EC_{iw} 2.5 dS/m, saline water of EC_{iw} 5.0 dS/m and saline water of EC_{iw} 7.5 dS/m were used for screening purpose.

The tolerance of cotton, wheat, pearl millet and mustard genotypes under saline water irrigation treatments was evaluated in lined micro-plots of 2 m x 2 m in size. The plots were constructed above ground and filled with the sandy loam surface soil (0-15 cm). The soil was allowed to stabilize before sowing the crop. The tolerance of seven genotypes of cotton (H-1098i, H-1300, H-1316, H-1353, H-1472, H-1476 and H-1477), fourteen genotypes of wheat (P-9109, P-9110, P-9111, P-9112, P-9113, P-9114, P-9115, P- 9116, P-9117, P-9118, P-9119, P- 9120, KRL-210 and Kh-65), seven genotypes of pearl millet (HHB-67, HHB-197, HHB-223, HHB-226, HHB-234, HC-10 and HC-20) and twenty genotypes of mustard (IVT: CSCN-14-1, CSCN-14-2, CSCN-14-3, CSCN-14-4, CSCN-14-5, CSCN-14-6, CSCN-14-7, CSCN-14-8 CSCN-14-9 and CSCN-14-10.

AVT-1: CSCN-14-11, CSCN-14-12, CSCN-14-13, CSCN-14-14, CSCN-14-15, CSCN-14-16, CSCN-14-17, CSCN-14-18, CSCN-14-19 and CSCN-14-20) were tested during 2014-2015. In 2015-2016 the tolerance of seven genotypes of cotton (H-1098i, Bio- 6488, H-1316, H-1353, RCH-650, RCH-602 and NCS-855), fourteen genotypes of wheat (P-9130, P-9131, P-9132, P-9133, P-9134, P-9135, P-9136, P-9137, P-9138, P-9140, P-9142, P-9143, KRL-19 and KRL-210), seven genotype of pearl millet (HHB-67, HHB-197, HHB-223, HHB-226, HHB-234, HHB-272 and HC-20) and twenty genotypes of mustard (IVT: CSCN-15-1, CSCN-15-2, CSCN-15-3, CSCN-15-4, CSCN-15-5, CSCN-15-6, CSCN-15-7, CSCN-15-8, CSCN-15-9 and CSCN-15-10) and (AVT: CSCN-15-11, CSCN-15-12, CSCN-15-13, CSCN-15-14, CSCN-15-15, CSCN-15-16, CSCN-15-17, CSCN-15-18, CSCN-15-19 and CSCN-15-20) was evaluated

under different saline water irrigation treatments *i.e.* canal water, ECiw 2.5, 5.0 and 7.5 dS/m. Recommended cultural practices and fertilizer doses were applied in raising the crops. Uniform fertilizer applications were made in all the treatments using urea, DAP and $ZnSO_4$. Irrigation schedule was based on the recommendations for the non-saline irrigated soils. The soil samples were collected before sowing and after the harvesting of the crops. The soil samples were air dried, ground to pass through a 2 mm sieve and analyzed for electrical conductivity.

Results 2014-15

Cotton: Increasing salinity led to a gradual decrease in seed cotton yield (Table 5.21). Among the seven genotypes of cotton, the seed cotton yield was highest (146.4 g/m^2) in H-1476 and lowest (95.4 g/m^2) in H-1316 genotype at salinity of 7.5 dS/m. At EC_{iw} of 7.5 dS/m, mean seed cotton yield reduced by 37.8% as compared to control. Overall mean seed cotton yield (165.0 g/m^2) of H-1476 was significantly higher than other genotypes followed by H-1472 (163.5 g/m^2), and the genotype H-1316 was the lowest yielder by having the mean seed cotton yield of 112.0 g/m^2.

Table 5.21 Effect of saline waters on seed cotton yield (g/m^2) of cotton genotypes

Genotypes	EC (dS/m)				Mean
	Control (0.3)	2.5	5.0	7.5	
H-1098i	253.4	131.3	120.7	96.4	150.5
H-1300	177.4	112.6	105.5	101.1	124.1
H-1316	134.3	114.0	104.4	95.4	112.0
H-1353	142.5	134.2	129.3	96.6	125.6
H-1472	183.5	169.4	164.3	136.7	163.5
H-1476	193.8	162.9	156.7	146.4	165.0
H-1477	159.3	145.7	136.7	100.7	135.6
Mean	177.7	138.6	131.1	110.5	
CD (5 %)	Variety (V)	= 8.7	Salinity (S)	= 6.6	V x S = 17.4

Table 5.22 Grain yield (g/m^2) of wheat varieties as affected by different salinity waters

Genotypes	EC_{iw} (dS/m)				Mean
	Control (0.3)	2.5	5.0	7.5	
P-9109	358.4	388.5	319.7	283.8	325.1
P-9110	416.5	388.6	355.7	323.7	371.1
P-9111	471.1	452.4	403.4	369.2	424.0
P-9112	526.9	513.5	463.3	421.5	481.3
P-9113	422.8	397.4	353.3	314.2	371.9
P-9114	392.2	369.6	331.6	319.6	353.2
P-9115	391.3	353.3	318.7	293.9	339.4
P-9116	438.5	421.6	387.9	352.3	400.0
P-9117	418.3	393.7	338.5	313.6	366.0
P-9118	449.9	398.4	363.9	308.5	380.2
P-9119	565.9	546.2	516.4	484.3	528.2
P-9120	469.4	429.3	384.3	351.4	408.6
KRL-210	473.6	431.5	411.0	333.5	412.4
KH-65	380.6	340.9	301.4	265.4	322.1
Mean	441.7	412.5	374.9	338.2	
CD (5 %)	Variety (V)	= 15.3	Salinity (S)	= 8.2	V X S = NS

Wheat: The data showed that the yield of different varieties of wheat decreased with an increase in EC of the irrigation water (Table 5.22). Wheat genotype P-9119 performed best at the highest saline water irrigation (7.5 dS/m) and gave 45.2% higher yield compared with KRL-210 (check). It is followed by P-9112 which gave 26.4 % higher yield than KRL-210 whereas the performance of Kh-65 was the poorest. On the basis of overall mean yield, P-9119 gave maximum yield (528.2 g/m^2) which was 28.1% higher than KRL-210, followed by P-9112 which out yielded KRL-210 by 16.7%, respectively.

Pearl millet: The data showed that the grain yield of different varieties of pearl millet decreased with an increase in EC of the irrigation water (Table 5.23). Pearl-millet variety HHB-226 performed best at the highest saline water irrigation (7.5 dS/m), followed by HHB-223 whereas the performance of HC-20 was the poorest. The mean yield (331.5 g/m^2) of HHB-226 was higher than other genotypes followed by HHB-223 (322.9 g/m^2) and HHB-234 (315.1 g/m^2). The genotype HC20 was the lowest yielder by having the mean seed yield of 196.0 g/m^2. At EC_{iw} of 7.5 dS/m, overall mean yield reduced by 20.1% as compared to canal treatment.

Table 5.23 Grain yield (g/m^2) of pearl-millet varieties as affected by different salinity waters

Genotypes	EC_{iw} (dS/m)				Mean
	Control (0.3)	2.5	5.0	7.5	
HHB-67	336.26	324.26	307.90	270.10	309.63
HHB-197	308.93	289.53	267.86	235.59	275.48
HHB-223	350.83	338.20	313.77	288.97	322.94
HHB-226	360.06	340.33	329.40	296.20	331.50
HHB-234	345.83	327.06	306.87	280.87	315.16
HC-10	250.70	230.33	210.63	195.43	221.75
HC-20	218.66	205.95	191.53	167.90	196.01
Mean	310.18	293.65	275.42	247.86	
CD (5 %)	Variety (V)	= 2.09	Salinity (S)	= 15.8	V X S = 4.19

Mustard: Ten genotypes of mustard were tested under IVT and AVT. The data showed that the seed yield of different genotypes of mustard decreased with an increase in EC of the irrigation water (Table 5.24 and 5.25). In IVT, the mustard genotypes CSCN-14-1 gave the highest seed yield (213.77 g/m^2) followed by CSCN-14-6 (171.13 g/m^2) at EC_{iw} of 7.5 dS/m and the lowest yield (108.33 g/m^2) was obtained in CSCN-14-5.

Table 5.24 Seed yield (g/m^2) of mustard genotypes under IVT as affected by waters of different salinities

Genotype	EC_{iw} (dS/m)				Mean
	Control (0.3)	2.5	5.0	7.5	
CSCN-14-1	253.50	243.87	235.33	213.77	236.62
CSCN-14-2	188.73	174.43	164.83	156.83	171.21
CSCN-14-3	226.53	192.37	177.17	155.33	187.85
CSCN-14-4	220.77	211.83	184.43	167.87	196.23
CSCN-14-5	179.70	142.50	130.67	108.33	140.30
CSCN-14-6	260.33	209.73	183.80	171.13	206.25
CSCN-14-7	214.43	209.30	184.87	169.90	194.63
CSCN-14-8	273.57	208.20	197.47	163.73	210.74
CSCN-13-9	244.33	196.57	170.30	166.37	194.40
CSCN-14-10	217.80	187.50	157.23	136.03	174.64
Mean	227.97	197.63	178.61	160.93	
CD at 5 %	V=13.41	S = 8.48	VxS= NS		

Table 5.25 Seed yield (g/m^2) of mustard genotypes under AVT as affected by different salinity waters

Genotype	EC_{iw} (dS/m)				Mean
	Control (0.3)	2.5	5.0	7.5	
CSCN-14-11	291.60	255.17	236.70	219.90	250.84
CSCN-14-12	231.33	210.83	192.37	178.50	203.26
CSCN-14-13	235.80	217.27	196.53	174.20	205.95
CSCN-14-14	222.50	205.47	193.70	184.33	201.50
CSCN-14-15	275.93	254.03	247.20	205.27	245.61
CSCN-14-16	255.27	227.90	197.87	180.33	215.33
CSCN-14-17	229.37	223.80	188.30	172.67	203.53
CSCN-14-18	262.36	213.17	200.47	164.37	210.09
CSCN-13-19	261.37	217.90	210.73	181.73	217.93
CSCN-14-20	251.00	243.90	230.23	183.23	227.09
Mean	251.65	226.94	209.41	184.45	
CD at 5 %	V=16.80	S = 10.63	VxS= NS		

In AVT, the mustard genotypes CSCN-14-11 gave the highest seed yield (219.90 g/m^2) followed by CSCN-14-15 (205.27 g/m^2) at EC_{iw} of 7.5 dS/m and the lowest yield (164.37 g/m^2) was obtained in CSCN-14-18. The mean salinity in the soil profile (0-45cm) at the time of sowing was varying from 1.53 to 10.03 dS/m in canal water to the highest EC irrigating water plot (Table 5.26).

