

# STUDIES ON SALINITY AND SODICITY ON THE RICE-GROWING GRUMUSOLS OF MURUNKAN

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## ABSTRACT

Two experiments were carried out to examine the effect of saline water on the growth and yield of rice. In the first experiment the salinity tolerance of four rice varieties, irrigated from four tubewells delivering water differing in salinity, was evaluated. The results showed that reasonable crop yields could be obtained with water of upto 1.7 mmhos/cm. However, complete crop failure was obtained with water of 2.85 mmhos/cm, although one rice variety, Bg 276-5 was much more tolerant of this salinity level than the other three, during the vegetative growth phase. The second experiment examined the ability of ten rice varieties to germinate in water of different salinity levels. All varieties germinated satisfactorily although there were considerable differences between varieties in the resistance of the seedlings to salinity. No evidence was found for potential long term sodicity problems on the grumusols of Murunkan.

## INTRODUCTION

The command area of the Giant's Tank (12,000 ha) is normally planted with a single Maha rice crop. The Murunkan area receives an annual rainfall of 1112 mm with two-thirds of the rainfall occurring during October, November and December and there is insufficient tank water for a second Yala crop except on a small area. In the mid 1970s during a succession of very dry years, over 100 tubewells were drilled to supplement Maha irrigation. Later, water from these wells was also used to cultivate a Yala crop. The water from many of these wells became highly saline and resulted in poor growth and crop failure. De Alwis (1978). Theiviyathan (personal communication), Jeganathan (1982), Davies and Selvaratnam (1982) reported conductivities of water from these wells varying from 0.75 to 49, mmhos/cm. Jeganathan also measured the conductivity of Giant's Tank water which varies from 0.2 mmhos/cm during the Maha rains to over 0.9 mmhos/cm during the dry season.

The soils of the Giant's Tank area are classified as grumusols (Moorman and Panabokke, 1961). Earlier reports (de Alwis, 1977; Robertson *et al.* (1978) mentioned the possible adverse long term effects of salinity, and of sodicity (alkalinity) if the soil exchangeable sodium percentage of the soil built

up to high levels. This would cause the deflocculation of the clay, difficulties in land preparation and in leaching through the salts applied in the irrigation water.

The purpose of the following experiments was:

- (1) to examine the salinity tolerance of four rice varieties irrigated from tubewells delivering waters differing in salinity;
- (2) to compare the effect of the salinity of water on the germination and growth of ten varieties of rice.

#### MATERIALS AND METHODS

##### **Experiment 1. The effect of quality of irrigation water on the growth and yield of four varieties of rice,**

This study was carried out during Yala 1980 (April to May) at four locations, chosen on the basis of quality of tubewell water. Electrical conductivity (EC) of the wells ranged from 1.2 to 2.8 mmhos/cm.

Four varieties were combined factorially with three levels of irrigation at each site (3x4 factorial with 3 replicates). The varieties were Bg 34-8 and Bg 276-5 which are 3 months varieties, and Bg 94-1 and Bg 94-2 which are 3 1/2 month varieties. The irrigation variable was the depth of standing water following each application of tubewell water: Some plots after irrigation had only the minimum of standing water consistent with keeping the soil saturated ( $I_0$ ), other plots 5 cm of standing water ( $I_1$ ) and others 12.5 cm of standing water ( $I_2$ ). The depth of water receded during the intervals between irrigation.

The rice seedlings were raised in nurseries using good quality water. Three week old seedlings were transplanted at 20 cmx15 cm apart and were irrigated immediately with tubewell water. Plant height, tiller number, percentage establishment and straw yield (site C only) and grain yield were recorded.

Soil samples (0-20 cm depth) were collected (1) after land preparation but before planting (2) one week after planting (3) mid season (1 1/2 months after planting) and at harvest. The samples were analysed for pH of the saturated soil paste; the conductivities and the soluble salts of the saturation extract (Na, K, Ca plus Mg) were also determined (for techniques see Jeganathan, 1982). A water sample was collected during each irrigation at the point of water delivery to the field and also analysed for soluble salts and pH.

