Technical Bulletin : CSSRI/Lucknow/2009/03

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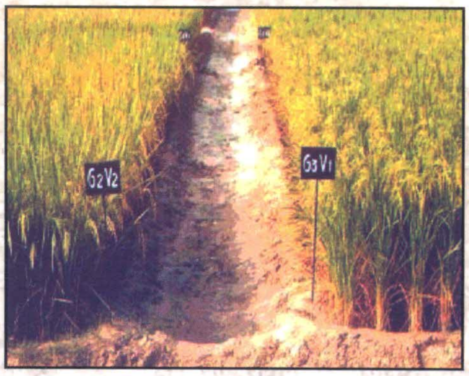
A LOW COST SODIC SOIL RECLAMATION TECHNOLOGY



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SYNERGY OF REDUCED GYPSUM AND SALT TOLERANT VARIETIES
A LOW COST SODIC SOIL RECLAMATION TECHNOLOGY

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EXECUTIVE SUMMARY

Rice and wheat are the important crops under sodic soils in the Indo-Gangetic plains. The prevailing technology (application of gypsum @ 50% G.R.) for the reclamation of sodic soils is very costly and beyond the reach of small and marginal farmers. To develop low cost technology for the reclamation of these soils, the field experiment on sandy loam, highly sodic soil having pH_2 10.5, EC_2 2.42 dSm^{-1} ESP 89 and G.R. 30.8 Mg ha^{-1} was conducted with rice-wheat for four years (2001-02 to 2004-05) at CSSRI, Research farm, Shivri, Lucknow. The experiment was laid out in split plot design consisting of 4 levels of gypsum and 2 varieties of salt tolerant and non-salt tolerant rice and wheat with the objectives to assess the feasibility and extent of minimizing chemical amendment by substitution with salt tolerant varieties in a rice-wheat cropping sequence, to determine the time frame for the substitution of salt tolerant varieties with high yielding varieties and also for crop diversification, to monitor the physico-chemical changes in soil due to synergy of gypsum and salt tolerant varieties and to work out the economics of proposed reclamation technology.

From the study, it was concluded that the increasing level of gypsum up to 25% G.R. significantly increased the growth, yield attributing characters and yields of rice and wheat. Maximum grain yields of salt tolerant and non-salt tolerant traditional varieties of rice and wheat were recorded at 50% G.R. level but the difference between 25 and 50% G.R. levels was not significant. Salt tolerant varieties of rice and wheat yielded 17% and 5% higher over non-salt tolerant traditional varieties. The pH_2 of surface soil (0.15 cm) with salt tolerant varieties of rice and wheat reduced from 10.5 to 8.87 and 9.12 at 50% and 25% G.R. levels respectively. However, with non-salt tolerant varieties it reduced to the levels of 8.9 and 9.2. Besides, infiltration rate increased from 2.0 mm day^{-1} to 11.30 mm and 19.30 mm day^{-1} with 25 and 50% G.R. levels respectively. Maximum gross return and B:C ratio was recorded from the treatment having 25% G.R. and salt tolerant varieties.

The results of the experiment revealed that, under the resource scarce situation, where the amendments are not easily available, biological-cum-chemical

amelioration technology with the application of reduced dose of gypsum @ 25% of G.R. along with salt tolerant varieties of rice (CSR 13) and wheat (KRL 19) ensures more productivity. By employing this approach, 50% gypsum could be saved and this saved amount can be utilized to bring more area under reclamation. This technology may trigger the reclamation process and be more cost effective, acceptable to small and marginal farmers and sustainable.

As the salt tolerant varieties are having low yield potential than the high yielding varieties in reclaimed sodic lands it needs to be replaced by high yielding varieties when the soil is reclaimed to compensate the reclamation cost and also to maximize the crop production. The study conducted to determine the time frame for replacement of salt tolerant varieties or crop diversification revealed that with 25% G.R., salt tolerant varieties of rice should be replaced after four years and wheat after three years. However, with 50% G.R. the replacement period of salt tolerant varieties of rice and wheat should be three and two years respectively.

The study on diversification of rice-wheat cropping system with highly remunerative crops in partially reclaimed sodic soils conducted for two years revealed that sweet basil (Tulsi) (*Ocimum basilicum*)-matricaria (*Matricaria chamomilla*), a medicinal and aromatic crop based cropping system was highly remunerative than rice-wheat. Sweet basil (*Ocimum basilicum*) - matricaria (*Matricaria chamomilla*) cropping system recorded, maximum reduction in soil pH_2 because matricaria absorbs higher amount of cations, especially sodium at a faster rate (Mishra, 1987). The organic carbon status in the soil has also improved slightly higher with sweet basil - matricaria cropping system over the traditional rice-wheat system.

1.0 INTRODUCTION

In India, about 6.73 million hectare salt affected soils lying barren or produce very low and uneconomical yields of various crops (Sharma *et al.*, 2006). Out of this 3.8 million hectare is sodic soil. These soils are mostly found in the states of Uttar Pradesh, Haryana, Punjab, Madhya Pradesh, Bihar and Andhra Pradesh. The major farming constraints of this soil are high pH (>8.2), exchangeable sodium (>15), excess of carbonate and bicarbonate of sodium, variable electrical conductivity (<4 dSm^{-1}), poor infiltration rate (<2.0 mm day^{-1}), poor organic carbon (<0.1g kg^{-1}), and poor fertility status. Under natural conditions, these soils contain 2-4% amorphous $CaCO_3$ in the surface and a hard kankar pan of variable thickness and depth below the surface. Plant growth, yield and quality of crops in these soils is affected by poor water and air permeability, low water availability due to poor conductance from the lower to the upper soil layers, hard crust on the surface layer and excess of Na which decreased availability of micronutrients.

Undoubtedly, these soils are to be reclaimed for increasing agricultural production. Uttar Pradesh is having the largest area (1.36 million hectare) i.e., 20% of the total salt affected area in the country. To bring these soils under cultivation is a challenging task to researchers and extension workers. Only 10% of the reclaimed salt affected area is under double crop, 30% is under mono-crop and 60% is completely barren. The yield losses due to presence of salt in the soil are about 15% of the cereals output. The productivity level of both mono-cropped and double cropped salt affected area is extremely low.

Rice - wheat is the important crop rotation in reclaimed as well as partially reclaimed sodic soils. Salt affected soil is largely confined to small and marginal farmers. To this category of farming community, subsistence with their own farming activities has always been questioned due to their poor and fragile resource base in agricultural activities. Gypsum ($CaSO_4$ $2H_2O$) which is generally recommended for the reclamation of sodic soils (Abrol and Bhumbla, 1979) is a costly input and costs about Rs. 2000 t^{-1}. On the basis of prevailing technology (50% G.R. technology), about 12-15

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tones of gypsum is required to reclaim one hectare sodic land. This means about Rs. 25000 ha^{-1} is needed on account of gypsum only. The share of gypsum amendment cost increased with severity of degradation. In case of severely affected soils it is about 60% of total reclamation cost followed by moderately affected soils (53%) and marginally affected area (39%) (Dutta and Joshi, 1996). The subsidy provided by the state government is only available to farmers covered under reclamation programme. The small and marginal farmers still find it difficult to reclaim their lands. Furthermore, government cannot provide such high subsidy in the future. Although, some other options like use of FYM @ 30 Mg ha^{-1} alone or 20 Mg ha^{-1} in conjunction with reduced dose of gypsum (25% G.R.) are also available but the availability of FYM in such a huge quantity is also a matter of serious concern. Under these situations, adoption of such costly technology for reclaiming the sodic soils by the resource poor farmers may not be a viable proposition.

There could be two possible ways to overcome sodic stress (i) either improve the soil environment for the normal plant growth or (ii) improve the plant itself which can be grown in that environment. The first approach is resource costly and invariably high and the second is development of salt tolerant varieties. There could be a third approach i.e hybrid approach, based on exploitation of synergies between the chemical amendment and salt tolerant varieties. This, therefore, calls for alternative low cost technology suitable to the resource poor small and marginal farmers for the reclamation of sodic soils. Salt tolerant varieties of rice (CSR 10, CSR 13, CSR 23, CSR 27 and CSR 36) and wheat (KRL 1-4 and KRL 19) evolved at CSSRI, Karnal can be successfully grown in highly sodic soils with lesser quantity of gypsum. The present study was therefore undertaken to develop a low cost technology through synergizing the gypsum and salt tolerant varieties of rice and wheat with the following objectives.

(i) To assess the extent and the degree of feasibility of minimizing need for chemical amendment requirement by salt tolerant varieties in a cropping sequence.

(ii) To determine the time frames for substitution of salt tolerant varieties with other high yielding varieties and also for crop diversification.

