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STUDIES ON THE TOLERANCE OF PADDY TO DIFFERENT SALTS

P. GOPALAKRISHNAN NAIR and N. SUBRAMONY

Agricultural College and Research Institute, Vellayani

The saline soils of Kerala have originated mainly as a result of salt water inundations from the sea and the back waters. There are vast areas in Kerala, like Kuttanad, with such soils. During rainy seasons, swept by flood waters, the surface soils in such areas get partly desalinised. During cropping season, the water sources get salinised due to tidal influence from the sea or back waters. Rice is the major crop in these areas and it has to face changing salinities in the soil and often has to suffer injury due to high salt concentrations. No precise information is available on the effect of various concentrations of salinities on the various life processes of paddy excepting the observations of Zacharia and Sankarasubramony (1960) that salt tolerance of paddy plants increased as they matured. Hence the present studies were made in which varying concentrations of salts (salinities) were produced in the soil artificially and the influence of different concentrations of the various salts on the growth and yield characteristics of rice observed. Studies were also made on the possibilities of lessening the injurious effect of sodium by the addition of magnesium salts.

Material and Methods

Earthenware pots 9 inches in diameter and 1 foot in height were used in these studies. The pots were given an internal coating of wax to prevent leakage of water. The soil used was a clay loam from the bed of the Vellayani lake. The rice variety used was PTB 10, a widely cultivated variety in the salt affected areas of Kerala. Equal quantities of powdered dry leaves and farmyard manure were incorporated into the soil at the rate of 2500 kg per acre as a basal dressing. One kilogram of this soil was put in each pot and kept flooded with water for a period of one month. After this period, the different salts or sea water as the case may be were added to the soils to give the varying conductivities, as detailed in Table 1, for the 1 : 2 soil water extracts.

The amount of salt required for preparing solutions of desired conductivities was obtained from the graph relating concentrations of single salt solution to electrical conductivity (Fig. 1). The desired conductivities of sea water were obtained by diluting it progressively and observing the resultant conductivity. A graph was drawn relating dilution of sea water with conductivity from which the extent of dilution for the required conductivity could be observed by interpolation. After treatment with the different sources of salinity three identical and healthy rice seedlings (14 days old) were transplanted into each pot. The treatments were replicated twice. The pots were irrigated with tap water to make up for the loss through evapo-transpiration. The soil in each pot was examined periodically to see that the desired conductivity was maintained. The growth characteristics of the plants were observed at intervals of one week until they were harvested.

Results

Results are given in Figs. *2 to 6* and Table 1. It is observed that mortality of the plants depended upon the form and concentration of the salts. Magnesium chloride was tolerated the most by plants and they survived a conductivity range of upto 12 m. mhos/cm. Sodium chloride was the least tolerated salt, the plants drying under conductivities over 4 m. mhos cm. It was also seen that paddy plants tolerated sea water and sodium-magnesium chloride mixture upto 10 m. mhos/cm and potassium chloride and calcium chloride upto 8 m. mhos/cm.

Height of plants (Fig. 2). The plants subjected to a salinity of 2 m. mhos/cm were taller than untreated plants and at this level the maximum height was reached by plants treated with the mixture of magnesium chloride and sodium chloride and this mixture stimulated plant growth upto a conductivity of 8 m. mhos cm. Chlorides of sodium, potassium, magnesium and calcium suppressed the plant growth at conductivities of 4, 6, 10 and 6 m. mhos/cm respectively and above. Sea water showed suppressing effect at a conductivity of 10 m. mhos/cm.

Number of tillers and earheads (Table 1). Magnesium chloride, sodium-magnesium chloride mixture and sea water showed increase in the number of tillers and earheads over the untreated plants at the lowest conductivities. At higher conductivities suppression of both tillers and earheads was evident with all the salts. Calcium chloride at the conductivity of 2 m. mhos cm also showed increase in the number of tillers per plant.