Table 5.26 Salinity in the soil at the time of sowing mustard in different treatment plots

Depth of Soil (cm)	EC_e (dS/m)			
	Control (0.3)	2.5	5.0	7.5
0-15	1.41	3.78	7.47	10.42
15-30	1.58	4.99	8.43	10.25
30-45	1.61	4.54	7.50	9.43
Mean	1.53	4.43	7.80	10.03

Results 2015-16

Cotton: Increasing salinity led to a gradual decrease in seed cotton yield (Table 5.27). Among the seven genotypes, H-1098i gave the highest (156.83 g/m^2) seed cotton yield and H-1316 resulted in the lowest seed cotton yield (103.70 g/m^2) at EC_{iw} 7.5 dS/m. The mean seed cotton yield reduced by 28.93 % at EC_{iw} 7.5 dS/m as compared to canal irrigation. Overall mean yield (195.09 g/m^2) of H-1098i was significantly higher than other genotypes followed by Bio-6488 (180.49 g/m^2) and H-1316 was the lowest yielder (125.49 g/m^2).

Table 5.27 Effect of saline waters on seed cotton yield (g/m^2) of cotton genotypes

Genotype/ Variety	EC (dS/m)				Mean
	Control (0.3)	2.5	5	7.5	
H- 1098i	225.3	209.93	188.3	156.83	195.09
Bio- 6488	205.76	191.33	176.63	148.23	180.49
H-1316	142.6	136.88	118.86	103.7	125.49
H-1353	158.26	146.33	129.76	105.73	135.02
RCH-650	195.73	184.7	169.73	146.4	174.14
RCH-602	191.3	184.73	167.23	134.36	169.4
NCS-855	172.43	162.06	149.73	124.56	152.2
Mean	184.88	173.7	157.18	131.4	
CD at 5 % = Variety (V) = 8.7, Salinity (S) = 6.5, V x S = NS					

Wheat: The data showed that the grain yield of different genotypes of wheat decreased with an increase in EC of the irrigation water (Table 5.28). Wheat genotype P-9131 performed the best at ECiw (7.5 dS/m) and gave 19.08% higher grain yield compared with KRL-210 (check). It was followed by P-9136 which gave 17.17 % higher grain yield than KRL-210 whereas; the performance of P-9130 was the poorest. On the basis of overall mean grain yield P-9136 gave maximum grain yield (510.78 g/m^2) which was 24.86% higher than KRL-210 followed by P-9131(491.05 g/m^2) which was 20.04% higher than KRL-210.

Table 5.28 Grain yield (g/m^2) of wheat genotypes as affected by different saline waters

Genotype	EC_{iw} (dS/m)				Mean
	Canal (0.3)	2.5	5.0	7.5	
P- 9130	296.17	284.70	261.57	224.87	266.82
P-9131	549.20	512.63	478.00	424.37	491.05
P-9132	496.77	461.63	437.93	398.60	448.73
P-9133	486.57	462.13	440.60	387.23	444.13
P- 9134	472.73	459.37	422.67	399.02	438.45
P-9135	494.23	472.90	452.37	407.80	456.82
P-9136	561.07	542.63	521.87	417.57	510.78
P- 9137	489.53	453.93	438.17	396.23	444.47
P-9138	515.33	492.90	455.50	408.57	468.08
P-9140	493.67	476.17	456.60	396.90	455.83
P-9142	522.80	501.40	480.60	398.17	475.74
P-9143	451.73	416.47	410.33	369.20	411.93
KRL-19	351.23	332.20	321.80	254.83	315.02
KRL-210	452.40	442.27	400.27	356.37	409.07
Mean	473.82	449.74	427.02	374.26	
CD (5%)	Variety (V) = 19.55, Salinity (S)= 10.45, V x S = NS				

Physiological data recorded for SPAD chlorophyll content at anthesis and 15 days after anthesis, canopy temperature and chlorophyll fluorescence (Fv/Fm) at anthesis revealed that promising genotypes for SPAD chlorophyll content were P- 9136, P-9132 and P-9133 having values 53.7, 46.1 and 46.2, respectively, grown under higher salinity level (7.5 dS/m). Low canopy temperature (26.5^{o}C, 26.6^{o}C and 30.0^{o}C) was found in P-9136, P-9132 and P-9133 respectively. But high chlorophyll fluorescence (Fv/Fm) was found in P-9131 (0.786), P-9143 (0.760) and P-9135 (0.763).

Pearl millet : The data showed that the grain yield of different genotypes of pearl millet decreased with an increase in EC of the irrigation water (Table 5.29). Pearl millet variety HHB-226 performed best at EC_{iw} (7.5

Table 5.29 Grain yield (g/m^2) of pearl-millet varieties as affected by different salinity waters

Genotype/ Variety	EC_{iw} (dS/m)				Mean
	Canal	2.5	5	7.5	
HHB-67	266	248.4	230	208.3	238.2
HHB-197	226.1	213.2	198.3	193	207.8
HHB-223	303	282	268	240	273
HHB-226	305.9	292	269.5	241.1	277.1
HHB-234	270.3	254.5	234.1	210.6	242.4
HHB-272	249.9	233.6	216.6	166.6	216.7
HC-20	204.3	189.9	173.3	152.5	180
Mean	260.71	244.77	227.02	201.76	
CD (5%)	Variety (V) = 13.61, Salinity (S) = 10.29, V x S = NS				

dS/m) followed by HHB-223 whereas the performance of HC-20 was the poorest. The mean grain yield (277.10 g/m^2) of HHB-226 was higher than other genotypes followed by HHB-223 (273.0 g/m^2) and HHB-234 (242.40 g/m^2). The genotype HC-20 was the lowest yielder with mean grain yield of 180.0 g/m^2 at EC_{iw} 7.5 dS/m, overall mean grain yield reduced by 22.61% as compared to canal treatment.

Mustard: Ten genotypes of mustard were tested under IVT and AVT each. The data showed that the seed yield of different genotypes of mustard decreased with an increase in EC of the irrigation water (Table 2.30-5.32). In IVT, the mustard genotypes CSCN-15-1 gave the highest seed yield (192.93 g/m^2) followed by CSCN-15-3 (189.23 g/m^2) at EC_{iw} 7.5 dS/m and the lowest seed yield (149.50g/m^2) was obtained in CSCN-15 -5.

Table 5.30 Seed yield (g/m^2) of mustard genotypes under IVT as affected by waters of different salinities

Genotype/ Variety	EC_{iw} (dS/m)				Mean
	Control (0.3)	2.5	5.0	7.5	
CSCN-15-1	308.87	293.83	267.57	192.93	265.80
CSCN-15-2	278.57	270.43	224.93	179.43	238.34
CSCN-15-3	297.83	282.27	253.77	189.23	255.77
CSCN-15-4	244.48	227.73	188.47	178.77	209.87
CSCN-15-5	214.93	202.67	174.40	149.50	185.37
CSCN-15-6	291.67	257.77	233.20	182.27	241.22
CSCN-15-7	274.50	267.67	215.43	174.33	232.98
CSCN-15-8	262.20	254.57	201.47	171.80	222.50
CSCN-15-9	260.30	240.60	197.47	168.23	216.65
CSCN-15-10	248.30	237.93	190.80	165.23	210.57
Mean	268.17	253.55	214.75	175.17	
CD (5 %)	Genotype (G) = 19.0, Salinity (S) = 12.0, VxS= NS				

Table 5.31 Effect of different saline waters on salinity susceptibility index (SSI) and Na^+/K^+ ratio of mustard genotypes under initial variety trial (IVT)

Genotype	Salinity susceptibility index (SSI)				Na^+/K^+ ratio			
	EC_{iw} (dS/m)							
	2.5	5.0	7.5	Mean	Control	2.5	5.0	7.5
CSCN-15-1	0.89	0.67	1.08	0.88	0.72	1.48	2.02	2.65
CSCN-15-2	0.54	0.97	1.03	0.84	0.68	1.39	1.71	3.47
CSCN-15-3	0.96	0.74	1.05	0.92	0.71	1.27	1.68	2.76
CSCN-15-4	1.26	1.15	0.78	1.06	0.62	1.52	1.62	4.01
CSCN-15-5	1.05	0.95	0.88	0.96	0.95	1.28	1.70	2.69
CSCN-15-6	2.13	1.01	1.08	1.41	0.43	0.99	2.21	4.62
CSCN-15-7	0.46	1.08	1.05	0.86	0.61	1.16	1.93	4.34
CSCN-15-8	0.53	1.16	0.99	0.90	0.82	0.68	2.16	3.89
CSCN-15-9	1.39	1.21	1.02	1.21	0.43	1.19	1.71	3.90
CSCN-15-10	0.77	1.16	0.96	0.96	0.61	0.94	1.47	3.45
Mean	1.00	1.01	0.99		0.66	1.19	1.82	3.58

Table 5.32 Seed yield (g/m^2) of mustard genotypes under AVT as affected by different salinity waters

Genotype/ Variety	EC_{iw} (dS/m)				Mean
	Control (0.3)	2.5	5.0	7.5	
CSCN-15-11	289.57	287.70	257.80	212.27	261.83
CSCN-15-12	209.97	192.57	176.60	144.60	180.93
CSCN-15-13	266.10	256.23	236.27	189.07	236.92
CSCN-15-14	277.10	268.20	243.87	185.77	243.73
CSCN-15-15	222.50	201.30	187.77	151.37	190.73
CSCN-15-16	356.47	336.20	319.87	246.63	314.79
CSCN-15-17	270.93	254.43	214.47	175.93	228.94
CSCN-15-18	290.77	274.53	203.17	146.90	228.84
CSCN-15-19	190.70	171.07	151.00	138.90	162.92
CSCN-15-20	254.2	248.00	233.70	187.47	230.84
Mean	262.83	249.02	222.45	177.89	
CD (5 %)	Genotype (G) = 18.4, Salinity (S) = 11.6, VxS= NS				

Salinity susceptibility index (SSI) used to test the sensitivity of genotypes to salinity stress ranged from 0.84 to 1.41 in different mustard genotypes. The mean values less than one was recorded in CSCN-15-1, CSCN-15-2, CSCN-15-3, CSCN-15-5, CSCN-15-7, CSCN-15-8 and CSCN-15-10. Salinity susceptibility index (SSI) increased with the increasing the waters of different salinities. The mean values less than one was recorded in CSCN-15-4, CSCN-15-5, CSCN-15-8 and CSCN-15-10 mustard genotype at 7.5 dS/m of salinity. Same trend was noticed in Na^+/K^+ ratio (Table 5.33).

