Chapter IV

Review of Literature
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This Chapter presents the review of literature encompassing the relevant references related to the aspect of the present investigation.

Plants differ in their capacity to tolerate salt stress in response to growth regulators. Even the different varieties and strains of a particular species may exhibit differential tolerance behaviour. Agricultural practices on saline soils required selection of suitable crop varieties for getting satisfactory yield under varying levels of salts. The harmful effect of the salts on plants growth may be due to the osmotic pressure of the external salts present in the soil solution or it is due to the toxic action of the ions of the salt. It is difficult to isolate the osmotic and ionic effects of salts to evaluate over all growth and yield by plants treated with growth regulators because both the phenomenon operate almost simultaneously. American soil salinity scientists generally pay more importance to osmotic inhibition on plants. According to them, different salts at equivalent osmotic pressure produced equal growth depressions (Bernstein and Hayward. 1958). Osmotic pressure produces a kind of physiological drought to plants, as a result plant growth is depressed because the plants are unable to obtain the amount of water needed for normal metabolic processes.

Bernstein et al. (1956) had observed that in orchard trees approximately half of the growth reduction might be due to osmotic effect and rest half because of chloride accumulation in the cells if they are grown on salty land. It was also found that there are many plants in which NaCl is more harmful than Na₂SO₄ and vice-versa. Beydemann (1964) was in opinion that knowledge of the ecology of the
species and their relation to hydrological and salinity factors were responsible for the growth and development of plants.

Singh and Mangal (1970) observed that sodium chloride inhibited the germination of Okra seeds (variety "Pusa Sawani") more than sodium sulphate at equal conductance. There was an increase in the reducing sugars in Okra pods with the sodium chloride but not with sodium sulphate. The pods obtained from sulphate salinized plants had more ascorbic acid than those obtained from chloride salinized plants.

Singh and Gupta (1971) concluded that vegetable crops like spinach, beet etc. have been found to be relatively tolerant upto salinity level of 8 mmhos/cm. Whereas vegetables viz., cabbage, cauliflower, knol-khol, lettuce, tomato, brinjal, chillies, potato, sweet potato, onion, garlic, carrot, mint, cucumber, guards and okara are moderately tolerant upto the salinity level of 5 mmhos/cm while beans, peas, radish, musk-melon and cereals are very sensitive. Cruciferous vegetable crops are more tolerant than leguminous and other fruit vegetables. The germination and seedling stages of the vegetable crops are more susceptible to salinity.

The germination percentage of seeds in a number of crop plants reduced progressively with the increasing concentration of different salts. It is perhaps due to a higher intake of ions in seeds which resulted in toxicity (Wahhab, 1961). Minor differences in salt tolerance behaviour of crops can also be attributed to varietal differences and experimental conditions. Higher levels of salinity delayed the emergence of seedlings and also retard final germination percentage (Paliwal and Maliwal, 1972; Varshney and Baijal, 1977, 1977a). Plant height, root number,
leaf number, leaf area, leaf area index and reproductive organs invariably decreased as the level of salinity increased in various crop plants. In general the root length and root/shoot ratio are increased from 4-20 mmhos/cm EC salinity level which indicates that the roots are less affected than shoots. Nieman (1962) suggested that soluble salts at higher salinity levels are sufficient to suppress the plant growth. Dry weight of shoot and root also decreased with the increase in salinity levels and the magnitude of reduction would be more significant at higher salinity levels (Alka et. al., 1981).

The growth regulators like IAA and Phenol causes a marked stimulation in number of sprouts (Buds) per mother rhizome and yield (Singh and Khan, 1996) under 0 mmhos/cm salinity of NaCl and Na₂SO₄. Generally plants are most sensitive to salinity during germination or early seedling growth (Carter, 1975); even germination of obligate halophytes, takes place under reduced conditions of salinity (Chapman, 1975).

