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Reclamation of saline sodic soils with brackish water

BY

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RECLAMATION OF SALINE SODIC SOILS WITH BRACKISH WATER

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Introduction

The canal irrigated areas of Pakistan are a part of the arid and semi arid regions of the earth, where the soils are inherently saline and saline sodic in nature. The seepage and perculation losses of water from the canal system have caused the ground water to rise which has further aggravated the situation with respect to salinity and sodicity.

In the Punjab, alone at present 2.68 million acres of the land (11.57%) is in the grip of salinity. This is on the basis of the visual soil salinity survey (1985-86). The magnitude of the problem in Pakistan has been assessed by the Planning Division WAPDA (1979) in the irrigated areas of 34.5 million acres. According to this assessment 25% of the irrigated land is affected by salinity to varying degree on the surface. The profile salinity has been on the other hand, assessed at 38% of the culturable commanded area. Almost all the saline lands show sodic characteristics. To ensure the prosperity of the people of the country the reclamation of these lands is a pre-requisite.

Reclamation of saline sodic lands involves the elimination of two components: Salinity and sodicity. Salts constituting salinity are mostly sodium chloride and sodium sulphate. At room temperature the solubility of sodium chloride is 360 parts per litre and that of sodium sulphate is 140 parts per litre. These are removed easily by leaching when adequate amount of irrigation water is applied for this purpose, but sodicity persistsas it forms sodium salt with the soil colloids. Hardly 2 mg/l of it come in solution at a time and it take 35 years to get rid of it by simple leaching, but with the application of new technology of using the chemical amendments which provide the diavalent cations the process of reclamation is completed within a month or so. (1985-86).

So far the reclamation process has been carried out mostly with the additional canal supply given at the rate of one cusec per 45 acres during the monsoon season, when there is ample water in the rivers. However, its provision has been limited by the water conveying capacity of our canal system. For 2.68 million acres of salinity affected lands in the Punjab alone about sixty thousand cusecs of additional canal water is needed for 3 to 5 years to get rid of the problem,whereas the supply for the last 5 years with areas operated and reclaimed are given hereunder:

TABLE - I

Reclamation Supply utilized, are operated and area reclaimed during the last five years in the Province of Punjab.

Years	Reclamation Supply Utilized (Cusecs)	Area operated (Acres)	Area Reclaimed.(Acres)
1981-82	1216.86	62387	15465
1982-83	1037.82	55682	25284

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Years	Reclamation Supply Utilized (Cusecs)	Area operated (Acres)	Area Reclaimed.(Acres)
1983-84	823.40	39505	18451
1984-85	805.80	37944	10092
1985-86	860.12	42738	8514
1986-87	1015.16	48866	

From the data given above it is inferred that the reclamation supply provided has been so meagre that the reclamation of 11.57% of the salinity affected lands cannot be achieved in the near future.

For achieving reclamation of the saline sodic lands the electrical conductivity of the saturation extract of the soil is to be brought down to 4mmohs/cm or less and the pH is to be reduced to less than 8.5 to suit many of the agricultural crops. With ground water even though its quality may be poor, it can be accomplished at any time during the year.

The hypothesis has been tested at the field level and the results achieved therefrom are discussed here.

Review of Literature

Kelly (1951) applied gypsum to an alkali soil at the rate of 10 to 12 and 15 tons per acre. The plots were flooded continuously for three weeks. He found that the exchangeable sodium was effectively removed to a depth of four feet and practically a barrne land was converted into a high productive land.

Haider (1959) reported that leaching with water alone was in-effective while gypsum in combination with leaching effectively reclaimed a " BARA " soil.

R.C. Renord and C.A. Bower (1960) used sea water for reclaiming a sodic soil. The sea water contained 11.6 meq/1 of Ca + Mg. They pointed out that with the use of only 4 feet of sea water combined with 6 feet of clorad, River water, reduced the initial exchangeable sodium percentage of the soil from 39 to 5 and reduced the time of reclamation from 120 days to 12 days.