(iii) To monitor the physico-chemical changes in soil due to synergy of gypsum and salt tolerant varieties.

(iv) Economic evaluation of proposed reclamation technology to find out the financial feasibility and sustainability of technology.

2.0 GENERAL FEATURES OF THE STUDY SITE

2.1 Site characteristics

2.1.1 Location

The field experiments were carried out for four years (2001-02 to 2004-05) at Research Farm of Central Soil Salinity Research Institute, *Regional Research Station,* Lucknow located at 26^0 47' 58" N and 80^0 46' 24" E, about 120m above mean sea level (AMSL). The soil of the experimental site was characterized as typic Natrustalfs, having sandy loam in texture on the surface and silty loam and clay loam in middle and sandy loam in lower layers (Sharma *et al.*, 2006). The soil was having physical and nutritional problems due to poor soil water cover and soil air relations caused by high bulk density (> 1.5 g cm^{-3}) and very poor infiltration rate. Formed on old alluvium, the farmlands have gentle slopes between contours of 99.0 m in the NE to 97.6 m in the SW direction (Fig.1).

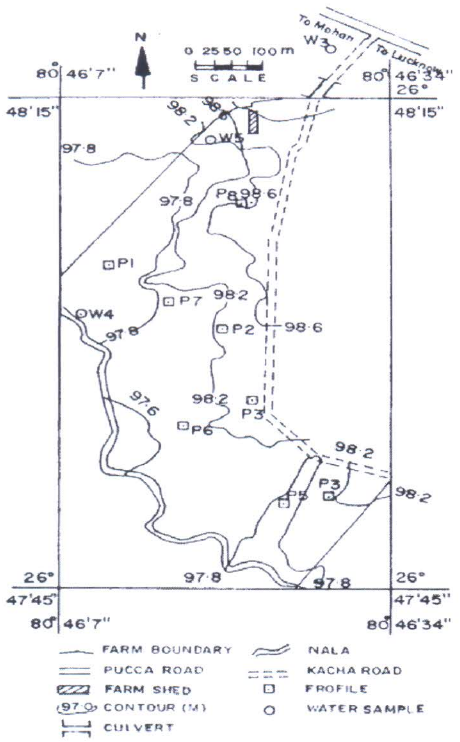

Fig. 1 Location map of CSSRI, Research farm, Shivri, Lucknow, Uttar Pradesh

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2.1.2 Climate

The climate is semi-arid, subtropical and monsoonic receiving an average annual rain fall of 817 mm. Maximum rainfall is received between 23-40 standard weeks (June-October) amounting to 741 mm, which is 91% of the total annual rain. The remaining 9% rainfall is received between 41-19 standard weeks (November to May). The average annual evaporation is 1580 mm. The evaporation rate, varies with increasing air temperature and atmospheric water demands gradually increase from 1-22 weeks (January to June). During the rainy season between 23-40 weeks (mid June to October) evaporation rate gradually decreases following rains. Further up to 52 weeks (December), the evaporation decreases gradually due to low temperature. The period from 23-40 weeks (mid June to mid October) remains in water surplus. The remaining period between 1-22 and 41-52 weeks remains in water deficit due to lower rains and higher evaporation rate. The mean maximum temperature of 39°C in the month of May and mean minimum temperatures of 7.1°C in the month of January indicate a seasonal climate. The mean annual temperature during the study period varied was recorded as 24.6 °C (Fig. 2).

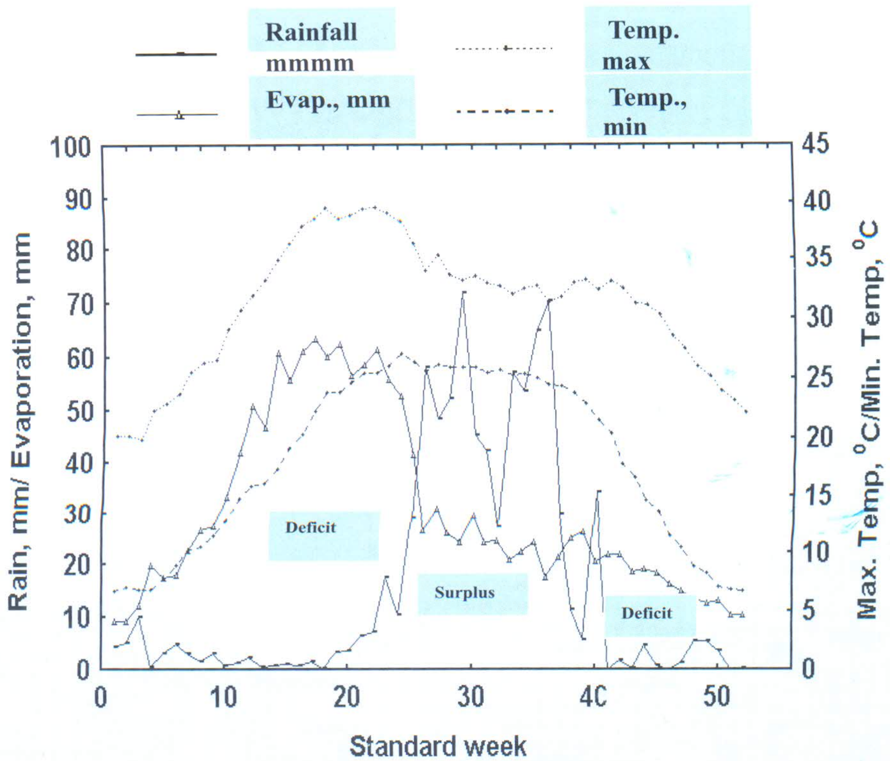

Fig. 2 The climatic feature of the experimental site

2.1.3 Initial soil properties

To study the soil properties of the experimental site, soil profile up to 120 cm deep was dug out before initiating the experiment during the year 2001-02. Soil of both the experimental sites was highly alkaline in nature having pH (1:2) 10.5, EC (1:2) 2.42 dSm^{-1} and gypsum requirement (G.R) 30.8 Mg ha^{-1}. A hard $CaCO_3$ presented in the soil varied from 2.40 per g kg^{-1} at surface to 12.46 g kg^{-1} at 120 cm depth. The soil was very poor in organic carbon (0.8 g kg^{-1}) and available nitrogen (94 kg ha^{-1}), medium in available phosphorus (25 kg ha^{-1}) and rich in available potash (388 kg ha^{-1}) (Table 1).

Original landscape of experimental site

Table 1. Soil properties of the experimental site

Soil parameters	Soil depth (cm)				
	0-15	15-30	30-60	60-90	90-120
Sand (%)	63.1	48.6	47.3	49.4	57.3
Silt (%)	17.5	25.4	20.9	23.4	25.3
Clay (%)	19.4	26.0	31.8	27.2	17.4
Bulk density (g cc^{-1})	1.6	1.57	1.53	1.5	1.49
pH (1:2)	10.5	10.4	10.4	10.0	9.6
EC (1:2) (dSm^{-1})	2.42	1.43	0.86	0.64	0.45
ESP	89	91	85	80	60
O.C. (g kg^{-1})	0.8	0.8	0.6	0.6	0.6
$CaCO_3$ concretion (g kg^{-1})	2.4	1.3	2.3	6.3	12.5
Alkaline $KMnO_4$ -N(kg ha^{-1})	94.0	62.7	54.6	45.1	40.6
Olsen's P (kg ha^{-1})	25.0	21.6	18.5	17.0	16.1
Available K (kg ha^{-1})	388.8	384.0	321.4	238.6	169.0

Gypsum requirement (G.R.) -30.8 Mg ha^{-1}

2.1.4 Ground water depth and quality

On the basis of four years data, it is concluded that the ground water remains more than 3 m from the ground level throughout the cropping season. Maximum water

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table depth (7.5m) was during the month of June and minimum (3.8 m) in the month of October. (Fig. 3). The experimental site was surrounded by the sodic soils where, rice-wheat crop rotation is the predominant. Tube well waters applied to the experimental crops having low electrolyte and EC ranging between 0.61-0.63 dSm^{-1} which is safe for irrigation. Amongst cations, Na dominates over Ca and Mg followed by K. Amongst anions, bicarbonates plus carbonates dominates over calcium, while sulphates are absent. These waters have residual alkalinity to the extent of 1.3 to 1.5 mel^{-1} (Table 2).