Table 5.33 Effect of different saline waters on salinity susceptibility index (SSI) and Na^+/K^+ ratio of mustard genotypes under advance variety trial (AVT)

Genotype	Salinity susceptibility index (SSI)				Na^+/K^+ ratio			
					EC_{iw} (dS/m)			
	2.5	5.0	7.5	Mean	Canal	2.5	5.0	7.5
CSCN-15-11	0.12	0.71	0.83	0.55	0.52	1.40	2.75	2.30
CSCN-15-12	1.58	1.03	0.96	1.19	0.83	0.97	1.97	2.83
CSCN-15-13	0.71	0.73	0.90	0.78	0.69	1.19	0.98	1.81
CSCN-15-14	0.61	0.78	1.02	0.80	0.86	1.29	1.36	3.28
CSCN-15-15	1.81	1.02	0.99	1.27	0.75	1.03	1.46	2.05
CSCN-15-16	1.08	0.67	0.95	0.90	0.35	1.35	1.57	4.24
CSCN-15-17	1.16	1.36	1.09	1.20	0.62	1.38	1.83	2.62
CSCN-15-18	1.06	1.96	1.53	1.52	1.41	1.04	1.90	1.83
CSCN-15-19	1.96	1.36	0.84	1.38	1.53	0.99	1.45	3.13
CSCN-15-20	0.46	0.52	0.81	0.60	0.63	0.77	2.65	3.94
Mean	1.06	1.01	0.99		0.82	1.14	1.79	2.80

Decreasing trend was observed in chlorophyll content (SPAD units) from 45.69 to 37.09 and seed yield (g/m^2) from 268.17 to 175.17 with every increment of waters of different salinities. Per cent decline in chlorophyll content was found higher in CSCN-15-5 (24.35 %) and lower in CSCN-15-4 (15.26 %) at 7.5 dS/m over their respective control. Whereas maximum per cent decline in seed yield was depicted in CSCN-15-1 (37.54 %) and minimum in CSCN-15-4 (30.44 %).

In AVT, the mustard genotypes CSCN-15-16 gave the highest seed yield (246.63 g/m^2) followed by CSCN-15-11 (212.27 g/m^2) at ECiw 7.5 dS/m and the lowest seed yield (138.90 g/m^2) was obtained in CSCN-15-19. Salinity susceptibility index (SSI) used to test the sensitivity of genotypes to salinity stress ranged from 0.55 to 1.52 in different mustard genotypes. The mean values less than one was recorded in CSCN-15-11, CSCN-15-13, CSCN-15-14, CSCN-15-16, and CSCN-15-20 Salinity susceptibility index (SSI) increased with the increasing the waters of different salinities. The mean values less than one was calculated in CSCN-15-11, CSCN-15-12, CSCN-15-13, CSCN-15-15, CSCN-15-16, CSCN-15-19 and CSCN-15-20

mustard genotype at 7.5 dS m^{-1} of salinity. Same trend was noticed in Na^+/K^+ ratio. Decreasing trend was observed in chlorophyll content (SPAD units) from 45.90 to 37.39 and seed yield (g/m^2) from 262.83 to 177.89 with every increment of waters of different salinities. Per cent decline in chlorophyll content was found maximum in CSCN-15-19 (25.14 %) and minimum in CSCN-15-12 (15.19%) at 7.5 dS/m over their respective control. Where as per cent decline in seed yield was depicted highest in CSCN-15-18 (49.48 %) and lowest in CSCN-15-20 (26.25 %) at 7.5 dS m^{-1} over their respective control. The mean salinity in the soil profile (0-45cm) at the time of sowing varied from 1.55 dS/m in canal water irrigated plot to 10.32 dS/m in plots receiving saline water irrigation of ECiw 7.5dS/m (Table 5.34).

Table 5.34 Salinity at different soil depths at the time of mustard sowing

Depth	EC_e (dS/m)			
(cm)	Canal (0.3)	2.5 dS/m	5.0 dS/m	7.5 dS/m
0-15	1.45	3.88	7.5	10.55
15-30	1.63	4.18	8.35	10.8
30-45	1.57	4.02	7.6	9.61
Mean	1.55	4.03	7.82	10.32

Screening of vegetable crops for sodicity tolerance under sodic black clay soils (Indore)

The information pertaining to sodicity tolerance of vegetable crops under sodic black clay soils environment is meager. Hence experiment was planned to study sodicity tolerance under sodic black clay soils. The different ESP levels such as 25, 35, 45 and 55 with ±2 were used to test two vegetable crops cabbage and cauliflower. The plot size was 5 m x 4 m. Data in Table 5.35 indicated that survival percentage and yield of vegetable crops decreased with the increasing levels of ESP. The maximum survival percent was observed in cabbage followed by cauliflower at ESP 25. Highest yield was recorded in case of cabbage (32.37 t ha^{-1}) followed by cauliflower (19.38 t ha^{-1}) at ESP 25. The survival percentage of cabbage and cauliflower was less than 50% at ESP 45.

Table 5.35 Survival (%) and yield (t/ha) of vegetable crops at different ESP levels

Crops	ESP levels			
	25±2	35±2	45±2	55±2
	Survival Percentage			
Cauliflower	85.3	51.3	32.5	11.5
Cabbage	93.8	58.8	36.3	14.8
	Yield (t/ha)			
Cauliflower	19.38	9.49	4.24	1.40
Cabbage	32.37	15.83	7.33	3.11

Screening of rice, wheat and mustard varieties/genotypes in sodic soil (Kanpur)

This experiment was planned for screening of rice, wheat and mustard varieties under sodic condition. List of varieties of these crops are provided in Table 5.36.

Table 5.36 Varieties of rice, wheat and mustard used for screening

Rice	Wheat	Mustard	Other Expt. Details	
CSR-23	KRL-210	CS-52	No of replication:	Three in each crop
CSR-27	KRL-213	CS-54	Design:	RBD
CSR-30	PBW-343	CS-56	Plot size:	20 m^2
CSR-36	PBW-502	Varuna	Year of start	2015
CSR-43	WH-147	Pitamvari	Location:	Crop Research Farm, Dalipnagar, Kanpur
Pant-12	K-307	Rohini	Initial soil status:	9.30
NDR-359	K-8434	Urvashi	pH	0.89
Kranti	DBW-17	Kanti	EC (dSm^{-1})	42.26
			ESP	0.28
			O.C. (%)	

The grain and straw yield of rice varied from 21.27 to 43.52 q/ha with mean value of 34.48 q/ha and 27.22-53.57 q/ha with mean value of 42.73 q/ha, respectively. The maximum yield 43.52 q/ha of rice was recorded from variety CSR-36 followed by CSR-23 and CSR-27 (Table 5.37). The minimum yield 21.27 q/ha was obtained from CSR-30.

Table 5.37 Yield of rice (q/ha) in sodic soil conditions

Varieties	Grain (2015)	Mean	Straw (2015)	Mean
CSR-23	39.82		49.77	
CSR-27	37.65		46.68	
CSR-30	21.27		27.22	
CSR-43	36.38		44.38	
CSR-36	43.52	34.48	53.57	42.73
Pant-12	28.69		35.86	
NDR-359	35.12		43.92	
Kranti	33.41		40.43	

The grain and straw yield of wheat varied from 26.10-34.55 q/ha with mean value of 30.48 q/ha and 27.22-53.57 q/ha with mean value of 42.73 q/ha respectively. The maximum yield 34.55 q/ha of wheat was recorded from variety KRL-210 followed by KRL-213 and PBW-342 (Table 5.38). The minimum yield 26.10 q/ha was obtained from WH-147.

Table 5.38 Yield of wheat (q/ha) in sodic soil conditions

Varieties	Grain	Mean	Straw	Mean
	(2015-16)		(2015-16)	
KRL-210	34.55		42.15	
KRL-213	33.84		40.94	
PBW-343	32.42		39.87	
PBW-502	31.27		36.89	
WH-147	26.10	30.48	31.84	36.90
K-307	28.77		34.25	
K-8434	29.52		36.72	
DBW-17	27.33		32.54	

The grain yield of mustard varied from 10.63 to 16.12 q/ha with mean value of 12.97 q/ha and stalk yield from 26.73 to 40.27 q/ha with mean value of 33.19 q/ha. The maximum yield 16.12 q/ha of mustard was recorded from variety CS-56 followed by CS-54 and CS-52 (Table 5.39). The minimum yield 10.63 q/ha was obtained from Urvasi.

