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Combined Effects of Temperature and Salinity Stress on Corn CV. Sunahry

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Abstract: Studies on the effects of salinity and temperature at germination and seedling growth stage of Corn cv. Sunahry were carried out. Water uptake by seeds was directly proportional to temperature and inversely to salinity stress. Decrease in temperature and increase in salinity, decreased and delayed the initiation of germination. Optimal temperature for germination and growth was 30°C. There was a direct relationship between growth and osmotic potential of the medium. Chloride type of salinity was more deleterious than sulphate, both at germination and growth stage. Above optimal temperature an interaction between temperature and salinity was observed.

Key words: Salinity, temperature, germination, growth, interaction

Introduction

Salinity and aridity are the main problems limiting the economical crop production in Pakistan. Out of total Pakistan's land area of 89.96 million hectare, only 29.54 million hectares are suitable for cultivation. The salt affected area ranges from 2.2 to 6.5 million hectares. The area annually damaged by salinity and water logging is estimated as 0.041 million hectares (El-Gambaty, 1976). This is caused by improper irrigation practices, lack of proper drainage system, evaporation from highly saline ground water table, seepage from canals and insufficient irrigation water supply during summer season.

A good deal of work has already been done on effects of salinity on germination, (Kayani and Rahman, 1987), growth (Kayani and Rahman, 1988; Anonymous, 1991; Rahman and Kayani, 1988; Hussain and Gul, 1991), anatomy, morphology and metabolism (Shimony, 1972). Besides salt concentration , environmental factors like temperature, air humidity, radiations also play an important role in germination of seeds and growth of plants. Temperature is an important factor for movement of salts in soil, uptake of salts, transpiration, respiration and overall biochemical processes in plants. Temperature also affects the flower bud formation and fruit development (Kumkura and Shishido, 1993). Unfortunately a very few studies have been carried out on combined affects of temperature and salinity (Francois and Goodin, 1972). In present studies the combined effects of temperature and salinity (chloride and sulphate) on Corn (*Zea mays* L.) cultivar Sunahry were carried out.

Materials and Methods

The seeds of Corn (*Zea mays* L.) cultivar *Sunahry* were obtained from Agriculture Research Center, Quetta. The seeds of uniform size were used through out the studies. Sodium chloride and sodium sulphate salinity treatments with osmotic potential 0.00, -4.23, -8.46, -12.69 bars were prepared by adding calculated amount of respective salt in Hoagland's solution. Concentration 0.00 served as control. Ten seeds were sown in Petriplate of 15 centimeter on Whatman's filter paper and was fed with 20 ml solution of the respective treatment. Each treatment was replicated thrice. There were four different temperatures i.e; 10, 20, 30 and 40°C on which the following studies were carried out.

Water uptake: Water uptake studies were carried out for initial 12 hours of sowing and was calculated as under:

$$\text{Water uptake, \%} = \frac{W_2 - W_1}{W_1} \times 100$$

W_1 = initial weight of seed
W_2 = weight of seed after 12 hours of sowing

Germination: Germination studies lasting for 20 days were carried out. The emergence of plumule was taken as index of germination. Initiation and completion of germination was recorded daily. Final germination per cent was calculated as under:-

$$\text{Germination, \%} = \frac{\text{No. of Germinated seeds}}{\text{Total No. of Seeds}} \times 100$$

Seedling growth: For growth studies seeds were grown in 17.5 cm. diameter plastic pots containing one kilogram sterilized washed sand, irrigated with 250 mL hoagland's solution of the respective treatment. The seedlings were harvested once after 20 days of germination. The seedlings were washed with distilled water and air dried. Length measurements were recorded for roots and shoots. For dry weight the plant material was oven dried at 80°C for 24 hours.

Salt tolerance: The salt tolerance at germination and seedling growth stage was calculated by the formula given below:-

$$\text{Salt Tolerance Index} = \frac{\text{Germination/growth in particular treatment}}{\text{Germination/growth in control}} \times 100$$

Interaction between temperature and salinity: Interaction between temperature and salinity was calculated according to Baule's principal cited by Poljakoff-Mayber and Gale (1975).

