ANNUAL TECHNICAL REPORT

2019-20

SOIL SALNITY RESEARCH INSTITUTE,

PINDI BHATTIAN, DISTRICT HAFIZABAD

DIRECTOR:

DR. SARFRAZ HUSSAIN

COMPILED BY:

DR. MUHAMMAD SARFRAZ

ASSISTANT RESEARCH OFFICER

REVIEWED BY:

DR. KHALIL AHMED

ASSISTANT RESEARCH OFFICER

1. RESEARCH STAFF POSITION

SR. NO.	DESIGNATION	SANCTIONED POSTS	FILLED POSTS	VACANT POSTS
1.	DIRECTOR	ONE	ONE	-
2.	AGRICULTURAL CHEMIST	FOUR	TWO	TWO
3.	ECONOMIC BOTANIST	ONE	ONE	-
4.	AGRONOMIST	ONE	ONE	*
5.	AGRICULTURAL ENGINEER	ONE	-	ONE
6.	ASSISTANT AGRI. CHEMIST	FOUR	ONE	THREE
7.	ASSISTANT BOTANIST	ONE	ONE	-
8.	ASSISTANT AGRONOMIST	ONE	ONE	-
9.	ASSISTANT AGRICULTURAL ENGINEER	ONE	ONE	-
10.	ASSISTANT RESEARCH OFFICER	TWELVE	SIX	SIX

2. LIST OF RESEARCHERS

Sr. No.	Name	Designation	Qualification	Duration
1	Dr. Sarfraz Hussain	Director	Ph.D. (Soil Science)	15.04.2019 to 11.05.2020
2	Dr. Muhammad Anwar Zaka	Agri. Chemist	Ph. D (Soil Science)	01.07.2019 to 01.03.2020
3	Mr. Abdul Rasul Naseem	Agri. Chemist	M.Sc (Soil Science)	01.07.2019 to 30.06.2020
4	Mr. Muhammad Khalid Bhatti	Economic Botanist	M.Sc (PB&G)	01.07.2019 to 30.06.2020
5	Mr. Muhammad Sarwar	Agronomist	M.Sc. (Agronomy)	07-07-2019 to 17-1-2020
6	Mr. Zaheen Manzoor	Assistant Agri. Chemist	M.Sc (Soil Science)	10.08.2019 to 30.06.2020
7	Dr. Muhammad Sarfraz	Assistant Research Officer	Ph. D (Soil Science)	01.07.2019 to 30.06.2020
8	Mr. Muhammad Sultan Ali Bazmi	Assistant Agronomist	M.Sc (Agronomy)	26.04.2019 to 25.06.2020
9	Dr. Ghulam Shabbir	Assistant Botanist	Ph. D (PB&G)	01.07.2019 to 30.06.2020
10	Dr. Muhammad Sarfraz	Assistant Research Officer	Ph. D (Soil Science)	01.07.2019 to 30.06.2020
11	Mr. Amar Iqbal Saqib	Assistant Research Officer	M.Sc (Soil Science)	01.07.2019 to 30.06.2020
12	Mr. Ghulam Qadir	Assistant Research Officer	M.Sc (Soil Science)	01.07.2019 to 30.06.2020
13	Mr. Muhammad Qaisar Nawaz	Assistant Research Officer	M.Sc (Agronomy)	01.07.2019 to 30.06.2020
14	Mr. Muhammad Rizwan	Assistant Agri. Engineer	M.Sc (Water Resources Engineering)	01.07.2019 to 30.06.2020
15	Dr. Khalil Ahmad	Assistant Research Officer	Ph. D (Soil Science)	01.07.2019 to 30.06.2020
16	Mr. Muhammad Faisal Nawaz	Assistant Research Officer	M.Sc (Soil Science)	16.010.2019 to 30.06.2020
17	Arsalan Nazarat	Assistant Research Officer	M.Sc (Soil Science)	23.12.2019 to 30.06.2020

3. BUDGET (18-AGRICULTURE (2019-20)

Major Object	Allocation (Rs.)	Expenditure (Rs.)
Pay of Officers	14412000	1121320
Pay of Staff	15725000	668370
Regular Allowances	20676000	3032016
Other Allowances	1081000	42055
Employment Related Expenses	**52782288**	**5271815**
Communication	65000	16240
Utilities	1324650	400079
Occupancy Cost	57310	-
Travel & Transportation	3145648	333207
General	4534108	445860
Encashment of LPR	1780140	-
PHYSICAL Assets	3428150	1007485
Repair and Maintenance	1168172	368956
Grand Total	**1478300**	**12783410**

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. Development of technology for reclamation of salt affected soil
2. Development of technology for management of brackish water
3. Development of crop production technology for salt affected soil
4. Management of plant Nutrition in salt affected soil
5. Screening of varieties of crops / fruit plants against Salinity/ sodicity
6. 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 to the farming community. 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.

5.0 RESREACH WORK

5.1 SOIL PHYSICS Division

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

The experiment was designed in 2013 to study the deleterious effect of high RSC water on soil physical properties under rice-mustard (Raya) crop rotation. A moderately salt affected field (pH_{s} = 8.82, EC_e = 4.71 dS m^{-1}, SAR = 26.82 (mmol $L^{-1})^{1/2}$, HC = 0.67 cm hr^{-1} and BD = 1.37 Mg m^{-3} was selected, prepared and leveled. Composite soil samples were collected and analyzed for salinity/sodicity and gypsum requirement. Experiment was laid out in RCBD with three 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. Gypsum and H_2SO_4 was applied on the basis of RSC of water with respect to number of irrigation. Guar was sown on 29-05-2019 and incorporated in soil before flowering. FYM was applied 15 days before transplanting of rice. The rice variety PS2 was transplanted on 15-07-2019. Recommended dose of fertilizers (150-90-60 NPK kg ha^{-1}) was applied to rice. All the phosphorus and potassium was applied at transplanting, while nitrogen (N) was applied in three splits. All agronomic and plant protection practices were kept constant. The crop was harvested at maturity. Soil samples were collected after harvesting of crop. Paddy yield data was recorded at maturity. The treatments tested along with paddy yield is as under.

Table 1: Effect of treatments on paddy yield (t. ha^{-1}) 2019

Treatments	Paddy Yield (t. ha^{-1})
T_1 Tube well water	3.20 C
T_2 Gypsum application on the basis of RSC of water	3.90 A
T_3 H_2SO_4 application on the basis of RSC of water	3.83 A
T_4 Green Manuring with Guar	3.57 B
T_5 FYM @ 10 t. ha^{-1}	3.62 B
LSD	0.2342

Data presented in Table-1 revealed that paddy yield was significantly higher in T_2 (gypsum application on the basis of RSC of water) and T_3 (H_2SO_4 application on the basis of RSC of water) followed by FYM @ 10 t. ha^{-1} and green manuring with Guar.The lowest yield was recorded in control(T_1).

Table 2: Soil analyses after rice harvest 2019

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	8.91	4.73	31.20	0.59	1.46
T_2 Gypsum application on the basis of RSC of water	8.40	3.29	13.50	0.79	1.21
T_3 H_2SO_4 application on the basis of RSC of water	8.44	3.69	14.80	0.74	1.24
T_4 Green Manuring with Guar	8.60	3.76	16.80	0.72	1.26
T_5 FYM @ 10 t. ha^{-1}	8.61	3.80	15.90	0.71	1.25

Soil analysis after rice harvest (Table 2) revealed that pH_s was above the safe limits in all the treatments except in T_2 and SAR was above the safe limit in T_1. EC_e was above the safe limit only in T_1 (control). 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 where gypsum was applied on the basis of RSC of water.

In the same layout raya crop was sown on 14-11-2019 after harvesting of rice and fertilizer was applied @ 70-70-60 NPK kg ha^{-1}. All the phosphorus and potassium were applied as basal, while N was applied in splits. All agronomic and plant protection practices were applied uniformly. Yield data of raya was recorded at maturity.

Table 3: Effect of treatments on raya yield 2019-20

Treatments	Grain Yield (t. ha^{-1})
T_1 Tube well water	1.02 C
T_2 Gypsum application on the basis of RSC of water	1.72 A
T_3 H_2SO_4 application on the basis of RSC of water	1.70 A
T_4 Green Manuring with Guar	1.37 B
T_5 FYM @ 10 t. ha^{-1}	1.40 B
LSD	0.1474

Results presented in Table 3 revealed that grain yield of raya remained at par in T_2 (Gypsum application on the basis of RSC of water) and T_3 (H_2SO_4 application on the basis of RSC of water) followed by FYM @ 10 t. ha^{-1} and green manuring with guar. Lowest grain yield was recorded in control.

Table 4: Soil Analysis after harvesting of Raya 2019-20

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	8.92	4.72	31.70	0.58	1.46
T_2 Gypsum application on the basis of RSC of water	8.37	3.25	12.90	0.80	1.20
T_3 H_2SO_4 application on the basis of RSC of water	8.40	3.66	14.30	0.75	1.23
T_4 Green Manuring with Guar	8.57	3.73	15.90	0.72	1.25
T_5 FYM @ 10 t. ha^{-1}	8.58	3.78	14.70	0.71	1.24

Soil analysis after harvesting of raya (Table 4) showed that pH_s was above the safe limit in T_1 (tube well water), T_4 (Green Manuring with Guar) and T_5 (FYM @ 10 t. ha^{-1}) while EC_e and SAR were above the safe limit in T_1 (tube well water) only. Hydraulic conductivity of soil increased and bulk density decreased in all the treatments when compared with control and minimum bulk density was recorded in T_2 (gypsum application on the basis of RSC of tube well water).

2. INTEGRATED USE OF SULPHUR AND ORGANIC AMENDMENT FOR RECLAMATION OF SALINE SODIC SOIL IN WHEAT-PEARL MILLET ROTATION

The experiment was designed in 2016 to study the effectiveness of combined use of sulphur and press mud for reclamation of saline sodic soil in wheat-pearl millet rotation. A salt affected field {pH_s = 8.97, EC_e = 4.52 dS m^{-1}, SAR = 40.70 (mmol $L^{-1})^{1/2}$, HC = 0.40 cm hr^{-1} and BD = 1.68 Mg m^{-3} and GR = 2.50 (t. $acre^{-1}$)} was selected, prepared and leveled. Composite soil samples were collected and analyzed for salinity/sodicity. Experiment was laid out in RCBD with three replications. Sulfur was applied on the basis of 25%, 50% and 100% of gypsum requirement alone and in combination with press mud according to the treatment plan. Press mud was applied @ 20 tons per hectare alone and @ 15 and 10 tons per hectare in combination with sulphur. Sulphur was applied 30 days and press mud was applied 15 days before sowing followed by flooding. All the treatments were applied at the start of study. After the harvest of wheat 2018-19, pearl millet variety Pioneer was sown in lines by rabi drill. Recommended dose of fertilizers @ 80-60-60 NPK kg ha^{-1} was applied. All the phosphorus and potassium was applied at sowing while N was applied in splits. Recommended agronomic and plant protection practices were kept constant. Yield data of pearl millet was recorded at maturity.

Table 5: Effect of Sulphur and press mud on grain yield of pearl millet (2019)

Treatments	Grain Yield (t. ha^{-1})
T_1 Control	1.26 D
T_2 Sulphur on the basis of 50%GR	1.36 CD
T_3 Sulphur on the basis of 100%GR	1.38 CD
T_4 Press mud @ 20 t ha^{-1}	1.62 A
T_5 Sulphur on the basis of 50% GR + Press mud @ 10 t ha^{-1}	1.51 AB
T_6 Sulphur on the basis of 25% GR + Press mud @ 15 t ha^{-1}	1.45 BC
LSD	0.1298

Results in Table 5 revealed that grain yield of pearl millet was non-significant in T_4 (Press mud @ 20 t ha^{-1}), T_5 (Sulphur on the basis of 50% GR + Press mud @ 10 t ha^{-1}) and T_6 (Sulphur on the basis of 25% GR + Press mud @ 15 t ha^{-1}). Lowest grain yield was obtained from T_1 (Control).

Table 6: Soil Analysis after harvesting of pearl millet 2019

Treatments	pH_s	EC_e (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$	HC (cm hr^{-1})	BD (Mg m^{-3})
T_1 Control	8.87	4.29	33.30	0.40	1.67
T_2 Sulphur on the basis of 50 % GR	8.39	4.10	25.36	0.46	1.64
T_3 Sulphur on the basis of 100 % GR	8.00	3.90	23.30	0.50	1.61
T_4 Press mud @ 20 t ha^{-1}	8.65	3.92	22.20	0.49	1.60
T_5 Sulphur on the basis of 50 % GR + Press mud @ 10 t ha^{-1}	8.64	3.98	24.90	0.48	1.63
T_6 Sulphur on the basis of 25 % GR + Press mud @ 15 t ha^{-1}	8.60	3.99	23.60	0.48	1.62

Soil analysis after pearl millet showed that (Table 6) showed that pH_s was above the safe limits in all the treatments except in T_3 (Sulphur on the basis of 100%GR) and T_2 (Sulphur on the basis of 50%GR). EC_e was above the safe limits in T_1 (Control) and T_2 (Sulphur on the basis of 50%GR) while SAR was above the safe limits in all the treatments. Hydraulic conductivity of soil increased in T_4 (Press mud @ 20 t ha^{-1}) as compared to control. However, bulk density decreased in T_4 (Press mud @ 20 t ha^{-1}) when compared with control.

In the same lay out wheat variety Faisalabad 2008 was sown and fertilizer was applied @ 120-110-70 NPK kg ha^{-1}. All the phosphorus and potassium was applied at sowing, while N was applied in three splits. All recommended agronomic and plant protection practices were applied uniformly. Yield data of wheat was recorded at maturity.

Table 7: Effect of sulphur and press mud on grain yield of wheat 2019-20

Treatments	Grain Yield (t. ha^{-1})
T_1 Control	1.87 C
T_2 Sulphur on the basis of 50%GR	2.20 BC
T_3 Sulphur on the basis of 100%GR	2.78 A
T_4 Press mud @ 20 t ha^{-1}	2.67 A
T_5 Sulphur on the basis of 50% GR + Press mud @ 10 t ha^{-1}	2.49 AB
T_6 Sulphur on the basis of 25% GR + Press mud @ 15 t ha^{-1}	2.59 AB
LSD	0.4021

Results revealed that in T_4 (Press mud @ 20 t ha^{-1}), T_6 (Sulphur on the basis of 25% GR + Press mud @ 15 t ha^{-1}), T_5 (Sulphur on the basis of 50% GR + Press mud @ 10 t ha^{-1}) and T_3(Sulphur on the basis of 100 % GR) remained non-significant with each other followed by T_2 (Sulphur on the basis of 50 % GR). However lowest grain yield was obtained from T_1 (Control).

Table 8: Soil analysis after wheat harvest 2019-20

Treatments	pH_s	EC_e (dS m^{-1})	SAR $(mmol\ L^{-1})^{1/2}$	HC (cm hr^{-1})	BD (Mg m^{-3})
T_1 Control	8.88	4.29	33.10	0.40	1.67
T_2 Sulphur on the basis of 50%GR	8.38	4.07	24.40	0.46	1.63
T_3 Sulphur on the basis of 100%GR	7.98	3.86	22.50	0.51	1.60
T_4 Press mud @ 20 t ha^{-1}	8.60	3.90	21.70	0.49	1.59
T_5 Sulphur on the basis of 50% GR + Press mud @ 10 t ha^{-1}	8.59	3.96	23.90	0.48	1.62
T_6 Sulphur on the basis of 25% GR + Press mud @ 15 t ha^{-1}	8.56	3.98	22.20	0.48	1.61

Soil analysis after wheat harvest (Table 8) showed that pH_s was above the safe limits in all the treatments except in T_3 (Sulphur on the basis of 100 % GR) and T_2 (Sulphur on the basis of 50%GR) and EC_e was above the safe limits in T_2 (Sulphur on the basis of 50%GR) and T_1 (control) while SAR was above the safe limit in all the treatments. Hydraulic conductivity of soil increased in T_4 (Press mud @ 20 t ha^{-1}) and T_3 (Sulphur on the basis of 100%GR) as compared to control. However, bulk density decreased in T_4 (Press mud @ 20 t ha^{-1}) when compared with control.

3. LONG TERM EFFECT OF DIFFERENT ORGANIC MANURES AND GYPSUM ON PHYSICAL PROPERTIES OF SALINE SODIC SOIL IN WHEAT-RICE ROTATION

The experiment was designed in 2016 to study the effectiveness of different amendments on downward movement of salts and rehabilitation of soil health with passage of time. A salt affected field {pH_s = 9.91, EC_e = 10.95 dS m^{-1}, SAR = 89.14 (mmol $L^{-1})^{1/2}$, HC = 0.26 cm hr^{-1} and BD = 1.75 Mg m^{-3}, and GR = 4.40 (t. $acre^{-1}$)} was selected, prepared and leveled. Composite soil samples were collected and analyzed for salinity/sodicity. Experiment was laid out in RCBD with three replications. Gypsum was applied @ 100% gypsum requirement while poultry manure, FYM, rice straw and press mud were applied @ 20 t ha^{-1}. Gypsum was applied 30 days and organic amendments were applied 15 days before sowing followed by leaching. All the treatments were applied at the start of study. Field was prepared and recommended dose of fertilizers @ 185-90-60 NPK kg ha^{-1} was applied. Rice variety PS-2 was transplanted on 24-07-19. All the phosphorus and potassium were applied at transplanting, while nitrogen (N) was applied in three splits. All agronomic and plant protection practices were kept constant. The crop was harvested at maturity and paddy yield data was recorded. Soil samples were collected after harvesting of crop. The treatments tested along with paddy yield are as under.

Table 9: Effect of organic manures and gypsum on paddy yield of rice 2019

Treatments	**Paddy yield** (t. ha^{-1})
T_1 Control	1.11 D
T_2 Gypsum on the basis of 100% GR	2.24 A
T_3 Poultry manure @ 20 t. ha^{-1}	2.11 A
T_4 FYM @ 20 t. ha^{-1}	1.81 B
T_5 Rice straw @ 20 t. ha^{-1}	1.41 C
T_6 Press mud @ 20 t. ha^{-1}	1.74 B
LSD	0.2669

The data revealed that paddy yield was maximum in T_2 (Gypsum on the basis of 100% GR) and statistically was at par with T_3 (Poultry manure @ 20 t. ha^{-1}) as compared to other treatments. While minimum was recorded in T_1 (Control) followed by T_5 (Rice straw @ 20 t. ha^{-1}).

Table 10: Soil analysis after rice harvest 2019

Treatments	**pH_s**	**EC_e** (dS m^{-1})	**SAR** (mmol $L^{-1})^{1/2}$	**HC** (cm hr^{-1})	**BD** (Mg m^{-3})
T_1 Control	9.27	6.70	50.30	0.33	1.60
T_2 Gypsum on the basis of 100%GR	8.73	5.58	36.40	0.42	1.38
T_3 Poultry manure @ 20 t. ha^{-1}	8.95	6.36	40.30	0.39	1.37
T_4 FYM @ 20 t. ha^{-1}	8.80	6.34	38.20	0.40	1.37
T_5 Rice straw @ 20 t. ha^{-1}	8.85	6.39	43.90	0.37	1.42
T_6 Press mud @ 20 t. ha^{-1}	8.90	6.66	40.10	0.39	1.40

Post-harvest soil analysis (Table 10) showed pH_s, EC_e and SAR were above the safe limits in all the treatments. Hydraulic conductivity of soil increased in T_2 (Gypsum on the basis of 100% GR) as compared to control. However, bulk density decreased in T_2 (Gypsum on the basis of 100% GR) when compared with control.

In the same lay out wheat variety Faisalabad 2008 was sown and fertilizer was applied @ 120-110-70 NPK kg ha^{-1}. All the phosphorus and potassium was applied at sowing while N was applied in three splits. All recommended agronomic and plant protection practices were applied uniformly. Yield data of wheat was recorded at maturity and crop was harvested.