Germination of seeds under saline conditions differ from one crop to the other and a significant variation is recorded amongst the different cultivars of same crop (Asana and Kale, 1965; Kumar and Bhardwaj, 1981). The sensitivity of various crops also varies at seedling emergence and further at various growth stages with respect to salinity (Allison, 1965). In fact, early stages of plant growth are most critical as later development and crop production depends on effective germination and seedling emergence (Pearson and Bernstein, 1959). Effective increment of salinity generally retards germination with little or no effect on the ultimate number of seedlings which emerge (Bernstein and Hayward, 1958). Higher dozes of salinity has adverse effect on shoot length of salt guar (Datta and Dayal, 1988). This reduction in shoot length is responsible for delayed germination
which is invariably observed under saline conditions (Kumar and Bhardwaj, 1981). Sheoran and Garg (1978) are also in support that, increasing salinity can reduce the crop growth. Khetawat et al., (1967) also found that, sulphate to be less harmful than chloride at germination stage in case of wheat but in case of onion, carbonate and bicarbonate ions are found to be more harmful than others an equal salt concentration basis.

Paliwal and Gandhi (1968) observed that the adverse effect of ions was in the order of HCO₃ > CO₃ > NO₃ > SO₄ at 16 meq/l. Soil salinity influences negatively, germination, growth and yield of crop plants (Strogonov, 1974). However, the magnitude of salinity effect varies with the plant species and types (Lauer and Munns, 1986; Promila and Kumar, 1982; Bishnoi et al, 1987).

Growth hormones have been claimed to be involved in the formation of storage organs in some instances. Auxins such as IAA, NAA and 4-D are seem to increase the size of the storage organs (Harmey et al, 1966) but not have any inductive effect. Application of IAA favoured rhizome initiation and ultimately increased crop yield (Kumar and Baijal, 1984). The response of growth hormones in various physiological processes of different crop plants have been reported under saline stress conditions. IAA synergise the action of low concentration of Phenols whereas, high concentration of IAA antagonise the plumule growth. For radical growth, higher concentration of both are synergistic (Tayal and Sharma, 1985). Phenols, one of the secondary metabolites have a significant effect on plant growth when applied at physiological conditions by acting as analogues of growth hormones (Wain and Taylor, 1965; Zinzmeister and Tamaszewski, 1964). IAA stimulate the growth of etiolated hypocotyl segments of bean. However, IAA in combination with cytokinine induces better growth and the low concentrations of
IAA proved highly stimulatory response (Sarma and Borah, 1974; Sarma and Deka, 1977).

Some information are available that Cytokinin partially or completely reverse the effect of salt stress (Adrine et al., 1978). Phenols, the secondary plant products, have the potentiality to play a significant role in the initiation and development of floral buds (Cleland and Azami, 1974) in qualitative short day plants (Nanda and Kumar, 1977). Phenols can be used to increase the productivity of chickpea (Singh, et al., 1990).

The nature of tolerance to salinity has been discussed by numerous investigators (Munns and Termaat, 1986 and Poljakoff-Mayber, 1982). There was a progressive decrease in the rate of germination under the increased salinity induced by sodium chloride (NaCl) and sodium sulphate (Na₂SO₄) solutions separately. It was also observed that high dose of NaCl salinity level caused more reduction in the rate of germination than that of Na₂SO₄ salinity (Kumar and Bhardwaj, 1981). Effective increment of salinity generally retarded germination. However, the rate of germination did not vary much with the salinity levels meanwhile root elongation was consistently increased, the shoot length decrease with the increment in salinity. The fresh weight of shoot and root was considerably reduced (Datta et al., 1985). Similarly shoot and root growth decrease with increase in salinity stress levels (Cachorro et al., 1993). Chloride salinity is more harmful to the growth and development of vegetable crops as compared with sulphate salinity with the exception of leafy vegetables.

