Pak. J. Bot., 19(1): 9–15, 1987.

SALT TOLERANCE IN CORN (*ZEA MAYS* L.) AT THE GERMINATION STAGE

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Abstract

Effects of chloride and sulphate types of salinity on water uptake by seeds and germination of 3 cultivars of corn viz., Agati 72 Yousafwala, Sultan Yousafwala and Sunahry were studied. Salinity reduced the water uptake by seeds and germination of all the cultivars. Salinity delayed the initiation of germination. Water uptake by seeds showed direct relationship with germination percentage. All the cultivars showed similar response in sulphate type, whereas reverse was true for chloride type of salinity. Agati 72 Yousafwala and Sultan Yousafwala showed greater salt tolerance than Sunahry.

Introduction

Chloride and sulphate are the principal anions present in salt affected soils and irrigation water of arid regions of the world (Poljakoff-Mayber & Gale, 1975). Due to high solubility of Cl^- and SO_4^- they are main contributing factors for potential salinity of irrigation water (Eaton, 1942). In Pakistan it has been estimated that more than 50% of total area of 46.5 million hectares of Indus plain is suffering from salinity and sodicity problem (Hassan, 1976) and about 100,000 acres of soil become salt affected each year (Asghar, 1960).

A few studies have been carried out on the relative salt tolerance of various cultivars of agricultural crops of Pakistan. (Wahhab, 1964). In the present work effects of different levels of chloride and sulphate types of salinity on 3 cultivars of corn viz;, Agati 72 Yousafwala, Sultan Yousafwala and Sunahry were investigated.

Materials and Methods

Seeds of corn cultivars obtained from Agricultural Research Institute, Quetta, were surface sterilized with 1% HgCl solution and rinsed thoroughly with distilled water. Water uptake by seeds after 12 h, and germination were studied in 9 cm diam., Petri dishes on Whatman No. 1 filter paper in an incubator at 30°C ± 1.0. In each dish 10 seeds were placed and 3 ml solution of osmotic potentials of 0.00, – 4.23, – 8.46, and 12.69 bars, prepared by adding calculated amount of salt (NaCl, Na_2SO_4) in distilled water was added in each dish after an interval of 24 h. Each treatment was replicated 3 times. The

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filter papers were changed after an interval of 48 h. The Petri dishes were placed in an incubator and observations on germination made every 24 h internal for 6 days. The emergence of coleoptile was taken as an index of germination.

Water uptake was calculated by the formula % Water uptake = $\frac{W_1 - W_2}{W_1} \times 100$ where:

W_1 = Dry weight
W_2 = Weight after 12 hours sowing.

Recovery test was applied on the ungerminated seeds after 6 days of treatment. Seeds were thoroughly washed with distilled water and placed in Petri dishes in an incubator at 30°C ± 1.0. Three ml of distilled water was added in each dish after an interval of 24 h.

Results

Water uptake: There was more or less gradual reduction in water uptake by seeds with an increase in salinity of the medium (Fig. 1). This was significant (p = 0.05) in few treatments of NaCl and Na_2SO_4 in cv. Sultan Yousafwala and Sunahry. Reduction in water uptake by seeds at – 12.69 bars osmotic potential achieved by chloride type of salinity was 23.69, 51.6, 50.73 and by sulphate type of salinity was 11.80, 20.90 and 42.6 % of control in cvs Agati 72 Yousafwala, Sultan Yousafwala and Sunahry, respectively. Greater reduction in water uptake took place in chloride than in sulphate type of salinity (Fig. 1) and the cultivars can be arranged in the following order:

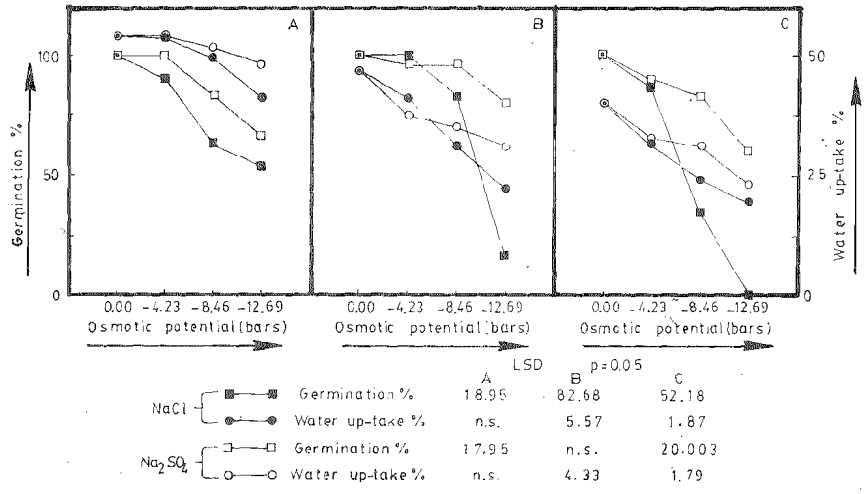

Fig. 1. Water uptake by seeds and final germination % of corn cultivars at various osmotic potentials A: Agati 72 Yousafwala B: Sultan Yousafwala C: Sunahry.