Bower (1962) recommended that for soils having a Gypsum requirement upto 5 meq/1 100 gms of soil, growing of rice and green manure crops could be depended upon for reclamation of a saline sodic soil in a reasonable period of time.

Zaidi and Qayyum (1968) reported that the rate of reclamation increased considerably with the use of Gypsum and farm yard manure and the income obtained with the use of amendments for reclamation is more than th=at with leaching without amendments.

Hussain Muhammad (1968) reported that it takes 6 to 8 years for reclaiming a saline sodic soil by rice culture and that application of gypsum accelerates the replacement of exchangeable sodium.

B.K. Khosla and I.P. Abral (1972) studied the effect of gypsum of varying finess on the composition of saturation extract of a saline sodic soil. They reported that much of the gypsum is utilized in precipitating the soluble carbonates to form relatively insoluble calcium carbonate. Gypsum of slightly finer than 0.59 mesh would be more effective than that of the coarse grades. The amount of gypsum needed to neutralize the soluble carbonates is shown to be indicative to the minimum amount of amendments required to start the reclamation of a saline sodic soil high in carbonates.

G. R. Dutt: Terkeltoul and Roa Shkoll R.S. (1972) pointed out that the amounts of water and gypsum required for reclaiming the soil were highly dependent upon the quality of water used for leaching.

Muhammad and Khaliq (1975) reported that gypsum sulpher combination with manure were quite efficient in reclaiming a saline sodic soil.

Hussain and Asghar (1985) found out that with the application of Gypsum even though it is applied to the extent of ½ or ¼th of the total requiement of the soil the reclamation of a saline sodic soil is accelerated and can be achieved within a limited period of time. The increase in infiltration rate of the soil is almost equal with ½ and ¼th of the gypsum requirement applications. They further concluded that rice is a highly sodic resistant crop.

Altaf (1985-86) reported that the relcamation of saline sodic/sodic calcarious lands can be achieved within a short period of time, when the chemical amendments are used for this purpose. Sulphuric acid and Gypsum are equally effective to increase the infilteration rate of the soil. Hydrochloric acid is also useful but the infilteration rate produced in the soil is almost half of that with sulphuric acid and gypsum.

Altaf (1986) pointed out that ½ and ¼th gypsum is almost equally useful to facilitate the leaching process of a saline sodic soil.

Material and Methods

An experiment was carried out in the field at the 112/15L Reclamation Research Station Mianchannu of the Land Reclamation Directorate on an absolutely barren land. The plot size was 22′ x 49.5′. The following treatments were tested:

1. Leaching with Canal water.
2. Leaching with tubewell water.
3. Leaching with tubewell water and canal water. (4 tubewell and one canal water).
4. Leaching with tubewell water with the application of gypsum to meet:
   i) ½ of the requirement of the Ist one foot of the soil.
   ii) ¼th of the requirements of the Ist one foot of the soil.
   iii) 1/8th of the requirements of the Ist one foot of the soil.

There were four replications of each treatment. Gypsum (100 mesh) was spreaded on the soil and was mixed with the upper 2″ to 3″ of the mass 20″ of water was applied for leaching in all the treatments. In treatment No. 3 where saline ground water was applied for leaching 16″

of saline ground water was followed by 4″ of canal water. Each irrigation was of 4″. Irrigation was repeated when the water given during the previous irrigation had just disappeared. The leaching process was completed within 20 days. i.e. on the average irrigation was repeated after every four days or so.

8″ water was supposed to be retained by the soil profile whereas 12″ was to pass down the soil profile to leach the salts.

Soil samples were taken from 0 - 6″, 6″ - 1′, 1′ - 2′ and 2′ - 3′ depths from the natural soil surface before and after completing the leaching process. These were analysed to find out the salinity and sodicity status of the soil. The first crop grown was the spring maize which is very sensitive to salinity/sodicity. The idea to grow the crop was to develop micro flora to make the soil viable after completing the leaching process. This crop was followed by the cotton crop.

The maize crop was sown on February 25, 1986 and was removed on June 7, 1986. The total delta applied to the crop was 30″ whereas cotton was sown on June 13, 1986 and was removed in the last week of November 1986. 30″ delta was applied to this crop as well and in addition to it 10.44″ rainfall was also received during the growth period of this crop.