Curtain, D; Steppuhn, H; Iselies, F. based on experiment - plant responses to sulphate and chloride salinity, growth and ionic relations (1993)
concluded that there are many possible inter-actions between salt concentration, salt type and plant nutrition. Growth regulators have been reported to increase yield by making the plants photosynthetically more effective (Greer and Anderson, 1965; Sinha and Ghildiyal, 1973). Various yield characters are affected at varying degrees with increasing salinity (Abel and Mackenzie, 1964).

The use of plant growth regulators has resulted in significant increase of yield in a number of vegetable crops and species. The vegetative growth of onion as measured by plant height, number of leaves per plant, fresh and dry weight of plant increased with increasing level of GA$_3$ and NAA (Salah and Abd, 1989). Pre-soaking treatment of onion seed with 20 ppm (IAA, NAA and GA$_3$) for 8 hours produced higher yield (Singh et.al., 1982). The physiological responses of plants for survival under stressed environment are based on their ability to express the adaptations by which the plants can adjust to the stress. Under stress conditions the adaptive responses by the plants are shown mainly through changes and balances in the endogenous levels of phytohormones (Levitt, 1980). The hormonal equilibrium under the new stressed environment probably plays an important role in the survival of plants (Amzallang and Lerner, 1995). However, under severe stress condition plants are fail to express their adaptation ability, probably because of high catabolism accompanied by abnormal activity and hydrolytic enzymes. The IAA treatment was found more effective in reduction of IAA-Oxidase activity than GA$_3$ as reported by Law and Hamilton (1984) in dwarf pea and Danger and Basu (1987) in *Phaseolus vulgaris*. Kapchina and Foudouli (1991) also observed that GA$_3$ and IAA enhanced the peroxidase activity and thereby eliminated the adverse effect of salt stress on pea plants. According to Dendsay (1989) the growth regulator induced acceleration in peroxidase activity rather than increase in
synthesis of enzyme protein because hormone induced increase in catalytic efficiency. The treatment of seeds soaking with growth regulators might help the plants in adaptation to salinity by directly substantiating the endogenous level of hormones (Law and Hamilton, 1984; Kumar and Baijal, 1990) and reducing oxidative breakdown by controlling the growth and yield attributes of soybean under salinity (Zaidi and Singh, 1993).

The endogenous levels of promoters and inhibitors changed with the development of seeds. Cytokinins, Gibberellins and Auxins regulate cell division, translocation and accumulation of photosynthates respectively. These hormones have also been used in exploiting plant physiological potential to maximise crop yield (Singh and Jain, 1982 and Setia et al., 1993). Salinity caused reduction in the growth of plants (Prisco and O’Leary, 1973). It may be due to decrease in internal cytokinin production (Kuiper et al., 1988). Kinetin induced osmotic adaptation in the cells under salinity stress to maintain turgidity for growth as reported by Morgan (1984). Phenolic compounds have adverse affect on germination and seedling growth of black gram (Vigna mungo L.) cultivar. However protein content Chl-a levels and Carotenoids also decrease significantly (Anandhi and Ramanujam, 1997). Phenols are capable of modifying growth and development of plants including germination (Mayer and Poljakoff, 1963), and early seedling growth (Kumar and Tayal, 1982). Caffeic acid and chlorogenic acid when used in low concentration have been found to synergise the action of IAA in Avena curvature test (Tomaszewski, 1961) whereas monophenols like p-hydrobenzoic acid and others antagonise it in same concentration up to a great extent (Tayal and Sharma, 1981). Lee and Skoog (1965), have shown that the promotion or inhibition properties, particularly shown by polyphenols and monophenols,
respectively may be interpreted due to promotion or inhibitional IAA oxidation. There are reports that exogenous application of Ethylene (C\textsubscript{2}H\textsubscript{4}) can check the adverse effect of salinity during germination (Abeles, 1986).

