As agriculture becomes more mechanized and science increases the possibilities for using inputs to enhance production, the role of PGRs becomes more vital. Plant growth regulators are chemical substances and when applied in small amounts, they bring rapid changes in the phenotypes of the plant and also influence the plant growth, right from seed germination to senescence either by enhancing or by stimulating the natural growth regulatory system. Plant growth regulators are known to enhance the source-sink relationship and stimulate the translocation of photo-assimilates thereby helping in effective flower formation, fruit and seed development and ultimately enhance productivity of the crops.

Growth, development and yield analysis in crop plants helps in understanding the contribution of various growth and yield components. Plant growth regulators considered as a new generation of agrichemicals when added in small amounts, modify the growth of plants usually by stimulating or modifying one part of the natural growth regulatory system, thereby the yield is enhanced. Higher production through breeding is a continuous endeavor of mankind. But, these methods are however, not only time consuming but also costly. The growth regulators have therefore, been known to be one of the quick means of increasing production. Similarly, nutrients are inorganic substances necessary for the normal growth and development of plants and have important role in various enzymatic processes, assimilation, oxidation and reduction reactions and help in increasing the biomass and pod yield. Hormones regulate plant growth and development by affecting a wide range of cellular, developmental and physiological response. PGRs are chemical messengers produced in one part of plant and translocated to the other parts, where they play critical roles in regulating plant responses to any type of stress at extremely low concentration. Salicylic acid (SA), jasmonic acid (JA) and brassinosteroids (BRs) are growth regulators which participates in regulation of many physiological processes (Fig 5.1) in plants such as stomatal closure, ion uptake and transport, inhibition of ethylene biosynthesis, transpiration, stress tolerance, membrane permeability photosynthesis and growth. Improving productivity of crop plants by exogenous application of some potential growth regulators is considered an effective technique. Hence, The main objectives of the present investigation is to evaluate the effect of foliar application of plant growth
regulators (SA, 24-EBL and JA) in soybean (*Glycine max* L.) cv. Pusa-9712 under normal as well as salt stressed condition. The results of the parameters analyze are discussed below.

Our results exhibited that foliar spray of SA exerted stimulatory effects on vegetative growth parameters of soybean plant compared with control at all the sampling stages (Table 4.1 to 4.6). Application of SA led to increase in the plant height, root length, number of branching and leaves per plant along with increase in the dry weight also. Regarding foliar application of SA, our obtained results are similar to those describe by Salarizdah *et al.* (2012) on canola, Dawood *et al.* (2012) on sunflower. The stimulatory effect of salicylic acid on soybean growth could be attributed to its stimulatory effect on photosynthesizing tissue. In the present study, foliar application of SA improved plant height in soybean cultivar. These results are consistent with those of Pakar *et al.* (2014) who demonstrated that positive effect on plant height was related to foliar applied SA. It is also reported that foliar application of SA enhanced the leaf area (Pancheva *et al.*, 1996; Pirasteh-Anosheh *et al.*, 2014), plant height (Pirasteh-Anosheh *et al.*, 2012) and other growth traits (Ashraf *et al.*, 2010). Similarly, treatment of SA enhanced the growth of wheat under saline or non-saline condition which can be attributed to an increase in photosynthesizing tissue in the leaves (Dhaliwal *et al.*, 1997). In another report, it has been observed that application of high concentration of SA negatively affected growth and yield of mungbean (Khan *et al.*, 2010).

In our study, number of leaves per plant was enhanced significantly by application of SA, JA and 24-EBL at all the sampling stages. The number of leaves formed and leaf area was found to be increased as compared to control due to application of SA in ornamental plants has been also reported by Hayat *et al.* (2007) and Martin-max (2005). Similar results were also obtained in maize (Khodary, 2004). The crop was also subjected to salt stress and the effect of SA was evaluated in mitigating the salinity stress in soybean. Salt stress adversely affected the plant growth by reducing root length/shoot length and fresh weight/dry weight of the soybean at all the sampling stages (Tables 4.25, 4.26, 4.29, 4.30). A significant decrease of root length and shoot length was observed under 150 mM NaCl concentration as compared to control seedlings. Fresh weight and dry weight of seedlings was also found to decrease maximally under 150 mM NaCl concentration as compared to control. A
remarkable decline in length of shoots and roots and no. of leaves of soybean plants was observed on 45th, 60th and 75th DAS under salt stress. Under saline condition reduction of growth has been well documented in various plants by many authors (Senaratna et al., 2000; Sivritepe et al., 2003). It can be suggested that under saline condition suppression of plant growth either may be due to decreased availability of water or to the toxicity of sodium chloride.

