Chapter - 1

INTRODUCTION
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*Lycopersicon esculentum* (Tomato) is the member of the family Solanaceae. A small genus of annual or short lived perennial herbs, indigenous to the western regions of tropical South America. One species *Lycopersicon esculentum* is widely cultivated throughout the world. In India, tomatoes can be grown nearly throughout the year. Favourable climatic conditions are available in one or the other part of the country.

Tomato plants are perennial dicot, typically reaching to 1.3 metres (3-10 ft) in height, it has a weak woody stem that often winds over other plants. The leaves are 10-25 centimeters (4 to 10 inch) long, odd pinnates, with 5-9 leaflets on petioles, each leaflet is up to 8 centimetres (3 inch) long, with a serrated margin; both the stem and leaves possess granular hairs. The flowers are 1-2 centimetres (0.4-0.8 inch) across, yellow with five pointed lobes on the corolla, they are borned in a cyme of 3-12 flowers together. Tomato fruit is classified as a berry. As a true fruit, it develops from the inferior ovary of the plants after fertilization; its flesh comprises the pericarp walls. Fruits contain hollow spaces full of seeds and pulp, called locular cavities. Fruits show slight variations, among cultivated species, according to the type. The seeds need to be picked from a mature fruits, and be dried/fermented before germination.

The tomato is grown worldwide for its edible fruits, with thousands of cultivars having been selected with varying fruit types and adjustability in different climatic conditions. The tomato plant requires a warm climate with plenty of sunshine and adequate moisture. It does not tolerate frost. It can be cultivated under irrigation in
arid tropics, but hot and dry or hot and humid conditions do not favour its growth. High humidity with high temperature renders the plant susceptible to foliage diseases. For the proper development of colour in the fruit, warm sunny days and moderately cool nights are necessary. As in most sectors of agriculture, there is increasing demand for tomato in developed and/or developing counties. According to FAOSTAT, 125 million tons of tomato was produced in the world in 2005. China being the largest producer, accounted for about one quarter of the global output followed by United States (11.0 million tons), Turkey (2.7 million tons) and India (7.6 million tons).

The chemical composition of tomato varies with variety and the stage of harvest. The pulp constitutes 85.4% of the whole fruit and contains 6-7% total solids. The principal organic acid present in the tomato fruit is citric acid but maleic acid also occurs in appreciable amounts. Carotenoids, β-carotene and lycopene constitute the chief colouring matter of tomato fruits; their concentration in the fruit depends on the variety and the stage of ripeness.

Tomatoes are now eaten freely throughout the world, and their consumption is believed to benefit the heart among other things. They contain lycopene, one of the most powerful natural antioxidants, which especially in the cooked tomatoes helps to prevent prostate cancer. Lycopene has also been shown to improve skin's ability to protect against harmful UV rays. Moreover, tomato is also used as tomato sauce, tomato soup, tomato juice. Unripe green tomato can also be breaded and fried to make salsa or pickled.

Soil salinity has become a serious environmental problem which affects the growth and productivity of many crops (Koca et al., 2007). About 20% of the world’s cultivated land area and 50% of all irrigated lands are affected by salinity (Moud and
High salt content affects the physiology of plants, both at the cellular as well as whole plant levels. Ionic imbalance occurs in the cells due to excessive accumulation of Na\(^+\) and Cl\(^-\) ions that reduce the uptake of mineral nutrients such as K\(^+\), Ca\(^{2+}\) and Mn\(^{2+}\) (Bayuelo-Jimenez et al., 2003). Excess amount of sodium ions in cells cause enzyme inhibition and metabolic dysfunction such as degradation of photosynthetic pigments (Chaves et al., 2009). Photosynthesis is one of the most severely affected processes during salinity stress which is mediated through a decrease in stomatal conductance (Parida et al., 2004), internal CO\(_2\) partial pressure and stomatal opening that affect gaseous exchange (Iyenger and Reddy, 1996). The decrease in photosynthesis under saline conditions is considered as one of the most important factor responsible for reduced plant growth and productivity (Manikandan and Desingh, 2009).

According to the incapacity to grow on high salt medium, plants have been classified as glycophytes or halophytes. Most cultivated plants are glycophytes and cannot tolerate salt stress (Sairam and Tyagi, 2004). The deleterious effects of salinity on plant growth are associated with: (1) low osmotic potential of soil solution (water stress), (2) nutritional imbalance, (3) specific ion effect (salt effect) or (4) a combination of these factors (Marschner, 1995). During the onset and development of salt stress within a plant, all the major processes such as photosynthesis, protein synthesis and energy and lipid metabolism are affected. The earliest response is a reduction in the rate of leaf surface expansion followed by its cessation as stress intensifies, but growth resumes when the stress is relieved (Parida and Das, 2005). Soil salinity causes a lower rate of photosynthesis by decreasing the chlorophyll content, the activity of rubisco (Soussi et al., 1998) and the closure of stomata thereby, decreases partial CO\(_2\) pressure (Bethke and Drew, 1992). Salinity reduces
plant productivity first by reducing plant growth during the phase of osmotic stress and subsequently by inducing leaf senescence during the phase of toxicity when excessive salt is accumulated in transpiring leaves (Munns, 2002). All of these cause adverse pleotropic effects on plants.

