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Effect of salinity at various growth stages of plants

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Abstract
Salinity is a major abiotic stress limiting growth and productivity of plants in many areas of the world due to increasing use of poor quality of water for irrigation and soil salinization. Plant adaptation or tolerance to salinity stress involves complex physiological traits, metabolic pathways, and molecular or gene networks. A comprehensive understanding on how plants respond to salinity stress at different levels and an integrated approach of combining molecular tools with physiological and biochemical techniques are imperative for the development of salt-tolerant varieties of plants in salt-affected areas. Recent research has identified various adaptive responses to salinity stress at molecular, cellular, metabolic, and physiological levels, although mechanisms underlying salinity tolerance are far from being completely understood. This paper provides little review on the work carried out by various scientists and the effect of the different concentration of the saline concentration on various classified crops.

Keywords: Salinity, various, plants, salinization, physiological

Introduction
There are several types of stresses which impact the growth of the plants basically as categorized as biotic stress caused by living organisms as if any disease occurs in the plants and abiotic stress such as moisture stress, salt stress, minerals stress and many more. The salinity stress is considered as one of the most impacting stress after the moisture or irrigation stress. There are several assumptions that salinity might decrease the world yield of the crops by 30% till the year of 2025 and 50% by the upcoming of 2050. There are various kinds of salt which are present inside the soil as in soluble state and the stress is defined as the condition in which there is an excess of the salt present inside the soil or in the region of root area thus increasing the accumulation of it much more than the required amount. Even in the India around 5% of total cultivated land is considered around soil affected soil. The soil concentration if increased then it affects the physiological, biological and chemical properties of the plants. The osmotic mechanism is the cause hindrance in the initial plant growth stages which resembles the effect produced in the drought tolerance mechanism of the plant

Saline Soil
The soil is considered to be saline if various types of the salt dissolved into it such as sodium, calcium, chlorides, potassium and magnesium salt are present more than its saturation capacity. Sometimes the salts are present inside the soil by their nature or in some cases it is dissolved in the irrigation water and supplied to the crops for the research trails or to check the performance of the various genotypes. The salinity of the soil or soluble salts is measured in dS/cm (decisimens per cm) the salinity is considered for the soil when the conductivity of the soil would be greater than $2dsm^{-1}$

Salinity stress and development
The impact of the salt excessiveness effects in the various mechanism such as nutritional disorders, defined ion toxicity and osmotic effect but the final result depends upon the several other attributes also such as the genotype of the plant, species of the plant on which the salinity is to be observed, age, concentration of the salt solution of which plant is treated and accumulation and uptake of the specific salt into the plant organs came into functioning. The final impact of the salinity is seen. Munns discovered in 2002 that the plant's characteristics continue to evolve before the crop reaches its full maturity. It is found that just after the stress in the form of salt is given to the plants there are several changes also occur at the cellular level such as shrinkage in size and reduction of the size and shortage of water in them but after

some duration those just come back again in their original form. Although the cells come back in their owns original state back but there is seen the decrement in the cycle of the division of the cell and the elongation process of the cell which furthermore get concluded when seen into the morphology of the leaf and the size of it. The visible changes in only seen the plants which are provided by the very much concentration of the salt and the noticeable significant differences can be seen in the later weeks in the several forms as when they are studied under a comparative study of treated and non-treated type. The type of temporary changes is generally concluded under 2 phases by Munn in year 2002. First where the changes are observed but they come to normal state after taking a little bit of time but even that stage or state will be not be same as the original form of the plants. While in the second phase the slower effects are present such as photosynthetic rate of the plant, accumulation of the salt generally in the older leaves of the plant might resulting in the dying which is a result of accumulation of the salt ions in the very much higher amount in the food vacuoles of the cell thus increasing in toxicity level of whole of the cell. Based of the impacts of these 2 phases in the first phase the first or rudimentary impacts are caused because of the osmosis process and movement of the salt ions and water within the root zone but while in the another phase the differences between the effected and the tolerant species can be found out by their ability or inability of accumulation of the various salts in the leaves where the process of transpiration is occurring.