Our results exhibited that jasmonic acid also exerted positive effect on vegetative growth parameters of soybean plant (Table 4.1 to 4.6). Application of JA to soybean enhanced yield in the form of pod number and seed weight under salinity stress (Soad, 2007). Similar results were also observed in MeJA treated soybean under drought stress condition (Anjum et al., 2011). Arfan et al. (2007) also reported increased growth and grain yield in salt stressed wheat treated with SA. In their report Sultana et al. (2001) characterized that yield parameters of rice plants found to be decline by seawater. Later on in their experiment, applying JA to salinized plants equally ameliorated the harmful effect of salt.

Present study revealed that exogenous application of 24-EBL was able to promote the growth of soybean plant (Tables 4.1 to 4.6). Growth parameters found to be enhanced especially at $10^{-7}$ M of 24-EBL as compared to control under both saline and non-saline condition in tested crop. Brassinosteroids when applied exogenously have unique growth promoting activity (Mandava et al., 1981). In the present study foliar spray of 24-EBL on soybean plant stimulated the positive response in growth parameters (shoot length, root length, fresh weight and dry weight). Vardhini and Rao (1999) analyzed induction of growth responses by BRs to changes in macromolecules such as nucleic acid and protein.

Salt treatment drastically reduced the growth and its attributes in soybean plants in our study. Similar results were observed in wheat in which salinity reduced the leaf area, leaf length, root and shoot dry weight of wheat (Ashrafuzzaman et al., 2002). Previous study in chickpea (Ali et al., 2009) had postulated that foliar spray of 24-EBL exerted a positive effect in promoting growth and development of plants exposed to saline condition by modulating a number of metabolic phenomena affecting a plant tolerance against salt stress (Ashraf et al., 2010).
Reduction in shoots and roots growth of maize (Khodary, 2004) and soybean (Shalhevet et al., 1995) was also observed under salinity stress. The effectiveness of epibrassinolide on the growth of stressed plants depends on the type of species, developmental stage and concentration of epibrassinolide and mode of application (Amzallag, 2002). Similarly, under abiotic stress exogenous application of BRs also have significant effect in increasing the resistance of pine and rice (Pullman et al., 2003). Application of BR’s enhanced the root growth as observed in maize (Romani et al. 1983) and soybean (Sathiyamoorthy & Nakamura, 1990). According to Zurek et al. (1994), BR’s are thought to be involved in wall loosening of epicotyls in soybean and hypocotyls of Brassica chinensis and Cucurbita maxima (Wang et al., 2001). So increase in the shoot growth of soybean might be due to the stimulation processes of cell responsible for the division and cell elongation. Under stress condition, Chon et al. (2000) reported that application of brassinolide (BL) in rice cultivars enhanced the growth by initiating the coleoptiles and mesocotyle elongation. Further, in Sorghum vulgare application of BR’s declined the osmotic stress by improving length of seedlings fresh and dry biomass of seedling.

Foliar applied SA overcame the salinity inhibited growth of plants of soybean at all the three sampling stages. Similar results were obtained by Shakirova et al. (2003) in wheat, EI-Tayeb (2005) for tomato, Yildirim et al. (2008) for cucumber and Khodary (2004) for maize who reported that application of SA mitigated the adverse effect of salt stress on plant growth. The damaging effect of salinity on plant growth can be reversed by foliar application of SA (Idrees et al., 2011). Our results are in agreement to Gutierrez-Coronado et al. (1998) who reported that foliar application of SA significantly increased the growth of root and shoots of soybean.