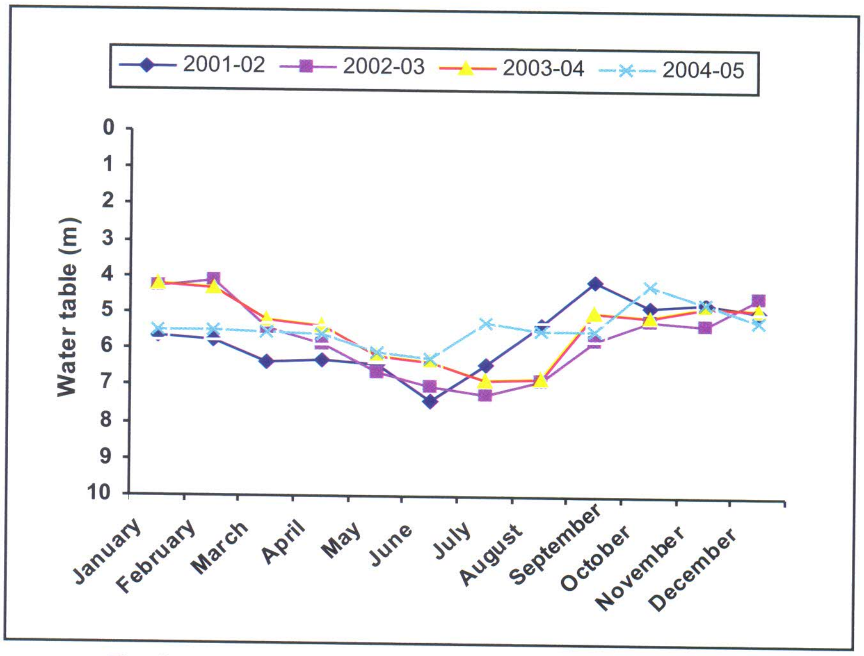

Fig. 3 Average monthly water table during cropping season

Table 2. Quality of irrigation water applied to the experiment

Quality parameters	Tube well no. 1	Tube well no.2
EC($dS\ m^{-1}$)	0.68	0.57
pH	7.56	8.08
CO_3(mel^{-1})	1.20	1.20
HCO_3(mel^{-1})	4.00	3.20
Cl (mel^{-1})	2.10	1.50
SO_4(mel^{-1})	0.00	0.00
Ca+Mg(mel^{-1})	3.70	3.10
Na(mel^{-1})	4.10	3.70
K(mel^{-1})	0.12	0.12
RSC(mel^{-1})	1.50	1.30
SAR	3.00	2.90

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3.0 SYNERGY OF REDUCED GYPSUM AND SALT TOLERANT VARIETIES

3.1 Methodology

The field experiment was laid out in a split plot design with four gypsum levels (control (no gypsum), 15% G.R. , 25% G.R. and 50% G.R.) in main plots and two rice varieties such as, CSR 13 (salt tolerant variety) and Pant 4 (non- salt tolerant traditional high yielding variety) and KRL 19 (salt tolerant variety) and PBW 343 non-salt tolerant traditional high yielding variety of wheat in sub plots (Fig. 4).

Overview of rice planting in the experimental plot

The treatments were replicated four times. Before initiating the experiment, gypsum requirement of the experimental plot was determined through Schoonover, (1952) method. The required amount of gypsum was applied in the surface soil (0-15 cm) in the month of May and mixed with cultivator followed by application of about 10 cm water for 10 days to displace the reaction product of Ca-Na exchange down to the root zone. The recommended doses of fertilizer (150 kg N: 60 kg P and 25 kg $ZnSO_4$ ha^{-1}) was applied uniformly in all the treatments. Half dose of N and full dose of P and $ZnSO_4$ were applied as basal and the remaining half dose of N was applied in two equal splits at 21 and 45 days of transplanting of rice. The layout was not disturbed and subsequent wheat crop with recommended dose of fertilizer (150 kg N ha^{-1} and 60 kg P ha^{-1}) was sown in the same plots as per treatment. Half dose of N and full dose of P was applied uniformly as basal and the remaining half dose of N was

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applied at crown root initiation (CRI) and tillering stages in 2 splits. After harvesting of each crop, soil samples from 0-15 and 15-30 cm soil depth were collected and analyzed to monitor the changes in soil properties.

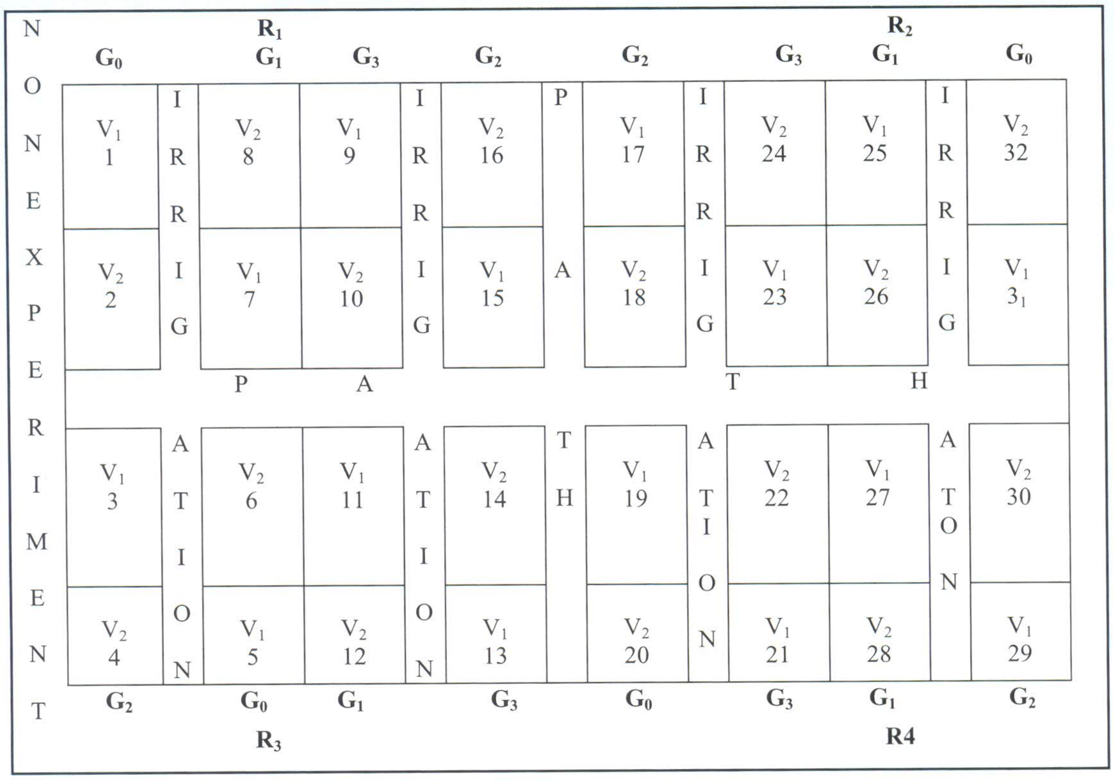

Fig. 4 Layout plan of experiment

3.2 Crop growth

Four years pooled data revealed that all the growth characters i.e. plant height, number of tillers and dry matter accumulation of rice and wheat increased with increasing levels of gypsum up to 50% G.R. though the difference beyond 15% G.R. were not significant (Table 3). Number of effective tillers increased significantly with every additional rate of gypsum up to 50% G.R. The dry matter accumulation also increased with increased rate of gypsum up to 50% G.R. but the difference between 25% and 50% G.R. was not significant. In wheat

Effect of gypsum levels on crop growth

also, plant height was significant at 15% G.R. over control and thereafter the increase in gypsum rates did not bring out significant differences in this character. Number of effective tillers m^{-1} row length and dry matter accumulation increased significantly with every increasing level of gypsum. However, the difference between 25% and 50% G.R. was statistically not significant. All the growth parameters of salt tolerant rice variety 'CSR 13' were significantly superior over the non-salt tolerant traditional variety, 'Pant 4'. However, in wheat there was no significant difference in plant height and number of effective tillers between the varieties. Salt tolerant wheat variety 'KRL 19' accumulated significantly higher dry matter than the salt sensitive variety 'PBW 343'.

