DISCUSSION

Salt at 0.5% level significantly reduced the emergence of seeds at the end of 48 hours of germination. An increase in the concentration of salt from 0.5 to 1.0% significantly reduced the emergence of seeds during 48, 72 and 96 hours of germination. However, the final percentage of germination was not significantly affected by salt at 0.5 and 1.0% levels. Salt at 1.5% level significantly reduced the rate of emergence and the final percentage of germination of seeds. Salt at a concentration of 2.0% totally inhibited germination of seeds. Thus a delay and decrease in germination was observed with increase in concentration of salt. Decreased rate of emergence and percentage of germination due to salinity have been reported in seeds of paddy (Rao *et al*., 1969), wheat (Sarin and Narayanan, 1968), Soybean (Abel and Mackenzie, 1964), sunflower (Karami, 1974), *Medicago* (Rizk *et al*., 1978) and wheat and barley (Maliwal and Paliwal, 1967). Total inhibition of germination of seeds under toxic levels of salt has been observed in *Cicer arietinum* (Ramesh and Sunil, 1979) and *Atriplex polycarpa* (Chatterton and Mc Kell, 1969).

Stimulated growth of root and shoot systems of seedlings was observed under low concentrations of sodium chloride viz., 0.05, 0.1 and 0.2%. However, a significant increase in the growth of root and shoot system was observed only under 0.1% salt. Similar stimulation of growth by lower concentrations of salt (NaCl) has been reported in paddy (Joshi, 1976) and jowar (Singh and Dastane). Salt at 1.0 and 1.5% level significantly reduced the growth of root and shoot system of seedlings. Inhibition of growth by higher concentrations of salt has been reported in cow pea and mung bean (Balasubrahmanian and Sinha, 1976), wheat (Bhardwaj and Rao, 1960), beans (Nieman and Bernstein, 1959), soybean (Abel and Mackenzie, 1964) and rice (Ehrler, 1960 and Korkor and Abdel, 1974). Reduction in the growth of embryo axis of mung bean (Sheoran and Garg, 1978) and radish (Ramana and Rama Das, 1978) under salinity has been attributed to the inhibition of hydrolysis of reserve food materials from the cotyledons. Stunted growth of plants under high levels of salinity has been reported by Strogonov (1962), Poljakoff-Mayber (1975) and Joshi (1976). According to Mizrahi _et al_. (1972) stress in plant tissues resulting from salinity causes an increase in the content of ABA and a decrease in the endogenous level of cytokinin. This may result in inhibition of growth. Thus the reduction in the growth of seedlings observed under high concentrations of salt may be due to a reduction in the endogenous level of cytokinin along with an increase in the level of ABA.

Effect of succinic acid on germination of seeds and growth of seedlings under different levels of salt :-

Succinic acid at all levels tried slightly improved the rate of emergence of seeds at the end of 48 hours of germination. The rate of emergence of seeds at the end of 72 and 96 hours of germination was significantly enhanced by succinic acid at a concentration of 5 mg/l under the influence of 1.5% salt. The final percentage of germination at 1.5% of salt was also significantly enhanced by 5 mg/l succinic acid. The germination of seeds under the influence of 2% salt was significantly increased by 5 and 20 mg/l succinic acid. Stimulation of germination of seeds by succinic acid has been reported in seeds of Siberian larch (Lagutina, 1966), cereals (Drozdov and Babuk, 1968), barley and lupine (Siuliauskas, 1967), corn (Koroleva, 1964 and Maurina _et al_., 1969. and Gertsuskii, 1959) and cotton (Blagoveshchenshii and Rakhmanov, 1964). Growth of seedlings under the influence of salt was not stimulated by any concentration of succinic acid tried. The growth of shoot system was significantly increased by succinic acid at 5 and 20 mg/l concentrations. Acceleration of growth by succinic acid has been reported in cucumber (Artemova, 1968), maize (Gertsuskii, 1959) and cereals (Drozdov and Babuk, 1968).

Effect of CCC on germination of seeds and growth of seedlings under different levels of salt :-

Treatment of seeds with CCC did not stimulate germination of seeds under the influence of salt. CCC at 500 mg/l significantly reduced the rate of emergence and final percentage of germination of seeds under the influence of 1% salt. CCC at 500 and 1000 mg/l inhibited the germination of seeds under the influence of 1.5 and 2% levels of salt. However, treatment of seeds with CCC alone did not show any adverse effect on germination of seeds. Treatment of seeds with CCC has been shown to inhibit germination of paddy seeds (Chakravarthy, 1969 and Tazul and Muhsi, 1973). However, in the present studies no such inhibition of germination of seeds by CCC was observed. This may be due to the varietal difference. Application of an antigibberellin phosphon-D has been shown to ameliorate the adverse effect of soil salinity on germination of peas (Uprety and Sarin, 1973).

