CHAPTER 2

Review of Literatures

A. Salinity in relation to seed germination and seedling growth parameter

Tiwari *et al*. (2000) studied the effect of abiotic stress on germination and seedling growth of oat (*Avena sativa* L.). Zheng and Shannon (2000) revealed the effects of salinity on grain yield and yield components at different seedling densities. Sobrado (2001) carried out the effect of external NaCl concentration on the osmolality of xylem sep, leaf glands secretion of the mangrove. Ghoulam and Fares (2001) have studied the effect of salinity on seed germination and early seedling growth of sugar beet. Singh and Hoque (2001) carried out the change in growth and metabolic activity in seedling of lentil (*Lens culinaris*) genotypes during salt stress. Soltani *et al*. (2002) have carried out the germination, seed reserve utilization and seedling growth of chickpea as affected by salinity and seed size. Jeannette *et al*. (2002) studied the salinity tolerance of *Phaseolus* species during germination and early seedling growth. They concluded that the wild *Phaseolus* species represent a genetic resource for improvement of salinity tolerance in commen bean. Khan and Gulzar (2003) studied the light, salinity and temperature effects on the seed germination of perennial grasses.

Azevedo *et al*. (2004) studied the effects of salt stress on plant growth stomatal response and solute accumulation of different maize genotypes. Sairam and Tyagi (2004) studied the physiology and molecular biology of salinity stress tolerance in plants. Alam *et al*. (2004) have studied the effect of salinity on growth of some modern rice cultivars. Rogers *et al*. (2005) studied the development of fodder plants for the salt-affected areas of southern and eastern. Jamil *et al*. (2005) have studied the salinity (NaCl) tolerance of *Brassica* species at germination and early seedling growth. Ahmad *et al*. (2005) suggested the varietal differences in agronomic performance of six wheat varieties grown under saline field environment. Srivastava *et al*. (2005) have studied the screening for salinity tolerance in pigeon pea (*Cajanus cajan* L.) and groundnut (*Arachis hypogea* L.). Mahajan and Tuteja (2005) investigated the cold, salinity and drought stresses. Jamil *et al*. (2006) carried out the effect of salt stress on germination and early seedling growth of four vegetable species. They concluded that the salinity caused significant reduction in germination percentage, germinate rate, root and shoot lengths and fresh weights of root and shoot. Liner relation was developed to find relation between salt stress and plant growth and also between germination and rest of plant characters. Jamil *et al*. (2007) studied the salt stress inhibits germination and early seedling growth in cabbage (*Brassica oleracea capitata* L.). They concluded that furthermore root growth was more affected then shoots growth by salt stress. Fresh weights of root, shoot and plant were also severely affected by different salinity treatments. Linera regression revealed a significant negative relationship between salinity and final germination, germination rate, root and shoot lengths and fresh weights of roots, shoots and plants. Dantas *et al*. (2007) have studied the germination, inhibit growth and cotyledon protein content of bean cultivars under salinity stress. Jamil *et al*. (2007) studied the salt stress inhibits germination and early seedling growth in cabbage (*Brassica oleracea capitata* L.).

Munns and Tester (2008) studied the mechanisms of salinity tolerance. They concluded that molecular genetics and functional genomics provide a new opportunity to synthesize molecular and physiological knowledge to improve the salinity tolerance of plants relevant to food production and environmental sustainability. Kaya and Day (2008) have studied the relationship between seed size and NaCl on germination, seed vigor and early seedling growth of sunflower (*Helianthus aonnuus* L.). Garg and Manchanda (2008) studied the effect of arbuscular mycorrhizal inoculation on salt-induced nodule senescence in *Cajanus cajan* (Pigeonpea). Agarwal *et al*. (2008) studied the salinity tolerance of some cultivated genotypes of *Brassica* species at germination and early seedling growth. Din *et al*. (2008) have studied the physiological response of wheat (*Triticum aestivum* L.) varieties as influenced by salinity stress.