Table 5.39 Yield of mustard (q/ha) in sodic soil conditions

Varieties	Grain (2015-16)	Mean	Stalk (2015-16)	Mean
CS-52	13.25		32.92	
CS-54	14.78		37.82	
CS-56	16.12		40.27	
Varuna	12.97	12.97	34.25	33.19
Pitambri	11.55		29.45	
Rohini	12.32		33.74	
Urvasi	10.63		26.73	
Kranti	12.14		30.35	

Evaluation of different crops for their tolerance to sodicity level (Tiruchirappalli)

The centre screened crop varieties viz. rice (TRY 1, CO42, TRY(R)^2, ADT 39, ADT 45, White Ponni), black gram (T9 and ADT 5), green gram (Pusa Bold), okra (Parbani Kranti), vegetable cowpea (VBN 37), cluster

bean (Pusa Nowbahaar), sunflower (CO 4, TCSH 1), sesame (CO 1), pearl millet (CO7, COHCu8, UCC17, ICMY221, PT1890) and Maize for sodicity tolerance and their tolerance limits under this scheme. This experiment is being continued in the same experimental plot with four ESP gradients with new cotton hybrids and variety during this year (2014). The cotton hybrid (RCH-20) and varieties (Surabhi and SVPR-2) were tested under different sodicity levels (ESP levels) during February 2014. The main plot treatment comprised of four ESP levels viz., ESP 8 of (M1), 16 (M2), 32(M3) and 40 (M4) were artificially created by application sodium bicarbonate at the beginning of the experiment (2012). At present the main plot ESP levels were analyzed before raising the third crop of cotton in the same plot and the ESP recorded was 9.6, 18.5, 29 and 38 for M1, M2, M3 and M4, respectively. In order to assess the tolerance of cotton hybrid (RCH-20) and varieties Surabhi and SVPR-2) were included in the subplot treatments. The experiment soil is clay loam in texture with initial pH of 8.9, EC 0.41 dS m-1, CEC 18 cmol (p+)/kg and an ESP of 16. Taxonomically soil of the experimental field belongs to fine, mixed, calcareous isohyperthemic Vertic Ustropept. The water used for irrigation is highly alkali with pH of 8.8, EC 1.42, RSC 9.2.

The results of the field experiment revealed that among the cotton hybrid and varieties tested, the cotton hybrid RCH-20 (BT Cotton) has recorded the maximum seed cotton yield of 2954 kg ha^{-1} and the variety SVPR-2 recorded the lowest seed cotton yield of 843 kg ha-1 (Table 5.40). It was also observed that with progressive increase in ESP levels from 9.6 to 38 of each hybrid and varieties showed significant reduction in seed cotton yield. Among the various ESP levels tried, ESP 9.2 recorded significantly higher yield of 2300 kg ha-1 compared to other ESP levels. Irrespective of the hybrid and variety tested the seed cotton yield had significantly reduced from 2300 to 1002 kg ha-1 for ESP level of 9.6 to 38.

Table 5.40 Seed Cotton yield under different ESP levels (kg ha^{-1})

Treatments (ESP levels)	Seed Cotton yield (kg ha^{-1}) Cotton variety / Hybrid*			
	S1 (Surabhi)	S2 (RCH-20)*	S3 (SVPR-2)	Mean
M1 (9.6)	2030	2954	1931	2300
M2 (18.5)	1461	2106	1464	1677
M3 (29)	1294	1333	1273	1300
M4 (38)	931	1234	843	1002
Mean	1429	1906	1377	
CD (p = 0.05)	M	S	M at S	S at M
	121.67	91.04	191.65	182.07

The effect of different ESP levels on cotton quality parameters of the experiment conducted during 2014 showed that the highest lint index (g) and GOT (%) was obtained at ESP of 9.6 and the lowest values are recorded at ESP of 38. Among the hybrid and varieties tested, the hybrid RCH-20 performed better and recorded higher Lint index (5.63g) and GOT (35.35%) at ESP 9.6 and these values are significantly different from the values obtained at ESP level 18.5. In the main plot treatments (at different ESP levels) except the ESP 9.6 (M1) and 18.5 (M2), the M3 and M4 did not show any significant effect on Lint index (g) and GOT (%). However, the varieties and hybrid under different ESP levels and their interaction effect was not significant in the quality parameters of cotton viz., Lint index (g) and GOT (%). The cotton seed index (g) recorded at ESP of 9.6 and 18.5 differ significantly from each other and the ESP levels increases higher levels (ESP 29 and 38) they did not show any significant difference and the values are on par. Whereas, the Micronaire value at different ESP levels (ESP 9.6, 18.5, 29 and 38) did not show any difference and the values are on par. With regards to variety and hybrids (subplot) under different ESP levels and their interaction effects are not significant in the quality parameters viz., cotton seed index (g) and Micronaire value.

With respect to Na/K ratio in cotton hybrids and varieties, the hybrid cotton RCH-20 recorded the lowest ratio than the varieties Surabhi and SVPR-2. It indicated that the under different sodicity levels the hybrid cotton excluded the Na uptake in the plant system than K compared to varieties (Table 5.41). It meant that

hybrid cotton can withstand even at higher ESP levels and salt stress (Na salt) than varieties and perform in terms of yield, yield attributing characters and biometrical parameters of cotton crop.

The post harvest soil analysis during 2014, with regards to soil pH at different ESP levels the pH values were increased as the ESP levels increased. However there is no much difference in buildup of soil EC (dSm-1) at post harvest soil compared to initial EC (dSm-1) values during 2014-15. The reduction in EC (dSm-1) might be due to leaching of salt and removal of salts by crop during the experiment.

Table 5.41 Na/K ratio in cotton crop under different ESP levels

Treatments (ESP levels)	Na/K ratio Cotton variety / Hybrid*			
	S1 (Surabhi)	S2 (RCH-20)*	S3 (SVPR-2)	Mean
M1 (9.6)	1.01	0.73	1.14	0.96
M2 (18.5)	1.17	0.80	1.23	1.06
M3 (29)	1.25	0.89	1.33	1.15
M4 (38)	1.35	0.95	1.46	1.25
Mean	1.19	0.84	1.29	

Sodicity tolerance experiment with chilli and onion (Tiruchirappalli)

An experiment was planned to assess the effect of different ESP levels of soil on growth and yield of Chilli and Onion and to know about their tolerance limits as well as uptake of Na and K in various plant parts. The experimental details are provided in Table 5.42.

Table 5.42 Field Experiment Details

Main plots	Sub plots	Other details
ESP Gradient: · 8 · 16 · 24 · 32 · 40 · 48	Chilli varieties: · Kovilpatti - 1 (K-1) · Ramanathapuram- Mundu (local) · Manaparai local · TNAU Hybrid Chilli CO-1	· Spacing: 60 x45 cm · Replication: 3 · Design: Split Plot Design · Date of sowing: 28 Sept. 2016 · Duration: 120 days

In experimental field, based on the ESP existed in the different main plots, the sodium bicarbonate was applied to main plots and mixed thoroughly with the soil to create different gradient ESP levels viz., 8, 16, 24, 32, 40 and 48 were artificially. Further, the ESP 8 was created through application of gypsum and leaching with good quality water. Then the experimental plot was thoroughly ploughed individually to bring optimum soil tilth and the ridges and furrows were formed with a spacing of 60 cm.

This experiment was continued in the same experimental plot with six ESP gradients with different chilli hybrids and varieties during 2015-16. Nursery was raised with various varieties *viz.,* Kovilpatti - 1 (K-1), Ramanathapuram- Mundur local, Manaparai local and TNAU Hybrid Chilli CO-1 at sodic soil during January 2016. Due to sodicity, the seeds were not germinated and thus the trial was abandoned during 2015-16 season.

Again trial was initiated during August, 2016. Nursery was raised during second week of August, 2016 with normal soil with good quality water. The existing main field also prepared in A6b farm of ADAC&RI, Trichy. Thereafter, chilli seedlings were transplanted along the ridges with a spacing of 60 cm between rows and 45 cm between plants during last week of September 2016. The seedling vigour was good when it was raised under normal soil with good quality water. Other management practices like gap filling weeding and other inter cultivation practices were carried out according to the recommended package of practices. Further, observations in the experiment are under progress.

6. ON-FARM TRIALS AND OPERATIONAL RESEARCH PROJECTS

Management of waterlogged saline soils at farmer's field (Agra)

A field trial on farmer's field (Shri Nand Ram's field) was initiated with provision of drain at village Pisawa (Mathura) to control waterlogging and salinity. Treatments were distance of drain channel (40m and 80 m) and FYM 5 (t/ha) and No FYM. The crop rotation was paddy-wheat. The experiment was initiated during 2015-16. The initial soil properties are given in Table 6.1 and layout is provided in Fig. 6.1.

Table 6.1 Initial status of soil salinity

Soil Depth (cm)	ECe (dS/m)	pH	SARe (mmol/l)1/2	RSC (meq/l)
0-15	56.5	7.3	31.9	NIL
15-30	23.5	7.3	16.8	NIL
30-50	19.1	7.4	16.7	NIL

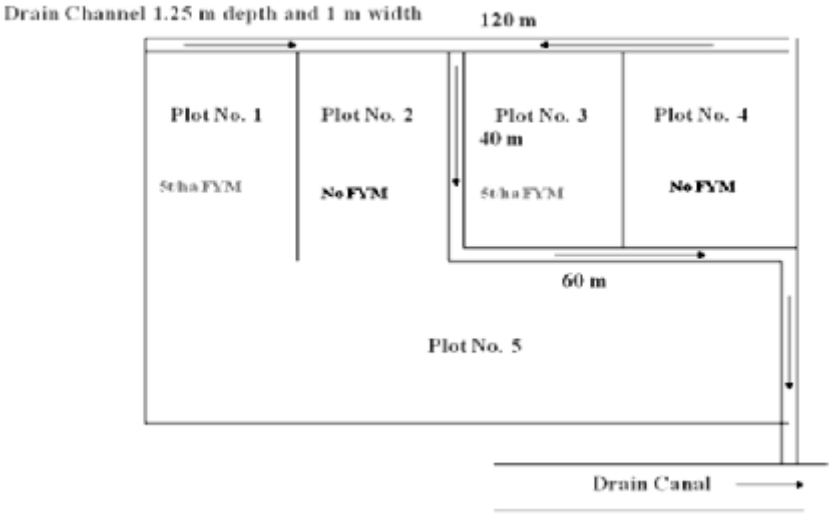

Fig. 6.1 Layout of field along with location of drain

The first year's yield data are presented in Table 6.2. The grain yield of paddy and wheat ranged from 0.70 to 4.00 q/ha and from 0.10 to 2.70 q/ha, respectively. This yield increase was 100 per cent as previously there was no crop The Table 6.2 also presented ECe (dS/m) at paddy transplanting which varied from 21.2 to 46.0 dS/m and at harvest ECe decreased and ranged from 17.4 to 26.6 (dS/m). At harvest of wheat crop ECe was very high as compared to paddy harvest and ranged from 37.9 to 50.9 (dS/m).

