Response of Maize to salt stress a critical review

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Abstract: **Maize is the important cereal crop which is the basic need of food and oil for human intake. It is also used as feed for livestock throughout the world but this crop is normally submissive to salt stress. Salinity is the most important abiotic stress that inhibits growth and productivity of crop. The salinity is worldwide problem that limits the growth and productivity of all vegetation's and it is going to increasing day by day. The salt stresses affect badly to the plant morphology, functioning, and homeostasis and decrease the plant biomass. But the exogenous applications of different plant growth regulators such as IAA enhance the plant growth, development, maintaining plant cell ion constancy and raise the plant biomass. The objective of the investigation was to study the response of Maize (Zea mays L.) in term of morphological, physiological, chemical and biochemical characteristics under salt stress conditions.**

Keywords: **Zea mays L., Salt stress, Morphological, Physiological, Biochemical attributes, (UOG) Pakistan**

I. INTRODUCTION

Maize (Zea mays L.) is used as a breakfast cereal crops in the sphere.Maize is the important cereal crop which is the basic need of food and oil for human intake. It is also used as feed for livestock (Hussain et al., 2010) throughout the world but this crop is normally submissive to salt stress. Salinity is the most important abiotic stress that inhibits growth and productivity of crop. Salt stress had adverse effects on the functioning and metabolism of plants considerably hinders the productivity (Khan & Srivastava, 1998). It provides essential food to many people. For farmers maize is a key basis of earning in which numerous have less resources frequently in evolving countries (Tagne et al., 1998). According to (Tagne et al., 2000) in the world maize agriculture is declined due to illnesses which result in loss of scrap about 11% of the whole production. To governor the maize illnesses it is very important to use opposite equipment to raise the maize yield. Above several periods many methods have been used to check the ailments in maize harvest. The vital oil taking out from three perfumed plants have been used to control of seed-borne fungi that contaminating the maize seeds.Maize (Zea mays L.) is the best key yield in Pakistan, which used as nutrition and corn oil to social desires, feed stuff of livestock and fowl and an outpoured matter for agro-based productions. Salinity has diverse outcome on plants for example salt in the soil solution diminishes the accessibility of water to the roots and the salt reserved in the plant will raise to poisonous points in several tissues of plants (Munnus et al., 1995).

Yield of maize has improved by means of progress tools by farmers. These skills involved better seeds alike crossbreed and open fertilized cultivars that are used, establishing in correct time, virtuous gaps and dig over at the suitable time and gathering in time. Soil potency improved by fertilizers which stimulated as well as declines weeds via herbicides. One of the severe ecological difficulties is salinity which effects osmotic pressure and decline in plant development and harvest of yield in water regions of dry and semi-arid parts. Salinity is the essential profit falling element in the farming yield in some ranges (Hasegawa et al., 1986). By means of dissimilar factors acceptances by other ecological strains as in the plants salinity can be measured. Plants that are underneath pressure in front of the difficult of reduction in osmotic potential by engaged open amino acids, ions and materials that are dissolvable. Through this technique, osmotic alteration is desired (Weimberg, 1986, 87; Salama et al., 1994). On behalf of measure the plant acceptance to salinity by means of process of the extent of proline application is a vital technique (Palfi & Juhasz., 1971). In plants that are in front of the difficult of salt stress osmotic pressure of vacuole fall gathering of proline.The salt strain effect is to reduce the plant progress which is result not simply causes of osmotic properties on water application but as well as due to numerous effects on metabolism of plant cell that are able to dissolve due to salt stress (Hussain et al., 2010). Fall in development of plants is typically due to severe possessions of salt stress on many other natural and functional procedures (Majeed et al., 2010). The absorption of ions in shoots, roots and leaves are retained through altering ion passage to diminish salt pressure (Tester et al., 2003). The response of plants to increased salinity is complex and included changes in plant morphology, physiology and metabolism (Parida & Das, 2005). Morphologically the most common symptom of saline problems for plants is reduction of their growth, (Azooz et al., 2004), which is due to result of many physiological responses including modification of balance of ions, water quality, mineral nutrition, photosynthetic efficiency, carbon accumulation and utilization (Sultana et al., 2002).

