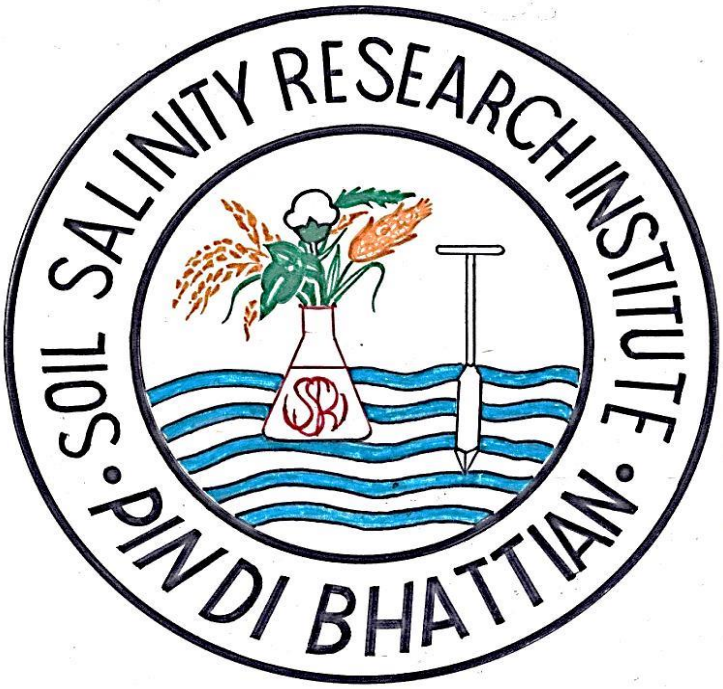
ANNUAL TECHNICAL REPORT

2015-16



SOIL SALINITY RESEARCH INSTITUTE
PINDI BHATTIAN

Director, SSRI:

Muhammad Yousaf

COMPILED BY:
Dr. Muhammad Sarfraz
ARO, SSRI

CHECKED BY:
Mr. Abdul Rehman Jami
AAC, SSRI

REVIEWED BY:
Dr. Muhammad Anwar Zaka
AC, SSRI

CONTENTS

1. ORGANIZATION

S.No	Designation	Sanctioned posts	Vacant posts
1	Director	One	-
2	Agricultural Chemist	Four	Three
3	Economic Botanist	One	-
4	Agronomist	One	-
5	Agricultural Engineer	One	One
6	Assistant Agri. Chemist	Four	Two
7	Assistant Botanist	One	-
8.	Assistant Agronomist	One	-
9	Assistant Agricultural Eng.	One	-
10	Assistant Research Officer	Twelve	Seven

2. LIST OF RESEARCHERS

S.No	Name	Designation	Qualification
1	Dr. Ehsan-ul-Haq	Director	Ph. D (Soil Science)
2	Mr. Ghulam Mustafa Wains	Agricultural Agronomist	M.Sc. Agronomy
3	Dr. Muhammad Anwar Zaka	Agricultural Chemist	Ph. D (Soil Science)
4	Mr. Muhammad Jamil	Assistant Agronomist	M.Sc. Agronomy
5	Mr. Abdul Rehman Jami	Assistant Agricultural Chemist	M. Sc (Soil Science)
6	Mr. Ghulam Shabbir	Asstt. Research Officer	M.Sc. (PB & G)
7	Dr. Muhammad Sarfraz	Asstt. Research Officer	Ph. D (Soil Science)
8	Mr. Amir Iqbal Saqib	Asstt. Research Officer	M.Sc. (Soil Science)
9	Mr. Syed Saqlain Hussain	Asstt. Research Officer	M.Sc. Agronomy
10	Mr. Muhammad Irfan	Asstt. Research Officer	M.Sc. (PB & G)
11	Mr. Muhammad Qaisar Nawaz	Asstt. Research Officer	M.Sc. Agronomy
12	Dr. Khalil Ahmed	Asstt. Research Officer	Ph. D (Soil Science)
13	Mr. Muhammad Rizwan	Asstt. Agri. Engineer	B.Sc. Agri. Engineering

2. BUDGET

18-Agriculture		Allocation(Rs)	Expenditure(Rs)
I	Pay of Officers	12387000	11090841
II	Pay of Staff	7808000	7356672
III	Regular allowances	16056000	14456657
IV	Other allowances	246500	182840
V	Operating Expenses	16294500	15733484
	Total	**52792000**	**48820494**

4. INTRODUCTION

Soil Salinity Research Institute, Pindi Bhattian was established in 1982-83 for conducting research to devise ways and means and proper technologies for economic utilization of salt affected soils and scientific use of brackish sub-soil water for agricultural purposes in the Punjab. The past work on salinity/sodicity was evaluated and found many deficiencies in the field. Many projects were launched to cover up such deficiencies. Since its establishment, many useful technologies have been developed for economic utilization of salt affected soils and brackish water and efforts are being made to achieve the objectives stated below=-

1. Economic utilization of salt affected soils.
2. Study of soil and water factors causing salinity/sodicity.
3. Development of reclamation technology for salt affected soils.
4. Development of measures/practices to avoid salinization - sodication of soils.
5. Improvement of plant nutrition in salt affected soils.
6. Standardization and evolution of salt resistant/tolerant crops/vegetables/horticultural plants etc.
7. Development of crop production technology for salt affected soils.
8. Identification and collection of natural vegetation capable of with-standing high salt concentrations.
9. Promotion of aquaculture, farm forestry in areas less favorable for crop cultivation.
10. Development of cheap drainage system and mechanical devices for better tillage.
11. Advisory service to the farmers.

The scientists of the institute have got published 205 Research Articles on various aspects of soil salinity and sub-soil brackish water management in scientific journals of national and international repute. Ph.D. level research is also conducted at this institute. The results of research experiments are regularly being disseminated through radio talks in agricultural broadcasts of radio Pakistan Lahore and Faisalabad as well as publication through Ziraat Nama etc. Brochures in Urdu on different aspects are published and distributed free of cost. Moreover, the electronic and print media are being utilized for dissemination and popularization of research findings / technologies developed.

The institute is comprised of seven divisions namely soil reclamation, water quality, plant nutrition, soil physics, agronomy, economic botany and agricultural engineering. Each division is conducting its own experiments in Rabi and Kharif seasons to solve the problems of salt affected areas. The results are being presented in this report.

5. RESEARCH WORK

5.1 SOIL PHYSICS

01. LONG TERM EFFECT OF HIGH RSC WATER ON PHYSICAL PROPERTIES OF SOIL UNDER RICE-MUSTARD ROTATION

Rice

The experiment was designed to study the deleterious effect of high RSC water on soil physical properties under rice-mustard (Raya) crop rotation. A moderately salt affected field was selected, prepared and leveled. Composite soil samples were collected and analyzed for salinity/sodicity and GR (pH_s = 8.70, EC_e = 4.08 dS m^{-1}, SAR = 20.87 (mmol L^{-1})$^{1/2}$, HC = 0.70cm hr^{-1}andBD = 1.30 Mg m^{-3}.Experiment was laid out in RCBD with four replications. Crop was irrigated with tube well water having EC 1.37dS m^{-1}, SAR 8.40 (mmol L^{-1})$^{1/2}$ and RSC 7.85 me L^{-1}. Recommended dose of fertilizers 110-90-60 NPK kg $ha^{-1}$was applied to rice. Paddy yield data were recorded at maturity. The date of rice transplantation and harvesting was 11-07-2015 and 05-11-2015, respectively. Soil samples were collected after harvesting of crop. The treatments tested along with paddy yield are as under.

Table 1: Effect of treatments on paddy yield (t. ha^{-1})

Treatments	Paddy yield (t. ha^{-1})
T_1= Tube well water (Control)	1.91 C
T_2=Gypsum application on the basis of RSC of water	3.49 A
T_3=H_2SO_4 application on the basis of RSC of water	3.57 A
T_4=Green Manuring with Guar	2.68 B
T_5=FYM @ 10 t. ha^{-1}	2.58 B
LSD	0.1887

Results presented in Table 1 revealed that the highest paddy yields were found in T_3 (H_2SO_4 application) and T_2 (Gypsum application) followed by T_4 (green manuring) and FYM.The lowest yield was recorded in T_1 (control).

Table 2: Soil analyses after Rice harvest 2015

Treatments	pH_s	ECe	SAR	HC	BD
		(dS m^{-1})	(mmol L^{-1})$^{1/2}$	(cm hr^{-1})	(Mg m^{-3})
T_1= Tube well water (Control)	8.79	4.58	25.25	0.66	1.33
T_2=Gypsum application on the basis of RSC of water	8.62	3.91	18.70	0.70	1.29
T_3=H_2SO_4 application on the basis of RSC of water	8.63	3.93	18.00	0.71	1.30
T_4=Green Manuring with Guar	8.73	3.95	21.82	0.70	1.30
T_5=FYM @ 10 t. ha^{-1}	8.72	4.05	20.57	0.71	1.27

In case of soil analysis (Table 2)pH_s and SAR were above the safe limits in all the treatments. EC_e was also above the safe limits in T_1 (control) and T_5 (FYM @ 10 t. ha^{-1}). Hydraulic conductivity of soil increased in all the treatments as compared to control. However, bulk density decreased in all the treatments when compared with control and minimum BD was recorded whereFYM was applied @ 10 t. ha^{-1}.

Raya

In the same layout Raya crop was sown and fertilizer was applied @ 70-70-60 N-P_2O_5-K_2O kg ha^{-1}. All agronomic practices were rendered till maturity. Yield data of crop was recorded at maturity. The dates of sowing and harvesting were 11-11-2015 and 30-03-2016, respectively.

Table 3: Effect of treatments on grain yield of Raya 2015-16

Treatments	Raya Yield (t. ha^{-1})
T_1= Tube well water (Control)	0.77C
T_2= Gypsum application on the basis of RSC of water	1.38 A
T_3= H_2SO_4 application on the basis of RSC of water	1.37 A
T_4= Green Manuring with Guar	1.01 B
T_5= FYM @ 10 t. ha^{-1}	1.03 B
LSD	0.0625

Results in Table 3 revealed that the highest grain yields of Raya were found in T_2 (Gypsum application) and T_3 (H_2SO_4 application) followed byT_4 (green manuring) and T_5 (FYM). Lowest grain yield was recorded in T_1 (control).

Table 4: Soil Analysis after Raya harvest 2015-16

Treatments	**pH_s**	**EC_e (dS m^{-1})**	**SAR (mmol$L^{-1})^{1/2}$**	**HC (cm hr^{-1})**	**BD (Mg m^{-3})**
T_1= Tube well water	8.79	4.57	25.00	0.68	1.34
T_2= Gypsum application on the basis of RSC of water	8.61	3.90	17.00	0.74	1.29
T_3= H_2SO_4 application on the basis of RSC of water	8.62	3.92	17.10	0.72	1.29
T_4= Green Manuring with Guar	8.73	3.82	19.32	0.70	1.30
T_5= FYM @ 10 t. ha^{-1}	8.73	3.94	18.11	0.74	1.30

Soil analysis (Table 4) showed pH_s and SAR were above the safe limits in all the treatments while EC_e was under the safe limits except inT_1. Hydraulic conductivity of soil increased in all the treatments as compared to control. However, bulk density decreased in all the treatments when compared with control. Minimum bulk density was recorded in T_2 (Gypsum application on the basis of RSC of tube well water) and T_3 (H_2SO_4 application on the basis of RSC of tube well water).

02. RESPONSE OF MAIZE-WHEAT ROTATION UNDER BRACKISH WATER MANAGEMENT STRATEGIES

Maize-2015

The experiment was designed to minimize the hazardous effect of brackish water for getting higher yield under maize –wheat rotation in normal soils. A normal field was selected, prepared and leveled. Composite soil samples were collected and analyzed for salinity / sodicity (pH_s = 8.05, EC_e = 2.83dS m^{-1}, SAR = 12.00 (mmol $L^{-1})^{1/2}$, HC = 0.87 cm hr^{-1} and BD = 1.41 Mg m^{-3}. Experiment was laid out in RCBD with four replications. Tube-well water (EC 1.37 dS m^{-1}, SAR 8.40 (mmol $L^{-1})^{1/2}$ and RSC 7.85 me L^{-1}) was used for irrigation. Recommended dose of fertilizers (125-90-60 N-P_2O_5-K_2O kg ha^{-1}) was applied to maize. All agronomic practices were rendered throughout growing period. Yield data of crop was recorded at maturity. Grain yield data was recorded at maturity. The date of sowing and harvesting of maize was 19-08-2015 and 12-11-2015, respectively. Grain yield responses of maize to the treatments applied are given in Table 5.

Table 5: Effect of brackish water on grain yield of maize 2015 (t. ha^{-1})

Treatments	Grain Yield (t. ha^{-1})
T_1=Canal water	4.63 AB
T_2=Tube well water (Control)	4.36 B
T_3=Gypsum application on the basis of RSC of tube well water	4.47 AB
T_4= Tube well water + PGPR	4.45 AB
T_5=Tube well water + PGPR + Gypsum application on the basis of RSC of tube well water	4.84 A
LSD	0.4585

Results revealed (Table-5) that grain yield of maize was the highest in T_5 (Tube well water + PGPR + Gypsum application). It was significantly higher than T_2 (Tube well water) while other treatments differed non-significantly with one another. Soil samples were collected after harvesting of maize and analyzed.

Table 6: Soil analyses after maize harvest 2015

Treatments	pH_s	EC_e (dS m^{-1})	SAR (mmolL^{-1})$^{1/2}$	HC (cm hr^{-1})	BD (Mg m^{-3})
T_1= Canal water	8.04	2.82	12.01	0.88	1.40
T_2=Tube well water (Control)	8.08	2.84	12.06	0.83	1.41
T_3= Gypsum application on the basis of RSC of tube well water	8.02	2.80	11.97	0.88	1.39
T_4= Tube well water + PGPR	8.06	2.81	12.03	0.86	1.40
T_5= Tube well water + PGPR + Gypsum application on the basis of RSC of tube well water.	8.00	2.79	11.90	0.89	1.39

The soil analysis data (Table 6) showed that pH_s, EC_e and SAR were within the safe limits in all the treatments. Hydraulic conductivity of soil in T_2 (Tube well water) was the lowest. It was the highest in T_5 (Tube well water + PGPR + Gypsum). However, bulk density decreased in all the treatments when compared with T_2 (control) and minimum BD was recorded in T_3 (Gypsum) and T_5 (Tube well water + PGPR + Gypsum application).

Wheat

In the same lay out wheat was sown and fertilizer was applied @ 120-110-70 N-P_2O_5-K_2O kg ha^{-1}. The crop was irrigated when required and all agronomic practices were done throughout the crop growth period. Straw and grain yields of wheat were recorded at maturity. The dates of sowing and harvesting were 18-11-2015 and 25-03-2016, respectively.

Table 7: Effect of brackish water on grain and straw yield of wheat 2015-16

Treatments	Grain Yield (t. ha^{-1})	Straw yield (t. ha^{-1})
T_1= Canal water	3.43 A	3.68 A
T_2=Tube well water (Control)	3.01 B	3.25 C
T_3= Gypsum application on the basis of RSC of tube well water	3.20 AB	3.40 BC
T_4= Tube well water + PGPR	3.03 B	3.25 C
T_5= Tube well water + PGPR + Gypsum appl. on the basis of RSC of tube well water	3.33 A	3.56 AB
LSD	0.2980	0.2119

Results revealed that grain yield of wheat was higher in T_1 (canal water) and T_5 (Tube well water + PGPR + Gypsum application) and significantly higher thanT_2 (Tube well water) and T_4 (Tube well water + PGPR) (Table-7). Lowest grain yield was obtained from T_2 (Tube well water). Similar trend was observed in the case of straw yield.

Table 8: Soil Analysis after wheat harvest 2015-16

Treatments	pH_s	EC_e (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$	HC (cm hr^{-1})	BD (Mg m^{-3})
T_1=Canal water	8.02	1.07	10.04	0.89	1.34
T_2=Tube well water (Control)	8.28	1.69	13.45	0.87	1.42
T_3=Gypsum application on the basis of RSC of tube well water	8.07	1.41	10.13	0.90	1.38
T_4= Tube well water + PGPR	8.15	1.59	11.20	0.88	1.35
T_5=Tube well water + PGPR + Gypsum appl. on the basis of RSC of tube well water	8.07	1.26	10.21	0.90	1.36

In case of soil analysis (Table 8) pH_s, EC_e and SAR were within the safe limits in all the treatments. Hydraulic conductivity of soil in T_2 (Tube well water) was the lowest. Bulk density decreased in all the treatments when compared with T_2 (Tube well water) and minimum bulk density was recorded in T_1 (canal water).

5.2 WATER QUALITY DIVISION

03. MANAGEMENT OF BRACKISH WATER FOR SUNFLOWER PRODUCTION

Shortage of good quality water is a great threat for agriculture in Pakistan. The purpose of this study was to mitigate the negative effects of brackish water on oilseed crop through chemical and biological amendments. Following treatments were studied in this experiment: T_1= Brackish water (Control), T_2= Brackish water + gypsum @ 100% RSC of water, T_3= Brackish water + gypsum @ 50% RSC of water, T_4= Brackish water + H_2SO_4 @ 50% RSC of water, T_5= Brackish water + poultry manure @ 10 t. ha^{-1}, T_6= Brackish water + press-mud @ 10 t. ha^{-1}.

Sunflower, (cv. FH-385), was sown. The experiment was laid out in RCBD with three replications. Gypsum, poultry manure and press-mud were applied before sowing. Sulfuric acid on the basis of RSC of water was applied with first irrigation. Initial soil analysis showed pH_s 8.09, EC_e = 3.18 dS m^{-1} and SAR = 8.65 (mmol $L^{-1})^{1/2}$. The chemical composition of brackish water was EC = 1.44 dS m^{-1}, RSC = 8.40 me L^{-1} and SAR = 12.72 (mmol $L^{-1})^{1/2.}$. Recommended dose of fertilizer NPK @ 150-100-62 kg ha^{-1} was applied. Full dose of P and K along with 1/3rd N were applied before sowing and sunflower sown on ridges (30-07-2015) keeping plant to plant distance 30 cm and row to row distance 60 cm. Pre-emergence weedicide pendi-methy-line was sprayed on 31-07-2015. Thinning of plants to maintain number of plants equal in all treatments was done. All agronomic practices were carried out till maturity. Sulphuric acid (H_2SO_4) was applied along with irrigation water in respective treatments. At maturity crop was harvested on 11-12-2015 and data recoded for plant height and achene yield of sunflower 2015.

Table 9: Effect of different treatments of brackish water on plant height and achene yield.

TREATMENTS	Plant height (cm)	Achene Yield (t. ha^{-1})
T_1 = Brackish water (Control)	107.37 D	1.62 D
T_2 = Brackish water + 100% Gyp. application equivalent to GR on the basis of RSC of brackish water.	118.10 A	2.26 A
T_3 = Brackish water + 50% Gyp. application equivalent to GR	110.23 C	1.89 B

on the basis of RSC of brackish water.		
T_4 = Brackish water + H_2SO_4 application equivalent to 50% GR on the basis of RSC of brackish water.	110.17 C	1.92 B
T_5 = Brackish water + poultry manure @ 10 t ha^{-1}	111.17 BC	1.80 C
T_6 Brackish water + press mud @ 10 t ha^{-1}	112.23 B	1.85 BC
LSD	1.74	0.0897

The results (Table 9) showed that all amendments are significantly higher plant height and achene yield over T_1 (control). Maximum plant height and achene yield was recorded in T_2 (100% Gypsum application). T_3 (50% Gypsum application) and T_4 (H_2SO_4 application) differed non-significantly. Same was observed in case of T_5 (Poultry manure) and T_6 (Press mud).

Table 10 Post-harvest soil analyses (sunflower-02015)

TREATMENTS	**pH_s**	**EC_e** (dS m^{-1})	**SAR** (mmol $L^{-1})^{1/2}$
T_1 = Brackish water (Control)	8.23	3.68	13.97
T_2 = Brackish water + 100% Gyp. application equivalent to GR on the basis of RSC of brackish water	7.97	3.28	7.80
T_3 = Brackish water + 50% Gyp. application equivalent to GR on the basis of RSC of brackish water	8.06	3.26	8.80
T_4 = Brackish water + H_2SO_4 application equivalent to 50% GR on the basis of RSC of brackish water	8.07	3.30	8.97
T_5 = Brackish water + poultry manure @10 t ha^{-1}	8.12	3.33	9.72
T_6 = Brackish water + press mud @ 10 t ha^{-1}	8.11	3.20	10.00

Table 10 showed that pHs, EC_e and SAR of soil decreased in all the treatments and slight increase in EC_e, pH_s and SAR of soil was observed in T_1.

04. IMPACT OF SALINE WATER ON MINERAL COMPOSITION AND DRY MATTER YIELD OF SORGHUM-OAT FODDER ROTATION

An experiment in cemented blocks was conducted in Kharif 2015 to investigate tolerance and mineral distribution in sorghum fodder against brackish water. The soil used had EC_e = 1.69 dS m^{-1}, pH_s = 7.97 and SAR = 6.06 (mmol $L^{-1})^{1/2}$. The sorghum (cv. Hegari) fodder was sown in cemented blocks (6 x 4 x 3 ft). Recommended dose of NPK @ 60-60-0 kg $ha^{-1}$was applied accordingly. Water salinity was developed with quadratic equation using NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$ keeping SAR within safe limit. The different salinity levels EC_{iw} 4.0, 6.0, 8.0 and 10.0 dS m^{-1} having control (canal water) were tested. Sorghum fodder yield and yield components data was recorded. Experimental design was CRD with four replications.

Table 11 Effect of saline irrigation water on fresh fodder yield, dry matter yield and plant height

TREATMENTS	**Fresh Fodder Yield (t. ha^{-1})**	**Dry matter yield (t. ha^{-1})**	**Plant height (cm)**
T_1 = Control (canal water)	63.04 A	10.1 B	199.79 A
T_2 = EC_{iw} 4.0 dS m^{-1}	54.05 AB	9.77 B	200.79 A
T_3 = EC_{iw} 6.0 dS m^{-1}	45.85 B	13.69 A	154.99 B
T_4 = EC_{iw} 8.0 dS m^{-1}	49.45 B	14.05 A	143.58 B
T_5 = EC_{iw} 10.0 dS m^{-1}	43.70 B	11.63 AB	144.62 B
LSD	11.318	2.79	26.293

The results (Table 11) showed that water with different salinity levels had significant effect on Fodder, Dry matter yield and Plant height of sorghum. Maximum sorghum fresh fodder yield (63.04 t. ha^{-1}) was observed in the treatment T_1. It was statistically non-significant with T_2, (54.05 t. ha^{-1}) and significant with all other remaining treatments. Minimum fodder yield (43.70 t. ha^{-1})

was recorded with T_5. Maximum dry matter yield (14.05 t. ha^{-1}) was observed with T_4 and it remained statistically non-significant with T_3 and significant with the remaining treatments. Maximum plant height (200.79 cm) was observed in T_2 which remained statistically non-significant with T_1 and significant with T_3, T_5 and T_4. Soil analysis after sorghum harvest given in table (12) depicted slight increase in pH_s, EC_e and SAR of soil except T_1. Maximum increase in EC_e, pH_s and SAR of soil was observed in treatment T_5.

