CHAPTER-1

Introduction

Salinity is one of the most brutal environmental factors limiting the productivity of crop plants because mpst of the crop plants are sensitive to salinity caused by high concentrations of salts in the soil, and the area of land affected by it is increasing day by day. For all important crops, average yields are only a fraction-somewhere between 20% and 50% of record yield; these losses are mostly due to drought and high soil salinity, environmental conditions which will worsen in many regions because of global climate change (Shrivastava and Kumar, 2015). Thus it is a serious threat to agricultural productivity especially in arid and semi-arid region (Parvaiz and Satyawati, 2008). Various environmental stresses viz. high winds, estreme temperatures, soil salinity, drought and flood have affected the production and cultivation of agriculture crops, among reductions in cultivated land area, crop productivity and quality (Shahbaz and Ashraf, 2013)

Osmotic potential is a function of the salt concentration in the soil solution and therefore affected by both salinity (measured as electrical conductivity at a certain water content and soil water content) Yan *et al*, (2015). The total concentration of dissolved salt in soil solutions, generally measured as the electrical conductivity (EC) of the soil solutions, is considered as the primary criterion affecting the yield. Thus, most of the research on crop salinity tolerance has focused on EC of soil solutions including osmotic pressure affecting water uptake by plants and the accumulation of specific ions in the plant over a period of time leading to ion toxicity or ion imbalance (Munns and Tester, 2008).Any kind of imbalance in soil composition results in to problem soil like usar soils, salty soils etc. increasing salt content of soil is a worldwide problem, however it is more wide spread and acute in arid and semiarid regions than humid ones of the world. Soils with high levels of salt are called saline soils. Calcium has a role a bheyuilding salt tolerance in plants. Adequate levels of calcium are necessary for the membrane to function normally (Jaleel *et al*., 2007).

Most of the interest in calcium in plants has centered on its role in the cytoplasm in controlling the developmental processes. Addition of calcium salt might restore adequate levels of potassium and calcium (Kent and Lauchli, 1985; Arshi et al., 2010). It also controls guard-cell turgor and stomatal aperture and helps in turgor maintenance (Bhattacharjee, 2009).Externally supplied Ca^{2+} reduces the toxic effects of NaCl. Presumably by facilitating a high K^+/Na^+ selectivity (Zhang *et al*., 2010). High salinity results in increased cytosolic Ca^{2+}, which is transport from the apoplast and the intracellular compartments (Shabala *et al*., 2016). This transient increase in the cytosolic Ca^{2+} initiates stress-signal transduction leading to salt adaptation. The accumulation of osmoprotectant as proline thought to function as osmoprotectant for proteins (Prochazkova *et al*., 2001; Misra and Gupta, 2005).

The general effect of soil salinity on plant is called an osmotic effect. This means that salt increase the energy with which water is held in the soil. In other words, the soil must be kept water to supply the same amount of plant-available water as would be present without the salts (Mckenzie, 2002). Plants then must increase the energy they expend to obtain water from the soil. The plant must use energy to get water that would otherwise be used for growth, flowering or fruiting. When soil salinity exceeds a plants tolerance, growth reductions occur. As salt concentration increase, water becomes increasingly difficult for the plant to absorb. A plant can actually die from water stress or drought a moist soil if the salt concentration becomes high enough. Other effects of salts on plants are toxicities of specific salt and nutritional imbalance (Blaylock, 1994).

Salt-affected soils are widespread over the world especially in arid, semi-arid and sub-humid regions. Soil salinity and water logging are two of the main constraints present in irrigated agricultural lands. A considerable amount of land in the world is affected by salinity which is increasing day by day. More than 45 million hectares (M ha) of irrigated land which account to 20% of total land have been damaged by salt worldwide and 1.5 M ha are taken out of production each year due to high salinity levels in the soil (Pitman and Lauchli, 2002; Munns and Tester, 2008). On the other hand, increased salinity of agricultural land is expected to have destructive global effects, resulting in up to 50% loss of cultivable lands by the middle of the twenty first century (Mahajan and Tuteja, 2005).

Salt-affected soils are naturally present in several countries where many regions are also affected by Irrigation-induced salinization. Dry-land salinity is becoming a major issue in many countries, particularly Australia (Rengasamy, 2006). Recent papers (Ganjegunte *et al*., 2014; Young *et al*., 2015) also highlight the growing problem of soil salinization. Salt affected areas on average represent 20% of the world's irrigated lands whereas this figure in arid and semiarid countries increases to more than 30% (Newar *et al*., 2013). Besides, Oldeman *et al*. (1991) also reported nearly 77 million hectares of the global land areas as salt affected due to human induced salinization while Tanji (1995) concurred that saline seeping dry land agriculture and secondary salinization in irrigated agriculture occupied 19.5% of the total area. Salinity is a major environmental factor determining plant productivity and plant distribution.

The salt-affected soils were classified according to norms for pH, electrical conductivity(EC) and exchangeable sodium percentage (ESP). The statewise extent of salt-affectedsoils in India. It shows that maximum area of salt-affectedsoils occur in Gujarat followed by Uttar Pradesh and Maharashtra whichaccount for about 62.4 %. Due to the limitation of small scale, some very small andisolated patches of salt-affected soils occurring in the states of Delhi, Jammu andKashmir and Himachal Pradesh could not be detected. The salt-affected soilsaccount for 6.727 Mha equivalent to 2.1 % of the geographical area of the country. Out of the total 6.727 million ha of salt-affected soils, 2.956 million ha are salineand the rest 3.771 million ha are sodic (Arora, 2017).