To see the high request of nutrition particle for people that are quickly rising there are several harvests raising agronomic procedures such as claim of various plant growth hormones that desires care. While plant advance controllers have been cast-off in cultivation for as long time their effects at this time has been comparatively slight detected and their request is one restricted to certain exact drives such as superiority and amount expansion (Pandey et al., 2001).Plant hormones are frequently formed internally from plants, yet, some researches exhibited that plants can react to the externally applied use of these substances. An internal hormonal design of the plant essential is exaggerated by outside use of plant growth hormones which altered the existing hormone stages (Arshad & Frankenberger, 1993). Hao and Ichii (1999) described main auxin resilient changed in rice (Oryza sativa L. ssp. japonica cv. Oochikara) in a shade for 2, 4-dichloro phenoxy acetic acid (2, 4-D) conflict and called it as Lrt1 (lateral rootless). It similarly exhibited conflict for artificial auxin 1-naphthaleneacetic acid and usual auxins indole-3-acetic acid and indole-3-butyric acid (Chhun et al., 2003).Plant hormones are consequently chief applicants for the ruling of this procedure of relationship and are identified to perform a more chief part in various supplementary growing methods (Davies, 1995).The internal amount of IAA and indole-3-butyric acid (IBA) was over again inspected by means of these delicate techniques, in mycorrhizal and main roots of maize (Ludwig-Muller et al. 1997).

The improvements of development of several plant classes over achievement of amino acid was studied by Phillips (1971), who described that numerous additional procedures of IAA manufacturing are current in plants and all initiate from amino acids. Russell (1982) informed that, the improvement in progress due to characteristics of amino acids could be due to altering of amino acids into IAA.An originator of iodole acetic acid (IAA) is zinc that is needed for the working of best enzymes, as well as the development for tryptophan. Zn and IAA shortages results in physical ailments in plants such as "little leaf disease" in fruit trees. In this result reduction of IAA construction in Zn-deficient might be result of repressed production or raises the degradation of IAA (Cakmak et al., 1989). Below Zn shortage the tryptophan, which is the instant originator of IAA, heightened, indicates that this amino acid was not the restrictive aspect in IAA. The substances that affect the plant progress when provided in exact slight quantity plant growth controllers. There is a number of information that showed the use of growth organizer enlarged progress of plant and construction of yield of the harvest (Ashraf et al., 1987, 1989; Hernandez, 1997).

The principal identified universally manufacturing auxin is indole-3-acetic acid (IAA), but various other similarities have also been described in certain classes. This halogenated composite have very great auxin-like action (Reinecke et al., 1995), displayed in the development of removed tissue (Katekar & Geissler 1982), rootling privileges kept.In adding, a rise of the financial income has also been established due torise of the amount of photosynthesis (Ahmad et al., 2001b). These hormones have diverse properties on plant functioning and conservational procedures, and are also have role in the organization of cell split, apical domination, anthocyanin creation, chloroplast improvement and have role in the source-sink association (Hutchkinson & Kieber, 2002).Plant morphogenic roles may be an outcome of diverse stages of plant hormones created by roots as wellas by rhizosphere bacteria (Muller et al., 1989). Various soil microorganisms containing bacteria (Muller et al., 1989), fungi (Stein et al., 1985) and algae (Finnie & Van Staden, 1985) are talented to manufacture physiologically vigorous amounts of auxins that may end an enormous quantity of roles in plant development and preservation. There is similarly stated that the hormones manufactured by the bacteria sometimes improve growth degrees and rise harvests of the host plants (Arshad & Frankenberger, 1991; Sarwar & Frankenberger, 1994). For example, a root is one of the plant's structures which are best delicate to fluctuations in IAA and its properties to improve amounts of externally applied IAA ranges from increase in length of the main root, making of adjacent and adventitious roots (Finnie & Van Staden, 1985).It is currently usually established that indole-3-acetic acid (IAA) is the actual significant and best plentiful auxin in plants. IAA shows a key role in the organization of plant expansion and development (Moore, 1989; Lüthen et al., 1999; Davies, 1995).

Changes in morphological attributes of Maize due to salinity:

Hussain et al. (2010) reported that changes in morphological attributes of Maize (Zea mays L.) under NaCl salinity. Bojovic et al. (2010) was conducted an experiment to determine the effects of NaCl on seed germination in some species from families Brassicaceae and Solanaceae. The ability of seeds to germinate at high salt concentration in the soil is crucial importance for the survival and perpetuation of many plant species.

Khatoon et al. (2010) determined the morphological variations in maize (Zea mays L.) under different levels of NaCl at germinating stage. Perti dishes experiments were conducted at Botany lab of University of Gujrat-Pakistan during 2010 for the study of NaCl effect on maize (Zea mays L.) at germinating stage. There were three levels of NaCl applied on growth medium of germinating seeds. All the growth attributes such as germination %, root and coleoptile lengths and plant fresh weight reduced with increase in salinity levels. It was concluded that salinity had adverse effect on growth of maize. NaCl concentrations at germinating stage could have much adverse effects on maize than later stages of growth.