Resutls and Discussions

Tue analysis of the canal water (Table-2) indicate that the water is of excellent quality to use for crop production, whereas the tubewell water is unfit for irrigation.

The textural classification of the soil under experiment shows (Table-3) that it varies from loam to clay loam. From this it is concluded that the land used in the experiment for study is quite representative and the findings from the experiment can safely be applied to the soils in the country.

The chemical analysis results of the soil (Table-4) indicate that it is the worst type of land in respect of salinity and sodicity. In all the treatments Ca + Mg is very low and very often free soluble carbonates are present in the soil. Thus the land is expected to give subtantial resistance to reclamation. The same is confirmed by the very high level of the gypsum requirements of the soil (Table-5).

After giving 20 delta for leaching,it is observed (Table-6) that first two feet of the soil profile in almost all treatments was mostly cleared from salinity, but in treatments No. 1 to 3 sodicity persisted and created conditions where ordinarily no crops could grow.

In treatments 4, 5 and 6 the situation was found to be different. In almost all the cases the sodicity had been completely neutralized and the normal productive capacity of land had been restored and it could be used for normal cropping.

The behaviour of the maize crop (Table-7) indicates that it being very sensitive to salinity and sodicity, failed to germinate in treatments No. 1 and 2. There was only scattered germination in treatment No. 3. In treatment No. 4 the performance of the crop could be considered as excellent. It has shown the decreasing trend with decrease in gypsum applications in treatments No. 5 and 6. The produce of green fooder in these treatments has been 4180, 2540 and 1346 killograms per acre.

In case of seed cotton the crop failed in treatments No. 1 to 3 whereas in Treatments No. 4 to 6 the yields were 682.4, 455.0 and 260.0 killograms per acre respectively. The yields in treatments No. 4 and 5 where gypsum was applied at the rate of ½ and ¼th of the requirements of the first foot of the soil, have been almost of the normal crop produced in a good soil.

Conclusions

1) Poor quality water can be used successfully for the reclamation of saline sodic lands.

2) The applications of Gypsum at the rate of ½ and ¼th of the Gypsum requirements of the first one foot of the soil are more beneficial than of 1/8 applications.

3) The difference of income between Rs. 1333.33 and Rs. 1285.70 is statistically insignificant.

4) The application of Gypsum at the rate of 1/8th of the requirements is also much better when compared with control (Table - 8).

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TABLE - 2

Analysis Results of :-

	$EC \times 10^6$	pH	Ca	Mg	Na	CO_3	HCO_3	Cl	SO_4	SAR
Canal Water	300	8.2	2.2	0.2	0.6	–	1.7	0.4	0.9	0.5
Tubewell Water	2400	8.0	4.4	1.9	17.7	–	4.1	3.1	16.8	10.0

Ca, Mg, Na, CO_3, HCO_3, Cl. SO_4
are given as milliequivalent per litre.

TABLE - 3

Textural Classification of the Soil
(International System)

Treatment	Rep:	Clay %	Silt %	Sand %	Textural Name
1	1	20	35	45	C.L
	2	25	30	45	C.L
	3	22	18	60	L.
	4	15	30	55	L.
2	1–	30	30	40	C.L.
	2–	22	28	50	C.L
	3–	23	22	55	C.L./L.
	4–	25	25	50	C.L.
3	1–	20	30	50	L.
	2–	20	30	50	L.
	3–	23	22	55	L.
	4–	18	27	55	L.
4	1–	20	35	45	L.
	2–	18	37	45	L.
	3–	22	33	45	L./C.L.
	4–	25	25	50	L.
5	1	20	35	45	C.L
	2	18	47	35	L/C.L.
	3	22	23	55	L
	4	20	30	50	L
6	1	18	47	35	L.
	2	22	33	45	C.L
	3	20	30	50	L/C.L.
	4	20	35	45	L.