According to Tayal and Sharma (1981) IAA and phenols alone or in combination had no any effect on germination percentage in mungbean and lentil but Thakur (1977), however reported reduced germination of lettuce and sugar maple seeds by exogenous applied phenols. The action of IAA in accelerating the growth of plumule and retardation of radical growth as well as synergistic interaction of IAA and phenols in oat and pea seedlings have been reported by Tomaszewski and Thimann (1966). Both IAA and phenols are widespread naturally and possibly they interact each other in plants. IAA - oxidase activity is supposed to be controlled by phenols (Lee and Skoog, 1965). The phenols when applied exogenously have shown marked increase in grain yield of crops (Datta and Nanda, 1985).

Salinity leads to suppression of growth and it increases as the salt concentration increases in the soil until the plants die off (Mass and Nieman, 1978). The effect of salinity on plant growth, under varied concentration of growth hormones may differ depending on its state of development but responses may be quite different at germination stage than at later stages. Higher levels of salinity caused delay in emergence and also retard final germination percentage (Paliwal and Maliwal, 1972; Varshney and Baijal, 1977, 1977a). It is generally accepted that germination take place when the salinity of the surface layers of the saline habitats is decreased (Chapman, 1960; Waisel, 1979). Different plant species have high capacity of salt tolerance at germination stage. Ungar (1962) observed 12 and 8 percent germination in 3 and 5 % solutions of NaCl at 21\textdegree C in Salicornia
europa*ae; later on increased germination was reported at higher temperature of 32°C (Ungar, 1967). Significant increase in germination at higher NaCl salinity was achieved in *Salicornia europa*ae with gibberellic acid treatment (Ungar, 1977).

The information available on crop performance under different saline conditions is very limited (Paliwal, 1972) and the effect of specific salt ion on the different parameters especially the germination and early seedling growth which limits the final crop yield. Paliwal and Gandhi (1968) and others found that emergence of seedling delayed and percentage germination decreased in the paddy and other crops as the degree of salinity increased. Specific salt ions affect the germination differentially. According to Khetawat et al., (1967) that sulphate to be less harmful than chloride at germination stage in case of wheat but in other crops carbonate and bicarbonate ions were found to be more harmful. Under saline treatment the germination and germination percentage reduced significantly (Kumar and Naidu, 1988). It may be due to the less availability of water or direct effect of excess of sodium on the germinating buds (Chhabra et al, 1979; and Singh and Abrol, 1987).

Salinity may affect plant growth by increasing the osmotic pressure of the rooting medium or by disturbing the normal mineral nutrition of plants and by the toxic effects of ions i.e., specific ion effects (Stroganov, 1964; Levitt, 1972). Salinity is one of the adverse factors in the soils. Some plants can grow well under saline stresses because of their adaptive interaction with various components of biological environment. The mineral requirements of the plants are not the same because of this fact some plants can adapt the better growth under adverse saline conditions (Greenway, 1965; Shalhevet and Bernstein, 1968). Salinity induced
reduction in growth is the consequence of modification of several physiological processes like, ion balance, water status, mineral nutrition, stomatal behaviour, photosynthesis carbon allocation and utilization (Flowers et al, 1977; Munns and Termaat, 1986).

A decreasing trend in plant height and dry matter with increase in salinity have been reported in pearl millet (Alam and Naqvi, 1991). The number of lateral roots, fresh and dry weight showed a gradual reduction with increasing sodium chloride salinity levels, have been reported in Broad bean (Katerji and Vanhoorn, 1992). Germination and seedling growth differed with the nature and concentration levels of salt. It may be due to the accumulation of inhibitors or imbalance of growth hormones observed by Bernstein and Hayward (1991) and Ramadevi and Gopalakrishnan (1996).

