Effect of Salinity on the Germination of Sorghum 100 and Wheat C.250

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Emergence of seedlings is gradually delayed and germination is reduced by progressive increase in salinity. The various salinity-producing salts differ considerably in their adverse effects even if they are added on milliequivalent basis to the soil. Magnesium sulphate and Sodium sulphate are the least harmful and Sodium chloride and Magnesium chloride are the most injurious for germination, while Sodium carbonate and Sodium bicarbonate occupy intermediate position.

INTRODUCTION

Among the multitude problems with which Pakistan is confronted today, salinisation of soil is one of the most important. Vast areas have already gone out of cultivation due to this menance and additional areas are being affected at an alarming rate. Yields of crops are decreasing due to adverse effects of salts on crop growth. Adverse effect of salinity is at the peak when crop is yet in the seedling stage. Consequently, a thin and patchy stand of the crop is obtained under such conditions which is the main reason for diminishing the yields. Therefore, germination test under saline conditions has been of interest since long. Early workers including Harris (1915) germinated wheat and a few other crops in salinised soil using different salts and reported that sodium chloride was the most harmful salt as compared with other salts. Ayers and Hayward (1948) standardised a method for testing germination in saline soil. They found barley as the most salt tolerant crop. Later, Ayers (1952, 1953) and Douglas and Deway (1962) investigated salt tolerance of some more crops. As a result, a detailed list of economic crops has been prepared in the Western countries with respect to their salt tolerance. But, limited information is available about the salt tolerance of common crops of West Pakistan. Ahmad and Mohammad (1956) and Wahhab (1961) investigated salt tolerance of a number of local crops in sodium chloride type of salinity, but they did not try the other salts which are commonly present in saline soils. Subsequently, sodium sulphate and sodium chloride were tried by Rashid and Butt (1963) on wheat and sodium sulphate, sodium chloride and sodium bicarbonate by Din (1965) on rice. Bhumbla and Singh (1965) tried mixture of sodium chloride and sodium sulphate.

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The salinity may be due to many salts, each of which has different effect (Strogonov, 1964). In the present investigation, six different salts were used to study their relative effect on the germination of wheat C. 250 and sorghum 100.

MATERIAL AND METHODS

Two types of soils, physical and chemical characteristics of which are given in Table 1, were used to produce artificial salinity. The soils were air-dried and passed through 2 mm. sieve. The salts used for artificial salinisation were: sodium chloride, magnesium chloride, sodium sulphate, magnesium sulphate, sodium carbonate and sodium bicarbonate. Three salinity levels, namely 3, 6 and 9 meq/100 gms. of soil were tried on sorghum while 2, 4 and 6 meq/100 gms. of soil were tried on wheat.

TABLE 1. *Physical and Chemical Characteristics of Soils Used.*

Characteristics		Soil No. 1	Soil No. 2
Mechanical Analysis	Sand percentage	69.6	82.0
	Silt percentage	14.5	8.5
	Clay percentage	16.0	9.5
	Soil type	Sandy loam	Loamy sand
Exchangeable Cations (meq./100 gms. soil)	Na^+	1.8	1.05
	K^+	1.2	0.25
	Ca^+Mg^+	15.5	10.55
Cation Exchange Capacity (meq./100 gms. soil)		18.5	11.85
pH of saturation paste		7.8	7.5
Saturation percentage		33.3	27.22
$ECe \times 10^3$		2.5	2.0
Saturation paste extract analysis. (meq./100 gms. soil)	Cations		
	Ca^{++}	0.33	0.25
	Mg^{++}	0.10	0.07
	Na^+	0.37	0.21
	K^+	0.032	0.014
	Anions		
	$CO_3^{=}$	nil	nil
	HCO_3^-	0.05	0.03
	Cl^-	0.35	0.24
	$SO_4^{=}$	0.432	0.274

The experiment was laid out in galvanised iron trays measuring $6\frac{1}{2} \times 8$ inches at the bottom, 8×10 inches at the top and 2 inches deep. One Kg. of soil was spread over a rubber sheet. Requisite quantities of salts were dissolved in water and the solution sprayed on the soil and mixed thoroughly with the help of a spatula. Calculated quantity of water was used for this purpose so that moisture level of soil was raised to 10 per cent on dry soil basis. The salinised soils were then put in respective trays. Sandy loam soil was used for sowing sorghum 100 and loamy sand for wheat C. 250. The experiment was run in three replications and trays were covered to minimise evaporation. Moisture content was kept at original level (10 per cent) by periodical weighing of the trays and spraying distilled water whenever needed. Observation of seed germination was recorded daily for 3 weeks. In addition, germination was also recorded in pot cultures containing 22 lbs. of soil.