Length of earheads (Fig. 3). The earheads were longer over the control in all treatments at a conductivity of 2 m. mhos cm. There was suppression in the earhead length with sodium chloride, potassium chloride, magnesium chloride, calcium chloride, sea water and with the mixture of sodium chloride and magnesium chloride at conductivities of 4, 4, 8, 6, 6 and 8 m. mhos cm and above respectively.

Number of grains (Fig. 4). The salinities which increased the grain number over the untreated plants were those of magnesium chloride, calcium chloride and with sodium chloride-magnesium chloride mixture at the conductivity of 2 m. mhos/cm. All other conductivities suppressed the grain number.

Table I

Effect of different degrees of salinity on tillering and earhead formation in rice

Sources of salinity	Conductivity (millimhos per cm)	Number of tillers per plant	Number of earheads per plant
Sodium chloride	2	3	3
	4	2	1
Potassium chloride	2	3	3
	4	3	3
	6	2	2
	8	2	2
Magnesium chloride	2	4	4
	4	4	4
	6	3	3
	8	3	3
	10	2	2
	12	1	1
Calcium chloride	2	4	3
	4	3	3
	6	2	2
	8	2	1
Sodium chloride + Magnesium chloride	2	4	4
	4	3	3
	6	2	2
	8	2	2
	10	1	1
Sea water	2	4	4
	4	3	3
	6	3	3
	8	2	2
	10	1	1
Control	–	3	3

Note: The plants did not survive bayond the salinities given above for the different salts.

Weight of grain and straw (Figs. 5 and 6). Significant increase in the grain yield over control was obtained with sodium chloride-magnesium chloride mixture at a conductivity of 2 m. mhos/cm. Reduction in yield was seen with sodium, potassium, magnesium and calcium chlorides and with sodium chloride-magnesium chloride mixture and sea water at conductivities of 4, 2, 8, 4, 8 and 4 m. mhos/cm respectively. The straw yield showed significant increases with magnesium chloride, calcium chloride and sodium chloride-magnesium chloride mixture at the conductivity of 2 m. mhos/cm (Fig. 5). At higher concentrations of the salts, the straw yield was reduced considerably.

Discussion

The above results show that growth of rice plants is adversely affected by increased concentrations of salts in the soil. This may be due to the osmotic effect of the salt solution and decreased absorption of certain cations caused by ion antagonism. Magistad *et al* (1943) observed reduction in growth of plants linearly correlated with increase in osmotic concentration. Mehta and Desai (1959) had shown that high concentrations of calcium chloride in soil solution inhibited the absorption of sodium, potassium and magnesium by plants.

The extent of salt injury to rice is seen to depend upon the nature of the salts involved. Thus the seedlings could not tolerate sodium chloride higher than 4 m. mhos/cm, whereas they tolerated magnesium chloride upto a conductivity of 12 m. mhos/cm. Magnesium chloride could also prevent the toxic effect of sodium chloride. Thus magnesium chloride appears to exert some protective influence against salt injury. This type of protective influence for certain salts was observed by Lipman and Gericke (1919). The tolerance of rice for higher concentrations of the magnesium salt may be considered as a specific effect of magnesium on rice. Specificity in tolerance of plants in relation to toxicity caused by different types of salts was expressed by Mibasher (1948) and Hassan and Overstreet (1952) as the salt tolerance of crops.

The higher adverse effects shown by sodium chloride may be attributed to the adverse effect sodium has on the soil microflora as shown by Lipman (1912) in the case of ammonification in soils. Iwaki (1956) also had shown similar adverse effect to rice plants caused by sodium. It is however, noted that in combination with magnesium chloride rice could tolerate sodium chloride upto a conductivity of 8 m. mhos/cm. This can be attributed to the protective action exerted by the complementary ion magnesium (Elagabaly 1955). Further, the monovalent sodium base may be less strongly absorbed than the divalent magnesium (Kelley 1951). It is thus indicated that the toxic effects of sodium chloride can be remedied by application of magnesium chloride.

The adverse effect on grain yield of higher concentrations of salts may be due to the reduction in carbohydrate contents of the plants taking place at these concentrations as reported by Iwaki *et al* (1958).