As in the case of germination, the growth of seedlings especially under saline condition was highly reduced by CCC. Thus treatment of seeds with CCC was not helpful in alleviating the toxic effect of salinity on growth of seedlings of paddy. Similar observations have also been made by Hegazi and Kausch (1978) in the case of maize and Naqivi et al. (1970) in wheat. Application of CCC to soil has been shown to reduce the toxic effect of soil salinity on the number of ears in wheat (Balasubrahmanian and Sarin, 1974). When seeds were treated with different concentrations of CCC, growth of root and shoot has been greatly reduced. However, growth of shoot system was not much affected by CCC. Increasing concentrations of CCC progressively decreased the growth of root system of seedlings. Similar inhibition of growth of roots by higher concentration of CCC has been reported in seedlings of <u>Cyamopsis tetragonoloba</u> (Kathju and Tewari, 1970).

Effect of thiourea on germination of seeds and growth of seedlings under different levels of salt :-

Treatment of seeds with 0.5% thiourea enhanced the rate of emergence at the end of 96 hours and the final percentage of germination of seeds significantly under the influence of 1.5% salt. Germination of seeds under the influence of 2% salt was significantly increased by thiourea tried at all concentrations. Treatment of seeds with thiourea alone did not show any effect on the germination of seeds. Thiourea is known to break dormancy of seeds of paddy (Srinivasulu and Murty, 1967) and Hazel beech and rowan (Frankland, 1961). In the present studies also thiourea has been found to partially break the dormancy of paddy seeds induced by the toxic level of salt.

A slight stimulation of growth of root and shoot systems of seedlings by thiourea at 0.2 and 0.5% levels was observed under the influence of 1% salt. Treatment of seeds with thiourea alone at 0.5 and 1% levels significantly increased the growth of root and shoot systems of seedlings. The increased growth of root and shoot systems may be due to the promoting effect of thiourea.

Effect of proline on germination of seeds and growth of seedlings under different levels of salt :-

Treatment of seeds with 5 and 10 mg/l proline resulted in a significant increase in the rate of emergence and final percentage of germination of seeds under the influence of salt at a concentration of 1.5%. Highest percentage of germination of seeds under the influence of 1.5% salt was observed at a proline concentration of 10 mg/l. Proline at all levels tried induced germination in seeds under the influence of 2% salt. Only 9% germination of seeds was observed under the toxic level of salt at 10 mg/l proline. Treatment of rice seeds with proline has been shown to increase their germination under saline conditions (Bal, 1976). Accumulation of proline in plants under stress conditions has been reported by Chu et al. (1974), Chu et al. (1976) and Storey and Jones (1977). Reduced rate of proline oxidation has been accounted for the accumulation of proline under stress condition (Stewart et al., 1976). However, the mechanism by which proline enables the plants in tolerating the stress conditions is not yet clearly understood.

Effect of 2-chloroethanol on germination of seeds and growth of seedlings under different levels of salt :-

The germination of seeds under the influence of 1.5% salt was significantly enhanced by 2-chloroethanol at 0.02 and 0.04% concentrations induce germination of seeds under the toxic level of salt. Among different concentrations of 2-chloroethanol tried maximum germination of seeds under 1.5 and 2% levels of salt was observed at a concentration of 0.02%. Increasing concentrations of 2-chloroethanol progressively decreased the germination of seeds under saline conditions. Treatment of wheat seeds with dilute solution of 2-chloroethanol was found to increase their resistance to high concentration of salt (Miyamoto, 1962). Increasing concentrations of 2-chloroethanol progressively decreased the growth of seedlings under saline conditions.

Effect of IAA on germination of seeds and growth of seedlings under different levels of salt :-

Treatment of seeds with IAA increased the germination of seeds under the influence of 1.5 and 2% levels of salt. An increase in percentage of germination of seeds was observed with increase in the concentration of IAA. IAA at a concentration of 4 mg/l significantly increased the germination of seeds under the influence of 1.5% salt. Germination of seeds under the influence of 2% salt was also significantly increased by IAA tried at all concentrations. Treatment of seeds with IAA has been shown to stimulate the germination of seeds of wheat under saline conditions (Darra et al., 1970). Treatment of seeds with IAA slightly stimulated the growth of root system of seedlings under saline conditions. Root systems of seedlings emerged from IAA treated seeds showed significantly enhanced growth. Soaking of wheat seeds in IAA overcome the depression of root growth by salt (Sarin, 1961). IAA was found to stimulate growth of guar varieties under saline conditions (Varshney, 1980).