i) NaCl: Sunahry > Sultan Yousafwala > Agati 72 Yousafwala
ii) Na_2SO_4: Sultan Yousafwala > Sunahry > Agati 72 Yousafwala

Germination: Salinity delayed germination upto 3 days in NaCl and upto 2 days in Na_2SO_4 (Fig. 2). There was a decrease in germination % with an increase in salinity of the medium. This decrease was significant (p = 0.05) in few treatments of NaCl and Na_2SO_4 in cvs. Agati 72 Yousafwala, Sultan Yousafwala and Sunahry (Fig. 1 & 2).

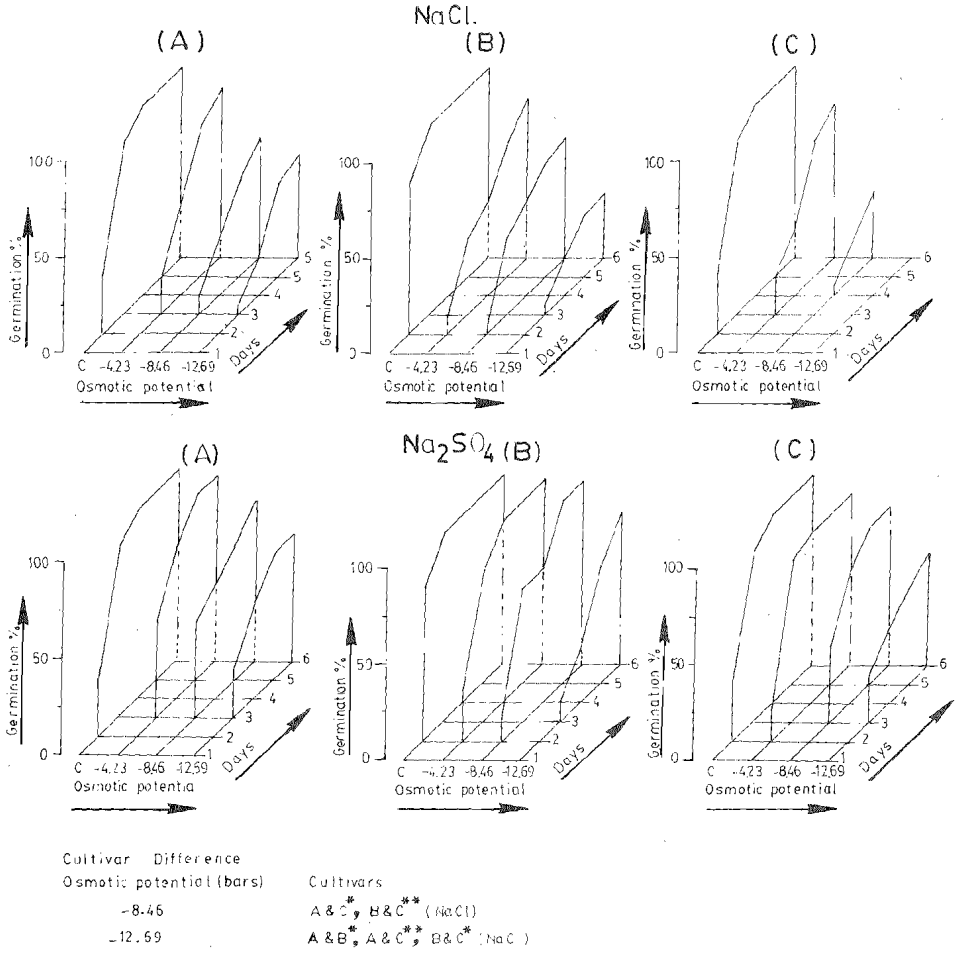

Fig. 2. Percentage seed germination of corn cultivars at different levels of osmotic potentials A: Agati 72 Yousafwala, B: Sultan Yousafwala, C: Sunahry.