It is also evident from the present study that the foliar application of plant growth regulators (SA, 24-EBL, JA) increased the chlorophyll content upto a significant level in soybean plant. The stimulatory effect of SA on photosynthetic pigment in our study is in agreement with those obtained by Barakat and Nassar (2011) on wheat and Saeidnjad et al. (2012) on maize. In another study on Brassica juncea, Fariduddin et al. (2011) also reported that foliar spraying of SA enhanced the net photosynthetic rate, intracellular Co2, water use efficiency, stomata conductance along with transpiration rate. Similar to our findings exogenous application of SA increased the chlorophyll content of soybean leaves as reported by (Khan et al., 2003). As
salinity is known to fluster a multitude of physiological processes including photosynthesis, such salt induced reduction in photosynthesis is in agreement with the earlier finding in *Brassica sp.* (Nazir et al., 2001) and in wheat (Raza et al., 2006). Our results are similar to those of Stepień and Klobus (2006) and Yildirim et al. (2008) who indicated that salt stress significantly declined the chlorophyll content in the leaves of spinach and cucumber with increasing salt concentration. In addition, Shi et al. (2006) reported that under salt stress foliar application of SA significantly enhanced the net photosynthetic rate. In the present study, under salt as well as normal growth condition foliar application of SA leads to significant enhancement in photosynthetic pigments particularly at SA3 level. This enhancing effect of SA on photosynthetic capacity could be attributed to its stimulatory effects on Rubisco activity and pigment contents as well as increased mineral uptake by the plant (Szepesi et al., 2005). Our results are in agreement with some earlier studies in which it was found that exogenously applied SA increased the photosynthetic rate in different crops, i.e, barley (Pancheva et al., 1996), wheat (Singh & Usha, 2003) and maize (Khan et al., 2003; Khodary, 2004). Under salinity stress application of JA enhanced chlorophyll contents and in turn rate of photosynthesis as reported in soybean (Soad, 2007) and *Brassica napus* (Kaur et al., 2013). It has been suggested that treatment of JA increases active cytokinin concentration further which enhanced the chlorophyll accumulation as reported in potato plants (Kovac and Ravnikar, 1994). Reduction in chlorophyll content due to salt stress found to be mitigated by exogenous application of MeJA in pepper plants. Treatment with JA improved chlorophyll content in pigeon pea under oxidative stress (Sharma et al., 2013).

In the present study, foliar application of JA leads to significant enhancement in net photosynthetic rate particularly at JA1 level under salt as well normal growth condition. Under drought stress methyl jasmonate, methyl ester of jasmonic acid, showed positive effects by enhancing carotenoids when applied exogenously to garlic plants. JA treatment could recover the salt induced defects on seedling development and photosynthetic activity in several cultivar crops (Yoon et al., 2009; Javid et al., 2011). Similarly, foliar application of JA improved carotenoid synthesis in presence of drought stress in marigold plants (Sedghi et al., 2012). It was further reported that JA treatment significantly increased carotenoid content in soybean under salinity stress.
Similar results were observed in *Cajanus cajan* plants treated with JA under copper induced oxidative stress (Sharma *et al*., 2013).

In our study, chloroplast pigments (a & b) drastically reduced (Table 4.30, 4.31) under salt stress, as our results agree with earlier work (Gunes *et al*., 1996; Kaya *et al*., 2001). This reduction in chloroplast pigments was found to be maintained by application of SA, JA and BRs in the present study. It has been suggested that application of BRs under salt stress leads to the accumulation of chlorophyll (Anuradha and Rao, 2003; Ali *et al*., 2007). It was further demonstrated that exogenous application of BRs removed the inhibitory effect of salt stress on pigment level as chlorophyll (a, b) and carotenoids are the main photosynthetic pigments and they play important role in photosynthesis. Application of BRs leads to the enhancement in the chlorophyll content indicated that photosynthetic processes were likely to be affected by BRs.

In the present study changes in chlorophyll a, chlorophyll b, chlorophyll (a+b) and carotenoids content in soybean upon supplementation with BRs confirms the hormonal activity of BRs. Foliar application of BRs has been shown to increase the total chlorophyll content and hence net photosynthetic rate in *Brassica juncea* (Fariduddin *et al*., 2009); rice (Farooq *et al*., 2009); wheat (Sairam *et al*., 2005). Our findings are in conformity of earlier researches (Hayat *et al*., 2001; Fariduddin *et al*., 2003; Yu *et al*., 2004) which supported that application of BRs to the non-stressed plants significantly increased the pigment content. The results of the present study also confirm and supplemented the previous observations (Vardhini and Rao, 1999). Biosynthesis of chlorophyll might be inhibited by the depressive effects of stress condition on the absorption of some ions involved in the chloroplast formation such as abscisic acid production, further which may enhance the senescence process as reported by (EI-Bagoury *et al*., 2010). Salt treatment drastically reduced the chloroplast pigments which may results from activation of chlorophyllase enzymes (Gunes *et al*., 1996).