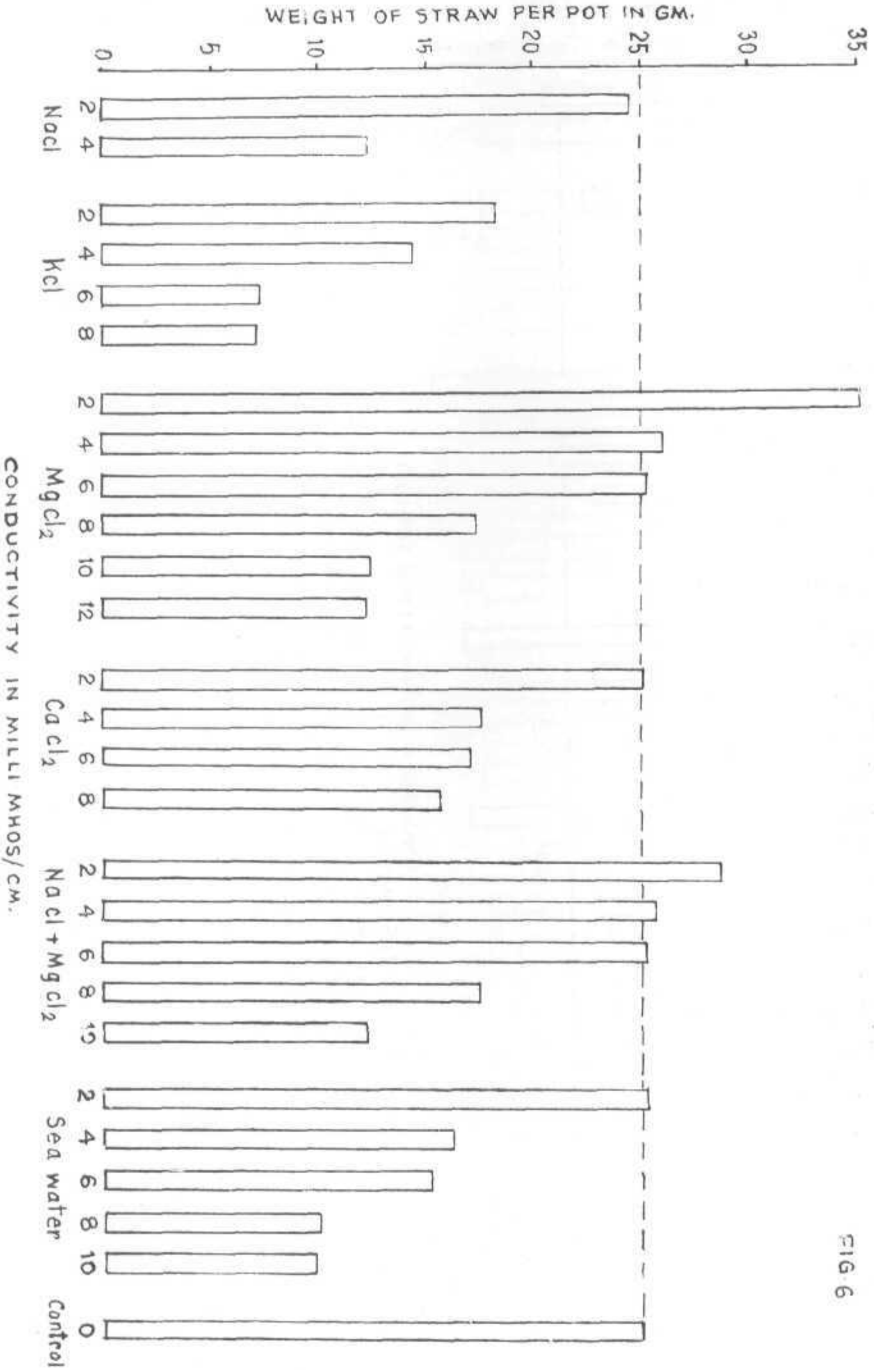

Fig. 6. Effect of salinity (conductivity) on weight of paddy straw.