##### **Experiment 2. Effect of salinity of water on the germination and growth of 10 rice varieties.**

This experiment was carried out in pots under indoor conditions at Murunkan Government Farm. The ten varieties are listed in Table 1.

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Table salt was added to rain water to obtain the required salinity level. Rain water (EC=0.075 mmhos/cm) was used as the control. The other four levels of salinity corresponded to 1.5, 1.8, 2.2 and 2.6 mmhos/cm. In a second trial, the germination percentage was examined over the range 2.5–10.5 mmhos/cm.

Polythene bags (15 cm diameter and 22 cm high) were partially filled with well leached grumusols. The bags (two per plot) were laid out in the form of a randomised block design. Each bag was sown with ten seeds.

The number of seeds germinated, plant height and number of plants surviving in each pot were recorded on the tenth and twenty-fifth day after planting so as to represent the early seedling stage and the termination of the nursery period.

### RESULTS

**Experiment 1.** Table 2 shows the mean yield of varieties and irrigation levels at the four sites. Table 3 summarises the differences in tubewell water salinity, soil salinity and sodicity, and the range in grain yields obtained at each site.

The main findings concern the quality of tubewell water necessary to obtain a reasonable yield and the critical salinity beyond which no yield is obtained. At site C the crop failed to produce any significant grain yield with tubewell water of 2.85 mmhos/cm. Water of this conductivity was therefore beyond the tolerance of all the varieties tested.

Irrigation with water with an EC of 1.64–1.76 mmhos/cm (site D) resulted in a rice yield of 2.5 t/ha (50 bu/ac) which is close to the average yield expected in this area during Yala. The standard deviation was 0.7/1.0 t/ha (14–20 bu/ac).

Irrigation with less saline water of EC of 1.20–1.35 mmhos/cm at the other two sites A and B, did not give higher yields than obtained at site D (EC 1.64–1.76 mmhos/cm.). The adverse effects of salinity are therefore found at EC levels over 1.8 mmhos/cm with complete crop failure at 2.8 mmhos/cm. Unfortunately, there was no tubewell site in the experiment to test the effects of water quality on yield between these two extremes. A more precise determination of the critical level of water quality for irrigated rice must await further trials.

There were differences in the performance of the four varieties at each site. Although none of the varieties produced any grain yield at site C, the establishment and vegetative growth of Bg 276–5 at this site was better than

the other varieties. Bg 276-5 had an establishment percentage of 58% and vegetative yield was 2200 kg/ha compared to mean values of 33% or 921 kg/ha for the other three varieties. Thus Bg 276-5 is far more tolerant of salinity in the vegetative phase of growth than the other varieties. More trials are required to examine its tolerance to salinity at conductivities between 1.8 and 2.8 mmhos/cm.

Other differences in the response of varieties were evident at the other three sites. Table 4 shows that at site A Bg 94-1 and Bg 94-2 yielded an average 0.73 t/ha more than Bg 34-8 and Bg 276-5 i.e. a 33% increase. At site B, however, only Bg 94-1 outyielded Bg 34-8 and Bg 276-5 by 0.62 t/ha. In contrast at site D with water of higher salinity (1.7 mmhos/cm compared with 1.3 at site A and B), Bg 34-8 and Bg 276-5 outyielded Bg 94-1 and Bg 94-2 by 0.87 t/ha i.e. a 40% increase.

Although salinity effects are confounded with site effects in this experiment, the results suggest that of the four varieties, Bg 34-8 and Bg 276-5 perform best if the conductivity of the tubewell water is about 1.7 mmhos/cm while Bg 94-1 and Bg 94-2 are better choices if the tubewell water is of lower salinity (1.3 mmhos/cm.)

The analyses of variance indicated that the effects on grain yield of different depths of standing water were small and not significant. The amount of water applied to irrigate plots to a depth of 12.4 cm above the soil surface was at least 12.5 times that used to irrigate the plot with no standing water, hence the water draining through the soil and available for leaching differed greatly between the irrigation levels. Table 5 shows that the salinity of saturation extracts differed little as a result of this treatment. Thus although the water applied to the  $I_2$  plots was over 12 1/2 times more than for the  $I_0$  plots, the salts accumulated in the soil profile differed little. The exception was at site C where the extra leaching of salts was evident as a difference in soil salinity between  $I_0/I_1$  and  $I_2$  after harvest (Table 5).

