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IONIC AND OSMOTIC EFFECTS OF SODIUM CHLORIDE ON GERMINATION RATE AND SUBSEQUENT GROWTH OF WHEAT SEEDLINGS

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Abstract

Effect of NaCl and PEG-4000 on the germination and growth of wheat seedlings were studied. It was found that NaCl and PEG-4000 solutions were absorbed at a comparatively higher rate during 0-4 h as compared to 4-8 h. The germination rate was significantly reduced when NaCl or PEG-4000 was provided only for 0-4 h. Pre-germination treatment of NaCl has no effect on growth of wheat seedlings but 0-36 h treatment of PEG-4000 significantly inhibited the growth. When NaCl treatment was given during 24-36 h a significant growth promotion was obtained.

Introduction

The conditions prevailing at the various phases of germination (imbibition activation, cell dvision and cell elongation c.f. Evenari, 1949) not only have a bearing on percentage germination but also on subsequent seedling growth (Meiri *et al.*, 1970). Plants raised under saline conditions, possess the ability to enhance their internal osmotic pressure (Eaton 1942) so as to neutralize external pressure. However even after the attainment of osmotic balance, growth remain supressed (Slatyer, 1961) due to internal ion accumulation in the cell sap (Walter, 1955) or because certain sub-cellular organelles fail to adjust themselves to high osmotic pressure of cell sap (Bernstein, 1961) but not owing to reduced water uptake (Slatyer, 1961). The germination rate is significantly depressed in high saline media (Khan & Patel 1972) and plants tolerate salinity to a lesser extent during germination than at subsequent stages of seedling growth (Sarin & Naryanan, 1968; Khan & Patel, 1972). The effect of continuous salinity on the germination has often been studied, therefore, it was thought desirable to study the effect of salinity on various phases of germination.

Materials and Methods

Seeds of *Triticum aestivum* Linn. (cv. Pak-70) were surface sterilized for three minutes with 0.2% mercuric ch oride solution and washed with distilled water. Seeds were germinated in four inch diameter sterilized petri plates containing three layers of tissue paper with three ml of test solution. Half-strength Hoagland solution (pH 6.0) was used, this is considered as the solution at zero atmosphere. Desired osmotic potential of test solution was obtained by adding soldium chloride or Polyethylene glycol (PEG-4000) in Hoagland solution. Three petri plates, each containing ten seeds were used for each treatment. The plates were kept in growth chamber maintained at 21±1°C with 10h of 6K Lux of white flourescent light supplemented with incandescent lamps. Re ative humidity ranged from 60 to 70%. The amount of solution absorbed by seeds was determined by increase in fresh weight of seeds

after 0-4, 0-8 and 0-12 h of treatment. For germination and growth study, wheat seeds were treated with 6 atm. of NaCl and 6 atm. of PEG-4000. Captions A to G indicates the period of seed exposure. In treatment A, seeds were continuously germinated in Hoagland solutions, in B seeds initially treated for 0-36 than transferred to control conditions, in CDEFG the time of exposure was 0-4, 4-8, 8-12, 12-24 and 24-36 h. respectively. Before and after exposure seeds were placed in Hoagland solution. Germination percentage were taken after 24 and 48 h and growth was taken after 96 h.

Results

Absorption rate of nutrients (Hoagland), NaCl and PEG solutions by dry wheat seeds.

To study the effect of NaCl and PEG-4000 at various stages of germination and growth, a preliminary experiment was conducted to determine the rate of absorption of nutrients, NaCl and PEG-4000 solutions by dry wheat seeds. The result presented in Table 1 indicate that all the three solutions absorbed at the similar rate (i.e. 16-17 mg). During 4-8 h, seeds absorb nutrient solution more as compared to NaCl and PEG-4000 solutions. During 8-12 h absorption of nutrients solution stopped, whereas NaCl and PEG-4000 were being absorbed continuously.

TABLE 1. Absorption rate of nutrients (Hoagland), NaCl and PEG-4000 solutions by dry wheat seeds. Values are given in weight (mg) at various time periods.

Treatment	0-4h	4-8h	8-12h
Control (Hoagland)	17.4 ± 5.7	10.13 ± 1.17	0.14 ± 0.72
NaCl (6 atm.)	16.74 ± 0.46	4.11 ± 0.50	6.96 ± 1.70
(PEG-4000	16.08 ± 0.22	8.11 ± 1.93	5.30 ± 4.7

Effect of NaCl and PEG-4000 at various stages of germination.

Germination percentage significantly declined over the control(A), in salt treatment for 0-36 h of germination as well as in PEG treatment for this duration. Salt treatment for 0-4 h also substantially reduced the percentage germination (Fig 1 (1), 1, (2)). PEG treatment for 0-36 h and 0-4 h though markedly retarded the germination rate but the final percentage germination (at 48 h) remained unaffected. Other treatments (D, E, F & G) did not significantly influence the germination percentage.

Effects of sodium chloride and polyethylene glycol on early seedling growth.

Effect of NaCl and PEG-4000 at an early seedling growth were also studied. The result presented in Fig. 2 showed that NaCl is ineffective in altering the growth of wheat seedlings when treated for different periods of germination except in treatment G in which sodium chloride was given after 24 h of germination a significant promotion ($p < 0.05$) was recorded. Polyethylene glycol (treatment B) inhibited the growth by 72% while in other treatments except in D where a slight promotion (10%) was observed and it remained ineffective in depressing the growth.