Table 12 Post harvest soil analysis sorghum 2015

TREATMENTS	**pH_s**	**EC_e (dSm^{-1})**	**SAR $(mmolL^{-1})^{1/2}$**
T_1- Control (canal water)	7.78	1.69	5.80
T_2- EC_{iw} 4.0 dS m^{-1}	8.01	2.96	6.30
T_3- EC_{iw} 6.0 dS m^{-1}	8.04	4.27	6.68
T_4- EC_{iw} 8.0 dS m^{-1}	8.06	5.29	7.20
T_5- EC_{iw} 10.0 dS m^{-1}	8.05	6.68	7.24

Table 13: CHEMICAL COMPOSITION OF SORGHUM FODDER

Treatments	**Dry matter (%)**	**Ash (%)**	**Crude fat (%)**	**Crude Protein (%)**
Canal Water	16.02 c	8.59 b	3.07 a	9.92 a
EC_{iw} 4.0 dSm^{-1}	17.71 bc	9.27 b	3.05 a	9.86 a
EC_{iw} 6.0 dSm^{-1}	18.39 abc	8.43 b	2.93 b	8.46 b
EC_{iw} 8.0 dSm^{-1}	20.42 ab	8.88 b	2.36 b	8.37 b
EC_{iw} 10.0 dSm^{-1}	21.77 a	11.45 a	2.29 b	8.14 b
CV (%)	**10.24**	**8.82**	**8.40**	**5.87**
LSD	**3.638**	**1.547**	**0.433**	**0.988**

Table-ii

Treatments	**Phosphorus (%)**	**Calcium (%)**	**Crude fiber (%)**	**NFE (%)**
Canal Water	0.154 a	0.089 a	28.34	50.09
EC_{iw} 4.0 dSm^{-1}	0.146 a	0.085 a	28.71	49.11
EC_{iw} 6.0 dSm^{-1}	0.118 b	0.081 ab	27.58	52.60
EC_{iw} 8.0 dSm^{-1}	0.116 b	0.081 ab	29.72	50.67
EC_{iw} 10.0 dSm^{-1}	0.110 b	0.076 b	28.71	49.41
CV (%)	**8.86**	**5.31**	**NS**	**NS**
LSD	**0.021**	**0.007**		

The result showed that canal water produced maximum crude fat (3.07 %) crude protein (9.92 %), phosphorus (0.154 %) and calcium (0.089 %) while maximum dry matter (21.77 %) and ash (11.45 %) was found in T5 where EC_{iw} 10.0 dSm^{-1} water was applied.

Oat

After harvesting the sorghum crop, in the same cemented blocks oat crop was sown with same set of saline irrigation water treatments. Tested variety was oats (S-2000). Recommended dose of NP @ 95-60 kg ha^{-1} was applied. Salinity was developed as mentioned previously. Oat fodder, dry matter yield and plant height were recorded. Experimental design was CRD with four replications.

Table 14 : Effect of saline irrigation water on fresh fodder yield, dry matter yield and plant height

Treatments	Fresh Fodder yield (t. ha^{-1})	Dry matter yield (t. ha^{-1})	Plant Height (cm)	Moisture % age
T_1=Control(Canal water)	70.27 A	13.08 A	93.50 A	81.39
T_2=EC_{iw} 4.0 dSm^{-1}	49.53 B	8.34 B	90.50 A	83.17
T_3= EC_{iw} 6.0 dSm^{-1}	49.53 B	7.08 B	84.75 B	83.38
T_4= EC_{iw} 8.0 dSm^{-1}	42.62 B	8.11 B	80.25 C	83.61
T_5=EC_{iw} 10.0 dSm^{-1}	38.01 B	6.51 B	78.75 C	82.85
LSD	13.282	2.3431	3.173	

The results (Table 14) showed that fresh fodder yield, dry matter yield and plant height were significantly affected by different treatments of saline irrigation water. Maximum fodder yield (70.27 t. ha^{-1}) was observed in the T_1, it remained statistically significant with all other treatments. Similarly maximum dry matter yield of oat (13.08 t. ha^{-1}) was observed in T_1 and it remained statistically significant with the remaining treatments. Maximum plant height in T_1 and it decreased in descending order in the remaining treatments.

Table 15 : Post harvest soil analysis.

Treatments	pH_s	EC_e (dSm^{-1})	SAR (mmol $L^{-1})^{1/2}$
T_1=Control (Canal water)	7.74	1.67	5.78
T_2=EC_{iw} 4.0 dS m^{-1}	8.08	2.95	6.27
T_3=EC_{iw} 6.0 dS m^{-1}	8.10	4.25	6.64
T_4= ECi_w 8.0 dS m^{-1}	8.10	5.24	7.20
T_5= EC_{iw} 10.0 dS m^{-1}	8.12	6.64	7.23

Soil analysis after oat harvest given in table 15 showed slight increase in EC_e and SAR of T_5 while in other treatments it decreased, pH_s decreased in T_1 and T_2 while it increased in all other treatments.

05. SUSTAINABLE USE OF BRACKISH WATER FOR COTTON –WHEAT ROTATION

Cotton

A field experiment was conducted to manage the deleterious effects of brackish water for sustainable production of cotton and wheat in normal soil EC_e = 2.34 dS m^{-1}, pH_s = 8.15 and SAR = 8.58 (mmol $L^{-1})^{1/2}$. Cotton crop was sown in Kharif 2015. Brackish water analysis showed EC = 1.17 dS m^{-1}, SAR = 6.75 (mmol $L^{-1})^{1/2}$ and RSC = 5.30 me L^{-1}. The following treatments were tested i.e T_1= Control Brackish Water (BW), T_2= BW + Gypsum application equivalent to GR on the basis of RSC of water, T_3= BW + H_2SO_4 equivalent to 50% GR on the basis of RSC of water, T_4= BW + Poultry manure @ 10 t ha^{-1}, T_5= BW+ Press mud @ 10 t ha^{-1}. Seed bed was prepared and cotton crop (cv. FH-942) was planted on 04-06-2015 at a spacing of 75 cm between rows and 30 cm between plants on ridges. Recommended dose of NPK for cotton was 150-60-50 kg ha^{-1}. All chemical and biological amendments except H_2SO_4 were applied 15 days before sowing of cotton crop. Sulfuric acid was applied at the time of first irrigation. Recommended agronomic and plant protection measures were adopted. Experimental layout was RCBD with four replications. Cotton pickings (3) were carried out. Post-harvest soil sampling was done on 28-11-2015.

Table 16: Effect of different treatments on seed cotton, plant height, number of bolls per plant and weight per boll of cotton 2015

TREATMENTS	Seed Cotton (t. ha^{-1})	Plant Height (cm)	No. of Bolls/plant	Weight/Boll (g)
T_1= Control [Brackish Water (B W)]	1.52 C	108.65 C	19.00 B	3.73 B
T_2= BW + Gypsum application@ 100% on the basis of RSC of water	2.29 A	115.73 A	23.00 A	4.00 A
T_3= BW + H_2SO_4 @50% application on the basis of RSC of water	2.23 A	112.80 B	20.00 B	3.98 A
T_4= BW+ Poultry manure @10 t ha^{-1}	1.80 B	111.60 B	21.00 AB	3.96 A
T_5= BW+ Press mud @ 10 t ha^{-1}	1.79 B	114.45 AB	20.00 B	3.83 AB
LSD	0.2464	2.8591	2.4074	0.1912

Maximum seed cotton yield (2.29 t. ha^{-1}), was obtained in the T_2 followed by the treatments T_3, (2.23 t. ha^{-1}), T_4, (1.80 t. ha^{-1}) and T_5, (1.79 t. ha^{-1}). The minimum (1.52 t. ha^{-1}) seed cotton yield was observed in control. In case of plant height, maximum plant height was observed in T_2, (115.73 cm), which was non-significant with T_5 followed by T_3 and T_4 which were also non-significant with each other. Minimum plant height was observed in T_1 (108.65 cm). Maximum number of bolls per plant was observed in T_2 followed by T_4 while T_3, T_5 and T_1were found non-significant with other. In case of seed cotton weight per boll T_2, T_3 T_4 was found non-significant with each other followed by T_5 while minimum seed cotton weight per boll was found in T_1.
Soil analysis (table 17) showed slight decrease in pH_s, EC_e of T_2 and T_3 except SAR. Maximum increase in EC_e, pH_s and SAR of soil was observed in T_1.

Table 17 POST-HARVEST SOIL ANALYSIS AFTER COTTON (2015)

TREATMENTS	pH_s	EC_e (dS m^{-1})	SAR (mmol L^{-1})$^{1/2}$
T_1= Control [Brackish Water (B W)]	8.41	2.89	16.10
T_2= BW + Gypsum application@ 100% on the basis of RSC of water	8.14	2.53	10.00
T_3= BW + H_2SO_4 @50% application on the basis of RSC of water	8.14	2.44	10.20
T_4= BW+ Poultry manure @10 t ha^{-1}	8.26	2.60	13.10
T_5= BW+ Press mud @ 10 t ha^{-1}	8.23	2.61	13.10

Wheat

After harvest of cotton in the same layout, wheat crop was sown with same set of treatments. Sulphuric acid (H_2SO_4) was applied on water RSC basis to wheat crop; all other inorganic and organic amendments were applied to previous cotton crop. Wheat seed (Faisalabad-2008) was drilled on 01-12-2015. Recommended dose of fertilizer @ 120-110-70 NPK kg ha^{-1} was applied. Standard agronomic and plant protection measures were followed throughout the growing season accordingly. Experimental layout was RCBD with four replications.

Table 18 Effect of brackish water treatments on Grain and Straw yield of wheat (2015-16)

Treatments	Grain yield (t. ha^{-1})	Straw yield (t. ha^{-1})
T_1= Control [Brackish Water (B W)]	3.67 C	4.59 C
T_2= BW + Gypsum application@ 100% on the basis of RSC of water	4.35 A	6.17 A
T_3= BW + H_2SO_4 @50% application on the basis of RSC of water	3.98 B	5.53 B

T_4= BW+ Poultry manure @10 t ha^{-1}	3.92 BC	5.43 B
T_5= BW+ Press mud @ 10 t ha^{-1}	3.83 BC	5.22 B
LSD	0.2866	0.5541

The results (Table 18) showed that maximum grain yield (4.35 t. ha^{-1}) of wheat was recorded in T_2 followed by T_3 while treatments T_4 and T_5 were found non-significant with each other. As for as the straw yield of wheat is concerned, maximum straw yield (6.17 t. ha^{-1}) was observed in T_2 while treatments T_3 T_4 and T_5 were non-significant with each other. The lowest straw yield was found in T_1 (4.59 t. ha^{-1}).

Table 19: Post harvest soil analysis of wheat (2015-16)

Treatments	**pH_s**	**EC_e** (dSm^{-1})	**SAR** $(mmol\ L^{-1})^{1/2}$
T_1= Control [Brackish Water (B W)]	8.39	2.88	15.88
T_2= BW + Gypsum application@ 100% on the basis of RSC of water	8.08	2.47	8.53
T_3= BW + H_2SO_4 @50% application on the basis of RSC of water	8.10	2.40	9.12
T_4= BW+ Poultry manure @10 t ha^{-1}	8.20	2.40	11.53
T_5= BW+ Press mud @ 10 t ha^{-1}	8.19	2.42	11.76

Soil analysis (table 19) showed a decrease in pH_s, EC_e and SAR with all treatments. All treatments showed soil analysis within safe limits of pH_s, EC_e and SAR.

06. EFFECTIVENESS OF DIFFERENT MANAGEMENT STRATEGIES FOR BRACKISH IRRIGATION WATER

A field experiment was conducted to manage the deleterious effects of brackish water (BW) for sustainable production of wheat-rice in a normal soil. The treatments studied were: T_1= Control [Brackish Water], T_2= Continuous treated water with sulfuric acid on the basis of RSC of water

T_3= Two irrigations with H_2SO_4 on RSC basis + Two Irrigations without H_2SO_4, T_4= Alternate irrigations with H_2SO_4 on RSC basis and T_5= One irrigation with H_2SO_4 on RSC basis after two irrigations without H_2SO_4. Recommended dose of fertilizer @ 120-110-70 NPK kg ha^{-1} for wheat was applied. The date of sowing and harvesting were 16-11-2015 and 25-04-2016 respectively. Standard agronomic and plant protection measures were followed throughout the season uniformly. The initial soil analysis was pH_s =8.20, EC_e =3.89 dS m^{-1} and SAR =14.53 $(mmol\ L^{-1})^{1/2}$. The brackish irrigation water analysis was EC_{iw} =1.33 dS m^{-1}, SAR =8.83 mmol L^{-1} and RSC =7.90, me L^{-1}.

Table 20 Effect of Brackish irrigation water treatments on wheat grain and Straw yield

Treatments	**Grain (t. ha^{-1})**	**Straw (t. ha^{-1})**
T_1= Control [Brackish Water]	2.50 B	3.00 B
T_2= Continuous treated water with sulfuric acid on the basis of RSC of water	3.33 A	4.03 A
T_3= Two irrigations with H_2SO_4 on RSC basis + Two Irrigations without H_2SO_4	3.00 AB	3.45 AB
T_4= Alternate irrigations with H_2SO_4 on RSC basis	3.10 AB	3.67 AB
T_5= One irrigation with H_2SO_4 on RSC basis after two irrigations without H_2SO_4	2.66 AB	3.23 B
LSD	0.6706	0.7466

Results regarding grain and straw yield and post-harvest soil analysis are presented in Table 20 and 21. Results revealed that the highest grain yield i. e 3.33 t. ha^{-1} was recorded with T_2. The lowest yield was obtained in T_1 i. e 2.66 t. ha^{-1}. The treatments T_3, T_4 and T_5 were found non-significant with one another. Post-harvest analysis, table 21, showed that application of H_2SO_4 reduced the pH_s, EC_e and SAR in all the treatments.

Table 21: Soil Analyses after wheat 2015-16

Treatments	pH_s	EC_e (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$
T_1= Control [Brackish Water]	8.20	3.88	14.00
T_2= Continuous treated water with sulfuric acid on the basis of RSC of water	8.10	3.73	12.90
T_3= Two irrigations with H_2SO_4 on RSC basis + Two Irrigations without H_2SO_4	8.14	3.80	13.50
T_4= Alternate irrigations with H_2SO_4 on RSC basis	8.15	3.79	13.40
T_5= One irrigation with H_2SO_4 on RSC basis after two irrigations without H_2SO_4	8.18	3.83	13.70

07. MANAGEMENT OF SALINE SODIC BRACKISH IRRIGATION WATER FOR SUCCESSFUL PRODUCTION OF WHEAT GRASS

An experiment was conducted to manage the deleterious effects of brackish water (BW) for sustainable production of wheat grass in a normal soil. The treatments were: T_1= Control [Brackish water], T_2= Gypsum @ 100% GR on the basis of RSC of water, T_3= Gypsum @ 50% GR on the basis of RSC of water, T_4= H_2SO_4 @ 100% GR on RSC basis and T_5= H_2SO_4 @ 50% GR on RSC basis.

A normal field was selected and gypsum was applied at the time of sowing. The field was irrigated while H_2SO_4 was applied with each irrigation on RSC basis as per treatment plan. Fertilizer @ 120-110-70 NPK kg ha^{-1} for wheat grass was applied. The date of transplantation and harvesting was 17-12-2015 and 17-06-2016 respectively. Results regarding fodder yield and post-harvest analysis are presented in table 22 and 23. Initial soil analysis was pH_s 8.42, EC_e 3.90 (dS m^{-1}) and SAR 17.58 (mmol $L^{-1})^{1/2.}$

Table 22: Effect of saline sodic water treatments on Fodder yield and Plant Height

Treatments	Fodder Yield (t. ha^{-1})	Plant Height (cm)
T_1= Control [Brackish Water (B W)]	4.81 E	68.10 D
T_2= Gypsum @ 100% GR on the basis of RSC of water	10.41 A	95.40 A
T_3= Gypsum @ 50% GR on the basis of RSC of water	7.27 CD	86.26 B
T_4= H_2SO_4 @ 100% GR on RSC basis	9.29 AB	79.00 C
T_5= H_2SO_4 @ 50% GR on RSC basis	8.04 BC	83.33 BC
T_6= Compost @ 10 t. ha^{-1}	5.64 DE	78.33 C
LSD	1.8218	7.210

Results revealed that the highest fodder yield i.e. 10.41 t. ha^{-1} was recorded in T_2 followed by T_4, T_5, T_3 and T_6. The lowest yield was obtained in T_1 i.e. 4.81 t. ha^{-1}. In case of plant height, maximum plant height, (95.40 cm) was observed in the treatment T_2 followed by T_3, T_5 and T_4. Minimum plant height, (68.10 cm) was observed in T_1.

Table 23: Soil Analyses after Wheat Grass 2015-16

Treatments	pH_s	EC_e (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$
T_1= Control [Brackish Water (B W)]	8.41	3.88	17.00
T_2= Gypsum @ 100% GR on the basis of RSC of water	8.36	3.78	14.60
T_3= Gypsum @ 50% GR on the basis of RSC of water	8.40	3.86	15.89
T_4= H_2SO_4 @ 100% GR on RSC basis	8.35	3.80	15.00
T_5= H_2SO_4 @ 50% GR on RSC basis	8.37	3.85	16.00
T_6= Compost @ 10 t. ha^{-1}	8.39	3.87	16.50

Post-harvest soil analysis table 23 showed a slight decrease in pH_s, EC_e and SAR of soil. Maximum decrease was in the treatment T_2.

5.3 SOIL RECLAMATION

08. TO STUDY THE AMELIORATIVE EFFECT OF HUMIC ACID IN SALT AFFECTED SOIL

Rice Crop

The experiment was designed to determine the best combination of gypsum and humic acid for amelioration of saline sodic soil. Treatments included T_1=Control, T_2= Gypsum @ 100 % GR, T_3 = Gypsum @ 75 % GR + HumicAcid @ 15 kg ha^{-1},T_4 = Gypsum @ 75 % GR + HumicAcid @ 30 kg ha^{-1}, T_5 = Gypsum @ 50 % GR + HumicAcid @ 15kg ha^{-1}, T_6Gypsum @ 50% GR + HumicAcid @ 30 kg ha^{-1}.A saline sodic field was selected, prepared and leveled. Composite soil samples were collected and analyzed for salinity/sodicity and GR. Analysis at the start of study showed that soil had pH_s = 9.18, EC_e = 4.71(dS m^{-1}), SAR = 41.00 (mmol $L^{-1})^{1/2}$ and GR = 3.30 t.$acre^{-1}$. Experiment was laid out in RCBD with 3 replications. Crop rotation used was rice – wheat. The amendment (gypsum) was applied in the respective treatment plots followed by leaching. Tube-well water (EC = 1.54 dS m^{-1}, SAR = 7.60 (mmol $L^{-1})^{1/2}$ and RSC = 4.8 me L^{-1}) was used for crop production. Recommended dose of fertilizers (110-90-60 NPK kg ha^{-1}) was applied to rice. Soil samples were collected after harvesting of crop. Paddy and straw yield data was recorded at maturity. The date of rice transplantation and harvesting was 11-07-2015 and 21-10-2015 respectively.

Table 24: Effect of different treatments on paddy and straw yield

Treatments	Paddy	Straw
	(t. ha^{-1})	
T_1 = Control	2.50 D	5.78 D
T_2 = Gypsum @ 100% GR	4.35 A	10.10 A
T_3 = Gypsum @ 75 % GR + HumicAcid @ 15 kg ha^{-1}	3.80 B	8.80 B
T_4 = Gypsum @ 75 % GR + HumicAcid @ 30 kg ha^{-1}	4.31 A	9.98 A
T_5 = Gypsum @ 50 % GR + HumicAcid @ 15kg ha^{-1}	3.37 C	7.83 C
T_6 = Gypsum @ 50% GR + HumicAcid @ 30 kg ha^{-1}	3.84 B	8.89 B
LSD	0.4035	0.9261

Results presented in Table 24 revealed that paddy yield 4.35 t. ha^{-1} was higher in T_2 (Gypsum @ 100 % GR) and was statistically at par with T_4. T_3 was at par with T_6 followed by T_5. The lowest yield 2.50 t. ha^{-1} was recorded in T_1 (control). Same trend was observed in straw yield.

Table 25: Soil analyses after rice

Treatments	pH_s	EC_e (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$
T_1 = Control	8.94	4.54	26.50
T_2 = Gypsum @ 100% GR	8.54	3.24	17.10
T_3 = Gypsum @ 75 % GR + HumicAcid @ 15 kg ha^{-1}	8.79	3.87	20.23
T_4 = Gypsum @ 75 % GR + HumicAcid @ 30 kg ha^{-1}	8.67	3.56	18.20
T_5 = Gypsum @ 50 % GR + HumicAcid @ 15kg ha^{-1}	8.84	3.97	23.75
T_6 = Gypsum @ 50% GR + HumicAcid @ 30 kg ha^{-1}	8.76	3.86	21.20

In case of soil analysis (Table 24) $pH_s$and SAR were above the safe limits in all the treatments while EC_e was in safe limits in all the treatments except in $T_{1=}$ (control).

Wheat

The experiment was conducted on the same lay out following same methodology and treatments on wheat crop with fertilizer addition 120-110-70 NPK kg ha^{-1}. All agronomic practices were rendered till maturity. The date of sowing and harvesting were 17-11-2015 and 22-04-2016 respectively.

Table 26: Effect of different treatments on grain and straw yield

Treatments	Grain	Straw
	(t. ha^{-1})	
T_1 = Control	1.92 E	2.67 C
T_2 = Gypsum @ 100% GR	3.62 A	4.41 A
T_3 = Gypsum @ 75 % GR + HumicAcid @ 15 kg ha^{-1}	2.85 C	3.81 B
T_4 = Gypsum @ 75 % GR + HumicAcid @ 30 kg ha^{-1}	3.23 B	4.08 AB
T_5 = Gypsum @ 50 % GR + HumicAcid @ 15kg ha^{-1}	2.31 D	2.88 C
T_6 = Gypsum @ 50% GR + HumicAcid @ 30 kg ha^{-1}	2.69 C	3.48 B
LSD	0.3635	0.6022

Results presented in Table 26 revealed that grain yield (3.62 t. ha^{-1}) was higher in T_2 followed by T_4 (3.23 t. ha^{-1}). T_3 (2.85 t. ha^{-1}) was statistically at par with T_6 (2.69 t. ha^{-1}) followed by T_5 (2.31 t. ha^{-1}). The lowest yield (1.92 t. ha^{-1}) was recorded in T_1 (control). Same trend was observed in case of straw yield.