The soils proved highly permeable to water but there were differences from site to site (Table 3). Build up of salts due to insufficient leaching was not a problem except where insufficient but highly saline water was applied in the  $I_0$  and  $I_1$  irrigation treatment at site C. The permeability of the soil did not restrict leaching at any of the sites. Exchangeable Sodium Percentage (ESP) levels exceeding 15% were only obtained at site C in association with highly saline irrigation water and high soil salinity (Table 3). These soils would only degrade if subsequently the salts were leached out by rainfall or good quality irrigation water.

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**Experiment 2.** Table 6 and Fig. 1 show the germination percentage of the different rice varieties under different saline waters. The results show that all varieties germinated satisfactorily upto salinity levels of 2.5 mmhos/cm, although the germination of a few declined at higher levels (upto 10 mmhos/cm). These results confirm the experience of other workers (e.g. Pearson, 1959). The effect of saline water on seedling development is shown in Table 7.

The development of tip burning, a sign of salinity, was apparent a week from sowing and was observed for plants irrigated with water of 1.8 mmhos/cm or more [although there were considerable differences between varieties]. Symptoms were intense in plants receiving 2.2 and 2.6 mmhos/cm. Those plants that survived upto the third week under the range of water qualities established themselves quite normally.

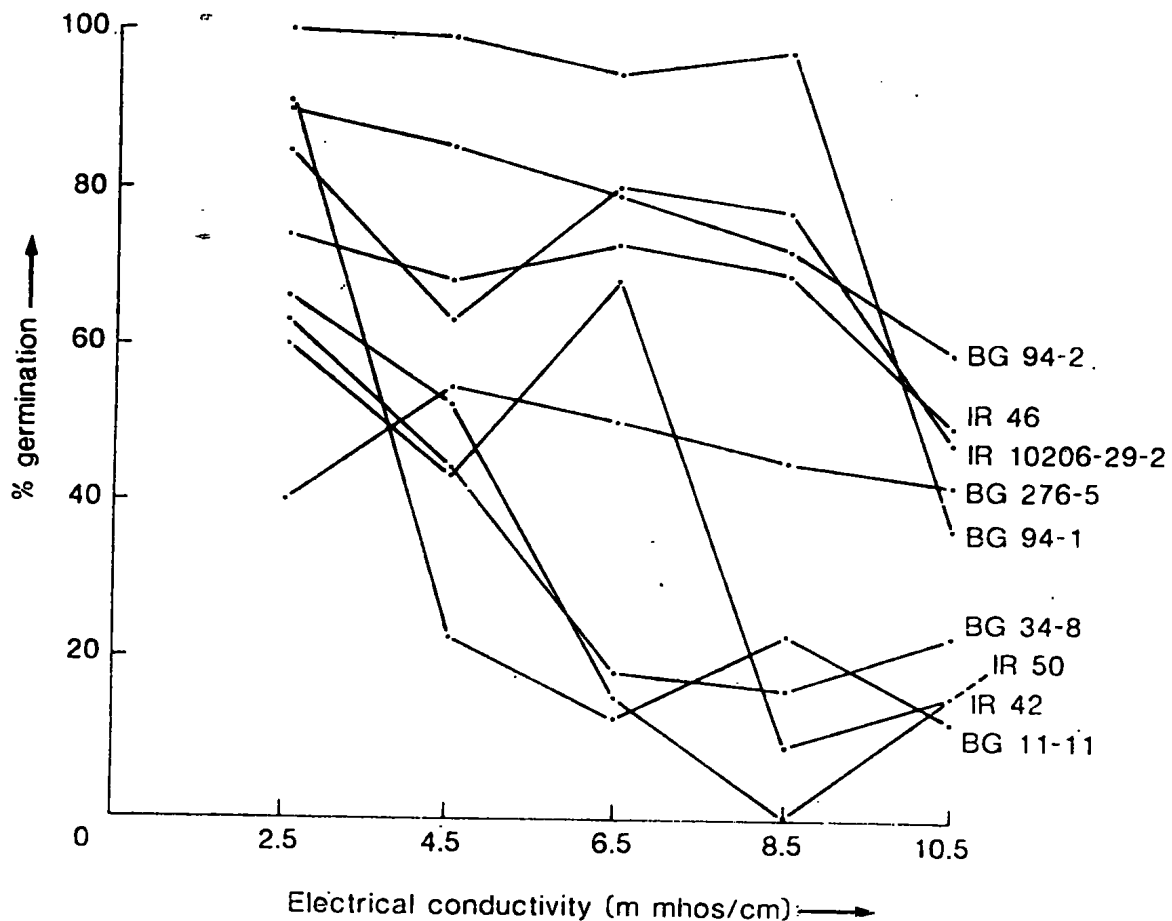


Figure 1 Ability of rice varieties to germinate in saline water

## DISCUSSION

The experiments described above illustrate the importance of the salinity of tubewell water in rice irrigation in the Giant's Tank area. Experiment I in the field showed that reasonable yields were obtained with water of upto 1.7 mmhos/cm. The adverse effects occur at higher salinity levels and complete crop failure resulted with water of 2.85 mmhos/cm. Bg 276-5 was much more tolerant than the other three varieties tested during the vegetative phase, but