Salt stress occurs in areas where soils are naturally high in salt and precipitation is low (Neumann, 1995) and/or where irrigation, hydraulic lifting of salty underground water, or invasion of sea water in coastal areas bring salt to the surface soil that inhibit plants. Globally 20% of irrigated land and 2.1% of dry land agriculture suffers from the salt problem and NaCl is the predominant salt causing salinization (Munns and Tester, 2008). Salinity adversely affects germination, growth, physiology and productivity by reducing the ability of plants to take up water causing imbalance in osmotic potential, ionic equilibrium and nutrient uptake (Niu *et al*., 1995).

Salt tolerance is a complex trait which involves numerous genes and various physiological and biochemical mechanisms (Cuartero *et al*., 2006). Salinity stress involves change in various physiological and metabolic processes, depending on severity and duration of the stress and ultimately inhibits crop production (James *et al*., 2011; Rozema and Flower, 2008). Initially soil salinity is known to represses plant growth in the form of osmotic stress which is then followed by ion toxicity (James *et al*., 2011; Rahnama *et al*., 2010). During the initial phases of salinity stress, water absorption capacity of root systems decreases and water loss from leaves is accelerated due to osmotic stress of high salt accumulation in soil and plants and therefore salinity stress is also considered as hyperosmotic stress (Munns, 2005). Salinity inhibition of plant growth is the result of osmotic and ionic effects and the different plant species have developed different mechanisms to cope with these effects (Munns, 2002). Greenway and Munns, (1980) reported that the initial phase of growth reduction is due to an osmotic effect, is similar to the initial response to water stress and shows little genotypic differences. The second, slower effect is the result of salt toxicity in leaves. In the second phase a salt sensitive species or genotype differs from a more salt tolerant one by its inability to prevent salt accumulation in leaves to toxic levels (Lauchli and Grattan, 2007). The osmotic adjustment, i.e., reduction of cellular osmotic potential by net solute accumulation, has been considered an important mechanism to salt and drought tolerance in plants. This reduction in osmotic potential in salt stressed plants can be a result of inorganic ion (Na^+, Cl^- and K^+) and compatible organic solute (soluble carbohydrates, amino acids, proline and betaines etc) accumulations (Hasegawa *et al*., 2000). Davenport, *et al*. (2005) determined the salinity affects agricultural production and its quality in arid and semi-arid region, where rainfall is limited and is not sufficient to transport salts from the plant root zone. Salt stress affects almost all aspects of plant development including germination, vegetative growth and reproductive development. Numerous physiological and biochemical changes occur in response to salt stress in various plant species.

Many researches have been made to overcome salinity problems in different crop plants, including proper management practices and exogenous application of different phytohormones. Application of wide variety of both naturally occurring and synthetic chemical growth regulators (CGR) have been extensively used in order to as definite their beneficial effects upon the growth and development of plants. A lot of synthetic growth regulators have been discovered and proved to be benefecial in agriculture (Hisamatsu*et al*., 2000).Exogenous application of gibberellic acid (GA_3) is one of the major concerns for plant scientists because of its potentials to enhanced crop growth under salinity (Gurmani *et al*., 2006). Gibberellic acid (GA_3) is also reported to increase nutrient uptake (Wen *et al.,* 2010) and ion accumulation (Ashraf *et al*., 2002). It also maintains different biochemical properties in plants and improves grain yield (Mahajan and Tutja, 2005; Seckin *et al*., 2009).

Considering the trends of growth reduction due to salinity and progressive impact of exogenous GA_3 application on differentmorphological, physiological and biochemicl activities, it can be stated that application of GA_3 is useful to mitigate salinity stress and its effectiveness is more active to salt tolerant varieties (Misratia *et al*., 2015). Gibberellins (GAs) are generally involved in growth and development. They control seed germination, leaf expansion, stem elongation and flowering (Magome *et al*., 2004). Mary and Merina (2012) reported that the application of GA_3 increases the amino acid content in embryo and cause release of hydrolytic enzyme required for digestion of endospermic starch when seeds renew growth at germination.Gibberllic acid causes the increase of cell division and increase of elastic properties of the cell wall. Rashid *et al*. (2006) reported that use of gibberellic acid makes water suctions and increase of seedling growth in plants. GA application enhances the catabolism of ABA (Gonai *et al*., 2004). However, the mechanisms by which GA_3-priming could induce salt tolerance in plants are not yet clear. Salinity perturbs the hormonal balance in plants. Therefore, hormonal homeostasis under salt stress might be the possible mechanism of GA_3-induced plant salt tolerance (Iqbal and Ashraf, 2010).

Objectives:

- To evaluate the response of different oat varieties to salinity stress on the basis of germination and early seedling growth.
- To evaluate the possible mode of interaction between salinity and exogenous application of gibberellic acid and exploring how gibberellic acid can mitigate the deleterious effects of salinity.
- To investigate the interactive effect of gibberellic acid (GA_3) and salt stress on proline accumulation in oat varieties at seedling stage.
- To investigate the effect of salinity with/without GA_3 treatment on Na^+ and K^+ ions uptake in related oat varieties.