Yu *et al*., (2004) reported that seeds soaked with BRs showed high green pigments at both growth stages. Similar effect of BRs also observed in many other plants. The results of the present study are in conformation with the findings of Fariduddin *et al*., (2003) and Ali *et al*., (2008) in *Brassica juncea*. Bajguz (2000) demonstrated that induction in chlorophyll pigment due to application of BL may be
due to activation of the enzymes involved in chlorophyll biosynthesis associated with a decrease in the level of catabolizing enzymes seems to be the dynamic reason to such an observation.

In the present study, exogenous application of SA maintained the protein content not only under salt stress condition but also under optimum conditions. Our observation are similar to those of Kumar et al. (1999) who reported that total soluble protein content found to be enhanced in soybean plants when sprayed with SA and this increase might be due to enhanced in the activity of nitrate reductase by following the SA application.

According to Levitt (1980) under salt stress decline in the activity of protein content might be due to the reducing availability of amino acid and deformation of enzyme that are necessary in the synthesis of amino acid and protein. Further in another study, wheat leaves when treated with SA provided a significant protection to the enzyme nitrate reductase thereby keeping the normal level of protein (Singh and Usha, 2003).

The declined in the level of soluble protein observed in present experiment (Fig. 4.21) can be related to the reduced rate of protein biosynthesis and increased breakdown of protein under limited environment. As suggested by earlier worker, degradation of protein might be the result of enhancement in the activity protease or other catabolic enzymes, which activate under salt stress or due to toxic effects of reactive oxygen species resulting in reduced protein content (Davies, 1987). Under salt stress condition free radical produced may damage the proteins and reduces its content (Noctor and Foyer, 1998). Due to salinity reduction in TSP also recorded in cotton as reported by Ashraf et al. (2002). This reduction in soluble protein may be due to the reduction of NRA (Ashraf et al., 2002). El-Tayeb (2005) studied conducted on maize conducted that foliar application of SA under saline condition increases the protein and amino acid content. Chandra et al. (2007) reported that application of SA increased the total soluble protein in cowpea plants. In another report it was observed that application of JA, significantly enhanced protein content in Cajanus cajan both in presence and absence of oxidative stress, (Sharma et al., 2013). Similar results were found in JA treated plants such as soybean (Anderson, 1981), rice (Rakwal and Komastu, 2001) and peanut (Kumari et al., 2006).
Present study also revealed that treatment of BRs enhanced the protein content under saline as well as non-saline soybean (Fig. 4.1, 4.2, 4.3, 4.16, 4.21). Enhancement of protein content provoked the transcription and translation processes of specific stress tolerance genes by BRs (Kagale et al., 2007). In rice seedling, exogenous application of BRs overcame the salinity stress by enhancing the synthesis of proteins (Anuradha and Rao, 2001). Activation of the growth of plant tissue and higher levels of RNA and DNA polymerase exhibited by the increase of the DNA, RNA and protein content as manifested by Bajguz (2000). Treatment of mungbean seedlings with 24-EBL exhibit elevated the activity of RNA polymerase and lowered the activity of RNase and DNase (Wu and Zhao, 1993). Our results are correlated with that of Sasse (1990) in which application of BRs can stimulate the synthesis of particular protein associated with growth. Nakajima et al. (1996) demonstrated that supplementation with 24-EBL the culture media increased cell division rate and soluble protein content in Chinese cabbage protoplasts (Sairam, 1994). Treatment with BRs in excised beans induced the protein, DNA and RNA content (Kalinich et al., 1985). Under salinity stress, treatment with BRs markedly increased the DNA and RNA content in maize plants (EI-Khallal et al., 2004). Exogenous application of BRs has been found to be enhanced protein content in normal plant as well as those subjected to different kind of stress (Bajguz et al., 2000; Arora et al., 2008; Behnamina et al., 2009; Anuradha and Rao et al., 2003). Application of BRs significantly increased the growth of the plants further which are associated with enhanced levels of DNA, RNA, soluble proteins and carbohydrate (Vardhini and Rao et al., 1998).