Results

Water uptake: Data presented in Fig. 1 showed that water uptake was directly proportional to the temperature and inversely proportional to salinity. The increase in water uptake with an increase in temperature was significant at $p = 0.05$ in all levels of salinity except between 20-30°C at -12.69 bars

Table 1: Time (Days) of initiation and attainment of maximum germination at different temperature of corn cultivar sunahry in various treatments of salinity

Type of Salinity	Temperature °C	Treatments							
		Osmotic Potential (Bars)							
		0.00		-4.23		-8.46		-12.69	
		Init.*	Max.**	Init.*	Max.**	Init	Max.	Init.*	Max.**
NaCl	10	6	9	7	10	-	-	-	-
	20	3	6	4	7	-	-	-	-
	30	2	4	3	6	3	6	-	-
	40	1	4	2	5	4	5	-	-
Na_2SO_4	10	6	9	7	10	8	10	-	-
	20	3	6	4	7	6	5	-	-
	30	2	4	2	4	3	7	3	6
	40	1	4	2	6	2	6	2	6

-, No Germination *, Time of initiation of germination **, Time of attainment of maximum germination

Table 2: Effects of chloride and sulphate types of salinity on salt tolerance index of corn cultivar sunahary at different temperature

Type of Salinity	Temperature °C	Germination			Seedling Growth		
		Osmotic Potential (Bars)			Osmotic Potential (Bars)		
		-4.23	-8.46	-12.69	-4.23	-8.46	-12.69
NaCl							
	10	50.00	00.00	00.00	47.50	0.00	00.00
	20	56.66	00.00	00.00	42.93	00.00	00.00
	30	86.66	33.33	00.00	24.45	13.42	00.00
	40	83.33	13.33	00.00	18.78	08.11	00.00
Na_2SO_4	10	66.66	16.66	00.00	46.28	14.21	00.00
	20	70.00	16.66	00.00	37.49	21.78	00.00
	30	90.00	83.33	60.00	28.54	19.18	06.82
	40	83.33	73.00	66.66	21.53	11.59	04.72

Table 3: An interaction between temperature 30-40°C and salinity levels of corn cv. sunahry

Treatments Osmotic Potential (Bars)	Reduction % By Salinity At 40°C As Compared To To Growth at 30°C	Growth, % At 40°C As By Temperature Compared To Growth at 30°C (A)	Reduction, % At 40°C As Compared To Growth at 30°C	Growth, % At 40°C As Compared To Growth at 30°C (B)	Growth Product, % Of A,b	Calculated Reduction, % By Temperature And Salinity	Observed Reduction, % By Temperature and Salinity at 40°C
			Chloride Type of Salinity				
-4.23	23.19	76.81	49.57	50.43	38.73	61.26	81.22
-8.46	39.58	60.44	49.57	50.43	30.55	69.45	91.89
-12.69	00.00	00.00	00.00	00.00	00.00	00.00	00.00
			Sulphate Type of Salinity				
-4.23	24.56	75.43	49.57	50.43	38.05	61.97	78.47
-8.46	30.79	69.21	49.51	50.43	34.90	65.10	88.41
-12.69	37.57	60.43	49.57	50.43	30.47	69.53	96.28

The 30°C is taken as optimal temperature for seedling growth. Interaction between and salinity at 10 and 20 and 20 and 30°C was not calculated because at these temperature both growth in control and reduction by salinity was lesser and these temperature were not suitable for seedling growth and germination of corn cv. sunahry.

osmotic potential of NaCl and between 30-40°C at -8.46 bar osmotic potential of Na_2SO_4. The increase in salinity stress significantly reduced the water uptake except between -8.46 and -12.69 bars osmotic potential at 20°C of Na_2SO_4 salinity. Fig. 1 also showed that water uptake was maximum at 40°C in control and minimum at 10°C at -12.69 bars osmotic potential of NaCl salinity.