Mahmood *et al*. (2009) investigated the effect of salinity on growth, yield and yield componenets in Basmati rice germplasm. Abogadallah and Quick (2009) studied the vegetative salt tolerance of barnyard grass mutants selected for salt tolerant germination. Kaymakanova (2009) carried out the effect of salinity on germination and seed physiology in bean (*Phaseolus vulgaris* L.). Khatoon *et al*. (2010) suggested the morphological variation in maize (*Zea mays* L.) under different levels of NaCl at germination stage. Nejad *et al*. (2010) studied the evaluation of salinity tolerance in rice genotypes. Sayar *et al*. (2010) carried out the effects of salt and drought stresses on germination, emergence and seedling growth of Durum wheat (*Triticum durum* Desf.). It was concluded that inhibition in germination at equivalent eater potentials of NaCl and PEG-8000 was mainly due to an osmotic effect rather than did salt toxicity. Rengasamy *et al*. (2010) studied the soil processes affecting crop production in salt-affected soils. Farehbakhsh and Saiid (2011) studied effect of seed priming with NaCl on maize germination under different saline conditions. Akbarimoghaddam *et al*. (2011) have studied the salinity effects on seed germination and seedling growth of bread wheat cultivars. It was concluded that the delay in germination was mainly due to higher sodium accumulation in the seeds rather than osmotic stress in wheat cultivars.

Rastegar *et al*. (2011) have studied the effect of salinity and seed size on seed reserve utilization and seedling growth of soybean (*Glycin max*). Abari *et al*. (2011) carried out the salt effects on seed germination and seedling emergence of two Acacia species. Yousofinia *et al*. (2012) have suggested the effects of salinity stress on barley (Hordeum vulgare), germination and seedling growth. Results indicated that increased salinity caused a significant reduction in percentage of germination and seed germination rate. Tabatabaei and Anagholi (2012) studied the effect of salinity on some characteristics of forage sorghum genotypes at germination stage. Ghazizada *et al*. (2012) suggested the effect of salinity stress on germination and seedling characters in safflower (*Carthamus tinctorius* L.) genotypes. Zhang *et al*. (2013) studied the effects of mixed salt stress on germination percentage and protection system of oat seedling.

Bahrami and Razmjoo (2012) investigated the effect of salinity stress (NaCl) on germination and early seedling growth of ten sesame cultivars (*Sesamu indicum* L.). They recognized that the experiment followed a randomized complete block design with four replications. Traits of germination percentage, plumule and radical length, plumule and radical dry weight were investigated under salinity stress. Results showed that the highest values for these traits were from the Abpaksh cultivars and traits in the other cultivars diminished with increasing water salinity. Germination and seedling growth were strongly inhibited by 12.05dSm^{-1}. Jouyban (2012) has studied the effects of salt stress on plant growth. They concluded that the salt stress decreases the photosynthesis and respiration rate of plants. Total carbohydrate, fatty acid and protein content were adversely affected due to salinity effect, but increased the level of amino acids, particularly proline. The content of some secondary plant products is significantly higher in plants grown under salt stress than in those cultivated in normal conditions. The salinity tolerance depends on the interaction between salinity and other environmental factors.Ratanakare and Rai (2013) studied the effect of sodium chloride salinity on seed and early seedling growth of trigonella (*Foenum-graecum* L.). They concluded that the lower concentrations of NaCl (upto 40mM) did not affect percentage germination, the germination was found to be delayed. At higher salinity levels, inhibitory effect on germination was recorded to an extent that seeds did not germinate at 80mM and above concentrations of NaCl. Gradual decrease in root length, shoot length, fresh weight and dry weight of the seedlings was observed with increasing concentrations of NaCl in the growth medium. Mosavian and Eshraghi-Nejad (2013) carried out the effect of seed size and salinity on seed germination characteristic in wheat (var. *Chamran*).

Anbumalarmathi and Mehta (2013) studied the effect of salt stress on germination of *Indica* rice varieties. Sozharajan and Natarajan (2014) studied the germination and seedling growth of *Zea mays* L. under different levels of sodium chloride stress. The results obtained showed that the inhibition of the germination percentage, germination rate, water uptake, growth and biomass accumulation of the seedling were observed to decrease with increasing NaCl concentrations. At the higher level of stress both plumule and radical decreased significantly. The salt stress decreased seed germination, biomass and growth of maize seedling due ion toxicity, decrease osmotic potential and oxidative stress. Tsegay and Gebreslassie (2014) studied the effect of salinity (NaCl) on germination and early seedling growth of *Lathyrus sativus* and *Pisum sativum var. abyssinicum*. They concluded that the germination percentage, shoot length and root length of both crops decreased with an increase in salinity level. Although both are low salt tolerant legumes, *Pisum sativum var. abyssinium* was found to be less tolerant than *L. sativus*. This study could be strengthened at mature vegetative and reproductive stage of the crops.