TABLE - 4

Chemical Analysis Results of the Soil Before Starting the Leaching Process

Treatment	Replication	Depth	SP	PH	ECx10³	Ca+Mg	Na	CO_3	HCO_3	Cl	SO_4	SAR
1	1	0 -60	37	9.6	50.0	2.0	708.0	34.0	33.0	380.0	263.0	708.0
		6″ -12″	37	9.7	35.0	2.0	478.0	27.0	15.0	265.0	173.0	480.0
		1′ - 2′	30	9.8	14.5	2.0	189.0	29.0	12.0	100.0	50.0	189.0
	2	0 - 6″	37	9.8	30.0	1.5	408.5	85.0	10.5	166.5	148.0	490.2
		6″-12″	35	9.9	25.0	1.5	328.5	81.0	12.5	100.0	136.5	327.3
1′ - 2′			37	9.9	18.5	2.0	243.0	66.0	15.0	113.0	51.0	243.0
	3	0 - 6″	38	9.7	50.0	2.0	708.0	135.0	12.5	303.0	259.0	708.0
		6″-12″	35	9.8	40.0	2.0	558.0	80.0	32.5	173.0	274.5	558.0
		1′ - 2′	36	9.8	13.0	2.0	160.0	71.0	31.0	50.0	410.0	160.0
	4	0 - 6″	36	8.8	35.0	1.5	478.5	3.0	3.5	185.0	288.5	574.2
		6″-12″	38	8.9	40.0	1.0	559.0	3.0	3.0	179.0	375.0	782.6
		1′ -2′	34	8.3	185.0	27.5	202.5	–	4.5	130.0	95.5	54.7

Ca+Mg,Na,CO_3,HCO_3, Cl,SO_4
are given as milliequivalent per litre.

Treatment	Replication	Depth	SP	PH	$ECx10^3$	Ca+Mg	Na	CO_3^-	HCO_3	Cl	SO_4	SAR
2	1	0 - 6″	35	9.3	22.5	2.0	298.0	6.0	6.5	101.5	186.5	288.0
		6″-12″	38	9.1	20.0	2.5	267.5	3.0	7.5	100.0	158.5	211.9
		1′ - 2′	34	9.9	24.0	1.0	319.0	48.0	12.0	130.0	90.0	448.0
	2-	0 - 6 6	37	0.8	25.0	1.5	328.5	44.0	4.0	117.0	165.0	327.3
		6″-12″	38	9.8	19.0	1.5	248.5	41.0	8.5	80.5	120.0	298.2
		1′ - 2′	36	9.9	12.5	1.5	160.5	41.0	9.0	74.0	38.0	192.6
	3-	0 - 6	35	9.7	45.0	2.0	613.0	110.0	22.0	283.0	205.0	618.0
		6″-12″	32	9.7	40.0	1.5	257.5	93.0	19.0	254.0	194.0	309.0
		1′ - 2′	40	9.8	28.0	2.0	368.0	77.0	18.0	174.0	101.0	368.0
	4-	0 - 6″	38	9.8	50.0	1.5	708.5	42.0	19.0	342.0	307.0	850.2
		6″-12″	36	9.8	17.0	1.5	218.5	60.0	18.0	278.0	136.0	262.2
		1′ - 2′	37	10.0	27.0	0.5	359.5	56.0	14.0	145.0	65.0	719.0

Treatment	Replication	Depth	SP	PH	ECx10^3	Ca+Mg	Na	CO_3	HCO_3	Cl	SO_4	SAR
3	1-	0 - 6″	37	9.7	18.0	2.0	228.0	31.0	14.0	130.0	55.0	228.0
		6″-12″	32	9.5	20.0	2.0	258.0	16.0	11.0	163.0	70.0	258.0
		1′ - 2′	35	9.9	42.5	1.0	599.0	54.0	23.0	208.0	315.0	838.6
	2-	0 - 6″	39	9.8	35.0	1.5	478.5	45.0	17.5	188.0	229.5	574.2
		6″-12″	38	9.7	25.0	1.5	328.5	25.0	17.0	132.0	156.0	394.0
		1′ - 2′	35	9.8	14.5	1.0	190.0	55.0	13.0	93.0	26.0	266.0
	3-	0 - 6″	33	9.3	30.0	2.0	408.0	8.0	10.5	171.0	220.5	408.0
6″-12″			32	9.6	25.0	2.0	328.0	30.0	14.0	80.0	188.0	328.0
		1′ - 2′	32	9.6	16.5	2.0	198.0	35.0	10.5	118.0	27.5	198.0
	4-	0 - 6″	37	9.9	45.0	2.0	618.0	53.0	18.5	252.0	296.5	618.0
6″-12″			35	9.8	40.0	1.0	559.0	44.0	6.0	308.0	202.0	782.6
		1′ - 2′	34	9.9	22.0	1.0	289.0	42.0	25.0	182.0	41.0	404.6