Table 3. Effect of gypsum levels and varieties on growth parameters of rice and wheat (Pooled data of 4 years)

Treatments	Plant height (cm)			No of effective Tillers $hill^{-1}$			Dry matter (g $hill^{-1}$)		
Rice									
	CSR13	Pant 4	Mean	CSR13	Pant 4	Mean	CSR13	Pant 4	Mean
Control	68.18	55.93	62.05	4.50	3.10	3.80	20.32	19.27	19.79
15% G.R.	97.98	88.66	93.32	8.00	5.94	6.97	47.35	40.93	44.14
25% G.R.	101.47	94.95	98.21	9.52	6.80	8.16	64.70	50.51	57.60
50% G.R.	109.43	99.04	104.23	11.44	8.27	9.85	68.03	55.73	61.88
Mean	94.26	84.64		8.36	6.02		50.10	41.61	
CD(P=0.05) for G			16.52			1.09			5.29
CD(P=0.05) for V			4.69			0.61			2.69
CD(P=0.05 for GXV			NS			NS			5.38

Treatments	Plant height (cm)			No of effective tillers m^{-1} row length			Dry matter (g $30cm^{-1}$ row length)		
Wheat									
	KRL 19	PBW 343	Mean	KRL 19	PBW 343	Mean	KRL 19	PBW 343	Mean
Control	37.80	27.74	32.77	12.00	10.77	11.38	15.30	12.27	13.78
15% G.R.	61.13	61.40	61.26	59.38	58.27	58.82	40.60	35.35	37.97
25% G.R.	66.34	69.31	67.82	77.58	80.38	78.98	44.60	46.55	45.57
50% G.R.	67.82	75.32	71.57	81.94	84.16	83.05	46.78	47.50	47.14
Mean	58.27	58.44		57.72	58.39		36.82	35.41	
CD(P=0.05) for G			10.83			6.42			4.02
CD(P=0.05) for V			NS			NS			1.71
CD(P=0.05) forGXV			NS			NS			3.41

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3.3 Yield attributes

Effect of gypsum levels & varieties on yield attributes of rice

Panicle length in rice increased with increase in gypsum rates up to 50% G.R. levels but significant difference in this character was recorded only up to 25% G.R. level. However, number of grains panicle^{-1} differed significantly with successive increase in the gypsum levels. Gypsum at 15 and 25% G.R. being at par between themselves produced significantly longer panicles over control treatment (Table 4). Again in terms of test weight, 25 and 50% G.R. were at par between themselves but significantly superior over control and 15% G.R. In wheat spike length with 15% G.R. did not differ significantly from control treatment but 25 and 50% G.R. being at par between them produced significantly taller spikes than former treatments. In terms of number of grains spike^{-1}, all the levels of gypsum were superior to control but at par among themselves. Increasing gypsum levels from 15 to 50% G.R. caused significant improvement in test weight over no gypsum treatment but remained at par from each other.

Effect of gypsum levels & varieties on yield attributes of wheat

Salt tolerant varieties 'CSR 13' of rice and 'KRL 19' of wheat gave significantly higher panicle and spike length over the non-salt tolerant traditional high yielding varieties 'Pant 4' and 'PBW 343'. Similarly salt tolerant varieties 'CSR 13' of rice and 'KRL 19' of wheat gave significantly higher number of grains panicle^{-1} and number of grains spike^{-1} respectively over the traditional high yielding varieties. The test weight of non-salt tolerant high yielding variety of rice 'Pant 4' was higher than the sodicity tolerant variety 'CSR 13' because of bolder grain size However, in wheat there was no significant difference in test weights between sa tolerant and non-salt tolerant varieties.

Table 4. Effect of gypsum levels and varieties on yield attributing characters of rice and wheat (Pooled data of 4 years)

Rice

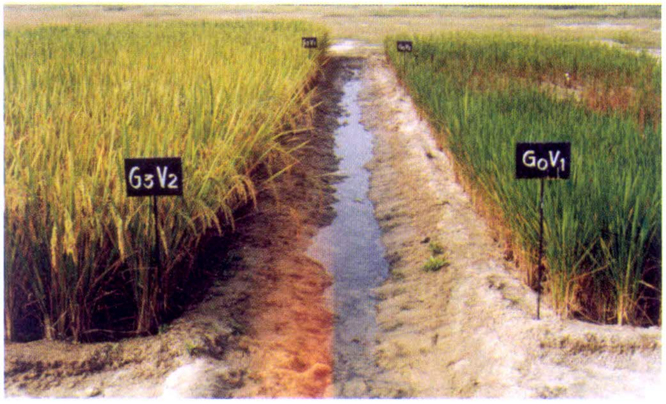
Treatments	Length of panicle (cm)			Grains Panicle^{-1}			Test weight (g)		
	CSR 13	Pant 4	Mean	CSR 13	Pant 4	Mean	CSR 13	Pant 4	Mean
Control	16.39	15.24	15.81	67.01	62.89	64.95	16.19	19.00	17.59
15% G.R.	22.75	23.17	22.96	96.80	81.37	89.08	21.13	24.48	22.80
25% G.R.	23.85	24.93	24.39	128.91	109.57	119.24	22.22	27.54	24.88
50% G.R.	24.40	25.68	25.04	132.14	126.61	129.37	23.37	28.21	25.79
Mean	21.84	22.25		106.21	95.11		20.72	24.80	
CD(P=0.05) for G			3.36			22.20			1.91
CD(P=0.05) for V			NS			7.71			1.65
CD(P=0.05) for GXV			NS			NS			NS

Wheat

Treatments	Length of spike (cm)			Grains spike^{-1}			Test weight (g)		
	KRL 19	PBW 343	Mean	KRL 19	PBW 343	Mean	KRL 19	PBW 343	Mean
Control	7.24	6.59	6.91	26.74	21.66	24.20	19.47	18.90	19.18
15% G.R.	9.53	9.11	9.32	40.94	36.23	38.58	31.64	32.27	31.95
25% G.R.	9.81	9.23	9.52	44.59	38.80	41.69	34.38	34.32	34.35
50% G.R.	10.18	9.36	9.77	46.02	41.37	43.69	37.11	37.05	37.08
Mean	9.19	8.57		39.57	34.51		30.65	30.63	
CD(P=0.05) for G			1.68			5.71			4.60
CD(P=0.05)for V			0.40			2.74			NS
CD(P=0.05) for GXV			NS			NS			NS

3.4 Grain yields

The grain yield of rice and wheat increased with increasing levels of gypsum during all the four consecutive years. Yield of rice was significantly higher up to 25% G.R. level over control and 15% G.R. level and beyond that there was no significant increase in rice grain yield (Table 5). Chhabra *et al.* (1989), Swarup and Singh (1994) have also reported non-significant difference in rice grain yield between 25 and 50% G.R. levels. The salt tolerant variety of rice gave 27.6%, 13.2% and 10.7% higher grain yield over non-salt tolerant



Effect of gypsum levels & varieties on grain yield of rice

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high yielding variety during the year 2001-02, 2002-03, 2003-04 respectively. Mishra *et al.* (1992) have also reported that the salt tolerant varieties of rice yielded higher up to pH 10.2 while most of the common ones failed beyond pH 9.8. During 2004-05, the grain yield of salt tolerant variety with reduced dose of gypsum (25% G.R.) was about 4.2% higher than the non-salt tolerant varieties but at 50% G.R. non-salt tolerant traditional variety gave about 3.0% higher grain yield over the salt tolerant variety. From the study, it was observed that during the initial two years (2001-02 and 2002-03), grain yield of salt tolerant variety with 25% G.R. was at par with the grain yield of non-salt tolerant traditional variety with 50% G.R. However, during third and fourth years the non-salt tolerant variety with 50% G.R. gave 5.0% and 4.2% higher yields over the salt tolerant variety with 25% G.R. because of more improvement in soil health.

Effect of gypsum levels & varieties on grain yield of wheat

Wheat grain yield increased significantly up to 25% G.R. level over the control and 15% G.R. The yield difference of 5.67, 4.00, 4.80 and 4.59 q ha^{-1} during 2001-02, 2002-03, 2003-04 and 2004-05 between 25 and 50% G.R. level was not significant. Salt tolerant variety of wheat yielded significantly higher over non-salt tolerant traditional high yielding variety during the year 2001-02 and 2002-03 a after that there was no significant difference between the varieties . During the ye 2003-04, yield of salt tolerant variety with 50% G.R. was lower than the non-s tolerant traditional variety but at 25% G.R. salt tolerant variety gave significar higher yield over the non-salt tolerant variety. It might be due to improvement in health and also low yield potential of salt tolerant varieties under the reclaimed s Therefore, it was analyzed that, with the reduced dose of gypsum (25% G.R.), tolerant variety of rice and wheat should be replaced with high yielding varieties a

Table 5. Effect of gypsum levels and varieties on grain yield of rice and wheat

Rice

Treatments	2001-2002			2002-2003			2003-2004			2004-05		
	CSR 13	Pant 4	Mean	CSR 13	Pant 4	Mean	CSR 13	Pant 4	Mean	CSR 13	Pant 4	Mean
Control	3.21	0.71	1.96	5.49	3.66	4.57	6.35	4.20	5.27	17.30	14.80	16.05
15% G.R.	27.30	15.68	21.49	30.13	24.72	27.42	32.79	28.10	30.44	34.80	29.30	32.05
25% G.R.	40.87	34.77	37.82	43.86	37.59	40.72	45.22	41.11	43.16	47.10	45.10	46.10
50% G.R.	45.56	40.50	43.03	47.93	43.68	45.80	49.60	47.55	48.57	47.73	49.20	48.66
Mean	29.24	22.91		31.85	27.41		33.49	30.24		36.73	34.60	
CD(P=0.05) of G			5.23			5.62			6.06			3.13
CD(P=0.05) of V			6.38			4.54			3.80			2.14
CD(P=0.05) of G x V			2.71			NS			2.76			NS