Salinity caused a decline in fresh and dry weight of all plant parts i.e. leaves, stem, roots and nodules. The reduction in plant growth was accompanied by reduction in the number and area of leaves. Increase in salinity caused reduction in root weight. These were accompanied by yellowing of the older leaves and nacrois on the margins (Sharma, 1997). Salinity is known to have adverse effects on plant growth and metabolism. Alteration of various cellular processes such as activity of enzymes, photosynthesis and degradation of macromolecules by NaCl is well documented (Levitt, 1980; Saha and Gupta, 1993). Salinity has been known to decrease the nucleic acids contents of the plant tissues by reducing their rates of synthesis and by increasing their rates of degradation (Nieman and Poulsen, 1964; Rauser and Hanson, 1966; Crisco and O’Leary, 1972). The excessive accumulation of both Na and Cl ions and increase in Na/K ion ratio under higher salinity are responsible for poor growth of seedling (Matsushita and Matoh, 1991).
High Yielding capability of a crop depends on its inherent potential associated with the soil, climatic and biotic conditions. The nature of soil is a very important factor in the growth and development of a crop. Crop Plants have decline in growth and yield when exposed to saline conditions. The deleterious effects of salinity in crop plants are due to toxic effect of ions, ionic imbalance or a combination of these two factors. The response of crop differ at various soil salinity levels (Dev and Bajwa, 1972). Salinity affected the number of leaves, leaf area and number of tillers. The significant decrease in these growth attributes has drastic impact on the photosynthetic activity of plant which ultimately effect the yield of sugarcane varieties (Sharma et al, 1977). NaCl has direct effect on photosynthetic apparatus has been reported for several plant species (Ball and Farquhar, 1984; Seemann and Critchley, 1985).

The tolerance of any crop to salinity mainly depends on the type of ions present in the soil rather than the total salt concentration in the medium. Bread wheat are less tolerant to salt stress than barley and rye (Mass and Hoffman, 1977). However, the numerically higher yield was observed with sulphate dominant salinity in some wheat varieties (Maliwal et al, 1976 and Chhipa and Lal, 1985).

Salinity is known to have depressive effects on metabolism and energy generating processes which are responsible for low yields because any alteration in metabolic processes have to affect on the quality of agricultural produce. But for a few studies where salinity mediated shift in metabolic pathways during seed development (Dhingra et al, 1992), improve the quality of fleshy fruits with decreased yield and without detectable change in the taste of peanuts (Mizrahi and Pasternak, 1985).
Salinity, in general, decreased starch and protein content but did not affect sugar content (Dhingra et al., 1990). Salt stress consists of osmotic, physiological and biochemical stresses have effects on cation and anions of plant cells (Munn and Termaat, 1986). Plant growth substances have shown an increase in soluble sugars under salinity stress, thus growth regulators playing a role in lowering osmotic potential as reported in wheat (Singh et al., 1985). Salt stress reduced the moisture percentage, soluble amino acids and sugar in the callus but level of proline increased (Thomas et al., 1992) due to increased proteolytic activity in chickpea (Sharma et al., 1986). The decrease protein content under salt stress was noted due to increased hydrolysis of proteins (Uprety and Sarin, 1976) contents under the effect of growth regulants.

Salts at their different concentrations have variable effect on metabolic processes which finally culminate in reduced plant growth and ultimately yield. Inhibition of growth of calli with increasing salt stress has also been reported in Cicer arietinum (Pandey and Ganapathy, 1984) and Lycopersicon (Guerrier and Bourgeois-Chaillou, 1994). Accumulation of sugar may be due to their less utilization in biosynthesis leading to reduction in growth of calli and the same may be used for osmotic adjustment of the cells (Yeo, 1981, Yang et al., 1990).

Chloride salinity also decreased the α-amylase activity. It is perhaps due to substrate limitation in the cells under salt stress as reported in gram and rice seedlings (Prakash et al., 1988). The salinity tolerance of many crops varies with the growth stages. The information which are available generally indicate that early growth stages are most salt sensitive in many crops. Some crops are found very sensitive during the vegetative and early reproductive stages, less sensitive
during flowering and least sensitive during the grain filling stage (Maas et al., 1986; Maas and Poss, 1989a,b). Pea, gram and beans were not as sensitive during germination as during latter stages of growth (Bernstein, 1975). Increasing NaCl salinity progressively and significantly decreased seed yield at all the growth stages. However, the reduction was more when salt stress imposed at the flowering stage as compared to seedling and vegetative stages. The dry matter was most adversely affected by NaCl salinity at the seedling stage and least at the flowering stage (Garg et al., 1997).