failed to produce grain at site C with water of 2.85 mmhos/cm. Bg 94-1 and Bg 94-2 were the most salt sensitive varieties but yielded 33% more than Bg 276-4 and Bg 34-8 when irrigated with the least salty water (1.3 mmhos/cm.) Conversely the latter yielded 40% more than the former when irrigated with water of 1.7 mmhos/cm. The critical salinity or salinity threshold at which these varieties will produce no economic yield lies somewhere between 1.7 and 2.8 mmhos/cm. Further experimentation is required for water over this range. Other experiments need to be carried out to determine whether highly saline water can be tolerated by rice if used after the flowering stage, since it has been reported that some farmers in the Giant's Tank area use tubewell water of upto 5 mmhos/cm to keep the crop alive at the later stages of Maha when Giant's Tank water ceases to be available.

There was no evidence of a potential long-term sodicity problem in the Murunkan areas as:

- (1) the clay content of the soils was found to be generally less than 40% and
- (2) the salts in the water keep the clay flocculated. The percolation rates measured by Bandara (1981) for different soils in the area were high (3.5-10 mm/day) and therefore the main problem encountered by farmers using tubewell water is one of salinity rather than sodicity.

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**Table 1—Rice varieties used in the germination and seedling growth study**

<i>Variety</i>	<i>Source</i>	<i>Duration months</i>
Bg 34-8	Sri Lanka	3
Bg 276-5		3
Bg 94-1		3-3 1/2
Bg 94-2		3-3 1/2
IR 50	IRRI	4
IR 46		4
IR 10206-29-2		4
IR 9884-54-3		4
Bg 11-11	Sri Lanka	4-4 1/2
IR 42	IRRI	4-4 1/2

**Table 2—Mean grain yields (t/ha) for irrigation levels in different locations, Giant's Tank command area, 1980**

<i>Location</i>	<i>Saturation</i>	<i>Irrigation</i>		<i>Mean</i>
		<i>5 cm</i>	<i>12.5 cm</i>	
A	2.11	2.57	2.91	2.53
B	2.15	1.88	2.73	2.24
C	0	0	0	0
D	-2.42	2.71	2.57	2.55
Mean	2.23	2.38	2.74	2.45

**Table 3—Comparison between mean grain yields, tubewell water quality and soil salinity and alkalinity for sites: Giant's Tank command area, 1980**