Wheat

Treatments	2001-2002			2002-2003			2003-2004			2004-05		
	KRL 19	PBW 343	Mean	KRL 19	PBW 343	Mean	KRL 19	PBW 343	Mean	KRL 19	PBW 343	Mean
Control	2.19	1.71	1.95	3.17	2.33	2.75	5.39	3.17	4.28	6.39	4.97	5.68
15% G.R.	13.46	10.33	11.89	13.73	12.82	13.27	17.65	16.48	17.06	19.06	16.21	17.63
25% G.R.	22.00	17.33	16.99	24.76	21.67	23.21	27.39	24.99	26.19	30.33	31.83	31.06
50% G.R.	23.86	21.67	22.76	28.75	25.67	27.21	30.42	31.56	30.99	34.62	36.73	35.67
CD(P=0.05) of G			5.72			5.39			2.93			1.85
CD(P=0.05) of V			3.67			2.10			NS			NS
CD(P=0.05) of G x V			2.11			NS			NS			NS

The interaction between gypsum levels and rice varieties was significant for grain yield during 2001 and 2003 and not in 2002. During 2001, variety 'CSR 13' significantly excelled 'Pant 4' in grain yield at gypsum levels from 15 to 50% G.R. However, the magnitude of difference decreased with increasing levels of gypsum. Salt tolerant rice varieties 'CSR 13' at 25% G.R. and 'Pant 4' at 50% G.R. gave practically similar yields. These observations indicate saving of gypsum to the tune of 25% by using salt tolerant

Table 6. Interaction effect of gypsum levels and varieties on grain yield (q ha^{-1}) of rice and wheat

Gypsum levels (% G.R.)	Rice				Wheat	
	2001-02		2003-04		2001-02	
	CSR 13	Pant 4	CSR 13	Pant 4	KRL 19	PBW 343
0	3.21	0.71	6.35	4.20	2.19	1.71
15	27.30	15.68	32.79	28.10	13.46	10.33
25	40.87	34.77	45.22	41.11	22.00	20.33
50	43.56	40.50	49.60	47.55	23.86	21.67
SEm ±	0.89		0.91		0.71	
CD (P=0.05)	2.71		2.76		2.11	

rice variety in sodic soils (Table 6). Significant interaction between wheat varieties and gypsum levels was recorded in 2001-02 with the result that salt tolerant variety 'KRL 19' with 25% G.R. produces similar grain yield (22.00 q ha^{-1}) as sensitive variety 'PBW 343' with 50% G.R. (21.67q ha^{-1}).

3.5 Soil improvement

After four years of rice-wheat cropping, the pH_2 of surface soil (0-15 cm) reduced from 10.5 to 8.9 where the gypsum was applied @ 50% of G.R. whereas, pH_2 with 25% G.R. reduced to the level of 9.1. In control plots where no gypsum was applied, the pH_2 of surface soil reduced to the level of 9.8. The reduction in soil pH due to varieties was not significant. The pH_2 of surface soil (0-15 cm) planted with salt tolerant varieties reduced to 8.9 and 9.1 at 50 and 25% G.R. levels respectively as compared to 8.9 and 9.2 with non-salt tolerant traditional varieties. The ESP of the surface soil where gypsum was applied @25% G.R. and salt tolerant varieties of rice and wheat were grown reduced from 89 to 30 and with non-salt tolerant varieties it reduced to the level of 33.40. Chhabra and Abrol (1977) have also reported the changes in ESP and improvement in physical properties of sodic soils with reduced dose of gypsum and growing of salt tolerant varieties. However, application of gypsum @ 50% G.R. and growing of salt tolerant and non-salt tolerant varieties ESP reduced to the levels of 26.0 and 28.5 respectively (Table 7). There was not much difference in infiltration rate due to varieties but with the addition of gypsum @ 25 and 50% G.R. doses it increased to 11.3 mm and 19.3 mm day^{-1} respectively over the control (4.8 mm day^{-1}) and 15% G.R. (7.0 mm day^{-1}). Acharya and Abrol (1991) have also reported considerable improvement in infiltration rate with the addition of gypsum in sodic soils. The application of gypsum and growing of salt tolerant varieties of rice and wheat have generated more organic acids, which mobilize the soil calcium and salts were also leached down from the root zone. As the levels of gypsum increased, the organic carbon content of the soil also increased because of higher crop biomass. The organic carbon content increased from 0.08 g kg^{-1} to 1.20 and 1.30 g kg^{-1} with the application of gypsum @ 25 and 50% G.R. and growing of salt tolerant varieties respectively.

Table 7. Improvement in soil properties due to synergy of gypsum and salt tolerant varieties of rice and wheat.

Soil properties	Control		15% G.R.		25% G.R.		50% G.R.	
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
2001-02								
pH(1:2)	10.18	10.24	9.95	9.98	9.50	9.58	9.22	9.40
EC(1:2) (dS m^{-1})	0.97	1.01	0.64	0.88	0.67	0.69	0.65	0.69
ESP	82.10	87.21	72.62	75.43	60.00	63.67	48.50	52.76
O.C. (g kg^{-1})	0.84	0.81	1.04	0.86	1.08	0.90	1.10	1.00
2002-03								
pH(1:2)	10.01	10.04	9.61	9.75	9.30	9.40	9.12	9.22
EC(1:2) (dS m^{-1})	0.82	0.82	0.50	0.74	0.59	0.63	0.53	0.67
ESP	80.03	82.60	62.56	66.64	52.65	54.85	46.61	45.43
O.C. (g kg^{-1})	*0.86*	*0.84*	*1.06*	*0.88*	*1.10*	0.95	1.15	1.16
2003-04								
pH(1:2)	9.88	10.01	9.36	9.47	9.16	9.28	8.89	9.04
EC(1:2) (dS m^{-1})	0.76	0.82	0.60	0.66	0.56	0.62	0.48	0.54
ESP	64.23	64.12	55.24	57.32	48.00	50.00	42.00	43.10
O.C. (g kg^{-1})	0.90	0.86	0.92	0.90	1.00	1.00	1.20	1.20
2004-05								
pH(1:2)	9.84	9.88	9.33	9.44	9.12	9.18	8.87	8.91
EC(1:2) (dS m^{-1})	0.50	0.47	0.30	0.50	0.50	0.44	0.35	0.35
ESP	60.20	62.50	48.20	50.30	30.00	33.40	26.00	28.50
O.C. (g kg^{-1})	0.90	0.88	1.10	1.00	1.20	1.10	1.30	1.26
Infiltration rate (mm day^{-1})	4.80	4.60	7.00	7.00	11.30	11.00	19.30	19.00
Alkaline $KMnO_4$ -N (kg ha^{-1})	115.60	97.80	192.50	132.50	192.50	186.72	201.65	192.60

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4.0 TIME FRAME FOR SUBSTITUTION OF SALT TOLERANT VARIETIES

4.1 Rice

During the three consecutive years (2001-02, 2002-03 and 2003-04) salt tolerant varieties of rice gave significantly higher yields at every increasing level of gypsum. The yield difference between salt tolerant and non-salt tolerant varieties during the year 2001-02 , 2002-03 at 25 and 50% G.R. levels was 6.1and 5.1q ha^{-1} and 6.2 and 4.2 q ha^{-1} respectively. After two years (2003-04) when the soil was partially reclaimed, the yield gap reduced to the level of 4.11 and 2.05 q ha^{-1} and during 2004-05 salt tolerant variety with 25% G.R. gave higher yield than the non-salt-tolerant traditional variety whereas, with 50% G.R. the yield of non-salt tolerant variety exceed the salt tolerant one (Fig. 5).