The plant growth is an interaction of many complex processes each of which is influenced by genetic and environmental factors. The genetic traits find full expression only when environmental conditions-chemical and micro meteorological are present in optimal form. The atmospheric factors such as radiation, temperature and humidity how they affect the rate of photosynthesis and transpiration, are important to develop suitable crop and agronomic practices for efficient crop production in a particular agro-climatic region. In number of crops including chick pea, the flowering and pod development are most sensitive stages of growth affecting the yield (Prasad et al., 1978). Salinity has specific effects on the photosynthesis, respiration and also reduced the leaf area thus reduce the production of photosynthates and thereby the total plant dry matter.

NaCl salinity decreased the starch content in all parts of the seedlings. The depletion of starch was higher in the root as compared with hypocotyl and cotyledon (Muthukumaraswamy and Panneerselvam, 1997). However, according to Siddiqui and Krishnamoorthy (1995), starch content increased in Vigna unguiculata seedling under salinity stress. The decrease in sugar content under NaCl stress was also observed in sugar beet (Iyengar and Pandya, 1973). Salt stress
sunflower and mungbean seedlings had increased sugar indicating its role in maintaining the osmotic balance (Saha and Gupta, 1993). Decrease in α-analase activity in wheat (Sarin and Narayanan, 1968) and mungbean (Sheoran 1980) under NaCl salinity could either be due to lowering of the synthesis of the amylase enzyme or because of inhibition in the activity of enzyme.

NaCl salinity decrease the accumulation of starch and soluble sugars by inhibiting the activity of the enzymes of carbohydrates metabolism (Muthukumarswamy and Pannecerselvam, 1997). The changes in the levels of protein, proline, saccharide etc. are the indication of salt influence on the growing plants. The proteins content was found lower in the plants growing in saline habitat compared to plants on non-saline habitat. A significant reduction in the protein content of chickpea seed treated with NaCl was reported by Kumar et al. (1983). Similarly, other scientists observed a decrease in the protein content in the seedlings of horse gram under salt stress condition. According to Krishnamurthy and Bhagwat (1987) the protein content in the salt tolerant rice was higher as compared to the salt sensitive variety.

Rathert (1983), while working on the carbohydrate status of rice varieties in relation to salinity found that both sugar and starch contents were higher in plants grown in saline habitat. Strogenov (1964) observed the accumulation of free amino acids in plants grown under saline conditions and concluded that it is due to the hydrolysis of storage proteins. The increased proline content in the plants grown in under saline conditions was reported by Greenway and Munns (1980). According to Bal (1975) increased proline in the plants may be an adaptation to overcome the stress conditions and proline accumulated under saline conditions
supplies energy for growth and survival and there by induces salinity resistance in rice varieties. Sheoran and Garg (1978) have reported that salinity either reduced, or had no effect on the protease activity in all organs, except the leaves in mungbean during germination and early seedling growth. Rakova et al. (1969) observed that in pea roots, sodium salts inhibited the synthesis as well as hydrolysis of basic proteins.

Prisco and Vieira (1976) reported that NaCl caused delay in the breakdown of protein due to inhibition of translocation of hydrolysis products than to inhibition of protease activity. Salinity generally alters the metabolism resulting in the reduction of yields (Reddy and Vora, 1986). Nitrogen metabolism of plants grown under various salinity treatments differed from that of normal plants because of disturbance in breakdown of protein (Dvate, 1974, Strogonov, 1962). Ehlg (1960); Pandey et al., (1971); Epstein (1962); Hamid and Talibuddeen (1976) have shown that greater sodium uptake promotes dry matter yield in barley and sugarbeet.