Table 11: Effect of organic manures and gypsum on grain yield of wheat 2019-20

Treatments	Grain Yield (t. ha^{-1})
T_1 Control	1.17 D
T_2 Gypsum on the basis of 100%GR	2.90 A
T_3 Poultry manure @ 20 t. ha^{-1}	2.62 B
T_4 FYM @ 20 t. ha^{-1}	2.80 A
T_5 Rice straw @ 20 t. ha^{-1}	1.49 C
T_6 Press mud @ 20 t. ha^{-1}	2.52 B
LSD	0.1253

The data revealed (Table 11) that wheat yield was maximum in T_2 (Gypsum on the basis of 100% GR) and statistically was at par with T_4 (FYM @ 20 t. ha^{-1}) as compared to other treatments. While minimum yield was recorded in T_1 (Control) followed by T_5 (Rice straw @ 20 t. ha^{-1}).

Table 12: Soil analysis after wheat harvest 2019-20

Treatments	pH_s	EC_e (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$	HC (cm hr^{-1})	BD (Mg m^{-3})
T_1 Control	9.26	6.59	49.30	0.33	1.60
T_2 Gypsum on the basis of 100%GR	8.70	5.55	35.40	0.43	1.37
T_3 Poultry manure @ 20 t. ha^{-1}	8.93	6.34	39.30	0.39	1.36
T_4 FYM @ 20 t. ha^{-1}	8.78	6.32	37.20	0.40	1.37
T_5 Rice straw @ 20 t. ha^{-1}	8.83	6.37	42.90	0.37	1.41
T_6 Press mud @ 20 t. ha^{-1}	8.88	6.64	39.10	0.39	1.39

Post-harvest soil analysis (Table 12) showed that pH_s, EC_e and SAR were above the safe limits in all the treatments. Hydraulic conductivity of soil increased in T_2 (Gypsum on the basis of 100% GR) as compared to control. However, bulk density decreased in T_2 (Gypsum on the basis of 100% GR) when compared with control.

4. SCREENING OF GUAVA VARIETIES AGAINST SALINITY / SODICITY LEVELS

The experiment was designed in 2019 for screening of guava varieties against different combinations of salinity / sodicity levels. A normal soil was selected and desired salinity/sodicity levels were developed using salts NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$. After establishing, desired levels of EC_e and SAR, the soil was filled in the pots as per treatment plan. Five guava(surahi medium, surkha gola, surahi large, sufaid gola and sundora gola) varieties were tested and design of experiment was CRD factorial with three replications. The guava plants were transplanted in pots according to treatment plan and base line data is given below (Table 13).

Table:13 Base line data of guava plants against salinity / sodicity

Treatments / Variety	Plant height (cm)			Stem diameter (inch)		
Surahi medium EC_e <4, SAR<15	87	83.5	84.5	0.23	0.27	0.35
Surkha gola EC_e <4, SAR<15	88	84	82	0.33	0.26	0.29
Surahi large EC_e <4, SAR<15	84	75.5	68	0.30	0.37	0.31
Sufaid gola EC_e <4, SAR<15	65.8	59	56	0.25	0.32	0.40
Sundora gola EC_e <4, SAR<15	87	81.5	58	0.24	0.27	0.28
Surahi medium EC_e 4, SAR 30	69	93	81	0.18	0.36	0.22
Surkha gola EC_e 4, SAR 30	67	60	87.5	0.30	0.23	0.28
Surahi large EC_e 4, SAR 30	64	77	75	0.34	0.27	0.28
Sufaid gola EC_e 4, SAR 30	65	54	67	0.28	0.29	0.31
Sundora gola EC_e 4, SAR 30	96	71	43	0.28	0.28	0.22
Surahi medium EC_e 4, SAR 45	65	71	64	0.30	0.25	0.27
Surkha gola EC_e 4, SAR 45	77	43	89	0.28	0.22	0.25
Surahi large EC_e 4, SAR 45	85	81	68.5	0.37	0.31	0.46
Sufaid gola EC_e 4, SAR 45	45	97	96	0.16	0.25	0.43
Sundora gola EC_e 4, SAR 45	95.5	67	58	0.26	0.21	0.22
Surahi medium EC_e 7, SAR 15	72	81	99	0.25	0.26	0.37
Surkha gola EC_e 7, SAR 15	83	53	79	0.23	0.25	0.24

Surahi large EC_e 7, SAR 15	73	74	58	0.30	0.31	0.27
Sufaid gola EC_e 7, SAR 15	59	86	72	0.25	0.25	0.27
Sundora gola EC_e 7, SAR 15	89	73	66.5	0.30	0.25	0.23
Surahi medium EC_e 7, SAR 30	67	88	73	0.35	0.28	0.39
Surkha gola EC_e 7, SAR 30	59	74	89	0.24	0.24	0.28
Surahi large EC_e 7, SAR 30	55	105	92.5	0.28	0.26	0.26
Sufaid gola EC_e 7, SAR 30	54	76	77	0.25	0.30	0.27
Sundora gola EC_e 7, SAR 30	73	83.5	79	0.29	0.31	0.37
Surahi medium EC_e 7, SAR 45	116	71	60	0.38	0.35	0.24
Surkha gola EC_e 7, SAR 45	76	72	109	0.25	0.29	0.29
Surahi large EC_e 7, SAR 45	102	75	87	0.31	0.23	0.36
Sufaid gola EC_e 7, SAR 45	32	66	62	0.28	0.22	0.26
Sundora gola EC_e 7, SAR 45	98	83	47	0.32	0.28	0.19
Surahi medium EC_e 10, SAR 15	57	103	62	0.23	0.36	0.39
Surkha gola EC_e 10, SAR 15	86	55	101	0.30	0.25	0.27
Surahi large EC_e 10, SAR 15	52	75	60	0.24	0.20	0.29
Sufaid gola EC_e 10, SAR 15	76	78.5	75.5	0.22	0.26	0.37
Sundora gola EC_e 10, SAR 15	82.5	74	50.5	0.29	0.29	0.23
Surahi medium EC_e 10, SAR 30	73.5	66	78	0.38	0.34	0.34
Surkha gola EC_e 10, SAR 30	59	44	86	0.33	0.26	0.23
Surahi large EC_e 10, SAR 30	69	88	79	0.36	0.38	0.34
Sufaid gola EC_e 10, SAR 30	64	83	75	0.23	0.31	0.25
Sundora gola EC_e 10, SAR 30	84	89	89	0.40	0.27	0.27
Surahi medium EC_e 10, SAR 45	91	83	62	0.27	0.26	0.24

Surkha gola EC_e 10, SAR 45	77	52	101	0.25	0.23	0.20
Surahi large EC_e 10, SAR 45	87	77	79	0.25	0.30	0.20
Sufaid gola EC_e 10, SAR 45	59	98	80	0.24	0.38	0.31
Sundora gola EC_e 10, SAR 45	73	72	58	0.25	0.24	0.18

5. SCREENING OF GRAPES VARIETIES AGAINST DIFFERENT SALINITY / SODICITY LEVELS

The experiment was designed in 2019 for screening of grapes varieties against different combinations of salinity / sodicity levels. A normal soil was selected and desired salinity/sodicity levels were developed using salts NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$. After establishing, desired levels of EC_e and SAR, the soil was filled in the pots as per treatment plan. Six grapes (king ruby, Priest, Perlet, Sundar khani, Muscat hambourg and NARC black) varieties were tested and design of experiment was CRD factorial with three replications. The grapes plants were transplanted in salinity blocks according to treatment plan and base line data is given below (Table 14).

Table:14 Base line data of grapes plant against salinity / sodicity

Treatments / Variety	Plant height (cm)			Stem diameter (inch)		
King ruby EC_e <4, SAR<15	58	49	39	0.29	0.22	0.29
Priest EC_e <4, SAR<15	70	19	36	0.24	0.24	0.25
Perlet EC_e <4, SAR<15	70	43	44	0.46	0.36	0.42
Sundar khani EC_e <4, SAR<15	17	23	46	0.14	0.34	0.35
Muscat hambourg EC_e <4, SAR<15	37	52	40	0.52	0.24	0.40
NARC black EC_e <4, SAR<15	44	24	32	0.20	0.34	0.49
King ruby EC_e 6, SAR 30	40	44	24	0.35	0.38	0.27
Priest EC_e 6, SAR 30	28	40	53	0.39	0.31	0.38
Perlet EC_e 6, SAR 30	19	25	47	0.14	0.22	0.24
Sundar khani EC_e 6, SAR 30	21	44	37	0.34	0.36	0.37
Muscat hambourg EC_e 6, SAR 30	43	31	12	0.48	0.25	0.19
NARC black EC_e 6, SAR 30	32	27	34	0.39	0.36	0.20

King ruby EC_e 6, SAR 40	32	35	43	0.24	0.27	0.37
Priest EC_e 6, SAR 40	35	13	42	0.46	0.37	0.44
Perlet EC_e 6, SAR 40	37	43	43	0.32	0.39	0.35
Sundar khani EC_e 6, SAR 40	38	38	39	0.38	0.33	0.51
Muscat hambourg EC_e 6, SAR 40	25	38	29	0.18	0.20	0.23
NARC black EC_e 6, SAR 40	21	19	19	0.16	0.47	0.49
King ruby EC_e 8, SAR 30	30	28	40	0.30	0.46	0.18
Priest EC_e 8, SAR 30	29	10	11	0.26	0.19	0.46
Perlet EC_e 8, SAR 30	31	35	30	0.38	0.34	0.20
Sundar khani EC_e 8, SAR 30	28	38	32	0.21	0.37	0.41
Muscat hambourg EC_e 8, SAR 30	32	39	38	0.31	0.18	0.55
NARC black EC_e 8, SAR 30	25	23	19	0.19	0.33	0.48
King ruby EC_e 8, SAR 40	09	17	25	0.12	0.12	0.22
Priest EC_e 8, SAR 40	29	11	05	0.30	0.26	0.30
Perlet EC_e 8, SAR 40	39	33	27	0.31	0.41	0.40
Sundar khani EC_e 8, SAR 40	28	35	24	0.23	0.55	0.52
Muscat hambourg EC_e 8, SAR 40	30	29	28	0.35	0.19	0.41
NARC black EC_e 8, SAR 40	30	27	24	0.23	0.20	0.33
King ruby EC_e 10, SAR 30	29	28	30	0.44	0.42	0.42
Priest EC_e 10, SAR 30	29	25	32	0.44	0.43	0.32
Perlet EC_e 10, SAR 30	44	37	43	0.38	0.33	0.46
Sundar khani EC_e 10, SAR 30	40	32	22	0.28	0.29	0.21
Muscat hambourg EC_e 10, SAR 30	14	30	32	0.48	0.33	0.41
NARC black EC_e 10, SAR 30	35	25	23	0.50	0.20	0.43

5.2 WATER QUALITY DIVISION

6. DISSEMINATION OF TECHNOLOGIES FOR SAFE UTILIZATION OF BRACKISH WATER AT PINDI BHATTIAN

An experiment was conducted to assess the level of brackishness of water samples collected from the farmer's tube wells at Pindi Bhattian and disseminate technologies for its safe use. Tube well water samples from twenty farmers at Pindi Bhattian were collected and analyzed for determining quality of water with respect to EC_{iw}, SAR and RSC.

During first quarter from July to September 2019, twenty farmers were contacted and collected 21 water samples. The detail of the water samples analysis is also given in the form of a table below:-

TABLE: 15 Table showing farmer's water sample analysis high in parameters

Unfit Due to			M. Fit Due to			Fit
EC	RSC	EC+RSC	EC	RSC	EC+RSC	
-	03	05	01	08	-	04
Total Unfit		08	Total M. Fit		09	04

Out of 21 tube-well water samples, eight were found unfit. It was observed that tube well water samples were unfit with respect to parameters, EC = 0, RSC= 03, and EC + RSC= 05. Out of 21 tube-well water samples, nine were found marginally fit. It was observed that tube well water samples were marginally fit with respect to parameters, EC = 01, RSC= 08, and EC + RSC= 0. The remaining four tube-well water samples were fit during random farmer's tube-well water sampling (Table 15).

During second quarter from October to December 2019, twenty soil samples were collected from the same 20 farmers contacted previously.

TABLE: 16 Table showing farmers 21 soils sample analysis high in parameters

pH_s	SAR	EC_e + SAR	pH_s + EC_e + SAR	Normal
01	02	01	01	15

Out of 20 soil samples, fifteen farmers soil samples were found normal while others detail is given in table above (Table 16).

During 3rd quarter from January to March 2020, twenty one farmers were contacted and collected 21 tube-well water samples. The detail of the water samples analysis is given in the form of a table below:-

TABLE 17: Table showing farmer's water sample analysis high in parameters

Unfit Due to			Marginally Fit Due to			Fit
TDS	RSC	TDS+RSC	TDS	RSC	EC+RSC	
03	07	00	00	01	-	10
Total Unfit		10	Total Marginally Fit		01	10

Out of 21 tube-well water samples, ten were found unfit. It was observed that tube well water samples were unfit with respect to parameters, TDS = 03, RSC= 07, and TDS + RSC = 0. Out of 21 tube-well water samples, one was found marginally fit. It was observed that one tube well water sample was marginally fit with respect to parameter, RSC= 01. The remaining ten tube-well water samples were fit during random farmer's tube-well water sampling (Table 17).

During 4th quarter from April to June 2020, twenty one soil samples were collected from the same 21 farmers contacted previously.

TABLE 18: Table showing farmers 21 soils sample analysis high in parameters

pH_s	pH_s + SAR	EC_e	EC_e + SAR	pH_s + EC_e + SAR	Normal
03	02	01	01	00	14

Out of 21 soil samples, fourteen farmers soil samples were found normal while others detail is given in table 18).

7. LONG TERM EFFECT OF HGH RSC TUBE WELL WATER IRRIGATION ON PHYSICO-CHEMICAL PROPERTIES OF SOIL UNDER RICE-WHEAT ROTATION

A field study was conducted to monitor the long term effect of brackish tube well-water on physico-chemical properties of soil and its sustainable management for successful crop production under rice-wheat rotation in a normal soil at Rakh Research Farm, Soil Salinity Research Institute, Pindi Bhattian. The treatments studied are given in table below. Field analysis showed, pH_s= 7.97, EC_e = 3.32 (dS m^{-1}), SAR = 13.25 (mmol L^{-1})^{½}, Available P= 6.80 mg kg^{-1}, Extractable K= 102.0 mg kg^{-1}, O.M = 0.40 %, HC = 0.89 cm hr^{-1}, BD = 1.28 g m^{-3}, Texture = Sandy Loam. Brackish tube-well irrigation water (EC_{iw} 1.33 dS m^{-1}, SAR 8.83 (mmol L^{-1})$^{1/2}$ and RSC 7.90 me L^{-1}) was used for irrigation. Recommended dose of fertilizer @ 150-85-60 NPK kg ha^{-1} to rice Basmati variety PS-2 was applied. Cultural practices were carried out as and when required. Crop was harvested at maturity. Rice transplantation and harvesting date was 21-06-2019 and 29-10-2019 respectively. Data regarding plant height, number of tillers per hill, paddy and straw yield was recorded and presented in table below. Post harvest soil analysis data is also given in the table below.

Table 19 : Effect of Brackish irrigation water treatments on Paddy and Straw yield of Rice (2019)

Treatments	Plant Height (cm)	No. of tillers / hill	Paddy (t. ha^{-1})	Straw (t. ha^{-1})
T_1: Canal water (Control)	137.67 A	38.00 AB	3.92 A	8.18 A
T_2: Brackish tube-well water	122.00 B	32.33 C	3.43 C	7.12 B
T_3: Alternate irrigations with Canal & brackish tube well water	131.00 B	35.00 BC	3.61 B	7.89 A
T_4: Cyclic use of Canal and brackish tube Well Water (Growing of kharif crop with brackish water and rabi crop with canal water)	123.67 C	32.66 C	3.46 BC	6.93 B
T_5: Gypsum on the basis of RSC of tube well water	136.00 AB	38.66 A	3.81 A	8.07 A
T_6: Gypsum on the basis of RSC of tube well water + 20% Leaching Fraction	137.67 A	38.33 A	3.84 A	8.10 A
LSD	5.1026	3.0802	0.1631	0.3897

Results (Table-19) showed that maximum plant height 137.67 cm was recorded in T_1 treatment which was non-significant with T_6 (137.67 cm) followed by T_5, T_3, T_2 and T_4. In case of number of tillers / hill, maximum tillers (38.66) were found in T_5 treatment but the increase was non-significant with respect to T_6 (38.33) followed by T_1. Highest paddy yield of 3.92 t/ ha was obtained from T_1 treatment which was significantly higher than all other treatments except T_6 and T_5. In case of straw yield, highest straw yield of 8.18 t. ha^{-1} was obtained in T_1 treatment which was non-significant with T_6, T_5 and T_3.

Table 20: Post Harvest Soil Analysis

Treatments	**pH_s**	**EC_e (dS m^{-1})**	**SAR (mmol $L^{-1})^{1/2}$**
T_1: Canal water (Control)	7.95	3.28	12.90
T_2: Brackish tube-well water	8.00	3.40	14.30
T_3: Alternate irrigations with Canal & brackish tube well water	7.99	3.35	14.20
T_4: Cyclic use of Canal and brackish tube Well Water (Growing of kharif crop with brackish water and rabi crop with canal water)	8.00	3.38	14.30
T_5: Gypsum on the basis of RSC of tube well water	7.94	3.30	12.80
T_6: Gypsum on the basis of RSC of tube well water + 20% Leaching Fraction	7.94	3.29	12.50

Post-harvest analysis (table 20) demonstrated that improvement was observed in T_1 and gypsum application reduced the pH_s, EC_e and SAR in T_5 and T_6.

Wheat variety Faisalabad-2008 was sown after rice harvest on the same layout and treatments. Recommended dose of fertilizer @ 120-110-70 NPK kg ha^{-1} was applied. Cultural practices were carried out as and when required. Wheat sowing and harvesting date was 12-11-2019 and 22-04-2020 respectively. Data regarding plant height, number of tillers per m^2, grain and straw yield was recorded and presented in table below. Post harvest soil analysis data is also given in the table below.

Table 21 Effect of Brackish irrigation water treatments on Grain and Straw yield of wheat (2019-20)

Treatments	Plant Height (cm)	No. of tillers/m^2	Grain (t. ha^{-1})	Straw (t. ha^{-1})
T_1: Canal water (Control)	128.67 A	234.67 A	4.03 A	4.17 A
T_2: Brackish tube-well water	120.00 B	227.00 B	3.40 C	3.50 D
T_3: Alternate irrigations with Canal & brackish tube well water	123.67 AB	231.67 AB	3.50 BC	3.53 D
T_4: Cyclic use of Canal and brackish tube well water (Growing of kharif crop with brackish water and rabi crop with canal water)	125.33 AB	232.33 A	3.58 B	3.73 C
T_5: Gypsum on the basis of RSC of tube well water	139.67 A	235.00 A	3.93 A	3.90 BC
T_6: Gypsum on the basis of RSC of tube well water + 20% Leaching Fraction	129.67 A	235.33 A	3.94 A	4.00 AB
LSD	6.1784	4.8929	0.1413	0.1965

Results (Table-21) showed that maximum plant height 129.67 cm was observed in T_5 which was non-significant with T_6, T_1 followed by T_4 and T_3. Maximum numbers of tillers per square meter (235.33) were recorded from T_6 which was non-significant with all other treatments except T_3 and T_2. Highest grain yield of 4.03 t. ha^{-1} was obtained from treatments T_1, T_6 and T_5 which were non-significant with each other. In case of straw yield maximum straw yield of 4.17 t. ha^{-1} was obtained from T_1 which was significantly higher than all other treatments. Minimum straw yield of 3.50 t. ha^{-1} was obtained from T_2 where brackish tube-well water was applied.

Table 22:- Soil Analysis after wheat 2019-20

Treatments	**pH_s**	**EC_e (dS m^{-1})**	**SAR (mmol $L^{-1})^{1/2}$**
T_1: Canal water (Control)	7.95	3.28	12.90
T_2: Brackish tube-well water	8.01	3.41	15.00
T_3: Alternate irrigations with Canal & brackish tube well water	8.00	3.36	14.80
T_4: Cyclic use of Canal and brackish tube well Water (Growing of kharif crop with brackish water and rabi crop with canal water)	8.00	3.38	14.20
T_5: Gypsum on the basis of RSC of tube well water	7.94	3.30	12.78
T_6: Gypsum on the basis of RSC of tube well water + 20% Leaching Fraction	7.93	3.28	12.50

Post-harvest analysis (table 22) demonstrated that improvement was remained almost same as observed after rice 2019 harvest. However SAR was improved somewhat in treatments where gypsum was applied.