Sam *et al*. (2014) investigated the effect of salinity on seed germination and seedling growth of pearl millet (*Pennisetum glaucum* L.) and sordhum (*Sorghum bicolor* L.). El-Goumi *et al*. (2014) have studied the salt stress effect on seed germination and some physiological traits in three Moroccan barley (*Hordeum vulgare* L.) cultivars. Gupta and Huang (2014) studied the mechanism of salinity tolerance in plants: Physiological, Biochemical and Molecular Characterization. Hoque *et al*. (2015) studied the evaluation of salinity tolerance in maize (*Zea mays* L.) genotypes at seedling stage. Liu *et al*. (2015) studied the effect of drought stress on seed germination and seedling growth of different maize varieties. Ali and Idris (2015) carried out the germination and seedling growth of pearl millet (*Pennisetum glacum* L.) cultivars under salinity conditions. Saad-Allah, (2015) has studied the impact of sea salt stress on growth and physiological attributes of some soybean (*Glycine max* L.) varieties. Nasri *et al*. (2015) have studied the effect of salinity on germination and seedling in lettuce. Shalini and Vimala (2016) investigated the effect of salt stress on germination and growth of T. *foenumgraecum*seedling. Aghamir *et al*. (2016) carried out the seed germination and seedling growth of bean (*Phaseolus vulgaris*) as influenced by magnetized saline water. El-Sabagh *et al*. (2016) carried out the physiological performance of soybean germination and seedling growth under salinity stress. Negrao *et al*., (2017) studied the evaluating physiological responses of plants to salinity stress.

B. Interaction salinity and gibberellic acid

Rademacher *et al*. (2000) studied the effect of growth retardants on gibberellin biosynthesis and other metabolic pathways. Yamaguchi and Kamiya (2000) investigated the biosynthesis of gas which is regulated by both developmental and environmental stimuli. Hisamatsu*et al*. (2000) carried out the role of gibberellin in the control of growth and flowering in *Matthiola incana*. Radi *et al*. (2001) studied the interactive effects of plant hormones (GA_3 or ABA) and salinity on growth and some metabolites of wheat seedling. Iqbal *et al*. (2001) carried out that gibberellins alleviation of NaCl salinity in chickpea (*Cicer arietinum* L.). Bishop and Yokota (2001) studied the steroid hormones and their molecular aspects on their synthesis/metabolism, transport, perception and response in plants. Angrish *et al*. (2001) have studied the effect of gibberellic acid and kinetin on nitrogen content and nitrate reductase activity in wheat under saline conditions. Hoque and Haque (2002) have studied the effects of gibberellic acid and its mode of application on morphology and yield parameters of mungbean (*Vigna radiate* L.).Sun and Gubler (2004) studied the molecular mechanism of gibberellins signaling in plant. Magome *et al.* (2004) reported that gibberellins (GAs) which are generally involved in growth and development. They control seed germination, leaf expansion, stem elongation and flowering. Finkelsrein *et al*. (2004) investigated the role of hormones during seed development and germination.

Kaufman and Jones (2006) revealed the regulation of growth in Avena sativa (Oat) stem segments by gibberellic acid and abscisic acid. This result was obtained previously with GA_3- indoleacetic acid (IAA) and GA_3-kinetin interactions with Avena stem sections. Ayeleet *et al*. (2006) reported that the development and embryo axis regulation of gibberellin biosynthesis during germination and young seedling growth of pea (*Pisum sativum* L.). Shah (2007) has studied the effects of salt stress on mustard as affected by gibberellic acid application. Chudasama and Thaker (2007) carried out the relationship between gibberellic acid and growth parameters in developing seed and pod of pigeon pea. Mohammed (2007) has studied the physiological aspects of mungbean (*Vigna radiate* L.) in response to salt stress and gibberellic acid treatment.