Usman et al. (2012) found that Effect of NaCl on Morphological Attributes of Maize (Zea mays L.) Checking out the response of maize (Zea mays L.) to the salt NaCl, the experiments being conducted at research Centre of Hafiz Hayat Campus University of Gujrat. The outdoor CRD experiments were used for this purpose. It was observed that maize show sensitive response against NaCl, as the salinity levels goes on increasing gradually; it greatly reduces the growth parameters. The morphological responses against the NaCl treatments are studied. These morphological parameters included Shoot, Root Length, Fresh and Dry Weight etc. There is a great variation exists for the morphological attributes. The reduction in different growth parameters results gradually from T1 to T2 (20mM to 40 mM), as compared to the control group. It is the clear indication that the plants which are salt sensitive do show reduced yield under the high salinity conditions. The Morphological changes do indicate the fact that the plant is suffering in its metabolic activities which clearly makes a guess towards the disturbance.

Changes in physiological parameters of Maize due to salinity:

Cicek et al. (2002) found the effect of salinity on some physiological parameters in two maize cultivars. Ragab et al. (2006) founded the influence of exogenous application of Silicon on physiological response of salt stressed maize (Zea mays L.). The influence of silicon (Si, 3 mM), sodium chloride, and Si, 3 mM + NaCl, 135 mM supply on chlorophyll content, photosynthetic activity, the concentration of malondialdehyde (MDA) and H2O2, activities of superoxide dismutase (SOD), catalase (CAT) enzymes, free proline and protein contents were studied in maize seedlings leaves after two month of treatments. The results indicated that silicon partially offset the negative impacts and increased tolerance of maize to NaCl stress by enhancing SOD and CAT activities, chlorophyll content and photosynthetic activity. Salt stress although decreased SOD, CAT activities and total soluble protein content, addition of silicon (3 mM) to the nutrient solution enhanced SOD and CAT activities and total protein. In contrast, salt stress considerably increased H2O2, free proline level and MDA concentration and Si addition significantly reduced H2O2, free proline level and MDA concentration in stressed maize leaves. Enhanced activities of SOD and CAT by Si addition may protect the plant tissues from salt induced oxidative damage, thus alleviating salt toxicity and improving the maize growth. These results suggest that the searching system forms the primary defense line in protecting oxidative damage under salt stress in crop plants.

Biochemical reaction of maize under salt stress:

Zorb et al. (2004) found the biochemical reaction of maize (Zea mays L.) to salt stress is characterized by a mitigation of symptoms and not by specific adaptations. Eker et al. (2006) conducted an experiment to found the effect of salinity stress on dry matter production and ion accumulation in hybrid maize varieties. The salt stress tolerance of 19 hybrid maize (Zea mays L.) varieties were tested in nutrient solution during the early growth stage under controlled environmental conditions. For the salt stress treatment, sodium chloride (NaCl) was applied to nutrient solution at a concentration of 250 mM for 6 days before the harvest. Plants were harvested after 17 days of growth and analyzed for shoot and root dry matter production, severity of leaf damage (necrotic patches on older leaves), and the concentrations of potassium (K), sodium (Na) and calcium (Ca) in the roots and shoots. The varieties differed greatly in their response to the NaCl treatment. The development time and severity of leaf symptoms caused by 250 mM NaCl were varied markedly among the varieties. Based on the severity of leaf symptoms, the varieties Maverik and C.7993 were classified as the most tolerant and sensitive varieties, respectively. The decreases in the shoot dry matter production as a consequence of the NaCl treatment were higher than the decreases in root growth. The higher salt tolerance in maize varieties based on the severity of leaf symptoms was associated with significantly lower Na concentrations in shoots. The K/Na and Ca/Na ratios were significantly greater in most of the tolerant varieties. The most sensitive variety, C.7993, contained a 4-fold greater Na concentration in shoots than the most tolerant variety, Maverik. The varieties RX.9292 and MF.714 also contained very high Na in shoots and showed severe toxicity symptoms on leaves. Besides Maverik, P.3394 and P.3223, with their low shoot Na concentrations, could also be considered tolerant varieties. Under salt treatment significant correlations were found between K/Na ratios and shoot dry matter production ($r = 0.541^{***}$), K/Na ratios and leaf damage ($r = -0.411^{***}$), and Ca/Na ratios and shoot dry matter production ($r = 0.444^{***}$). The results indicate the existence of a large genotypic variation in tolerance to NaCl toxicity in maize that should be exploited in breeding programs aiming to develop maize varieties with high NaCl tolerance during the early growth stages.