8. TEMPORAL CHANGES IN SOIL pH AFTER SULFURIC ACID APPLICATION IN HIGHLY SALINE SODIC SOIL

A field study was conducted to observe the changes in soil pH with the passage of time after sulfuric acid application in highly salt affected soil at Rakh Research Farm, Soil Salinity Research Institute, Pindi Bhattian. The treatments studied are given in table below. The selected field analysis showed pH_s 10.94, EC_e 11.39 dS m^{-1}, SAR 100.38 (mmol $L^{-1})^{1/2}$, available P= 5.20 mg kg^{-1}, Extractable K= 89.00 mg kg $^{-1}$, O. M = 0.21%, GR = 5.80 t $acre^{-1}$, HC= 0.27 cm hr^{-1}, BD = 1.65 g m^{-3}, Texture = Loam and $CaCO_3$ = 10.80%. Brackish tube-well irrigation water (EC_{iw} 1.05 dS m^{-1}, SAR 7.03 (mmol $L^{-1})^{1/2}$ and RSC 5.10 me L^{-1}) was used for irrigation. Recommended dose of fertilizer @ 150-85-60 NPK kg ha^{-1} to Basmati rice variety PS-2 was applied. Cultural practices were carried out as and when required. Crop was harvested at maturity. Rice transplantation and harvesting date was 22-07-2019 and 28-10-2019 respectively. Data regarding plant height, number of tillers per hill, paddy and straw yield was recorded and is presented in table. Post harvest soil analysis data is also given in the table below.

Table 23: Effect of Brackish irrigation water treatments on Paddy and Straw Yield of Rice (2019)

Treatments	**Plant Height (cm)**	**No. of tillers/hill**	**Paddy (t. ha^{-1})**	**Straw (t. ha^{-1})**
T_1: Control	0.00 B	0.00 D	0.00 D	0.00 D
T_2: Sulfuric acid application equivalent to 100 % GR of soil	117.33 A	31.33 A	1.83 A	3.90 A
T_3: Sulfuric acid application equivalent to 75 % GR of soil	116.00 A	30.00 A	1.50 B	3.46 B
T_4: Sulfuric acid application equivalent to 50 % GR of soil	116.00 A	21.33 B	0.53 C	1.23 C
T_5: Sulfuric acid application equivalent to 25 % GR of soil	115.00 A	14.00 C	0.39 C	0.89 C
LSD	3.9119	4.7633	0.2395	0.3768

Results (Table-23) showed that maximum plant height 117.33 cm was recorded in T_2 treatment which was at par with all other treatments except control. In case of number of tillers / hill maximum tillers (31.33) were found in T_2 treatment which was non-significant with T_3. Highest paddy yield of 1.83 t. ha^{-1} was obtained from T_2 treatment which was significantly higher than all other treatments while lowest paddy yield of 0.00 t. ha^{-1} was recorded in T_1 (control). In case of straw yield, highest straw yield of 3.90 t. ha^{-1} was obtained in T_2 treatment which was significantly higher from all other treatments.

Table 24: Post Harvest Soil Analysis

Treatments	pH_s	EC_e (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$
T_1: Control	10.20	12.00	97.00
T_2: Sulfuric acid application equivalent to 100 % GR of soil	8.48	5.20	30.56
T_3: Sulfuric acid application equivalent to 75 % GR of soil	8.70	6.10	45.50
T_4: Sulfuric acid application equivalent to 50 % GR of soil	8.90	8.00	60.00
T_5: Sulfuric acid application equivalent to 25 % GR of soil	9.40	8.65	72.00

Post-harvest analysis (table 24) demonstrated that application of H_2SO_4 reduced the pH_s, EC_e and SAR in all the treatments, however it remained un-affected in all parameters in control plot where H_2SO_4 was not used.

Table 25: Temporal changes in Soil pH after Sulfuric Acid Application (Depth 0-15 cm)

Treatments	After 24 Hours	After Two Days	After Two Weeks	After One Month	After Two Months	Quarterly	Quarterly
T_1	10.30 A	10.27 A	10.28 A	10.25 A	10.26 A	10.25 A	10.24 A
T_2 100%	5.54 E	6.40 C	7.40 D	8.36 C	8.48 D	8.52 D	8.48 D
T_3 75%	7.03 D	7.54 BC	8.06 C	8.60 BC	8.77 C	8.78 CD	8.72 C
T_4 50%	7.80 C	7.35 BC	8.50 BC	8.53 C	8.90 C	8.91 C	8.78 C
T_5 25%	8.36 B	8.20 b	8.58 B	9.10 B	9.26 B	9.26 B	8.95 B
LSD	0.5606	1.6281	0.4602	0.5367	0.194	0.3225	0.131

Post-harvest analysis (table 25) showed that application of H_2SO_4 reduced pH_s with the passage of time in all the treatments except control where H_2SO_4 was not used.

Wheat variety Faisalabad-2008 was sown after rice harvest on same layout and treatments. Recommended dose of fertilizer @ 120-110-70 NPK kg ha^{-1} was applied. Cultural practices were carried out as and when required. Wheat sowing and harvesting date was 11-11-2019 and 22-04-2020 respectively. Data regarding plant height, number of tillers per m^2, grain and straw yield was recorded and presented in table below. Post harvest soil analysis data is also given in table below.

Table 26: Effect of Brackish irrigation water treatments on Grain and Straw yield of wheat (2019-20)

Treatments	Plant Height (cm)	No. of tillers/m^2	Grain (t. ha^{-1})	Straw (t. ha^{-1})
T_1: Control	0.00 D	0.00 E	0.00 E	0.00 E
T_2: Sulfuric acid application equivalent to 100 % GR of soil	125.00 A	229.33 A	1.60 A	1.65 A
T_3: Sulfuric acid application equivalent to 75 % GR of soil	117.67 B	200.00 B	1.31 B	1.35 B
T_4: Sulfuric acid application equivalent to 50 % GR of soil	113.33 B B	173.33 C	0.67 C	0.75 C
T_5: Sulfuric acid application equivalent to 25 % GR of soil	104.33 C	141.67 D	0.51 D	0.55 D
LSD	5.0288	13.470	0.0786	0.1010

Results (Table-26) showed that maximum plant height 125.00 cm was observed in T_2 treatment and was higher than all other treatments. In case of number of tillers per square meter, maximum number of tillers per square meter (229.33) was recorded from T_2 which were significantly higher than all other treatments.

Highest grain yield of 1.60 t. ha^{-1} was obtained from T_2 treatment which was significantly higher than all other treatments, whereas minimum grain yield of 0.00 t. ha^{-1} was obtained from T_1 (control). In case of straw yield maximum straw yield of 1.65 t. ha^{-1} was obtained from T_2 which was significant over all other treatments whereas minimum straw yield of 0.00 t. ha^{-1} was obtained from T_1 (control).

Table 27: Soil Analysis of Chemical Properties after wheat 2019-20

Treatments	pH_s	EC_e (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$
T_1: Control	10.10	10.00	95.00
T_2: Sulfuric acid application equivalent to 100 % GR of soil	8.40	4.20	26.00
T_3: Sulfuric acid application equivalent to 75 % GR of soil	8.50	5.10	32.80
T_4: Sulfuric acid application equivalent to 50 % GR of soil	8.80	6.00	50.00
T_5: Sulfuric acid application equivalent to 25 % GR of soil	9.00	7.65	62.00

Post-harvest analysis (table 09) showed that application of H_2SO_4 reduced the pH_s, EC_e and SAR in all the treatments while the parameters remained same in control where H_2SO_4 was not used.

Table 28: Soil Analysis of Physical Properties after wheat 2019-20

Treatments	HC cm hr^{-1}	BD g m^{-3}	CaCO3 %
T_1: Control	0.26	1.69	10.00
T_2: Sulfuric acid application equivalent to 100 % GR of soil	0.88	1.30	4.00
T_3: Sulfuric acid application equivalent to 75 % GR of soil	0.57	1.35	4.50
T_4: Sulfuric acid application equivalent to 50 % GR of soil	0.52	1.51	5.50
T_5: Sulfuric acid application equivalent to 25 % GR of soil	0.33	1.61	6.68

Post-harvest analysis (table 28) showed that application of H_2SO_4 improved HC, increased BD and decreased $CaCO_3$ % in all the treatments except control where H_2SO_4 was not used.

Table 29: Changes in Soil pH after Sulfuric Acid Application (Depth 0-15 cm)

Treatments	After 24 Hours	After Two Days	After Two Weeks	After One Month	After Two Months	Quarterly	Quarterly	Quarterly	Quarterly	Quarterly
T_1	10.30 A	10.27 A	10.28 A	10.25 A	10.26 A	10.25 A	10.24 A	10.25 A	10.28 A	10.03 A
T_2	5.54 E	6.40 C	7.40 D	8.36 C	8.48 D	8.52 D	8.48 D	8.50 B	8.48 B	8.43 B
T_3	7.03 D	7.54 BC	8.06 C	8.60 BC	8.77 C	8.78 CD	8.72 C	8.69 B	8.70 B	8.50 B
T_4	7.80 C	7.35 BC	8.50 BC	8.53 C	8.90 C	8.91 C	8.78 C	8.76 B	8.70 B	8.46 B
T_5	8.36 B	8.20 b	8.58 B	9.10 B	9.26 B	9.26 B	8.95 B	8.73 B	8.76 B	8.56 B
LSD	0.5606	1.6281	0.4602	0.5367	0.1940	0.3225	0.1310	0.3686	0.3700	0.4266

Po-harvest analysis (table 29) showed that application of H_2SO_4 reduced pH_s with the passage of time in all the treatments except control where H_2SO_4 was not used.

9. EFFECT OF EXOGENOUS APPLICATION OF SALICYLIC ACID USING SALINE WATER ON YIELD OF BRINJAL AND TURNIP

A pot study was conducted to investigate the effect of exogenous application of salicylic acid using saline water on yield of Brinjal (Solanummelongena) and Turnip (Brassica rapa subsp. rapa) at campus, Soil Salinity Research Institute, Pindi Bhattian. The treatments studied were A- Salinity Levels (SL):- T_1- Control, T_2- EC_{iw} 3.0 dS m^{-1}, T_3- EC_{iw} 5.0 dS m^{-1}, T_4- EC_{iw} 7.0 dS m^{-1}, B:- Salicylic acid (SA) Levels: 1-No SA spray, 2- 150 ppm SA, 3- 300 ppm SA and 4- 450 ppm SA. The selected field analysis showed pH_s = 8.02, EC_e = 1.48 (dS m^{-1}), SAR = 4.41 (mmol L^{-1})^{½}, Available P = 5.60 mg kg^{-1}, Extractable K = 96.0 mg kg^{-1}, O. M = 0.46% and Texture = Sandy Loam. Brackish tube-well irrigation water (EC_{iw} 0.80 dS m^{-1}, SAR 3.27 (mmol L^{-1})$^{1/2}$ and RSC 3.35 me L^{-1}) was used for irrigation. Recommended dose of fertilizer @ 75-20-20 NPK kg ha^{-1} to Brinjal variety Black Beauty was applied. One third nitrogen was applied as basal dose while remaining two third N was top dressed in two splits 30 and 55 days after sowing. Cultural practices were carried out as and when required. Crop was harvested at maturity. Brinjal transplantation and harvesting date was 22-07-2019 and 28-10-2019 (6 to 7 pickings) respectively. Data regarding brinjal yield was recorded. Post harvest soil analysis data is given in the table below. Water salinity was developed by using Na_2SO_4, NaCl, $CaCl_2$ and $MgSO_4$ (4:3:2:1). Salicylic Acid was sprayed on the next day after saline water application. Salicylic Acid was dissolved in ethanol.

Table 30: Effect of Salicylic Acid and Different Salinity Levels on Brinjal Yield

Salinity Levels	NO SA	150 ppm	300 ppm	450 ppm	Mean
Canal Water	348.67 CDE	376.67 CD	460.00 A	460.00 A	411.33 A
3 dS/m	340.00 CDE	346.67 CDE	430.00 AB	436.67 A	388.33 A
5 dS/m	330.00 DE	343.33 CDE	376.67 CD	383.33 BC	358.33 B
7 dS/m	328.33 DE	308.33 E	343.33 CDE	320.00 E	325.00 C
Mean	336.75 B	343.75 B	402.50 A	400.00 A	-------------
Parameter	LSD				
SL	24.644				
SA	24.644				
Interaction	49.289				

Results (Table-30) showed that maximum brinjal yield of 402 grams was obtained from salicylic acid spray level @ 300 ppm followed by 450 ppm while lowest brinjal yield of 325 grams was recorded at salinity level 7.0 dS m^{-1}. Maximum brinjal yield was obtained at SA levels 300 ppm and 450 ppm and both were non-significant with each other.

Table: 31 Post-Harvest Soil Analyses:

A: Salinity Levels	**B: Salicylic acid Levels**											
	NO SA			SA @ 150 ppm			SA @ 300 ppm			SA @ 450 ppm		
	pH_s	EC_e	SAR	pH_s	EC_e	SAR	pH_s	EC_e	SAR	pH_s	EC_e	SAR
Control	8.01	1.47	4.40	8.00	1.47	4.40	8.00	1.46	4.37	8.00	1.45	4.36
3 dS/m	8.10	1.50	4.40	8.10	1.48	4.41	8.00	1.46	4.40	8.00	1.47	4.39
5 dS/m	8.10	1.51	4.42	8.10	1.48	4.41	8.10	1.46	4.40	8.10	1.47	4.40
7 dS/m	8.11	1.53	4.42	8.10	1.48	4.41	8.10	1.47	4.40	8.10	1.47	4.41

Post-harvest analysis (table 31) showed that pH_s, EC_e and SAR somewhat increased with increase in salinity levels. Increasing salicylic acid levels showed improvement in chemical-parameters.

Turnip variety white was sown after brinjal harvest on same layout and treatments. Recommended dose of fertilizer @ 125-75-00 NPK kg ha^{-1} was applied. Cultural practices were carried out as and when required. Turnip sowing and harvesting date was 05-11-2019 and 16-03-2020 respectively. Data turnip yield was recorded and presented in table below. Post harvest soil analysis data is also given in table below.

Table 31: Effect of Salicylic Acid and Different Salinity Levels on Turnip Yield

Salinity Levels	**NO SA**	**150 ppm**	**300 ppm**	**450 ppm**	**Mean**
Canal Water	383.33 EF	467.67 ABC	500.00 A	479.67 AB	459.92 A
3 dS/m	403.33 DE	426.67 CDE	446.67 BCD	436.67 BCD	428.33 B
5 dS/m	350.00 FG	410.00 DE	403.33 DE	385.00 EF	387.08 C
7 dS/m	290.00 H	320.00 GH	283.00 H	310.00 GH	300.83 D
Mean	356.67 B	408.33 A	408.33 A	402.83 A	-------------
Parameter					
SL	25.674				
SA	25.674				
Interaction	51.348				

Results (Table-31) showed that maximum turnip yield of 408.33g was obtained from at salicylic acid spray level @ 300 ppm followed which was non-significant with SA level 450 ppm while lowest turnip yield of 300.83g was recorded at salinity level 7.0 dS m^{-1}. Maximum turnip yield was obtained at SA levels 300 ppm and 450 ppm and both were non-significant with each other.

Table: 32 Post- Harvest Soil Analyses:

A: Salinity Levels	**B: Salicylic acid Levels:**											
	NO SA			**SA @ 150 ppm**			**SA @ 300 ppm**			**SA @ 450 ppm**		
	pH_s	**EC_e**	**SAR**	**pH_s**	**EC_e**	**SAR**	**pH_s**	**EC_e**	**SAR**	**pH_s**	**EC_e**	**SAR**
Control	8.01	1.46	4.38	8.00	1.46	4.40	7.99	1.45	4.30	7.98	1.43	4.25
3 dS/m	8.10	1.51	4.41	8.10	1.47	4.41	8.04	1.45	4.41	8.08	1.48	4.43
5 dS/m	8.11	1.53	4.43	8.00	1.49	4.43	8.13	1.45	4.43	8.16	1.49	4.44
7 dS/m	8.12	1.53	4.44	8.11	1.49	4.43	8.15	1.48	4.45	8.20	1.50	4.46

Post-harvest analysis (table 32) showed that pH_s, EC_e and SAR somewhat increased with increase in salinity levels. Increasing salicylic acid levels showed improvement in chemical-parameters.

5.3 SOIL RECLAMATION DIVISION

10. REHABILITATION OF BARREN SALT AFFECTED SOIL USING BRACKISH WATER

The objective of the experiment was to monitor the reclamation process using brackish water in rice-wheat cropping system. A five-acre barren field {pH_s = 8.95-9.43, EC_e = 7.86-9.02 (dS m^{-1}), SAR = 83.22-95.68 (mmol $L^{-1})^{1/2}$, GR = 3.61-4.13 (t. $acre^{-1}$)} was selected at Rakh Farm, Pindi Bhattian. Soil samples were collected from each acre and were analyzed for salinity and sodicity parameters. Field was laser levelled and thoroughly prepared through deep ploughing and planking. Gypsum was applied according to laboratory analysis and followed by leaching. Rice variety ‘‘Basmati 515’’ was transplanted on 01-08-2019 and recommended dose of fertilizers (150-90-60 NPK kg ha^{-1}) was applied. Tube-well water (EC = 1.00 dS m^{-1}, SAR = 6.97 (mmol $L^{-1})^{1/2}$ and RSC = 5.10 me L^{-1}), was used for crop production. All agronomic and plant protection measures were applied uniformly. Crop was harvested on 12-11-2019 and paddy yield data was recorded. Soil samples were collected after harvesting of crop.

Table 33: Effect of gypsum application on paddy yield of rice 2019

Field	**Paddy yield** (t. ha^{-1})
Acre No.1	2.76
Acre No.2	2.65
Acre No.3	2.84
Acre No.4	2.59
Acre No.5	2.91

Results (Table 33) indicated that paddy yield recorded from all five acres ranged from 2.59-2.91 t. ha^{-1} having little variation among different fields.

Table 34: Soil analysis after rice harvest 2019

Field	**pH_s**	**EC_e** (dS m^{-1})	**SAR** (mmol $L^{-1})^{1/2}$
Acre No.1	8.43-8.50	3.65-3.95	14.90-19.68
Acre No.2	8.42-8.48	3.90-4.10	15.26-18.96
Acre No.3	8.39-8.46	3.59-4.00	13.98-17.64
Acre No.4	8.49-8.54	3.98-4.12	17.16-20.48
Acre No.5	8.36-8.45	3.58-3.92	14.52-16.14

Post-harvest soil analysis (Table 34) showed that there was significant depreciation in, all salinity and sodicity parameters i.e. EC_e, pH_s and, SAR.

After harvesting of rice 2019, in the same field with same layout wheat (Faisalabad 2008) was sown. Field was thoroughly prepared by repeated ploughing and planking. Recommended dose of fertilizer 160-114-60 NPK kg ha^{-1} was applied. The date of wheat sowing was 05-12-2019. All agronomic and plant protection measures were applied uniformly. Crop was harvested on 07-05-2020 and grain yield data was recorded. Soil samples were collected after harvesting of crop and were analyzed in laboratory for salinity and sodicity.

Table 35: Effect of gypsum application on grain yield of wheat 2019

Field	**Grain yield** (t. ha^{-1})
Acre No.1	2.46
Acre No.2	2.61
Acre No.3	2.76
Acre No.4	2.49
Acre No.5	2.81

Results (Table 35) indicated that wheat grain yield recorded from all five acres ranged from 2.46-2.81 t. ha^{-1} having little variation among different fields.

Table 36: Soil analysis after wheat harvest 2019-20

Field	**pH_s**	**EC_e** (dS m^{-1})	**SAR** (mmol $L^{-1})^{1/2}$
Acre No.1	8.31-8.35	3.19-3.57	13.28-14.38
Acre No.2	8. 23-8.32	3.38-3.71	13.10-13.78
Acre No.3	8.26-8.29	2.97-3.48	12.77-14.18
Acre No.4	8.18-8.25	3.58-3.76	12.98-13.62
Acre No.5	8.20-8.31	2.89-3.32	13.86-14.36

Post-harvest soil analysis (Table 36) showed that there was significant depreciation in, all salinity and sodicity parameters i.e. EC_e, pH_s and, SAR and all these parameters were under the safe limit.