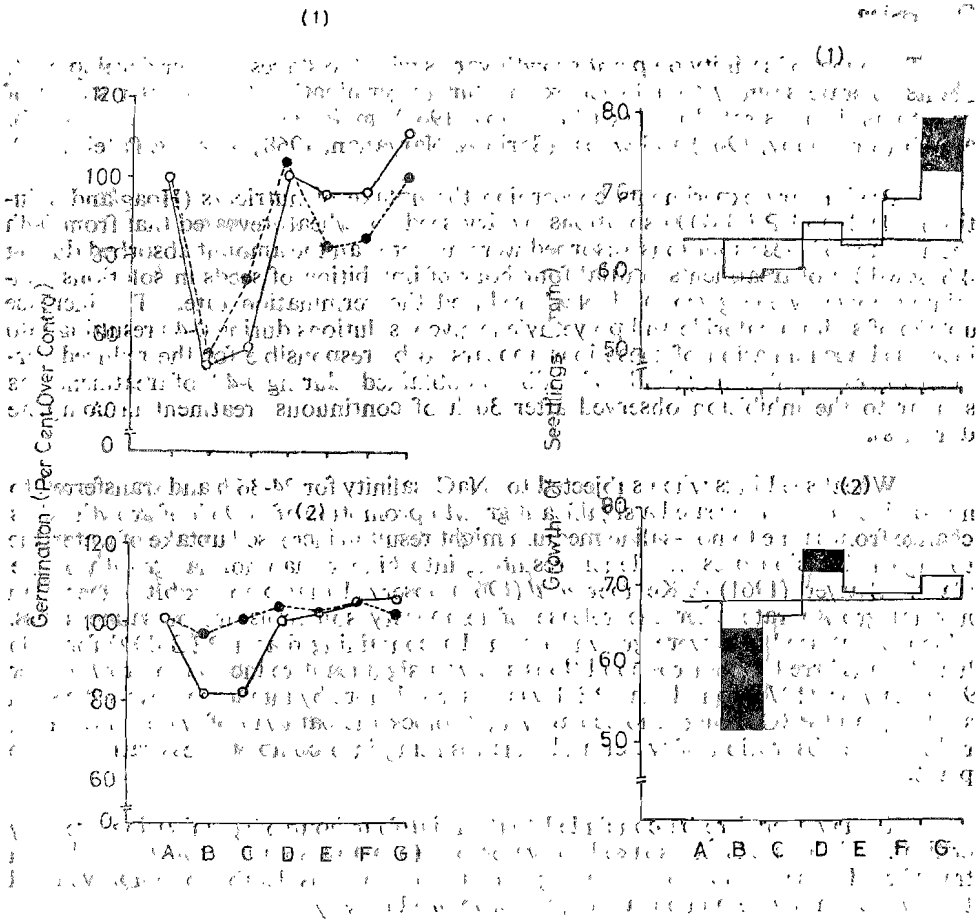

Fig 2.

Fig 3

Fig. 1. The effect of 6 atm NaCl and 6 atm PEG-4000 at various time intervels on the germination of *Triticum aestivum* Linn. (cv Pak-70) seeds. Captions A to G indicates the period of seed exposure. In treatment A seeds are continuously germinated in Hoagland solutions in B seeds initially treated for 0-36 h then transfered to control conditions; in C seeds treated for initial 0-4 h and shifted to control condition and in DEFG the time of exposure was 4-8, 8-12, 12-24, 24-36 h respectively.

24th (1)

48h (2)

6 atm. NaCl ● - ●

6 atm. PEG-4000 0—0

Fig. 2. Effect of NaCl and PEG-4000 on the growth of wheat seedlings treated at various time intervals.

NaCl (1)

PEG-4000 (2)

Dark area showing the level of significance at $P < 0.05$.

Discussion

The effect of salinity on plant growth varies with the stages of their development. Plants tolerate salinity to a lower extent during germination than at later stages of growth as demonstrated in flax (Strogonov, 1962), maize (Harrison & King, 1925). alfalfa (Strogonov, 1962) and wheat (Sarin & Naryanan, 1968; Khan & Patel 1972).

Preliminary experiments concerning the uptake of nutrients (Hoagland solution), NaCl and PEG-4000 solutions by dry seeds of wheat, revealed that from 0-4h the amount of these solutions absorbed were higher than the amount absorbed during 4-8 & 8-12 h of treatments. Initial four hour of imbibition of seeds in solutions containing polyethylene glycol and NaCl reduced the germination rate. The increase uptake of sodium chloride and polyethylene glycol solutions during 0-4h resulting into increased accumulation of these ions appears to be responsible for the reduced germination rate. The magnitude of inhibition obtained during 0-4 h of treatment was similar to the inhibition observed after 36 h of continuous treatment in complete darkness.

Wheat seedlings when subjected to NaCl salinity for 24-36 h and transferred to non-saline medium revealed a significant growth promotion after 96 h of growth. This change from saline to non-saline medium might result in increased uptake of water due to higher diffusion pressure deficit resulting into higher than normal growth of the plant. Slatyer (1961) & Kemper *et al* (1961) observed that plant exibit higher than normal growth rate after the release of temporary soil moisture or saline stress. When wheat seedlings were grown in a media containing 6 atm PEG-4000 for 0-36 h and transferred to control conditions shows a significant reduction in growth after 96 h. Lawlor (1970) found that PEG was absorbed more by intact than excised cotton seedlings and PEG of high molecular weight block the pathway of water movement, reduces the absorption of water and thus resulting into complete dessication of the plant.

It may therefore be concluded that initial four hour of germination are very critical. If the seeds are soaked in water or Hoagland solution for 4 h and than transferred to saline soil percentage germination can considerably be improved and that will certainly help in enhancing the crop productivity.

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