	<i>Site A</i>	<i>Site B</i>	<i>Site C</i>	<i>Site D</i>
Mean grain yield (t/ha)	1.01	0.91	nil	1.02
<b>Tubewell water quality</b>				
EC mmhos/cm	1.28-1.35	1.20-1.30	2.70-2.85	1.64-1.76
SAR	3.31-4.19	3.16-4.38	8.56-11.74	5.93-8.16
Classification*	C3-S1	C3-S2	C4-S3	C3-S2
<b>Soil salinity and alkalinity</b>				
EC mmhos/cm**	1.43-1.97	1.73-2.35	2.60-5.63	1.48-2.33
ESP (%)	1.80-6.80	2.90-6.90	8.30-56.8	1.30-12.10
Exch. Na (meq/100g soil)	0.65-1.26	0.66-1.44	0.86-2.43	0.10-1.30
CEC (meq/100g soil)	17.7-24.2	10.7-15.2	5.10-11.6	7.70-10.7
pH	7.4-7.5	7.3-7.4	7.2-7.4	6.5-6.7
Soil texture	SCI	SI	SI	SI
Percolation	least rapid	medium	less rapid	rapid

\* USDA

\*\* By saturation extract

than B & D

**Table 4—Mean grain yield (t/ha) of the four varieties in different locations: Giant's Tank command area, 1980**

<i>Location</i> ( <i>EC mmhos/cm</i> )	<i>Varieties</i>				<i>Mean</i>
	<i>Bg 34-8</i>	<i>Bg 276-5</i>	<i>Bg 94-1</i>	<i>Bg 94-2</i>	
A (1.28-1.35) ...	2.26	2.06	3.31	2.48	2.52
B (1.20-1.30) ...	2.35	2.36	2.77	1.93	2.25
C (2.70-2.85) ...	0	0	0	0	0
D (1.64-1.76) ...	3.02	2.88	2.34	2.02	2.57
Mean ...	2.47	2.36	2.80	2.15	2.45

**Table 5—Soil salinity (EC mmhos/cm) variation for different irrigation treatments with time of sampling across sites: Giant's Tank command area, 1980**

<i>Irrigation</i> ( <i>cm standing water</i> )	<i>Sites</i>											
	<i>A</i>			<i>B</i>			<i>C</i>			<i>D</i>		
	1	2	3	1	2	3	1	2	3	1	2	3
0	1.6	1.6	1.6	1.7	1.8	1.8	2.6	3.7	5.8	1.7	2.3	2.1
5	2.0	1.7	1.8	2.3	1.8	2.1	3.1	4.2	5.2	2.8	2.1	2.0
12.5	1.4	1.8	2.0	1.8	2.4	1.9	3.1	3.9	3.5	1.3	2.0	2.3

1—Before planting  
2—Mid season  
3—at harvest

**Table 6—Germination percentage of different varieties of rice in different salinity waters at low concentration**

<i>Variety</i>	<i>Rain water</i>	<i>Electrical conductivity (mmhos/cm)</i>				
		1.2	1.3	1.8	2.2	2.5
IR 46	72	91	87	89	97	90
Bg 11-11	99	98	98	97	96	89
IR 42	58	68	69	79	66	64
Bg 94-1	98	81	87	52	52	54
IR 10206-29-2	100	85	72	82	85	84
Bg 34-8	82	99	94	85	86	60
Bg 276-5	44	38	47	67	32	38
IR 9884-543	50	70	70	72	69	35
IR 50	76	68	87	87	83	67
Bg 94	56	85	50	82	74	30

**Table 7—Mean plant height (cm) 10 days after sowing of ten varieties of rice growing under different water qualities**

<i>Variety</i>	<i>Rain water</i>	<i>Water quality (EC mmhos/cm)</i>				<i>Mean</i>
		1.5	1.8	2.2	2.6	
IR 46	15.40	14.68	14.00	14.12	13.37	14.32
Bg 11-11	8.43	8.87	8.87	8.06	7.81	8.41
IR 42	13.50	12.62	12.56	12.81	13.75	13.05
Bg 94-1	12.00	12.37	13.75	11.31	13.06	12.50
IR 10206-29-2	14.50	13.44	13.44	13.81	14.00	13.84
Bg 34-8	14.18	12.75	12.62	11.94	12.00	12.69
Bg 276-5	13.75	13.87	13.02	13.00	13.81	13.49
IR 9884-543	16.44	16.02	14.75	15.25	15.20	15.53
IR 50	15.44	15.62	15.31	15.37	16.12	15.57
Bg 94-2	9.44	9.62	9.87	9.06	10.00	9.59