11. REHABILITATION OF SALINE SODIC SOILS THROUGH CULTIVATION OF SALT TOLERANT GRASSES

A field study was conducted to investigate the performance of various perennial salt tolerant grasses under salt affected conditions and their impact in improving soil health. A salt affected field was selected, prepared and leveled. Composite soil samples were collected and analyzed for salinity/sodicity. Grasses tested were; 1. Mott grass, 2. Para grass, 3. Rhodes grass and 4. Kallar grass. Experiment was laid out in RCBD with three replications. Tufts of grasses were planted in October 2017 according to treatment plan. One bag of DAP and SOP and half bag of Urea/acre was applied at land preparation while one bag of Urea/acre was applied after every harvest (three months). Fresh fodder yield was recorded five times in a year (up to 28-06-20).

Table 37: Fresh fodder yield of grasses

Treatment	Fodder yield (t. ha^{-1})	Soil analysis at the start of study		
		pH_s	**EC_e** (dSm^{-1})	**SAR** (mmol $L^{-1})^{1/2}$
Mott grass	7.93 D	9.96	8.55	88.08
Para grass	56.44 B	9.96	8.07	87.87
Rhodes grass	65.47 A	9.99	7.36	80.96
Kalar grass	47.90 C	9.88	7.87	76.92
LSD	5.0474			

Fodder yield analysis data (Table 37) showed that maximum fodder yield (65.47 t. ha^{-1}) was obtained by rhodes grass followed by para grass (56.44 t. ha^{-1}). Kalar grass recorded the fodder yield of 47.90 (t. ha^{-1}), while minimum fodder yield (7.93 t. ha^{-1}) was observed in mott grass. Maximum mortality rate of tufts was observed in mott grass. Salinity/sodicity significantly reduced the fodder yield of mott grass as compare to its yield potential (1200 to 1500 mond /acre/year of mott grass) in normal soil.

Table 38: Soil analysis after five cuttings

Treatment	pH_s	EC_e (dSm^{-1})	SAR (mmol $L^{-1})^{1/2}$
Mott grass	9.42	7.92	69.20
Para grass	8.93	4.53	51.74
Rhodes grass	8.82	5.68	49.86
Kalar grass	8.89	4.87	53.24

Post-harvest soil analysis (Table 38) showed that there was significant depreciation in, all salinity and sodicity parameters i.e. EC_e, pH_s and, SAR after five cuttings. However, all parameters were above the safe limit in all the fields.

12. COLLECTION, MAINTENANCE AND COMPARATIVE BIOMASS PRODUCTION ABILITY OF PERENNIAL GRASSES

Experiment was started with objective to collect, maintain and multiply the grasses germplasm for assuring the availability of material for future research. Moreover, relative biomass production ability of these grasses was investigated in normal soil. Grasses tested were: 1-Blue panic (*Panicum Antidotable*), 2- Green Panic (*Panicum Maximum*), 3-Tall Panic (*Panicum Virgatum*) 4- Survinola, 5- Steria Anceps, 6- Steria Seplanda (*Steria Seplanda*), 7-Dhalis Grass (*Paspalum Dilatatum*), 8- Rhodes Grass (*Chloris gayana*), 9- Elephant Grass (*Pennisetum purpureum*), 10- Buffel Grass (*Cenchrus ciliaris*), 11- Ona Grass, 12-Bajra Napier Hybrid, 13-Mott Apimatic (*Pennesetum Apimecticum*), 14- Mott Soft (*Pennesetum benthium*), 15- Mott grass, 16-Silk Sorghum (*Sorghum* spp), 17-Sucro Sorghum (*Sorghum* spp), 18-Vetivar Grass, 19-Lemon Grass, 20- Mott grass (office), 21- Buber Grass, 22- Para gras, 23- Sporobulus arabicus. A normal field was selected and prepared. Experiment was laid out in RCBD with three replications. Tufts of thirteen grasses were transplanted on 25-1- 2018 and nine grasses were transplanted on 20-3-18 depending upon their availability, keeping the R X R distance of 60 cm and P X P distance of 60 cm. One bag of DAP, SOP and half bag of Urea acre^{-1} was applied at land preparation while one bag of Urea acre^{-1} was applied after every harvest. Field was irrigated according to crop requirement. All the agronomic practices were kept uniformly in all the treatments. Growth of all the grasses is in progress and satisfactory. Fresh fodder yield was recorded five times in a year (up to 28-06-20).

Table 39: Fresh fodder yield of perennial grasses (total of five cuttings)

Grasses	**Fodder yield (t. ha^{-1})**
1-Blue panic	24.26 KLM
2-Green Panic	46.44 HIJ
3-Tall Panic	22.76 LM
4- Survinola	92.97 EF
5- Steria Anceps	41.23 HIJKL
6- Steria Seplanda	119.49 D
7-Dhalis Grass	35.43 IJKL
8-Rhodes Grass	54.72 GHI
9- Elephant Grass	149.55 C
10- Buffel Grass	19.35 LM
11-Ona Grass	69.61 G
12-Bajra Napier Hybrid	143.25 C
13- Mott Apimatic	151.68 BC
14- Mott Soft	72.60 FG
15- Mott grass	172.96 B
16-Silk Sorghum	45.19 HIJK
17-Sucro Sorghum	29.75 JKLM
18-Vetivar Grass	58.28 GH
19-Lemon Grass	21.52 LM
20- Mott grass (office)	203.11 A
21- Buber Grass	12.63 M
22-Para grass	94.91 E
23- Sporobulus arabicus	208.39 A
LSD	22.138

Fodder yield (Table 39) analysis data showed that maximum fodder yield (208.39 t. ha^{-1}) was obtained by *sporobulus arabicus* which was statistically at par with mott grass. Minimum fodder yield (12.63 t. ha^{-1}) was produced by buber grass.

13. PERFORMANCE AND QUALITY EVALUATION OF PEARL MILLET GERMPLASM ON SALT AFFECTED SOIL

The experiment was planned to screen out the most salt tolerant lines/varieties of pearl millet. A moderately salt affected field {pH_s = 8.67-9.10, EC_e = 4.2-6.10 (dS m^{-1}), SAR = 29.80-43.56 (mmol $L^{-1})^{1/2}$)} was selected, prepared and leveled. Composite soil samples were collected and analyzed for salinity/sodicity. Following lines/varieties of pearl millet were tested; 1. Composite-I, 2. Composite-II, 3. Composite-IV, 4. Wt-Bajra, 5. GJ-Bajra, 6. RCBK-948, 7. Y-84, 8. CZK-923, 9. Q-Bajra, 10. BS-2000, 11. Sgd Bajra 2011, 12. MB-87. Experiment was laid out in RCBD with three replications having plot size 1.8m x 5m. Lines/varieties were sown on 30-8-19. Recommended dose of fertilizers 70-60-37.5 NPK kg ha^{-1} was applied. All agronomic and plant protection measures were applied uniformly. Crop was harvested on 12-12-19 and fresh fodder yield data was recorded.

Table 40: Effect of salinity/sodicity on pearl millet germplasm

VARIETIES/LINES	Yield (t. ha^{-1})
T_1= Composite-I	20.73 c
T_2= Composite-II	26.58 a
T_3= Composite-IV	25.72 ab
T_4= Wt-Bajra	6.90 e
T_5= Gj-Bajra	20.10 cd
T_6= RCBK-948	25.09 ab
T_7= Y-84	6.85 e
T_8= Czk-923	18.03 d
T_9= Q-bajra	24.88 ab
T_{10}= BS-2000	24.17 b
T_{11}= Sgd bajra 2011	24.01 b
T_{12}= MB-87	5.10 e
LSD	2.2005

Results (Table 40) showed that maximum fresh fodder yield (26.58 t. ha^{-1}) was produced by Composite-II followed by Composite-IV, RCBK-948 and Q-bajra, however all these lines/varieties were statistically at par with each other. Lowest fresh fodder yield (5.10 t. ha^{-1}) was produced by MB-87.

Table 41: Post-harvest soil analysis after harvesting of pearl millet 2019

pH_s	EC_e (dS m^{-1})	SAR (m mol $L^{-1})^{1/2}$
8.62- 9.10	3.70-6.00	28.00-40.68

Soil analysis data (Table 41) showed that pH_s, EC_e and SAR were reduced to some extent after harvesting of crop. pH_s ranges from 8.62- 9.10, EC_e ranges from 3.70-6.00 (dSm^{-1}) and SAR ranges from 28.00-40.68.

14. EFFECT OF SALT STRESS ON YIELD AND QUALITY PARAMETERS OF SORGHUM GERMPLASM

The experiment was planned to screen out the most salt tolerant lines/varieties of sorghum. A moderately salt affected field {$pH_{s} =$ 8.65-8.98, EC_e = 4.60-7.30 (dS m^{-1}), SAR = 30.50-51.00 (mmol $L^{-1})^{1/2}$)} was selected, prepared and leveled. Composite soil samples were collected and analyzed for salinity/sodicity. Following lines/ varieties of sorghum were tested; 1. YS-98, 2. Sgd- 013-1, 3. Sgd-013-2,4. Sorghum-2011, 5. Hegari, 6. JS-2002, 7. No.1572, 8. No.80010, 9. I-6, 10. PVK-801, 11.FRI-07, 12.S-145. Experiment was laid out in RCBD with three replications having plot size 1.8m x 5m. Recommended dose of fertilizers 80-57-37.5 NPK kg ha^{-1} was applied. Lines/varieties were sown on 30-8-19. All agronomic and plant protection measures were applied uniformly. Crop was harvested on 31-10-19 and fresh fodder yield data was recorded.

Table 42: Effect of salinity/sodicity on sorghum germplasm

VARIETIES/LINES	Yield (t. ha^{-1})
T_1= YS-98	25.10 AB
T_2= Sgd-013-1	22.40 C
T_3= Sgd-013-2	19.10 D
T_4= Sorghum-2011	10.400 E
T_5= Hegari	17.60 D
T_6= JS-2002	9.80 E
T_7= No.1572	24.40 AB
T_8= No.80010	24.40 AB
T_9= I-6	9.10 E
T_{10}= PVK-801	25.60 A
T_{11}= FRI-07	23.80 BC
T_{12}= S-145	24.90 AB
LSD	1.7649

Results (Table 42) showed that maximum fresh fodder yield (25.60 t. ha^{-1}) was produced by PVK-801 followed by YS-98, S-145 and No.80010, however, all these lines/varieties were statistically at par with each other. Lowest fresh fodder yield (9.10 t. ha^{-1}) was produced by I-6.

Table 43: Post-harvest soil analysis after harvesting of sorghum 2019

pH_s	EC_e (dS m^{-1})	SAR (m mol $L^{-1})^{1/2}$
8.55- 8.93	3.57-6.23	29.03-56.57

Soil analysis data (Table 43) showed that pH_s, EC_e and SAR were reduced to some extent after harvesting of crop. pH_s ranges from 8.55- 8.93, EC_e ranges from 3.57-6.23 (dSm^{-1}) and SAR ranges from 29.03-56.57.

15. COMPARATIVE PERFORMANCE OF RHODES GERMPLASM UNDER SALINE SODIC ENVIRONMENT

A field study was conducted to study the performance and quality evaluation of Rhodes varieties in saline sodic soil under field condition. A salt affected field was selected, prepared and leveled. Composite soil samples were collected and analyzed for salinity/sodicity. Rhodes's varieties tested were; 1. Tolgor, 2. Sabre, 3. Fine cut, 4. Toro, 5. Reclaimer, 6. Kotombra. Experiment was laid out in RCBD with three replications. Tufts of grasses were planted in November 2018 according to treatment plan. One bag of DAP and SOP and half bag of Urea/acre was applied at land preparation while one bag of Urea/acre was applied after every harvest (three months). Fresh fodder yield was recorded six times in a year (up to 28-06-20).

Table 45: Initial Soil Analysis

varieties	pH_s	EC_e (dSm^{-1})	SAR ($mmol\ L^{-1})^{1/2}$
Tolgor	8.89	8.12	59.45
Sabre	8.58	10.63	51.65
Fine cut	8.75	9.40	51.92
Toro	8.88	8.74	73.90
Reclaimer	8.64	10.27	49.06
Kotombra	8.89	7.57	54.43

Table 46: Fresh fodder yield of (total of six cuttings)

Grasses	Fodder yield (t. ha^{-1})
Tolgor	64.92 C
Sabre	78.66 B
Fine cut	55.20 C
Toro	89.71 A
Reclaimer	56.47 C
Kotombra	56.83 C
LSD	10.059

Fodder yield analysis data (Table 46) showed that maximum fodder yield (89.71 t. ha^{-1}) was produced by Toro followed by Sabre. While, minimum fodder yield (55.20 t. ha^{-1}) was produced by Fine cut.

Table 47: Post-harvest soil analysis after six cuttings

pH_s	EC_e ($dS\ m^{-1}$)	SAR ($m\ mol\ L^{-1})^{1/2}$
8.55- 8.86	6.73-8.87	48.60-71.42

Soil analysis data (Table 47)showed that pH_s, EC_e and SAR were reduced to some extent after six cuttings. However, all parameters were above the safe limit in all the fields. pH_s ranges from 8.55- 8.86, EC_e ranges from 6.73-8.87 (dSm^{-1}) and SAR ranges from 48.60-71.42.

16. RESPONSE OF RYE GRASS UNDER DIFFERENT LEVELS OF SALINITY AND SODICITY

The experiment was planned to study the performance of rye grass against different salinity and sodicity levels in pots and then performance will be evaluated under field conditions. A normal soil was selected and the desired salinity/sodicity levels were developed using salts NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$. After establishing, desired levels of EC_e (6, 12 and 18 dSm^{-1}) and SAR (25, 35 and 45), the soil was filled in the glazed pots as per treatment plan. Seed of ryegrass were sown in 15-10-2019. Experiment was laid out in CRD with three replications. Fresh fodder yield was recorded five times in a season (up to 20-04-20).

Table 48: Effect of salinity/sodicity on fresh fodder yield of rye grass (total of five cuttings)

Treatments	Desired EC_e (dSm^{-1})	Desired SAR ($mmol\ L^{-1})^{1/2}$	EC_e (dSm^{-1}) Developed	SAR ($mmol\ L^{-1})^{1/2}$ Developed	Yield (g pot^{-1})
T_1	<4	<15	3.41	16.16	764.00 A
T_2	6	25	5.56	27.99	543.00 B
T_3	6	35	5.78	39.79	439.00 C
T_4	6	45	5.20	46.85	379.00 DE
T_5	12	25	11.47	23.27	398.00 D
T_6	12	35	10.17	37.99	369.00 DE
T_7	12	45	12.33	50.35	213.00 G
T_8	18	25	11.60	23.16	350.00 E
T_9	18	35	13.80	31.54	278.00 F
T_{10}	18	45	13.93	46.19	163.00 H
LSD					34.013

Fodder yield analysis data (Table 48) showed that maximum fodder yield (764 g/pot) was produced in control, whereas dual stress of salinity and sodicity decreased the fodder yield of rye grass and minimum fodder yield (163 g/pot) was produced at the highest level of EC_e (18 dSm^{-1}) + SAR (45).

5.4 PLANT NUTRITION DIVISION

17. FERTILIZER REQUIREMENTS OF SALT TOLERANRT FINE ADVANCE RICE LINES IN SALINE-SODIC SOIL

The experiment was conducted to determine optimum rate of NPK for salt tolerant fine advance rice lines in saline-sodic soil. Two advance fine rice lines SRI 23 and SRI 25 were tested with different fertilizer application rates i.e. T_1 0-0-0, T_2 0-86-60, T_3 75-86-60, T_4 150-86-60, T_5 225-86-60, T_6 150-0-60, T_7 150-43-60, T_8 150-129-60, T_9 150-86-0, T_{10} 150-86-30, T_{11} 150-86-90 NPK kg ha^{-1}. A moderately saline-sodic field {pH_s, 8.65 EC_e 5.73 dS/m, SAR 35.19 $(mmol/L)^{1/2}$, O.M 0.40 (%), available P 8.20 mg/kg, and extractable 106.70 mg/kg} was selected. Field was prepared and leveled. Experiment was conducted according to split plot design. Fertilizer rates were kept in sub plot, while rice Advanced lines were kept in main plot. Sub plot size was 6m x4m. Whole P, K and 1/3 N was applied at the time of rice transplanting, while remaining N was applied in two splits i.e. 25 and 45 days after transplanting. Data regarding paddy yield was recorded at maturity. Results (Table 49) showed that different rates of fertilizer application have significant effect on paddy yield of rice advance lines. Maximum paddy yield (2.82 t/ha) of both rice advance lines was recorded in the treatment where NPK was applied @ 225-86-60 kg/ha and it remained statistically non-significant with NPK application rate @ 150-129-60 kg/ha producing paddy yield (2.68 t/ha). Minimum paddy yield (1.05 t/ha) was observed in control treatment without NPK application. Both varieties differed significantly from each other, Advance line SRI-25 gave higher yield than SRI-23. Interaction between Fertilizer application rates and advance rice lines was significant. Maximum paddy yield of advance line SRI-25 (2.94 t/ha) was observed at fertilizer application rate 225-86-60 NPK kg/ha and it differed non-significantly with advance lines SRI-23 at same fertilizer application rate producing (2.71 t/ha) paddy yield. Minimum paddy yield (0.98 t/ha) and (1.11 t/ha) was produced by SRI-23 and SRI-25 advance rice lines respectively in control treatment without fertilizer application.

Table 49: Effect of different treatments of NPK application on paddy yield of two advance salt tolerant rice lines

Treatments (NPK kg ha^{-1})	Variety SRI 23	Variety SRI 25	Mean
T1(0-0-0)	0.98 l	1.11 kl	1.05 H
T2 (0-86-60)	1.33 jk	1.51 ij	1.42 FG
T3 (75-86-60)	1.75 hi	1.90 gh	1.82 E
T4 (150-86-60)	2.33 def	2.54 bcd	2.43 CD
T5 (225-86-60)	2.71 abc	2.94 a	2.82 A
T6 (150-0-60)	1.22 jkl	1.32 jk	1.27 G
T7 (150-43-60)	1.50 ij	1.68 hi	1.59 F
T8 (150-129-600	2.59 bcd	2.77 ab	2.68 AB
T9 (150-86—0)	1.89 gh	2.15 fg	2.02 E
T10 (150-86-30)	2.19 efg	2.46 cde	2.32 D
T11 (150-86-90)	2.48 bcde	2.70 abc	2.59 BC
Mean	1.90 B	2.09 A	

LSD for Treatments = 0.2109 , LSD for varieties = 0.1534, LSD for interaction = 0.2982

Table 50: Post harvest soil analysis: Salinity / Sodicity parameters

Treatments	pH_s		EC_e (dS m^{-1})		SAR (mmol $L^{-1})^{1/2}$	
	V_1	V_2	V_1	V_2	V_1	V_2
T_1 (0-0-0)	8.63	8.61	5.75	5.60	33.10	32.26
T_2 (0-86-60)	8.63	8.60	5.82	5.58	32.56	30.42
T_3 (75-86-60)	8.63	8.60	5.80	5.58	32.15	30.05
T_4 (150-86-60)	8.62	8.60	5.72	5.40	30.82	29.62
T_5 (225-86-60)	8.61	8.60	5.62	5.30	30.25	29.38
T_6 (150-0-60)	8.61	8.60	5.58	5.52	30.06	28.72
T_7 (150-43-60)	8.61	8.59	5.56	5.48	29.82	28.45
T_8 (150-129-60)	8.61	8.59	5.54	5.46	29.45	28.22
T_9 (150-86-0)	8.61	8.59	5.54	5.44	28.75	27.82
T_{10} (150-86-30)	8.60	8.57	5.52	5.42	28.12	27.48
T_{11} (150-86-90)	8.60	8.57	5.50	5.40	27.92	27.16

Table 51: Post harvest soil analysis: Fertility parameters

Treatments	Organic matter (%)		Available P (mg kg^{-1})		Extractable K (mg kg^{-1})	
	V_1	V_2	V_1	V_2	V_1	V_2
T_1 (0-0-0)	0.38	0.36	5.26	5.13	102.40	99.80
T_2 (0-86-60)	0.40	0.42	9.00	8.86	122.60	114.60
T_3 (75-86-60)	0.44	0.47	9.26	9.13	119.40	112.25
T_4 (150-86-60)	0.46	0.49	9.40	9.26	116.60	114.30
T_5 (225-86-60)	0.50	0.49	9.40	9.53	115.20	112.80
T_6 (150-0-60)	0.42	0.46	9.80	9.00	118.53	116.70
T_7 (150-43-60)	0.46	0.48	8.06	8.26	116.80	114.70
T_8 (150-129-60)	0.52	0.49	10.25	10.00	114.10	112.23
T_9 (150-86-0)	0.50	0.51	9.20	9.13	106.20	102.40
T_{10} (150-86-30)	0.52	0.51	9.16	9.00	114.30	112.76
T_{11} (150-86-90)	0.56	0.52	9.06	9.13	116.0	110.0

Salinity /Sodicity parameters of soil decreased slightly (Table 50) after rice harvest and there was better built up in fertility parameters of soils (Table-51) with increasing rates of NPK application.