EXPERIMENTAL RESULTS AND DISCUSSION

Sorghum 100

Emergence of seedlings is delayed and per cent germination is reduced by salinity, but the delay and decrease varies with different salts and their concentration (Fig. 1). In non-saline soil, maximum number of seeds germinated within 3 days and germination is completed within 4 days (Table 2). When soil contains salts, the emergence of seedlings is delayed, especially at higher concentration of salts seed continued germinating after 10 and 15 days in medium and high concentrations, of sodium chloride respectively. Only 47 per cent germination is given by 6 meq. of sodium chloride in 10 days and it rose to 60 per cent in 21 days. Magnesium chloride has similar delaying effect but to a lesser extent, as 6 meq. of it gave 60 per cent germination in 10 days and it rose to 70 per cent in 15 days. Similar depressing effect on germination by higher levels of sodium chloride is also reported by Ayers and Hayward (1948), Ayers (1952, 1953), Wahhab (1961) and Ahmad and Mohammad (1956).

There is no delaying effect in case of sodium sulphate and magnesium sulphate at 3 meq. concentration. Higher concentrations of these salts retard the emergence rate, but to much less degree as compared with chlorides. These results are in agreement with the findings of Rashid and Butt (1963), Harris (1915) and Din (1965).

Sodium carbonate and sodium bicarbonate cause retardation in germination more than sulphates but less than chlorides. Harris (1915) also observed similar effect of sodium carbonate on germination as compared with other salts.

Mehrotra and Gangwar (1964) studied germination of several crops in naturally saline soil and made a generalization that *kharif* crops are more sensitive to salts but can fairly stand to soil aklali. The present study has also lent support to their generalization when sodium carbonate and sodium bicarbonate are compared with chlorides. However, it does not hold good if comparison is made with sulphates.

TABLE 2. *Effect of salts on the rate of germination of sorghum* 100.

Salts	Concentration meq/100 gms. soil	Days after sowing						
		3	4	5	7	10	15	21*
		Progressive Germination Percentage						
Control ..	..	90	97	97	97	97	97	97
Sodium chloride (NaCl) ..	3.0	13	50	87	93	93	93	93
	6.0	0	0	3	7	47	53	60
	9.0	0	0	0	0	0	0	3
Magnerium chloride ($MgCl_2$) ..	3.0	27	90	97	97	97	97	97
	6.0	0	0	13	33	60	70	70
	9.0	0	0	0	0	13	13	13
Sodium sulphate (Na_2SO_4) ..	3.0	77	97	97	97	97	97	97
	6.0	0	17	50	87	93	93	93
	9.0	0	3	10	43	67	73	73
Magnesium sulphate ($MgSO_4$) ..	3.0	77	97	97	97	97	97	97
	6.0	17	27	47	83	93	97	97
	9.0	0	10	30	60	90	93	93
Sodium carbonate (Na_2CO_3) ..	3.0	13	73	100	100	100	100	100
	6.0	10	37	57	63	77	77	77
	9.0	3	13	20	23	23	23	23
Sodium bicarbonate ($NaHCO_3$) ..	3.0	47	90	100	100	100	100	100
	6.0	3	30	43	57	60	60	60
	9.0	0	0	7	7	10	10	10

*Least significant difference for total germination was 16.35 and 12.30 at 1 and 5 per cent levels, respectively.