Malondialdehyde (MDA) is the end product of lipid peroxidation which leads to severe damage to various biological macromolecules. In the present study, MDA content was found to be enhanced as plants matured (Fig. 4.4, 4.5, 4.6, 4.17) and under salinity stress, elevated levels of MDA was observed (Fig 4.22). However foliar spray of PGRs alone or in combination lowered the MDA content considerably both under stressed and non-stressed condition. Our results are in agreement with those of Bor et al. (2003) who reported that salt stress increase the lipid peroxidation in the leaves of two beet species. This phenomenon has been observed in rapeseed and wheat under salinity condition (Hasanuzzaman et al., 2011). Parida and Das et al. (2005) also reported that with increasing in the salt stress, electrical conductivity got enhanced thereby indicating an elevated leakiness of ions due to loss of membrane integrity.
Meloni et al. (2003) further reported that MDA was produced when polyunsaturated fatty acid in the membrane undergo peroxidation. However, in salt treated seedlings exogenous application of SA declines the MDA content as compared to salt treatment. In SA treated plants, similar reduction in MDA content was also observed elsewhere (Hayat et al., 2010; Alam et al., 2013). As salt level increase, lipid peroxidation increase depending upon different plant species (EI-Beltagi et al., 2008). This enhancement in lipid peroxidation may be due to the fact that salinity could modify the membrane structure and stimulate O$_2$ production (Zhang et al., 1996). Similarly, SA treatment of wheat leaves under water stress condition resulted in less production of MDA (Agarwal et al., 2005). Foliar spray of SA ameliorated the negative effects of abiotic stress in wheat (Shakirova et al., 2003), cucumber (Yildirim et al., 2008) and maize (Khodary, 2004). It has been observed that low level of the induced leakiness of membrane is caused by lipid peroxidation resulting from uncontrolled ROS increase (Rodrigues-Rosales et al., 1999).

In the present study, enhancement in MDA content was observed under salt as well optimum condition. Under salt condition, generation of free radicals found to be enhanced further which results in disruption of cellular functioning by affecting lipid metabolism process. The reduction in the levels of MDA demonstrates the efficient stress management due to application of BRs. Application of BRs regulated MDA content may be due to the scavenging of ROS and thus declined the membrane destruction caused due to peroxidation of lipids (Cao et al., 2005). Our results co-relate with those of EBL, in which application of EBL mitigated the adverse effect of salt by reducing the MDA content in Lycopersicon esculentum (Slathia et al., 2012). Zhang et al. (2007) reported that seed priming with BL improved the seedling growth in Medicago sativa when subjected to salt stress by reducing the MDA content (Zhang et al., 2007). Application of JA increases lipid peroxidation that was harmful to the cell (Orozco-Cardenas and Ryan, 1999). However application of JA is very much dose dependent along with absence or presence of any type of stress factors. Kumari et al. (2006) reported that application of 24, 100 and 250 µM JA enhanced the MDA content was noticed in peanut seedlings. Bandurska et al. (2003) reported that application of JA protects membrane from damage by various stress factors by declined the MDA content.
Proline, a potent non-enzymatic antioxidant increased in plants when subjected to salt stress (Fig. 4.23) in the present study. Proline, act as a stabilizer for membrane and protein synthesis machinery, a trappe of free radicals, a founder for energy to regulate redox potential as it is an amino acid which acts as a cytoplasmic osmoticum. Also, it serves to protect the protein against denaturation. Accumulation of proline is found to be associated with tolerance against osmotic and saline stress. Its concentration was found to be enhanced either by foliar spraying of SA, JA or 24-EBL or salt stress. Against salinity stress proline is the one of the most important component of the adaptation of plants (Abbaspour, 2012) and pretreatment with SA also contributed to accumulation of this amino acid under stress possibly through maintaining an enhancement level of ABA in the plants (Ervin, 2005). Present study is in conformity with that of Hayat et al. (2010) who reported that application of SA enhanced the endogenous level of the proline content in leaves. Exogenous SA application altered proline oxidase activity in Rauwolfia serpentina under salt stress (Neelam and Rahul, 2012). A large amount of proline found to be accumulated in wheat seedling under salinity stress (Shakirova et al., 2003) thereby upgrading the tolerance against salinity (Yusuf et al., 2008). It is well known that under any type of biotic or abiotic stresses plant need more energy which is provided by energy rich compounds like sugar, protein and proline (Bhattachrjee et al., 2005). Tolerance against salinity stress in soybean was related to the accumulation of soluble protein. Under saline condition, proline supplement enhanced salt tolerance in olive (Olea europea) by amelioration of some antioxidative activities, photosynthetic activity and the preservation of a suitable plant water status (Fariduddin et al., 2003). Priming with SA in chickpea plant under saline condition caused a considerable increasing in proline content (Asadi et al., 2013). Rohwar et al. (2008) reported that proline content was conformed highest in drought stressed shoot tips supplemented to MeJA. Similarly, Anjum et al. (2011) asserted that application of MeJA in drought stressed soybean plant enhanced the proline content and also helped to maintain relative water content with respective to control plant.