Treatment	Replication	Depth	SP	PH	$ECx10^{-3}$	Ca+Mg	Na	CO_3	HCO_3	Cl	SO_4	SAR
4	1-	0 -6″	38	9.8	28.0	1.5	368.5	32.0	15.5	160.0	162.5	441.6
		6″-12″	34	9.9	19.0	1.5	243.5	30.5	8.0	111.5	95.5	292.2
		1′ - 2′	37	9.9	21.0	2.0	273.0	31.0	10.0	102.0	127.0	273.0
	2-	0 - 6″	34	9.5	50.0	1.0	709.0	107.0	38.0	310.0	257.0	992.6
		6″-12″	37	9.7	35.0	1.5	478.5	87.0	12.0	229.0	152.0	574.0
		1′ - 2′	37	9.7	16.5	2.0	218.0	54.0	9.5	70.0	86.5	218.0
3-		0 - 6″	34	9.6	25.6	1.5	328.5	44.0	17.0	116.0	153.0	394.2
		6″-12″	33	9.7	25.5	1.5	328.5	43.0	14.0	149.0	124.0	394.2
		1′ - 2′	38	9.9	16.0	1.5	195.5	74.0	23.5	151.5	48.5	238.2
	4-	0 - 6″	36	9.0	35.0	2.0	478.0	6.0	7.0	225.0	242.0	478.0
		6″-12″	35	8.2	35.0	14.0	466.0	–	8.0	162.0	310.0	177.1
		1′ - 2′	35	7.9	23.0	23.5	286.5	–	5.0	123.0	182.0	83.1

Treatment	Replication	Depth	SP	PH	ECx10^{-3}	Ca+Mg	Na	CO_3	HCO_3	Cl	SO_4	SAR
5	1-	0 - 6″	39	9.8	40.0	2.0	268.0	39.0	26.0	274.0	221.0	268.0
		6″-12″	37	9.6	15.0	2.0	558.5	19.5	15.0	80.0	66.0	558.0
		1′ - 2′	32	9.8	13.5	1.5	175.5	15.0	11.0	2.0	69.0	210.6
	2	0 - 6″	36	9.8	50.0	1.0	709.0	161.0	36.0		150.0	992.6
		6″-12″	34	9.9	35.5	1.5	473.5	94.0	28.0		62.5	574.2
		1′ - 2′	37.0	9.8	17.0	2.0	218.0	86.0	8.5		8.5	218.0
	3	0 - 6″	37	9.6	25.0	2.0	328.0	33.0	10.0	444.0	142.5	328.0
		6″-12″	37	9.8	22.5	1.5	298.5	44.0	17.5	110.0	128.5	358.2
		1′ - 2′	38	10.0	21.0	1.5	273.5	68.0	25.0	151.0	31.0	328.2
	4	0 - 6″	38	9.4	40.0	2.0	558.0	28.0	14.0	263.0	255.0	558.0
		6″-12″	36	9.2	40.0	2.0	558.0	12.0	7.5	220.0	330.5	558.0
		1′ - 2′	34	9.7	22.0	2.0	188.0	22.0	25.5	95.0	14.75	288.0