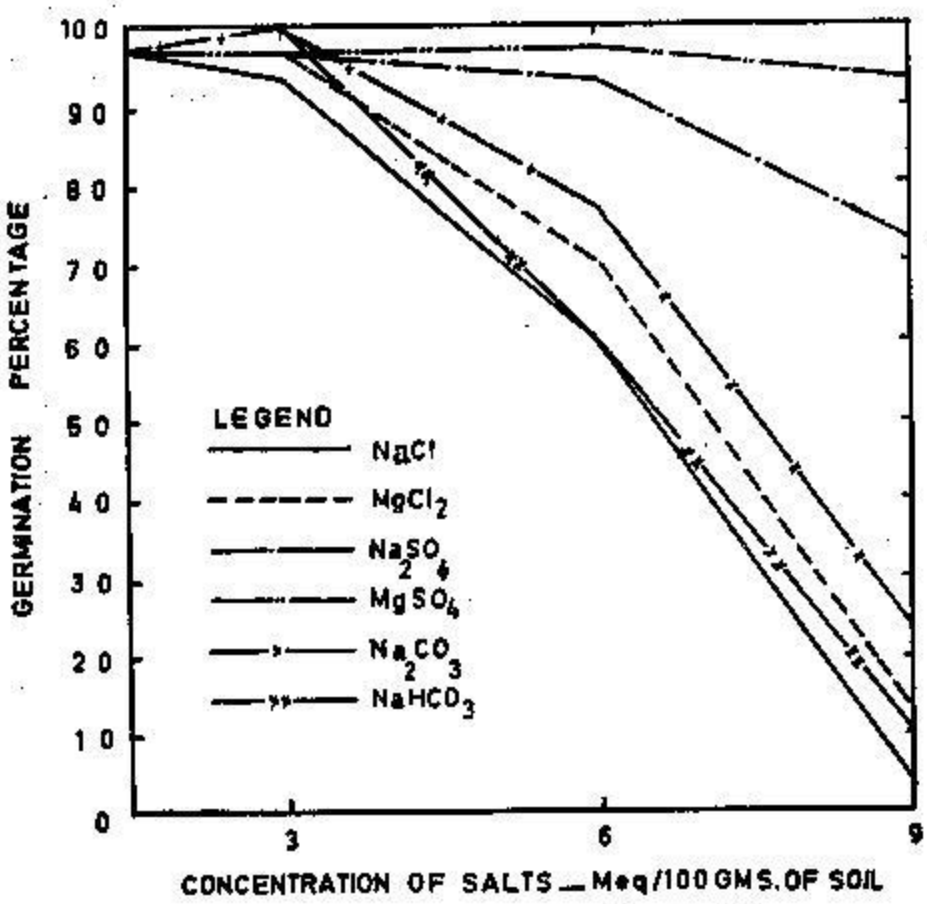

Fig. 1. Germination of Sorghum 100 as affected by Salts.

It is interesting to note that only magnesium sulphate has given sufficiently high germination (87 per cent) at 12 meq. salt concentration. Sodium sulphate gave only 27 per cent germination while all others exhibited a complete inhibition at such a high level of salinity. Total germination is extremely poor at 9 meq. concentration in case of sodium chloride, magnesium chloride, sodium carbonate and sodium bicarbonate, but it is as high as 93 and 73 per cent respectively in case of magnesium sulphate and sodium sulphate. It clearly shows that among the anions, sulphates are the least injurious as compared with other salts at germination stage.

There is no significant difference in germination at the low concentrations of salts studied. Germination capacity is significantly reduced beyond 3 meq. of sodium chloride, magnesium chloride, sodium bicarbonate and sodium carbonate and 6 meq. of sodium sulphate. The various salts, as they affect

the germination of sorghum 100 are placed in the decreasing order of their deleterious effects: Sodium chloride, magnesium chloride, sodium bicarbonate, sodium carbonate, sodium sulphate and magnesium sulphate,

Wheat C.250

The germination of wheat C. 250 is severely suppressed by sodium chloride and magnesium chloride (Table 3 & Fig. 2). The delaying effect of these salts starts even with the lowest concentration which is highly intensified by higher levels of these salts. Among these two salts, sodium chloride is more deleterious than magnesium chloride as the former gives 63 and 10 per cent germination, while the latter gives 87 and 57 per cent germination at 4 and 6 meq. concentrations respectively. Ahmad and Mohammad (1956) and Wahhab (1961) reported toxic effects of sodium chloride on various varieties of wheat and other crops at germination stage. Ayers and Hayward (1948) found inhibiting effect of sodium chloride on the germination of alfalfa, sugar beets, barley, corn and beans.