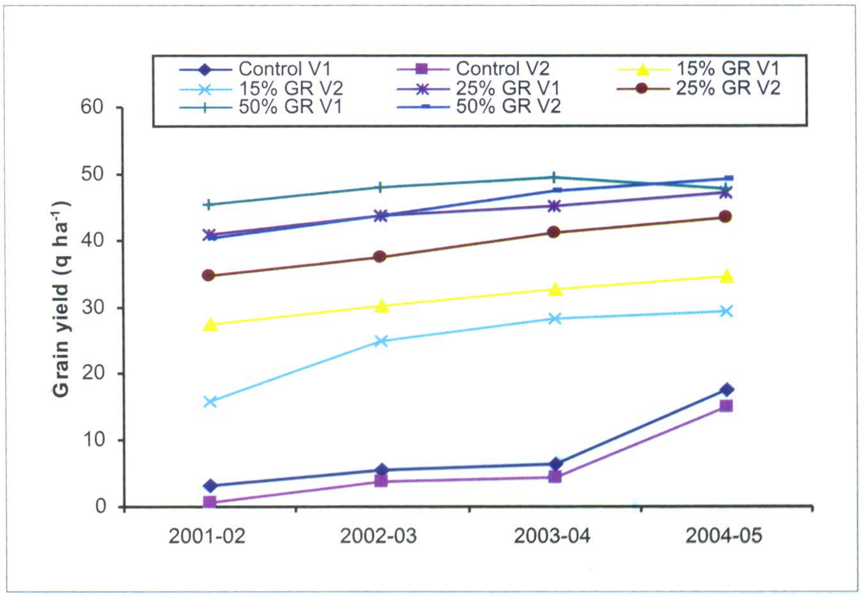

Fig. 5 Time frame for substitution of salt tolerant varieties of rice

4.2 Wheat

The yield difference between salt tolerant and non-salt tolerant varieties wheat at 25 and 50% G.R. levels during 2001-02 and 2002-03 was 4.67, 5.33, 2.69 a 3.08 q ha^{-1} respectively. During third year (2003-04) when the soil was partia reclaimed (pH_2 9.2) the yield gap between salt tolerant and non-salt toler traditional varieties at 25% G.R. reduced to 2.4 q ha^{-1}. However, at 50% G.R. when pH_2 is reduced to the level of 9.0, the non salt tolerant variety gave higher yield t the salt tolerant one but the difference between them was not significant. This is the time for substitution of salt tolerant varieties with non-salt tolerant traditional varieties in case gypsum is applied @ 50% G.R. During 2004-05 when the pH_2 of the soil at 25% G.R. and 50% G.R. reduced to the level of 9.1 and 8.9, non-salt tolerant traditional variety gave higher yields (31.83 and 36.73 q ha^{-1}) than the salt tolerant variety (30.33 and 34.62 q ha^{-1}) respectively. Therefore, it is inferred that after application of gypsum @ 25% G.R., salt tolerant variety of wheat should be grown only for three years and after that it should be replaced with high yielding varieties to get higher yields. However, with 50% G.R. salt tolerant variety may be replaced with high yielding varieties even after two years (Fig. 6).

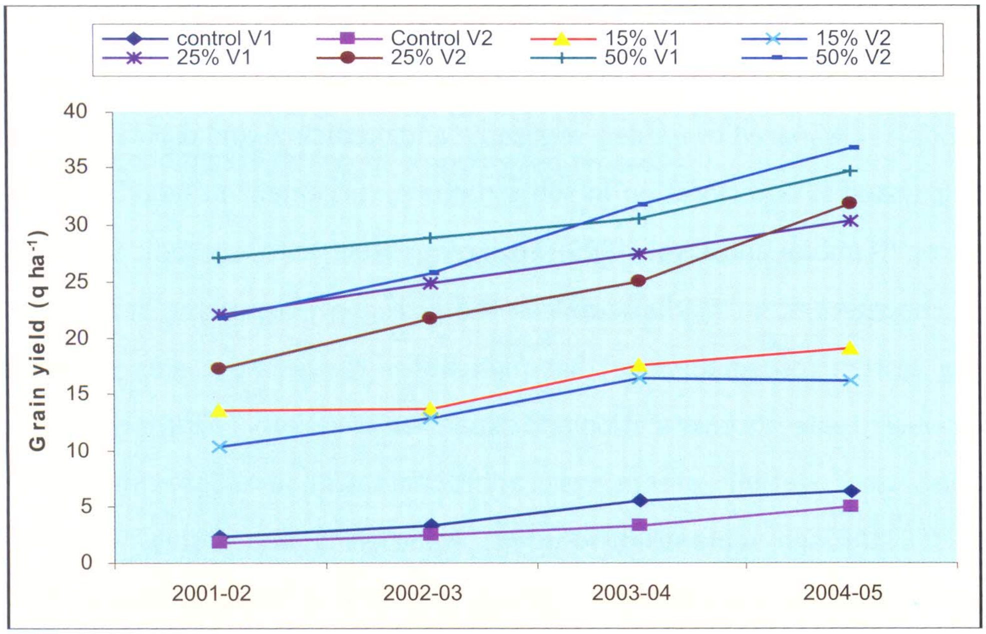

Fig. 6 Time frame for substitution of salt tolerant varieties of wheat

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5.0 CROP DIVERSIFICATION

5.1 Importance of study

Rice-wheat is the predominant cropping system in the reclaimed sodic s occupying about 60-70% area. Wide adoption of this system is due to l productivity and less element of risk. Though, it is very remunerative cropping sys but created many serious ecological problems such as exhaustion of undergrc water resulting depletion in ground-water from 15 to 80 cm every year. Moreover, irrigation water is a costly and scarce resource. The availability of water agriculture is going down because of increasing demand for domestic and indus uses. Due to continuous cultivation of rice-wheat cropping system in part reclaimed sodic soils for a longer period, the sustainability of the system is beco questionable due to reduction in yield and factor productivity, increasing co production as compared to fodder, vegetable and medicinal and aromatic crop b cropping systems, deterioration in soil structure, increment in weed infestati wheat crop (Nambiar and Abrol, 1989). High crop response to N in sodic soil unde wheat cropping system further reduces the nitrogen pool of the soil. Rice-w *cropping* system (especially rice) has high water requirement and in area h shallow water table, intensification and expansion of salinity hazards have occu This is because irrigation water brings in additional salts and releases immobiliz in the soil through mineral dissolution, weathering and losing water th evaporation and concentration of the dissolved salts in upper layer of soil. Ther a need was felt to conduct experiment to explore the possibility of remunerative alternate cropping system to traditional rice-wheat system for pa reclaimed sodic soils.

5.2 Methodology

After determining the time frame for substitution of salt tolerant varieti high yielding variety, a four times replicated field experiment on diversifica rice-wheat cropping sequence in partially reclaimed sodic soil (pH_2 9.: application of gypsum @ 25% G.R. and growing of salt tolerant varieties of r wheat for 3 consecutive years) was conducted for two years (2004-05 and 2005-06). The experiment was laid in randomized block design with 4 cropping sequences viz. rice-wheat (control), sorghum-berseem (forage crops), tulsi (sweet basil) - matricaria (medicinal and aromatic crops) and chillie-garlic (vegetable crops). The initial properties of the experimental field are given in Table 8. Recommended packages and practices were followed for cultivation of all the crops. The irrigation was applied according to the need of the crop. To analyze the changes in soil fertility after each cropping sequence, composite soil samples (0-15 cm) were collected after harvesting of each cropping sequence and analyzed for pH, EC and organic carbon following standard methods. Rice equivalent yield of all the crops was worked out on the basis of prevailing market rate of the produce and land use efficiency was calculated by dividing the total equivalent yield ha^{-1} of the sequence by the duration of the crops in that sequence. The prevailing market rates of different commodities were used to work out the economics of different cropping sequences.

Table 8. Initial properties of experimental soil

Soil parameters	Soil depth (cm)	
	0-15	15-30
pH_2	9.20	9.36
EC_2 (dSm^{-1})	1.43	1.52
O.C. ($g\ kg^{-1}$)	1.10	1.15
CO_3 ($meql^{-1}$)	0.25	1.00
HCO_3 ($meql^{-1}$)	3.75	4.63
Na^+ ($meql^{-1}$)	26.19	79.60
Cl^- ($meql^{-1}$)	14.00	16.40
K ($meql^{-1}$)	0.12	0.13
Mg^{++} ($meql^{-1}$)	7.25	10.50
Ca^{++} ($meql^{-1}$)	*0.75*	1.25
Available N ($kg\ ha^{-1}$)	186.72	102.02
Available P($kg\ ha^{-1}$)	16.87	8.24
Available K ($kg\ ha^{-1}$)	116.20	139.62

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5.3 Crop yields

Crop diversification in reclaimed sodic soil

Rice-wheat cropping system gave 7.37 Mg ha^{-1} grain yields. Sorghum -berseem cropping sequence produced 29.62 Mg ha^{-1} sorghum and 36.85 Mg ha^{-1} forage yields. Sweet basil-matricaria cropping sequence yielded 0.074 Mg ha^{-1} oil and 0.80 Mg ha^{-1} flowers respectively (Table 9). Sweet basil - matricaria cropping sequence gave highest (14.21 Mg ha^{-1}) equivalent yield followed by chillie -garlic (12.91 Mg ha^{-1}) and sorghum-berseem Mg ha^{-1}) with the lowest (7.74 Mg ha^{-1}) in the rice-wheat system. The highe equivalent yield in sweet basil-matricaria cropping sequence was because o market rate of sweet basil oil (Rs.500 lit^{-1}) and matricaria flowers (Rs.50 k medicinal and aromatic uses. Though, a good yield of sorghum (29.62 Mg ha berseem (36.85 Mg ha^{-1}) was obtained from fodder based cropping system, but not economical. Sweet basil - matricaria, cropping sequence got highest poter to give better return. Thakur *et al.* (1989) have also reported the higher returr medicinal and aromatic crops over rice-wheat system. Adoption of chillie vegetable based cropping sequence in partially reclaimed sodic soils is alsc remunerative than rice-wheat cropping sequence.