18. RESPONSE OF SUNFLOWER TO BORON APPLICATION IN SALINE SODIC SOIL

Boron has ability to improve sunflower yield due to improved K/Na ratio under salt stress condition. The experiment was planned to determine the optimum level of boron for yield improvement of sunflower in saline-sodic soil. A moderately saline-sodic field {pH_s 8.65, EC_e 6.35 dS m^{-1}, SAR 36.99 (mmol $L^{-1})^{1/2}$, O.M. 0.36%, available P 6.46 mg kg^{-1}, extractable K 88.73 mg kg^{-1} and available B 0.22 mg kg^{-1}} was selected. Soil samples were collected and analysed for pH_s, EC_e, SAR, O.M. available P, extractable K and available B. Field was prepared and leveled. Sunflower crop was sown on ridges in wattar condition keeping ridge to ridge distance 75 cm and plant to plant distance 23 cm. Recommended dose of fertilizer was applied @

125-75-60 NPK kg ha^{-1}. Whole P, K, B and 1/2 N was applied at the time of sowing and remaining 1/2 N was applied at flowering stage. Source of B was Boric acid. Tested variety was FH -331. Experimental Design was RCBD with three replications. Crop was harvested at maturity. Data of Achene yield was recorded. Post-harvest soil samples were analysed for pH_s, EC_e, SAR and available B. The results are described as under:

Table 52: EFFECT OF DIFFERENR RATES OF BORON APPLICATION ON ACHENE YIELD OF SUNFLOWER (2019)

TREATMENTS	**ACHENE YIELD** (t. ha^{-1})
T_1 Control (without B application)	0.791 D
T_2 B application @ 1.0 kg ha^{-1}	0.831 D
T_3 B application @1.5 kg ha^{-1}	0.918 C
T_4 B application @ 2.0 kg ha^{-1}	0.961 BC
T_5 B application @ 2.5 kg ha^{-1}	1.005 B
T_6 B application @ 3.0 kg ha^{-1}	1.077 A
LSD	0.0608

Different treatments of boron application have significant effect on achene yield of sunflower. Results (Table 52) showed that boron application increased achene yield of sunflower. Maximum Achene yield (1.077 t. ha^{-1}) was observed in T_6 where B was applied @ 3.0 kg ha^{-1} and it was followed by boron application rate 2.5 kg ha^{-1} producing achene yield 1.005 t. ha^{-1} (Table 5). Minimum Achene yield (0.791 t. ha^{-1}) was recorded in control treatment without boron application where only recommended dose of fertilizer was applied.

Table 53: SOIL ANALYSIS AFTER HARVEST OF SUNFLOWER (2019)

TREATMENTS	**pHs**	**ECe** (dS m^{-1})	**SAR** (mmol $L^{-1})^{1/2}$	**Available B** (mg kg^{-1})
T_1 Control (without application)	8.64	6.33	32.94	0.22
T_2 B application @ 1.0 kg ha^{-1}	8.64	6.32	30.77	0.28
T_3 B application @1.5 kg ha^{-1}	8.63	6.31	32.06	0.36
T_4 B application @ 2.0 kg ha^{-1}	8.62	6.30	31.84	0.40
T_5 B application @ 2.5 kg ha^{-1}	8.62	6.30	31.81	0.44
T_6 B application @ 3.0 kg ha^{-1}	8.62	6.29	31.31	0.46

Soil analysis after sunflower harvest (Table 53) showed that salinity/sodicity parameters of the soil decreased and there was better built up of boron with increasing rates of boron application in soil.

19. INVESTIGATION OF SALT TOLERANCE OF POMEGRANATE UNDER SALINE SODIC CONDITIONS

The objective of study was to investigate salt tolerance potential of pomegranate saplings under saline-sodic soil conditions. A normal sandy loam soil wasselected and characterize for EC_e, pH_s, SAR, organic matter, available P, extractable K and soil texture. Desired Salinity/Sodicity levels were developed artificially using Na_2SO_4, NaCl. $CaCl_2$ and $MgSO_4$ using quadratic equation.

Tested varieties of pomegranate were Sahiwal Red and Sahiwal white. Earthen pots of 10 kg capacity were filled with soil after developing desired salinity/sodicity levels. Six month old one sapling per pot was planted. One percent urea solution will be applied after every six month. Experimental Design CRD with three replications. Data regarding Plant height, stem girth, No. of branches and leaf per plant recorded after the plantation of saplings and after every six months. Leaves samples will be analyzed for N, P, K, Na, Ca and Mg after every six months and same elements will be determined from leaves, stem and roots after three year.

Table 55: Base line data of Sahiwal red variety of pomegranate

Treatments	**Stem girth (cm)**	**Plant Height (cm)**	**No.of branches/plant**
T1 EC< 4.0, SAR< 15	0.86	83.0	4.66
T2 EC6.0, SAR 25	0.68	80.3	2.66
T3 EC 8.0, SAR 25	0.23	76.0	2.66
T4 EC 10.0, SAR 25	0.48	82.3	3.33
T5 EC6, SAR 30	0.23	83.6	3.66
T6 EC8, SAR 30	0.48	77.3	4.0
T7 EC 10, SAR 30	0.40	91.0	2.0
T8 EC 6.0, SAR 35	0.40	56.6	3.33
T9 EC 8.0, SAR 35	0.35	65.3	3.33
T10 EC 10.0, SAR 35	0.25	82.6	3.66

Each figure is average of three plants

Table: 56 Base line data of Sahiwal white variety of pomegranate

Treatments	Stem girth (cm)	Plant Height (cm)	No.of branches/plant
T1 EC< 4.0, SAR< 15	0.76	87.6	4.66
T2 EC6.0, SAR 25	0.20	57.0	3.00
T3 EC 8.0, SAR 25	0.30	75.6.	4.33
T4 EC 10.0, SAR 25	0.53	82.3	3.33
T5 EC6, SAR 30	0.40	64.6	5.00
T6 EC8, SAR 30	0.33	57.3	4.33
T7 EC 10, SAR 30	0.46	50.3	4.00
T8 EC 6.0, SAR 35	0.63	44.6	4.66
T9 EC 8.0, SAR 35	0.56	68.0	5.33
T10 EC 10.0, SAR 35	0.30	66.6	4.66

Each figure is average of three plants

20. FEASIBILITY OF GROWING QUINOA IN SALT AFFECTED SOIL WITH BRACKISH WATER

The experiment was conducted to check the performance of quinoa in highly{ pHs 8.80 EC 7.62 dS m^{-1}, SAR 36.14 (mmol $L^{-1})^{1/2}$, O.M. 0.35%, Available P 6.80 mg kg^{-1} and Extractable K 5.8598.0 mg kg^{-1} } and moderately salt affected soil { pHs 8.56 EC 5.85 dS m^{-1}, SAR 24.60 (mmol $L^{-1})^{1/2}$, O.M. 0.46%, Available P 8.80 mg kg^{-1} and Extractable K 112.0 mg kg^{-1}} with brackish water { EC 1.35 dS m^{-1}, SAR 8..06 (mmol $L^{-1})^{1/2}$ and RSC 6.40 meL^{-1}}. Field were leveled and prepared. Quinoa varieties were sown with ridge sowing technique. Ridge to ridge distance was 45 cm and plant to plant distance was 30 cm. Seed rate was 7.0 kg ha^{-1}. Fertilizers were applied @ 100-75-60 NPK kg ha^{-1}. Whole P, K, and 1/2 N was applied at the time of sowing, while remaining 1/2 N was applied at first irrigation. Crop was harvested at maturity. Grain yield data was recorded (Table 6). After the harvest of quinoa, soil samples were collected and analyzed for pH_s, EC_e, SAR, OM, available P and K. Experimental Design was RCBD with three replications.

Table 57: Grain yield of quinoa varieties at medium and high soil salinity

Varieties	**Medium Salinity level EC (5.85dS m^{-1})**	**High Salinity Level EC (7.62 dS m^{-1})**
V9	1.125 A	0.625 A
V11	0.950 B	0.575 AB
V15	0.875 BC	0.525 AB
V45	0.900 BC	0.600 AB
V81	0.850 BC	0.550 B
V82	0.825 C	0.565 AB
LSD	0.1014	0.1052

Grain yield of quinoa (Table 57) in medium salinity field ranged from 1.125 to 0.825 t. ha^{-1}. Maximum grain yield 1.125 t. ha^{-1} was produced by quinoa line V9 and it differed significantly with all remaining five lines of quinoa . Quinoa lines V11, V15, V45, and V81 remained statistically at par with each for producing grain yield. Minimum grain yield 0.825 t. ha_{-1} was produced by line V82 which remained statistically at par with lines V81, V45 and V15 producing grain yield 0.850, 0.900, 0.875 t. ha^{-1} respectively. Grain yield of quinoa at high salinity field ranged from 0.625 to 0.525 t. $ha^{-1.}$ Maximum grain yield 0.625 t. ha^{-1} was produced by quinoa line V9 and it differed non significantly with quinoa lines V11, V15, V45 and V82 and significantly with line V81 line of quinoa. Quinoa lines V11, V15, V45, V81 and V82 remained statistically at par with each kfor producing grain yield. Minimum grain yield 0.525 t. ha^{-1} was produced by line V15 which remained statistically at par with all remaining five lines of quinoa.

TABLE 58: P**ost harvest soil analysis of medium salinity field**

Varieties	**pHs**	**ECe** (dS m^{-1})	**SAR** $(mmolL^{-1})^{1/2}$	**O.M.** (%)	**Available** P (mg kg^{-1})	**Extractable** K (mg kg^{-1})
V9	8.55	5.81	23.48	0.53	10.26	121.36
V11	8.54	5.78	23.36	0.52	10.46	122.46
V15	8.52	5.74	23.21	0.53	10.66	119.53
V45	8.51	5.73	23.56	0.57	10.46	120.26
V81	8.51	5.72	23.24	0.58	10.73	118.80
V82	8.50	5.70	23.10	0.59	10.86	118.06

TABLE 59: Post harvest soil analysis of high salinity field

Varieties	pHs	ECe (dS m^{-1})	SAR $(mmolL^{-1})^{1/2}$	O.M. (%)	Available P (mg kg^{-1})	Extractable K(mg kg^{-1})
V9	8.69	7.58	35.19	0.40	8.73	104.13
V11	8.67	7.57	34.93	0.44	8.93	105.36
V15	8.67	7.54	34.75	0.45	9.00	107.43
V45	8.66	7.55	35.58	0.41	8.53	102.60
V81	8.66	7.57	36.01	0.40	8.40	101.93
V82	8.66	7.56	35.36	0.39	8.53	103.70

Soil analysis after harvesting of quinoa (Table 58 & 59) showed that salinity / sodicity parameters of soil decreased and there was slight improvement in fertility parameters of the soil.

21. RESPONSE OF CANOLA TO SULPHUR AP{PLICATION IN SALINE SODIC SOIL

The objective of this study was to determine optimum rate of sulphur for yield improvement of canola in saline- sodic soil. The experiment consisted of five treatments T1: NPK @ 80-60-60 kg ha^{-1}, T2: R.D. + S @ 10 kg ha^{-1}, T3: R.D. + S @ 15 kg ha^{-1}, T4: R.D. + S @ 20 kg ha^{-1} and T5: R.D. + S @ 25 kg ha^{-1}. Moderately salt affected field (pH_s 8.63, EC_e 5.65 dS m^{-1}, SAR 27.16 $(mmmolL^{-1})^{1/2}$, O.M. 0.42%, Available P 8.40 mg kg^{-1}, extractable K 110 mg kg^{-1}, Sulphate sulphur 6.80 mg kg^{-1} and soil texture sandy loam was selected. Field was leveled and prepared in wattar condition. Treatments were applied according to treatment plan. Seed rate was 5.0 kg ha^{-1}. Fertilizers were applied @ 80-60-60 kg ha^{-1}. Whole P, K, and S were applied at the time of sowing, while N was applied in two splits. i.e. 1/2N at first irrigation and remaining 1/2 N was applied at flowering stage. Crop was harvested at maturity. Data regarding grain yield was recorded. Experimental design was RCBD with tree replications. Plot size was 5m x 4m. The source of S was gypsum (18.60 % S)

Table 60: Effect of different rates of sulphur on grain yield of canola

Treatments	Grain yield (t. ha^{-1})
T_1 (80-60-60 NPK kg ha^{-1})	0.56 D
T_2 (R.D. + S @ 10 kg ha^{-1})	0.63 CD
T_3 (R.D. + S @ 15 kg ha^{-1})	0.74 BC
T_4 (R.D. + S @ 20 kg ha^{-1})	0.86 AB
T_5 (R.D. + S @ 25 kg ha^{-1})	0.91 A
LSD	0.1230

Different treatments of sulphur application have significant effect on grain yield of canola. Maximum grain yield of canola 0.91 t. $ha^{-1}$was recorded in the treatment where S @ 25 kg ha^{-1} with recommended dose of NPK was applied and it remained statistically at par with S rate applied @ 20 kg ha^{-1} producing canola yield 0.86 t. ha^{-1}. Minimum grain yield of canola 0.56 t. ha^{-1} was observed in control treatment where only recommended dose of NPK was applied without S application (Table 60).

Table 61: Post harvest Soil Analysis

Treatments	pH_s	EC_e (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$	SO_4- S (mg kg^{-1})	O.M. (%)	Available P (mg kg^{-1})	Extractable K (mg kg^{-1})
T_1 (80-60-60 NPK kg ha^{-1})	8.62	5.63	26.60	6.20	0.47	8.80	124.66
T_2 (R.D. + S @ 10kg ha^{-1})	8.62	5.62	25.54	7.20	0.48	8.60	118.80
T_3 (R.D. + S @ 15 kg ha^{-1})	8.61	5.59	25.19	7.60	0.51	8.60	116.60
T_4 (R.D. + S @ 20 kg ha^{-1})	8.60	5.56	24.80	8.40	0.54	8.40	113.33
T_5 (R.D. + S @ 25 kg ha^{-1})	8.59	5.55	24.67	9.60	0.57	8.20	113.33

5.5 AGRONOMY DIVISION

22. EFFECT OF TRANSPLANTING DATES ON THE YIELD OF FINE GRAIN RICE LINES IN SALT AFFECTED SOILS

Study was conducted with objective to determine the transplanting date of new fine grain rice lines for getting optimum yield in salt affected soils. A salt affected field (pH= 8.75, EC= 5.33 (dS/m) and SAR= 35.49 (mmol/L)$^{1/2}$)was selected. The experiment was laid out in split plot design with three replications. rice varieties were kept in main plot and sowing date in sub-plots. Treatments included were A; Varieties (SRI-23, SRI-25) B; Sowing dates (1st June, 15 June, 1st July, 15 July). Recommended dose of fertilizers (150-85-60 NPK kg ha^{-1}) was applied to rice. The rice varieties were transplanted on different sowing dates according to the layout plan. All agronomic and plant protection measures were applied uniformly. Crop was harvested on 29-10-2019and paddy yield data was recorded.

Table 62: Effect of different transplanting dates on rice varieties 2019

Treatments	SRI-25	SRI-23	Mean
1st June	2.81 ABC	2.43 C	2.62 B
15 June	2.96 ABC	2.50 BC	2.73 AB
1st July	3.19 A	2.77 ABC	2.98 A
15 July	2.97 AB	2.69 ABC	2.83 AB
Mean	2.98 A	2.60 B	

The results (Table 62) indicated that the maximum paddy yield (3.19 t/ha) was recorded from SRI-25and where crop was sown on 1st July which was statistically similar to transplanting date of15 July (2.97 t/ha) and SRI-23,sown on 1st July and 15 July. Among the varieties, SRI-25 gave more paddy yield (2.98 t/ha) when compared with SRI-23. Similarly, 1st July produced higher paddy yield (2.98 t/ha) followed by 15 July (2.83 t/ha). The minimum paddy yield (2.62 t/ha) was obtained where crop was sown on 1st June.

Table 63: Soil analysis after rice 2019

Treatments	SRI-25			SRI-23		
	pH_s	EC_e (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$	pH_s	EC_e (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$
1st June	8.73	5.20	32.60	8.74	5.22	32.63
15 June	8.72	5.23	32.20	8.72	5.23	32.10
1st July	8.72	5.21	32.26	8.72	5.20	32.10
15 July	8.72	5.21	32.27	8.72	5.20	32.00

In case of soil analysis (Table 63) pH_s, EC_e and SAR were above the safe limits in all the treatments.

23. INVESTIGATION OF SALT TOLERANCE OF MORINGA SAPLINGS UNDER SALINE SODIC CONDITION

Study was conducted with objective to investigate salt tolerance potential of moringa saplings under saline sodic soil condition. Trial was laid out in CRD design with three replications. A normal soil was selected and the desired salinity / sodicity levels were developed using quadratic equation by adding salts of NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$. Treatments included were combinations of EC_e and SAR (<4,6,912 and <13.2,20.30,40 respectively). After establishing desired levels of Ec_e and SAR, the soil was filled in 20 kg earthen pots as per treatment plan. Three saplings of two month age were transplanted in each pot and after plant establishment one plant per pot was maintained. All agronomic and plant protection measures were applied uniformly.

Data: All the saplings not survived/ dried in all treatments except control.

24. INVESTIGATION OF SALT TOLERANCE POTENTIAL OF MORINGA UNDER SALINE SOIL CONDITION

Study was conducted with objective to investigate salt tolerance potential of direct seeded moringa plants under saline soil condition. Trial was laid out in CRD design with three replications. A normal soil was selected and the desired salinity / sodicity levels were developed using quadratic equation by adding salts of NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$. Treatments included were combinations of Ec_e and SAR (<4,6,912 and <13.2,20.30,40 respectively). After establishing desired levels of Ec_e and SAR, the soil was filled in 20 kg earthen pots as per treatment plan. Three seeds were planted in each pot and after plant establishment one plant per pot was maintained. All agronomic and plant protection measures were applied uniformly.

Data: germination %age was below normal in all the pots except in control.

25. SCREENING OF SUGAR BEET VARIETIES IN SALINITY BLOCKS AGAINST DIFFERENT SALINITY / SODICITY LEVELS

The experiment was conducted in salinity blocks at Soil Salinity Research Institute, Pindi Bhattian to study the performance of sugar beet varieties against different salinity / sodicity levels. Artificial salinity and sodicity levels were developed in the salinity blocks by adding calculated quantity of salts i.e. NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$ using quadratic equation. The experiment was laid out in CRD with factorial arrangement having three replications. The treatments included in the experiment were as follows: A). Sugar beet varieties (California, Arnestina, Aranka & Serenada) and B). Salinity / Sodicity levels (i. EC_e<4 dSm^{-1} + SAR <15 $(mmolL^{-1})^{1/2}$, ii. EC_e=8 dSm^{-1} + SAR =20 $(mmolL^{-1})^{1/2}$ and iii. EC_e=12 dSm^{-1} + SAR =40 $(mmolL^{-1})^{1/2}$). Recommended dose of fertilizer (120-70-45 NPK kg ha^{-1}) was applied to the crop. The crop was planted in each salinity block manually on 22.11.2019. All other agronomic measures were adopted uniformly. The crop was harvested at maturity on 05.05.2020 and data were recorded. The soil samples were also collected after the harvest of crop to determine the change in the pHs, EC_e and SAR of the soil. Data regarding the sugar beet yield (Table-1) clearly indicated that the highest yield was recorded in Serenanda (97.91 t ha^{-1}) which was found statistically at par with Arnestina (92.86 t ha^{-1}). However California (85.73 t ha^{-1}) and Aranka (79.74 t ha^{-1}) were statistically non-significant. Similarly among the salinity levels, the maximum sugar beet yield was obtained at EC_e<4 dSm^{-1} + SAR <15 $(mmolL^{-1})^{1/2}$ followed by EC_e=8 dSm^{-1} + SAR =20 $(mmolL^{-1})^{1/2}$ gave 116.46 and 91.08 t ha^{-1} respectively. The lowest sugar beet yield (59.64 t ha^{-1}) was obtained at EC_e=12 dSm^{-1} + SAR =40 $(mmolL^{-1})^{1/2}$).