Effect of GA_3 on germination of seeds and growth of seedlings under different levels of salt :-

GA_3 at 5, 10 and 25 mg/l concentrations significantly enhanced the rate of emergence of seeds under all concentrations of salt tried. The final percentage of germination of seeds under the influence of 1.5 and 2% levels of salt was significantly increased by all concentrations of GA_3 tried. GA_3 at a concentration of 10 mg/l brought about the highest percentage of germination of seeds under the influence of 2% salt. Studies on Hordeum jabatum by Benner (1978) indicate that GA_3 is stimulatory to germination under salinity stress and GA_3 apparently alleviates a portion of the dormancy induced by low water potentials. GA_3 has also been shown to stimulate the germination of seeds of Spergularia media under salinity (Ungar and Binet, 1975). Seed dormancy induced by osmotic stress could also be alleviated by treatment of seeds with GA_3 (Boucaud and Ungar, 1976).

Treatment of seeds with GA_3 at 5 and 10 mg/l concentrations slightly stimulated the growth of roots of seedlings under the influence of 1% salt. GA_3 tried at all concentrations significantly enhanced the growth of roots of seedlings. GA_3 at 5 and 10 mg/l concentrations promoted growth of shoot system of seedlings under the influence of salt at 1 and 1.5% levels. Growth of shoot of seedlings under the influence of 2% salt was significantly enhanced by GA_3 at a concentration of 10 mg/l. Promotion of shoot growth by GA_3 under saline conditions has been reported in beans (Nieman and Bernstein, 1959) and pea (Uprety and Sarin, 1973).

Among different chemicals tried (Tables 1-17), GA_3 has been found to be capable of bringing about as high as 52% germination of seeds under the influence of 2% salt at which control seeds totally failed to germinate. Further studies were therefore, carried out to understand the mechanism by which GA_3 brings about germination of seeds under the toxic level (2%) of salt.

The results on the changes in the dry weight of endosperm of seeds during germination clearly suggest the mobilization of food materials from the endosperm to the growing axis. This results in a loss of dry weight of endosperm. Sodium chloride at 2% level almost inhibited mobilization of food materials from the endosperm as evidenced by a greater dry weight of endosperm as compared to the control. High concentrations of NaCl is known to inhibit the hydrolysis of stored food materials in the storage organs (Sheoran, 1975; Ramana and Rama Das, 1978; Sheoran and Garg, 1978 a and Gururaj Rao et al., 1980). Endosperms of seeds treated with 10 mg/l GA_3 showed a lesser dry weight under the influence of salt as compared to that of the control (salt alone). This may be due to the slightly enhanced mobilization of the food materials from the endosperm by GA_3. Endosperms of seeds treated with GA_3 alone showed a rapid loss in its dry weight as compared to the pure control. Enhanced rate of mobilization of food materials from cotyledons under the influence of GA_3 has also been reported in cotton (Dave, 1976), cucumber (Halevy et al., 1964), rice (Hayashi, 1940) and sorghum (Kamalavalli, 1969) seeds during germination.

Starch content of endosperms of seeds decreased steadily during germination and this process was enhanced by GA_3. When seeds were set for germination in presence of