Table 27: Soil analyses after wheat harvest

Treatments	pH_s	EC_e (dS m^{-1})	SAR (mmol L^{-1})$^{1/2}$
T_1 = Control	8.97	4.53	27.16
T_2 = Gypsum @ 100% GR	8.46	3.19	14.92
T_3 = Gypsum @ 75 % GR + HumicAcid @ 15 kg ha^{-1}	8.73	3.82	19.34
T_4 = Gypsum @ 75 % GR + HumicAcid @ 30 kg ha^{-1}	8.62	3.49	16.88
T_5 = Gypsum @ 50 % GR + HumicAcid @ 15kg ha^{-1}	8.79	3.93	22.67
T_6 = Gypsum @ 50% GR + HumicAcid @ 30 kg ha^{-1}	8.72	3.79	20.64

In case of soil analysis (Table 27) $pH_s$and SAR were above the safe limits in all the treatments except in T_2 while EC_e was under the safe limits except in T_1 (control).

09. INTEGRATED USE OF DIFFERENT AMENDMENTS FOR IMPROVING SOIL HEALTH

Rice Crop

The experiment was designed to determine performance of different amendments for improving soil health. Treatments included T_1 = Control, T_2 = Gypsum @ 100 % GR, T_3 = $CaCl_2$ @ 50 % GR T_4 = $CaCl_2$ @ 50 % GR + Bio gasslurry@ 10 t. ha^{-1}, T_5 = H_2SO_4 @ 25 % GR, T_6 = H_2SO_4 @ 25 % GR + Bio gasslurry@ 10 t. ha^{-1}. A saline sodic field was selected, prepared and leveled. Composite soil samples were collected and analyzed for salinity/sodicity and GR. At the start of study soil had pH_s = 9.15, EC_e = 4.86 (dS m^{-1}), SAR = 42.52 (mmol L^{-1})$^{1/2}$, GR = 3.50 (t.acre^{-1}). Experiment was laid out in RCBD with 3 replications. The amendments gypsum and $CaCl_2$ were applied in the respective treatment plots followed by leaching. Tube-well water EC = 1.54 dS m^{-1}, SAR = 7.60 (mmol L^{-1})$^{1/2}$ and RSC = 4.8 me L^{-1} was used for crop production. Recommended dose of fertilizers (110-90-60 NPK kg ha^{-1}) was applied to rice. Soil samples were collected after harvesting of crop. Paddy and straw yield data was recorded at maturity. The date of rice transplantation and harvesting was 10-07-2015 and 21-10-2015 respectively.

Table 28: Effect of different treatments on paddy and straw yield

Treatments	Paddy	Straw
	(t. ha^{-1})	
T_1 = Control	2.34 D	4.49 D
T_2 = Gypsum @ 100 % GR	3.63 A	8.13 A
T_3 = $CaCl_2$ @ 50 % GR	3.05 B	7.01 B
T_4 = $CaCl_2$ @ 50 % GR + Bio gasslurry @ 10 t. ha^{-1}	3.52 A	8.12 A
T_5 = H_2SO_4 @ 25 % GR	2.83 C	6.22 C

T_6 = H_2SO_4 @ 25 % GR + Bio gas slurry @ 10 t. ha^{-1}	3.13 B	6.70 BC
LSD	0.2126	0.6568

Results presented in Table 28 depicted that paddy yield (3.63t. ha^{-1}) was higher in T_2 followed by T_4 (3.52 t. ha^{-1}). T_3 (3.05 t. ha^{-1}) was statistically at par with T_6 (3.13 t. ha^{-1}) followed by T_5 (2.83 t. ha^{-1}). The lowest yield (2.34 t. ha^{-1}) was recorded in T_1 (control). Same trend was observed in straw yield.

Table 29: Soil analyses after rice harvest

Treatments	**pH_s**	**EC_e (dS m^{-1})**	**SAR (mmol $L^{-1})^{1/2}$**
T_1 = Control	8.94	4.66	38.40
T_2 = Gypsum @ 100 % GR	8.62	3.76	19.24
T_3 = $CaCl_2$ @ 50 % GR	8.71	3.91	29.82
T_4 = $CaCl_2$ @ 50 % GR + Bio gasslurry @ 10 t. ha^{-1}	8.65	3.80	24.68
T_5 = H_2SO_4 @ 25 % GR	8.79	4.12	31.90
T_6 = H_2SO_4 @ 25 % GR + Bio gas slurry @ 10 t. ha^{-1}	8.69	3.94	28.72

In case of soil analysis (Table 29) pH_s, and SAR were above the safe limits in all the treatments, while EC_e was under the safe limits except in T_1 (control).

Wheat

The experiment was sown on the same lay out following same methodology and treatments with fertilizer application 120-110-70 NPK kg ha^{-1}. The date of sowing and harvesting was 13-11-2015 and 22-04-2016 respectively. Recommended agronomic and plant protection measures were adopted upto maturity. After harvesting grain and straw yield of wheat was recorded.

Table 30: Effect of different treatments on grain and straw yield

Treatments	**Grain**	**Straw**
	(t. ha^{-1})	
T_1 = Control	2.04 E	2.64 E
T_2 = Gypsum @ 100 % GR	3.46 A	4.18 A
T_3 = $CaCl_2$ @ 50 % GR	2.91 C	3.59 C
T_4 = $CaCl_2$ @ 50 % GR + Bio gas slurry @ 10 t. ha^{-1}	3.22 B	3.88 B
T_5 = H_2SO_4 @ 25 % GR	2.39 D	2.98 D
T_6 = H_2SO_4 @ 25 % GR + Bio gas slurry @ 10 t. ha^{-1}	2.78 C	3.43 C
LSD	0.2158	0.2501

Results in Table 30 revealed that maximum grain yield 3.46 t. ha^{-1} was observed in T_2 followed by T_4 (3.22 t. ha^{-1}). Where as T_3 (2.91 t. ha^{-1}) was statistically at par with T_6 (2.78 t. ha^{-1}) followed by T_5 (2.39 t. ha^{-1}). The lowest yield 2.04 t. ha^{-1} was recorded in control. Same trend was observed in straw yield.

Table 31: Soil analyses after wheat harvest

Treatments	**pH_s**	**EC_e (dS m^{-1})**	**SAR (mmol $L^{-1})^{1/2}$**
T_1 = Control	8.93	4.68	37.88
T_2 = Gypsum @ 100 % GR	8.48	3.70	17.54
T_3 = $CaCl_2$ @ 50 % GR	8.68	3.91	27.48
T_4 = $CaCl_2$ @ 50 % GR + Bio gas slurry @ 10 t. ha^{-1}	8.59	3.74	21.16
T_5 = H_2SO_4 @ 25 % GR	8.77	4.06	30.62
T_6 = H_2SO_4 @ 25 % GR + Bio gas slurry @ 10 t. ha^{-1}	8.65	3.88	26.24

Soil analysis (Table 31) revealed that pH_s, and SAR were above the safe limits in all the treatments, while EC_e was under the safe limits except in T_1 (control).

10. RESPONSE OF CONOCARPUS ERECTUS SEEDLINGS TO DIFFERENT LEVELS OF SALINITY AND SODICITY

The experiment was designed to determine salinity/sodicity tolerance of *Conocarpus Erectus* and suitability of Conocarpus cultivation on waste salt affected soils. Performance of Conocarpus was tested on different salinity and sodicity levels in pots first and then performance was evaluated under field conditions later on. Sixteen treatments having different combination of salinity 20, 30, 40 and sodicity levels i.e. SAR 20, 40, 60, 80, and 100 mmol L^{-1} were planned. While salinity level < 4 and SAR <15 was kept as control. A normal soil having pH_s 8.17, EC_e0.85 dS m^{-1},SAR 4.50 (mmol $L^{-1})^{1/2}$ and SP was 33.70% was used, sieved on 03-02-2015 and the desired salinity/sodicity levels were developed using salts NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$ by Quadratic Equation. After establishing the desired levels of EC_e and SAR, the soil was filled in the glazed pots as per treatment plan on 05-02-2015. Three seedlings of *Conocarpus erectus* were transplanted in each pot. Experiment was laid out in CRD with three replications. Fertilizer @ one liter of 1% urea, TSP and SOP was applied at the start and after six months. The data regarding plant height and stem diameter was recorded. The detail of which is given in table 09.

Table 32: Effect of different levels of ECe and SAR on plant height (cm)

EC (d Sm^{-1})		**SAR** (m mol $L^{-1})^{1/2}$	**Plant height at transplanting**	**Plant height after one year**	**% increase over initial value (after one year)**
T_1	<4	<15	70.00	105.33	50.47
T_2	20	20	57.00	84.66	48.53
T_3	20	40	58.00	86.33	48.85
T_4	20	60	52.00	76.00	46.15
T_5	20	80	58.00	83.66	44.25
T_6	20	100	62.00	87.00	40.32
T_7	30	20	66.00	90.66	37.36
T_8	30	40	53.00	73.33	38.36
T_9	30	60	62.00	83.33	34.40
T_{10}	30	80	59.66	77.00	29.06
T_{11}	30	100	58.00	71.33	22.98
T_{12}	40	20	62.00	82.33	32.79
T_{13}	40	40	64.00	85.66	33.85
T_{14}	40	60	67.33	85.00	26.24
T_{15}	40	80	70.00	81.00	15.71
T_{16}	40	100	62.00	68.00	9.67

Data after one year revealed (Table 32) that dual stress of salinity and sodicity significantly affected the plant height as compared to unstressed plants (control). Average height of plants was 105.33 cm in unstressed plants (control). It was only 68.00 cm under highest level of salinity and sodicity (EC_e 40(dS m^{-1}) + SAR 100 (mmol $L^{-1})^{1/2}$).

Table 33: Effect of different levels of EC_e and SAR on stem diameter (cm)

EC ($d\ Sm^{-1}$)		SAR ($m\ mol\ L^{-1})^{1/2}$	Stem diameter at transplanting	Stem diameter after one year	% increase over initial value (after one year)
T_1	<4	<15	0.77	1.49	93.93
T_2	20	20	0.60	1.15	92.21
T_3	20	40	0.62	1.20	94.08
T_4	20	60	0.57	1.08	90.05
T_5	20	80	0.69	1.26	83.57
T_6	20	100	0.70	1.22	75.24
T_7	30	20	0.77	1.43	86.58
T_8	30	40	0.53	0.99	87.41
T_9	30	60	0.63	1.16	84.12
T_{10}	30	80	0.59	1.01	71.74
T_{11}	30	100	0.76	1.19	57.46
T_{12}	40	20	0.66	1.17	77.27
T_{13}	40	40	0.63	1.05	67.73
T_{14}	40	60	0.73	1.25	71.37
T_{15}	40	80	0.79	1.23	56.11
T_{16}	40	100	0.76	1.04	36.84

Results (Table 33) revealed that increasing levels of salinity and sodicity had negative effect on plant diameter.. Data after one year revealed that dual stress of salinity and sodicity significantly affected the plant diameter as compared to unstressed plants (control). Average diameter of plants was 1.49 cm in unstressed (control) plants which was only 1.04 cm under highest level of salinity and sodicity (EC_e40($dS\ m^{-1}$) + SAR 100 ($mmol\ L^{-1})^{1/2}$).

11. ENHANCING THE SOLUBILITY OF GYPSUM WITH H_2SO_4.

Study was planned to find out the best combination of sulfuric acid and gypsum for reclamation of saline sodic soil in rice-wheat cropping rotation. Treatments included were T_1= Control, T_2= Gypsum @ 100 % of GR, T_3 = Gypsum @ 100 % of GR + 10 Kg H_2SO_4 $acre^{-1}$, T_4 = Gypsum @ 100 % of GR + 50 Kg H_2SO_4 $acre^{-1}$, T_5 = Gypsum @ 100 % of GR + 100 Kg H_2SO_4 $acre^{-1}$. A saline sodic field was selected, prepared and leveled. Composite soil samples were collected and analyzed for salinity/sodicity and GR. At the start of study soil had pH_s = 8.85, EC_e = 4.85 ($dS\ m^{-1}$), SAR = 43.82 ($mmol\ L^{-1})^{1/2}$, GR = 3.96 ($t.acre^{-1}$). Experiment was laid out in RCBD with 3 replications. The amendment (gypsum) was applied in the respective treatment plots followed by leaching. Tube-well water (EC = 1.54 dS m^{-1}, SAR = 7.60 ($mmol\ L^{-1})^{1/2}$ and RSC = 4.8 me L^{-1}), was used for crop production. Recommended dose of fertilizers 110-90-60 NPK kg ha^{-1} was applied to rice. Soil samples were collected after harvesting of crop. Paddy and straw yield data was recorded at maturity. The date of rice transplantation and harvesting was 13-07-2015 and 03-11-2015 respectively.

Table 34: Yield data (Rice2015)

Treatments	Paddy yield	Straw Yield
	($t\ ha^{-1}$)	
T1 = Control	1.70 C	4.04 D
T2 = Gypsum @ 100 % of GR	2.68 B	6.12 C
T3 = Gypsum @ 100 % of GR + 10 kg H_2SO_4 $acre^{=1}$	2.69 B	6.14 C
T4 = Gypsum @ 100% of GR + 50 kg H_2SO_4 $acre^{=1}$	2.85 B	6.52 B
T5 = Gypsum @ 100% of GR + 100 kg H_2SO_4 $acre^{-1}$ -1	3.15 A	7.18 A
LSD	0.2159	0.2997

Results indicated that paddy yield was the highest in T_5 (3.15 t.ha^{-1}) followed by T_4 (2.85 t.ha^{-1}), which was at par with T_3 (2.69 t.ha^{-1}) and T_2 (2.68 t.ha^{-1}). The lowest yield 1.70 t. ha^{-1} was recorded in control. The same trend was observed in straw yield.

Table 35: Soil analysis after rice 2015

Treatments	pH_s	EC_e (dS m^{-1})	SAR (mmol L^{-1})$^{1/2}$
T1 = Control	8.84	4.82	43.29
T2 = Gypsum @ 100 % of GR	8.75	4.65	36.22
T3 = Gypsum @ 100 % of GR + 10 kg H_2SO_4 acre$^{=1}$	8.75	4.64	36.16
T4 = Gypsum @ 100% of GR + 50 kg H_2SO_4 acre$^{=1}$	8.72	4.62	33.92
T5 = Gypsum @ 100% of GR + 100 kg H_2SO_4 acre^{-1} -1	8.69	4.56	30.08

In case of soil analysis pH_s, EC_e, and SAR were above the safe limits in all the treatments. In the same layout wheat (Inqlab 91) was sown. Recommended dose of fertilizer 120-110-70 NPK kg ha^{-1} was applied.

Table 36: Yield data (wheat 2016)

Treatments	Grain yield	Straw Yield
	(t ha^{-1})	
T1 = Control	0.85 C	1.10 C
T2 = Gypsum @ 100 % of GR	2.60 B	3.25 B
T3 = Gypsum @ 100 % of GR + 10 kg H_2SO_4 acre^{-1}	2.61 B	3.28 B
T4 = Gypsum @ 100% of GR + 50 kg H_2SO_4 acre^{-1}	2.85 A	3.64 A
T5 = Gypsum @ 100% of GR + 100 kg H_2SO_4 acre^{-1}	2.82 A	3.60 A
LSD	0.1998	0.3056

The results indicated that grain yield was the highest in T_4 (2.85 t.ha^{-1}) followed by T_5 (2.82 t. ha^{-1}), however both treatments were non-significant with each other. The lowest yield (0.85 t. ha^{-1}) was recorded in control. The same trend was observed in straw yield.

Table 37: Soil analysis after wheat 2016

Treatments	pH_s	EC_e (dS m^{-1})	SAR (mmol L^{-1})$^{1/2}$
T1 = Control	8.83	4.87	43.44
T2 = Gypsum @ 100 % of GR	8.71	4.50	34.00
T3 = Gypsum @ 100 % of GR + 10 kg H_2SO_4 acre$^{=1}$	8.72	4.48	33.55
T4 = Gypsum @ 100% of GR + 50 kg H_2SO_4 acre$^{=1}$	8.68	4.39	30.33
T5 = Gypsum @ 100% of GR + 100 kg H_2SO_4 acre^{-1} -1	8.67	4.46	30.53

In case of soil analysis pH, EC, and SAR were above the safe limits in all the treatments.

12. Use of hyacinth compost in salt affected soils

Objective of the experiment was to determine the effectiveness of hyacinth compost as an ameliorant for reclamation of saline sodic soil and crop production. Treatments included T_1 = Control, T_2 = Gypsum @ 100 % GR, T_3 = Gypsum @ 50 % of GR, T_4 = Hyacinth compost @ 15t. ha^{-1}, T_5 = Gypsum @ 50 % of GR+ hyacinth compost @ 5 t. ha^{-1}, T_6 = Gypsum @ 50 % of GR+ hyacinth compost @ 10 ha^{-1}, T_7 = Gypsum @ 50 % of GR+ hyacinth compost @ 15 t. ha^{-1}. At the start of study soil had pH_s = 8.91, EC_e = 5.02(dS m^{-1}), SAR = 44.24(mmol L^{-1})$^{1/2}$, GR = 4.12(t.acre^{-1}) BD = 1.66 (Mg m^{-3}) HC = 0.35 (cm hr^{-1}). Experiment was laid out in RCBD with 3 replications. The amendment (gypsum and compost) was applied in the respective treatment plots

followed by leaching. Tube-well water (EC = 1.54 dS m^{-1}, SAR = 7.60 (mmol L^{-1})$^{1/2}$ and RSC = 4.8 me L^{-1}), was used for crop production. Recommended dose of fertilizers (110-90-60 NPK kg ha^{-1}) was applied to rice. Soil samples were collected after harvesting of crop. Paddy and straw yield data was recorded at maturity. The date of rice transplantation and harvesting was 13-07-2015 and 03-11-2015 respectively.

Table 38: Yield data (Rice2015)

Treatments	Paddy Yield	Straw Yield
	(t ha^{-1})	
T_1 = Control	1.67 E	4.01 E
T_2 = Gypsum @ 100% of GR	2.93 A	6.73 A
T_3 = Gypsum @ 50 % of GR	2.29 D	5.48 CD
T_4 =Hyacinth compost @ 15 t. ha^{-1}	2.26 D	5.28 D
T_5 = Gypsum @ 50 % of GR + hyacinth compost @ 5 t. ha^{-1}	2.52 C	5.84 C
T_6 = Gypsum @ 50 % of GR + hyacinth compost @ 10t.ha^{-1}	2.67 BC	6.27 B
T_7 = Gypsum @ 50 % of GR + hyacinth compost @ 15t.ha^{-1}	2.76 B	6.32 B
LSD	0.1472	0.4001

Results in Table 38 revealed that maximum paddy yield was the highest in T_2 (2.93.ha^{-1}) followed by T_7 (2.76 t. ha^{-1}) which was at par with T_6 (2.67 t. ha^{-1}) followed by T_5 (2.52 t. ha^{-1}). The lowest yield 1.67t. ha^{-1} was recorded in (control).Same trend was observed in straw yield.

Table 39: Soil analysis after rice 2015

Treatments	**pH_s**	**EC_e (dS m^{-1})**	**SAR (mmol L^{-1})$^{1/2}$**	**BD (Mg m^{-3})**	**HC (cm hr^{-1})**
T_1 = Control	8.92	5.00	44.18	1.70	0.35
T_2 = Gypsum @ 100% of GR	8.77	4.76	35.35	1.67	0.40
T_3 = Gypsum @ 50 % of GR	8.85	4.87	37.16	1.69	0.38
T_4 =Hyacinth compost @ 15 t. ha^{-1}	8.88	4.86	37.84	1.69	0.38
T_5 = Gypsum @ 50 % of GR + hyacinth compost @ 5 t. ha^{-1}	8.85	4.83	36.90	1.69	0.39
T_6 = Gypsum @ 50 % of GR + hyacinth compost @ 10 t. ha^{-1}	8.81	4.78	36.72	1.68	0.39
T_7 = Gypsum @ 50 % of GR + hyacinth compost @ 15 t. ha^{-1}	8.80	4.75	35.84	1.67	0.41

In case of soil analysis pH_s, EC_e, and SAR were above the safe limits in all the treatments.

Table 40: Yield data (Wheat 2016)

Treatments	**Grain Yield**	**Straw Yield**
	(t ha^{-1})	
T_1 = Control	1.47 D	1.86 D
T_2 = Gypsum @ 100% of GR	2.64 A	3.27 A
T_3 = Gypsum @ 50 % of GR	2.10 BC	2.60 BC
T_4 =Hyacinth compost @ 15 t. ha^{-1}	1.89 C	2.41 C
T_5 = Gypsum @ 50 % of GR + hyacinth compost @ 5 t. ha^{-1}	2.24 B	2.78 B
T_6 = Gypsum @ 50 % of GR + hyacinth compost @ 10 t. ha^{-1}	2.48 A	3.06 A
T_7 = Gypsum @ 50 % of GR + hyacinth compost @ 15 t. ha^{-1}	2.59 A	3.29 A
LSD	0.2151	0.2703

In the same field with same layout wheat (Inqulab 91) was sown. Recommended dose of fertilizer 120-110-70 NPK kg ha^{-1} was applied. All agronomic practices were rendered till maturity. The crop was sown on 27.11.2015 and harvested on 22.04.2016. The results (table 40) indicated that grain yield was the highest in T_2 (2.64 t.ha^{-1}) followed by T_7 (2.59 t. ha^{-1}) and T_6 (2.48 t. ha^{-1}) which were at par among themselves. The lowest yield 1.47 t. ha^{-1} was recorded in control. Same trend was observed in straw yield.

Table 41: Soil analysis after wheat

Treatments	**pH_s**	**EC_e (dS m^{-1})**	**SAR (mmol $L^{-1})^{1/2}$**	**BD (Mg m^{-3})**	**HC (cm hr^{-1})**
T1 = Control	8.93	4.98	44.24	1.66	0.34
T2 = Gypsum @ 100% of GR	8.72	4.69	32.12	1.62	0.46
T3 = Gypsum @ 50 % of GR	8.82	4.77	35.42	1.63	0.39
T4 =Hyacinth compost @ 15 t. ha^{-1}	8.86	4.82	36.54	1.60	0.40
T5 = Gypsum @ 50 % of GR + hyacinth compost @ 5 t. ha^{-1}	8.78	4.76	35.06	1.61	0.43
T6 = Gypsum @ 50 % of GR + hyacinth compost @ 10 t. ha^{-1}	8.79	4.70	34.28	1.59	0.44
T7 = Gypsum @ 50 % of GR + hyacinth compost @ 15 t. ha^{-1}	8.74	4.67	33.78	1.59	0.45

Soil analysis pH, EC, and SAR were above the safe limits in all the treatments.