Tuna *et al*. (2008) carried out the combined effects of gibberellic acid and salinity on some antioxidant enzyme activities, plant growth parameters and nutritional status in maize plants. Akbari *et al*. (2008) studied the effect of gibberellic acid on agronomic traits of green gram (*Vigna radiate* L.) irrigated with different levels of saline water. Atia *et al*. (2009) evaluated the ABA, GA_3 and nitrate may control seed germination of *Crithmum maritimum* (Apiaceae) under saline conditions. Maggio *et al*. (2010) studied the contrasting effects of GA_3 treatments on tomato plants exposed to increasing salinity. Asli *et al*. (2011) reported the effect of exogenous application of gibberellic acid on growth behavior of different grains within a spike of wheat. Javid *et al*. (2011) found that the role of gibberellic acid (GA) and other hormones in alleviating salt stress in some crops. Azizi *et al*. (2012) investigated the effect of different concentrations of gibberellic acid on seed yield components of soybean genotypes in summer intercropping.

Roychowdhury (2012) has studied the effect of gibberellic acid, kinetin and indole 3-acetic acid on seed germination performance of *Dianthus caryophyllus* (Carnation). Nasri *et al*. (2012) studied the effect of exogenous gibberellic acid on germination , seedling growth and phosphatase activities in lettuce under salt salt stress. Bahrani and Pourreza (2012) reported that the germination percentage rate were significantly increased by GA under salinity conditions compared to control. Saeidi-Sar *et al*. (2013) have studied the effects of ascorbic acid and gibberellic acid on alleviation of salt stress in common bean (*Phaseolus vulgaris* L.) seedling. Afrigan *et al*. (2013) carried out the effect of plant hormone gibberellic acid on germination indices *Secale montanum* in vitro and pot experiments under drought conditions. Ozhan and Hajibabaei (2013) studied the germination responses of wheat to gibberellic acid under salinity stress. Misratia *et al*. (2013) studied the effect of salinity and alleviating role of gibberellic acid (GA_3) for improving the morphological, physiological and yield traits of rice varieties.

Shohani *et al*. (2014) studied the effect of gibberellic acid (GA_3) on germination and early growth of lentil seedling under salinity stress. Abdel-Hamid and Mohamed (2014) suggested the effect of the exogenous gibberellic acid on two salt stressed barley cultivars. Batool *et al*. (2014) studied the evaluation of drought stress effects on germination and seedling growth of (*Zea mays* l.). Kandil *et al*. (2014) have evaluated the effect of gibberellic acid on germination behavior of sugar beet cultivars under salt stress condition of Egypt. Rahdari and Hoeini (2015) have studied the evaluation of germination percentage and some physiologic factors under salinity stress and gibberellic acid hormone (GA_3) treatments in wheat (Triticum aestivum L.). Nimir *et al*. (2015) suggested the seed priming with an appropriate concentration of exogenous antioxidant defense system of sweet sorghum under conditions of high temperature and salinity. Eskandari and Shokuhfar (2015) carried out the effect of different gibberellic acid hormone levels on yield and yield components of wheat cultivars. Misratia *et al*. (2015) studied the interactive effects of gibberellic acid and salt stress on growth and biochemical parameter of two rice (*Oryza sativa* L.) varieties differing in salt tolerance.

C. Biochemical Parameter

a- Na^+ and K^+ uptake

Munns (1985) studied Na^+, K^+ and Cl^- in xylem sap flowering to shoots of NaCl-treated barley. Begum *et al*. (1992) reported that salt stress consistently decreased the rate of germination in wheat. Due to increase in salinity accumulation of Na^+ and Cl^- was increased and K^+ accumulation was decreased in germinated seeds. Na^+ specific damage is associated with the accumulation of Na^+ in leaf tissues and results in necrosis of old leaves. Growth and yield reductions occur as a results of the shortening of the lifetime of individual leaves, thus reducing net productivity and crop yield (Munns, 1993, 2002). Rahman *et al*. (1993) carried out the salinity induced effects on the nutrient status of soil, corn leaves and kernels. Niu (1995) has studied Na^+ ion is toxiccell metabolism and has deleterious effect on the functioning of some enzymes. Munns and Rawson (1999) studied the effect of salinity on salt accumulation and reproductive development in the apical meristem of wheat and barley. Asch *et al*. (1999) carried out the sodium and potassium uptake of rice panicles as affected by salinity and season in relation to yield and yield componenets. Sekeroglu *et al*. (1999) have studied the effect of salinity on germination, early seedling growth, Na and K constituents of chickpea. Erdal *et al*. (2000) carried out the effect of potassium fertilization on cucumber (*Cucumis sativus* L.) seedling growth and changes of some nutrient contents under salt stress.