Table 6.2 ECe (dS/m) at Sowing and harvest of wheat crop at Pisawa village (2015-16)

Field No.	Soil Depth (cm)	Paddy			Wheat	
		ECe (dS/m) at transplanting	ECe (dS/m) at harvest	Grain yield (q/ha)	ECe (dS/m) at harvest	Grain yield (q/ha)
1	0-15	35.2	20.2	3.20	46.6	1.75
	15-30	25.0	19.6		33.6	
2	0-15	22.3	17.4	4.00	37.9	2.70
	15-30	21.2	16.3		30.3	
3	0-15	21.2	17.7	3.05	33.6	1.75
	15-30	16.3	16.9		17.7	
4	0-15	40.5	23.1	0.70	40.2	0.10
	15-30	28.7	20.6		34.2	
5	0-15	46.0	26.6	2.00	50.9	0.30
	15-30	27.7	23.4		37.9	

ORP: Operational Research Program for the use of underground poor quality waters at farmer's field (Agra)

The field demonstrations in operational research project for the use of poor quality water were initiated in *kharif* 1993 in Karanpur village of Mathura district .The village is located at Fareh-Achhnera road only 6 km away from Fareh town. In 1999 the program was extended to two other villages' i.e. Nagla Hridaya and Bhojpur. At these sites, medium and high SAR saline water was available. In the year 2000 the program was further extended to Savai village of Agra district to demonstrate the technologies on the use of alkali water. In *kharif* 2004, ORP was also initiated at Odara village of Bharatpur district in medium and high SAR saline water (EC_{iw} 6.0 to 23.5 dS/m and SAR 11-30 $(mmol/l)^{1/2}$. In 2006, one other site was also selected for dry land salinity demonstrations at Nagla Parasuram in Bharatpur District. The year of 2014-15, the total 12 farmers are selected in two villagse i.e. Odara (District Bharatpur, Rajasthan) using high SAR saline water and another village is Savai (District Agra) using alkali water. Whereas in 2015-16, the total 23 farmers selected, 12 farmers of 2014-15 and remaining 11 farmers are selected for saline water use (ECiw ranges 7.1 to 13.0 dS/m) of different villages i.e. Deen Dayal Dham (Nagla Chandra Bhan), Dhana Khema, Nagla Jalal, Garhi Pachauri and Dalatpur in district Mathura (U.P.) and Odara in Bhratpur district (Rajasthan). The water quality parameters pertaining to tube well water of the selected farmers are given in Table 6.3 During the year 2014-15 and 2015-16, salinity of RSC waters varied from 3.0-5.1 dS/m, RSC 6.2 – 8.8 meq/l and SAR 17.0 – 24.7 $(mmol/l)^{1/2}$. In saline waters, EC_{iw} varied from 10.0 to 23.5 dS/m, RSC Nil and SAR 11.0 – 24.9 $(mmol/l)^{1/2}$.

Table 6.3 Groups of farmers based on ground water quality

Sr. No.	Name of farmer	ECiw	RSC (meq/l)	SAR (mmol/l)1/2
		Alkali/ RSC water		
1	Mr. Harvans Kumar	3.0	8.8	17.0
2	Mr. Om Prakash	4.4	7.6	23.9
3	Mr. Hakim Singh	5.1	6.2	24.7
		Saline Water		
1	Mr. Subhash Chand	10.0	-	11.0
2	Mr. Ram Bharosee	15.0	-	19.0
3	Mr. Hari Prasad	13.5	-	12.5
4	Mr. Lal Hans	10.9	-	16.2
5	Mr. Dinesh Chand	11.0	-	17.0
6	Mr. Mukesh Kumar	13.8	-	24.0
7	Mr. Roop Singh	23.5	-	24.9
8	Mr. Birendra Singh	19.9	-	23.5
9	Mr. Jagan Singh	12.6	-	15.5

Kharif season

In alkali water, 3 farmers grew pearl millet crop during kharif season. The average yield of 2014 and 2015 for pearl millet varied from 1.82 to 2.25 t/ha in gypsum treated fields and 1.70 to 1.90 t/ha in without gypsum fields. Whereas the per cent increase was recorded from 15.8 to 18.4 in gypsum added fields over no gypsum (Table 6.4).

In high SAR saline water, the pearl millet crop was grown on six farmers' field while sorghum fodder on six farmers fields during kharif season (Table 6.5). The average of 2014 and 2015, pearl millet grain yield varied from 1.37 to 2.20 t/ha in ORP demonstration field (rain water recharge). The pearl millet yield increased by 10.0 to 16.4 per cent as compared to farmer's practice. Sorghum fodder yield varied from 24.30 to 42.50 t/ha in ORP demonstration fields. In ORP field, sorghum fodder increased about 7 per cent over conventional method.

Table 6.4 Pearl millet grain yield (t/ha) and Dhaincha Green manure in alkali water and soil characteristics at harvest crop (0-30cm) Average 2014 and 2015 (Alkali water Group)

Sr. No.	Name	Treatments	Variety	ORP yield (t/ha)	% increase over control	EC_e (dS/m)	pH_2	SAR $(mmol/l)^{1/2}$	ESP
1	Mr. Harvans Kumar	Gypsum	P. Millet MRB 204	2.25	18.4	2.7	7.9	10.4	16.2
		No Gypsum	-do-	1.90	-	3.5	8.2	12.4	20.7
		Gypsum	Dhaincha G.M.	-	-	3.1	8.2	15.6	15.8
		No Gypsum	-do-	-	-	3.5	8.4	17.4	20.7
2	Mr. Om Prakash	Gypsum	P. Millet MRB 204	1.82	15.8	2.8	8	12.3	18.8
		No Gypsum	-do-	1.57	-	2.9	8.2	13.5	21.7
3	Mr. Hakim Singh	Gypsum	P. Millet MRB 204	1.97	16.3	6.2	8	12.5	23
		No Gypsum	-do-	1.70	-	4.8	8.1	16.5	25

GM = Green Manure

Table 6.5 Pearl millet and sorghum fodder yield t/ha in saline water and soil characteristics at harvest crop (0-30cm) Average 2014 and 2015 (Saline group with GW recharge)

Sr. No.	Name of farmer	Crop/ Variety	ORP yield (t/ha)	Farmers Yield (t/ha)	% increase over farmer's field	EC_e (dS/m)	pH_2	SAR $(mmol/l)^{1/2}$
1	Mr. Lal Hans	Pearl millet/MRB 204	1.69	1.45	16.4	3.5	7.5	7.3
2	Mr. Birendra Singh	Pearl millet/MRB 2210	1.83	1.57	16.3	3.3	7.5	6.6
3	Mr. Roop Singh	Sorghum GF/Poorbiwhite	30.8	-	-	3.3	7.7	8.8
		Pearl millet/MRB 2210	1.37	1.20	14.2	3.0	7.7	10.1
4	Mr. Subhash Chand	Pearl millet/MRB 204	2.20	1.97	11.4	2.2	7.7	9.1
5	Mr. Ram Bharose	Sorghum GF/Poorbiwhite	38.30	-	-	2.7	7.5	9.9
		Pearl millet/MRB 204	1.87	1.70	10.0	3.1	7.6	8.0
6	Mr. Mukesh Kumar	Sorghum GF/Poorbiwhite	33.8	40.0	9.3	3.1	7.6	7.4
7	Mr. Hari Prasad	Sorghum GF/Poorbiwhite	25.70	-	-	2.3	7.4	8.7
8	Mr. Dinesh Chand	Dhaincha GM	-	-	-	3.5	7.3	8.3
		Sorghum GF/Poorbiwhite	42.5	40.0	6.3	3.5	7.7	12.5
9	Mr. Jagan Singh	Sorghum GF/Poorbiwhite	24.3	-	-	6.0	7.1	10.0
		Pearl millet/MRB 204	1.62	1.45	11.7	2.4	7.4	9.2

GF = Green Fodder; GM = Green Manure

Rabi Season

In alkali water, wheat crop was shown at 3 farmers' fields in Savai village, district Agra. The average wheat yield increased 10.9 per cent in gypsum treated fields over control (without gypsum). The maximum yield (3.88 t/ha) was recorded in the field of Mr. Harvans Kumar in alkali water area (Table 6.6). The soil pH, SAR and ESP decreased in gypsum treated fields over control.

Table 6.6 Effect of Gypsum on wheat yield (t/ha) and soil characteristics (0-30 cm) at harvest (Average 2014-15 and 2015-16) (Alkali Water Group)

Sr. No.	Name	Treatment	O.R.P yield t/ha	% increase over control	EC_e (dS/m)	pH2	SAR $(mmol/l)^{1/2}$	ESP
1	Mr. Harvans	With Gyp.	3.88	10.2	3.6	7.5	13.7	20.4
	Kumar	No gyp	3.52	-	3.7	7.6	17.6	22.0
2	Mr. Om Prakash	With Gyp.	3.75	10.85	6.2	7.8	18.1	22.4
		No gyp.	3.33	-	5.7	7.9	21.3	23.3
3	Mr. Hakim	With Gyp.	3.69	11.05	7.4	7.7	19.0	24.3
	Singh	No gyp.	3.30	-	6.9	7.8	22.6	27.6

In *rabi* season 2015-16 the ten farmers and two site of Deen Dayal Dham Smarak, the mustard and wheat crop grown in saline water irrigated condition, 4 farmers field mustard and 8 farmers grown wheat crop. The mustard grain yield varied 2.10 to 2.20 t/ha and average increase the grain yield about 14.3 per cent as compared to traditional method. In case of wheat yield varied 2.43 to 4.33 t/ha. The highest yield of wheat grain were recorded in Mr. Chandan Lal (4.33 t/ha) and the lowest yield were recorded Deen Dayal Dham Smarak (2.43 t/ha). The average of eight farmer's field, wheat yield increased about 9.8 per cent. The soil ECe, pH and SARe was also presented in Table 6.7 The ECe ranges 7.7 to 12.6 (dS/m), pH ranges 7.3 to 8.3 and SARe ranges 16.1 to 20.9 $(mmol/l)^{1/2}$ in all the farmers fields.