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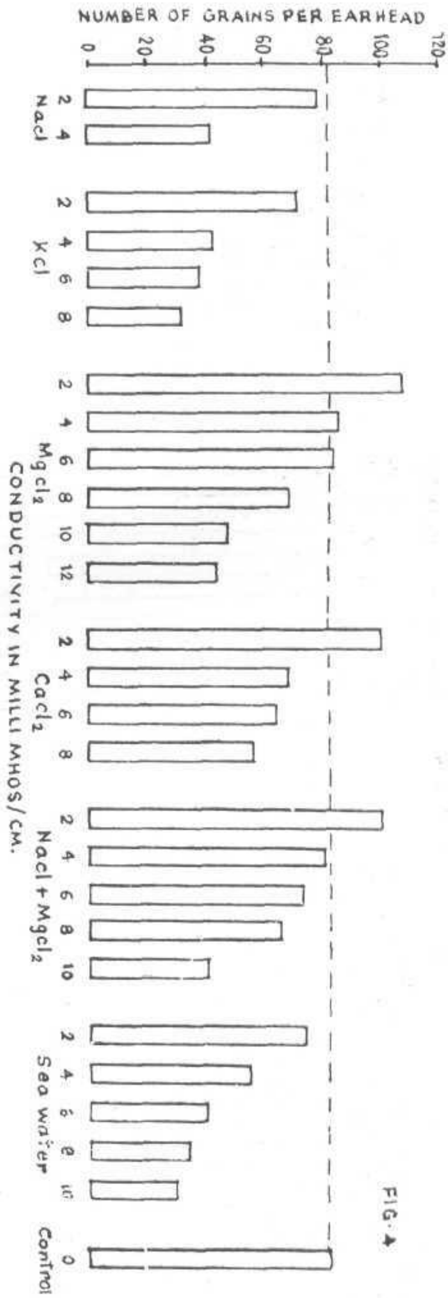


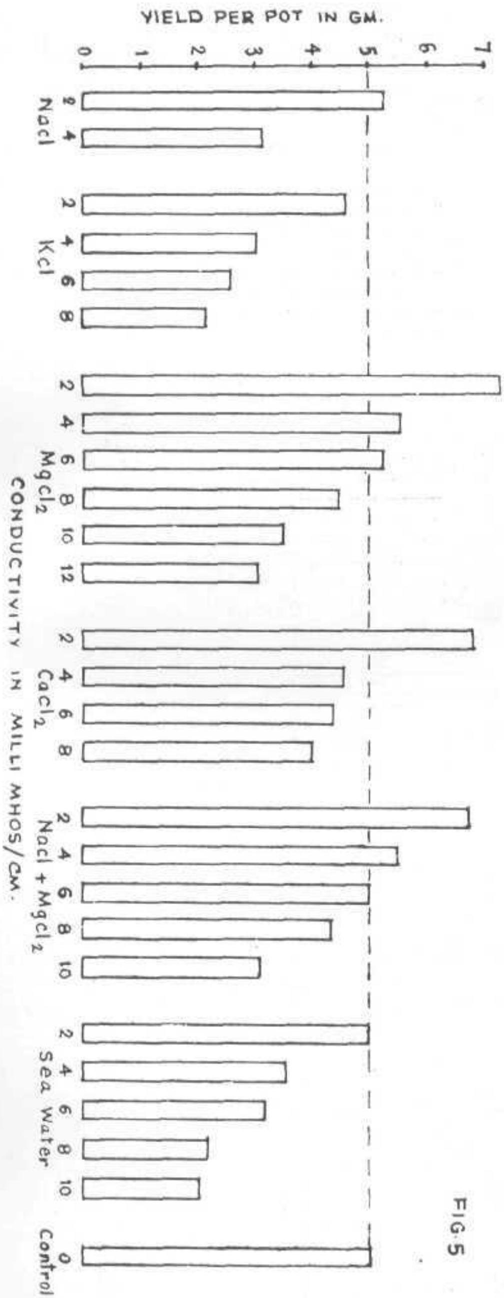
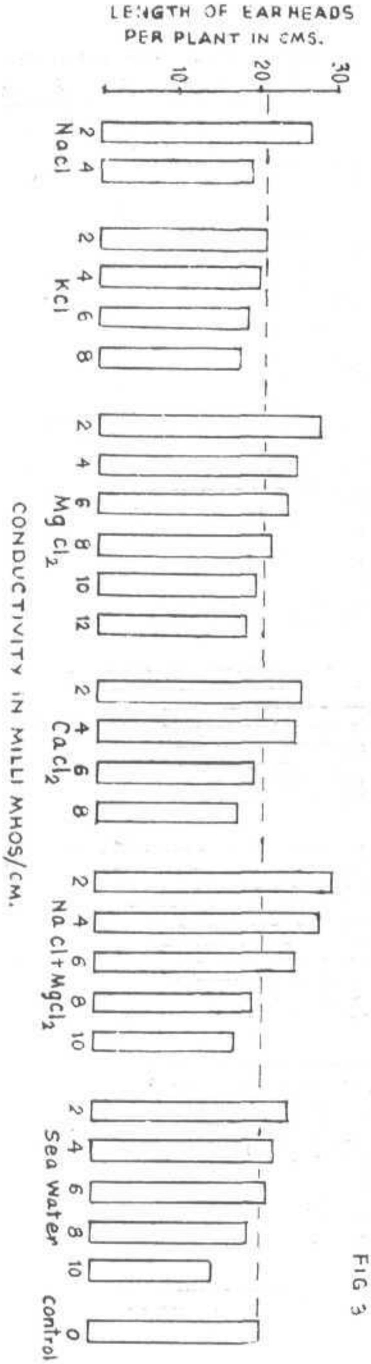