Salinity is also responsible to induce the metabolic changes during germination. Levitt (1972) and Epstein (1972) have pointed the genotypic differences between salt tolerant and salt sensitive plants in respect to a number of physiological and bio-chemical parameters. Their observations are important in an effort to develop rapid screening methods to separate salt tolerant from salt sensitive plants by synthesis of appropriate enzymes which in turn is “gene controlled”. Sufficient genetic variability in relation to salinity exists in number of agricultural crops (Ogra and Baijal, 1978).
Salinity is known to have depressive effects not only on the metabolic pathways but also on energy generating process but so far very little is known regarding the accumulation of metabolites in seeds under saline conditions, (Promila and Kumar, 1982, Murumkar and Chavan, 1986). According to Sheoran and Garg (1978) the effect of salinity on protease also depends upon the plant parts used. Besides, osmosis and specific ion effects, the plant growth is also regulated by hormonal balance. The endogenous level of IAA in a system is balanced by IAA oxidase activity (Lee, 1971, Verne and Tudd, 1972). It promotes anion concentration of \( \text{CO}_3^2^- > \text{HCO}_3^- > \text{Cl} > \text{SO}_4^{2-} \) upto toxicity level, (Shukla and Baijal, 1979). The decrease in IAA level resulted in reduced germination, seedling and further plant growth. IAA oxidase/IAA level is inversely proportional to salt concentration (Shukla and Baijal, 1979). Thus IAA plays a significant role in regulation of plant growth, the activity of which is controlled by IAA oxidase and anions.

Saline conditions have direct toxic effects on plants growth and metabolism (Bernstein, 1975). Plant growth under saline conditions depends on the regulation of metabolic processes. Keto acids and certain amino acids, have been found to play a protective role under saline conditions. Keto acids play a pivotal role in detoxifying ammonia which tends to accumulate under saline conditions and participate in direct amination with ammonia (Rakova et al., 1978). However, the trends and magnitudes of metabolic changes varied according to the level and duration of salinisation treatment as well as plant species used (Shaddad and Zidan, 1989; Zidan, 1990 and Malifari, 1993). According to Thakur and Rai (1982) that in drought resistant maize cultivars more protein was accumulated than in susceptible ones when exposed to osmotic stress. Similar results were obtained
by Singh and Rai (1982) with chikpea cultivars, under NaCl stress, the metabolism of proline and other free amino-acids and their accumulation in salt stressed plants was at opposite pattern, indicating that the increase in proline is at the expense of other amino acids through an effect of salinity in promoting their conversion, (Boggess et al., 1976). Protein has been suggested to act as a compatible cytoplasmic osmoticum (Stewart and Lee, 1974; Shah et al., 1990).

Increased levels of NaCl salinity caused reduction in plant height, fresh and dry weight of plant, leaf area and number of leaves (Sharma and Garg, 1985). Maximum leaf area was recorded at the emergence stage which declined later because of senescence. Reduction in leaf area was more severe than the number of leaves thus indicating that cell elongation is more sensitive than the cell division (Sharma and Garg, 1985).

Heikal et al., (1982) and Shaddad and Zidan (1989) recorded a promotion in the dry weight of some salinised plants. Jarvis and Hopper (1982) found an increase in the yield of shoots and roots of Lolium perenne L. with increasing NaCl in the solution during the early growth stages. Under salt stress the maintenance and repair of cellular damage required more energy (Schwarz and Gale, 1981).

Chloride and Sulphate salinities are also known to influence water relations, protein accumulation, mineral composition, carbohydrate and nucleic acid metabolism, (Hason and Poljakoff, 1970; Meiri et al., 1971; Datta and Sharma, 1990) and also affect growth, development and yield attributes in various crop plants to different extent (Manchanda et al. 1982; Lauchi and Epstein, 1994;
Manchanda and Sharma, 1989). Midan et. al., (1986) reported the increased in crop yield with the application of auxin because growth regulators induced the cells to become physiologically active to build up sufficient food reserves for vegetable and reproductive phases of plants and ultimately higher yield.