2% salt, no appreciable change in the level of starch content of endosperms was observed. Treatment of seeds with GA_3 slightly enhanced the depletion of starch from the endosperms of seeds during germination under the influence of salt. As the content of starch of endosperm decreased during germination a parallel increase in the contents of soluble and reducing sugars was observed. The soluble and reducing sugars of endosperm of seeds set for germination in presence of salt did not show any appreciable change in their contents. However, treatment of seeds with GA_3 enhanced the release of soluble and reducing sugar contents in the endosperm of seeds under the influence of salt. The decrease in the starch content with an increase in the levels of soluble and reducing sugars of endosperm observed during germination of seeds was found due to an increased activity of amylases. Increased activities of maltase and invertase have also been found responsible for the increase in the reducing and soluble sugar contents of endosperm observed during germination. The poor rate of depletion of starch along with very low levels of soluble and reducing sugars observed in the endosperms of seeds under the influence of salt during the germination period studied are due to highly reduced activity of amylases (α and β), invertase and maltase. Enhanced rate of depletion of starch along with increased levels of soluble and reducing sugars observed in the endosperms of seeds under the influence of salt and GA_3 during the period of germination studied are found due to enhanced activity of amylases (α and β), invertase and maltase. Treatment of seeds with GA_3 alone highly stimulated the said processes. A reduction in the activity of amylase as well as the content of reducing sugars under the influence of salt in the endosperm of wheat during germination has been reported by Sarin and Narayanan (1968). Supply of GA_3 to seeds has been shown to ameliorate the adverse effect of salt on the activity of amylase and the release of reducing sugars during germination (Sarin and Narayanan, 1968). A decrease in the activity of amylase during germination of wheat seeds under the influence of salt and its enhancement by GA_3 has been reported by Naqvi and Azmi (1977). A rapid depletion of starch and the corresponding accumulation of reducing sugars in the treated seeds suggest an enhanced amylolytic activity as a result of GA_3 treatment (Paleg <u>et al</u>., 1962; Roswell and Goad, 1964 and Ingle and Hageman, 1965). A marked increase in the activity of maltase in endosperms of barley during germination has been reported under the influence of GA_3 (Briggs, 1963). Treatment of seeds with GA_3 resulted in an increase in the activity of invertase during germination of cotton (Prathapasenan, 1970) and sorghum (Kamalavalli, 1969).

As in the case of starch depletion of total nitrogen from the endosperm has also been inhibited by salt. Treatment of seeds with GA_3 slightly enhanced the depletion of total nitrogen from the endosperm under the influence of salt. However, depletion of protein from the endosperm was not inhibited by salt to the same extent as observed in the case of total nitrogen. The protein content of seeds under the influence of salt and GA_3 depleted more rapidly as compared to the control (salt alone). Highest rate of depletion of protein in the endosperm was observed in seeds treated with GA_3. The reduced rate of depletion of protein under the influence of salt has been found due to a reduced activity of protease. Treatment of seeds with GA_3 enhanced the activity of protease under the influence of salt and this was found responsible for the enhanced rate of depletion of protein from the endosperm under the influence of salt and GA_3. Highest rate of depletion of protein observed in the endosperm of GA_3 treated seeds was due to a highly stimulated activity of protease. Inhibition of mobilization of proteins and reduced activity of protease in cotyledons of seeds of

Vigna sinensis under the influence of salt have been reported by Prisco and Gustavo (1976). A reduction in the activity of protease in cotyledons of germinating mung seeds under the influence of NaCl has been observed by Sheoran and Garg (1978). Enhanced mobilization of reserve nitrogen from the cotyledons of lettuce seeds to the growing axis under the influence of GA_3 has been reported by Rai and Laloraya (1965). Treatment of seeds with GA_3 is known to stimulate the activity of protease during germination of paddy (Goyal and Baijal, 1979), cotton (Dave, 1976) and maize (Harvey and Oaks, 1974). An increase in protease activity during the germination of seeds of Medicago sativa under the influence of GA_3 has been observed by Cohen et al. (1969). According to them increase in the protease activity during germination could be due to de novo synthesis of protease rather than its activation as GA_3 fails to activate the enzyme in vitro. Marcus (1971) suggested that a primary site of GA_3 action is in inducing proteolysis, thereby making different amino acids available for the synthesis of broad range of enzymes.

A rapid depletion of phytin was observed in the endosperm of paddy during germination and this has been found due to an increased activity of phytase. A highly reduced activity of phytase was found responsible for the extremely low rate of depletion of phytin observed in the endosperm of seeds under the influence of salt. A stimulated activity of phytase by GA_3 resulted in a rapid depletion of phytin from the endosperm of seeds during germination under the influence of salt. Stimulated activity of phytase under the influence of GA_3 has been reported in seeds of cotton (Dave, 1976) and barley (Srivastava, 1964) during germination. Though the phytin content of endosperm of seeds got almost completely depleted by the end of 120 hours of germination,no decline in the activity of phytase was observed. A similar paradox is apparent in rice, where the phytase activity reaches its maximum after the phytin reserves have been hydrolysed (Mukherji _et al_., 1971). Perhaps phytase has an additional, undefined role in metabolism (Bewley and Black, 1978).

Thus it has been observed that GA_3 brings about germination of seeds under the toxic level of salt by stimulating the mobilization of food materials from the endosperm as evidenced by the changes in the dry weight of endosperm and increased activities of hydrolases viz. amylases, invertase, maltase, protease and phytase.

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