Table 6.7 Yields of salt tolerant varieties under saline water irrigation on farmers' fields and soil characteristics (0-30 cm) at harvest (2015-16) (Saline Water Group with salt tolerant varieties)

Sr. No.	Farmers Name	EC_{iw} (dS/m)	Variety	ORP Yield (t/ha)	Farmers Yield (t/ha)	% Increase over traditional method	EC_e (dS/m)	pH_2	SAR $(mmol/l)^{1/2}$
1	Mr. Amar Chand	13.5	CS 54	2.17	1.88	15.4	12.6	7.8	18.4
2	Mr. Om Veer	12.6	CS 52	2.20	1.90	15.8	11.7	7.3	17.6
3	Mr. Parashu Ram	10.9	CS 52	2.10	1.88	11.7	10.8	7.7	19.4
4	Mr. Satya Pal	10.2	CS 54	2.17	1.90	14.2	11.1	7.7	20.6
5	Mr. Chandan Lal	7.8	Raj.4120	4.33	3.90	11.0	7.7	8.1	15.8
6	Mr. Ram Babu	8.2	KRL 210	4.10	3.70	10.8	8.5	7.9	17.2
7	Mr. Mahendra	7.1	,,	3.97	3.50	13.4	10.5	8.2	16.1
8	Mr. Kishan Singh	11.1	,,	3.80	3.50	9.4	12.1	8.1	20.4
9	Mr. Sukhram	7.8	,,	4.03	3.70	8.9	8.6	8.3	16.8
10	Mr. Ram Murti	11.4	,,	4.17	3.75	11.2	12.5	8.3	20.9
11	D.D. Dham (Smarak)a	10.4	,,	4.17	3.85	8.3	9.3	8.3	18.6
12	D.D. Dham (Smarak)b	10.4	,,	2.43	2.20	10.5	9.3	8.3	18.6

In 2014-15 and 2015-16 the nine farmers had wheat crop and five farmers had mustard crop under rain water recharge condition (Table 6.8). The average yield of wheat crop found in ORP field varied 3.85 to 4.37 (t/ha) and increase was about 12.4 per cent over traditional farming. In case of mustard variety CS 52 and CS 54 the yield varied 1.97 to 2.17 t/ha in ORP field while in traditional method yield varied from 1.7 to 1.87 t/ha. The mustard yield increased about 15.0 per cent as compared to traditional farming. The soil ECe, pH and SARe are also presented in Table 6.8. The ECe ranges 6.5 to 12.2 (dS/m), pH ranges 7.1 to 7.4 and SARe ranges 10.1 to 25.6 $(mmol/l)^{1/2}$ in all the farmers' fields.

Table 6.8 Effect of saline water on grain yield of mustard and wheat at water recharge sites of Odara village (Average 2014-15 and 2015-16) and soil characteristics (0-30 cm) at harvest (Saline Water Group with Recharge)

Sr. No.	Farmers Name	EC_{iw} (dS/m)	Wheat/ mustard variety	O.R.P Yield (t/ha)	Farme yield (t/ha)	% Increase	EC_e (dS/m)	pH_2	SAR (m mol/l)$^{1/2}$
1	Mr Jagan Singh	12.6	Raj. 4037	4.25	3.75	13.3	6.5	7.2	16.6
2	Mr Jagan Singh	12.6	CS-54	2.07	1.75	18.3	8.9	7.3	19.7
3	Mr Jagan Singh	12.6	CS-52	2	1.7	17.6	8.9	7.3	19.7
4	Mr Subhash Chand	13.8	Raj. 4037	4.37	3.85	13.6	11.4	7.2	11.9
			CS-54	2.17	1.87	15.7	9.2	7.4	18.9
5	Mr Birendra Singh	19.9	Raj. 4037	4	3.55	12.7	9.3	7.2	22.7
			CS-54	2	1.8	11.1	11	7.3	25.6
6	Mr Roop Singh	23.5	Raj. 4037	3.85	3.5	10.7	8.5	7.2	19.7
			CS-52	2.1	1.85	13.5	12.2	7.4	22.2
7	Mr.Hari Prasad	13.5	CS 52	1.97	1.73	13.9	10.1	7.1	13.7
8	Mr. Lal Hans	10.9	Raj.4037	4.3	3.85	11.7	10.8	7.2	12.5
9	Mr. Ram Bharose	15	,,	4.13	3.67	11.5	11.7	7.2	11.7
10	Mr. Dinesh Chand	11	,,	4.24	3.8	11.8	9.7	7.2	12.4
11	Mr Mukesh Kumar	13.8	,,	3.87	3.65	13.7	7.5	7.1	10.1

At recharge sites, initial ECiw of tube well water ranged from 10.9 to 23.5 (dS/m) and it decreased with rain water recharge (Table 6.9). In 2014-15 the tube well ECiw decreased of first irrigation varied 4.98 to 8.00 (dS/m) and in case of 2015-16 is varied 5.2 to 8.6 (dS/m) at pre-sowing stage. The ECiw of tube well water decreased due to dilution of underground water with rain water harvesting. It helped in irrigating the crop with relatively low saline water at initial stage and therefore increasing crop yield.

Table 6.9 EC_{iw} (dS/m) during different irrigations at rain water recharging sites (2014-15 and 2015-16) (Saline Water Group with Recharge)

Sr. No	Name	Initial	Pre-sowing irrigation	Ist irrigation	Iind irrigation	IIIrd irrigation	IVth irrigation
			2014-15				
1	Mr. Lal Hans	10.9	RCM	4.98	8.8	9.9	-
2	Mr. RamBharosi	15.0	,,	6.04	9.01	11.7	-
3	Mr. Jagan Singh	12.6	,,	5.71	10.41	12.3	-
4	Mr Mukesh Km	13.8	,,	5.68	9.44	11.8	-
5	Mr.Hari Prasad	13.5	,,	-	7.68	10.5	-
6	Mr.Dinesh Chand	11.0	,,	5.25	8.67	10.5	-
7	Mr.BirendraSingh	19.9	,,	7.92	12.93	17.2	-
8	Mr.Roop Singh	23.5	,,	8.00	13.06	17.5	-
9	Mr.Subhash Chand	11.0	,,	7.32	9.05	9.6	-

				2015-16			
1	Mr. Lal Hans	10.9	RCM	4.6	5.3	9.7	10.4
2	Mr. RamBharosi	15.0	RCM	6.3	8.2	11.1	-
3	Mr. Jagan Singh	12.6	5.2	8.6	10.5	-	-
4	Mr Mukesh Kumar	13.8	RCM	6.5	10.4	11.3	12.9
5	Mr.Hari Prasad*	13.5	RCM	13.5	13.5	13.5	-
6	Mr.DineshChand	11.0	RCM	5.8	8.7	9.6	-
7	Mr.BirendraSingh	19.9	7.9	10.4	13.5	-	-
8	Mr.Roop Singh	23.5	8.6	11.5	15.3	-	-
9	Mr. Subhash Chand	10.0	6.9	8.7	9.5	-	-

RCM = Rain conserved moisture; * Recharge well failed

Performance of wheat varieties under varying salinity of irrigation water on farmer's field (Bikaner)

Four varieties of wheat namely, KRL-19, KRL-210, KRL-213 and Raj 3077 were evaluated for their performance under saline water irrigation. Three modes of irrigation water application were used *viz.,* BAW, cyclic irrigation with BAW and Saline water and saline water high EC (11.5 dS/m). Altogether six irrigations were given during crop period. Results (Table 6.10) indicated that variety Raj 3077 out yielded and proved significantly superior to KRL-210 and KRL-19. Application of saline and BAW alternately found at par with BAW, which clearly indicated that three irrigations of saline water could easily be used for raising the wheat crop without affecting the yield. However, use of high saline irrigation water alone caused significant reduction of 53.1 and 50 per cent, respectively, over BAW and cyclic mode. Combined effect of treatments showed that all the four varieties tested performed equally in terms of grain yield under cyclic mode of irrigation but there was reduction in yield as compared to BAW in all the four varieties (Table 6.11).

Table 6.10 Grain yield of wheat as influenced by different treatments (Trial on farmer's field at Kawani)

Treatments	Grain yield (q/ha)
Varieties	
V1 = KRL 19	23.7
V2 = KRL 210	23.4
V3 = KRL 213	25.3
V4 = Raj 3077	25.4
C.D. (0.05)	1.7
Mode	
M1 = BAW	30.5
M2 = Cyclic	28.6
M3 = High EC (11.5 dS/m)	14.3
C.D. (0.05)	2.1

Table 6.11 Combined effect of treatments on grain yield

Variety	BAW	Cyclic	High EC (11.5 dS/m)
KRL 19	28.8	28.2	14.3
KRL 210	29.3	27.6	13.5
KRL 213	31.4	29.9	14.6
Raj 3077	32.5	28.8	14.8
C.D.	3.6		

An in vitro observation trial was also conducted using all the four varieties to see the germination behaviour with varying water salinity levels. Raj 3077 and KRL-213 varieties were found superior to KRL 210 and KRL 19 in terms of germination, development of radical, seminal roots and length of coleoptile, which clearly indicates that these varieties are superior to other two varieties in tolerance to water salinity (Plate 6.1).