Iqbal *et al*. (2001) reported that the contents of sodium and chloride in leaf sap increased that while potassium ions decreased under salinity as compared to control. Among the genotypes Pb-25, Pb-28, SARC-6, KLR-1-4 and !4 Bakhtawar stopped the uptake of Na^+ and favoured K^+ and thus maintained high K^+, Na^+ ratio. Marked decline in K^+ at high level of NaCl concentrations could also indicate some damage to cell membranes and lekage of solutes (Munns, 2002, 2005). Ashraf *et al*. (2001) studied the interactive effects of gibberellic acid (GA_3) and salt stress on growth and ion accumulation of wheat (*Triticum aestivum* L.) cultivars differing in salt tolerance. Flowers and Hajiabagheri (2001) revealed the salinity tolerance and ion concentration in root cells of *Hordeum vulgare* differing in salt tolerance. Essa (2002) have studied the effect of salinity stress on growth and nutrient composition of three soybean (Glycine max L.) cultivars.

El-Arquan *et al*. (2002) studied the nutrient uptake of sugar beet as affected by soil salinity levels. Ashraf *et al*. (2002) carried out the interactive effects of gibberellic acid (GA_3) and salt stress on growth and ion accumulation of two spring wheat (*Triticum aestivum* L.) cultivars differing in salt tolerance. Ansari *et al*. (2003) reported that sodium uptake increased and potassium decreased with increasing salinity. Gopal and Dube (2003) reported that the high concentration of Na^+ and Cl^- ions in soil solution reduced the uptake of K^+ ions which ultimately caused K^+ deficiency in plants. Zhu (2003) observed salt stress disturbs cytoplasmic K^+/Na^+ homeostasis, causing an increase in Na^+ to K^+ ratio in the cytosol. Tester and Davenport (2003) carried out the low accumulation of Na^+ in the shoots reflects the avoidance of sodium toxicity. It has long been known that NaCl toxicity is largely attributable to the effects of Na^+ and only rarely those of Cl^-.

Moussa (2004) reported that root exudates of three weed plants, jungle rice, cocklebur and purslane were used as foliar spray into salt stressed soybean seedling to test their possible ameliorative effets on NaCl induced injury. Azevedo *et al*. (2004) studied the effect of salt stress on plant growth stomatal response and solute accumulation of different maize genotypes. Hu and Schmidhalter (2005) suggested the drought and salinity can differentially affect the mineral nutrition of plants. Parida and Das (2005) observed in R. *communis*, osmotic adjustment was achieved by K^+ (as evidenced by higher K^+ than Na^+ content in tissues) and increased in the quantity of proline in tissues when water content decreased because of salinity. In addition to its conventional osmoprotective role, proline prevents NaCl induced K^+ efflux from roots and may operate as ion channel regulators, Na^+ accumulation and Na^+/K^+ ratio in salt stressed plants depend on salt stress treatments, while K^+ accumulation is generally decreased (Cuin and Shabala, 2005; Sabir and Ashraf, 2007).

Gurmani *et al*. (2006) investigated the effect of growth regulator on growth, yield and ion accumulation of rice. Othman *et al*. (2006) have studied the variation in germination and ion uptake in barley genotypes under salinity conditions. Ashley *et al*. (2006) studied the plant responses to potassium deficiencies a role for potassium transport proteins. Shah *et al*. (2006) carried out the effect gibberellic acid spray on growth, nutrient uptake and yield attributes during various growth stage of black cumin (*Nigella sativa*). Shaddad *et al*. (2006) investigated the interaction effect of salinity and GA_3 on growth K^+/Na^+ ratio, antioxidant enzyme and salt stress. Reema (2007) suggested the effect salt stress on growth, productivity and nutrient uptake in lentil (*Lens culinaris*). Chen *et al*. (2007) studied the compatible solute accumulation and stress-mitigating effects in barley genotypes contrasting in their salt tolerance. Akram *et al*. (2007) investigated the competitive seedling growth and K^+/Na^+ ratio in different maize (*Zea mays* L.) hybrids under salinity stress. Suarez and Medina (2008) carried out the salinity effects on leaf ion composition and salt secretion rate in *Avicennia germinans* (L.).