Table-64: Effect of different salinity/ sodicity levels on the yield (t ha^{-1}) of different sugar beet varieties in salinity blocks

TREATMENTS	**EC_e = <4 dSm^{-1} & SAR = <15 $(mmolL^{-1})^{1/2}$**	**EC_e = 8 dSm^{-1} & SAR = 20 $(mmolL^{-1})^{1/2}$**	**EC_e = 12 8 dSm^{-1} & SAR = 40 $(mmolL^{-1})^{1/2}$**	**Mean**
California	111.10 bc	88.10 ef	58.00 gh	85.73 B
Arnestina	120.67 ab	95.50 de	62.40 g	92.86 A
Aranka	108.90 c	78.93 f	51.40 h	79.74 B
Serenada	125.17 a	101.80 cd	66.77 g	97.91 A
Mean	116.46 A	91.08 B	59.64 C	

LSD for Salinity levels = 5.3880, LSD for interaction= 10.776 and LSD for varieties= 6.2215

Table-65: Post harvest change in the salinity/ sodicity status of the salinity blocks

Variety	**EC_e = <4 dSm^{-1}& SAR = <15 $(mmolL^{-1})^{1/2}$**			**EC_e = 8 dSm^{-1} & SAR = 20 $(mmolL^{-1})^{1/2}$**			**EC_e = 12 8 dSm^{-1} & SAR = 40 $(mmolL^{-1})^{1/2}$**		
	pH_s	**EC_e**	**SAR**	**pH_s**	**EC_e**	**SAR**	**pH_s**	**EC_e**	**SAR**
California	8.27	3.52	10.71	8.47	9.56	22.3.64	8.54	12.89	42.87
Arnestina	8.33	3.47	11.45	8.52	10.25	23.33	8.35	12.86	43.41
Aranka	8.31	3.44	9.11	8.45	10.11	23.87	8.64	12.70	43.18
Serenada	8.26	3.31	8.47	8.41	9.47	22.89	8.41	13.81	41.22

26. PERFORMANCE OF SUGAR BEET VARIETIES ON MODERATELY SALINE SODIC SOIL

The experiment was planned in collaboration with sugarcane research board (AARI-Faisalabad), Safina Sugar Mill, Lalian (Chiniot) and Soil Salinity Research Institute (Pindi Bhattian). Sugarcane Research Board provided only one variety (Serenada) during the Rabi-2019-20. The trial was conducted at Research Farm, Soil Salinity Research Institute, Pindi Bhattian during the Rabi-2019-20 to check the performance of sugar beet varieties suitable for cultivation in salt affected. For this purpose a moderately saline sodic field (pH_s=8.67, EC_e=4.65 dSm^{-1} and SAR= 36.72 $mmolL^{-1})^{1/2}$) was selected and well prepared for sowing. The variety was planted on double row beds spaced at 45 cm by maintaining plant to plant distance of 15cm. The crop was on 21.11.2019.The requisite data were recorded at maturity of the crop. The crop was harvested on 06.05.2020. Table-3 depicted that serenada gave yield of 89.3 t ha^{-1} under saline-sodic field conditions.

Table-66: Performance of sugar beet variety (Serenada) on moderately saline sodic soil

Variety	Yield (t/ha)
SERENADA	89.3

Note: During year 2019-20 seed of only one variety (Serenada) was available for field experiment

Table-67: Post harvest soil analyses

Variety	pH_s	EC_e (dSm^{-1})	SAR (mmol $L^{-1})^{1/2}$
SERENADA	8.63	4.47	33.85

27. YIELD PERFORMANCE OF DIFFERENT WHEAT VARIETIES AS AFFECTED BY VARIOUS SOWING DATES IN SALT AFFECTED SOIL

The experiment was designed to study the performance of wheat varieties to optimize the sowing dates in view of the erratic changes in climate for salt affected soils. The trial was conducted on Research Farm, Soil Salinity Research Institute, Pindi Bhattian during the Rabi 2019-20. A salt affected field was selected and well prepared for sowing of the crop according to the treatment plan. The treatments used in the study were: A). Sowing dates (10 November, 20 November, 30 November & 10 December) and B). Wheat varieties (FSD-08, Johar-16, Anaj-17 & Ujala-16). The experiment was laid out in split plot design with three replications. Sowing dates were placed in main plots while the wheat varieties were kept in sub plots. The crop was sown with tractor drawn rabi drill. Recommended dose of fertilizer (120-110-70 NPK ha^{-1}) was applied to each experimental unit. The crop was harvested on 08.05.2020 and data were recorded. Results presented in the table 5 indicated that the maximum grain yield was obtained where crop was sown on 20 November (3.31 t ha^{-1}) followed by 10 November (3.02 t ha^{-1}). However the lowest grain yield was recorded in the crop planted on 10 December (1.94 t ha^{-1}). The wheat variety FSD-08 out yielded (3.05 t ha^{-1}) the other varieties. Anaj-17 and Ujala-16 were statistically at par with each other with grain yield of 2.79 and 2.68 t ha^{-1} respectively. The interactive effect of sowing dates and wheat varieties was statistically non-significant. Soil samples were also collected and analyzed for pH_s, EC_e and SAR. The change in these soil parameters is presented in the table-68.

Table-67: Effect of various sowing dates on the yield performance of different wheat varieties under salt affected soil

TREATMENTS	10 November	20 November	30 November	10 December	Mean
FSD-08	3.25 b	3.72 a	2.98 cd	2.27f	3.05 A
Johar-16	2.89 de	2.93 de	2.12 fg	1.65 i	2.40 C
Anaj-17	2.99 cd	3.38 b	2.80 de	2.00 gh	2.79 B
Ujala-16	2.95 de	3.21bc	2.71 e	1.83 hi	2.68 B
Mean	3.02 B	3.31 A	2.65 C	1.94 D	

LSD for Sowing dates =0.1183, LSD for interaction= 0.2380 and LSD for varieties= 0.1196

Table-68: Post harvest soil analyses

Treatments	10 November			20 November			30 November			10 December		
	pH_s	EC_e (dS m^{-1})	SAR (mmol L^{-1})$^{1/2}$	pH_s	EC_e (dS m^{-1})	SAR (mmol L^{-1})$^{1/2}$	pH_s	EC_e (dS m^{-1})	SAR (mmol L^{-1})$^{1/2}$	pH_s	EC_e (dS m^{-1})	SAR (mmol L^{-1})$^{1/2}$
FSD-08	8.62	6.55	30.11	8.61	6.57	30.37	8.62	6.60	29.87	8.68	6.65	30.12
Johar-16	8.63	6.57	31.20	8.58	6.61	29.82	8.64	6.69	30.67	8.71	6.67	31.15
Anaj-17	8.65	6.61	30.80	8.61	6.63	30.23	8.63	6.66	30.55	8.68	6.72	30.23
Ujala-16	8.65	6.60	30.55	8.60	6.63	30.47	8.64	6.67	31.11	8.71	6.66	30.76

5.6 ENGINEERING DIVISION

28. EFFECT OF DIFFERENT IRRIGATION FREQUENCIES ON DIRECT SEEDED RICE IN SALT AFFECTED SOIL

The trial was conducted to find out the delta of water and irrigation frequencies for direct seeded rice in salt affected soils. For this purpose four irrigation intervals 4 days, 6 days, 8 days and 10 days were studied. Moderately salt affected field as described in table 01 was selected, leveled and prepared. Irrigations were applied using cut-throat flume. The experiment was conducted for rice crop in RCB Design having three replications.

Table 69 :Soil analyses before start of study

Parameter	Soil Depth (0-15) cm	Soil Depth (15-30) cm
pH_s	8.80	9.01
EC_e (dS m^{-1})	4.33	3.46
SAR (mmol $L^{-1})^{1/2}$	30.15	30.77
BD (Mg m^{-3})	1.53	----
HC (cm hr^{-1})	0.48	----

In kharif season rice crop was sown on 18th June, 2019 and recommended dose of NPK for rice 150-85-60 kg ha^{-1} was applied. Data on paddy was recorded on 25th October, 2019.

Table 70: Effect of Irrigation Frequencies on Paddy and Straw Yield (t ha^{-1})

Irrigation Frequency	Paddy Yield (t ha^{-1})	Straw yield (t ha^{-1})	No. of Irrigations Applied	Delta of water (Inches)	Water use Efficiency (kg ha^{-1} mm^{-1})
4 Days	3.14 B	6.31 B	24	84.85	1.46
6 Days	3.39 A	6.81 A	15	57.85	2.31
8 Days	3.28 AB	6.69 AB	12	48.85	2.64
10 Days	2.45 C	5.45 C	8	36.85	2.62
LSD	0.2294	0.3840			

Note: Rainfall (12.85 inches) occurred during kharif-2019 is included in delta of water.

Results (table 70) showed that maximum paddy yield (3.39 t ha^{-1}) was obtained where irrigation was applied after 6 days interval and minimum paddy yield (2.45 t ha^{-1}) was obtained using irrigation interval of 10 days. However maximum water use efficiency (2.64 kg $ha^{-1}mm^{-1}$) was obtained in the treatment where irrigation was applied after 8 days interval which was followed by 10 days irrigation interval i.e. 2.64 kg $ha^{-1}mm^{-1}$.

Table 71:Soil analysis after harvest of rice crop

Irrigation Interval	pH_s	EC_e (dS m^{-1})	SAR (mmol $L^{-1})^{1/2}$
4 Days	8.72	3.08	24.20
6 Days	8.73	3.27	25.34
8 Days	8.74	3.42	26.47
10 Days	8.75	3.69	26.95

After the harvest of rice crop soil samples were collected to analyze the soil for EC_e, pH_s and SAR as shown in table 71. Results indicated that salinity / sodicity parameters have been reduced after harvest of rice crop.

29. PERFORMANCE OF BIO-DRAINAGE PLANTS FOR THE UTILIZATION OF SALINE WATER LOGGED SOILS

This experiment was conducted to study the performance of three bio drainage plants in water logged soils as well as for utilization of water logged soils to generate income from barren land. For this purpose three bio-drainage plants were selected to check the performance of these bio-drainage plants. Water logged field was selected and analyzed for salinity sodicity parameters as shown in table 04.

Table 72:Soil analyses before start of study

Parameter	Soil Depth (0-15) cm
pH_s	8.88
EC_e (dS m^{-1})	10.32
SAR (mmol $L^{-1})^{1/2}$	65.15

Land was prepared and one foot deep furrows were made as per treatment plan. Six month old saplings were transplanted at the shoulders of these furrows. Plant to plant and row to row distance for eucalyptus, arjun and acacia ampliceps was maintained 1.5m X 1.5m, 2.5m X 2.5m and 2m X 2m respectively. Three Piezometers were installed to monitor water table depth of these three bio-drainage plants whereas one piezometer was installed on barren field. Baseline data was recorded on 28.03.2019 after survival of plants as shown in table 05.

Table 73: Baseline data

Treatments	Plant height (ft)	Plant stem girth (cm)	Water table depth (ft)
Eucalyptus	11.11	11.23	6.20
Arjun	2.76	3.195	6.25
Acacia Ampliceps	2.11	3.46	6.17
Barren	-	-	6.27

Table 74: Plant height and Plant stem girth (March 2020)

Treatments	Plant height (ft)	Plant stem girth (cm)	Water table depth (ft)
Eucalyptus	24.12 A	23.01 A	5.79
Arjun	6.03 C	9.25 C	5.86
Acacia Ampliceps	9.57 B	13.72 B	5.77
Barren	-	-	5.92
LSD	2.0468	3.0043	-

Results (table 74) showed that maximum plant growth was observed in eucalyptus plants i.e. maximum plant height of eucalyptus 24.12 feet and plant stem girth 23.01 cm which remained statistically significant with arjun and acacia ampliceps plants. Whereas, minimum water table depth was recorded with the treatment plot of acacia ampliceps plants.

Table 75: Soil analysis (March 2020)

Treatments	Soil depth (inch)				
	0-6	6-12	12-24	24-36	36-48
	pH_s				
Eucalyptus	9.25	9.00	8.62	8.56	8.44
Arjun	9.33	9.05	8.67	8.65	8.51
Acacia Ampliceps	9.29	9.02	8.65	8.58	8.48
Barren	9.37	9.16	8.79	8.72	8.65
Treatments	EC_e (dS m^{-1})				
Eucalyptus	8.55	7.85	2.96	1.69	1.63
Arjun	9.05	8.41	2.90	2.64	1.87
Acacia Ampliceps	8.86	7.30	2.42	1.76	1.40
Barren	9.44	8.78	3.29	2.66	2.13
Treatments	SAR (mmol $L^{-1})^{1/2}$				
Eucalyptus	42.43	38.48	35.99	28.91	22.50
Arjun	44.60	40.06	37.97	31.81	24.31
Acacia Ampliceps	43.18	39.96	36.88	26.98	23.16
Barren	48.89	46.65	38.64	29.07	25.90

Soil samples were also collected and analyzed for pH_s, EC_e and SAR and results (table 75) depicted that salinity sodicity has be reduced after survival of plants.

30. COMPARISON OF DIFFERENT SOWING METHODS FOR IMPROVING YIELD AND WATER USE EFFICIENCY UNDER BRACKISH WATER IRRIGATION

The experiment was conducted to compare the efficacy of different sowing methods for yield and water use efficiency improvement using brackish water in Rice-Wheat rotation. Four sowing methods i.e Broadcast sowing (Flat), Drill sowing (Flat), Ridge Sowing and Bed sowing were used in this research experiment. A normal field (table 08) was selected and prepared for sowing of rice (Shaheen basmati) by direct seeding according to treatment plan. Irrigations were applied using cut throat flume. Number of irrigations for whole season was recorded to calculate the delta of water and ultimately water use efficiency was calculated. Design was RCBD with three repeats having plot size 8m x 12m.

Table 76: Soil analyses before start of study

Parameter	Soil Depth (0-15) cm	Soil Depth (15-30) cm
pH_s	8.21	8.55
EC_e (dS m^{-1})	1.81	1.75
SAR (mmol $L^{-1})^{1/2}$	11.18	11.04
BD (Mg m^{-3})	1.44	----
HC (cm hr^{-1})	0.79	----

In Kharif season rice crop was sown on 17th June, 2019 and recommended dose of fertilizer for rice150-85-60 N, P_2O_5, K_2O kg ha^{-1} was applied. Paddy yield data was recorded on 25th October, 2019 as shown in (table 77).

Table 77: Effect of sowing methods on Yield and Water use efficiency

Sowing Method	Paddy Yield ($t\ ha^{-1}$)	Delta of water (Inches)	Water use Efficiency ($kg\ ha^{-1}\ mm^{-1}$)
Broadcast Sowing	3.13 C	48.85	2.52
Drill Sowing	3.80 A	48.85	3.06
Ridge Sowing	3.62 AB	36.85	3.87
Bed Sowing	3.46 B	28.85	4.75
LSD	0.2373		

Note: Rainfall (12.85 inches) occurred during kharif-2019 is included in delta of water.

Results (Table 77) showed that maximum paddy yield (3.80 t ha^{-1}) was recorded using Drill sowing method which remained statistically significant with other sowing methods. Whereas, maximum water use efficiency (4.75 kg $ha^{-1}mm^{-1}$) was found in the treatment where, bed sowing method was used.

Table 78:Soil analysis after harvest of rice crop

Sowing Method	pH_s	EC_e ($dS\ m^{-1}$)	SAR ($(mmol\ L^{-1})^{1/2}$)
Broadcast Sowing	8.29	3.21	16.54
Drill Sowing	8.28	2.98	15.22
Ridge Sowing	8.26	2.21	13.15
Bed Sowing	8.25	1.89	12.43

After the harvest of rice crop soil samples were collected to analyze the soil for EC_e, pH_s and SAR as shown in table 78. Results indicated that salinity / sodicity parameters have been increased in treatment of broadcast sowing and drill sowing method whereas salinity / sodicity parameters have been relatively reduced where ridge sowing and bed sowing methods were used because of less utilization of high RSC water. Moreover 12.85 inches rainfall may have helped to mitigate ill effects of brackish water.

In Rabi season wheat crop was sown on 2nd December, 2019 and recommended dose of fertilizer for wheat 120-110-70 NPK kg ha^{-1} was applied. Wheat grain yield data was recorded on 5th May, 2020 as shown in table 79.

Table 79: Effect of sowing methods on Yield and Water use efficiency

Sowing Method	Wheat Grain Yield ($t\ ha^{-1}$)	Delta of water (Inches)	Water use Efficiency ($kg\ ha^{-1}mm^{-1}$)
Broadcast Sowing	3.17 C	13	9.60
Drill Sowing	3.67 A	13	11.11
Ridge Sowing	3.48 AB	10	13.70
Bed Sowing	3.38 BC	8	16.63
LSD	0.2871		

Results (Table 79) showed that maximum wheat grain yield (3.67 t ha^{-1}) was recorded using Drill sowing method which remained statistically significant with other sowing methods. Whereas, maximum water use efficiency (16.63 kg ha^{-1} mm^{-1}) was found in the treatment where, bed sowing method was used.

Table 80: Soil analysis after harvest of wheat crop

Sowing Method	**pH_s**	**EC_e** ($dS\ m^{-1}$)	**SAR** ($(mmol\ L^{-1})^{1/2}$)
Broadcast Sowing	8.33	3.76	17.87
Drill Sowing	8.32	3.28	16.45
Ridge Sowing	8.28	2.54	14.08
Bed Sowing	8.26	2.21	13.11

After the harvest of wheat crop soil samples were collected to analyze the soil EC_e, pH_s and SAR as shown in table 80. Results indicated that salinity / sodicity parameters have been increased due to application of brackish water.

31. LONG TERM EFFECT OF CROP RESIDUE MANAGEMENT USING DIFFERENT TILLAGE PRACTICES ON YIELD AND PHYSICO-CHEMICAL PROPERTIES OF MODERATELY SALT AFFECTED SOILS

This study was planned to study the long term effect of crop residue management on yield of wheat-rice system and soil physico-chemical properties of moderately salt affected soils. For this purpose, five treatments were studied i.e (i) Removal of crop residue, (ii) Incorporation of crop residue by disc harrow and MB plough, (iii) Incorporation of crop residue by disc harrow and MB plough + Urea @ 40 kg ha^{-1} for decomposition, (iv) Incorporation of crop residue by straw chopper and (v) Incorporation of crop residue by straw chopper + Urea @ 40 kg ha^{-1} for decomposition. A moderately salt affected field as described in table 13 was selected and prepared for the sowing of wheat crop.

Table 81: Soil analyses before start of study

Parameter	**Soil Depth (0-15) cm**
pH_s	8.79
EC_e ($dS\ m^{-1}$)	5.08
SAR $(mmol\ L^{-1})^{1/2}$	32.48
O.M (%)	0.52
BD ($Mg\ m^{-3}$)	1.52
HC ($cm\ hr^{-1}$)	0.47

In Kharif season transplanting of rice seedling was completed on 17^{th} July, 2019 and recommended dose of fertilizer for rice 150-85-60 N, P_2O_5, K_2Okg ha^{-1} was applied. Paddy yield data was recorded on 25^{th} October, 2019 as shown in table 82.

Table 82: Effect of crop residue management techniques on Paddy Yield

Treatments	Paddy Yield ($t\ ha^{-1}$)
Removal of crop residue	2.34 C
Incorporation of crop residue by disc harrow and MB plough	2.41 BC
Incorporation of crop residue by disc harrow and MB plough + Urea @ 40 kg ha^{-1} for decomposition	2.57 AB
Incorporation of crop residue by straw chopper	2.48 BC
Incorporation of crop residue by straw chopper + Urea @ 40 kg ha^{-1} for decomposition	2.71 A
LSD	0.1864

Results showed that maximum paddy yield (2.71 t ha^{-1}) was recorded where incorporation of crop residue was done by straw chopper + Urea @ 40 kg ha^{-1} which remained statistically significant with other crop residue management techniques. Whereas, minimum paddy yield (2.34 t ha^{-1}) was recorded in removal of crop residue treatment (Table 82).