5.4 PLANT NUTRITION DIVISION

13. EFFECT OF SEED PRIMING AND FOLIAR APPLICATION OF SALICYLIC ACID ON NUTRIENT UPTAKE OF WHEAT IN SALINE SODIC SOIL

Salicylic acid is a plant hormone of phenolic nature. It is synthesized in plants from Phenyl alanine. Salicylic acid reduces the uptake of sodium and promotes uptake of NPK when applied to wheat in salt stress condition. The experiment was planned to study the effect of seed priming and foliar application of salicylic acid on nutrient uptake of wheat in saline sodic condition. A moderately saline sodic field {pH_s 8.68 =EC_e 5.71dS m^{-1}=SAR 26.50 (mmol $L^{-1})^{1/2}$=O.M 0.42%, Available P = 8.66 mg kg^{-1},Extractable K =105.60 mg kg^{-1}}was selected. Field was prepared and leveled. Different treatments of salicylic acid i.e. T_1 = Control (Without Salicylic acid application),T_2 = Seed priming of wheat with 0.5 mM Salicylic acid,T_3 = Seed priming of wheat with 1.0 mM Salicylic acid, T_4 = Seed priming of wheat with 2.0 mM Salicylic acid,T_5 = Seed priming and foliar application of wheat with 0.5 mM Salicylic acid, T_6= Seed priming and foliar application of wheat with 1.0 mM Salicylic acid T_7= Seed priming and foliar application of wheat with 2.0 mM. Salicylic acid was applied according to treatment plan. For seed priming 500 g seed of wheat was soaked in 1000 mL solution of salicylic acid of different concentration for 12 hours. Seed was dried to its original moisture level under shade. Three foliar applications of salicylic acid were done at booting stage at 10 days interval. Test variety was Galaxy 2013. Fertilizers were applied @ 120-110-70 NPK kg ha^{-1}. Sources of NPK were Urea, SSP and SOP. Whole P, K and 1/3rd N was applied at the time of sowing while remaining N was applied in two splits at second and third irrigation. Crop was harvested at maturity. Grain and straw yield data were recorded. After the harvest of wheat, soil samples were collected and analyzed for pH_s, EC_e, SAR, OM, available P and K. The results are described as under:

Table 42: Effect of different treatments of salicylic acid on grain and straw yield of wheat

Treatments	Grain Yield (t. ha^{-1})	Straw yield (t. ha^{-1})
T_1= Control (Recommended dose of NPK)	2.28 C	2.39 D
T_2= Seed priming with 0.5 mM Salicylic acid	2.31 C	2.45 DE
T_3= Seed priming with 1.0 mM Salicylic acid	2.46 BC	2.65 CD
T_4= Seed priming with 2.0 mM Salicylic acid	2.54 B	2.69 C
T_5= Seed priming and Foliar application with 0.5 mM Salicylic acid	2.59 B	2.75 BC
T_6= Seed priming and Foliar application with 1.0 mM Salicylic acid	2.82 A	2.94 AB
T_7= Seed priming and Foliar application with 2.0 mM Salicylic acid	2.84 A	2.98 A
LSD	0.2213	0.2083

Different treatments of salicylic acid have significant effect on grain and straw yield of wheat. Results (Table 42) showed that maximum grain yield (2.82 t. ha^{-1}) with straw yield (2.98 t. ha^{-1}) was observed in the treatment where seed priming and foliar application with 2.0 mMsalicylic acid was done and it remained statistically non-significant with T_6 where seed priming and foliar application with 1.0mM salicylic acid was done. Minimum grain (2.28 t. ha^{-1}) and straw yield (2.39 t. ha^{-1}) was recorded in control treatment i.e. without seed priming and foliar application of salicylic acid which remained statistically at par with T_2(Seed priming with 0.5 mM salicylic acid) and T_3(Seed priming with 1.0 mM salicylic acid) and differed significantly with T_4, T_5, T_6 and T_7.

Table 43: Post harvest soil analysis wheat (2015-16):

Treatments	pH_S	EC ($dS\ m^{-1}$)	SAR $(mmol\ L^{-1})^{1/2}$	O.M. (%)	Available P ($mg\ kg^{-1}$)	Extractable K ($mg\ kg^{-1}$)
T_1= Control (NPK fertilizer only)	8.68	5.67	25.87	0.52	10.00	109.26
T_2 = Seed priming of wheat with 0.5 mM Salicylic acid	8.68	5.65	25.31	0.52	10.80	109.26
T_3 = Seed priming of wheat with 1.0 mM Salicylic acid	8.67	5.65	25.14	0.55	10.13	111.10
T_4 = Seed priming of wheat with 2.0 mM Salicylic acid	8.67	5.64	24.70	0.55	10.20	111.10
T_5 = Seed priming and foliar application ofwheat with 0.5 mM Salicylic acid	8.66	5.62	24.56	0.55	10.33	111.80
T_6 = Seed priming and foliar application ofwheat with 1.0 mM Salicylic acid	8.65	5.61	24.42	0.55	10.46	112.20
T_7 = Seed priming and foliar application ofwheat with 2.0 mM Salicylic acid	8.60	5.60	24.28	0.55	10.46	112.20

Soil analysis (Table 43) after wheat harvest showed slight decrease in salinity/sodicity parameters of soil with minor increase in fertility status of soil.

14. INVESTIGATION OF SALT TOLERANCE OF CAMELINA UNDER SALINE SODIC CONDITIONS

A normal soil (pH_s 8.14, EC_e2.34 dS m^{-1}, SAR 6.79 (mmol L^{-1})$^{1/2}$, Saturation percentage 28.64%, O.M. 0.44%, Available P 8.13 mg kg^{-1} and Extractable K 105.96mg kg^{-1} with Sandy loam texture was selected. The desired combinations of EC 4.0, 8.0, 12.0 dS m^{-1} with SAR 20, 30 and 40 (mmol L^{-1})$^{1/2}$were developed artificially using NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$.
The normal soil was kept as control. Quadratic equation was used to calculate different amounts of sodium, calcium and magnesium salts for the development of desired levels of EC_e and SAR. After establishing, 10 kg soil per pot was filled. Experimental design was CRD with 3 replications. Ten seed of camelina were sown in each pot and three plants allowed to grow per pot. Recommended dose of fertilizers75-60-50 kg ha^{-1} was applied. Plants were grown to maturity. Biomass and grain yield data were recorded. Post-harvest soil analysis for EC_e, pH_s and SAR was done after harvesting of camelina. The results are described as under:

Table 44: Effect of different combinations of salinity/sodicity on total biomass per pot

Treatments			Total Biomass (g)	% decrease over control
	EC (dS m^{-1})	SAR (mmolL^{-1})$^{1/2}$		
T_1	<4	<13.2	11.40 A	-
T_2	4	20	9.84 B	13.68
T_3	8	20	8.53 C	25.17
T_4	12	20	6.60 DE	42.10
T_5	4	30	7.37 D	35.35
T_6	8	30	6.12 E	46.31
T_7	12	30	4.95 F	56.57
T_8	4	40	3.87 G	66.05
T_9	8	40	3.40 GH	70.17
T_{10}	12	40	2.87 H	74.82
LSD			0.8660	-

Effect of different combinations of EC and SAR on total biomass per pot of camelina is given in Table 44. Results showed that maximum biomass (11. 40 g) per pot of camelina was observed in T_1 which decreased significantly with increasing level of salinity and sodicity. Biomass per pot obtained (6.60 g) in T_4 is statistically non-significant with T_5 and T_6. Higher combinations of salinity/sodicity decreased the biomass yield. Minimum biomass per pot was observed (2.87 g) in T_{10}. While maximum decrease due to salinity was observed (74.82%) in $T_{10.}$ Which remained statistically non-significant with $T_{9,}$ registering 70.17% decrease with respect to control.

Table 45: Effect of different combinations of salinity/sodicity on grain yield per pot

Treatments			Grain yield (g)	% decrease over control
	EC (dS m^{-1})	SAR (mmolL^{-1})$^{1/2}$		
T_1	<4	<13.2	4.48 A	-
T_2	4	20	3.84 B	14.28
T_3	8	20	3.21 C	28.34
T_4	12	20	2.42 DE	45.98
T_5	4	30	2.70 D	39.73
T_6	8	30	2.26 E	49.55

T_7	12	30	2.09 E	53.34
T_8	4	40	1.43 F	68.08
T_9	8	40	1.26 F	71.87
T_{10}	12	40	1.08 F	75.89
LSD			0.4235	-

Effect of different combinations of EC and SAR on grain yield per pot of camelina is given in Table 45. Results showed that maximum grain yield 4.48g/pot was observed in T_1 which decreased significantly with increasing level of salinity and sodicity. Grain yield obtained 2.42 g/pot in T_4 which is statistically non-significant with T_5,T_6 and T_7. Higher combinations of salinity/sodicity decreased grain yield per pot of camelina. Minimum grain yield observed (1.08 g) in T_{10}.While maximum decrease due to salinity was observed (75.89%) in T_{10}.Which remained statistically non-significant with T_9 (1.26g), registering 71.87% decrease and T_8 (1.43g), registering 68.08% decrease with respect to control.

Table 46: Effect of different combinations of salinity/sodicity on plant height of camelina

Treatments	EC (dS m^{-1})	SAR ($mmolL^{-1})^{1/2}$	Plant height (cm)	Percent decrease over control
T_1	<4	<13.2	65.0 A	-
T_2	4	20	62.0 A	4.61
T_3	8	20	55.0 B	15.38
T_4	12	20	50.0 C	23.07
T_5	4	30	47.0CD	27.69
T_6	8	30	45.0 DE	44.44
T_7	12	30	42.0 E	35.38
T_8	4	40	34.0 F	47.69
T_9	8	40	31.0 FG	52.30
T_{10}	12	40	29.0 G	55.38
LSD			4.6017	-

Effect of different combinations of EC and SAR on plant height of camelina is given in Table 45. Results showed that maximum plant height (65 cm) in T_1 which decreased significantly with increasing level of salinity and sodicity. Plant height measured 50 cm in T_4 was statistically non-significant with plant height of T_5. Higher combinations of salinity/sodicity decreased plant height of camelina. Minimum plant height was observed in T_{10} (29 cm) with 55.38% decrease over control and remained statistically non-significant with T_9 (31 cm) with 52.30% decrease over the control.

Table 47: Effect of different combinations of salinity/sodicity on No. of branches/plant

Treatments	EC (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$	No. of branches/plant	Percent decrease over control
T_1	<4	<13.2	12.0 A	-
T_2	4	20	10.0 B	16.66
T_3	8	20	9.33 BC	22.25
T_4	12	20	9.00 BC	25.00
T_5	4	30	8.67 BC	27.75

T_6	8	30	8.00 CD	33.33
T_7	12	30	7.00 DE	41.66
T_8	4	40	6.00 EF	50.00
T_9	8	40	5.00 FG	58.33
T_{10}	12	40	4.00 G	66.66
LSD			1.4913	-

Effect of different combinations of EC and SAR on number of branches per plant of camelina is given in Table 6. Results showed that maximum number of branches per plant 12 was observed in T_1 which decreased significantly with increasing salinity and sodicity level. Number of branches per plant obtained (9.33) in T_3 was statistically non-significant with T_5 and T_6. Higher combinations of salinity/sodicity decreased number of branches per plant. Minimum number of branches per plant of camelina was observed in T_{10} (4.00) with 66.66% decrease over control and remained statistically non-significant with T_9 (5.0) with 58.33% decrease over the control.

Table 48: Post harvest Soil analysis of Camelina (2015-16)

Treatments	EC ($dS\ m^{-1}$)	SAR ($mmol\ L^{-1})^{1/2}$	pH_s	EC ($dS\ m^{-1}$)	SAR ($mmol\ L^{-1})^{1/2}$
T_1	<4	<13.2	8.12	2.25	6.18
T_2	4	20	8.28	3.92	18.46
T_3	8	20	8.32	7.90	18.59
T_4	12	20	8.33	11.47	18.61
T_5	4	30	8.35	3.89	27.89
T_6	8	30	8.44	7.89	28.67
T_7	12	30	8.45	11.18	28.70
T_8	4	40	8.46	3.81	38.22
T_9	8	40	8.52	7.81	38.64
T_{10}	12	40	8.61	11.56	37.81

After harvesting of camelina, Soil samples were collected and analyzed for pH_s, EC_e and SAR. The results (Table 48) showed slight decrease in salinity/sodicity parameters of soil.

15. SCREENING OF QUINOA AGAINST DIFFERENT COMBINATIONS OF SALINITY AND SODICITY

A pot study was conducted to test the salt tolerance potential of newly introduced crop plant quinoa against different combinations of salinity/sodicity in 2015-16. A normal soil having (EC_e 1.20 dS m^{-1}, pH_s 8.05, SAR 4.90 (mmol $L^{-1})^{1/2}$, saturation percentage 28.72%, O.M. 0.52%, available P 8.38 mg kg^{-1} and extractable K 104.50 mg kg^{-1} was selected. The desired combinations of EC and SAR {normal soil with EC <4.0 dS m^{-1}, SAR <15 ($mmolL^{-1})^{1/2}$ and EC 4.0, 8.0, 12.0, 16.0, 20.0, 24.0 dS m^{-1} with SAR 20, 30, and 40 ($mmolL^{-1})^{1/2}$ were developed artificially using NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$. Quadratic equation was used to calculate different amounts of sodium, calcium and magnesium salts for the development of desired levels of EC and SAR. After establishing, 10 kg soil per pot was filled following experimental design CRD with three replications. Ten seed of quinoa were sown in each pot and two plants per pot were kept after establishing the plants. Recommended dose of NPK fertilizers @ 75-60-50 kg $ha^{-1}$was applied. Plants were grown to maturity. Biomass grain yield, straw yield and plant height data were recorded.

Table 49: Effect of different combinations of salinity/sodicity on total biomass per pot

Treatments			Total Biomass (g)	Percent decrease over control
	EC ($dS\ m^{-1}$)	SAR ($mmol\ L^{-1})^{1/2}$		
T_1	<4	<15	474.83 A	-
T_2	8	20	454.28 B	5.17
T_3	12	20	439.29 C	7.48
T_4	16	20	423.45 D	1.82
T_5	20	20	297.38 F	37.35
T_6	24	20	169.65 I	64.27
T_7	8	30	458.74 B	3.38
T_8	12	30	431.93C	9.03
T_9	16	30	399.27 E	15.91
T_{10}	20	30	263.25 G	44.55
T_{11}	24	30	148.69 J	68.68
T_{12}	8	40	457.76 B	3.59
T_{13}	12	40	437.87 C	7.78
T_{14}	16	40	249.11 H	47.53
T_{15}	20	40	174.63 I	63.22
T_{16}	24	40	111.45 K	76.52
LSD			7.6119	-

Data regarding the effect of different combinations of salinity/sodicity on total biomass of quinoa (Table 49) showed that total biomass of quinoa per pot was significantly affected by the different combinations of salinity/sodicity. Maximum biomass 474.83 g/pot was observed in T_1 (EC < 4.0 $dS\ m^{-1}$ and SAR < 15.0 $(mmol\ L^{-1})^{1/2}$) which decreased with increasing level of salinity. Biomass yield of quinoa in T_2 454.28 g/pot was statistically non –significant with T_7 458.74 g/pot and T_{12} 457.76 g/pot with 3.38% and 3.59% decrease over control respectively. Minimum biomass 111.45 g/pot of quinoa was observed in T_{16} (EC 24 dSm^{-1} and SAR 40 $(mmol\ L^{-1})^{1/2}$and decrease in total biomass was 76.52% per pot over control.

Table 50: Effect of different combinations of salinity/sodicity on grain yield per pot

Treatments	EC ($dS\ m^{-1}$)	SAR ($mmolL^{-1})^{1/2}$	Grain yield (g)	Percent decrease over control
T_1	<4	<15	93.60 A	-
T_2	8	20	90.09 B	3.75
T_3	12	20	86.29 C	7.80
T_4	16	20	82.88 D	11.45
T_5	20	20	58.99 F	36.97
T_6	24	20	35.10 I	62.50
T_7	8	30	86.29 C	7.80
T_8	12	30	82.88 D	11.45
T_9	16	30	78.49 E	16.14
T_{10}	20	30	52.65 G	43.75
T_{11}	24	30	30.62 J	67.28
T_{12}	8	40	89.21 B	4.69

T_{13}	12	40	84.92 CD	9.27
T_{14}	16	40	48.75 H	47.91
T_{15}	20	40	35.69 I	61.86
T_{16}	24	40	24.77 K	73.53
LSD			2.7971	-

Table 50 showed that grain yield of quinoa was significantly affected by different combinations of salinity/sodicity. Maximum grain yield of quinoa 93.60 g/pot was observed in control T_1 (EC < 4.0 dS m^{-1} and SAR < 15.0 (mmol $L^{-1})^{1/2}$which decreased with increasing level of salinity. Grain yield of quinoa in T_2 90.09 g/pot was statistically non–significant with T_{12} 89.21 g/pot with 4.69% decrease over control. Minimum grain yield 24.77 g/pot was observed in T_{16} (EC 24 dSm^{-1} and SAR 40 (mmol $L^{-1})^{1/2}$and decrease in grain yield was 73.53% per pot over control.

Table 51: Effect of different combinations of salinity/sodicity on straw yield per pot

Treatments	EC_e (dS m^{-1})	SAR (mmol$L^{-1})^{1/2}$	Straw yield (g)	Percent decrease over control
T_1	<4	<15	381.23 A	-
T_2	8	20	367.19 C	3.68
T_3	12	20	353.00 D	7.40
T_4	16	20	340.57 E	1.66
T_5	20	20	238.39 G	37.46
T_6	24	20	134.55 J	64.70
T_7	8	30	372.45 B	2.30
T_8	12	30	349.05 D	8.44
T_9	16	30	320.78 F	15.85
T_{10}	20	30	210.60 H	44.75
T_{11}	24	30	118.07 K	69.02
T_{12}	8	40	368.55 BC	3.32
T_{13}	12	40	352.95 D	7.41
T_{14}	16	40	200.36 I	47.44
T_{15}	20	40	138.94 J	63.55
T_{16}	24	40	86.68 K	77.26
LSD			5.2343	-

Table 51 showed that straw yield of quinoa was significantly affected by different combinations of salinity/sodicity. Maximum straw yield 381.23 g/pot was observed in control T_1 (EC < 4.0 dS m^{-1} and SAR < 15.0 (mmol $L^{-1})^{1/2}$which decreased with increasing level of salinity. Straw yield of quinoa in T_7 372.45 g/pot was statistically non –significant was T_{12} 368.55 g/pot with 3.32% decrease over control. Minimum straw yield of quinoa 86.68 g/pot was observed in T_{16} (EC 24 dSm^{-1} and SAR 40 (mmol $L^{-1})^{1/2}$and decrease in straw yield was 77.26% per pot over control.

Table 52: Effect of different combinations of salinity/sodicity on plant height of quinoa

Treatments	EC	SAR	Plant height	Percent decrease
T_1	<4	<15	80.0 A	-
T_2	8	20	79.0 AB	1.25
T_3	12	20	75.5 ABC	5.62
T_4	16	20	73.0 CD	8.75
T_5	20	20	61.50 E	23.12
T_6	24	20	53.0 F	33.75
T_7	8	30	76.0 ABC	5.00
T_8	12	30	72.50 CD	9.37
T_9	16	30	65.5 E	18.12
T_{10}	20	30	54.0 F	32.50

T_{11}	24	30	51.0 FG	36.25
T_{12}	8	40	75.0 BCD	6.25
T_{13}	12	40	70.5 D	11.87
T_{14}	16	40	62.0E	22.50
T_{15}	20	40	46.5 G	41.87
T_{16}	24	40	41.5 H	48.12
LSD			4.9065	-

Effect of different combinations of salinity/sodicity on plant height of quinoa is given in (Table52) showed that plant height was significantly affected by different combinations of salinity/sodicity. Maximum plant height 80.0 cm was observed in control T_1 (EC < 4.0 dS m^{-1} and SAR < 15.0 (mmol L^{-1})$^{1/2}$. It was statistically at par in T_7 (76 cm) and T_{12} (75 cm) with 5% and 6.25% decrease over the control respectively. Minimum plant height (41.5 cm) per plant was observed in T_{16} (EC24 dSm^{-1} and SAR 40(mmol L^{-1})$^{1/2}$ and decrease in plant height 48.12% per plant over control.

Table 53: Post-harvest soil analysis after harvest of quinoa (2015-16)

Treatments	EC_e (dS m^{-1})	SAR (mmol L^{-1})$^{1/2}$	pH_s	EC_e (dS m^{-1})	SAR (mmol L^{-1})$^{1/2}$
T_1	<4	<15	8.02	1.09	4.62
T_2	8	20	8.23	7.72	18.93
T_3	12	20	8.27	11.80	19.15
T_4	16	20	8.33	15.32	19.47
T_5	20	20	8.36	18.82	18.89
T_6	24	20	8.39	23.05	19.03
T_7	8	30	8.53	7.71	28.19
T_8	12	30	8.59	11.27	28.67
T_9	16	30	8.63	15.18	29.13
T_{10}	20	30	8.65	18.51	29.10
T_{11}	24	30	8.70	22.88	28.63
T_{12}	8	40	8.73	7.67	37.97
T_{13}	12	40	8.75	11.21	38.31
T_{14}	16	40	8.77	15.22	38.73
T_{15}	20	40	8.82	18.72	38.90
T_{16}	24	40	8.88	22.23	38.72

Soil samples after the harvest of quinoa were analyzed for pH_s, EC_e and SAR. There was slight change in EC_e, pH_s and SAR of soil after the harvest of crop.

16. RESPONSE OF QUINOA TO NPK FERTILIZER UNDER DUAL STRESS OF SALINITY

A field experiment was conducted to determine the response of newly introduced quinoa crop to fertilizer application in moderately salt affected soil by using brackish water for irrigation. A moderately salt affected field pH_s = 8.70, EC_e=5.98 (dS m^{-1}), SAR = 33.66 (mmol L^{-1})$^{1/2}$, O.M = 0.46 %, available P = 7.20 mg kg^{-1}, extractable K =110.36 mg kg^{-1} was selected. Field was prepared and leveled. Experiment was laid out in randomized complete block design with three replications. Quinoa crop was sown in wattar condition. Different fertilizer treatments were applied i.e. T_1 = Control (No fertilizer), T_2 = 75% NPK of recommended dose, T_3 = Recommended dose (75-60-50 NPK kg ha^{-1}), T_4 =125% NPK of recommended dose, T_5 =150% NPK of recommended dose, T_6 =200% NPK of recommended dose. Fertilizer sources were urea, SSP and SOP. Brackish water, EC 1.34(dS m^{-1}), SAR 12.72 (mmol L^{-1})$^{1/2}$, RSC = 8.30 me L^{-1}

was used for irrigation throughout the crop season. Crop was harvested at maturity and grain, straw yield were recorded.