Table 9. Yield of different cropping sequences (mean data of 2 years)

Cropping sequence	Yield (Mg ha^{-1})		Rice equival yield (Mg ha
	Kharif crop	Rabi crop	
Rice-Wheat	4.04(G)	3.33 (G)	7.74
Sorghum-Berseem	29.62 (F)	36.85 (F)	9.28
Sweet basil-Matricaria	0.074(O)	0.80(F*)	14.21
Chillie-Garlic	1.57(F**)	2.85 (R)	12.91
CD(P=0.05)	-	-	0.65

G-grain, F-Fodder, O-Oil, F* -Flower, F**- Fruit, R- Rhizome

5.4 Land and water use and production efficiency

Sorghum-berseem cropping system achieved the highest land use efficiency (78.35%) followed by rice-wheat (65.75%), chillie-garlic (54.38%) and sweet basil - matricaria (63.56%). It is primarily due to the longer duration of winter crops. Berseem crop during winter season gave fodder for a longer period followed by wheat, garlic and matricaria. Production efficiency was highest (61.25 kg ha^{-1} day^{-1}) in sweet basil - matricaria cropping sequence followed by chillie-garlic (54.93 kg ha^{-1} day^{-1}), sorghum-berseem (32.44 kg ha^{-1} day^{-1}) and rice-wheat (32.25 kg ha^{-1} day^{-1}) (Table 10). This is because of higher rice equivalent yield of sweet basil - matricaria than the other cropping sequences.

Different cropping sequences consumed varied quantity of irrigation water Maximum water (125.65 cm) was applied with rice-wheat cropping sequences and minimum (85.65 cm) in chilli-garlic. However, highest water use efficiency (150.72 kg ha^{-1} cm) was recorded with Chilli-garlic cropping sequences followed by sweet basil-matricaria (141.18 kg ha^{-1} cm), sorghum-berseem (80.24 kg ha^{-1} cm) and rice-wheat (61.59 kg ha^{-1} cm). The water requirements of sorghum-berseem, sweet basil-matricaria and chilli-garlic cropping sequences are about 8.0, 19.8 and 31.8% less than the water requirement of rice-wheat cropping sequences.

Table 10. Land and water use and production efficiency of different cropping sequences

Cropping sequence	System duration	Land use efficiency (%)	Water use efficiency (kg ha^{-1} cm)	Production efficiency (kg ha^{-1} day^{-1})
Rice - Wheat	240	65.75	61.59	32.25
Sorghum-berseem	286	78.35	80.24	32.44
Sweet basil-matricaria	232	63.56	141.18	61.25
Chillie-garlic	235	54.38	150.72	54.93

5.5 Energetics

The total energy input in different cropping sequences ranged from 22.04 to 27.50 x 10^3 MJ ha^{-1} (Table 11). In general, nitrogen accounted for single largest share of energy input followed by diesel and human labour. The energy input through seed, phosphatic and potassic fertilizers and irrigation was of lower magnitude. Sweet basil-matricaria cropping sequences gave the highest energy use efficiency (11.99) wh the lowest was observed in chilli-garlic (9.66). Though, the total energy out put w high in rice-wheat (314.46 x 10^3MJ ha^{-1}) cropping system, the total energy input w also higher (27.50 x 10^3 MJ ha^{-1}) resulting in lower energy use efficiency. Simil findings were observed by Subbiah *et al.* (1995).

Table 11. Total energy (Mg x 10^3 ha^{-1}) input and output of different cropping system

Cropping systems	Human labour	Diesel	N	P_2O_5	K_2O	Seeds	Irrigation	Total input	Energy output	Energy use efficienc
Rice-wheat	4.26	5.12	11.41	1.33	0.44	2.42	2.52	27.50	314.46	11.43
Sorghum-berseem	5.80	4.34	7.63	1.11	0.30	1.18	1.68	22.04	262.62	11.91
Sweet basil-matericaria	7.68	3.14	9.42	1.21	0.42	0.52	1.34	23.73	284.63	11.99
Chilli-garlic	6.09	2.89	8.43	1.31	0.48	1.69	1.21	22.10	213.52	9.66

5.6 Soil improvement

Among the cropping sequences tested in the experiment, sweet basil- matricari cropping sequence shown maximum reduction in soil pH (1:2) followed by rice-wheat chillie-garlic and sorghum-berseem (Table 12). It is because, matricaria uptake highe amount of cations, especially sodium at a faster rate (Mishra, 1987). The organi carbon status in the soil has also improved slightly higher with sweet basil -matricari cropping sequence over the traditional rice-wheat sequence.

Table 12. Changes in soil properties due to different cropping sequences

Cropping sequence	Soil pH (1:2)	EC(1:2) (d Sm^{-1})	O.C. (g kg^{-1})
Rice- wheat	8.95	0.60	1.20
Sorghum- berseem	9.01	1.01	1.20
Sweet basil-matricaria	8.86	0.41	1.30
Chillie-garlic	9.00	0.99	1.10
Initial	9.20	1.43	1.10

5.7 Cost economics

As the experiment was conducted with different cropping sequences, consisting of crops having diverse in nature, it is worthwhile to compare cropping sequences on the basis of gross return, net return and benefit: cost ratio. Economic analysis of different cropping sequences showed that the highest production cost (Rs. 28778 ha^{-1}) was incurred in sweet basil- matricaria followed by rice-wheat (Rs. 25978 ha^{-1}), chillie - garlic (22800 ha^{-1}) and sorghum -berseem (Rs. 19837 ha^{-1}) because of higher labour required for picking the matricaria flowers. Sweet basil - matricaria cropping sequence gave maximum net return (Rs. 50222 ha^{-1}) followed by chillie -garlic (Rs. 32510 ha^{-1}), sorghum -berseem (Rs.30377 ha^{-1}) and rice-wheat (Rs.29861 ha^{-1}). Analysis of benefit: cost ratio (gross return: cost of cultivation) revealed that, maximum benefit: cost ratio (2.74) was obtained from sweet basil - matricaria followed by chillie -garlic (2.42), sorghum-berseem (2.32) and rice-wheat (2.14) (Table 13). These results confirm the findings of Roy bardhan *et al.* (1999).

Table 13. Cost economics of diversified cropping systems

Cropping sequences	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit: cost ratio
Rice-wheat	25978	55593	29816	2.14
Sorghum-berseem	19837	46021	30377	2.32
Sweet basil-matricaria	28778	78851	50222	2.74
Chillie-garlic	22800	55176	32510	2.42

Sale price of produce: rice@ Rs.540 q^{-1}, sorghum fodder@ Rs.70 q^{-1}, sweet basil oil @ 500l^{-1}, Wheat @ Rs. 600 q^{-1}, berseem fodder@ Rs.80 q^{-1}, matricaria flower@ Rs.50 kg^{-1}, Chillie@1500 q^{-1} and garlic@ Rs.15 kg^{-1}

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6.0 ECONOMICS OF TECHNOLOGY

Application of reduced dose of gypsum (25% G.R.) and growing of salt tolera varieties of rice and wheat fetched higher benefit: cost ratio (1.49) for first ye than that of application of 50% G.R. and growing of non-salt tolerant tradition varieties (1.12). With the application of reduced dose of gypsum (25% G.R.) an growing of salt tolerant varieties about Rs. 10000 ha^{-1} on account of cost of gypsum ca be saved. During first year of reclamation, the yield of non-salt tolerant traditiona varieties of rice and wheat after application of gypsum @ 50% G.R. was 40.50 an 21.67q ha^{-1}. However, with the application of reduced dose of gypsum (25% G.R.) an growing of salt tolerant varieties, the yield was 40.87 and 22.00 q ha^{-1} respectivel which is about the same. During second year onwards highest B: C ratio was observed with 50% G.R. and growing of salt tolerant varieties because of higher yields but the saving of Rs. 10000ha^{-1} achieved due to the application of reduced dose of gypsum during the first year was not compensated even up to three years with 50% G.R. and growing of traditional varieties. Moreover, with the saving amount of Rs. 10000 on account of gypsum with this technology, the resource poor farmer can reclaim double the area with the same amount of gypsum and get good yields (Table 14).