Germination: Table 1 revealed that decrease in temperature and increase in salinity delayed the initiation of germination. There was no germination at -12.69 bars osmotic potential in all temperatures in both types of salinity and also at -8.46 bars osmotic potential at 10 and 20°C in chloride type of salinity. It is also clear from Fig. 1 that in all treatments of The delay in germination varied in between 1-7 days from day of sowing. The attainment of maximum germination varied from 1-5 days after the germination of first seed in various treatments of salinity and temperature. Data regarding final germination percent (Fig. 1) exhibited that germination increased upto 30°C and then it decreased slightly. The increase or decrease in germination per cent with an elevation in temperature was significant ($p = 0.05$) in sulphate type of salinity. Data also revealed that increase in salinity stress significantly reduced the germination per cent.
salinity and temperature, germination was much better at 30°C than other temperatures. The reduction in germination was greater in chloride type of salinity than sulphate type.

Seedling growth: There was a gradual increase in seedling growth at the time of harvest i.e., growth of 20 days after the

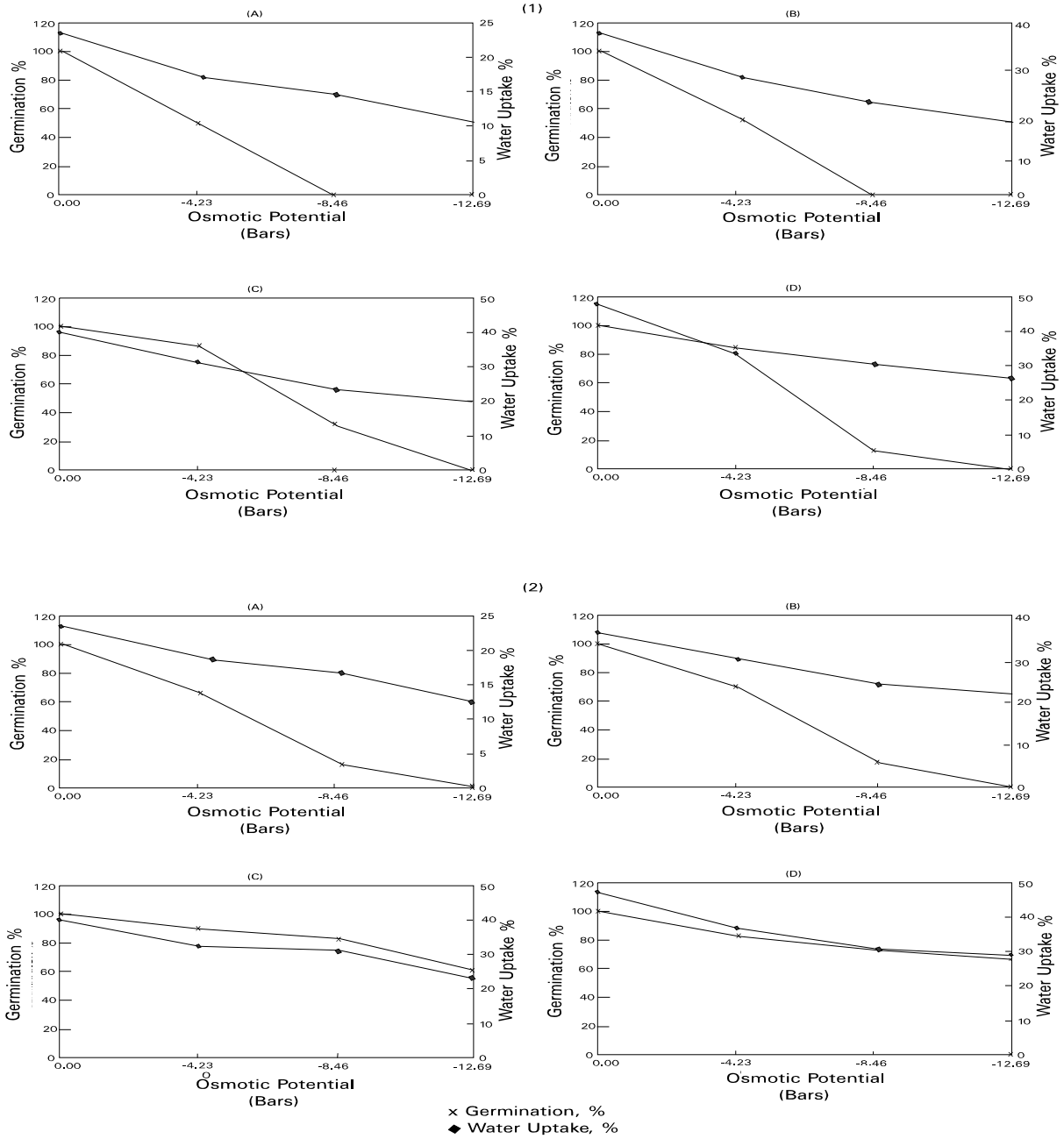

Fig. 1: Effects of chloride and sulphate types of salinity on water uptake, % and germination, % of corn cv. sunahry.
1. Chloride Type of Salinity. A: 10°C B: 20°C C: 30°C D: 40°C

Salinity Treatments Osmotic Potential (Bars)	LSD p = 0.05		Temperature °C	LSD p = 0.05	
	Germination	Water Uptake		Germination	Water Uptake
00.00	Not Significant	1.62	10	17.32	1.54
- 4.23	Not Significant	2.10	20	20.82	0.62
- 8.46	Not Significant	1.65	30	52.18	1.87
-12.69	Not Significant	1.87	40	14.36	1.46
2. Sulphate Type of Salinity		A: 10°C	B: 20°C	C: 30°C	D: 40°C
00.00	Not significant	1.62	10	10.30	1.54
-4.23	13.74	1.68	20	27.69	0.62
-8.46	45.35	2.46	30	20.00	1.87
-12.69	11.54	2.46	40	Not significant	1.40

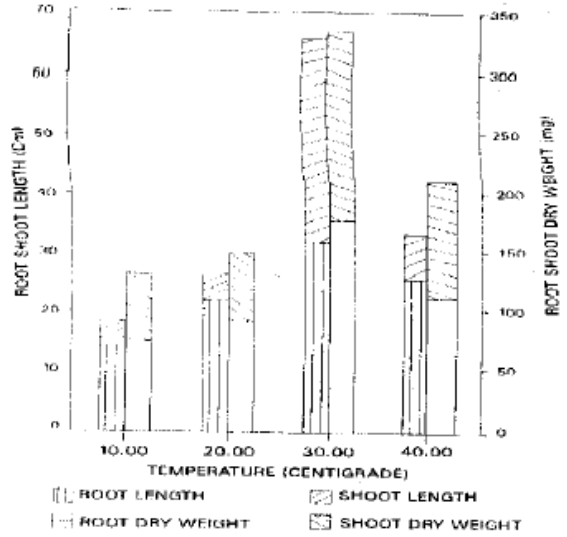

Fig. 2: Effect of various temperatures on growth of corn cv. Sunahry

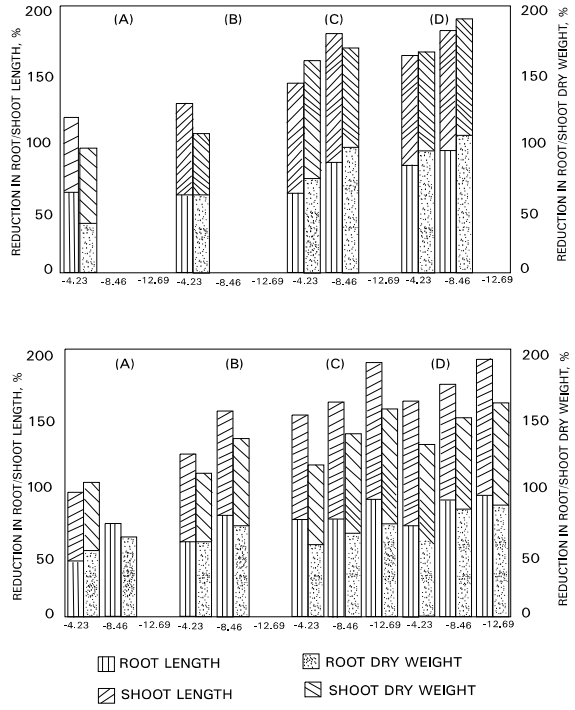

Fig. 3: Reduction % in seedling growth of corn cv. sunahry by salinity at different temperatures