Wu *et al*. (2009) suggested the interactive of potassium and sodium on root growth and expression of K/Na transporter genes in rice. Turan *et al*. (2010) studied the effect of salt stress on growth and ion distribution and accumulation in shoot and root of maize plant. Gandonou *et al*. (2011) carried out the effect of NaCl on Na^+ and K^+ ions accumulation in two sugarcane (*Saccharum* sp.) cultivars differing in their salt tolerance. Tavakkoli *et al*. (2011) studied the additive effects of Na^+ and Cl^- ions on barley growth under salinity stress. Samad and Karmoker (2012) have studied the effect of gibberellic acid on seed germination and accumulation of Na^+ and K^+ in the seedling of *Triticale aestivum* under salinity stress. Akca and Samsunlu (2012) investigated the effects of irrigation water salinity on growth, nutrients accumulation and K/Na ratio in three walnut cultivars. Wang *et al*. (2012) carried out the effect of salt stress on ion balance and nitrogen metabolism of old and young leaves in rice.

Yousufinia *et al*. (2013) suggested the effect of NaCl on the growth and Na^+ and K^+ content of barley (*Hordeum vulgare* L.) cultivars. Maathuis *et al*. (2014) carried out the most detrimental effects of salinity is the accumulation of Na^{+} and Cl^{-} ions in tissues of plants subjected to soils with high concentration of NaCl.Hakim *et al*. (2014) studied the effect of salinity on growth, ion accumulation and yield of rice varieties. Misratia *et al*. (2015) investigated the interactive effects of gibberellic acid (GA_3) and salt stress on growth and ion accumulation of two rice (*Oryza sativa* L.) varieties differing in salt tolerance. Salachna and Piechoki (2016) studied the effects of sodium chloride on growth and mineral nutrition of Purpletop vervain.

b. Proline

Bates *et al*. (1973) gave a detailed for rapid determination of free proline for water stress studied. Hanson *et al*. (1977) reported that the significance proline accumulation in response to salt has been contentious. Proline has been suggested to act as compatible cytoplasmic osmoticum. The role played by the NaCl supply in modifying some other facts of metabolisms to withstand the proline and other amino acid accumulation in salt stressed plants with caraway and cumin the pattern of changes in proline was opposite to that of other amino acids, indicating that the increasing in proline is at the expence of other amino acid through an effect of salinity in promoting their conversion.

Shah *et al*. (1990) reported that proline accumulation is important for cell growth only when a certain level of salt stress is attained, and this level will depend on presence or absence of other protectant mechanisms in the tissue. Alia and Pardha-Saradhi (1991) suggested the accumulation of free proline may also contribute to the scavenging of abiotic stress induced active oxygen species by enhancing photochemical electron transport activities. Bolarin *et al*. (1995) reported that the proline accumulation in leaf and particularly roots compared to RGS cultivars, thus using this cultivar of plants is use as a sensitivity index to salinity recommended, which use to supporting different salinity rates. Misra *et al*. (1996) studied the growth and proline accumulation in mungbean seedling as affected by sodium chloride. Gilbert *et al*. (1998) studied amino acid accumulation in sink and source tissues of *Coleus blumei* during salinity stress.

Sultana *et al*. (2000) studied the gibberellic acid and proline promote germination of wheat seeds by stimulating *a*-Amylase. Mansour (2000) reported that the proline an amino acid is considered to be an essential compatible solute and a part of the adaptation mechanism to several stresses in plants. Proline accumulation in response to environmental stresses has been considered by a number of authors as an adaptive trait concerned with stress tolerance, and it is generally assumed that proline was acting as a compatible solute in osmotic adjustment. Ghoulam *et al*. (2002) investigated the effects of salt stress on growth and proline accumulation in relation to osmotic adjustment in five sugar beet cultivars. Maggio *et al*. (2002) have studied the proline accumulation play an active role in stress-induced growth reduction. Kumar *et al*. (2003) investigated the salt effects on proline metabolism in two high yielding genotypes of mulberry (*Morus alba* L.) with contrasting salt tolerance.