Due to salinity membrane changed patchy that results in decay of chlorophyll (Ashra et al., 2005). (Iqbal et al., 2006) also told that drop in chlorophyll matters as a result of salt stress. According to Al-aghabary et al., 2004 both chlorophyll a and chlorophyll b content reduced due to salt stress; however, IAA actions better them under salt tension.It has been noticed that the rate of CO_2 reduced to NaCl pressure and fall the applications of leaf chlorophyll of barley (Popova et al., 1995) and bean (Sibole et al., 1998). These results were similar with that of Liang (1998) and Al-aghabary et al., 2004, who start that chlorophyll content and photosynthetic deed of salt-treated barley and tomato increase due to addition of Si. In this way (Jacobs, 1979) reported that, may be IAA performances such as coenzyme in the breakdown in higher plants, thus it perform a major part in the increase of the photosynthetic pigments. Naguib et al., 2003 working on periwinkle indicated that most clear raise in chlorophylls a and b amounts were due to applications of IAA at 100 ppm. Transpiration rate reduced due to salt stress.

When salt move in plant tissues and it reduce the osmotic pressure and as a result plants close their stomata and then transpiration rate decreases. Similar results were found by (Davies & Wareing, 1965) they told that, IAA produced a backing movement of nutrient and quickly having an influence on the transportation method (Altman & Wareing, 1975).Earlier study also tells that plants have to close their stomata due to loss of water under salt stress (Chatrath et al., 2000).According to Weimberg, (1987), high conc. of Na+ prevent the K+ application that result of in the increase of Na+/K+ ratio. It was suggested that the characteristic of ion collecting of plants is related to their taking of salt stress. It was originate that accepting types added decrease Na+, and dropping of K+ was smaller than other species (Weimberg, 1986, 1987; Hagibagheri et al., 1989; Tipirdamaz and Çakirlar, 1989).Watering effect induced due to salt has former been found in many crops, e.g. Lycopersicon esculentum (Al-Karaki et al., 2001), Spinacia oleracea (Kaya et al., 2001), Physalis peruviana (Miranda et al., 2010), as well as in Zea mays L.(Collado et al., 2010). Membrane absorbency (MP) typically reviewed as outward movement of electrolyte is a major sign of membrane consistency in plants that are endangered to pressure conditions (Farkhondeh et al., 2012; Mansour, 2012).

Enhancement of growth with different plant growth regulator:

Plant hormones play a great role in the plant development, the definite effect reliant on the uses of the constituents extant and the compassion of the tissue anxious. Similar results were detected by Chaudhary (1995 & 1997). Babu et al. (2012) found that the effect of salinity on growth, hormones and mineral elements in leaf and fruit of tomato cultivar pkm1. Tomato cultivar PKM 1 were subjected to 25, 50, 100, 150 and 200 mM NaCl stress and response of tomato plant to salt stress were determined by assessing the variability of different biochemical parameters. In this present study endogenous content of growth hormones IAA and ABA in leaves, proline and mineral (Na+ and K+) content in leaves and mature fruits were estimated. Leaf area and dry matter content of tomato fruits under salt stress were determined to study the effect of salinity on photosynthetic yield. Results showed that leaf area and dry matter content of tomato fruits decreased with application of elevated salt stress, however endogenous content of IAA, ABA and proline was found to be increasing with increase in salt treatment. Application of NaCl caused increase in Na+ content, while K+ content and K+/Na+ ratio decreased with increase in salt stress.

Effect of NAA on plants growth:

Bakhsh et al. (2012) found that effect of plant growth regulator application at different growth stages on the economical yield potential of coarse rice (Oryza Sativa L.) The study was conducted to find out the growth behaviour of transplanted coarse rice as influenced by plant growth regulator (NAA) under the agro climatic conditions of Dera Ismail Khan, Pakistan, during 2004 and 2005 using Randomized Complete Block Design with split plot arrangements. Main plot consisted of three critical growth stages of paddy rice, namely S1 (tillering) S2 (panicle initiation) and S3 (grain formation stage), while sub plot contained four levels of 0, 60, 90 and 120 ml ha-1 of plant growth regulator (Naphthalene Acetic Acid). The data was recorded on plant height (cm) at maturity, number of panicle (m-2), number of spikelets panicle-1, 1000-grain weight (g) and paddy yield (Mg ha-1). The effect of plant growth regulator levels, growth stages of paddy rice and interactions between them were found highly significant in term of enhancement in paddy yield and yield components. The application of plant growth regulator at 90 ml ha-1 at the stage of panicle initiation proved most beneficial in terms of attaining 130.4cm and 130 cm as maximum plant height, 324.5 m2 and 328 m2 as highest number of panicles, 164.3 and 168.5 as maximum number of spikelets panical-1, 78.5% and 80.5% as maximum normal kernels, 20.76g and 21.02g as higher 1000-grain weight, 7.65 Mg ha-1 as economical paddy yield during 2004 and 2005 respectively.