Plate 6.1 In *vitro* study on effect of saline water (collected from farmer tube well) on germination on wheat varieties

Performance of mustard varieties under varying salinity of irrigation water on farmer's field (Bikaner)

Ten mustards varieties were evaluated for their performance under saline water irrigation applied in different modes during 2014-15 at farmer field. All the ten varieties of mustard could not perform satisfactorily due to poor management. Hence experiment was considered as failure.

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

A field experiment was carried out at farmers' field in Mallapur block (Sindhanur Taluk) in an area of 50 ha by considering three SSD spacing treatments i.e., 40 m, 50 m and 60 m spacing each with a lateral depth of 1.0 m. List of farmers (39 Nos) with survey number and area (127 acre) was also collected.

A total of 73 soil samples to a depth of 60 cm with 15 cm increment were collected (0-15, 15-30 and 30-60 cm) were collected using GPS during May-June 2012 and analyzed for soil pH and ECe. Surface soil pH and ECe varied from 7.21 to 9.30 and 1.17 to 61.18 dS/m, respectively, with a mean of 8.2 and 12.23 dS/m, respectively. At 15-30 cm, soil pH and ECe varied from 7.29 to 9.23 and 1.65 to 55.86 dS/m with a mean value of 8.32 and 11.1dS/m respectively. At 30-60 cm, soil pH and ECe varied from 7.33 to 9.19 and 2.10 to 53.20 dS/m with a mean value of 8.29 and 11.50 dS/m respectively. The hydraulic conductivity of the soil at a depth 1.2 m varied from 0.089 to 0.451 m/day with a mean value of 0.161 m/day. The water table depth was measured by augur hole method and it ranged from 111 to 144 cm below the ground. The soil texture at 60-90 cm was found to be clay with clay content varying from 45 to 60% in the study area. Laying of SSD work was completed in *Kharif* 2013. Only three and two times monitoring of drainage discharge was carried out during *Kharif* 2013 and Rabi 2013-14, respectively.

Average soil salinity (ECe,dS/m) values as influenced by spacing of sub surface drainage system are given in Table 6.12 In general, there is reduction in soil salinity except in case of 50 m spacing.

Table 6.12 Average soil salinity (ECe,dS/m) as influenced by spacing of sub surface drainage systems

Season	40 m spacing				50 m spacing				60 m spacing			
	A	B	C	D	A	B	C	D	A	B	C	D
Initial	20.8	18.1	17.6	-	6.4	6.3	6.8	-	9.1	7.7	8.5	-
Kharif -2013	-	-	-	-	-	-	-	-	-	-	-	-
Rabi 2013-14	24.9	19.4	14.4	13.6	9.3	7.96	8.06	7.98	5.0	5.0	6.3	8.7
Kharif 2014	23.7	22.6	18.3	21.3	9.7	8.54	7.57	6.34	6.4	7.1	7.6	8.4
Rabi 2014-15	23.4	13.1	7.7	11.5	9.9	14.7	11.0	14.0	13.3	10.7	12.1	11.1
Kharif 2015	15.5	18.9	13.0	13.2	6.4	7.03	8.74	7.36	5.46	5.77	6.81	7.3

A=0 - 15 cm; B=15 – 30 cm; C= 30 - 60 cm; D = 60 - 90 cm

The average drain discharge observed was 0.22, 0.20 and 0.27 mm/d for 40, 50 and 60 m spacing respectively in rabi 2014-15. Thus, the drain discharge was the maximum in 60 m spacing and could be attributed to larger cultivated area compared to 40 and 50 m spacing. The average salinity of the drainage effluent observed was 11.9, 9.4 and 9.32 dS/m, for 40, 50 and 60 m spacing. Initially salt removal was higher from 60 m spacing as observed 2.84, 2.32 and 4.75 t/ha for 40, 50 and 60 m spacing, respectively. However, in rabi 2014-15, salt removal was higher in case of 40 m spacing as observed 1.36, 1.0 and 0.99 t/ha from 40, 50 and 60 m spacing.

Prior to the installation of SSD, the paddy grain yield levels of farmers were in the range of 25-30 q/ha as per farmers' feedback. Based on the yield data (Table 6.13) collected randomly at different spacing SSD plots, grain yields varied from 45.11 q/ha (40 m spacing) to 52.31 q/ha (60 m spacing) during Rabi 2014-15 season reflecting increased grain yields due to SSD at all the spacing compared to initial (prior to SSD installation) yield levels.

Table 6.13 Variation of crop yield (qt/ha) as influenced by spacing of sub surface drainage systems

Spacing (m)	Kharif-2013	Rabi 2013-14	Kharif-14	Rabi 2014-15	Kharif- 2015
40	43.25	43.70	52.8	45.11	47.2
50	46.53	47.10	67.4	46.20	49.4
60	49.27	49.8	55.9	52.31	54.2

Effect of Lagoon Sludge/ Spent wash application on crop production and soil chemical environment on farmers' fields (Indore)

Demonstrations on farmers' fields were undertaken for economized application of Spent Wash / Lagoon Sludge for reclamation of black alkali soils. Treatments were as below.

2014-15	2015-16
1.Control	1. Control
2.Raw Spent Wash @ 5 lakh L/ha	2. Lagoon Sludge @ 5.0 t ha-1+ Raw Spent Wash @ 2.5 lakh L ha-1

The demonstrations during 2014-15 on the field of Mr. Hariram Malviya and Mr. Afsar Pathan (Village – Bapalgaon) were conducted during *kharif* and *rabi* with paddy (CSR-30) and wheat (HI 1077) as respective test crop. One time application of raw spent wash (RSW) was done 30 days prior to transplanting of rice seedlings. Wheat crop was raised in the same area during *rabi* season. The demonstrations in the year 2015-16, on the field of Mr. Hariram Malviya (Village – Bapalgaon) were conducted with paddy (CSR-30) and wheat (HI 1077) as respective test crop. One time application of lagoon sludge (LS) and raw spent wash (RSW) was done 30 days prior to transplanting of rice seedlings. Wheat crop was raised in the same area during *rabi* season. Initial chemical properties of the soils of the fields of Mr. Hariram Malviya and Mr. Afsar Pathan fields in the year 2014-15 viz. ESP, CEC and ECe of the soil were 45.8, 36.3 cmol (p+) /kg & 1.98 dSm^{-1} and 38.4, 42.4 cmol (p+) /kg and 2.7 dSm^{-1} respectively. However the initial ESP, CEC and ECe of the soil of Mr. Mr. Hariram Malviya field in the year 2015-16 were 40.8, 36.3 cmol (p+) /kg & 1.98 dSm^{-1}. Necessary plant protection and inter-culture operations were adopted as per package of practices.

Data during the year 2014-15 (Table 6.14) revealed that application of Raw Spent Wash @ 5.0 lakh L ha^{-1} increased grain yield of paddy by 294 and 160 % over control at fields of Mr. Hariram Malviya and Mr. Afsar Pathan, respectively. Similarily the grain yield of wheat was also improved by 186 and 178% over control. Application of RSW @ 5.0 lakh L ha^{-1} reduced the ESP from 44.9 to 26.9 and 37.5 to 18.6 after harvest of paddy and from 43.2 to 24.9 & 36.1 to 17.9 at harvest of wheat as compared to control.

Table 6.14 Effect of spent wash applications on grain yield (t ha^{-1}) of paddy on farmer's field

Treatments	Grain Yield		% increase in yield over control		ESP after harvest of crop	
	Hariram Malviya	Afsar Pathan	Hariram Malviya	Afsar Pathan	Hariram Malviya	Afsar Pathan
			Paddy			
Control	0.57	0.98	-	-	44.9	37.5
Raw Spent Wash @ 5.0 lakh L ha^{-1}	2.23	2.55	294	160	26.9	18.6
			Wheat			
Control	1.10	1.28	-	-	43.2	36.1
Raw Spent Wash @ 5.0 lakh L ha^{-1}	3.15	3.55	186	178	24.9	17.9

The data of 2015-16 (Table 6.15) revealed that application of Lagoon Sludge @ 2.5 t ha^{-1} along with Raw Spent Wash @ 2.5 lakh L ha^{-1} increased grain and straw yield of paddy by 187 and 160% over control, respectively. Plate 6.2 shows the paddy crop with farmer. Similarily the grain and straw yield of wheat was also improved by 163 and 171 % over control. Application of Lagoon Sludge @ 5.0 t ha^{-1} + RSW @ 2.5 lakh L ha^{-1} decreased the ESP to 22.4 after harvest of wheat as compared to its initial level of 40.8.

Table 6.15 Effect of lagoon sludge and spent wash applications on grain yield (t ha^{-1}) of paddy and wheat on farmer's field

Treatments	Yield (t ha^{-1})		% increase in yield over control		ESP after harvest of crop
	Grain	Straw	Grain	Straw	
			Paddy		
Control	0.86	0.98	-	-	-
Lagoon Sludge @ 5 t ha^{-1} Raw Spent Wash @ 2.5 lakh L ha^{-1}	2.47	2.55	187	160	-
		Wheat			
Control	1.25	1.26	-	-	40.1
Lagoon Sludge @ 5 t ha^{-1} Raw Spent Wash @ 2.5 lakh L ha^{-1}	3.28	3.41	163	171	22.4

Plate 6.2 Farmer with paddy crop

Effect of CSR-Bio on tomato and cabbage in sodic soil at farmer's field (Kanpur)

The purpose of this experiment was to find out the suitable application method of CSR-Bio for vegetable production and to understand physico-chemical changes in soil. Treatment details are given in Table 6.16.

Table 6.16 Experimental details

Treatments:	Other details:	
T_1- Control	Crop	Tomato and cabbage
	Varieties	Azad T-5 and Golden acre
T_2- CSR-Bio (soil application)	No of treatments	Three
	No of replication	Three
T_3- CSR-Bio (soil application + foliar spray)	Design	RBD
	Plot size	20 m^2
	Spacing	40x40 cm (cabbage)
		60x60 cm (tomato)
	Year of start	2015
	Location	Farmers field at Vinova Nagar, Kanpur Dehat

The pH, ECe, ESP and O.C. were 9.10, 0.96, 42.20 and 0.29, respectively. The maximum survival percentage, fruit/plant, diameter of fruit and yield of tomato was recorded 54%, 20.78, 3.22 cm and 119.25 q/ha and minimum in control plot (Table 6.17).The incensement of yield was recorded 37.9% more treated with CSR-Bio (soil application + foliar spray) and 29.5% with CSR-Bio (soil application) over control.