1. Chloride type of salinity.a:10°C B: 20°C C: 30°C D: 40°C
2. Sulphate Type of Salinity.a:10°C B: 20°C C: 30°C D: 40°C

germination of seed, from 10 to 30°C and then a decreased from 30-40°C (Fig. 2). The growth parameters show significant differences at various temperatures and salinity treatments. The roots were less affected than shoots. The pattern of increase or decrease in seedling growth was same as that of germination, with an increase in temperature. The increase in root and shoot growth averages about 56 and 86%, respectively, from 10 to 30°C.

Figure 3 showed that the reduction in growth with an increase in salinity varies from treatment to treatment and type of salinity. At same level of salinity growth reduction was higher at 40°C. At same temperature decrease in growth was greater at higher levels of salinity than at lower levels.

Salt tolerance: Table 2 showed that salt tolerance was greater at germination stage (20 days after sowing) than at seedling growth of 20 days after germination. The salt tolerance was greater at 30°C in all levels of salinity.

Interaction between temperature and salinity: Data presented in Fig. 1-3 showed that maximum germination and growth took place at 30°C which indicates that it was the optimal temperature for germination and growth. Thus 30°C was taken as optimal temperature for the calculation of interaction. Table 3 showed that an interaction between temperature and salinity exists between 30 and 40°C in both types of salinity in all treatments. Interaction between temperature and salinity at 10 and 20 and 20 and 30°C was not calculated because at these temperature both growth in control and reduction by salinity was lesser.

Discussion

An increase in germination with an increase in temperature (10-30°C) and a slight decrease above 30°C was observed. Lowering of temperature also resulted in delay in initiation of germination. A decrease and delay in germination below 30°C is due to low water uptake. At higher temperatures promotion of germination could be due to increase in water uptake by seeds (Kollar and Hades, 1982; Uchiyama, 1981), changes in membrane permeability (Taylorson and Hendricks, 1977), leakage of organelle membranes and enhanced metabolic activity over that at lower temperatures (Kollar and Hades, 1982). H owever the exact nature of these mechanisms is not yet properly understood (Ungar, 1982). Ahi and Powers (1938) reported that temperature is optimal factor in germination and growth in saline environment. The present results are in line with Ahi and Powers (1938) that there was an increase in adverse effects of salinity with an increase/decrease in temperature above/below optimum (30°C). Ota and Yasue (1959) reported that salinity was more inhibitory to rice at higher temperature and low humidity. Ehlig (1960) observed extensive damages by salts above 37.80°C and less at 32.20°C. The present results showed that chloride type of salinity was more injurious than sulphate on both germination and growth stage. Khan *et al*. (1984) reported that germination retardation was more pronounced in Na_2SO_4 than in NaCl salinity. In our results corn showed greater tolerance at germination than growth stage while reverse reported. Khan and Patel (1971). Ayers and Hayward (1948) reported that there may not be a positive correlation between salt tolerance at germination and during later phase of growth. An interaction between temperature and salinity was calculated according to Baule's principle and was found that it exists between temperature 30 and 40°C and three levels of salinity (-4.23, -8.46 and -12.69 bars osmotic potential). Various workers have also reported an interaction between temperature and salinity namely, (Khan

and Ungar, 1984; Unger, 1982; Khan and Khan, 1978).

From the above studies it can be safely concluded that for Corn cultivar Sunahry 30°C temperature is optimal for growing in slightly saline soil. It does not grow well at lower temperature and higher levels of salinity. Results also showed that while evaluating salt tolerance of particular crop beside salinity level environmental factors like temperature, radiation, air humidity may also be taken into account.

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