Effect of IAA on plants growth:

IAA pays role in plant development by improving photosynthetic and activities of spreading leaves in plants. It also starts the movement of carbohydrates during their manufacture (Ritenour et al., 1996; Awan et al., 1999). Shahab et al. (2009) reported that Indole acetic acid production and enhanced plant growth promotion by indigenousPhosphate solubilization(PSBs). Thayamini et al. (2009) found that Influence of Indole Acetic Acid (IAA) on the establishment of stem cuttings in lemon (Citrus lemon L.) The treatments included five IAA concentration along with a control (distrilled water). Lemon cuttings having three nodes were dipped in IAA concentrations and distilled water as control. Then these cuttings were planted in polythene bags containing soil and cow manure with ratio of 2:1. IAA treated cuttings performed better in all growth parameters compared to control. It was further noted that after 8th weeks of planting, shoot length (5.73 cm), rooting percentage (73.33%) and survival rate (90.0%) of cuttings were significantly higher in cuttings dipped in 2500 ppm IAA concentration than other treatments. The data also showed that growth parameters were gradually increased with increase in IAA concentration from 0 ppm to 2500 ppm. The exogenous supply of IAA had a positive effect on the establishment of stem cuttings of lemon and application of 2500 ppm IAA prove to be the best treatment for better root and shoot formations.

Due to IAA the fall in root length was earlier indicated by (Pilot & Saugy; 1985). Lee et al., (2000) informed that IAA affects increase in length when they were working on Zinnia cultures. However, the existing results do not satisfy with these results. The fall in length was going along with extension in width of sprout. In present studies the exogenous applications of 50ppm IAA and 25 ppm IAA under salt stress improve the root and shoot length through raising the absorption of water and mineral. These results were similar with the effects of (Mukhtar, 2004; Chauhan et al., 2009). The enhancing effect of growth hormones in a definite amount is an important characteristic. The IAA has more obvious influence on the root fresh and dry weight of root and shoot of maize varieties critically disturbs due to salt stress. These results are similar to earlier results of reduction in plant growth due to salt stress (Ashraf & McNeilly, 1990; Mishra et al., 1991; Ashraf & O'leary, 1997). From these results it was observed the fresh and dry weight of shoot and root improve due to exogenous application of IAA. These results were similar with earlier (Hartman et al., 1990; Davies, 1995). It was confirmed from previously research on salinity because fall in the growth of leaf were (Brungnoli & Lauteri, 1991; Alberico & Cramer, 1993). But, it was reported that leaf area was not constant symbols of salt tolerance (Alberico & Cramer., 1993). Touminen et al., (1997) identified that due to IAA similar enlargement in leaf area occur.

Effect of IAA and Kinetin on plants:

Shoukat H.S. (2012) reported that Comparative effects of 4-Cl-IAA and kinetin on photosynthesis, nitrogen metabolism and yield of black cumin (Nigella sativa L.). The leaves of 40-day old plants of black cumin (Nigella sativa L.) were sprayed with 10–7, 10–6, 10–5M4-Cl-IAA, and 10–6, 10–5 and 10–4M kinetin. Both the hormones improved vegetative growth, photosynthetic efficiency and seed yield of the test plants as compared to deionized water (control). However, 10–6 M 4-Cl-IAA was most prominent in its effect, generating 42, 30, 40, 41 and 51% higher values for carbonic anhydrase, nitrate reductase, net photosynthetic rate, leaf protein content and dry mass respectively, as compared to the control in 70-day old plants. Similarly, capsule number and seed yield per plant were elevated by 41 and 43% over the untreated control at harvest (130 days after sowing) following the same treatment. Overall, the auxin showed a higher efficiency than kinetin in all treatment concentrations.

Auxin Transport:

Naqvi et al. (1965) found that Auxin Transport in Zea mays L. Coleoptiles I. Influence of Gravity on the Transport of Indole acetic Acid-2 14C1. 'IC-methylene labeled IAA was used to determine the influence of reorientation with respect to gravity on auxin transport in Zea mays L. coleoptile segments. It was observed that inversion of the segments leads to a decrease in the capacity to transport 1'C-IAA basipetally, as well as, in certain instances, the linear velocity of that transport. Segments were also reoriented horizontally, and the transport velocity and capacity of the upper and lower tissue halves compared with vertical halves. There was no significant change in the velocity, but the transport capacity of lower halves was higher than that of the vertical halves, which in turn was higher than the capacity of the horizontal upper halves. It is suggested that the geo curvature of horizontally placed coleoptiles may be caused primarily by the effect of reorientation on auxin transport.