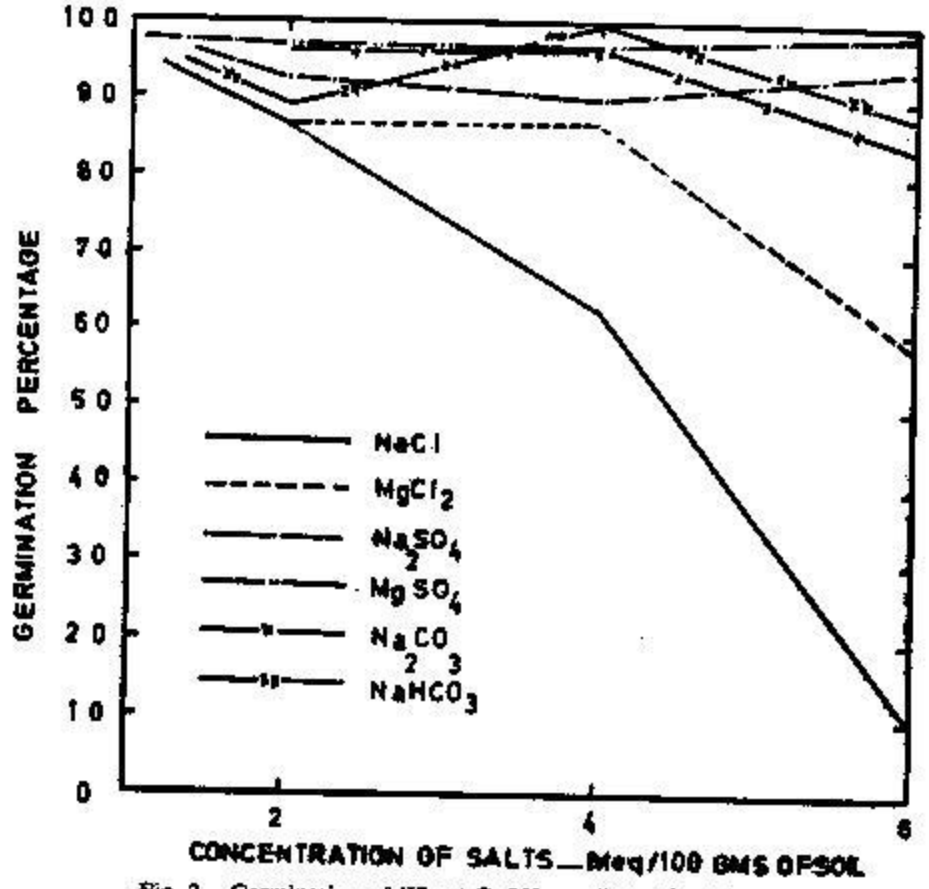

Fig. 2. Germination of Wheat C. 250 as affected by Salts.

TABLE 3. *Effect of salts on the rate of germination of wheat C. 250.*

Salts	Concentration meq/100 gms. soil	Days after sowing						
		3	4	5	7	10	15	2*
		Progressive Germination Percentage						
Control	.. ..	23	87	93	97	97	97	97
NaCl	.. 2	0	23	53	87	87	87	87
	4	0	0	0	23	43	63	63
	6	0	0	0	0	0	7	10
$MgCl_2$	.. 2	0	27	73	87	87	87	87
	4	0	0	13	60	87	87	87
	6	0	0	0	0	10	53	57
Na_2SO_4	.. 2	40	87	90	93	93	93	93
	4	10	63	87	90	90	90	90
	6	3	33	70	90	90	93	93
$MgSO_4$	.. 2	60	93	93	97	97	97	97
	4	7	77	93	97	97	97	97
	3	6	60	90	93	97	97	97
Na_2CO_3	.. 2	7	83	93	97	97	97	97
	4	3	80	90	93	97	97	97
	6	7	60	77	80	80	83	83
$NaHCO_3$	.. 2	10	77	83	90	90	90	90
	4	27	93	93	97	100	100	100
	6	0	37	63	77	83	87	87

*The Least Significant Difference for total germination is 22.27 and 16.56 per cent at 1 and 5 per cent levels respectively.

Magnesium sulphate has no adverse influence as its highest concentration produces the same germination as control. Sodium sulphate is next to magnesium sulphate in this respect. Thus, wheat C. 250 proved highly tolerant to sulphates but sensitive to chlorides. Rashid and Butt (1963) also reported that sodium sulphate was less toxic than sodium chloride for wheat C. 271 and C. 273 at germination stage.

The actual mechanism of the adverse effects of the salts has not been studied intensively. Strogonov (1964) concluded from his experiments that high salinity causes destruction of the plasmodesmata and a disturbance of the intercellular connections between some of the cells. This phenomenon is much more marked in plants growing in chloride than sulphate salinisation. The changes in the protoplasm prevent the normal co-operation between cells and their natural interdependence in general and the exchange of water and nutrient in particular. During seedling stage, mobilization of storage materials from the seed is much slower under chloride type than sulphate type of salinity. The subsequent synthesis of organic materials during the autotrophic growth-phase is especially depressed. As a result, in chloride salinisation germination is comparatively more inhibited and growth of seedlings depressed.

Low and medium concentrations of sodium sulphate, sodium carbonate and sodium bicarbonate have neither delayed nor caused any reduction in total germination percentage. The high concentration of these salts have negligible delaying effect as they complete most of their germination on the 7th day along-with control. Moreover, the total germination at higher concentrations of these salts is not significantly different from the germination in the control.

Germination was also recorded in pots, the results of which were almost the same as discussed above, except that the delaying effect of salts was more pronounced. This may be due to the fact that upper 2 inches of soil might have developed more salinity because of evaporation and capillary rise of saline water to the surface. The seed, therefore, was in more saline environment in pots as compared with trays. In trays, daily spraying of distilled water and low depth of the soil did not permit accumulation of salts at the surface. Furthermore, evaporation tended to reduce the moisture content of surface layers of pots, thereby aggravating the effects of salinity. High effects of salinity at low moisture percentages are also reported by Ayers (1952) and Wahhab (1961). These factors account for the more pronounced effects of salinity in pots as compared with trays at germination stage.

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