The total chlorophyll content was higher in plants grown in the saline medium irrespective of the varietal tolerance to salinity (Siegal and Bjarsch, 1962; Strogonov, 1974). The decrease in the total chlorophyll content in plants grown in saline media may be due to an increase in the water content (succulence), specially in case of chloride salinity (Nieves et.al., 1991). The effect of NaCl salinity on total chlorophyll, chlorophyll-a and b depends on the varietal tolerance of rice (Oryza sativa L.) to salinity (Boniface and Anoma 1993). The chlorophyll content is in a progressively decreasing trend with an increase in the salinity levels at all growth stages of crops (Lapina and Popov, 1970; Weimberg, 1975; Garg et al., 1993) as well as in cluster bean (Varshney, 1980; Garg et al., 1986). It has been shown that salinity due to sodium salts under the response of growth regulators can reduce the chlorophyll content. It is due to higher toxicity of chloride ions over sulphate ions. Reduction in leaf chlorophyll under NaCl or Na2SO4 salinity is well known (Levitt, 1972; Prisco and O’Leary, 1972). There are evidences to show that accumulation of salts in leaves, causes a decrease in the extractability of pigment from the chloroplasts especially when the chloride ions predominate in the soil (Varshney and Baijal, 1977). It is also noted that chlorophylase level is responsible for the chlorophyll degradation in detached leaves of barely and oats under stress conditions (Sabatar and Rodrigue, 1978). According to Perbodh et. al., (1988) the chlorophyll-a and b contents increased in the developing fruit wall of mashbean (Vigna mungo L.) at early stages of development under 1 ppm and 10 ppm of
phenolic compounds and then decreased towards the maturity 24 Days After Anthesis (DAA).

One ppm of Tannic acid treatment recorded maximum chlorophyll-a and b contents in the fruit wall at 16 DAA (days after antithesis). In seed coat, the level of chlorophyll-a and b considerably enhanced upto 16 DAA stage and then it lowered down during 24 DAA stage. Similar trend was observed in developing cotyledons. Chlorophyll b content in different parts of the developing fruits during different stages of their development remained higher than the amount of chlorophyll-a. The leaf photosynthetic rates and chlorophyll concentration are significantly reduced under salt stress in many crop plants. A reduction in both the rate of photosynthesis and chlorophyll concentration in salinised plants is a common occurrence and has been recorded for wheat (Kingsburg et. al., 1984) and grapes (Divate and Pandey, 1981). The salt stress affected photosynthesis more drastically compared to transpiration and the resultant increase in transpiration-to-net photosynthesis ratio could have led to low water use efficiency (Augustino, 1990). Singh and Gill (1985) reported that 100 ppm NAA increased chlorophyll content of leaves in late sown wheat and barley. Chlorophyll content of fresh leaves increase with NAA spray in paddy (Grewall and Gill, 1986).

Excess of salts in the soil adversely affects the crop growth, flowering and yield, however, the magnitude of the salinity effects varies with the plant species, types and the levels of salinity (Leuter and Munns, 1986). The intensity of flower production was progressively reduced by increasing levels of chloride and sulphate stresses (Sharma et. al., 1993). The reduction in flower production was due to suppression of growth that occurred under salinity stress during vegetative phase of plants (Sharma et.al., 1993). These results are in agreement with the
results of other workers (Ansari et al., 1980; Siddiqui and Kumar, 1985 and Bishnoi et al., 1987).

A large volume of roots under saline conditions would facilitate the plants for higher absorption of water and nutrients (O’toole and Chang, 1979). Higher leaf area was also reported by Arjunan and Chandrasekaran (1988) in salt susceptible varieties of rice. Dry matter accumulation decreased with the increase in salinity levels and a lesser reduction was noted in the tolerant varieties of rice. Grain yield was also reduced linearly with the increase in salinity levels (Arjunan and Chandrasekaran, 1988). The main cause for the reduction of crop yield due to salinity was found to be the increase in Na⁺ and Cl⁻ levels. The positive factor to reduce these hazards might be due to the accumulation of K⁺, especially in the tolerant varieties (Yeo and Flowers, 1982).