In the present study, we also have studied that treatments of plant both in presence or absence of stress enhanced the proline content. The elevation in the proline content on exogenous application of EBL may be due to the activation of the genes of proline biosynthetic pathway (Ozdemir et al., 2004). Our results are co-relate with an
earlier work, who demonstrated that exogenous application of 24-EBL increase the proline content in plants (Vardhini and Rao, 2003). Due to application of BR increase in the pool of proline resulted in increased in tolerance against salt further which manifested in terms of improved growth and photosynthesis. Against salinity stress assemblage of proline content is a common metabolic response of higher plants. Under the effect of stress an enhancement in the proline content has been reported for various plants such as sugar beet (Ghoulam et al., 2002) and rice (Demiral and Turkan, 2005). Accumulation of proline under salt stress acts as an antioxidant by stabilizing the membrane and scavenging of ROS (Bandurska, 2001; Sharma and Dietz, 2006). The exogenous application of 24-EBL under salt stress plants leads to decrease in proline content. The significant decline in the proline levels of this compatible is in keeping with the previously observed properties of these plant growth regulators (Sasse 1997, Gonzalez-Olmedo et al., 2005). Elevation in the proline content under salt stress has an action on lowering the generation of free radicals associated with declined in the lipid peroxidation linked membrane damage resulting in their stabilization (Cao et al., 2005). The results of the present study are also consistent with finding of Vardhini and Rao (2003) on sorghum. Accumulation of proline in plant tissue due to application of EBL may be associated with reduction in proline utilization due to minimum protein formation, proline degradation and enhancement in proline formation due to the hydrolysis of protein (Shahid et al., 2011).

Oxidative stress occurs when there is a serious imbalance in any cell compartment between the production of ROS and antioxidative defence, thereby leading to damage (Fig 5.2). From the present work it was evaluated that antioxidant enzyme activities of soybean plant were increased in response to different concentration of SA. Oxidative stress which is generated in the plants can be removed with the help of antioxidant enzymes activity. Elevation in the antioxidative system is one of the possible mechanisms against salt tolerance in soybean cultivars. Erasalan et al. (2007) reported SA act as antioxidant. In the present study it was conformed that oxidative damage which is induced by salt stress might be reduced by exogenous application of SA, later on its buildup a protective mechanism to plant. Furthermore, Ghassemi-Golezani et al. (2009) reported that under saline condition accumulation of non-enzymatic and enzymatic antioxidant compounds is positively correlated with tolerance. In plants at various concentration of SA like $10^{-7}$ M or $10^{-4}$ M antioxidant
activities like guaiacol peroxidase (POD), ascorbate peroxidase (APX), superoxidase dismutase (SOD) and glutathione reductase (GR) have all been reported to showing different changes (Sakhabutdinova et al., 2003). Similarly, our results indicate the role of JA in plant defense mechanism which involved assemblage of more antioxidant system SOD, POD, CAT and contribute to investigation of JA role in soybean cultivars. Application of JA enhanced antioxidant activity up to some extent which helps the plant upgrading its antioxidant capacity to scavenge more free radicals. Stress resistance in plants found to be increase by enhancing the activity of CAT, SOD and POX as compared to corresponding drought stress level after pre-soaking plants with MeJA.