Treatment	Replication	Depth	SP	PH	ECx10^3	Ca+Mg	Na	CO_3	HCO_3	Cl	SO_4	SAR
6	1	0 - 6″	37	10.0	35.0	1.5	478.5	79.0	29.5	183.5	188.0	574.2
		6″-12″	38	10.0	45.0	1.5	618.5	142.0	30.5	276.5	171.0	742.2
		1′ - 2′	33	10.0	22.0	1.0	289.0	60.0	11.0	30.6	18.0	404.6
	2	0 - 6″	33	9.8	55.0	1.0	799.0	155.0	50.5	352.0	242.5	1118.6
		6″-12″	35	9.8	38.0	2.0	408.0	108.0	36.0	200.0	66.0	408.0
1′ - 2′			37	9.8	33.0	1.5	438.5	109.0	14.5	87.0	229.5	528.2
	3	0 - 6″	33	9.7	45.0	2.0	618.0	31.0	8.5	260.0	320.5	618.0
		6″-12″	32	9.5	48.0	1.0	559.0	23.0	5.0	218.0	314.0	782.6
		1′ - 2′	37	9.7	18.0	2.0	248.0	42.0	22.0	174.0	11.0	248.0
	4	0 - 6″	38	9.8	22.0	1.0	289.0	28.0	19.0	114.0	129.0	404.6
		6″-12″	40	9.8	16.0	2.0	198.0	43.0	21.5	105.0	30.5	198.0
		1′ - 2′	35	9.9	21.0	1.0	279.0	36.0	18.5	202.0	23.5	390.6

TABLE - 5

Gypsum Requirement of the First One Foot of the Soil

Replication	T_1	T_2	T_3	T_4	T_5	T_6
1-	18.4	20.5	17.5	19.9	15.1	22.7
2-	17.0	18.6	15.0	18.5	24.8	25.1
3-	20.0	17.9	19.0	17.2	16.5	14.8
4-	19.0	21.0	21.0	11.0	14.5	15.8

T - Treatment

TABLE - 6

Chemical Analysis Results of Soil After Completing the Leaching Process

Treatment	Replication	Depth	SP	PH	$ECx10^3$	Ca+Mg	Na	CO_3	HCO_3	Cl	SO_4	SAR
1	1	0 - 6″	29	8.4	5.2	3.0	55.0	0.5	5.5	22.0	30.0	44.5
		6″-12″	30	8.7	8.0	3.0	92.0	1.5	3.0	33.0	57.5	74.5
		1′ - 1′	30	9.7	15.0	2.0	188.0	15.0	–	119.0	56.0	188.0
	2	0 - 6′	30	8.3	4.2	3.5	44.5	–	7.0	14.0	27.0	33.3
		6″-12″	29	8.7	4.5	2.0	49.0	1.0	4.5	16.0	29.5	49.0
		1′ - 2′	31	9.3	6.0	2.0	68.0	4.0	5.0	23.5	37.5	68.0
	3	0 - 6″	27	8.8	4.5	2.0	49.0	1.0	7.5	17.5	25.0	49.0
		6″-12″	28	9.2	3.1	2.0	30.0	2.0	6.5	10.0	15.5	32.0
		1′ - 2′	26	9.6	4.1	2.0	44.0	4.0	9.5	10.5	22.0	44.0
	4	0 - 6″	32	8.5	4.2	2.0	46.0	1.0	2.5	11.5	33.0	46.0
		6″-12″	35	8.1	5.0	6.0	50.0	–	2.0	10.0	44.0	28.5
		1′ - 2′	40	8.0	11.0	19.5	115.5	–	2.0	36.0	97.0	36.9