Table 83: Soil analysis after harvest of rice crop

Treatments	pH_s	EC_e ($dS\ m^{-1}$)	SAR $(mmol\ L^{-1})^{1/2}$
Removal of crop residue	8.79	4.91	31.63
Incorporation of crop residue by disc harrow and MB plough	8.76	4.76	31.34
Incorporation of crop residue by disc harrow and MB plough + Urea @ 40 kg ha^{-1} for decomposition	8.76	4.71	31.06
Incorporation of crop residue by straw chopper	8.75	4.74	31.12
Incorporation of crop residue by straw chopper + Urea @ 40 kg ha^{-1} for decomposition	8.74	4.70	30.87

After the harvest of rice crop soil samples were collected to analyze the soil EC_e, pH_s and SAR as shown in table 82. Results indicated that salinity / sodicity parameters have been reduced slightly.

In Rabi season wheat crop was sown on 4th December, 2019 and recommended dose of fertilizer for wheat 120-110-70 NPK kg ha^{-1} was applied. Wheat grain yield data was recorded on 5th May, 2020 as shown in table 83.

Table 84: Effect of crop residue management techniques on Wheat Grain Yield

Treatments	Wheat Grain Yield ($t\ ha^{-1}$)
Removal of crop residue	2.28 C
Incorporation of crop residue by disc harrow and MB plough	2.39 BC
Incorporation of crop residue by disc harrow and MB plough + Urea @ 40 kg ha^{-1} for decomposition	2.58 AB
Incorporation of crop residue by straw chopper	2.53 AB
Incorporation of crop residue by straw chopper + Urea @ 40 kg ha^{-1} for decomposition	2.70 A

LSD	0.2021

Results showed that maximum wheat grain yield (2.70 t ha^{-1}) was recorded where incorporation of crop residue was done by straw chopper + Urea @ 40 kg ha^{-1} which remained statistically significant with other crop residue management techniques. Whereas, minimum wheat grain yield (2.28 t ha^{-1}) was recorded in removal of crop residue treatment (Table 84).

Table 85: Soil analysis after harvest of wheat crop

Treatments	pH_s	EC_e (dS m^{-1})	SAR (mmol L^{-1})$^{1/2}$
Removal of crop residue	8.78	4.88	31.44
Incorporation of crop residue by disc harrow and MB plough	8.75	4.71	30.91
Incorporation of crop residue by disc harrow and MB plough + Urea @ 40 kg ha^{-1} for decomposition	8.74	4.62	30.29
Incorporation of crop residue by straw chopper	8.74	4.67	30.62
Incorporation of crop residue by straw chopper + Urea @ 40 kg ha^{-1} for decomposition	8.71	4.59	29.87

After the harvest of wheat crop soil samples were collected to analyze the soil EC_e, pH_s and SAR as shown in table 85. Results indicated that salinity / sodicity parameters have been reduced slightly.

5.7 ECONOMIC BOTANY DIVISION

32. MAINTENANCE OF RICE GERM PLASM/ GENEPOOL.

The experiment was designed to preserve the genetic stock/genepool for future breeding programme. Forty-four rice varieties/lines were transplanted keeping net plot size of 5m x 0.25m. The nursery was transplanted on 11.07.2019 and crop was harvested on 23.10.2019. Recommended dose of fertilizer @ 150-90-60 NPK kg ha^{-1} was applied to trial plots. During the crop season off type plants were roughed out to maintain the purity. At maturity the seed of these 44 lines was harvested and preserved for next season.

33. HYBRIDIZATION FOR EVOLUTION OF EXTRA LONG GRAIN RICE VARIETIES TOLERANT TO SALINITY

The experiment was designed to create genetic variability for the evolution of salt tolerant rice varieties. The nursery was raised in normal soil at two different dates keeping the interval of fifteen days to synchronize the flowering and transplanted in normal soil. The recommended dose of NPK (150-90-60) kg ha^{-1} fertilizer was applied. Fifty different cross combinations were attempted and at maturity fourteen successful cross combinations were harvested and preserved for raising F_1 generation in next year.

34. EVALUATION OF F_1 GENERATION

The experiment was conducted to produce seed for raising F_2 generation. The F_1 seed of 25 crosses was soaked and got germinated in petri dishes and then was shifted in the earthen pots. The nursery from earthen pots was translated in normal soil. The plot size was kept according to availability of nursery. The recommended dose of NPK fertilizer (150-90-60) kg ha^{-1} was applied. The seed of nine cross combinations was harvested and preserved for evaluation in F_2 generation.

35. YIELD EVUALTION OF ADVANCE RICE VARIETIES/LINES IN SALT AFFECETED SOIL

The experiment was conducted to compare the yield performance of different advance lines/varieties rice in saline sodic field. The trial was laid out according to randomized complete block design with three replications having a plot size of 5m x 3m. The nursery was raised in normal soil and transplanted on 09.07.2019 and crop was harvested on 20.10.2019. Recommended dose of fertilizer @ 150-90-60 NPK kg ha^{-1} was applied. The yield performance of these lines/varieties are presented in table 86 below.

Table 86: Paddy yield of advance rice varieties/lines

Sr#	Name of entry	Yield (t ha^{-1})
1	SRI-23	2.93 A
2	SRI-25	2.91 A
3	SRI-22	2.68 B
4	SRI-24	2.57 B
5	SRI-26	2.39 C
6	Shaheen Basmati	2.38 C
7	SRI-27	2.37 C
8	SRI-28	2.20 D
9	SRI-29	2.11 DE
10	SRI-30	2.08 DEF
11	SRI-31	2.05 EFG
12	SRI-32	2.01 EFGH
13	SRI-33	1.98 FGHI
14	SRI-34	1.94 GHI
15	SRI-35	1.90 HI
16	SRI-36	1.89 HI
17	Chenab Basmati	1.88 I
18	PS-02	1.87 I
19	Noor Basmati	1.61 J
	LSD	0.1251

Results (Table 86) showed that highest paddy yield (2.93 t ha^{-1}) was produced by advance line SRI-23 that was statistically at par with SRI-25 (2.91 t ha^{-1}) whereas the lowest paddy yield (1.61 t ha^{-1}) was recorded in Noor Basmati on salt affected soil.

Initial soil analyses	**Post-harvest soil analyses**
pH_s 8.65	pH_s 8.60
EC_e 5.67 dS m^{-1}	EC_e 5.42 dS m^{-1}
SAR 35.29 (mmol L^{-1})$^{1/2}$	SAR 33.24 (mmol L^{-1})$^{1/2}$

36. ADAPTABILITY STUDY OF NEW SALT TOLERANT RICE LINES AT DIFFERENT LOCATIONS

This experiment was planned to find out the yield performance of new rice lines under different locations. The nursery was transplanted in normal field at different locations and crop harvested on different dates during the season. The recommended dose of NPK (150-90-60) kg ha^{-1} fertilizer was applied. The experiment was laid out according to RCBD having net plot size of 5m x 3m. The recommended cultural practices were carried out till maturity. At maturity yield and yield components data were recorded. Paddy yield data of all six locations are given in table 87.

Table 87: Paddy yield of rice at different locations

Sr .#	Name of variety	Location wise Paddy Yield t ha^{-1}						
		Sargodha	**Gujranwala**	**Pindi Bhattian**	**Faisalabad**	**Multan**	**Farooqabad**	**Avg.**
1	SRI-23	3.61 A	4.36 A	4.44 A	3.83 A	3.45 AB	4.69 A	4.06
2	SRI-24	2.78 DE	4.08 AB	3.04 BCD	2.81 E	3.66 A	4.28 BC	3.44
3	SRI-25	3.32 B	4.12 AB	4.21 A	3.65 AB	3.24 BC	4.54 AB	3.84
4	SRI-26	2.92 CD	4.09 AB	2.98 BCD	2.97 DE	2.87 C	4.11 C	3.32
5	SRI-27	2.56 F	3.11 D	2.83 CD	3.18 CD	3.15 BC	3.02 F	2.97
6	SRI-28	3.22 B	3.49 C	2.94 BCD	3.44 BC	2.97 C	4.04 CD	3.35
7	SRI-29	2.36 G	3.16 D	3.27 B	3.29 C	3.25 BC	4.25 C	3.26
8	SRI-30	2.83 CDE	3.51 C	2.75 D	2.91 DE	2.95 C	3.37 E	3.05
9	Shaheen	2.95 C	4.01 B	3.21 CD	2.72 E	2.24 D	3.52 E	3.10
10	Chenab	2.13 H	4.25 AB	3.13 BC	3.15 CD	2.03 D	3.41 E	3.01
11	PS-02	2.74 E	3.65 C	2.94 BCD	2.01 F	1.96 D	3.82 D	2.85
LSD		0.1700	0.2980	0.3704	0.2914	0.3955	0.2897	

Five lines out yielded all the check varieties on an average basis for six locations. The maximum average yield of 4.06 t/ha was produced by the line SRI-23 followed by SRI-25 (3.84 t ha^{-1}) SRI-24 (3.44 t ha^{-1}) SRI-28 (3.35 t ha^{-1}), SRI-26 (3.32 t ha^{-1}) and SRI-29 (3.26 t ha^{-1}) against the check varieties Shaheen Basmati (3.10 t ha^{-1}), Chenab Basmati (3.01 t ha^{-1}) and PS-02 (2.85 t ha^{-1}) respectively (Table 87).

37. SCREENING OF 20 RICE VARITIES/LINES COLLECTED FROM DIFFERENT INSTITUTES

The experiment was conducted to screen out various rice lines against salinity/sodicity. The trial was conducted in developed artificial salinity levels of EC_e 4, 6, 8 and 10 dS m^{-1} along with sodicity levels of SAR 15, 25, 30 and 35 (mmol $L^{-1})^{1/2}$ by adding salts i.e. NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$in cemented blocks. The nursery of 20 advanced lines/varieties was transplanted on 11-07-2019 keeping net plot size of 5m x 0.25m. Recommended dose of fertilizer (150-90-60 NPK kg ha^{-1}) was applied. At maturity crop was harvested on 12-11-2019. Yield data recorded are given below in table 88:

Table 88: Paddy yield under saline sodic soil

Sr. No.	Name of line/ variety	Initial Soil Analyses of salinity blocks			
		EC_e 2.57 (dS m^{-1}) SAR 11.63 $(mmolL^{-1})^{1/2}$	EC_e 5.72 (dS m^{-1}) SAR 22.35 $(mmolL^{-1})^{1/2}$	EC_e 7.64 (dS m^{-1}) SAR 29.21 $(mmolL^{-1})^{1/2}$	EC_e 9.53 (dS m^{-1}) SAR 33.46 $(mmolL^{-1})^{1/2}$
		Paddy Yield (grams/plant)			
1	SRI-22	14.65	11.03	9.00	7.00
2	SRI-23	27.20	24.12	22.00	16.00
3	SRI-24	14.89	12.61	10.80	9.00
4	SRI-25	26.07	23.15	18.80	14.08
5	SRI-26	17.60	14.60	11.00	8.00
6	SRI-27	14.69	11.15	9.00	6.00
7	SRI-28	18.04	15.09	12.00	8.00
8	SRI-29	18.00	14.07	10.00	7.00
9	SRI-30	13.60	11.21	9.00	7.00
10	SRI-31	15.02	12.57	11.00	6.00
11	SRI-32	16.70	13.18	12.20	8.00
12	Noor Bas	17.80	14.01	11.00	7.00
13	Chenab Bas	16.21	12.16	10.20	5.00
14	Shaheen Bas	14.40	13.08	12.00	9.00
15	PS-02	10.50	9.91	7.00	3.00
16	SRI-23	21.14	19.16	16.05	12.00
17	Super Bas	19.15	17.02	14.00	6.00
18	SRI-36 (p1)	14.00	13.08	11.50	6.50
19	SRI-36 (p2)	18.34	16.71	14.00	8.00
20	SRI-36 (p3)	17.00	15.02	13.00	8.50
		Post-harvest Soil Analyses of salinity blocks			
		EC_e 2.45 (dS m^{-1}) SAR 10.27 $(mmolL^{-1})^{1/2}$	EC_e 5.58 (dS m^{-1}) SAR 20.19 $(mmolL^{-1})^{1/2}$	EC_e 7.51 (dS m^{-1}) SAR 27.38 $(mmolL^{-1})^{1/2}$	EC_e 9.39 (dS m^{-1}) SAR 32.23 $(mmolL^{-1})^{1/2}$

The rice lines SRI-23 (27.20, 24.12, 22 & 16 g/plant) and SRI-25 (26.07, 23.15, 18.80 & 14.08 g/plant) performed best at all salinity levels.

38. NATIONAL UNIFORM RICE YIELD TRIAL

The experiment was arranged to compare the adoptability and yield performance of rice lines in saline sodic field. The trial was laid out in randomized complete block design with three replications keeping net plot size of 5m x 3m. The nursery was transplanted on 16.07.2019 and crop was harvested on 26.10.2019. Recommended dose of fertilizer @ 150-90-60 NPK kg ha^{-1} was applied. Paddy yield data recorded are presented in table 89 & table 90 below.

Table 89: Paddy yield under saline sodic soil

Fine Rice		
Sr. No	**ENTRY NO.**	**Yield kg ha^{-1}**
1	RF-19235	3656 A
2	RF-19221	3585 B
3	RF-19209	2646 C
4	RF-19240	2488 D
5	RF-19201	2479 E
6	RF-19243	2343 F
7	RF-19247	2305 G
8	RF-19230	2298 H
9	RF-19239	2267 I
10	RF-19250	2219 J
11	RF-19222	2196 K
12	RF-19207	2183 L
13	RF-19237	2161 M
14	RF-19244	2144 N
15	RF-19215	2133 O
16	RF-19233	1928 P
17	RF-19225	1922 Q
18	RF-19213	1878 R
19	RF-19227	1876 S
20	RF-19205	1872 T
21	RF-19211	1843 U
22	RF-19245	1773 V
23	RF-19229	1708 W
24	RF-19219	1323 X
LSD		**1.7581**

Results presented in table 89 showed that highest paddy yield 3656 kg ha^{-1} was produced by advance line RF-19235 followed by RF-19221 with 3585 kg ha^{-1} whereas the lowest paddy yield 1323 kg ha^{-1} was recorded in RF-19219 on salt affected soil.

Table 90: Paddy yield under saline sodic soil

Coarse		
Sr. No.	**ENTRY NO.**	**Yield kg ha^{-1}**
1	RC-19181	3109 A
2	RC-19159	3102 A
3	RC-19185	3101 A
4	RC-19175	3098 A
5	RC-19182	3020 B
6	RC-19195	2878 C
7	RC-19151	2813 D
8	RC-19155	2795 E
9	RC-19180	2780 EF
10	RC-19170	2779 F
11	RC-19163	2774 F
12	RC-19160	2464 G
13	RC-19169	2458 G
14	RC-19187	2418 H
15	RC-19173	2412 H
16	RC-19179	2350 I

17	RC-19152	2338I J
18	RC-19165	2323 J
19	RC-19171	2193 K
20	RC-19177	2137 L
21	RC-19190	2104 M
22	RC-19161	2088 N
23	RC-19167	1970 O
24	RC-19157	1739 P
	LSD	**15.052**

Results presented in table 90 showed that highest paddy yield 3109 kg ha^{-1} was produced by advance line RC-19181, that is statistically at par with RC-19159 (3102 kg ha^{-1}), RC-19185 (3101 kg ha^{-1}) & RC-19175 (3098 kg ha^{-1}) whereas the lowest paddy yield of 1739 kg ha^{-1} was recorded in RC-19157 on salt affected soil.

Initial soil analyses	**Post-harvest soil analyses**
pH_s 8.70-8.95	pH_s 8.63-8.89
EC_e 4.55-5.67 dS m^{-1}	EC_e 4.49-5.60 dS m^{-1}
SAR 33.24-37.59 (mmol $L^{-1})^{1/2}$	SAR 31.76-36.08 (mmol $L^{-1})^{1/2}$

39. PRE-BASIC SEED PRODUCTION OF SHAHEEN BASMATI

The experiment was laid out for the production of pre-basic seed of approved variety Shaheen Basmati. Forty panicles of selected plants from Shaheen Basmati were grown in plant to row progenies. Nine uniform progeny lines were selected to develop individual progeny blocks. Five most uniform progeny blocks were also selected and bulked to produce seed. Six kg BNS and Eighty kg pre-basic seed of Shaheen Basmati was produced.

40. MAINTENANCE OF WHEAT GERMPLASM / GENEPOOL

The experiment was conducted to preserve the genetic stock/genepool for future breeding programme. These varieties/genotypes were grown in normal soil keeping plot size of 5m x 3m. The experiment was planted 28.11.2019 and harvested on 20.04.2020. Following genotypes are maintained under this experiment.

Galaxy	SIS-27	Fateh Jang 2016
Faisalabad 2008	SIS-13	Shafaq-06
Johar-16	$14S_1P_1$	Pasban 90
Punjab 2011	SIS-12	Sahar-06
Gold	Ujala	Annaj
BAH-2809	AARI-11	Biotechnology Lines 12

Off type plants were roughed out and after harvesting seed was preserved for next year.

41. YIELD TRIAL OF PROMISING WHEAT LINES/VARIETIES

The experiment was designed to see the performance and yield potential of promising lines of wheat in saline sodic soil. The experiment was laid out in a saline sodic field according to randomize complete block design with three replications by keeping the plot size 5 m x 2.5m. Recommended dose of fertilizer (120-110-70) NPK kg ha^{-1}) was applied. The experiment was planted 30.11.2019 and harvested on 02.05.2020. Grain yield data recorded is presented in table 91 below.

Table 91: Grain yield in moderately saline sodic soil

Sr.No	Name of varieties/lines	Grain Yield (t ha^{-1})
1	$14S_1P_1$	2.73 A
2	Faisalabad	2.53 A
3	SIS-32	2.31 B
4	SIS-12	2.29 BC
5	SIS-13	2.27 BC
6	Ujala	2.26 BCD
7	Inqlab-91	2.21 BCD
8	Pasban	2.18 BCD
9	Galaxy	2.05 CDE
10	BAH-2809	2.00 DEF
11	SIS-27	1.96 EFG
12	Punjab	1.92 EFG
13	Lasani	1.89 EFG
14	Gold	1.87 FG
15	Johar-16	1.78 G
LSD		0.2105

The results (Table 91) indicated that the highest grain yield of 2.73 t ha^{-1} was recorded in advance line $14S_1P_1$ that was statistically at par with Faisalabad-2008 (2.53 t ha^{-1}) and the lowest grain yield was produced by Johar-16 that 1.78 t ha^{-1}.

Initial soil analyses

pH_s 8.25

EC_e 6.39 dS m^{-1}

SAR 28.13 (mmol $L^{-1})^{1/2}$

Post-harvest soil analyses

pH_s 8.21

EC_e 6.22 dS m^{-1}

SAR 26.45 (mmol $L^{-1})^{1/2}$

42. SCREENING OF TWENTY WHEAT VARIETIES/LINES COLLECTED FROM DIFFERENT INSTITUTES UNDER CONTROLLED CONDITION FOR SALT TOLERANCE

The experiment was designed to find out suitable lines/varieties of wheat having better yield potential under controlled salinity levels in artificially constructed cemented blocks. The salinity levels were maintained by adding salts i.e. NaCl, Na_2SO_4, $CaCl_2$ and $MgSO_4$. A single row of each variety/line was sown at each salinity level keeping net plot size of 5m x 0.20m.

Recommended dose of fertilizer (120-110-70 NPK kg ha^{-1}) was applied. The experiment was planted 27.11.2019 and harvested on 20.04.2020. The of grain yield are presented in table 92.