Meloni *et al*. (2004) carried out the effects of salt stress on growth, proline and glycinebetaine accumulation in *Prosopis alba*. Kavi *et al*. (2005) suggested the regulation of proline biosynthesis, degradation and transport in higher plants and their implications in plant growth and abiotic stress tolerance. Misra and Gupta (2005) studied the effect of salt stress on proline metabolism in two high yielding genotypes of green gram. Ghorbanli *et al*. (2006) investigated the effects of different saline condition on proline of two colza cultivars. Jaleel *et al*. (2007) studied on germination, seedling vigour and proline metabolism in *Catharanthus roseus* seedling under salt stress. Uedo *et al*. (2007) carried out the salt stress enhances proline utilization in the apical region of barley roots. Pakniyat and Armion (2007) have studied sodium and proline accumulation as osmoregulatores in tolerance of sugar beet genotypes to salinity. Hameed and Ashraf (2008) reported that the proline accumulation under dehydrated conditions is mainly due to increased biosynthesis and decreased degradation. Enhanced synthesis of proline under drought or salinity conditions has been involved in the alleviation of the stress in various plants such as Cynodon dactylon. Tuna *et al*. (2008) found that foliar application of gibberellic acid increased proline content which counteracted some of the adverse effects of salinity by maintaining membrane permeability. Goudarzi and Pakniyat (2009) suggested the salinity cause increase in proline and protein contents and peroxidase activity in wheat cultivars. Cha-Um and Kirdmanee (2009) studied the effect of salt stress on proline accumulation and growth characters in two maize cultivars.

Khan *et al*. (2010) reported that production of proline was higher in GA_3 and Ca_2^+ exposed *Linum usitatissimum* plants. This enhanced accumulation of proline may represent a major biochemical adaptation in plants osmotic adjustment. Amirjani (2010) has studied the effect of salinity stress on growth, proline content, and antioxidant enzymes of soybean. Summart *et al*. (2010) carried out the effect of salt stress on growth and proline accumulation in Thai aromatic rice. Nazarbeygi *et al*. (2011) studied the effects of different levels of salinity on proline in canola. Ali *et al*. (2011) studied the enhanced proline synthesis may determine resistance to salt stress in tomato cultivars. Somayeh *et al*. (2012) investigated the effect of salinity stress on proline, germination, growth and dry weight of three seedling barley (*Hordeum vulgare* L.) cultivars. Dominic and Jithin (2012) studied the effect of NaCl on proline biosynthesis of *Oryza sativa*. Sonam *et al*. (2013) carried out the effect of salinity on seed germination and accumulation of proline in *Pennisetum glaucum* (L.). Jaarsma *et al*. (2013) studied the effect of salt stress on growth and proline metabolism in potato (*Solanum tuberosum*) cultivars. Wahid *et al*. (2014) have studied in vitro assessment of tomato (*Lucopersicon esculentum*) and cauliflower (*Brassica oleracea*) seedlings growth and proline production under salt stress.

c. Chlorophyll content

Aldesuquy and Gaber (1993) studied the effect of growth regulators on *Vicia faba* plants irrigated by leaf area, pigment content and photosynthetic activity. Ma *et al*. (1997) observed reduced chlorophyll 'a' content and increased chlorophyll a/b ratio under moderate and severe salt stress. Zayed and Zeid (1997/98) carried out the effect of water and salt stress on growth, chlorophyll and enzyme activity in mung bean seedling. Ashraf and Bhatti (2000) have studied the effect of salinity on growth and chlorophyll content of rice. Yuan and Xu (2001) investigated the stimulation effect of gibberellic acid short-term treatment on leaf photosynthesis related to the increase in broad bean and soyaben. Khan (2003) have studied NaCl inhibited chlorophyll synthesis and associated changes in ethylene evolution and antioxidative enzyme activity in wheat. Beinsan *et al*. (2003) observed that decrease in leafs chlorophyll content was due to increase in activity of chlorophyll destroying enzyme named chlorophylls enzyme that would lead to destruction in chloroplast and instability of protein complexity of pigments.