Table 54: Effect of different rates of NPK on grain yield of quinoa (2015-16)

Treatments	Grain yield (t. ha^{-1})	Straw yield (t. ha^{-1})
T_1 Control (without NPK)	0.479 D	0.645 D
T_2 75 % recommended dose	1.387 C	2.924 C
T_3 Recommended dose	1.670 B	3.533 B
T_4 125% recommended dose	1.986 A	4.137A
T_5 150% recommended dose	1.992 A	4.166 A
T_6 200% recommended dose	2.075 A	4.187A
LSD	0.1808	0.3314

The results (Table 54) showed that different rates of NPK application have significant effect on grain and straw yield of quinoa. Maximum grain yield 2.075 t. ha^{-1} was observed in the treatment T_6 (200% recommended dose of NPK was applied) and it remained statistically non-significant with T_5 and T_4 producing 1.992 and 1.986 t. ha^{-1} grain yield and 4.187, 4.166 and 4.137 t. ha^{-1} straw yield respectively. Minimum grain yield 0.479 t. ha^{-1} and straw yield 0.645 t. ha^{-1} of quinoa was observed in control treatment without NPK application.

Table 55: Post harvest soil analysis of quinoa (2015-16)

Treatments	PH_s	EC_e (dS m^{-1})	SAR (mmol L^{-1})$^{1/2}$	O.M. (%)	Available P(mg kg^{-1})	Extractable K (mg kg^{-1})
T_1	8.68	5.94	31.78	0.39	5.80	105.66
T_2	8.68	5.93	31.33	0.48	9.06	117.13
T_3	8.67	5.92	30.54	0.52	9.33	121.00
T_4	8.67	5.92	30.38	0.54	9.93	123.80
T_5	8.67	5.88	29.47	0.57	10.33	126.43
T_6	8.66	5.86	29.43	0.59	10.60	127.60

Soil analysis after harvest of quinoa (Table 55) showed that salinity/sodicity parameters of soil were decreased while there was slight increase in fertility parameters of soil.

17. INTEGRATED PHOSPHOROUS MANAGEMENT IN SALINE SODIC SOIL

Integrated use of chemical fertilizer and organic manure is an effective strategy to improve crop yield, soil physical and chemical properties as well as to improve soil fertility status. A field experiment was conducted in 2015-16 to determine the best combination of organic and inorganic phosphatic fertilizers in sorghum–wheat rotation in saline sodic soils. A moderately salt affected field having pH_s= 8.50, EC_e =5.12 (dS m^{-1}), SAR = 30.60 (mmolL^{-1})$^{1/2}$, O.M = 0.47%, available P =8.20 (mg kg^{-1}) and extractable K =108.60 (mg kg^{-1}) was selected. Field was prepared and leveled. Sorghum (Hegari) crop was sown in wattar condition in kharif 2015. Different combinations of inorganic and organic P were applied according to treatment plan. The treatments tested were T_1 = Control (without NPK), T_2 = 100% inorganic P, T_3 = 80% inorganic P + 20% organic P, T_4 = 70% inorganic P + 30% organic P, T_5 = 60% inorganic P + 40% organic P. Sources of phosphorus were SSP and press mud. Recommended dose of fertilizer for sorghum was 60-60-0 (N-P_2O_5-K_2O) kg ha^{-1}. Quantities of fertilizer were calculated on P equivalent basis. Nitrogen and potassium in press mud were also taken into account. Chemical composition of press mud used for sorghum crop was: Total nitrogen 1.28%, total P = 0.69% and total K= 0.62%, Moisture percentage =11.10%. Press mud as organic P was applied 15 days before sowing and inorganic P as SSP was applied at the time of sowing of crop along with basal dose of N.

Sorghum crop was grown as fodder. The experimental design was randomized complete block design with four replications.

Table 56: Effect of different combinations of inorganic and organic P on sorghum fodder yield (t. ha^{-1})

Treatments	Fodder yield (t. ha^{-1})
T_1 = Control (without NPK)	15.76 D
T_2 = 100% inorganic P	32.98 A
T_3 = 80% inorganic P + 20% organic P	28.09 C
T_4 = 70% inorganic P + 30% organic P	31.21 B
T_5 = 60% inorganic P + 40% organic P	33.25 A
LSD	1.2961

The results (Table 56) showed that different combinations of inorganic and organic P have significant effect on sorghum fodder yield. Maximum sorghum fodder yield 33.25 t. ha^{-1} was recorded in T_5 (60% inorganic P + 40% organic P) was applied and it remained statistically non-significant with T_2 (100% inorganic P application) by producing 32.98 t. ha^{-1} fodder yield. Minimum sorghum fodder yield 15.76 t. ha^{-1} was observed in control treatment T_1 without (NPK) application.

Table 57: Effect of different combinations of inorganic and organic P on soil parameters after sorghum harvest (2015)

Treatments	pH_s	EC_e (dS m^{-1})	SAR (mmol L^{-1})$^{1/2}$	O.M. (%)	Available P (mg kg^{-1})
T_1 = Control (without NPK)	8.47	5.08	27.70	0.42	7.60
T_2 = 100% inorganic P	8.46	4.96	26.89	0.47	9.8
T_3 = 80% inorganic P + 20% organic P	8.46	4.95	26.64	0.52	10.40
T_4 = 70% inorganic P + 30% organic P	8.45	4.88	26.07	0.55	10.80
T_5 = 60% inorganic P + 40% organic P	8.45	4.87	25.20	0.57	11.20

After the harvest of sorghum fodder soil samples were collected and analyzed for pH_s, EC_e, SAR, O.M, available P and extractable K. The results (Table 57) showed that salinity/sodicity parameters of soil decreased and there was slight increase in organic matter and available P contents of the soil after sorghum harvest.

In the same layout wheat (Inqulab-91) crop was sown in Rabi 2015-16 with same combinations of inorganic and organic P were applied to wheat. Recommended dose of NPK for wheat was 120-110-70 kg ha^{-1}. Press mud having same composition was applied 15 days before sowing of wheat crop. Inorganic P, half recommended of recommended N and whole K was applied at the time of sowing to wheat crop, while remaining half N was applied at first irrigation. All the cultural practices were rendered till maturity and crop was harvested.

Table 58: Integrated effect of phosphorus on grain and straw yield of wheat (2015-16)

Treatments	Grain yield (t. ha^{-1})	Straw yield (t. ha^{-1})
T_1 = Control (without NPK)	1.93 D	2.13 D
T_2 = 100% inorganic P	3.42 A	3.76 A

T_3 = 80% inorganic P + 20% organic P	2.62 C	2.84 C
T_4 = 70% inorganic P + 30% organic P	3.16 B	3.45 B
T_5 = 60% inorganic P + 40% organic P	3.39 AB	3.72 AB
LSD	0.2508	0.2799

Grain and straw yields data were recorded. The results (Table 58.) depicted that different combinations of inorganic and organic P have significant effect on grain and straw yield of wheat. Maximum grain 3.42 t. ha^{-1} and straw yield 3.76 t. ha^{-1} was observed in T_2 (100% inorganic P) which remain statistically non-significant with T_5 (60% inorganic P + 40% organic P) by producing 3.39 t. ha^{-1} and 3.72 t. ha^{-1} grain and straw yields. Minimum grain yield 1.93 t. ha^{-1} and straw yield 2.13 t. ha^{-1} was observed in control treatment T_1 without NPK application.

Table 59: Effect of different combinations of inorganic and organic P on soil parameters

Treatments	**pH_s**	**EC_e (dS m^{-1})**	**SAR (mmol $L^{-1})^{1/2}$**	**O.M (%)**	**Available P (mg kg^{-1})**
T_1 = Control (without NPK)	8.45	4.88	26.42	0.36	5.73
T_2 = 100% inorganic P	8.44	4.80	26.36	0.50	11.40
T_3 = 80% inorganic P + 20% organic P	8.44	4.76	26.29	0.55	12.20
T_4 = 70% inorganic P + 30% organic P	8.43	4.65	24.64	0.58	12.73
T_5 = 60% inorganic P + 40 % organic P	8.42	4.63	23.61	0.59	12.86

After the harvest of wheat soil samples were collected and analyzed for pH_s, EC_e, SAR, O.M, available P and extractable K. The results (Table 59) showed that salinity/sodicity parameters of soil decreased and there was slight built up organic matter and available P contents of the soil after wheat harvest.

18. IMPROVEMENT OF RICE YIELD USING DIFFERENT ZINC APPLICATION METHODS IN SALINE SODIC SOIL

Availability of Zn is low in saline sodic soil due to high pH. A field experiment was conducted to study improvement in zinc use efficiency using different application methods for the promotion of rice yield in saline-sodic soil in 2015. A saline-sodic field pH_s =8.56, EC_e =5.20 dS m^{-1}, SAR =32.60 (mmol $L^{-1})^{1/2}$, O.M= 0.57%, available P =8.40 mg kg^{-1}, extractable K =114 mg kg^{-1} and AB-DTPA Zn =1.10 mg kg^{-1} was selected, prepared and leveled. The treatments tested were T_1: Control (without zinc), T_2= Zinc sulphate @ 12.5 kg ha^{-1}, T_3= Chelated zinc @ 12.5 kg ha^{-1}, T_4= Zinc sulphate application to nursery @ 75 kg ha^{-1}, T_5= Chelated zinc application to nursery @ 75 kg ha^{-1}. Recommended dose of NPK for rice was 110-90-60 applied. Sources of NPK were urea, SSP and SOP. Foliar spray of zinc (2 sprays after 15 and 30 days after transplanting) were done. Whole phosphorus, potassium and half recommended N was applied at the time of rice transplanting, while remaining half nitrogen was applied 30 days after rice transplanting. The experimental design was RCBD with four replications. The crop was harvested at maturity. Paddy and straw yield data were recorded.

Table 60:Effect of different methods of zinc application of paddy and straw yield

Treatments	**Paddy yield**	**Straw yield**
	(t. ha^{-1})	
T_1 Control (without Zinc)	2.81 D	7.81D
T_2 Zinc sulphate @ 12.5 kg ha^{-1}	3.23 A	9.98 A
T_3 Chelated zinc @12.5 kg ha^{-1}	2.94 BCD	9.08 BC

T_4 Zinc sulphate application to nursery @75 kg ha^{-1}	3.10 ABC	9.41 AB
T_5 Chelated zinc application to nursery @ 75 kg ha^{-1}	2.89 CD	8.51 C
T_6 Foliar spray of 0.3% zinc (2 Sprays)	3.14 AB	9.45 AB
LSD	0.2177	0.6625

The results (Table 60) showed that different treatments of zinc application have significant effect on paddy and straw yield of rice. Maximum paddy 3.23 t. ha^{-1} and straw yield 9.98 t. ha^{-1} was observed in the treatment T_2 (zinc sulphate @ 12.5 kg ha^{-1}) remained statistically at par with T_4 (zinc sulphate application to nursery @ 75 kg ha^{-1}) by producing 3.10 t. ha^{-1} paddy and 9.41 t. ha^{-1} straw yield of rice and T_6 (two foliar spray of 0.3% Zinc) producing 3.14 t. ha^{-1} paddy and 9.45 t. ha^{-1} straw yield of rice . Minimum paddy 2.81 t. ha^{-1} and straw yield 7.81 t. ha^{-1} was observed in the control treatment T_1 (without zinc application).

5.5 AGRONOMY DIVISION

19. Response of finger millet to nitrogen levels under different sowing method in salt affected soil

Fodder scarcity is a major problem in the months of October-November in Rice-wheat cropping system. To overcome this shortage, new fodder crop finger millet was introduced. Keeping in view the importance of this crop the experiment was planned to investigate the effect of different nitrogen levels under various sowing methods for getting good fodder yield. A salt affected field was selected with pH_s=8.81, EC_e=6.26 dS m^{-1} and SAR=39.88 (mmol L^{-1})$^{1/2}$.The study was laid out in split plot design with three replications. The treatments included were: Nitrogen levels (30-30-0 NPK kg ha^{-1}, 40-30-0 NPK kg ha^{-1} & 50-30-0 NPK kg ha^{-1}) and methods of sowing/transplanting (Ridge, Drill, Broadcast sowing and Transplanting). Nitrogen levels were kept in main plots and methods of sowing/ transplanting in sub plots.

Table 61: Response of finger millet to nitrogen levels under different sowing methods

Treatments	**30-30-0 (NPK Kg.ha^{-1})**	**40-30-0 (NPK Kg.ha^{-1})**	**50-30-0 (NPK Kg.ha^{-1})**	**Mean**
Ridge sowing	27.60 h	32.53 d	35.61 b	31.917 B
Drill sowing	24.36 j	28.76 g	31.01 e	28.050 C
Broadcast	22.40 k	26.56 i	29.30 fg	26.089 D
Transplanting	29.65 f	34.00 c	37.46 a	33.706 A
Mean	26.004 C	30.467 B	33.350 A	

LSD For nitrogen levels =0.3637 LSD for Sowing methods =0.2708 LSD for Interaction = 0.4691

Results (Table 61) indicated that the highest green fodder yield 37.46 t. ha^{-1} was recorded with 50-30-0 NPK kg ha^{-1} in transplanting followed by ridge sowing (35.61 t. ha^{-1}) with the same nitrogen level. Results also showed that maximum fodder yield 33.35 t. ha^{-1} was found with 50-30-0 NPK kg ha^{-1} followed by 40-30-0 NPK kg ha^{-1} (30.46 t. ha^{-1}) as compared with 30-30-0 NPK kg ha^{-1} 26.00 t. ha^{-1} among the nitrogen levels. Transplanting gave more fodder yield 33.70 t ha^{-1} when compared with other sowing methods followed by ridge sowing 31.91 t. ha^{-1}. Soil samples were collected and analyzed for EC_e, pH_s and SAR determination before and after the harvest of crop. The trial was sown on 17-06-2015 and harvested on 06-10-2015 and post harvest soil status is given (Table 62).

Table 62: Post-harvest soil analysis

Treatments	50-30-0 NPK kg ha^{-1}			40-30-0 NPK kg ha^{-1}			30-30-0 NPK kg ha^{-1}		
	pH_s	EC_e (dS m^{-1})	SAR (m mol L^{-1})$^{1/2}$	pH_s	EC_e (dS m^{-1})	SAR (m mol L^{-1})$^{1/2}$	pH_s	EC_e (dS m^{-1})	SAR (m mol L^{-1})$^{1/2}$
Ridge sowing	8.59	6.10	37.81	8.61	6.20	37.35	8.72	6.19	36.81
Drill sowing	8.67	6.18	36.92	8.38	6.18	37.81	8.50	6.21	37.91
Broadcast sowing	8.71	6.21	38.90	8.52	6.17	36.75	8.65	6.16	36.77
Transplanting	8.58	6.16	37.84	8.47	6.20	37.00	8.72	6.14	37.81

20. Management of saline sodic water by using different amendments and sowing techniques

The study was planned to assess the role of organic & inorganic amendments by using different sowing techniques to mitigate the harmful effects of high RSC water on paddy yield through direct seeded rice. A normal field was selected with pH_s=8.10, EC_e=2.88 dS m^{-1} and SAR=17.90 (mmol L^{-1})$^{1/2}$. The study was laid out in split plot design with three replications. Rice Shaheen Basmati was used as test variety. Sowing techniques were placed in main plots, whereas the soil amendments were applied in sub plots. The treatments included were: A; sowing techniques, Ridge & Broadcast sowing and B; Soil amendments Gypsum on the basis of RSC of water, Press mud @ 10 and 20 t. ha^{-1} and Biogas slurry @ 10 and 20 t. ha^{-1}. Recommended dose of fertilizer 110-90-60 NPK kg ha^{-1} was applied to rice crop. Only Tube well water having EC_{iw}=1.44 dS m^{-1}, SAR=8.06 (mmol L^{-1})$^{1/2}$ & RSC=8.40 me L^{-1} was used for irrigation.

Table 63: Effect of different amendments and sowing techniques on paddy yield (t. ha^{-1})

Treatments	Sowing Methods		Mean
	Ridge	Broadcast	
T_1 = Gypsum on the basis of RSC of Water	2.71 def	2.55 f	2.64 C
T_2 = Press-mud @ 10 t ha^{-1}	2.79 cde	2.66 ef	2.73 C
T_3 = Press-mud @ 20 t ha^{-1}	3.00 bc	2.89 cd	2.95 B
T_4 = Biogas slurry @ 10 t ha^{-1}	3.11 ab	2.91 bcd	3.01 B
T_5 = Biogas slurry @ 20 t ha^{-1}	3.32 a	3.11 ab	3.22 A
Mean	2.99 A	2.83 B	

LSD for sowing methods =0.0875 LSD for amendments = 0.1556
LSD for interaction = 0.0.2201

The results (Table 63) indicated that the maximum paddy yield (3.32 t. ha^{-1}) was recorded with ridge sowing where biogas slurry was applied @ 20 t. ha^{-1} which was statistically at par with broadcast sowing with the same soil amendment applied @ 20 t. ha^{-1} 3.11 t. ha^{-1} and biogas slurry applied @ 10 t. ha^{-1} with ridge sowing 3.11 t. ha^{-1}. Among the sowing methods, ridge sowing gave more paddy yield (2.99 t. ha^{-1}) when compared with broadcast sowing (2.83 t. ha^{-1}). Similarly biogas slurry @ 20 t. ha^{-1} produced higher paddy yield (3.22 t. ha^{-1})followed by biogas slurry applied @ 10 t. ha^{-1}, 3.01 t. ha^{-1} which was non-significant with press mud applied @ 20 t. ha^{-1}, (2.95 t. ha^{-1}) with other soil amendments. The minimum paddy yield (2.64 t. ha^{-1}) was obtained with gypsum applied on the basis of RSC of water. Soil samples were collected and analyzed for pH_s, EC_e and SAR determination before and after the harvest of crop. The trial was sown on 18-06-2015 and harvested on 29-10-2015.

Table 64: Amendments Analyses (%)

	N	P	K
Press-mud	1.25	0.90	0.60
Bio-slurry	1.50	1.35	0.40

Table 65: Soil analyses after the harvest of rice

Treatments	Ridge Sowing			Broadcast sowing		
	pH_s	EC_e (dS m^{-1})	SAR (mmol L^{-1} $^{1/2}$)	pH_s	EC_e (dSm $^{-1}$)	SAR (mmol L^{-1} $^{1/2}$)
T_1 = Gypsum on the basis of RSC of Water	8.10	3.35	18.57	8.11	3.36	18.59
T_2 = Press-mud @ 10 t ha^{-1}	8.11	3.39	18.59	8.11	3.49	18.52
T_3 = Press-mud @ 20 t ha^{-1}	8.11	2.36	18.47	8.12	3.41	18.48
T_4 = Biogas slurry @ 10 t ha^{-1}	8.19	3.37	18.49	8.17	3.40	18.56
T_5 = Biogas slurry @ 20 t ha^{-1}	8.18	3.33	18.29	8.16	3.40	18.53

21. Yield improvement of direct sown rice on raised beds using priming Techniques in salt affected soils

The experiment was conducted to investigate the yield enhancement of direct sown rice with different seed priming agents using raised bed sowing method in salt affected soil. A salt affected field having pH= 8.81, EC= 5.52 (dS m^{-1}) and SAR= 38.42 (mmol L^{-1})$^{1/2}$was selected. The experiment was laid out in RCBD design with three replications. Rice KSK-133 was used as test variety. Treatments included in the study were are given in table (Table 66) with paddy yield.

Table 66: Paddy Yield (t ha^{-1})

Treatment	Paddy Yield t ha^{-1}
T_1 = Potassium dihydrogen phosphate (2%)	4.40 BC
T_2 = Zinc Sulphate (2%)	4.23 C
T_3 = Single super phosphate (1%)	5.50 A
T_4 = $MgSO_4$ (2%)	5.00 ABC
T_5 = Single super phosphate + Urea (1%) each	5.33 AB
LSD	0.9802

Results (Table 66) indicated that the maximum paddy yield was obtained in T_3 (5.50 t ha^{-1}) which was statistically at par with T_5 (5.33 t ha^{-1}) and T_4 (5.00 t. ha^{-1}). However minimum paddy yield (4.23 t. ha^{-1}) was obtained from T_2. Soil samples were collected and analyzed for pH_s, EC_e and SAR determination before and after the harvest of crop. The trial was sown on 19-06-2015 and harvested on 22-10-2015.

Table 67: Post-harvest soil analysis

Treatments	pH_s	EC_e (dS m^{-1})	SAR (m mol L^{-1} $^{1/2}$)
T_1 = Potassium di-hydrogen phosphate (2%)	8.52	5.41	38.10
T_2 = Zinc Sulphate (2%)	8.50	5.43	38.00
T_3 = Single super phosphate (1%)	8.46	5.36	37.75
T_4 = $MgSO_4$ (2%)	8.51	5.39	37.91
T_5 = Single super phosphate + Urea (1%) each	8.47	5.40	37.82

22. Utilization of salt affected land using pit planting technique for sugarcane

After gone through the review it is revealed that there is little work done for the production technology of sugarcane crop for cultivation in salt affected soils. Keeping this view experiment was designed for utilization of highly salt affected soils. A saline sodic field having pH= 8.96, EC= 10.55 (dSm^{-1}) and SAR= 41.37 $(mmol\ L^{-1})^{1/2}$ and GR = 3.25 t. $acre^{-1}$ was selected. The experiment was laid out in RCBD design having three replications. The treatments included were T_1=Pits without amendments,T_2 = Pits with gypsum @ 50% GR, T_3 = Pits with gypsum @ 100% GR,T_4 = Pits with FYM @ 20 t ha^{-1}, T_5 = Pits with @ 50 % GR + FYM @ 10 t ha^{-1}.

Table 68: Cane Yield (t ha^{-1})

Treatments	**Yield t. ha^{-1}**
T_1 = Pits without amendment	45.35 D
T_2 = Pits with Gypsum @ 50 % GR	72.21AB
T_3 = Pits with Gypsum @ 100 % GR	77.73A
T_4 = Pits with FYM @ 20 t. ha^{-1}	55.55CD
T_5 = Pits with Gypsum @ 50 % + FYM @ 10 t. ha^{-1}	64.80BC
LSD	12.090

It was depicted from the yield (Table 68) that the highest cane yield (77.73 t. ha^{-1}) was obtained in T_3, which was statistically at par with T_2 (72.21 t. ha^{-1}). Minimum cane yield (45.35 t ha^{-1}) was obtained from the T_1. Soil samples were collected and analyzed for pH_s, EC_e and SAR determination before and after the harvest of crop. The trial was sown on 25-10-2014 and harvested on 17-03-2016.