Table 92: Grain yield in salinity blocks

Sr. No.	Entry Name	**Initial Soil Analyses of salinity blocks**			
		EC_e 3.41 (dS m^{-1}) SAR 13.68 $(mmolL^{-1})^{1/2}$	**EC_e 7.34 (dS m^{-1}) SAR 24.59 $(mmolL^{-1})^{1/2}$**	**EC_e 11.78 (dS m^{-1}) SAR 33.21 $(mmolL^{-1})^{1/2}$**	**EC_e 15.72 (dS m^{-1}) SAR 43.51 $(mmolL^{-1})^{1/2}$**
		Grain Yield grams/plot			
1	**18C116**	291	280	240	189
2	**18C119**	211	205	176	101
3	**18C120**	181	174	139	96
4	**18C121**	193	186	151	90
5	**18C122**	288	282	144	107
6	**18C124**	298	289	237	191
7	**18C125**	294	286	243	196
8	**18C127**	145	140	113	93
9	**18C128**	171	163	126	85
10	**16C038**	175	170	139	81
11	**CH-50**	263	251	219	163
12	**Dharabi**	239	224	171	168
13	**Ihsan-16**	191	183	115	91
14	**Barani-17**	201	189	123	105
15	**Fsd-2008**	247	232	189	123
16	**SIS-2010**	237	203	163	115
17	**Fsd-85**	211	205	161	129
18	**Inqlab-91**	219	209	143	105
19	**Auqab-2000**	198	189	125	83
20	**C-518**	184	176	116	105
		Soil Analyses of salinity blocks after harvest of wheat			
		EC_e 3.29 (dS m^{-1}) SAR 12.84 $(mmolL^{-1})^{1/2}$	**EC_e 7.21 (dS m^{-1}) SAR-23.76 $(mmolL^{-1})^{1/2}$**	**EC_e 11.65 (dS m^{-1}) SAR-32.53 $(mmolL^{-1})^{1/2}$**	**EC_e 14.59 (dS m^{-1}) SAR 42.85 $(mmolL^{-1})^{1/2}$**

The results (Table 100) indicate that five lines 18C124, 18C125, 18C116, 18C122 and CH-50 produced better grain yield than other at all salinity levels.

43. EVALUATION OF NUYT WHEAT LINES UNDER 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 was laid out in RCBD with two replications keeping plot size 5m x 1.15m. The saline-sodic field having pHs 8.64-8.76 ECe 5.15 -5.98 dS m^{-1} SAR 26.09-37.12 (mmol $L^{-1})^{1/2}$ was selected. Recommended dose of fertilizer (120-110-700) NPK kg/ha was used. Sixty entries were tested. All kind of recommended agronomic practices ware followed. The experiment was planted 29.11.2019 and harvested on 02.05.2020. The yeild data are given in table 93.

Table 93 Grain Yield in saline sodic soil

Entry No	Replication	Grain Yield (Kg/ha)	Entry No	Replication	Grain Yield (Kg/ha)	Entry No	Replication	Grain Yield (kg/ha)
1	1	1608	41	1	1842	81	2	1437
2	1	1552	42	1	2161	82	2	1320
3	1	1784	43	1	1897	83	2	1480
4	1	1913	44	1	1524	84	2	1320
5	1	1625	45	1	1697	85	2	1407
6	1	1813	46	1	1753	86	2	1451
7	1	1547	47	1	1981	87	2	1350
8	1	1856	48	1	1697	88	2	1480
9	1	1958	49	1	1641	89	2	1262
10	1	2190	50	1	1608	80	2	1363
11	1	1892	51	1	1080	91	2	1190
12	1	1697	52	1	1608	92	2	1582
13	1	1981	53	1	1682	93	2	1453
14	1	1556	54	1	1798	94	2	1315
15	1	1608	55	1	1639	95	2	1552
16	1	1798	56	1	1944	96	2	1408
17	1	1763	57	1	1958	97	2	1363
18	1	1958	58	1	1653	98	2	1247
19	1	1608	59	1	1553	99	2	1233
20	1	1753	60	1	2043	100	2	2008
21	1	1741	61	2	1697	101	2	1508
22	1	1856	62	2	1842	102	2	1407
23	1	1546	63	2	1653	103	2	1363
24	1	1898	64	2	1842	104	2	1523
25	1	1842	65	2	1784	105	2	1088
26	1	1601	66	2	1653	106	2	1407
27	1	2043	67	2	1363	107	2	1480
28	1	1958	68	2	1668	108	2	1378
29	1	1842	69	2	1808	109	2	1218
30	1	1897	70	2	1509	110	2	1509
31	1	1718	71	2	1231	111	2	1335
32	1	1798	72	2	1436	112	2	1277
33	1	1897	73	2	1553	113	2	1308
34	1	1753	74	2	1363	114	2	1598
35	1	1639	75	2	1219	115	2	1553
36	1	1958	76	2	1798	116	2	1518
37	1	1608	77	2	1218	117	2	1161
38	1	1741	78	2	1886	118	2	1741
39	1	1987	79	2	1306	119	2	1888
40	1	1944	80	2	1509	120	2	1437

The entry no. 10 performed best for grain yield by producing 2190 kg ha^{-1} and the lowest grain yield 1080 kg ha^{-1} was recorded by entty no 51.

6.0 LIST OF PUBLICATIONS

6.1 Papers published from July 2019 to June 2020

1. Nawaz, M.Q., K. Ahmed, G. Qadir, M. Rizwan, M. F., Nawaz, M. Sarfraz. 2020. Growth and Yield of Turnip (*Brassica rapa* L.) in Response to Different Sowing Methods and Nitrogen Levels in Salt-Affected Soils. Pakistan Journal of Agricultural Research. 33(1); 126-134
2. Rizwan, M., K. Ahmed, M. Sarfraz, M.Q. Nawaz, A.I. Saqib, G. Qadir, F. Nawaz. 2019. Effect of different tillage implements and Gypsum for fodder production in salt Affected soils using high RSC water. Cercetări Agronomice în Moldova Vol. LII , No. 2 (178) / 2019: 166-177
3. Rizwan, M., K. Ahmed, M. Nadeem, M. F., Nawaz, M.Q. Nawaz, S. Nawaz, M. Arif, A. Umair, I. A. Warriach. 2019. Effect of nitrogen application methods and tillage implements on wheat production in salt affected soils. International Journal of Biosciences. Vol. 15, No. 6, p. 194-201, 2019
4. M. Rizwan, K. Ahmed, M. Sarfraz, M.Q. Nawaz, A.I. Saqib, G. Qadir, F. Nawaz. 2019. Effect of different tillage implements and Gypsum for fodder production in salt Affected soils using high RSC water. Cercetări Agronomice în Moldova Vol. LII , No. 2 (178) / 2019: 166-177
5. SAQIB1, A.I., K. Ahmed, G. Qadir, M.Q. Nawaz, A.R. Naseem. 2019. Enhancing the solubility and reclamation Efficiency of gypsum with H2SO4. Cercetări Agronomice în Moldova Vol. LII , No. 2 (178) / 2019: 128-140
6. Nawaz, M.Q., K. Ahmed, M. Sarfraz, G. Qadir, Z. Manzoor, M. F. Nawaz, M. Nadeem, I. A. Warriach, M. S. A. Bazmi. 2109. Yield improvement of direct sown rice on raised beds using different priming techniques in salt affected soils. International Journal of Biosciences. Vol. 15, No. 1, p. 155-160, 2019.
7. Ahmed, K., G. Qadir, M.Q. Nawaz, M. Sarfraz, M. Rizwan, M.A. Zaka, S. Hussain. 2019. Feasibility of different crop rotations for cultivation in salt affected soils. Acta agriculturae Slovenica, 114(1): 21–31, Ljubljana 2019

6.2 RADIO TALKS

تفصیل ریڈیو ٹاکس

نمبر شمار	عنوان ٹاک
1	کلراٹھی زمینوں کاشتہ مردی ہوئی مونجی نوں بچانا
2	ٹیوب ویل کے کھارے پانی دا فصلاں لئی محفوظ استعمال
3	کلراٹھی زمیناں لئی جپسم دے استعمال دی اہمیت
4	کلراٹھی زمیناں تے مونجی دی کاشت
5	کلراٹھی زمیناں تے کاشتہ فصلاں لئی کھاداں دے مناسب تے متناسب استعمال دی اہمیت
6	کلراٹھی زمیناں تے کاشتہ مونجی لئی کھاداں دا استعمال
7	کلراٹھی زمینوں میں گندم کے متبادل فصلوں کی کاشت
8	کلراٹھی زمیناں وچ موسم ربیع دے چارہ جات دی کاشت تے کھاداں دا استعمال
9	کلراٹھی زمیناں دی اصلاح دے طریقے
10	کلراٹھی زمینوں میں کنوا دی کاشت
11	کلراٹھی زمیناں وچ کنک دی کاشت لئی اقسام دا چناو
12	کلراٹھی زمیناں وچ کنک لئ کھاداں دا استعمال
13	کنک لئی ٹیوب ویل دے کھارے پانی دا استعمال
14	مٹی تے پانی دے تجزیہ دی اہمیت
15	کلراٹھی زمیناں لئی نامیاتی مادے دی اہمیت
16	کلراٹھی زمیناں تے پھل دار پودیاں دی کاشت
17	کلراٹھی زمیناں وچ نامیاتی تے غیر نامیاتی کھاداں دے استعمال دی اہمیت
18	کلراٹھی زمینوں میں کاشتہ برسیم کےلئے کھاداں دا استعمال
19	کلراٹھی زمینوں میں گندم کی کاشت کے طریقے
20	موسمیاتی تبدیلیاں دے تناظروچ کلراٹھی زمیناں لئی جپسم دا استعمال
21	موسمیاتی تبدیلیاں دے تناظر وچ کلراٹھی زمیناں تے پھل دار درختاں دی کاشت
22	کلراٹھی زمیناں لئی نامیاتی کھاداں دا استعمال
23	

7.0 ADVISORY SERVICES

7.1 LIST OF FARMERS BENEFITTED THROUGH SOIL ANALYSIS

S.No.	Date	Name of Farmers	Address	No. of Samples
1	1-7-19	Rab nawaz	Barak pur	4
2	1-7-19	Zeshan Ahmed	Sukhaki	4
3	1-7-19	Abdul ghani	kasoor	2
4	8-7-19	Nazar hussain	Chak No. 2	5
5	10-7-19	Junaid saifullah	Sukhaki	2
6	16-7-19	Fiaz Ahmed	Jalal pur bhattian	1
7	17-7-19	Sikander hayat	Kot mohabat	2
8	18-7-19	Muhammad yar	jhumra	9
9	23-7-19	Mubashir cheema	Faisalabad	4
10	24-7-19	Shoaib Ali	Sanghla hill	3
11	25-7-19	Manazir hussain	Pindi bhattian	2
12	31-7-19	Sayed ishtiaq	Chadar chak	2
13	1-8-19	Nasir qayuoom	Par lakhan	1
14	28-8-19	Aniqa nawaz	Faisalabad	6
15	29-8-19	Rizwan ahmed	ambaltas	4
16	26-9-19	Shokat Ali	Shukhaki	3
17	10-10-19	Shahid iqbal	Pindi bhattian	2
18	16-10-19	Naseeb ullah	Jalal pur	1
19	24-10-19	Arsalan	Sanghla hill	8
20	28-10-19	Kalay khan	Thatha hashmat	2
21	30-10-19	M. imtiaz	Bhopra	4
22	4-11-19	Saifullah	Kishan garh	6
23	4-11-19	Zahid Hussain	Sanghla hill	6
24	5-11-19	Shaher yar	Sanghla hill	4
25	5-11-19	Ali sahfique	Sanghla hill	4
26	6-11-19	Sohail abbas	Pindi bhattian	1
27	6-11-19	Saqib anayat	Chodu khuda yar	1
28	13-11-19	Arif ali	Pindi bhattian	1
29	14-11-19	M. shahid	Pindi bhattian	4
30	26-11-19	Ahmed ali	Bhopra	2
31	2-12-19	Fahad hassan	Chodu ahmed yar	3
32	16-12-19	Shahid iqbal	Solangi kharal	10
33	31-12-19	Shokat Mahmood	Ghabrika	1
34	31-12-19	Chohdury Zubair	Thatha karim dad	1
35	27-1-20	Zahid Mubashar	Chak Bhatti	1
36	5-2-20	Hassam Saleem	Ali ka Thatha	24
37	11-2-20	Babir Sajjad	Kot dilawer	6
38	27-2-20	Niaz Asghar	Dulaky	1
39	3-3-20	Fiaz bashir	Khanqah dogran	3
40	10-3-20	Mansab Ali	Thatha karim dad	1
41	11-3-20	Tamoor haider	Mustafa abad	4
42	13-3-20	Masroor anwar	Sabit shah	3
43	16-3-20	Sabteen Abass	Kohli wala	2

44	23-4-20	M. naveed	Maqam wala	2
45	28-4-20	Ghulam qadir	Pindi bhattian	1
46	4-5-20	Niaz asghar	Dulaki	1
47	8-5-20	M. saqlain	Pindi bhattian	2
48	11-5-20	Javed Iqbal	Pindi bhattian	2
49	11-5-20	Arfan Ali	Nankana	1
50	12-5-20	M. ameen	Kasisay	3
51	13-5-20	Hasnain Aftab	Mustafa abad	2
52	13-5-20	Aqeel haider	Mona manika	1
53	18-5-20	M. ameen	Kasisay	1
54	19-5-20	Fard Iqbal	Sukhaki	1
55	19-5-20	Akhlaq ahmed	Vanikay tarar	6
56	19-5-20	Tamoor haider	Mustafa abad	7
57	20-5-20	Sayed Ghulam Murtaza	Pindi bhattian	2
58	28-5-20	Arsalan Ali	Thatha mona sabit	3
59	28-5-20	Hasan Ali	Pindi bhattian	4
60	2-6-20	Gulzar Ahmad	Rai chan	6
61	2-6-20	M. tariq	Sanghla hill	4
62	4-6-20	M. ilyas	Pindi bhattian	1
63	4-6-20	M. junaid	Sukhaki	2
64	9-6-20	Asif ali	Mustafa abad	8
65	10-6-20	Saifullah	Shadi wala	5
66	10-6-20	Fida Hussain	Mustafa abad	3
67	18-6-20	Mian aslam	Meeraj kalan	4
68	22-6-20	Amir Shahbaz	Ghari Wahab	10
69	23-6-20	Malik asif	Khoshab	1
70	23-6-20	Riazulabass	Kot nakka	18
71	24-6-20	Malik mujahid	Watwan wala	1
72	29-6-20	Faisal abass	Mona sabit	2
			Total	**264**

7.2 LIST OF FARMER'S BENEFITTED THROUGH WATER ANALYSIS

S.No.	Date	Name of Farmers	Address	No. of Samples
1	1-7-19	Rai mumtaz	chokarian	1
2	1-7-19	Zeshan Ahmed	sukhayki	8
3	1-7-19	Zulifqar Ali	Madoran kala	3
4	4-7-19	Rab Nawaz	Bharak pur	1
5	4-7-19	Aslam hayat	Hinduana	1
6	4-7-19	Ijaz Hussain	Pindi bhattian	1
7	8-7-19	Nazar Hussain	Chak No.2	2
8	8-7-19	Ijaz ahmed	Par masoo	1
9	9-7-19	Muhammad arshid	Khat rani	3
10	18-7-19	Muhammad yar	Jhumra	2
11	22-7-19	Muhammad anwar	Kot khushal	1

12	25-7-19	Manazir hussain	Pindi bhattian	1
13	31-7-19	Sayed ishtiaq	Chadar chak	2
14	1-8-19	Nasir qayuoom	Par lakhan	1
15	8-8-19	Sultan Muhammad	chokarian	1
16	19-8-19	Rizwan ahmed	ambaltas	1
17	26-8-19	Shahid Irfan	Muqam wala	1
18	29-8-19	abdurazaq	Pindi bhattian	2
19	2-9-19	Shokat ali	sukhaki	2
20	12-9-19	Rai abid	Tiba shah bahlol	2
21	16-9-19	Arshad javed	Mustafa abad	3
22	19-9-19	Haji Karamat ali	Pindi bhattian	1
23	3-10-19	Majid Ghafoor	Pindi bhattian	5
24	24-10-19	Arsalan	Sanghla hill	3
25	28-10-19	Kalay khan	Thatha hashmat	1
26	4-11-19	Saifullah	Kishan garh	1
27	4-11-19	Sohail abbas	Pindi bhattian	1
28	5-11-19	Ali sahfique	Sanghla hill	1
29	25-11-19	M. Arsalan	Pindi bhattian	15
30	25-11-19	Awaise ijaz	Pindi bhattian	14
31	2-12-19	Fahad hassan	Chodu ahmed yar	2
32	31-12-19	Mahmood Shokat	Ghabrika	1
33	31-12-19	Chohdury Zubair	Pindi bhattian	1
34	4-2-20	Hassam Saleem	Ali ka thatha	1
35	16-2-20	Zafar Abbas	Pindi bhattian	2
36	23-2-20	Shahid Iqbal	Kot Khushal	2
37	26-2-20	Muhammad Hussain	Thatha Ali	1
38	2-3-20	Liaqat Ali	Qadir abad	1
39	3-3-20	Fiaz bashir	Khanqah dogran	1
40	11-3-20	Tamoor haider	Mustafa Abad	1
41	13-3-20	Masrro anwar	Sabit shah	3
42	16-3-20	Sabteen Abass	Kohli wala	1
43	4-5-20	Abdul hafeez	sukhaki	5
44	11-5-20	M. ameen	Kasisay	1
45	12-5-20	Nadeem shahzad	Pindi bhattian	1
46	12-5-20	Umar hayat	Kasisay	1
47	12-5-20	Hasnain aftab	Mustafa Abad	1
48	13-5-20	Aqeel hayder	Mona manika	1
49	18-5-20	M. faheem	Sanghla hill	1
50	19-5-20	Ikhlaq ahmed	Vanikay tarar	3
51	21-5-20	Sardar Rafique	Thatha matmal	2
52	1-6-20	Javed Iqbal	Tiba shah bahlol	1
53	10-6-20	Saifullah	Shadi wala	1
54	18-6-20	Talib Hussain	Sharbhagha	2
55	22-6-20	Shahbaz	Ghari Wahab	2
56	23-6-20	Malik asif	Khoshab	1
57	24-6-20	Malik mujahid	Watwan	1

58	25-6-20	Riazulabbas	Kot nakka	1
59	29-6-20	Faisal abbas	Mona salabit	3
60	29-6-20	Riasat Ali	nankana	1
61	29-6-20	Ibrar bhatti	nankana	1
			Total	**129**

7.3 LIST OF FARMER'S BENEFITTED THROUGH FERTILIZER ANALYSIS

S.No.	Date	Name of Farmers	Address	No. of Samples
1	1-7-19	Mubshar sultan	Beran wala	1 Gypsum
2	16-7-19	Mohsan Ali	Jalal pur	1 SSP
3	28-7-19	Mudassar Hussain	Meloana	1 SSP
4	1-8-19	Nasir qayoom	Par lakhan	1 DAP
5	5-8-19	Mudassar Hussain	Meloana	2 SSP
6	16-10-19	Liaqat ali	dulayki	1 SSP
7	18-10-19	Liaqat ali	dulayki	1 SSP
8	1-11-19	Waqas rauf	sanghla	1 DAP
9	18-11-19	Sajjad Hussain	Hujan	1 SSP
10	19-11-19	Asghar ali	Meeran wala	1 DAP
11	25-11-19	Ali ahmed	Thatha sabit shah	1 DAP
12	25-11-19	M. iqbal	Jalal pur	1 DAP
13	25-11-19	Rai tanveer ahmed	bhopra	1 DAP
14	10-4-20	Sagheer Ahmed	Pindi Bhattian	1 DAP
15	28-5-20	Haq nawaz	Tiba sshah bahlol	1 gypsum
16	29-5-20	Ansar Nawaz	Pindi Bhattian	1 gypsum
17	29-5-20	M. asghar	Pindi Bhattian	1 gypsum
18	10-6-20	M. moosa	Macho nika	1 gypsum
19	17-6-20	Ahmed Ali	Tiba sshah bahlol	1 gypsum
20	17-6-20	M. mushtaq	Jam tarer	1 gypsum
21	22-6-20	M. shahzad	Pindi Bhattian	1 gypsum
22	25-6-20	Saleemullah	Pindi Bhattian	1 gypsum
23	26-6-20	Jahngir khan	Pindi Bhattian	1 gypsum
24	29-6-20	Riasat Ali	Macho nika	1 gypsum
25	30-6-20	Amir shahzad	hafizabad	2 DAP
			Total	**27**