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Santo (2004) has studied the regulation of chlorophyll biosynthesis and degradation by salt stress in sunflower leaves. Tort and Turkyilmaz (2004) observed that the exposure of barley (Hordeum vulgare) to zero, 120 and 240 mM of sodium chloride led to the decrease in chlorophyll *a*, chlorophyll *b* and total chlorophyll content. Ali *et al*. (2004) carried out the effect of salinity on chlorophyll concentration, leaf area, yield and yield components of rice genotypes grown under xsaline environment. Al-aghabary *et al*. (2005) have studied the influence of silicon (Si), sodium chloride (NaCl) and both Si and NaCl supply on chlorophyll content and chlorophyll fluorescence in tomato (*Lycopersicon esculentum* L.) leaves. Turhan and Eris (2005) have studied the changes of dry weight and chlorophyll contents in strawberry plants under salt stress. Akram *et al*. (2006) carried out the chlorophyll fluorescence in different wheat genotypes grown under salt stress. Zhao *et al*. (2007) studied the growth gas exchange, chlorophyll fluorescence and content of naked oat in response to salinity.

Jamil *et al*. (2007) reported that the decreasing chlorophyll content with increasing salinity in rooting medium has been explained by increasing activity of enzyme responsible for the degradation of chlorophyll, (Chlorophyllase). Paknejad *et al*. (2007) studied the effects of drought stress on chlorophyll fluorescence parameters, chlorophyll content and grain yield of wheat cultivars. Siler *et al*. (2007) observed that chlorophyll a, b and total chlorophyll decreased with the increase of salt concentration on (*Centaurium erythraea*) species. Yadegari *et al*. (2007) reported that chlorophyll *a* and *b* content decrease when plants are subjected to cold stress. The possibility of low chlorophyll and carotenoid content could be oxidative stress caused by low temperature treatment. Chaum and Kirdmanee (2009) studied decrease in chlorophyll content under salinity stress mentioned which can imply to its increase in *Zea mays*. Li *et al*. (2010) suggested that chlorophyll fluorescence and hyperspectral reflectance at leaf scale can provide useful tools for non-destructive estimates of photosynthetic function. Ayala-Astorga and Alcaraz-Melendez (2010) carried out the effects of saline stress on soluble proteins, lipid peroxidation (TBAR), chlorophyll *a*, chlorophyll *b*, *B*-carotene in *Paulownia imperialis* and *Paulownia fortune* plants.

Akram and Ashraf (2011) studied the salt stress reduces the chlorophyll content, the extent of the reduction depends on salt tolerance of plant species. McLachlan (2011) investigated the effect of salinity on growth and chlorophyll content representative classes of marine algae. Jasmine and John (2012) studied the effects of gibberellic acid on seedling growth, chlorophyll content in okra (*Abelmoschus esculentus* L. Moench) under saline stress. Zhani *et al*. (2012) carried out the impact of salt stress (NaCl) on growth, chlorophyll content and fluorescence of Tunisian cultivars of chili pepper (*Capsicum frutescens* L.). Khaleghi *et al*. (2012) have studied the evaluation of chlorophyll content and chlorophyll fluorescence parameters and relationship between chlorophyll *a*, *b* and chlorophyll content index under water stress in *Olea europaea*. Ali *et al*. (2012) studied the effect of gibberellic acid on growth and photosynthetic pigments of (*Hibiscus sabdariffa* L.). Yildiz and Terzi (2013) suggested the effect of NaCl on chlorophyll biosynthesis, lipid peroxidation and antioxidative enzymes in leaves of salt tolerant and salt sensitive barley cultivars. Xing *et al*. (2013) reavealed the influence of natural saline-alkali stress on chlorophyll content and chloroplast ultrastructure of two contrasting rice (*Oryza sativa* L.) cultivars. Sneha *et al*. (2014) studied the effect of short term salt stress on chlorophyll content, protein and activities of catalase and ascorbate peroxidative enzymes in pearl millet.