Fig. 4. Effect of salinity (conductivity) on number of grains per earhead.

Fig. 5. Effect of salinity (conductivity) on yield of paddy.



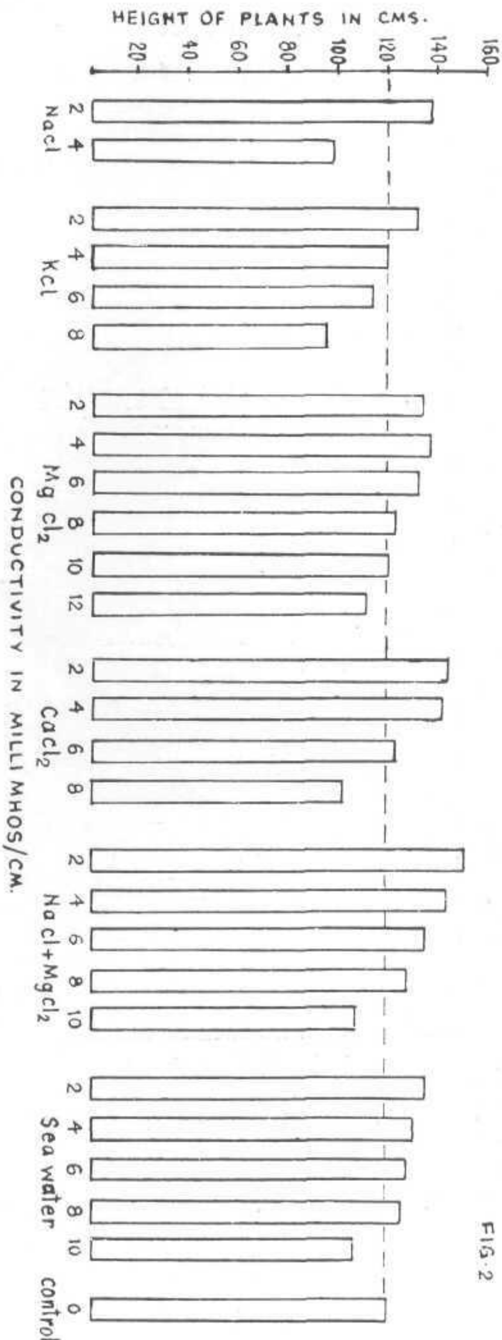


Fig. 2. Effect of salinity *(conductivity)* on height of plants.