Treatment	Replication	Depth	SP	PH	ECx10^{3}	Ca+Mg	Na	CO_3	HCO_3	Cl	SO_4	SAR
2	1	0 - 6″	27	8.7	5.0	2.0	52.0	1.0	7.5	23.0	24.5	54.0
		6″-12″	25	9.0	4.7	2.0	50.0	3.0	4.0	18.5	27.5	54.0
		1′ - 2′	31	9.5	7.5	2.0	86.0	12.0	1.0	32.5	43.5	54.0
	2	0 - 6″	30	8.5	5.5	5.0	57.0	1.0	4.5	21.0	35.5	35.9
		6″-12″	30	8.6	4.0	2.0	43.0	1.0	3.0	16.0	25.0	43.0
		1′ - 2′	27	9.3	5.6	2.0	62.0	6.0	1.0	26.0	31.0	62.0
	3	0 - 6″	27	8.6	3.3	2.0	34.0	1.0	7.0	12.0	16.0	32.0
		6″-12″	9.0	3.6	2.0	39.0	2.0	5.5	15.0	17.5		38.0
		1′ - 2′	28	9.3	4.6	2.0	50.0	6.0	4.0	18.5	23.5	50.0
	4	0 - 6″	28	8.6	3.2	2.0	33.0	1.0	5.0	11.5	17.5	33.0
		6″-12″	27	8.6	2.1	1.5	20.5	1.0	4.0	9.0	8.0	23.5
		1′ - 2′	27	9.2	3.2	2.0	33.0	3.0	4.5	15.0	12.5	33.0

Treatment	Replication	Depth	SP	PH	$ECx10^3$	Ca+Mg	Na	Co_3	HCO_3	Cl	SO_4	SAR
3	1	0 - 6″	27	8.5	4.7	3.0	50.0	1.0	5.0	17.0	30.0	40.0
		6″-12″	29	8.5	6.7	2.0	76.0	2.0	2.0	30.0	44.0	76.0
		1′ - 2′	32	8.8	12.5	2.0	153.5	21.0	–	74.5	59.5	153.0
	2	0 - 6″	28	8.6	5.0	2.5	53.5	1.0	8.0	24.5	22.5	47.6
		6″-12″	27	9.2	5.0	2.0	53.0	3.0	5.0	19.0	29.0	54.0
		1′ - 2′	30	9.6	5.8	2.0	65.0	8.0	2.0	19.0	38.0	65.0
	3	0 - 6″	30	8.6	4.6	2.6	50.0	.5	7.0	17.0	27.5	50.0
		6″-12″	27	9.0	4.3	2.0	47.0	2.5	4.5	17.0	25.0	47.0
		1′ - 2′	30	9.5	3.8	2.5	30.0	6.0	6.5	20.0	9.5	40.0
	4	0 - 6″	27	8.7	2.6	1.5	26.5	1.0	5.5	10.5	11.0	30.1
		6″-12″	27	9.0	3.4	3.0	35.0	2.0	6.0	14.0	15.0	35.0
		1′ - 2′	29	9.5	3.8	2.5	35.5	6.0	3.5	14.0	18.5	40.0

Treatment	Replication	Depth	SP	PH	ECx10^3	Ca+Mg	Na	Co_3	HCO_3	Cl	SO_4	SAR
4	1	0 - 6"	34	8.2	5.5	20.5	41.5	–	3.5	17.5	41.0	12.8
		6"-12"	38	8.3	4.5	3.5	47.5	–	4.5	12.5	34.0	35.6
		1' - 2'	30	8.9	4.7	2.0	50.0	3.0	3.0	10.0	37.0	54.2
	2	0 - 6"	30	8.2	3.3	21.0	15.0	–	3.5	6.0	26.5	4.5
		6"-12"	30	8.0	4.5	20;5	9.4	–	2.0	6.5	42.5	9.4
		1' - 2"	28	9.0	3.7	2.5	38.5	2.0	3.0	7.0	29.0	34.2
	3	0 - 6"	31	8.6	3.1	3.5	30.5	1.0	9.5	11.0	12.5	22.8
		6"-12"	28	8.8	2.8	1.5	29.5	1.0	7.0	10.5	12.5	33.9
		1' - 2'	27	9.4	3.8	2.0	40.0	5.0	3.5	16.0	17.5	40.0
	4	0 - 6"	35	8.3	2.4	3.5	22.5	T	3.0	11.0	12.0	16.8
		6"-12"	35	8.5	3.8	3.0	39.0	T	3.0	11.0	12.0	16.8
		1' - 2'	35	8.1	3.2	4.5	30.5	–	2.0	10.0	23.0	20.1