C = Control * = Significant difference at p = 0.05 ** = Significant difference at p = 0.01

Reduction in final germination % at – 12.69 bars osmotic potential achieved by NaCl was 46.67, 67.67, 100.00 and by Na_2SO_4 was 33.34, 20.00 and 60.00 % of control in cvs. Agati 72 Yousafwala, Sultan Yousafwala and Sunahry, respectively. There was greater reduction in germination by chloride than sulphate type of salinity. In chloride type of salinity Agati 72 Yousafwala showed minimum, Sultan Yousafwala intermediate and Sunahry maximum reduction in germination, whereas in sulphate type of salinity, Sultan Yousafwala showed minimum, Agati 72 Yousafwala intermediate and Sunahry maximum reduction in germination. There was a direct relationship between water uptake and germination percent in all the cultivars (Fig. 1).

Recovery test: In lower levels of salinity greater recovery took place in chloride type of salinity than in sulphate type of salinity (Table 1). The percentage of recovery varied from cultivar to cultivar.

Table 1. Final germination % of corn (*Zea mays* L.) cultivars after the application of recovery test.

Type of salinity	Osmotic Potential (bars)	Corn cultivars: Agati 72 Yousafwala	Sultan Yousafwala	Sunahry
NaCl	– 4.23	(3) 66.6	(–)	(4) 50.00
	– 8.46	(10) 50.00	(5) 100.00	(17) 47.00
	– 12.69	(14) 50.00	(25) 100.00	(30) 46.6
Na_2SO_4	– 4.23	(–)	(1) 100.00	(3) 66.6
	– 8.46	(5) 60.00	(1) 100.00	(4) 50.00
	– 12.69	(10) 30.00	(4) 25.00	(13) 8.34

Figures in parentheses are number of non germinated seeds sown in each treatment.

Relative salt tolerance: The salt tolerance of cultivars varied with the type of salinity and osmotic potential of the medium. There was significant ($p = 0.05/0.01$) difference of salt tolerance between Agati 72 Yousafwala and Sultan Yousafwala and Sultan Yousafwala and Sunahry at osmotic potential of – 8.46 and – 12.69 bars and between Agati 72 Yousafwala and Sultan Yousafwala at osmotic potential of – 12.69 bars of chloride type of salinity, whereas all the cultivars showed similar behaviour (non significant difference) to sulphate type of salinity.

Discussion

Decrease and delay in germination in saline medium has been reported by many workers (Ayers *et al.*, 1958; Ayers & Hayward, 1948; Bernstein & Hayward, 1958; Dewey, 1960; Dotzenko & Dean, 1959; El-Zhab, 1971; George & Williams, 1964; Khan & Sheikh, 1976; Mirza & Mehmood, 1986). Salinity affects germination in two ways:

1. There may be enough salt in the seed bed to decrease the osmotic potential of the medium which will retard or prevent uptake of necessary water (Fig. 1).

2. Certain salt constituents or ions may be toxic to the embryo. Our resuts are similar to the reports of Shive (1916), Ziglstra (1946) and Eperjessy (1930) who found that germination was directly related to the amount of water absorbed and delay in germination was directly proportional to the salt concentration of the medium.

After the application of recovery test those seeds which germinated did not get their embryo damaged by the excess of ions (Na^+, Cl^-/SO_4^{--}) while the seeds which did not germinate even after the application of recovery test (Table 1) their embryo probably was damaged. Greater recovery in higher osmotic potentials (– 4.23 bars) than at lower osmotic potentials (– 8.46 and – 12.69 bars) has also been reported by Uhvit (1946). He suggested that this might be due to the low concentration of ions. The salt tolerance of plants varies with the type of salt and osmotic potential of the medium (Ayers & Hayward, 1948, Khan *et al.*, 1984).

NaCl delayed and inhibited germination more than Na_2SO_4 (Fig. 2). Harris & Pitman (1918, 1919) found that chloride salts are most toxic, sulphate least and carbonate intermediate but the toxicity of NaCl and Na_2SO_4 depends upon the concentration of salts. In contrast, Khan *et al.*, (1984) reported that germination retardation in wild desert species is greater in Na_2SO_4 than in NaCl.

Corn cvs. Agati 72 Yousafwala, Sultan Yousafwala and Sunahry showed different degree of tolerance in NaCl whereas in Na_2SO_4 all the cultivars showed similar response upto the osmotic potential (– 12.69 bars). Significant varietal differences in salt tolerance has been reported in wheat (Ota & Yasue, 1957. Wahhab, 1964), rice (Ota *et al.*, 1958),

cotton and maize (Wahhab, 1964) and alfalfa (Dotzenko & Dean, 1959). Wahhab (1964) reported that corn varieties hybrid 7 and hybrid 59 showed excellent salt tolerance upto 0.4 % NaCl concentration and that salt tolerance depends upon the soil moisture present in the seed bed.

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(Received for publication 28 December, 1986)