Fig. 3. Effect of salinity *(conductivity)* on length of earhead.

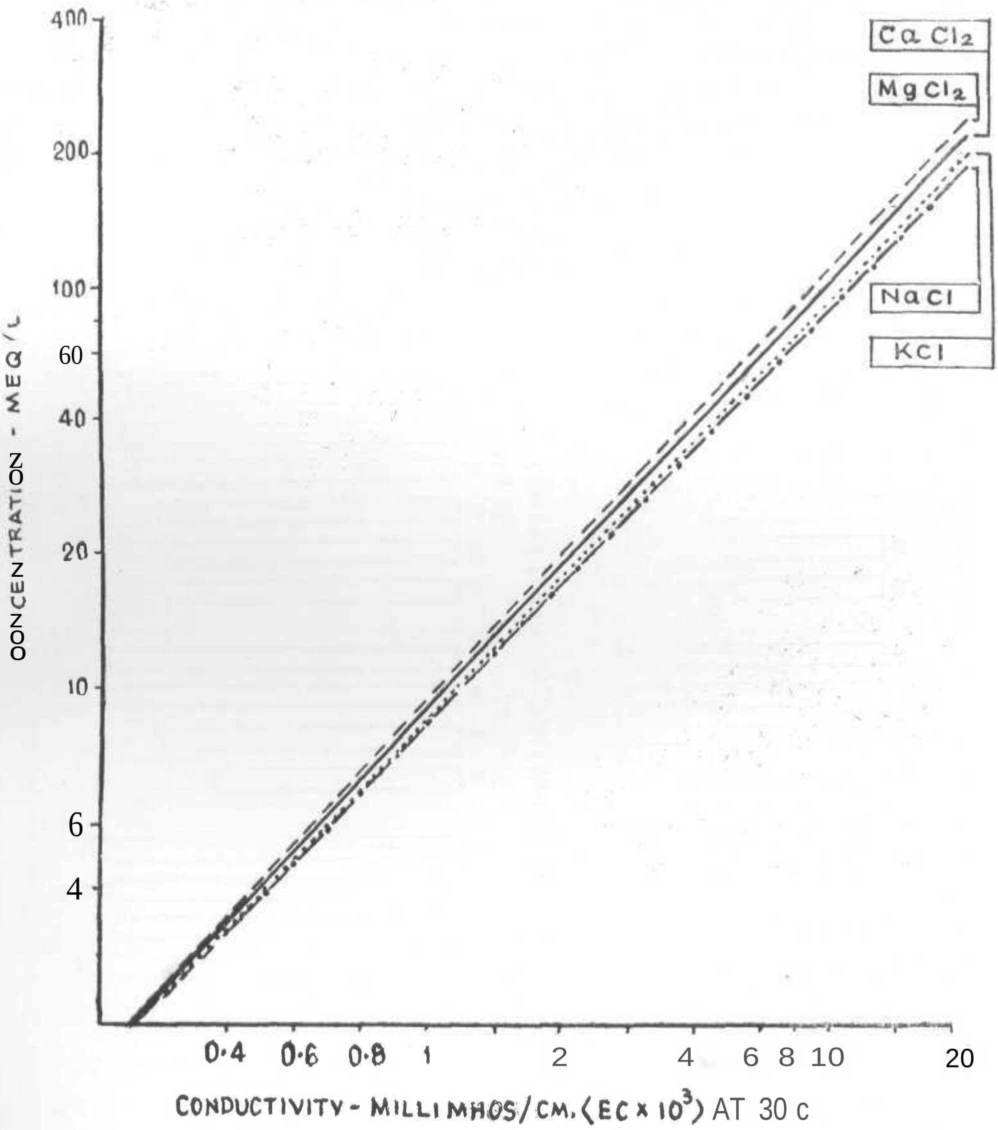


Fig. I. Relation between concentrations of salts and electrical conductivity.