Table 69: Post-harvest soil analysis

Treatments	**pH_s**	**EC_e ($dS\ m^{-1}$)**	**SAR ($m\ mol\ L^{-1}$)$^{1/2}$**
T_1 = Pits without amendment	8.82	10.22	40.10
T_2 = Pits with Gypsum @ 50 % GR	8.76	9.95	40.20
T_3 = Pits with Gypsum @ 100 % GR	8.70	9.88	39.82
T_4 = Pits with FYM @ 20 t ha^{-1}	8.78	9.98	39.50
T_5 = Pits with Gypsum @ 50 % + FYM @ 10 tha^{-1}	8.74	9.92	39.10

23. Performance of new sugarcane clones/varieties in salt affected soils

This study was planned to find out the best suitable sugarcane variety for salt affected soils. A salt affected field having pH_s= 9.01, EC_e= 5.69 (dSm^{-1}) and SAR= 27.51 $(mmol\ L^{-1})^{1/2}$ was selected. The experiment was laid out in RCBD design with three replications. The varieties included were: HSF-240, CPF-246, CPF-247, CPF-248, S-2003-us-127, S-2003-us-633, S-2003-us-704, S-2006-SP-93, S-2006-us-272 and S-2006-us-658. Recommended dose of fertilizer 170-112-112 NPK kg ha^{-1} was applied. Recommended seed rate 75000 DBS ha^{-1} was used.

Table 70: Cane Yield (t ha^{-1})

Treatments	**Yield t ha^{-1}**
T_1 = S-2003-us-704	96.66 A
T_2 = CPF-248	66.63 FG
T_3 = S-2003-us-127	73.73 EF
T_4 = S-2006-us-272	86.10 BC
T_5 = S-2003-us-633	75.00 DE
T_6 = HSF-240	87.33 BC
T_7 = S-2006-SP-93	60.53 G
T_8 = S-2006-us-658	92.76 AB
T_9 = CPF-247	89.43 ABC
T_{10} = CPF-246	82.33 CD
LSD	7.9748

Yield data (Table 70) revealed that the highest cane yield (96.66 t ha^{-1}) was obtained from the S-2003-US-704 which was statistically at par with S-2006-US-658 (92.76 t. ha^{-1})and CPF-247 (89.43 t. ha^{-1}). However minimum yield (60.53 t. ha^{-1}) was obtained from the S-2006-SP-93. Soil samples were collected and analyzed for pH_s, EC_e and SAR determination before and after the harvest of crop. The trial was sown on 23-10-2014 and harvested on 17-03-2016.

Table 71: Post-harvest soil analysis

Treatments	**pH_s**	**EC_e (dS m^{-1})**	**SAR (m mol L^{-1} $^{1/2}$)**
T_1 = S-2003-us-704	8.10	4.13	14.82
T_2 = CPF-248	8.14	4.18	14.90
T_3 = S-2003-us-127	8.16	4.22	14.99
T_4 = S-2006-us-272	8.15	4.19	14.94
T_5 = S-2003-us-633	8.15	4.21	14.96
T_6 = HSF-240	8.17	4.24	15.00
T_7 = S-2006-SP-93	8.14	4.16	14.94
T_8 = S-2006-us-658	8.10	4.11	14.83
T_9 = CPF-247	8.11	4.13	14.82
CPF-246	8.13	4.15	14.84

24. Role of organic amendments using different sowing techniques for yield improvement of wheat in salt affected soil

It is an established fact that organic and chemical amendments play a vital role to replace excessive exchangeable sodium from calcareous soil. The experiment was planned to study the effectiveness of organic amendments using different sowing techniques for getting better grain yield of wheat from salt affected soil. A salt affected field having pH_s=8.79, EC_e=4.40 dS m^{-1} and SAR=33.20 (mmol L^{-1})$^{1/2}$ was selected. The treatments tested were A. Organic amendments (FYM and press mud @ 10 t. ha^{-1} each) and B. Sowing techniques (Broadcast, Drill sowing, Raised bed and Ridge sowing).

Table 72: Grain yield (t. ha^{-1})

Sowing Methods	**Soil amendments**		**Mean**
	Press-mud	**FYM**	
Broadcast	2.27 d	2.08 e	2.18 D
Drill	2.52 c	2.29 d	2.40 C
Bed	2.70 b	2.56 c	2.63 B
Ridge	2.96 a	2.80 b	2.88 A
Mean	2.61 A	2.43 B	--

LSD for Methods=0.0976 LSD for Amendments= 0.0725 LSD for Interaction= 0.1380

It depicted from the yield data (Table 72) that the highest grain yield 2.96 t. ha^{-1} was obtained with press mud in ridge sowing followed by FYM 2.80 t. ha^{-1} in ridge sowing and press mud with bed sowing 2.70 t. ha^{-1}. However the lowest yield 2.08 t. ha^{-1} was recorded with FYM when sown employing broadcast sowing technique. Results also showed that Ridge sowing technique 2.88 t. ha^{-1} was found to be best technique followed by bed sowing 2.63 t. ha^{-1} among the other sowing techniques in salt affected soils. Soil samples were collected and analyzed for pH_s, EC_e and SAR determination before and after the harvest of crop. The trial was sown on 18-11-2015 and harvested on 17-04-2016.

Table 73: Amendments Analyses (%)

Amendments	N	P	K
Press-mud	1.25	0.90	0.60
FYM	1.02	0.5	0.48

Table 74: Post harvest soil analyses

Sowing Methods	Press-mud			FYM		
	pH_s	EC_e (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$	pH_s	EC_e (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$
Broadcast	8.72	3.21	25.91	8.76	3.35	27.31
Drill	8.70	3.24	28.42	8.75	3.56	30.24
Bed	8.66	3.28	28.10	8.76	3.60	30.00
Ridge	8.68	3.26	27.71	8.72	3.71	29.10

25. Management of saline sodic water by using different amendments and sowing techniques

The study was planned to assess the role of organic & inorganic amendments by using different sowing techniques to mitigate the harmful effects of high RSC water on yield of wheat crop. A normal field was selected with pH_s=8.10, EC_e=2.88 dS m^{-1} and SAR=17.90 (mmol $L^{-1})^{1/2}$. The experiment was laid out in split plot design having three replications. Wheat variety Faisalabad-2008 was used as test crop. The treatments included were: A. Sowing techniques (Ridge & Broadcast) and B**.** Soil Amendments gypsum on the basis of RSC of water, Press mud @ 10, 20 t. ha^{-1}, Biogas slurry @ 10, 20 t. ha^{-1}. Sowing techniques were placed in main plots while the soil amendments were applied in sub plots. Recommended dose of fertilizer 120-110-70 NPK kg ha^{-1} was applied to wheat crop.

Table 75: Grain Yield (t. ha^{-1})

Soil amendments	Sowing methods		Mean
	Ridge	Broadcast	
T_1 = Gypsum on the basis of RSC of Water	2.64 de	2.33 f	2.49 D
T_2 = Press-mud @ 10 t ha^{-1}	2.58 e	2.27 f	2.43 D
T_3 = Press-mud @ 20 t ha^{-1}	3.08 b	2.95 bc	3.02 B
T_4 = Biogas slurry @ 10 t ha^{-1}	2.90 c	2.75 d	2.83 C
T_5 = Biogas slurry @ 20 t ha^{-1}	3.36 a	3.03 bc	3.20 A
Mean	2.91 A	2.67 B	--

LSD for sowing methods =0.0479 LSD for amendments =0.1082 LSD for interaction = 0.1530

The results (Table 75) showed that the maximum grain yield 3.36 t. ha^{-1} with biogas slurry applied @ 20 t. ha^{-1} when crop was sown on ridges followed by press mud applied @ 20 t. ha^{-1} with ridge sowing 3.08 t. ha^{-1} which was statistically at par with biogas slurry and press mud where applied @ 20 t. ha^{-1} with broadcast sowing 3.03 t. ha^{-1} and 2.95 t. ha^{-1} respectively. It was also observed that the maximum grain yield 3.20 t. ha^{-1} was given by biogas slurry when applied @ 20 t. ha^{-1} followed by press mud 3.02 t. ha^{-1} applied at same rate. However ridge sowing gave more grain yield 2.91 t. ha^{-1} when compared with broadcast sowing 2.67 t. ha^{-1}. Soil samples were collected and analyzed for pH_s, EC_e and SAR determination before and after the harvest of crop. The trial was sown on 17-11-2015 and harvested on 17-04-2016.

Table 76: Amendments Analyses (%)

Amendments	N	P	K
Press-mud	1.25	0.90	0.60
Bio-slurry	1.50	1.35	0.40

Table 77: Post-harvest soil analysis

Treatments	Sowing methods					
	Ridge			Broadcast		
	pH_s	EC_e (dS m^{-1})	SAR (mmol $L^{-1)1/2}$	pH_s	EC_e (dSm^{-1})	SAR (mmol $L^{-1})^{1/2}$
T_1 = Gypsum on the basis of RSC of Water	8.58	3.46	21.71	8.20	3.19	22.77
T_2 = Press-mud @ 10 t ha^{-1}	8.57	4.35	21.72	8.18	3.20	22.70
T_3 = Press-mud @ 20 t ha^{-1}	8.59	4.33	21.73	8.19	3.18	22.68
T_4 = Biogas slurry @ 10 t ha^{-1}	8.57	4.39	21.72	8.18	3.19	22.66
T_5 = Biogas slurry @ 20 t ha^{-1}	8.60	4.30	21.65	8.19	3.18	22.61

26. Effect of planting geometry on yield of quinoa in salt affected soil

The experiment was to find out the best planting geometry for getting maximum grain yield of newly introduced quinoa crop in salt affected soils. A salt affected field was selected with pH_s=8.65, EC_e=7.26 dS m^{-1} and SAR=33.09 (mmol $L^{-1})^{1/2}$ was selected, leveled and well prepared for sowing the crop. The treatments included were: Plant Spacing i.e. 15cm x 30cm, 22cm x 30cm, 30cm x 30cm, 15cm x 45cm, 22cm x 45cm and 30cm x 45 cm. The trial was laid out in RCBD with three replications. Recommended dose of fertilizer (75-60-0 NPK kg ha^{-1}) was applied**.** All other agronomic practices were kept constant.

Table 78: Table. Effect of different planting geometry on quinoa grain yield

Planting geometry	Grain yield (t ha^{-1})
15cm x30 cm	1.59 D
22cm x30 cm	1.74 CD
30cm x30 cm	2.04 A
15cm x45 cm	1.71 CD
22cm x45 cm	1.84 BC
30cm x45 cm	1.96 AB
LSD	0.1694

Results indicated in the above given table 78 showed that maximum grain yield 2.04 t. ha^{-1} was obtained with 30cm x 30cm which was statistically similar to 30cm x 45cm 1.96 t. ha^{-1} when compared with other plant spacings. The lowest grain yield 1.59 t. ha^{-1} was given by 15cm x 30cm.Soil samples were collected and analyzed for pH_s, EC_e and SAR determination before and after the harvest of crop. The trial was sown on 17-11-2015 and harvested on 23-04-2016.

Table 79: Post harvest soil analysis

Planting geometry	pH_s	EC_e (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$
15cm x30 cm	8.60	7.22	32.05
22cm x30 cm	8.62	7.24	33.00
30cm x30 cm	8.61	7.23	32.10
15cm x45 cm	8.59	7.20	32.03
22cm x45 cm	8.60	7.19	31.85
30cm x45 cm	8.60	7.18	32.60

27. Impact of sowing methods and seed rates on quinoa yield in salt affected soil

The study was planned to determine the best sowing method and seed rates for quinoa crop in salt affected soils. A salt affected field having pH_s=8.65, EC_e=7.26 dS m^{-1} and SAR=33.09 (mmol L^{-1})$^{1/2}$ was selected, leveled and well prepared for sowing the crop. Treatments included in the study were: Sowing methods (Ridge & Drill) and Seed rates 3.0, 5.0, 7.0 & 9.0 kg ha^{-1}. The experiment was laid out in split plot design with three replications. Sowing methods were kept in main plots and seed rates were placed in sub plots. Recommended dose of fertilizer (75-60-0 NPK kg ha^{-1}) was applied.

Table 80: Sowing methods and seed rates on quinoa yield (t ha^{-1})

Seed rates	Sowing methods		Mean
	Ridge	Drill	
3.0 kg ha^{-1}	1.50 cd	1.33 d	1.42 C
5.0 kg ha^{-1}	1.76 b	1.52 c	1.64 B
7.0 kg ha^{-1}	1.90 a	1.77 ab	1.84 A
9.0 kg ha^{-1}	1.93 a	1.80 ab	1.87 A
Mean	1.77 A	1.61 A	--

LSD for seed rate=0.0925 LSD for sowing methods=0.1895 LSD for interaction=0.1308

It was found that (Table 80) the maximum grain yield 1.93 t. ha^{-1} was recorded with ridge sowing when seed was used @ 9 kg ha^{-1}. It was statistically at par with 7 kg ha^{-1} seed in ridge sowing (1.90 t. ha^{-1}) and 9 kg ha^{-1} seed with drill sowing (1.80 t. ha^{-1}). However the minimum grain yield (1.33 t. ha^{-1}) was recorded when crop was sown with drill using seed @ 3 kg ha^{-1}. Results also indicated that the maximum grain yield 1.87 t. ha^{-1} was recorded in the treatment where seed was used @ 9 kg ha^{-1} and was statistically at par with the treatment where 7 kg seed per hectare was used (1.84 t. ha^{-1}). Soil samples were collected and analyzed for pH_s, EC_e and SAR determination before and after the harvest of crop. The trial was sown on 17-11-2015 and harvested on 23-04-2016.

Table 81: Post harvest soil analysis

Treatments	Sowing methods					
	Ridge			Drill		
	pH_s	EC_e (dS m^{-1})	SAR (mmol L^{-1})$^{1/2}$	pH_s	EC_e (dS m^{-1})	SAR (mmol L^{-1})$^{1/2}$
T_1 = 3.0 kg ha^{-1}	8.60	7.20	32.81	8.62	7.21	33.10
T_2 = 5.0 kg ha^{-1} (RD)	8.59	7.16	32.00	8.60	7.19	32.60
T_3 = 7.0 kg ha^{-1}	8.58	7.15	31.60	8.56	7.23	32.40
T_4 = 9.0 kg ha^{-1}	8.58	7.14	30.80	8.61	7.16	31.60

28. RESPONSE OF WHEAT VARIETIES TO CLIMATE CHANGE UNDER DIFFERENT SOWING DATES IN SALT AFFECTED SOIL

The study was planned to evaluate the effect of climate change on different varieties of wheat. A salt affected field having pH_s= 8.75, EC_e= 7.62dS m^{-1} and SAR= 30.50 (mmol L^{-1})$^{1/2}$ was selected, leveled and well prepared for sowing the crop. Treatments included in the study were: Sowing dates (10, 20, 30 November and 10 December) and wheat varieties (FSD-08 and Galaxy-13).The experiment was laid out in split plot design with three replications. Sowing dates were kept in main plots and wheat varieties were placed in sub plots. Recommended dose of fertilizer (120-90-60 NPK kg ha^{-1}) was applied.

Table 82: Grain yield (t.ha^{-1})

Treatments	FSD-08	Galaxy-13	Mean
10 November	2.26 bcd	1.84 d	2.06 BC
20 November	3.22 a	2.87 ab	3.05 A
30 November	2.82 abc	2.24 bcd	2.53 B
10 December	2.23 cd	1.76 d	2.00 C
Mean	2.6 A	2.18 B	

LSD For varieties = 0.2825 LSD for Sowing dates = 0.4815 LSD for Interaction = 0.6810

Table 83: Data of Crop Growth Rate (g. day^{-1})

Treatment	FSD-08	Galaxy-13	Mean
10 November	21.30 de	19.34 f	20.32 c
20 November	29.27 a	27.61 b	28.44 a
30 November	27.07 b	24.77 c	25.92 b
10 December	22.68 d	19.89 ef	21.28 c
Mean	25.08	22.90	

LSD for varieties = 0.3828 LSD for sowing dates = 1.3002 LSD for interaction = 1.8388

The results depicted (Table 82) maximum grain yield (3.22 t ha-1) was observed in wheat variety FSD-08 when sown on 20 November however its yield was statistically similar to wheat variety Galaxy-13 with grain yield of 2.87 t. ha-1sown on same date. Minimum grain yield of 1.76 t. ha-1 was recorded in Galaxy-13 when sown on 10 December. With respect to varieties maximum yield (2.6 t. ha^{-1}) was noted in FSD-08 as compared to Galaxy-13 (2.18 t. ha^{-1}). In case of sowing dates maximum grain yield (3.05 t. ha^{-1}) was observed with 20 November followed by 30 November (2.53 t ha^{-1}).

In case of growth rate of the crop results depicted (Table 83) maximum growth rate (29.27 gday-1) was observed in wheat variety FSD-08 when sown on 20 November followed by 30 November with in same variety. With respect to varieties maximum growth rate (25.08 gday-1) was noted in FSD-08 as compared to Galaxy-13 (22.90 g day-1). In case of sowing dates maximum growth rate (28.44 gday-1) was observed with 20 November followed by 30 November (25.92 gday-1). Soil samples were collected and analyzed for pHs, ECe and SAR determination before and after the harvest of crop. The trial was sown on 17-11-2015 and harvested on 17-04-2016.

Table 84: Post-harvest soil analysis

Treatments	FSD-08			Galaxy-13		
	pH_s	EC_e (dS m^{-1})	SAR (mmol L^{-1} $^{1/2}$)	pH_s	EC_e (dS m^{-1})	SAR (mmol L^{-1} $^{1/2}$)
10 November	8.74	7.59	28.80	8.75	7.58	28.82
20 November	8.73	7.58	28.30	8.73	7.58	28.72
30 November	8.73	7.58	28.28	8.72	7.57	28.60
10 December	8.73	7.56	28.42	8.72	7.56	28.28

29. PERFORMANCE OF CAMELINA UNDER DIFFERENT SEED PRIMING AND SOWING TECHNIQUES IN SALT AFFECTED SOILS

The experiment was conducted to investigate the yield enhancement of camelina with different seed priming agents and sowing method in salt affected soil. A salt affected field having pH= 8.63, EC= 5.26 (dS m^{-1}) and SAR= 26.85 (mmol L^{-1})$^{1/2}$ was selected. Experiment was laid out in split plot design with three replications. Sowing methods were kept in main plots and seed priming agents in sub-plots. Treatments included in the study were: A) Seed priming agents (Canal water soaking), $CaCl_2$ (2% soln.), $MgSO_4$ (2 %), CAN (2% soln.) and K_2SO_4 (2% soln.). B) Sowing methods (Drill sowing, Ridge sowing and Broadcast sowing).

Table 84: Camelina Grain yield (t. ha^{-1})

Treatments	Sowing methods			Mean
	Drill	Ridge	Broadcast	
T_1 = Canal water soaking	0.47 g	0.61 f	0.30 h	0.46 D
T_2 = $CaCl_2$ (2% soln.)	1.02 ab	1.08 a	0.87 cd	0.99 A
T_3 = $MgSO_4$ (2% soln.)	0.96 abc	0.92 bc	0.83 cde	0.90 B
T_4 = CAN (2% soln.)	0.72 ef	0.69 ef	0.46 g	0.62 C
T_5 = K_2SO_4 (2% soln.)	0.88 cd	0.94 bc	0.74 def	0.85 B
Mean	0.81 A	0.85 A	0.64 B	

The results (Table 84) indicated that the maximum grain yield 1.08 t. ha^{-1} was recorded when camelina seeds were primed with $CaCl_2$ (2% soln.) in ridge sowing however it was statistically at par with $CaCl_2$ 2% soln (1.02 t. ha^{-1}) and $MgSO_4$ 2% soln (0.96 t. ha^{-1}) in drill sowing. Data also showed that minimum grain yield (0.30 t. ha^{-1}) was noted in broadcast sowing with canal water soaking. With respect to seed priming agents maximum grain yield (0.99 t. ha^{-1}) was observed with $CaCl_2$ (2% soln.) followed by $MgSO_4$ (2% soln.) and K_2SO_4 (2% soln.). maximum grain yield (0.85 t. ha^{-1}) was found with Ridge Sowing which was statistically alike with Drill Sowing (0.81 t. ha^{-1}) followed by broadcasting (0.64 t. ha^{-1}). Soil samples were collected and analyzed for pH_s, EC_e and SAR determination before and after the harvest of crop. The trial was sown on 5^{-1}1-2015 and harvested on 22-03-2016.

Table 85: Post harvest soil analysis

Treatments	Sowing methods								
	Drill			Ridge			Broadcast		
	pH_s	EC_e (dS m^{-1})	SAR (m mol L^{-1})$^{1/2}$	pH_s	EC_e (dS m^{-1})	SAR (m mol L^{-1})$^{1/2}$	pH_s	EC_e (dS m^{-1})	SAR (m mol L^{-1})$^{1/2}$
T_1=Canal water soaking	8.58	5.22	24.96	8.58	5.18	24.80	8.59	5.24	25.10
T_1=$CaCl_2$ (2% soln.)	8.57	5.20	24.38	8.58	5.16	24.48	8.58	5.22	24.92
T_1=$MgSO_4$ (2% soln.)	8.56	5.18	24.14	8.57	5.14	24.32	8.57	5.20	24.56
T_1 =CAN (2% soln.)	8.56	5.16	23.92	8.56	5.14	23.80	8.57	5.20	24.18
T_1=K_2SO_4 (2% soln.)	8.56	5.16	23.86	8.55	5.12	23.62	8.55	5.18	23.92

5.6 AGRICULTURAL ENGINEERING DIVISION

30. CONJUNCTIVE USE OF DIFFERENT TILLAGE IMPLEMENTS AND SULPHURIC ACID FOR THE RECLAMATION OF SALT AFFECTED SOILS

The objective of this experiment was to find out the best combination of tillage implement with gypsum and sulphuric acid for the reclamation of salt affected soils. Implements used in the study were, T_1= Disc Plough, T_2= Rotavator, T_3= Chisel plough, T_4= Sub-Soiler. Whereas five levels of amendments were used, F_1=Without amendments, F_2= Sulphuric acid equivalent to 50% GR of soil, F_3= Sulphuric acid equivalent to 100% GR of soil, F_4= Gypsum application @50% GR of soil, F_5= Gypsum application @100% GR of soil. Moderately salt affected field as described in table (86) was selected. Field was leveled, prepared and amendments were applied according to treatment plan. Implements were kept in main plots and amendments in sub plots. The experiment was conducted following sorghum-oat crop rotation in Split Plot Design in three replications.