Present study co-relate with that application of JA activate the enzymatic and non-enzymatic antioxidant of Wolffia arrhiza (Piotrowska et al., 2009). These results are in agreement with Majid et al. (2006) who found that MeJA increased the production of several antioxidant enzymes. Exogenous application of MeJA under drought stress in case of strawberry and maize seedling mitigates the ROS effects (Norastehnia et al., 2006).

Further it was found that application of low concentration of SA increased the activity antioxidant enzymes like CAT, APOX, GPOX, SOD. This increase in the activity of antioxidant enzymes might be due to the regulatory role of SA at the level of transcription/Translation. Foliar spray of SA to soybean plant leads to significant increased in SOD and CAT activity. Similarly, Yusuf et al. (2008) observed that supplementation of SA enhanced the activities of POD, SOD and CAT when sprayed exogenously under salt stress Brassica juncea. Among the enzyme here, CAT and SOD most effective in preventing cellular damage by converting superoxide anoin to H₂O₂ to H₂O (Scandalios, 1993).

It was found that increased SOD activity was accompanied by increase in CAT and POD because of high demands of H₂O₂ quenching. It was clear that increment in SOD and POD simultaneously affect each other. First line of defense which was provided by SOD against the cellular due to environmental stress along with its major superoxide scavenger. Gossett et al. (1994) reported that oxidative stress generated by salt stress leads to the inhibition of the carbon dioxide assimilation, exposing chlorooplast to excessive excitation energy, which in turn enhances the production of ROS from triplet chlorophyll.
Fig 5.1 Possible mechanism of action SA, BRs and JA in alleviating salt stress
Imbalance between the production of ROS and antioxidative defence system leads to stress (modified after Mittler, 2002)

Fig. 5.2. Imbalance between the production of ROS and antioxidative defence system leads to stress (modified after Mittler, 2002)
Similarly, in leaves of maize saline condition resulted in significantly higher SOD activity (Fahad and Bano, 2012). In another study, Senaratna et al. (2000) reported that SA confers tolerance to pepper plants and the tolerance was associated with changes in antioxidant system. Catalase found to be a major enzyme in salicylic acid induced stress tolerance, which varies according to the time of its assay and intensity of stress (Chen et al., 1993). Generally, enhancement in the activity of CAT is a strategy for improving the salt tolerance. In our present study activity of CAT significantly increased after treatment of SA under salt stress as well as optimum condition which suggest an unambiguous role of SA in scavenging H$_2$O$_2$. Our results are in agreement to those of that supplementation of SA under salt stress enhanced the activity of CAT (Yusuf et al., 2008; Noriega et al., 2012).