Effect of combination ofauxin and cytokinins:

Ezeibekwe et al. (2009) reported that effects of combination of Different Levels of Auxin and Cytokinins on in Vitro Propagation of Dioscorea Rotundata L. (White Yam).

Effect of auxin and cytokinins in callus induction:

Gopitha et al. (2010) found that Effect of the different auxin and cytokinin in callus induction, shoot, root regeneration in sugarcane Studies on micro propagation of callus culture was undertaken. Which explants were inoculated in MS medium fortified with various concentration of 2, 4-D, auxin, cytokinin, sucrose at different pH level .Best regeneration of shoot was achieved when they were cultured on MS medium supplemented with BAP 1.0mg/L and IBA 0.5mg/L. Among the different media tested with 3mg/L NAA and 5% sucrose supplemented media proved best production of roots.

Effect of macronutrients and micronutrients with IAA on plants growth:

Ahmed et al. (2012) found that the Effect of Zinc, Tryptophan and Indole Acetic Acid on Growth, Yield and Chemical Composition of Valencia Orange Trees. The present study was carried out during two successive seasons of 2003 and 2004 to study the effect of different levels of Zn (0, 37.5 and 75 ppm), tryptophan (25, 50 and 100 ppm) and IAA (100, 200 and 300 ppm) foliar applications on growth, fruit yield and fruit quality of Valencia orange trees. Also, the replacement of Znfoliar application with tryptophan or IAA was investigated. Generally, the results reveal that all treatments improved growth characters (shoot length, shoot thickness, leaves number, and leaves area), yield and fruit quality through their favorable effects on leaves chemical composition (plant pigments, total sugars, total soluble phenols, total free amino acids, tryptophan and endogenous plant hormones balance of leaves) as well as nutritional status (N, P, K, Mg, Zn, Cu, Fe and Mn concentrations) of leaves. Moreover, the results indicate that, tryptophan foliar application at the rates of 25, 50 and 100 ppm and IAA at the rates of 100, 200 and 300 ppm, to some extent; can be replace zinc foliar application at the recommended dose (37.5 ppm Zn).

Saber F. Hendawy et al. (2012) found that Response of Two Species of Black Cumin to Foliar Spray Treatments. Field experiment was carried out to investigate the effect of fertilizer foliar spray treatments on the growth, fixed oil and fatty acids contents of Nigella sativa and Nigella damascena plants. Foliar spray, black cumin species and their interactions had a significant effects on the growth characters, fixed oil and fatty acids contents of both Nigella sativa and Nigella damascena.

Alleviation of salt stress:

Kaya and Okant (2013) found that alleviation of salt stress-induced adverse effects on maize plants by exogenous application of indole acetic acid (IAA) and inorganic nutrients. The effects of indole acetic acid (IAA) and inorganic nutrients (K and P) on some physiological parameters and kernel yield of maize (Zea mays L.) were investigated in two parallel experiments conducted in the same growth season in a saline field. Sodium chloride equivalent to 100 mM was added to the irrigation water and saline water applied to the field using a drip irrigation system. Indole acetic acid was applied as foliar spray. Potassium and P were applied to the soil at the sowing time. Salinity significantly reduced shoot dry mass, cob yield, total kernel yield, weight of 1000 kernels, chlorophylls “a” and “b” and relative water content in the maize plants, but increased proline accumulation, activities of the key antioxidant enzymes superoxide dismutase (SOD; EC 1.15.1.1), peroxidase (POD; EC. 1.11.1.7), catalase (CAT; EC. 1.11.1.6) and polyphenol oxidase (PPO; 1.10.3.1), and electrolyte leakage. However, application of K and P or foliar spray of IAA mitigated the adverse effects of salinity on maize plants. The most promising effect of IAA or K and P on alleviation of salt stress on maize was found when they were applied in combination. Leaf sodium (Na+) concentration increased substantially, but leaf K+, Ca2+ and P concentrations decreased markedly in the salt stressed maize plants. However, exogenous application of nutrients, IAA, or their combination considerably reduced Na+ concentration and significantly improved K+, Ca2+, and P levels in the salt stressed maize plants. The exogenously applied inorganic nutrient- or auxin-induced growth promotion in maize plants was found to be associated with increased photosynthetic pigment concentration and leaf Na+/K+ ratio, reduced membrane permeability, and altered activities of some key antioxidant enzymes such as SOD and CAT under saline conditions.