Treatment	Replication	Depth	SP	PH	ECx10^3	Ca+Mg	Na	CO_3	HCO_3	Cl	SO_4	SAR
5	1	0 - 6"	32	8.2	4.0	8.5	36.5	–	7.5	11.5	26.0	17.5
		6"-12"	27	8.3	4.5	3.0	48.0	–	5.5	14.5	31.0	38.8
		1' - 2'	27	8.5	3.7	2.5	38.5	5.0	3.0	9.5	23.5	34.2
	2	0 - 6"	30	8.2	3.1	6.0	28.0	–	5.0	8.5	20.5	15.9
		6"-12"	27	8.3	3.1	2.5	31.5	–	4.0	9.0	21.0	28.0
		1' - 2"	27	8.9	4.4	2.0	48.0	1.5	4.5	3.5	40.5	48.0
	3	0 - 6"	28	8.5	2.7	2.5	27.5	1.0	4.0	9.0	16.0	24.4
		6"-12"	27	8.8	3.6	2.0	30.0	2.0	5.0	20.5	12.5	35.9
		1' - 2'	30	9.3	5.2	1.5	56.5	5.0	2.5	27.0	23.5	64.9
	4	0 - 6"	30	8.2	2.5	6.0	21.0	–	3.0	12.0	12.0	11.9
		6"-12"	28	8.2	2.5	3.0	24.0	–	2.0	13.0	12.0	19.4
		1' - 2'	28	8.8	2.7	2.0	28.0	2.0	2.5	12.5	13.0	28.0

Treatment	Replication	Depth	SP	PH	ECx10³	Ca+Mg	Na	CO_3	HCO_3	Cl	SO_4	SAR
6	1	0 - 6″	30	8.3	2.2	4.5	18.5	–	6.5	7.0	9.5	12.2
		6″-12″	30	8.5	4.2	2.5	45.5	1.0	4.0	13.5	29.5	40.5
		1′ - 2″	29	8.7	4.8	2.0	52.0	2.0	2.5	15.0	34.5	52.0
	2	0 - 6″	30	7.9	8.5	12.5	89.5	–	2.5	33.0	66.5	35.8
		6″-12″	27	8.2	8.5	4.5	110.5	1.0	2.5	37.0	74.5	72.9
		1′ - 2′	27	9.3	6.3	2.0	70.0	4.0	5.0	22.5	40.5	70.0
	3	0 - 6″	30	8.6	3.9	2.0	42.0	1.0	4.5	21.5	17.0	42.0
		6″-12″	32	8.5	5.2	1.5	56.5	1.0	4.5	20.0	33.0	64.9
		1′ - 2′	31	9.0	5.5	1.5	60.5	3.0	3.5	23.0	32.5	69.5
	4	0 - 6″	29	8.5	4.2	3.0	45.0	1.5	2.5	19.0	25.5	36.4
		6″-12″	29	8.8	3.8	2.5	40.0	1.5	3.0	19.0	18.5	40.0
		1′ - 2′	28	9.2	3.9	2.0	42.4	3.5	2.5	19.0	19.0	40.0

TABLE - 7

Yield Per Acre.
(Kgms.)

Crops	T_1	T_2	T_3	T_4	T_5	T_6
Maize. (Green Fodder)	–	–	400	4180	2540	1346
Seed Cotton	–	–	–	682.4	455	260

T – Treatment

TABLE - 8

Economics of Soil Reclamation with Gypsum Application.

Item	T_1	T_2	T_3	T_4	T_5	T_6
Average cost of Gypsum applied. (Rs.)	–	–	–	3077.89	1543.55	881.90
INCOME FROM						
1. Maize Fodder @ Rs. 5/40K. Grams.	–	–	Rs. 50.00	Rs. 525.00	Rs. 317.50	Rs. 166.50
2. Seed Cotton @ Rs.225.00/40K. Grams.	–	–	–	Rs.3838.50	Rs.2559.38	Rs.1462.50
TOTAL:				4363.50	2876.88	1629.00
INCOME			Rs. 50.00	Rs.1285.70	Rs.1333.33	Rs. 741.10