Plant evolves antioxidant defense system for scavenging ROS and to counter the oxidative stress. Bajguz and Hayat (2009) investigated that application of BRs have the potential to regulate the activities of various antioxidant enzymes like SOD, POD and CAT in plants grown under a stressful environment. SOD consider as the most efficient scavenger of the superoxide anion (Gill and Tuteja, 2010). Under salt stress, Faba beans plants induced the activation of antioxidant enzymes such as SOD, POD and APX in the leaves. Our results are in agreement with those of Hassanein et al. (2009), who reported application salt stress enhanced the activities of antioxidant enzymes in leaves of *Zea mays* plants. Plants have the potential to neutralize the ROS generated under oxidative stress by synthesizing the antioxidant activities like SOD, POD and CAT (Seckin et al., 2010) as well as some non-enzymatic antioxidant activities ascorbic acid, tocopherols, carotenoids and flavonoids. Experimentally it has been proved that exogenous application of BRs could enhance the expression of antioxidant genes and increase the activities of some enzymes including superoxide dismutase, peroxidase and catalase (Xia et al., 2009). In rice grown under salinity higher activity of antioxidant system were observed by (Nunez et al., 2003) . Our results are in conformity with those of earlier work which showed that exogenous application of BRs modified the antioxidant enzyme activity (Arora et al., 2008; Ali et al., 2007). Similarly under water deficient enhancement in POD activities in soybean plant due to application of BRs (Zhang et al., 2004). An increase in POX activity in response to the application of BRs has also been reported (Arora et al., 2010).
Under water stress supplementation of BRs resulted in further elevation of CAT activity. Production of H\textsubscript{2}O\textsubscript{2} always accompanied by decomposition of O\textsubscript{2} which diffuse across the plasma membrane and act as both antioxidant as well as reductant (Foyer et al., 1997). Application of BRs further increase the oxidative stress resistance in Arabidopsis by increasing the transcript levels of defense gene CAT. Our results agree with Behnamnia et al. (2009) who reported that foliar sprayed of 24-EBL enhanced the CAT activity under drought stress in *Lycopersicon esculentum*. Application of BRs enhance the oxidative stress resistance in Arabidopsis by elevated the transcript levels of defense gene catalase (Cao et al., 2005). After treatment of BRs activity of CAT found to be elevated, it has been reported earlier in groundnut (Vardhini and Rao et al., 1998); Zea mays L. (Bhardwaj et al., 2007; Arora et al., 2008); tomato et al., (Behnamnia et al., 2009); *Brassica juncea* L. et al., (Arora et al., 2008; Sharma and Bhardwaj, 2007). It may be inferred from the enhancement in CAT activity that BR application modulated the antioxidative metabolism resulting in better growth of plants (Vardhini and Rao et al., 1998).

Salicylic acid functioned as endogenous growth regulators of flowering and florigenic effects conformed by Raskin et al. (1987). The results of the present study are in conformity those of Hayat et al. (2007) who demonstrated that under non-stress condition the increase in plant yield performance has been reported by many crops including safflower and many vegetables crops. Gomes et al. (1993) also reported an improvement in yield of wheat genotype under water stress with SA application. Martin- Mex (2005) reported that fruit yield enhanced significantly when the lower concentration of SA were sprayed on cucumber and tomato. In case of number of seeds per plant, SA3 treated plants produced more seeds than that of control followed by EBL and JA. This increase in number of seeds may be attributed to the increased in number of branches, leaves and pods per plant in the present study (Table-4.3,4.4,4.11, 4.15,4.16,4.23). It was also demonstrated that foliar application of SA enhanced the flowering and pod formation in soybean plant (Hayat, 2010). Present study revealed that foliar spray of SA to soybean cultivars enhanced the yields and its attribute. When the lower concentration of SA applied the fruit yield in cucumber and tomato enhanced significantly as reported by (Ayala-Zavala et al., 2004). It was reported that exogenous application of SA also enhanced the flowering and pod formation (Kumar et al., 1999).
Combined effect of SA3 and EBL2 recorded higher yield than that with SA3 or EBL2 alone. SA3 at $10^{-6}$ M in combination with EBL2 at $10^{-7}$ M exhibited highest additive effect increasing number of pods per plant by 43.6 percent as compared to 37 percent at SA3 and 18.9 percent at JA alone. Combination of (SA3 +EBL2) also increased the number of seeds per plant significantly (Table 4.23). The present finding are in agreement with the reports of (Khodary et al., 2004; EI –Tayeb, 2005) where they demonstrated that application of SA increases the fruit weight and fruit per plant. Pieterse and Muller (1977) concluded that exogenous application of SA by acting as a chelating agents induced flowering in plants. Similar growth promoting responses due to foliar sprayed with SA have been reported in barley seedlings (Pancheva et al., 1996; Shakirova, 2007; Pirasteh-Anosheh et al., 2014). In this study it was shown that under salinity condition foliar applied SA improved the grain number in the plants. Beneficial effect of SA on improvement in grain number might be achieved through improving growth attributes such as photosynthetic capacity along with the rubisco activity.

Application of salt stress leads to the reduction in yield of various crops as reported by (Abbas et al., 2010; Gay et al., 2010). In the present study, application of EBL significantly overcame the adverse effects of salt stress improving number of seeds per pod, seed weight, yield per plant and seed proteins as compared to control. Our results are also similar to the findings of Ali et al. (2007) who reported that treatment of *Cicer arietinum* with BRs significantly increment in seed weight, seed protein and plant yield.