Nitric oxide (NO), at an elevated level acts as a toxic air pollutant, which is produced in the atmosphere mainly by electrical discharge, automobile engines and power plants (Stohr and Ullrich, 2002). In the air it is converted to nitric acid, which is an important component of acid rain and in association with nitrogen dioxide (NO₂) participates in ozone layer depletion (Kramlich and Linak, 1994). However, at a very low concentration, this inorganic free molecule has been described as gaseous phytohormone (Leshem, 2000) which is endogenously formed in many biological systems. NO production in plant tissues was first observed by Klepper (1975). Later on four different enzymatic pathways involved in NO production have been proposed; (a) nitric oxide synthase, (b) plasma membrane bound nitrate reductase, (c) mitochondrial electron transport chain and (d) non-enzymatic reactions (Durzan and Pedroso, 2002; Guo et al., 2003; Hayat et al., 2010b). Nitric oxide is a signaling plant growth regulator (Beligni and Lamittina, 2000; Stohr and Stremlau, 2005) that acts mainly against oxidative stress (Neill et al., 2003). At low concentrations of NO either endogenously produced or exogenously applied, it exerts a significant growth promoting effects (Leshem, 1996) and acts as an intra and intercellular messenger and a functional metabolite, involved in the regulation of diverse biochemical and physiological processes in plants (Hayat et al., 2010b). The processes regulated by NO include seed germination, growth and development (Hayat et al., 2009), apoptosis, hypersensitive response and phytoalexin production (Zhang et al., 2005; Besson-Bard et al., 2008). Root organogenesis, hypocotyl growth, defense responses
and stomatal closure are the other responses assigned to NO (Chaki et al., 2009).

The biological activities of NO are diverse, concentration dependent (Hayat et al., 2010b) and are exerted on phylogenetically distant species that opens a fantastic window for yet unexplored field of NO’s function in plant kingdom.

In the recent past, Brassinosteroids (BRs) have emerged as a new paradigm in the category of phytohormones. Like other plant hormones (auxins, gibberellins, cytokinins and abscisic acid), BRs, were shown to participate at very low concentration in the control of numerous processes associated with plant growth and development (Mandava, 1988; Friedrichsen and Chory, 2001; Bajguz and Hayat, 2009). Brassinosteroids have the ability to cause cell elongation and cell division in stems, inhibit root growth, promote xylem differentiation, and abscission (Mandava, 1988; Nemhauser et al., 2004). They have also been noted to control several other process in plants, such as induced synthesis of nucleic acid and protein synthesis (Khripach et al., 2003), activation of several enzymes (Hasan et al., 2008), photosynthesis (Hayat et al., 2007a) and increased fruit set (Kamuro and Takatsuto, 1999; Ali et al., 2006). Increased stress tolerance in the plants is another role assigned to brassinosteroids (Clouse and Sasse, 1998). Among abiotic stresses, BR has been reported to counter high and low temperature stress (Kulaeva et al., 1991; Wilen et al., 1995), moisture stress (Sairam, 1994; Hayat et al., 2008), drought stress (Schilling et al., 1991; Fariduddin et al., 2009), heavy metal stress (Alam et al., 2007; Hayat et al., 2007a; Ali et al., 2008a, Hasan et al., 2008; Fariduddin et al., 2009; Sharma et al., 2007; Bhardwaj et al., 2007), salinity stress (Ali et al., 2007, 2008b) and nitrosative stress (Hayat et al., 2010b).

Keeping in view the above roles assigned to BRs and nitric oxide and the ever increasing salinity stress in soil, the present research was designed with an objective
to relate changes in growth, photosynthetic parameters and the level of antioxidative enzymes, in salinized plants of *Lycopersicon esculentum* with the induced resistance and to neutralize the effects of salinity stress by the application of brassinosteroids and nitric oxide. The hypothesis that is put to trail is that the application of brassinosteroids and nitric oxide will ameliorate the toxic effects of salinity on the growth of the test plant, *Lycopersicon esculentum* which is widely consumed throughout the world and easily accepted by the local farmers as a cash crop.

The following objectives were kept in mind while planning the experiments.

1. To select the tolerant and resistant level of salinity on tomato among the two modes of application i.e. seed soaking and soil treatment.

2. To screen out the best concentration treatment of sodium nitroprusside by seed soaking for given tomato cultivars.

3. To find out the best concentration of HBL/EBL spray treatment for given tomato cultivar.

4. To assess the effect of foliage applied HBL/EBL (10^{-8} \text{ M}) on tomato plants raised from the seeds, soaked in three concentration of NaCl solution.

5. To observe the effect of foliage applied HBL/EBL (10^{-8} \text{ M}) on tomato plants fed with three levels of NaCl in the soil.

6. To assess the effect of nitric oxide treatment on tomato seeds soaked in three concentrations of NaCl solution.

7. To observe the effect of nitric oxide on tomato plants, raised in the soil treated with three doses of NaCl.

8. To select the metabolic and growth parameters showing maximum response to the treatment and that may be designated as a scale or forecasting further growth and crop productivity.