Table 86: Soil analyses before start of study

Parameter	Soil Depth (0-15) cm	Soil Depth (15-30) cm
pH_s	8.62	8.69
EC_e (dS m^{-1})	4.16	4.60
SAR (mmol $L^{-1})^{1/2}$	32.35	33.76
BD (Mg m^{-3})	1.59	------
HC (cm hr^{-1})	0.43	------
GR (t $acre^{-1}$)	2.66	------

Sorghum

In kharif season sorghum was sown on 8thJune, 2015 and recommended dose of NP 60-60 kg ha^{-1} was applied. All agronomic practices were rendered throughout maturity. Crop was harvested and fodder yield was recorded on 12thAugust, 2015.

Table 87: Effect of tillage implements and amendments on sorghum fodder yield

Treatments	Control	Amendments				Mean
		H_2SO_4 50%	H_2SO_4 100%	Gyp. 50%	Gyp. 100%	
		GR of soil				
T_1= Disc Plough	26.83 hi	37.95 fg	44.43 ab	37.95 fg	42.90 bcd	38.01 B
T_2= Rotavator	25.85 i	36.50 g	43.08 bcd	36.67 fg	42.03 cd	36.83 C
T_3= Chisel plough	27.00 hi	37.77 fg	44.50 ab	38.13 fg	43.45 bc	38.17 B
T_4= Sub-soiler	28.78 h	38.92 ef	45.73 a	40.88 de	45.77a	40.02 A
Mean	27.12 D	37.78 C	44.43 A	38.41B	43.54A	

LSD for Treatment = 0.9796 LSD for Amendments= 1.1385
LSD for Treatment * Amendments = 2.2770

The results (table 87) showed that various tillage practices and amendments application had significant effect on fodder yield of sorghum. Maximum fodder yield of sorghum (45.77 t ha^{-1}) was recorded with sub-soiler (twice) + Sulphuric acid equivalent to 100% GR of soil; it was at par with Sub-soiler and gypsum @ 100% GR of soil and remained statistically significant with all other treatments. Minimum fodder yield of sorghum (25.85 t ha^{-1}) was recorded in treatment where Rotavator was used without any amendment. After the harvest of sorghum fodder, soil samples were collected and analyzed for pH_s, EC_e and SAR.

Table 88: Soil analysis after harvesting of sorghum fodder 2015 pH_s

Treatments	Control	H_2SO_4 50%	H_2SO_4 100%	Gyp. 50%	Gyp. 100%
		GR of soil			
T_1= Disc Plough	8.60	8.51	8.49	8.52	8.50
T_2= Rotavator	8.61	8.53	8.51	8.53	8.51
T_3= Chisel plough	8.59	8.50	8.48	8.50	8.47
T_4= Sub soiler	8.59	8.49	8.46	8.50	8.45

Table 89: EC_e (dSm^{-1})

Treatments	Control	H_2SO_4 50% GR of soil	H_2SO_4 100% GR of soil	Gyp. 50% GR of soil	Gyp. 100% GR of soil
T_1= Disc Plough	4.05	3.58	3.48	3.65	3.42
T_2= Rotavator	4.16	3.71	3.61	3.69	3.57
T_3= Chisel plough	3.95	3.46	3.33	3.47	3.35
T_4= Sub soiler	3.89	3.34	3.25	3.38	3.24

Table 90: SAR (mmol L^{-1})$^{1/2}$

Treatments	Control	H_2SO_4 50% GR of soil	H_2SO_4 100% GR of soil	Gyp. 50% GR of soil	Gyp. 100% GR of soil
T_1= Disc Plough	29.86	27.05	25.70	26.94	25.63
T_2= Rotavator	30.13	27.37	25.85	27.36	25.84
T_3= Chisel plough	29.54	26.70	25.02	26.65	24.97
T_4= Sub soiler	29.32	26.22	24.71	26.23	24.64

The soil analysis (table 88, 89 and 90) after harvesting of sorghum crop showed that salinity/sodicity parameters of soil decreased due to application of gypsum, sulphuric acid and operating deep ploughing implements.

Oats

In Rabi season Oats was sown on 11thDecember, 2015 and recommended dose of NP 95-60 kg ha^{-1} was applied. All agronomic practices were rendered throughout maturity. Crop was harvested and fodder yield was recorded on 17thMarch, 2016.

Table 91: Effect of tillage implements and amendments on oats fodder yield.

Treatments	Factors					Mean
	Control	H_2SO_4 50% GR of soil	H_2SO_4 100% GR of soil	Gyp. 50% GR of soil	Gyp. 100% GR of soil	
Disc Plough	39.97 k	44.90 i	53.97 c	49.37 g	53.50 cd	47.74 C
Rotavator	35.50 k	44.33 i	53.37 cd	47.30 h	52.03 de	46.51 D
Chisel plough	37.20 jk	50.13 fg	57.27 ab	51.10 efg	57.13 b	50.57 B
Sub-soiler	38.90 j	51.63 def	59.03 a	53.10 cd	58.67 ab	52.28 A
Mean	37.14 D	47.75 C	55.91 A	50.22 B	55.33 A	

Results (table 91) showed that tillage implements improved the fodder yield of different levels of amendments. Maximum fodder yield 59.03 t ha^{-1} was recorded where sulphuric acid equivalent to 100% GR of soil was applied in combination with sub-soiler. Minimum fodder yield of oats 35.50 t ha^{-1} was recorded where rotavator was used without application of amendments.

Table 92: Soil analysis after harvesting pH_s

Treatments	Control	H_2SO_4 50% GR of soil	H_2SO_4 100% GR of soil	Gyp. 50% GR of soil	Gyp. 100% GR of soil
T_1= Disc Plough	8.59	8.50	8.48	8.50	8.48
T_2= Rotavator	8.61	8.53	8.50	8.52	8.49
T_3= Chisel plough	8.58	8.50	8.46	8.49	8.45
T_4= Sub soiler	8.57	8.48	8.44	8.48	8.44

Table 93: $EC_e(dSm^{-1})$

Treatments	Control	H_2SO_4 50% GR of soil	H_2SO_4 100% GR of soil	Gyp. 50% GR of soil	Gyp. 100% GR of soil
T_1= Disc Plough	3.97	3.51	3.35	3.52	3.34
T_2= Rotavator	4.13	3.60	3.47	3.59	3.46
T_3= Chisel plough	3.81	3.35	3.27	3.36	3.28
T_4= Sub soiler	3.75	3.30	3.19	3.31	3.20

Table 94: SAR $(mmol\ L^{-1})^{1/2}$

Treatments	Control	H_2SO_4 50% GR of soil	H_2SO_4 100% GR of soil	Gyp. 50% GR of soil	Gyp. 100% GR of soil
T_1= Disc Plough	28.45	25.85	23.95	25.82	23.96
T_2= Rotavator	28.84	26.19	24.82	26.21	24.71
T_3= Chisel plough	28.10	25.48	23.51	25.47	23.48
T_4= Sub soiler	27.96	25.11	22.91	25.08	22.95

The soil analysis (table 92, 93 and 94) after harvesting of oats fodder showed that salinity/sodicity parameters of soil decreased due to application of gypsum, sulphuric acid and operating deep ploughing implements.

31. ROLE OF SEED COVERING TECHNIQUES AND TILLAGE PRACTICES ON YIELD PERFORMANCE OF DIRECT SEEDED RICE IN SALT AFFECTED SOILS

The objective of this experiment was to investigate the best seed covering technique and tillage implement for better performance of direct seeded rice. Implements used in the study were, T_1=Cultivator, T_2=Disk harrow + Cultivator, T_3= Rotavator + Cultivator. Whereas three sowing techniques were used, F_1=Seed covering with planking 40 kg weight, F_2=Seed covering with planking 60 kg weight and F_3=Drill sowing. Moderately salt affected field as described in (table 95) was selected and prepared according to treatment plan. Implements were kept in main plots whereas seed covering techniques were applied in sub plots. The experiment was conducted for rice crop in Split Plot Design in three replications.

Table 95: Soil analyses before start of study

Parameter	Soil Depth (0-15) cm	Soil Depth (15-30) cm
pH_s	8.71	8.76
EC_e $(dS\ m^{-1})$	4.07	4.45
SAR $(mmol\ L^{-1})^{1/2}$	30.12	31.04
BD $(Mg\ m^{-3})$	1.51	------
HC $(cm\ hr^{-1})$	0.49	------

Rice

In Kharif season rice was sown on 22nd June, 2015 and recommended dose of NPK110-90-60 kg ha^{-1} was applied. All agronomic practices were rendered throughout maturity. Crop was harvested and paddy yield data was recorded on 02nd November, 2015.

Table 96: Effect of tillage practices and sowing techniques on Paddy Yield (t ha^{-1})

Treatments	Seed covering with planking 40 kg	Seed covering with planking 60 kg	Drill sowing	Mean
Cultivator	2.08 c	1.95 c	2.06 c	2.03 B
Disk harrow + Cultivator	2.69 ab	2.65 b	2.84 ab	2.73 A
Rotavator + Cultivator	2.69 ab	2.75 ab	2.92 a	2.79 A
Mean	2.49 AB	2.45 B	2.61 A	

Results (table 96) showed that maximum paddy yield 2.92 t. ha^{-1} was obtained where Rotavator was used with drill sowing and minimum paddy yield 1.95 t. ha^{-1} was obtained using cultivator and seed covering with 60 kg planking.

Table 97: Soil analysis after harvest of rice crop pH_s

Treatments	Seed covering with planking 40 kg	Seed covering with planking 60 kg	Drill sowing
Cultivator	8.69	8.70	8.70
Disk harrow + Cultivator	8.67	8.68	8.66
Rotavator + Cultivator	8.68	8.69	8.68

Table 98: EC_e (dSm^{-1})

Treatments	Seed covering with planking 40 kg	Seed covering with planking 60 kg	Drill sowing
Cultivator	3.82	3.87	3.81
Disk harrow + Cultivator	3.41	3.53	3.42
Rotavator + Cultivator	3.55	3.64	3.52

Table 99: SAR (mmol $L^{-1})^{1/2}$

Treatments	Seed covering with planking 40 kg	Seed covering with planking 60 kg	Drill sowing
Cultivator	28.38	28.63	28.52
Disk harrow + Cultivator	27.66	28.15	27.54
Rotavator + Cultivator	28.09	28.27	27.85

After the harvest of rice crop soil samples were collected to analyze the soil EC_e, pH_s and SAR as shown in table 97, 98 and 99. Results indicated that salinity / sodicity parameters have been reduced after harvest of rice crop.

32. EFFECT OF TILLAGE AND NITROGEN ON WHEAT PRODUCTION IN SALT AFFECTED SOILS

The objective of this experiment was to study the effect of tillage practices on nitrogen use efficiency of salt affected soils for wheat crop. Four tillage implements cultivator, disc harrow, M.B plough, chisel plough and three nitrogen application methods broadcast, band placement and side dressing were used in this study. Moderately salt affected field as described in (table 100) was selected, leveled and prepared according to treatment plan.

Table 100: Soil analyses before start of study

Parameter	Soil Depth (0-15) cm
pH_s	8.48
EC_e (dS m^{-1})	4.48
SAR (mmol $L^{-1})^{1/2}$	27.36
BD (Mg m^{-3})	1.55
HC (cm hr^{-1})	0.51
O.M (%)	0.40

Wheat

Recommended dose of fertilizer for wheat 120-110-70 kg ha^{-1}(NPK) was applied. Whole P, K and half N were applied as basal dose whereas remaining Nitrogen was applied with first irrigation. In Rabi season Wheat crop was sown on 18thNovember, 2015.All agronomic practices were rendered throughout maturity. Crop was harvested and grain yield data was recorded on 15thApril, 2016

Table 101: Wheat Grain yield (t ha^{-1}) 2015-16

Treatments	Fertilizer application method			Mean
	Broadcast	Band Placement	Side dressing	
Cultivator	2.28 d	2.51 bc	2.44 c	2.41 C
Disk harrow	2.44 c	2.58 bc	2.52 bc	2.51 B
MB Plough	2.52 bc	2.62 b	2.60 bc	2.58 B
Chisel plough	2.57 bc	2.84 a	2.62 b	2.68 A
Mean	2.45 C	2.64 A	2.55 B	

LSD for Treatment = 0.0958 LSD for Amendments= 0.0780
LSD for Treatment * Amendments = 0.1560

Results (table 101) showed that, maximum wheat grain yield 2.84 t ha^{-1} was obtained where chisel plough was used with band placement fertilizer application method and minimum wheat grain yield 2.28 t ha^{-1} was obtained where cultivator with broadcast fertilizer application.

Table 102: Soil analysis after harvesting of wheat crop 2015-16 pH_s

Treatments	Broadcast	Band Placement	Side dressing
Cultivator	8.62	8.60	8.61
Disk harrow	8.60	8.58	8.58
MB Plough	8.60	8.57	8.58
Chisel plough	8.57	8.54	8.55

Table 103: EC_e (dS m^{-1})

Treatments	Broadcast	Band Placement	Side dressing
Cultivator	4.45	4.44	4.44
Disk harrow	4.39	4.36	4.38
MB Plough	4.36	4.35	4.37
Chisel plough	4.29	4.24	4.26

Table 104: SAR (mmol L^{-1})$^{1/2}$

Treatments	Broadcast	Band Placement	Side dressing
Cultivator	27.34	27.22	27.25
Disk harrow	27.12	26.61	26.74
MB Plough	27.01	26.50	26.67
Chisel plough	26.83	26.06	26.19

Table 105: O.M

Treatments	Broadcast	Band Placement	Side dressing
Cultivator	0.40	0.46	0.40
Disk harrow	0.52	0.54	0.52
MB Plough	0.52	0.58	0.57
Chisel plough	0.54	0.60	0.57

After the harvest of wheat crop soil samples were collected to analyze the soil EC_e, pH_s, SAR and O.M as shown in table 102-105. Results indicated that salinity / sodicity parameters have been reduced after harvest experiment and organic matter status has been improved.

5.7 ECONOMIC BOTANY DIVISION

This division is engaged in conducting research for evolution/screening of rice, barley, oats and wheat germplasm for salt tolerance potential. Following trials were conducted during 2015-16.

33. RICE VARIETAL TRIAL UNDER SALINE SODIC CONDITION

The experiment was designed to compare the yield performance of salt tolerant rice advance lines / varieties in saline sodic fields. A field with EC_e 4.61-5.38 dS m^{-1} and SAR 32.75-37.55 (mmol L^{-1})$^{1/2}$ was selected. The trial was laid out in randomized complete block design with three replications. The nursery was transplanted on 21.07.2016 and harvested on 08.11.2016. Recommended dose of fertilizer @ 110-90-70 NPK kg ha^{-1} was applied. The crop was harvested at maturity and paddy yield was recorded.

Table: 106 Paddy yield under saline sodic soil.

Sr. No.	Varieties/lines	Paddy Yield (t. ha^{-1})
1	PB-95	3.29 A
2	T-05	2.85 C
3	SRI-12	2.65 C
4	SRI-13	2.89 B
5	Basmati-515	1.74 D
6	Shaheen Basmati	3.19 A
7	Super Basmati	1.57 E
LSD		0.0875

Initial soil analyses
pH_s 8.73
EC_e 4.68 - 5.66 dS m^{-1}
SAR 32.25 - 37.65 $(mmol\ L^{-1})^{1/2}$
Post harvest soil analyses
pH_s 8.71
EC_e 4.59 - 5.31 dS m^{-1}
SAR 30.36 - 34.36 $(mmol\ L^{-1})^{1/2}$

Results presented in table 106 showed that highest paddy yield (3.29 t ha^{-1}) was produced by advance line PB-95 which was statistically at par with Shaheen Basmati (3.19 t ha^{-1}) whereas the lowest paddy yield (1.57 t ha^{-1}) was found in Super Basmati on salt affected soil.

34. SCREENING OF RICE ADVANCE LINES FOR SALT TOLERANCE

The experiment was conducted to screen out various rice lines against salinity/sodicity. The trial was conducted in salinity blocks by artificially developed salinity levels of EC_e 5, 6 and 7 dS m^{-1} along with sodicity levels of SAR 30 and 40 $(mmol\ L^{-1})^{1/2}$ developed by adding salts i.e. NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$. Using CRD layout, 7 advanced lines/varieties were tested by transplanting each variety in a single row of 150cm length. The nursery was transplanted on 25-07-2016 and harvested on 28-10-2016. Recommended dose of fertilizer (110-90-70 NPK kg ha^{-1}) was applied to each experimental unit. At maturity, yield data was recorded and tabulated below:

Table: 107 Effect of salinity / sodicity on paddy yield

		Initial Soil Analyses of salinity blocks			
		EC_e – 2.24 (dS m^{-1}) SAR-11.38 $(mmolL^{-1})^{1/2}$	**EC_e-5.16 (dS m^{-1}) SAR-27.88 $(mmolL^{-1})^{1/2}$**	**EC_e-6.15 (dS m^{-1}) SAR-30.38 $(mmolL^{-1})^{1/2}$**	**EC_e-6.78 (dS m^{-1}) SAR-33.74 $(mmolL^{-1})^{1/2}$**
Sr. No.	**Lines /Varieties**	**Yield(t h^{-1})**			
1	PB-95	3.94 AB	3.18 A	2.16 A	1.08 A
2	SRI-12	3.69 DE	2.85 C	1.95 BC	0.86 BC
3	T-05	3.41 E	2.64 C	1.81 CD	0.77 BCD
4	1121	4.06 AB	1.94 D	1.66 E	0.62 D
5	SRI-13	3.64 CD	2.96 B	1.91 ABC	0.84 AB
6	Basmati-515	4.18 A	2.05 D	1.68 DE	0.65 CD
7	Shaheen Basmati	3.91 BC	3.06 AB	2.08 AB	0.91 AB
	LSD	0.2406	0.1590	0.1912	0.2129
Soil Analyses of salinity blocks after harvest of rice					
		ECe – 2.26 (dS m^{-1}) SAR-10.48 $(mmolL^{-1})^{1/2}$	**ECe-5.08 (dS m^{-1}) SAR-27.68 $(mmolL^{-1})^{1/2}$**	**ECe-6.08 (dS m^{-1}) SAR-30.26 $(mmolL^{-1})^{1/2}$**	**ECe-6.76 (dS m^{-1}) SAR-33.58 $(mmolL^{-1})^{1/2}$**

The data in table 107 showed that the highest paddy yield in fine rice (4.18 t ha^{-1}) was recorded with Basmati-515 at EC_e 2.24 dS m^{-1}&SAR-11.38 $(mmolL^{-1})^{1/2}$ which is statistically at par with 1121 (4.06 t ha^{-1}) & PB-95 (3.94 t ha^{-1}). Advance line PB-95 and Shaheen Basmati produced higher paddy yield at all salinity/sodicity levels than other advance lines and varieties of rice crop while SRI-13 is also at par with PB-95 at two salinity levels EC_e 6.15 dS m^{-1}&SAR 30.38 $(mmolL^{-1})^{1/2}$ and at EC_e 6.78 dS m^{-1}&SAR 33.74 $(mmolL^{-1})^{1/2}$. The lowest paddy yield was found in advance line 1121 at all EC_e and SAR levels. The results indicated that the paddy yield decreases gradually with the increase of EC_e& SAR levels.

35. MAINTENANCE OF SALT TOLERANT RICE VARIETY SHAHEEN BASMATI

The experiment was laid out for prolongation of approved variety Shaheen Basmati in their true to type form in order to avoid degeneration through mechanical mixing and mutation. Thirty panicles of selected plants from Pre-basic seed of salt tolerant approved variety Shaheen Basmati in order to grow plant progenies next year. Six uniform progeny lines developed (through collected panicles) were further selected to develop individual progeny blocks. Five most uniform progeny blocks were also selected and bulked to produce seed for farmer's distribution. Four kg BNS and Ten kg pre-basic seed of Shaheen Basmati was produced during the year.

36. WHEAT GERM PLASM SCREENING IN SALINE SODIC SOIL

The study was carried out to test the suitability and tolerance of exotic as well as local germplasm in salinity blocks. Before sowing of wheat germplasm, salinity and sodicity levels were developed by using the salts NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$. The crop was sown on 01-12-2015 Recommended dose of fertilizer (120-110-70 NPK kg ha^{-1}) was applied to the wheat crop. At harvesting time on 08-05-2016, data of grain yield were recorded and given in table 108.

Table: 108 Effect of salinity / sodicity on wheat grain yield.

Entries	EC_e 2.24 dS m^{-1} SAR 11.76 (mmol $L^{-1})^{1/2}$	EC_e 9.23 dS m^{-1} SAR 23.47 (mmol $L^{-1})^{1/2}$	EC_e 12.36 dS m^{-1} SAR 31.89 (mmol $L^{-1})^{1/2}$
SIS-12	3.90 B	2.84 A	1.72 A
SIS-13	3.59 CD	2.42 C	1.41 BC
SIS-32	3.68 BC	2.49 BC	1.56 AB
DH-31	3.36 D	2.13 D	1.17 D
6C002	3.49 CD	2.11 D	1.19 D
06-FSJ-2013	3.66 BC	2.08 D	1.27 CD
9C037	3.51 CD	2.30 CD	1.15 D
Galaxy	4.35 A	2.67 AB	1.44 BC
Punjab-2011	3.85 B	2.54 BC	1.48 BC
Inqlab-91	3.72 BC	2.45 BC	1.54 AB
LSD Value	0.2451	0.2403	0.2085
	Post-Harvest Soil Analysis		
	EC_e = 2.13 dS m^{-1} pH_s = 8.47 SAR=10.48 (mmol $L^{-1})^{1/2}$	EC_e = 9.08 dS m^{-1} pH_s = 8.51 SAR= 21.75(mmol $L^{-1})^{1/2}$	EC_e = 12.24 dS m^{-1} pH_s = 8.53 SAR= 29.07(mmol $L^{-1})^{1/2}$

The results indicated that the Galaxy produced highest grain yield (4.35 t ha^{-1}) followed by the SIS-12 (3.90 t ha^{-1}) and Punjab-2011 (3.85 t ha^{-1}) at normal salinity level (EC_e 2.24 dS m^{-1} &SAR 11.76 (mmol $L^{-1})^{1/2}$). At salinity levels of EC_e 9.23 dS m^{-1} & SAR 23.47 (mmol $L^{-1})^{1/2}$ and EC_e 12.36 dS m^{-1} &SAR 31.89 (mmol $L^{-1})^{1/2}$, SIS-12 (2.84 & 1.72 t ha^{-1}) was on top in grain production but statistically at par with Galaxy (2.67 t ha^{-1}) on salinity level with EC_e 9.23 dS m^{-1} & SAR 23.47 (mmol $L^{-1})^{1/2}$ and followed by SIS-32 (1.56 t ha^{-1}) and Inqlab-91 (1.54 t ha^{-1}) at salinity-sodicity level of EC_e12.36 dS m^{-1} & SAR 31.89 (mmol $L^{-1})^{1/2}$ whereas, lowest grain yield was recorded in DH-31 & 6C002 at all three salinity-sodicity levels. The results also indicated that the grain yield of all varieties of wheat decreased drastically with the increase in EC_e& SAR levels.