Table 14. Cost economics of combined effect of gypsum and salt tolerant varietie

Treatments	Cumulative cost of cultivation (Rs. ha^{-1})	Cumulative gross return (Rs. ha^{-1})	Cumulative net return (Rs. ha^{-1})	B:C ratio			
				Ist year	IInd year	IIIrd year	IVth year
Control+ STV	93779	47858	-45921	0.20	0.25	0.72	0.82
Control+ NSTV	93779	25685	-68094	0.10	0.18	0.28	0.51
15% G.R.+STV	99796	142522	42726	1.07	1.49	1.55	1.58
15% G.R.+NSTV	99796	119044	19248	0.88	1.22	1.28	1.36
25% G.R.+ STV	103794	190803	87009	1.49	1.84	1.95	2.04
25% G.R.+ NSTV	103794	207588	77041	1.35	1.77	1.88	1.93
50% G.R.+STV	113763	213671	99908	1.24	2.03	2.09	2.11
50% G.R.+NSTV	113763	209424	95661	1.12	2.00	2.04	2.15

STV: Salt tolerant varieties, NSTV: Non-salt tolerant varieties

7.0 CONCLUSION

Application of gypsum @ 25% G.R. and growing of salt tolerant varieties of rice and wheat during the initial years may reduce the reclamation cost by about 43% over 50% G.R. level. The yields of non-salt tolerant traditional varieties of rice and wheat with 50% G.R. was at par with that of reduced level (25% G.R.) of gypsum and salt tolerant varieties during first and second years but the difference in terms of cost of gypsum between 25 and 50% G.R. levels was Rs. 10000 ha^{-1}. During third year onwards, the yield difference between 50% G.R. with non-salt tolerant traditional varieties of rice and wheat over 25% G.R. with salt tolerant varieties was 5 and 15% respectively but the saving of Rs. 10000 ha^{-1} achieved due to the application of reduced dose of gypsum during the first year was not compensated even up to three years with 50% G.R. and growing of non-salt tolerant traditional varieties. In order to adopt the reclamation technology at a fast rate, it is concluded that application of gypsum @25% G.R. (instead of 50% G.R. as a recommended dose) along with salt tolerant varieties of rice and wheat will not only reduce the reclamation cost but also help to increase the productivity of salt affected soils. The salt tolerant varieties have low yield potential under reclaimed sodic soils, and needs to be replaced with high yielding varieties. On the basis of four years study, it is concluded that salt tolerant varieties of rice should be replaced with high yielding varieties after four years and of wheat after three years or diversify the rice -wheat cropping system with highly remunerative medicinal and aromatic crops like sweet basil in kharif and matricaria in rabi.

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8.0 TECHNICAL RECOMMENDATIONS

1. On the basis of above findings, it is recommended that apply gypsum@25% GR only and grow salt tolerant varieties of rice (CSR 10, CSR 13, CSR 27 and CSR 36) and wheat (KRL 1-4 and KRL 19) instead of 50% G.R. with non-salt tolerant traditional varieties for sustainable reclamation of sodic soils.
2. It is further recommended that salt tolerant varieties of rice should be replaced with non-salt tolerant traditional high yielding varieties of rice such as pant 4 after four years and wheat (PBW 343) after 3 years to maximize the productivity of sodic soils.
3. Diversification of rice-wheat cropping system with highly renumerative cropping system having medicinal and aromatic crops like sweet basil-matricaria and vegetables like chillie-garlic is recommended once the soil pH reaches at level of 9.2.

9.0 तकनीकी संस्तुतियाँ

4 वर्ष तक किये गये प्रयोगों के आधार पर निम्नलिखित संस्तुतियों की सिफारिश की जाती है :-

1. ऊसर सुधार की प्रचलित तकनीक जिसमें जिप्सम की 50% जी.आर. मात्रा की सिफारिश की जाती है के स्थान पर कम लागत वाली तकनीक जिसमें जिप्सम की मात्रा केवल 25% जी.आर. डालकर धान (सी.एस.आर. 13, सी.एस.आर. 23, सी.एस.आर. 27 एवं सी.एस.आर 36) और गेहूँ, (के.आर. एल. 1-4 एवं के.आर.एल. - 19) की लवण सहनशील किस्मों को उगाया जाय तो लगभग उतनी ही पैदावर ली जा सकती है जितनी कि 50% जी.आर. जिप्सम की मात्रा डालकर लवण असहनशील किस्में उगाकर प्राप्त की जाती है। इस प्रकार जिप्सम पर होने वाले खर्च को आधा किया जा सकता है और प्रति हैक्टेयर रु. 10,000/- की बचत की जा सकती है।
2. प्रयोगों के आधार पर यह भी सिफारिश की जाती है कि 25% जिप्सम डालकर चार वर्ष के बाद धान एवं तीन वर्ष के बाद गेहूँ की लवण सहनशील किस्मों के स्थान पर अधिक पैदावार देने वाली सामान्य किस्में उगायी जायं तो ऊसर भूमियों से अधिक पैदावार ली जा सकती है।
3. 25% जी.आर. दर से जिप्सम डालकर धान की लवण सहनशील किस्मों को अगर चार वर्ष एवं गेहूँ की लवण सहनशील किस्मों को तीन वर्ष तक उगाया जाय तो ऊसर भूमि जिसका पी.एच. मान 10.5 था, घटकर 9.2 तक आ जाता है और इस पी. एच. मान पर फसल विविधीकरण करके धान-गेहूँ फसल चक्र से हटकर अधिक आय देने वाली औषधीय एवं सगंध फसलें उगायी जा सकती हैं।

केन्द्रीय मृदा लवणता अनुसंधान संस्थान CSSRI 1969

10.0 REFERENCES

Abrol, I.P. and Bhumbla, D.R.1979. Crop responses to different gypsum applications in a highly sodic soil and the tolerance of several crops to exchangeable sodium under field conditions. Soil Sci. 127: 79-85.

Acharya, C.L. and Abrol, I.P. 1991. Soil- water relation and root-water extraction in alkali soils. Bulletin. 16, CSSRI, Karnal.

Chhabra, R., Singh, N.T., and Hansen, A. 1989. Interaction between type of amendment and P availability. Annual Report. Central Soil Salinity Research Institute, Karnal, India. P.38.

Chhabra, R. and Abrol, T.P. 1977. Reclaiming effect of rice grown in sodic soils. Soil Sci. 124: 49-55.

Dutta, K.K. and Joshi, P.K. 1996. Technological options for reclamation of salt affected soil under resource constraint Environment in Uttar Pradesh. Agricultural Situation in India. April 1996.

Mishra, B., Bhattacharya, R.K. and Singh, R.K. 1992. CSR-10, a newly developed high yielding salt tolerant rice variety. International Rice Research Notes 17 (1), 19.

Mishra, P.N. 1987.German chamomile. (In). Eco-development of alkaline land: a case study, pp. 80. T.N. Khoshoo, (Ed.), NBRI, Lucknow.

Nambiar, K.K.M. and Abrol, I.P.1989. Long term fertilizer experiments in India: an overview, Fertilizer News, 34, (4), 11-20, 26.

Roy Bardhan, S.K., Walker, T., Khatana, V.S., Saha, N.K., Verma, V.S., Kadian, M.S., Haverkort, A.J. and Bowen, W., Identification of potato production in rice based cropping system: a rapid rural appraisal in West Bengal, (In) Impact on a changing world. International Potato Centre Programme Report, 1999, pp. 205-212.

Schoonover, W.R. 1952. Examination of soils for alkali. University of California, Extension Service, Berkely, California, USA

Sharma, R.C., Singh, Ranbir, Singh, Y.P. and Singh, Gurbachan 2006. Sodic Soils of Shivri Experimental Farm: Site characteristics, reclaimability and use potential for different land uses. CSSRI Bulletin 1/2006 pp 1-32.

Subbiah, Piana Gopalsundaran, P.P. 1995. Energetics and energy use efficiency of intensive cropping systems. Indian Journal of Agronomy 40, 308-402.

Swarup, A and Singh, K.N. 1994. Effect of gypsum, farm yard manure and nitrogen on amelioration of a sodic soil and yield s of rice and wheat. International Rice Research Notes 19(3): 22-23

Thakur, R.S., Puri, H.S. and Hussain, A. 1989, Major medicinal plants of India, pp 338 CIMAP (CSIR), Lucknow.

SYNERGISTIC

Synergy of gypsum, salt tolerance and traditional varieties


Comperative performance of salt tolerant & traditional varieties of rice at farmers field


Demonstration of salt tolerant variety of rice with reduced dose of gypsum

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