Table 6.17 Effect of CSR-Bio on yield and yield attributes of tomato

Treatments	Survival (%)	Fruit/ plant	Diameter of fruit (cm)	Yield (q/ha)	Increase (%)
Control	36	18.22	2.72	86.50	--
CSR-Bio (soil application)	52	20.61	3.19	112.30	29.8
CSR-Bio (soil application + foliar spray)	54	20.78	3.22	119.25	37.9

The data presented in Table 6.18 indicated that there was reduction in pH, electrical conductivity and exchangeable sodium percentage in both the treatments including control. However, maximum decrease was observed in CSR-Bio (soil application + foliar spray) treated plot. There was increase in organic carbon with the application of CSR-Bio treated plots.

Table 6.18 Effect of CSR-Bio on physico chemical properties of experimental soil (Tomato)

Treatments	pH	EC	ESP	OC
Control	9.0	0.94	40.6	0.30
CSR-Bio (soil application)	8.9	0.91	37.2	0.33
CSR-Bio (soil application + foliar spray)	8.9	0.90	36.8	0.34
Initial soil status	9.1	0.96	42.2	0.29

The maximum survival percentage, no of leaves, head weight and yield was recorded 65, 10.22, 0.72 kg and 138.30 q/ha and minimum in control plot (Table 6.19). The incensement of yield was recorded 45.2% more treated with CSR-Bio (soil application + foliar spray) and 42.3% with CSR-Bio (soil application) over control.

Table 6.19 Effect of CSR-Bio on yield and yield attributes of cabbage

Treatments	Survival (%)	No. of leaves	Head wt (kg)	Yield (q/ha)	Increase %)
Control	48	8.86	0.58	95.20	--
CSR-Bio (soil application)	63	9.52	0.69	135.45	42.3
CSR-Bio (soil application + foliar spray)	65	10.22	0.72	138.30	45.2

The data presented in Table 6.20 indicated that there was reduction in pH, electrical conductivity and exchangeable sodium percentage in both the treatments including control, maximum decrease, however was observed in CSR-Bio (soil application + foliar spray) treated plot. The organic carbon improved with the application of CSR-Bio treated plots.

Table 6.20 Effect of CSR-Bio on physico chemical properties of experimental soil (Cabbage)

Treatments	pH	EC	ESP	OC
Control	9.0	0.93	39.5	0.30
CSR-Bio (soil application)	8.9	0.90	36.8	0.33
CSR-Bio (soil application + foliar spray)	8.8	0.89	35.4	0.33
Initial soil status	9.1	0.96	42.2	0.29

Performance of banana under the influence of CSR-BIO in sodic soil at farmer's field (Kanpur)

This experiment was planned to study the effect of CSR-Bio on the growth parameters of banana and to study its effect of yield parameters and yield. The experimental details are provided in Table 6.21.

Table 6.21 Experimental details

Treatments:	Other details:	
T_1-without CSR-Bio	Crop	Banana
T_2-With CSR-Bio	Varieties	G-9
	No of treatments	Two
	No of replication	Three
	Design	RBD
	Spacing	1.8 x 1.8 m
	Year of commencement:	2015
	Location:	Farmers field at Vinova Nagar, Kanpur Dehat

The pH, ECe, ESP and O.C. were 9.10, 0.96, 42.20 and 0.29, respectively. The maximum survival percentage, plant height, no of hands/bunch, no of fingers/bunch and weight of bunch of banana was recorded 48%, 2.16 m, 5.8, 66 and 4.81 kg with CSR-Bio and minimum in without CSR-Bio (Table 6.22).

Table 6.22 Effect of CSR-Bio on yield and yield attributes of banana

Treatments	Survival percentage	Plant height (m)	No of hands/bunch	No of fingers/bunch	Weight of bunch (kg)
With CSR-Bio	48	2.16	5.8	66	4.81
Without CSR-Bio	30	1.95	4.6	48	3.72

The data presented in Table 6.23 indicated that there was reduction in pH, electrical conductivity and exchangeable sodium percentage in both the treatments, maximum decrease, however was observed in CSR-Bio treated plot. The maximum improved in organic carbon was noticed with the application of CSR-Bio.

Table 6.23 Effect of treatments on physic-chemical properties of experimental soil

Treatments	Soil properties			
	pH	EC	ESP	OC
With CSR-Bio	9.0	0.89	36.40	0.31
Without CSR-Bio	9.2	0.91	38.90	0.29
Initial values	9.3	0.92	40.20	0.28

ORP on Sodic soil Reclamation Technology (Tiruchirappalli)

To demonstrate the sodic soil reclamation technology, five farmers were selected in different locations of Trichirappalli district based on soil test values and awareness among the farmers was done (Plate 6.3).
Plate 6.3 Dissemination of gypsum reclamation technology at Ariyavur village

Gypsum requirement was estimated based on soil test and reclamation was done. Initial and post harvest soil samples were collected and analyzed for pH, EC, ESP. Grain and straw yield was recorded after harvest. The results showed that application of gypsum @ 50 % GR along with package of practice increased the grain and straw yield of rice. The grain yield increased to the tune of 2135 to 2715 kg/ha at various locations due to application of gypsum @ 50 % GR along with package of practice when compared to control (Table 6.24). Regarding the initial soil properties at various locations, pH varied from 9.50 to 10.2, EC varied from 0.36 to 1.20 and ESP varied from 23.8 to 34.1. The post harvest soil analysis revealed that application of gypsum considerably reduced the pH and ESP of soil. The pH reduced to the level of 8.40 - 8.70 and ESP to the level of 15.8 - 18.4. There is no considerable change in EC of the soils.

Plate 6.3 Dissemination of gypsum reclamation technology at Ariyavur village

Gypsum requirement was estimated based on soil test and reclamation was done. Initial and post harvest soil samples were collected and analyzed for pH, EC, ESP. Grain and straw yield was recorded after harvest. The results showed that application of gypsum @ 50 % GR along with package of practice increased the grain and straw yield of rice. The grain yield increased to the tune of 2135 to 2715 kg/ha at various locations due to application of gypsum @ 50 % GR along with package of practice when compared to control (Table 6.24). Regarding the initial soil properties at various locations, pH varied from 9.50 to 10.2, EC varied from 0.36 to 1.20 and ESP varied from 23.8 to 34.1. The post harvest soil analysis revealed that application of gypsum considerably reduced the pH and ESP of soil. The pH reduced to the level of 8.40 - 8.70 and ESP to the level of 15.8 - 18.4. There is no considerable change in EC of the soils.

Table 6.24. Influence of Gypsum reclamation technology on grain and straw yield of rice at different locations

Sr. No.	Farmer's Name	Location	Grain yield, kg/ ha		Straw yield, kg/ ha		pH		EC (dSm^{-1})		ESP (%)	
			C	G50	C	G50	C	G50	C	G50	C	G50
1	P.Sebasthiyar	Mathiyanipatti	1865	4120	2178	4831	10.2	8.7	1.21	1.30	32.4	18.4
2	C.Sahayam	Mathiyanipatti	2360	4850	2700	5650	9.8	8.6	0.36	0.41	26.2	17.2
3	N.Chanthiran	Thuraikudi	2145	4645	2465	5350	9.5	8.4	0.63	0.76	28.3	14.2
4	D.Selvakrishnan	Thuraikudi	2410	5125	2850	5945	9.7	8.7	0.45	0.56	23.8	18.2
5	R. Gnanavel	Sembarai	2050	4185	2396	4865	10.1	8.6	0.51	0.59	34.1	17.6

C= Control; G50= Gypsum 50% GR

ORP II -DSW Reclamation Technology

Six farmers were selected in different locations of Trichirappalli district based on soil test values. Distillery spent wash was applied @ 5 lakh liters per ha and DSW reclamation technology procedure was followed. Initial and post harvest soil samples were collected and analyzed for pH, EC and ESP. Grain and straw yield was recorded after harvest. The results showed that application of DSW @ 5 lakh litres per ha along with

package of practice tremendously increased the grain and straw yield of rice. The grain yield increased to the tune of 2531 to 3040 kg per ha in various locations due to application of DSW along with package of practice when compared to control (Table 6.25). The initial soil properties at various locations indicated that pH varied from 8.9 to 10.8, EC varied from 0.32 to 0.98 dSm^{-1} and ESP varied from 24.3 to 39.2 %. The post harvest soil analysis revealed that application of DSW considerably reduced the pH and ESP of soil. The pH reduced to the level of 8.35 - 8.61 and ESP to the level of 14.4 – 17.8 %. Application of DSW slightly increased the EC of post harvest soil.

Table 6.25 Influence of DSW technology on grain and straw yield of rice at different locations

Sr. No.	Farmer's Name	Location	Grain yield, kg/ ha		Straw yield, kg/ ha		pH		EC (dSm^{-1})		ESP (%)	
			C	DSW	C	DSW	C	DSW	C	DSW	C	DSW
1	D.Selvakrishnan	Thuraikudi	2120	4720	2461	5486	10.8	8.56	0.61	0.98	39.2	17.8
2	S. Maniyarasu	Sembarai	2345	4960	2789	5809	9.2	8.48	0.46	0.86	24.3	15.4
3	P. Krishnamoorthy	Sembarai	2650	5480	3012	6498	9.6	8.61	0.40	0.73	28.6	16.6
4	R. Tharmaraj	Sembarai	3120	6160	3786	7350	8.9	8.35	0.98	1.26	26.8	14.4
5	A.Gnanapragasam	Sembarai	2410	4941	2798	5861	9.8	8.60	0.32	0.59	30.2	16.3

C= Control; DSW= DSW @ 5 lakh litres per hectare

7. GENERAL