37. YIELD TRIAL OF PROMISING WHEAT LINES / GENOTYPES

The experiment was conducted to see the performance and yield potential of promising lines/varieties of wheat in saline sodic soil. The trial was laid out in RCBD with three replications. Recommended dose of fertilizer (120-110-70 NPK kg ha^{-1}) was applied. The trial was sown on 27-11-2015 and harvested on 11-05-2016. The grain yield data was recorded and given as under:

Table:109 Wheat grain yield in saline sodic soil

Entries	Grain yield (t ha^{-1})
SIS-12	2.45 A
SIS-13	2.06 AB
SIS-27	1.85 C
4S1P1	2.24 B
LSD Value	**0.1618**

Initial soil status

pH_s = 8.60

EC_e = 8.10 (dS m^{-1})

SAR = 29.58 (mmol L^{-1})$^{1/2}$

Soil analysis after harvesting of wheat

pH_s = 8.57

EC_e = 7.96 (dS m^{-1})

SAR = 28.80 (mmol L^{-1})$^{1/2}$

The data presented in table 109 indicated that the wheat advance lines SIS-12 produced highest grain yield (2.45 t ha^{-1}) and statistically at par with the SIS-13 (2.06 t ha^{-1}) whereas, check variety SIS-27 produced lowest grain yield (1.85 t ha^{-1}) under saline sodic conditions.

38. SCREENING OF BARLEY (*Hordeum Vulgare. L*) VARIETIES IN SALINE SODIC SOIL

The experiment was conducted to test the performance and potential of barley varieties / lines in salinity blocks. Three salinity / sodicity levels were developed artificially by using salts NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$. The recommended dose of fertilizer (60-30-0 NPK kg ha^{-1}) was applied to the barley crop. The trial was sown on 01-12-2015 and harvested on 08-05-2016. The grain yield data recorded and given in table 110.

Table: 110 Effect of salinity/sodicity on barley grain yield

Entries	Grain yield (t ha^{-1})
B-9	2.20 A
B-4	2.11 AB
B-1	2.03 BC
B-7	1.97 C
B-11	1.86 D
B-8	1.84 D
B-3	1.81 D
B-6	1.62 E
B-10	1.55 E
B-5	1.39 F
B-12	1.34 F
B-2	1.24 F
LSD Value	**0.0976**

Initial soil status

pH_s = 8.54

EC_e = 8.56 (dS m^{-1})

SAR = 31.65 (mmol L^{-1})$^{1/2}$

p **Soil analysis after harvesting of Barley**

pH_s = 8.53

EC_e = 8.32 (dS m^{-1})

SAR = 30.48 (mmol L^{-1})$^{1/2}$

The entry B-9 is high yielded with 2.20 t/h^{-1} and B-2 is lowest yielded with 1.24 t/h^{-1} .

39. SCREENING OF SUNFLOWER GERMPLASM COLLECTED FROM NATIONAL & PROVINCIAL RESEARCH INSTITUTIONS UNDER SALT AFFECTED SOIL FOR HIGH YIELD POTENTIAL

The experiment was conducted to evaluate the yield and test adaptability of most promising sun flower lines evolved by the National Research Organizations. The trial was laid out in RCBD with three replications. Recommended dose of fertilizer (120-110-70 NPK kg ha^{-1}) was used . Eleven entries were tested. Yield data is given as under.

Table:111 SUNFLOWER ACHENE YIELD (t ha^{-1}) 2016

Entries	Achene Yield (t ha^{-1})
FH-17	1.52A
FH-572	1.41B
FH-615	1.40B
FH-612	1.35BC
FH-614	1.31C
FH-622	1.19D
FH-620	1.16D
FH-545	1.11D
FH-331	1.00E
FH-19	0.87F
FH-16	0.76G
LSD Value	0.1135

Initial soil analyses

pH_s = 8.54

EC_e = 6.53(dS m^{-1})

SAR =27.31 (mmol L^{-1})$^{1/2}$

Soil analyses after harvesting of wheat

pH_s = 8.53

EC_e = 6.42(dS m^{-1})

SAR =26.98 (mmol L^{-1})$^{1/2}$

It is clearly depicted from the above figure that FH-17 (1.52 t. ha^{-1}) out yielded than other lines yield . While minimum yield was recorded (0.76 t. ha^{-1}) in FH-16

40. SCREENING OF WHEAT GERMPLASM COLLECTED FROM DIFFERENT INSTITUTIONS UNDER SALINE-SODIC SOIL

The experiment was conducted to see the performance and yield potential of promising lines/varieties of wheat in saline sodic soil. The trial was laid out in RCBD with three replications in the research farm at desire salinity levels. Recommended dose of fertilizer was applied in total

21 lines were tested in the field. All agronomic practices were rendered throughout the maturity. The grain yield data was recorded and given as under:

Table: 112 GRAIN YIELD (t ha^{-1}) 2015-16

Entries	GRAIN YIELD (t ha^{-1})
SD-14	1.96A
SD-10	1.94AB
SD-1	1.90B
SD-6	1.85BC
SD-4	1.78C
SD-2	1.67D
SD-11	1.49E
SD-17	1.49E
SD-3	1.36F
SD-15	1.31FG
SD-5	1.27FG
SD-8	1.24G
SD-9	1.14H
SD-19	1.06HI
SD-20	1.03IJ
SD-13	0.97JK
SD-16	0.93 KL
SD-7	0.92KLM
SD-12	0.86LM
SD-18	0.83 M
LSD Value	0.0933

Initial soil analyses

pH_s = 8.54

EC_e = 7.85(dS m^{-1})

SAR =29.53 (mmol L^{-1})$^{1/2}$

Soil analyses after harvesting of wheat

pH_s = 8.53

EC_e = 7.69(dS m^{-1})

SAR =28.85 (mmol L^{-1})$^{1/2}$

The above result showed that for grain yield SD-14 and SD-10 are statistically at par under salt stress condition.

41. EVALUATION OF NUYT LINES UNDER NATURAL FIELDS OF SALT AFFECTED SOIL

The experiment was conducted to evaluate the yield and test adaptability of most promising wheat lines evolved by the National Wheat Research Organizations. The trial had two parts, early sowing and late sowing and was laid out in RCBD with three replications. Recommended dose of fertilizer (120-110-70 NPK kg ha^{-1}) was used. 25 entries were tested; yield data is given as under.

Table: 113 National uniform wheat yield trial 2015-16

Entries	Grain yield (t ha-1)
NUYT-10	2.28 A
NUYT-9	2.22B
NUYT-2	2.13C
NUYT-8	2.01 D
NUYT-11	1.99DE
NUYT-12	1.93E

NUYT-7	1.86F
NUYT-19	1.85F
NUYT-6	1.82F
NUYT-1	1.76G
NUYT-18	1.76G
NUYT-15	1.70GH
NUYT-3	1.70GH
NUYT-4	1.69H
NUYT-5	1.61I
NUYT-17	1.49 J
NUYT-14	1.27K
NUYT-21	1.24 K
NUYT-20	1.22 K
NUYT-16	1.14 L
NUYT-25	1.12LPP
NUYT-24	1.02M
NUYT-22	1.01M
NUYT-13	0.97 MN
NUYT-23	0.94N
LSD	0.0612

Initial soil analyses

pH_s = 8.54

EC_e = 7.85(dS m^{-1})

SAR =29.53 (mmol L^{-1})$^{1/2}$

Soil analyses after harvesting of wheat

pH_s = 8.53

EC_e = 7.69(dS m^{-1})

SAR =28.85 (mmol L^{-1})$^{1/2}$

The result showed in table 113 that NUYT 10 line gave the maximum yield (2.28 t. ha^{-1}) While NUYT-23 registered lowest yield (0.94 t .ha^{-1})

6. LIST OF PUBLICATION

6.1.1 Research Paper / Articles

6.1.2 Published.

Khalil Ahmed, Ghulam Qadir, **Abdul-Rehman Jami,** M. Qaisar Nawaz, Abdur Rehim, Khawar Jabran and Mubshar Hussain. Gypsum and farm manure application with chiseling improve soil properties and performance of fodder beet under saline-sodic conditions. International Journal of Agriculture & Biology ISSN Print: 1560–8530; ISSN Online: 1814–9596 14–495/2015/17–6–1225–1230 DOI: 10.17957/IJAB/14.0036 http://www.fspublishers.org.

6.1.2 Submitted

Syed Saqlain Hussain, Muhammad Jamil, M.Qaisar Nawaz, Ghulam Mustafa Wains, Ehsan -ul- Haq and ***Abdul Rehman Jami****.* Integrated use of seed priming and chemical amendments for improving wheat crop yield in saline sodic soils has been submitted in Soil & Environment Journal for publication.

اردو آرٹیکل

۱۔ کلراٹھی زمینوں میں دھان کی کاشت

۲۔ کلراٹھی زمینوں میں کاشت سے پہلے بیج بھگونا اور اس کے فوائد

۳۔ کلراٹھے رقبوں پر دھان کی منتقلی کے بعد بڑھوتری کا رکنا اور اس کا علاج

۴۔ کلراٹھی زمینوں میں السی کی کاشت

۵۔ کلراٹھی زمینوں میں گندم کی کاشت

۶۔ کمزور اور ناکارہ زمینوں کو بحال کرنے کے اقدامات

۷۔ کلراٹھی زمینوں میں نامیاتی مادہ کی اہمیت

۸۔ کلراٹھی زمینوں میں کماد کی کاشت

۹۔ کلراٹھی زمینوں میں چارہ جات کی کاشت

۱۰۔ کلراٹھی زمینوں میں فصلوں کا ادل بدل

6.3 *Radio Talks*

تفصیل ریڈیو ٹاکس

۱۔ کلراٹھی زیناں وچ فصل لئی کھاداں دا مناسب استعمال
۲۔ کلراٹھی زمینوں میں کھارے پانی کا استعمال
۳۔ کلراٹھی زمینوں میں مردی مونجی نوں بچانا
۴۔ زمین تے پانی دے تجزیے دی اہمیت
۵۔ کلراٹھی زیناں وچ برسیم لئی کھاداں دا استعمال
۶۔ کلراٹھی زیناں وچ کاشتہ چارہ لئی کھاداں دا استعمال
۷۔ کلراٹھی زیناں وچ پھل دار درخت دی اہمیت
۸۔ کلراٹھی زیناں دی اصلاح دے طریقے
۹۔ کلراٹھی زیناں وچ کنک دی کاشت
۱۰۔ کلراٹھی زیناں وچ کھارے پانی دا استعمال
۱۱۔ کلراٹھی زمینوں میں چارہ جات کی کاشت
۱۲۔ کلراٹھی زیناں وچ کنک لئی کھاداں دی ضرورت
۱۳۔ کلراٹھی زیناں وچ درختوں کی کاشت
۱۴۔ کلراٹھی زیناں دا تجزیہ تے اہمیت
۱۵۔ کلراٹھی زیناں دا بہتر استعمال
۱۶۔ کلراٹھی زمینوں میں گندم کی فصل کی آبپاشی
۱۷۔ کلراٹھی زمینوں میں کماد کی کاشت
۱۸۔ کلراٹھی زمینوں میں کاشتہ گندم کے لئے کھادوں کا استعمال
۱۹۔ کلراٹھی زمینوں کی اصلاح کے طریقے
۲۰۔ کلراٹھی زیناں دا تجزیہ تے اہمیت
۲۱۔ کلراٹھے پانی دا منافع بخش استعمال
۲۲۔ کلراٹھی زیناں دا بہتر استعمال
۲۳۔ کلراٹھی زیناں لئی نامیاتی مادے دی اہمیت
۲۴۔ کلراٹھی زیناں دا تجزیہ تے اس دی اہمیت
۲۵۔ کلراٹھی زیناں دی طبعی خصوصیات
۲۶۔ کلراٹھی زیناں وچ مونجی دی کاشت
۲۷۔ کلراٹھی زیناں دی اصلاح دے طریقے
۲۸۔ کلراٹھی زیناں لئی نامیاتی تے غیر نامیاتی کھاداں دا استعمال

7. ADVISORY SERVICES

Advisory services to farming community on all aspects of salinity/sodicity viz land use, utilization of brackish groundwater and quality of gypsum/fertilizer were provided on the prioritized basis. The farmers either submit their soil, tube well water and fertilizer samples or request for sampling and subsequent analysis. Another mode of seeking advisory services is submission of test reports from this nearby district laboratory and getting expert recommendations from SSRI, Pindi Bhattian. Detailed recommendations are made on the basis of case-to-case study. During the year 2015-16, soil 314, water 69 and fertilizer 19 samples were analyzed and detailed reports were conveyed to the concerned farmers. The detail of these services is as under:

7.1 SOIL ANALYSIS

LIST OF FARMERS BENEFITED THROUGH SOIL ANALYSIS (2015-16)

S. No	DATE	NAME	MAUZA/VILLAGE	NO. OF SAMPLES
1	01.07.15	M.NAVEED	QASIM ABAD	2
2	06.07.15	M.IMTIAZ	SUKHEKI	2
3	22.07.15	SAIF ULLAH	MUSTAFA ABAD	1
4	13.10.15	ARSHAD ALI	CHAH MASTI	2
5	19.10.15	TANZEEM	HUJAN	4
6	21.10.15	AKHTAR ABBAS	CHAK # 2	8
7	21.10.15	M.YASEEN	SUKHEKI	21
8	02.11.15	M.IQBAL	THATA KARIM DAD	6
9	03.11.15	M.ARSHAD HUSSAIN	HARSA SHEIKH	3
10	16.11.15	RAI AHMAD	KHURAM CHORARA	1
11	16.11.15	BHAI KHAN	CHAK NO.1	1
12	27.11.15	M.IMRAN KHAN	PINDI BHATTIAN	1
13	30.11.15	M.ARSHAD HUSAIN	HARSA SEIKH	1
14	30.11.15	SHAH NAWAZ	THATHA MASTA	2
15	23.12.15	ZAHOOR	NABOORARA	1
16	11.01.16	MANZOOR HUSSAIN	JANGLA	2
17	13.01.16	RAJ MUHAMMAD	KOTNIZAM	2
18	15.01.16	M.NAJEEB ASLAM	PINDI BHATTIAN	1
19	28.01.16	NAVEED HUSSAIN	CHOCHAK	14
20	28.01.16	MUNAWAR ABBAS	CHOCHAK	6
21	12.02.16	ARSHAD MAHMOOD	CHAK NO.1 ZAKHEERA	5
22	25.02.16	AQIB SAJJAD	MAHES SHAMALI	1
23	01.03.16	QASIM KHAN	BAHU MAN	40
24	09.03.16	M.AZAM	VANI KAY TARER	4
25	07.04.16	M.ARSHAD	BURKAN	2
26	14.04.16	NIAZ HUSSAIN	THATHA KANJU	1
27	20.04.16	M.SABIR	THATHA LANGER	68
28	25.04.16	M.TARIQ ZAMAN	M.K.FARM	10
29	02.05.16	FALAK SHER	KOT NAKA	2
30	10.05.16	NAWAZ CHATTA	SNAGLA HILL	16
31	15.05.16	SOHAIL SULTAN	DARBAR SAIR SHAH	4
32	25.05.16	SARFRAZ AHMAD	HAVALI HARBJRAY	1
33	25.05.16	JAVAID IQBAL	PINDI BHATTIAN	7
34	25.05.16	M.AKBAR	PAR AHMAD PINDI BHATTIAN	1
35	31.05.16	M.ZIA	THATHA LANGER	1
36	01.06.16	SHAH NAWAZ	NAWAN MANIKA	6
37	01.06.16	SARWAR	HARSA SHEIKH	6
38	03.06.16	ZAHIR	SUKHEKI	1
39	03.06.16	BABAR	SUKHEKI	1
40	03.06.16	GHAFOOR	SUKHEKI	1
41	03.06.16	ARSHAD	SUKHEKI	1
42	17.06.16	KHALID MAMOOD	PINDI BHATTIAN	6
43	21.06.16	RAI HAFIZ SAFI ULLAH	WIGWAN	30
44	24.06.16	HAYYAT MUHAMMAD	MALLWALI	4
45	29.06.16	M.ARSHAD	NOROZPUR	1
46	29.06.16	QASIM KHAN	NISHAT AGRI FARM	10
47	29.06.16	FAISAL SHAHZAD	MONA THATHA	3
			TOTAL	**314**

7.2 WATER ANALYSIS

LIST OF FARMERS BENEFITED THROUGH WATER ANALYSIS (2015-16)

Sr. No.	Date	Name of farmers	Address of farmer	Number of samples
1	01.07.15	M. NAVEED	QASIM ABAD	1
2	06.07.15	M. IMTIAZ	SUKHEKI	1
3	15.07.15	ZULIFQAR	BHOBRA	1
4	22.07.15	SAIF ULLAH	MUSTAFA ABAD	1
5	24.08.15	TIKA KHAN	SUKHEKI	2
6	25.08.15	KHALID MAHMOOD	SUKHEKI	1
7	05.10.15	ABDUL RASOOL NASEEM	SARGODHA	1
8	05.10.15	M. ARIF	MONA SALABAT	1
9	21.10.15	AKHTAR ABASS	CHAK#2	1
10	21.10.15	M. YASEEN	SUKHEKI	1
11	03.11.15	M. YASEEN	SUKHEKI	5
12	10.11.15	MUSHTAQ AHMED	GARHI GONDAL	1
13	16.11.15	RAIAHMED	KHURAM CHORAR	1
14	27.11.15	MOJAHID WASEEM	SUKHEKI	7
15	21.12.15	ZAFAR IQBAL	CHAK #1	1
16	23.12.15	ZAHOOR	NABOORARA	1
17	04.01.16	MUNAWAR HUSSAIN	SADIQ ABAD	1
18	06.01.16	ZAHID MAHMOOD	THATHA ALIKE	1
19	11.01.16	MANZOOR HUSSAIN	JANGLA	2
20	22.01.16	FIAZ AHMED	SUKHEKI	1
21	12.02.16	ARSHAD MUHAMMAD	CHAK #1 ZAKHEERA	1
22	23.02.16	ZAFAR IQBAL	CHAK #1 ZAKHEERA	1
23	25.02.16	AQIB SAJJAD	MAHES SHAMALI	1
24	07.04.16	M. ARSHAD	BURKAN	1
25	21.04.16	IMTIAZ AHMED	CHAK #11	2
26	25.04.16	M, TARIQ ZAMAN	M. K. FARM	2
27	02.05.16	ZAHID MAHMOOD	THATHA ALIKE	2
28	02.05.16	FALAK SHER	KOT NAKKA	1
29	05.05.16	M. JAVED IQBAL	ATTARAN WALA	1
30	05.05.16	SAFDAR IQBAL	KOT NAKKA	2
31	08.05.16	BASHER AHMED	CHAK #2 ZAKHEERA	1
32	31.05.16	M. ZIA	THATHA LANGAR	1
33	01.06.16	ORANGZEB	ATTARAN WALA	1
34	08.06.16	SAMAR ABBAS	MUSTAFA ABAD	2
35	14.06.16	UMAR DRAZ	PINDI BHATTIAN	2
36	14.06.16	AHMED KHAN	SHEKHU PURA	1
37	14.06.16	KHALID MAHMOOD	SHEKHU PURA	1
38	14.06.16	WAQAS AHMED	SHEKHU PURA	1
39	14.06.16	TANVIR BHATTI	SHEKHU PURA	1
40	18.06.16	HAYAT MUHAMMAD	SHEKHU PURA	1
41	20.06.16	HASSAN DAD	NOTHAIN	1
42	20.06.16	MAQBOOL AHMED	KHOI MUSA	1
43	20.06.16	HAYAT MUHAMMAD	SHEKHU PURA	1
44	23.06.16	M. HUSSAIN	SUKHEKI	1
45	29.06.16	M. IRSHAD	NOR PUROZ	2
46	29.06.16	QASIM KHAN	NISHAT AGRI FARM	3
47	29.06.16	FAISAL SHAHZAD	MONA THATHA SALABAT	2
			TOTAL	**69**

7.3 FERTILIZER ANALYSIS

LIST OF FARMERS BENEFITED THROUGH FERTILIZER ANALYSIS (2015-16)

S.No	DATE	NAME OF FARMERS	ADDRESS OF FARMERS	NO OF SAMPLES
1	08.07.15	ABU BAKAR SADDIQUE	WAJHO KAY, KALIKI MANDI, HAFIZABAD	2
2	04.08.15	RAY M. ASHRAF	THATHA KHERO MATMAL, PINDI BHATTINA	1
3	07.08.15	SARANG KHAN	BURJ MASTI , PINDI BHATTIAN	1
4	01.10.15	SARFRAZ AHMAD	PERA DA KOT , PINDI BHATTIAN	1
5	03.11.15	AMANAT ALI	TALI GURYA , PINDI BHATTIAN	1
6	09.11.15	KHADIM HUSSAIN	KOT MURAD , PINDI BHATTIAN	2
7	27.11.15	ZAFAR ABBAS	SADHU KI, PINDI BHATTIAN	1
8	01.12.15	MUHAMMAD AKRAM	SUKHEKI, , PINDI BHATTIAN	1
9	21.12.15	MUHAMMAD MUSHTAQ	THATA KARIM DAD, PINDI	1

			BHATTIAN	
10	18.01.16	MUHAMMAD AKBAR	THATA BURO, PINDI BHATTIAN	1
11	05.05.16	MUHAMMAD FAROOQ	PINDI BHATTIAN	1
12	23.05.16	RAY SANA ULLAH	THATA GHARA, PINDI BHATTIAN	1
13	27.05.16	ASIF ALI	GHARI GUNDAL, PINDI BHATTIAN	1
14	10.06.16	BASHRAT ALI	PAR MASU, PINDI BHATTIAN	1
15	13.06.16	ATTA ULLAH	MANGAT , SAFDARABAD, NANKANA SAHIB	1
16	28.06.16	MUHAMMAD AZAM	NAWAN MANIKEA, PINDI BHATTIAN	2

DIRECTOR
SOIL SALINITY RESEARCH INSTITUTE
PINDI BHATTIAN