Salt stress tolerance:

Murkute et al. (2006) reported that studies on salt stress tolerance of citrus rootstock genotypes with arbuscular mycorrhizal fungi. Citrus is grouped under the salt sensitive crops. Mycorrhizal fungi, a symbiotic relationship between plant roots and beneficial fungi, are supposed to impart the stress tolerance in the host plants. Pesqueira et al. (2006) found that NaCl effects in Zea mays L. x Tripsacum dactyloides (L.) L. hybrid calli and plants. High salt concentrations in soils negatively affect maize growth. In order to determine the usefulness of Tripsacum to improve salt tolerance in maize, the effects of NaCl, in vitro and in vivo, were evaluated in an intergeneric hybrid (MT) obtained from crossing Zea mays with Tripsacum dactyloides. Organogenic calli, induced from immature MT hybrid embryos, were exposed to different NaCl concentrations and the survival and regeneration percentages were calculated. Plants of the MT hybrid, obtained from the organogenic calli, were exposed to NaCl concentrations considered harmful for maize. The shoot dry weights of plants exposed to 250 mM NaCl did not show significant differences respect to the control ones. Although sodium content in shoots was incremented 2, 5 fold, it was not toxic for this material. The MT hybrid showed better behavior, in vitro and in vivo, that maize genotypes exposed to similar conditions.

Farsiani et al. (2009) conducted an experiment to determine the effect of PEG and NaCl on two cultivars of maize (Zea mays L.) at germination and early seedling stages. To study on effect of PEG and NaCl stress on germination and early seedling stages on two cultivar of corn. This investigation was performed as factorial experiment under Complete Randomized Design (CRD) with three replications. Cultivar factor contains of two varieties (sweet corn SC403 and Flint corn SC704) and five levels of stress (0, -2, -4, -6 and -8 bar). Results indicated that significant decrease was observed in percentage of germination, germination rate, length of radicle and plumule and radicle and plumule dry matter. On the basis of the results, NaCl as compared with PEG had more effect on germination and early seedling stage and sweet corn had more resistant than flint corn in both stress conditions.

Khodarahmpour et al. (2012) determined the effect of NaCl salinity on maize (Zea mays L.) at germination and early seedling stage.The response of eight maize hybrids against five different salinity levels namely 0, 60, 120, 180 and 240mM were studied at germination and early seedling stage. This investigation was performed as factorial experiment under completely randomized design (CRD) with three replications for each salinity level. Analysis of variance (ANOVA) showed that there were significant differences between salinity stress levels, hybrids and interaction effects for all investigated traits. Supplementary analysis showed that there were significant differences between hybrids for germination percentage, germination rate, mean germination time and seed vigor in all salinity levels. But, there were nosignificant differences found between studied hybrids at salinity level of 240 mM for the length of radicle, the length of plumule and the length of whole seedling. Results also indicated that maximum reduction in germination percentage (77.4%), germination rate (32.4%), length of radicle (79.5%) andplumule (78%), seedling length (78.1%) and seed vigour (95%) were obtained in highest level of salinity. Results further depicted that hybrid was the most tolerant hybridthan other hybrids under salinity stress.

Screening for salt tolerance in maize:

Akram et al. (2010) determined the Screening for salt tolerance in maize (Zea mays L.) hybrids at an early seedling stages. The study was conducted in solution culture exposed to four salinity levels (control, 40, 80 and 120 mM NaCl). Seven days old maize seedlings were transplanted in thermopol sheet in iron tubs containing ½ strength Hoagland nutrient solutions and salinized with common salt (NaCl). The experiment was conducted in the rain protected wire house of Stress Physiology Laboratory of NIAB, Faisalabad, Pakistan. Ten maize hybrids were used for screening against four salinity levels. Seedling of each hybrid was compared for their growth under saline conditions as a percentage of the control values. Considerable variations were observed in the root, shoot length and biomass of different hybrids at different salinity levels. The leaf sample analysed for inorganic osmolytes (sodium, potassium and calcium) showed that hybrid Pioneer32B33 and Pioneer30Y87 have high biomass, root shoot fresh weight and high K^+/Na^+ ratio and showed best salt tolerance performance at all salinity levels on overall basis.

Effect of growth promoting Rhizobacteria on plants:

Saharan et al. (2011) found that Plant Growth Promoting Rhizobacteria. Plant growth-promoting rhizobacteria (PGPR) are naturally occurring soil bacteria that aggressively colonize plant roots and benefit plants by providing growth promotion. Inoculation of crop plants with certain strains of PGPR at an early stage of development improves biomass production through direct effects on root and shoots growth. Inoculation of ornamentals, forest trees, vegetables, and agricultural crops with PGPR may result in multiple effects on early-season plant growth, as seen in the enhancement of seedling germination, stand health, plant vigor, plant height and shoot weight, nutrient content of shoot tissues, early bloom, chlorophyll content, and increased nodulation in legumes. PGPR are reported to influence the growth, yield, and nutrient uptake by an array of mechanisms. They help in increasing nitrogen fixation in legumes, help in promoting free-living nitrogen-fixing bacteria, increase supply of other nutrients, such as phosphorus, sulphur, iron and copper, produce plant hormones, and enhance other beneficial bacteria or fungi, control fungal and bacterial diseases and help in controlling insect pests.

Effectof Azospirillium inoculation on maize:

Bano et al. (2013) performed an experiment which is found the effect of Azospirillium inoculation on maize (Zea mays L.) under drought stress.Azospirillum strains isolated from water stressed conditions can mitigate drought effects when used as inoculants. In this context, the research was designed to study the effects of Azospirillum lipoferum strain inoculation on biochemical attributes and growth of maize plant under drought stress. Effect of seed inoculation and rhizosphere inoculation were studied in two varieties of maize, which were subjected to drought stress at vegetative stage. Water deficiency affected accumulation of free amino acids, soluble sugars, proline and soluble protein contents. However, seed inoculated plants had an increased accumulation of 54.54 percent and 63.15 percent free amino acids and soluble sugars respectively, while rhizosphere inoculated plants showed 45.45 percent increase in free amino acids and 31.57 percent increase in soluble sugars as compared to control. The concentrations of soluble proteins on the contrary decreased in the similar order. The plants growth aspect i.e. shoot and root fresh weight, shoot and root dry weight, shoot length and root length, also showed results in consistence with the biochemical attributes. Thus Azospirillum strain showed promising effects and can be a potent inoculant for maize that can help the crop to endure limited water availability.

Inoculation of maize arbuscular mycorrhizal fungus:

Kaldorfa and Muller. (2000) reported that Inoculation of maize (Zea mays L.) with the arbuscular mycorrhizal (AM) fungus Glomus intraradices resulted in a root phenotype 10 days after inoculation. Al-though the fresh weight of inoculated and control roots was about the same, the AM-inoculated roots showed a significant increase in the percentage of lateral fine roots. This increase coincided with an increase in free indole-3-butyric acid (IBA) as well as an increase in IBA synthesis. At later time points (31 days after inoculation), the free IBA content was not increased in infected roots; however, the fraction of bound IBA increased compared to controls. The phenotype of are mycorrhizal maize roots could be mimicked by IBA applied exogenously to non-mycorrhizal roots. Addition of IBA (TFIBA), an inhibitor of IBA-induced root growth and lateral root induction, simultaneously with IBA resulted in a phenotype resembling that of untreated controls. In roots treated with TFIBA the inoculation with AM fungi did not increase the formation of fine roots. The TFIBA treatment also reduced endogenous free IBA and the AM infection rate in mycorrhizal roots. The results are discussed with respect to a possible role of IBA in the establishment of AM symbiosis.

II. Conclusion

This study was conducted to assess the morphological and physiological response of iodole acetic acid (IAA) on maize to foliar application of IAA under saline conditions. Growth of Maize was significantly reduced due to salt stress, and this reduction was improved due to exogenous applications of IAA. Different concentrations of IAA show non- significant effect on growth attributes such as, shoot length and on root length. 100ppm show the significant effect on root fresh weight, shoot fresh weight, root dry weight and on shoot dry weight and for leaf area. Gas exchange characteristics such as Sub stomatal CO2 concentration, net CO2 assimilation rate, stomatal conductance and transpiration rate increased with increasing concentration of IAA. Photosynthetic pigments such as carotenoid contents, chlorophyll a and b increased with changing concentrations of (IAA) indole acetic acid. Foliar application of IAA significantly raises the K^+ concentration under salt stress. It might be concluded at the end that introduction of maize to toxic levels of Indole acetic acid and salt causes a number of closely inter-related structural and functional procedures in the stressed plants.

Acknowledgements

The authors express their thanks to Department of Botany, Institute of Chemical and Biological Sciences (ICBS), University of Gujrat (UOG), Hafiz Hayat Campus (HHC), Gujrat, Punjab, Pakistan, for the study resources.

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