Germination and seedling stages

Amira m.s and abdul quados have studied in the broad bean found significant differences in the length of the plants at certain concentration but no the later stages of the experiment there are no significant differences but there are some differences we can still note and the concentration used in the experiment is 60 mM and 240 mM and there can be seen 40 death of the plants at the higher toxicity level. The supporting references towards the result can be seen in the further references such as Hamada (1995) studied the effect and impact of NaCl and Na2SO4 maize Zea mays and found out the length and differences in the shoot system after treating with the salt with in first 2-3 weeks against the control and some cultivar leaf directly showed the toxicity symptoms. L., Misra *et al*. (1997) with their study on rice seedlings Oryza sativa L. vr. Damodar, Dantus *et al*. (2005) in their evaluation on cowpea found out the difference of the length of the shoot as compared to the control variety, meanwhile Memon *et al*. (2010) [11] in their experiment on *Brassica* L. (pak choi) concluded that the by treat in with mild concentrations of NaCl can provides with the good results i.e increment in height of the plant, but the same salt when used in strong or high concentration are used then there is seen the decrement in the height of the plant. Contrary results were registered as well, including the study done by Mathur *et al*. (2006) on moth bean *Vigna aconitifolia* L., Jamil *et al*., (2007) found out the effect of the salt solution on the spring cabbage and the autumn cabbage thus concluded that the shoot weight is greatly effected on the autumn cabbage as compared to the spring one Jamil *et al*., (2007) on radish plant, *Raphanus sativus* L., Taffouo *et al*. (2009) on cowpea *Vigna unguiculata* L., and Kapoor and Srivastava (2010) on *Vigna mungo* L. They found that increasing the concentrations of NaCl developed a decline in the lengths of the plants.

Generally speaking, we may infer that, the elongation of the stem when treated with low concentrations of salts may induce osmotic adjustment activity in the plants which may improve 2growth. On the other hand, the noticed decrease in the length of the stem, also due to treatment with sodium chloride solution, could be due to the negative effect of this salt on the rate of photosynthesis, the changes in enzyme activity (that subsequently affects protein synthesis), and also the decrease in the level of carbohydrates and growth hormones, both of which can lead to inhibition of the growth (Mazher *et al*., 2007).

Vegetative growth

Several precious work of many of the different scientists at majority have concluded that most of the plant species are particularly react able to the impact of the salinity during the early and the seedling stage rather than compared to the germination stages. There are several examples are found such as barley (Ayers *et al*., 1952), corn (Maas *et al*., 1983), cotton(Abul-Naas and Omran, 1974) [2], cowpea (Maas and Poss, 1989b), melon (Botia *et al*., 2005), New Zealand spinach (Wilson *et al*., 2000), red orach (Wilson *et al*., 2000), rice (Pearson and Ayers, 1966), sorghum (Maas *et al* 1986), tomato (del Amor *et al*., 2001), and wheat (Maas and Poss, 1989a). Maas *et al*, 1983; Maas and Poss, 1989a concluded that in greenhouse conditions where corn and wheat plants are studied and if found that the total shoot biomass of the plant which are observed under the salt stress rather than when compared to the plant which are not provided with any of the stress and the complete overall impact is seen on the final yield of the crop. Nerson and Paris, 1984 stated in their work that it is not golden rule with most of the crops because some scientists have concluded that the final yield at the end of the season is directly related with the melons which have shown salt tolerance among the melon cultivar in their early seedling stage.

Roots

It is well known that salinity generally refers to the more than optimum supply of the various salt which results in the reduction of the growth of shoot region of the plant, particularly affecting the leaf area of the plant even if it is compared with the root zone of the plant and it is also concluded by the Lauchli and Epstein in 1990. In despite of the insufficient supply of the calcium ion under the salinity stress conditions can results in effecting the membrane function and development of the root even within very short interval of time (Epstein, 1961; Läuchli and Epstein, 1970; Cramer *et al*. 1988). In the experiment with the cotton performed by Kurth *et al.* in the year of 1986 comes out with the conclusion that whenever the salinized soil if supplemented with the Ca then there would be no hindrance in the cell elongation is seen. More studies with the cotton revealed that the cotton shows more cell enlargement due to higher value of the salts present inside the supplied medium near the root area of the plant but there is noted the reduction in size with is result of the impact of the salt is not again can be overcome by the application of Ca (Zhong and Läuchli, 1993). Whenever the very high amount of the salt is present that leads to higher deposition value of Na ion nearby the root area of the plant and due to that K ion selectiveness in the root get decrease if studied with reference of Na. The latter effect was partly mitigated by supplemental Ca, but only in the apical 2mm region (Zhong and Läuchli, 1994). The

conclusion of these studies is that supplemental Ca alleviates the inhibitory effect of salt on cotton root growth by maintaining plasma membrane selectivity of K over Na (Zhong and Läuchli, 1994; reviews: Läuchli 1990, 1999).

Shoots

Läuchli and Epstein 1990 in their work concluded that the most general aspects of the salinity stress is shown by reduction in the shoot growth, reduction in the leaf area and decreased length of the roots. The various factors which conclude the final leaf size are elongation of the cell and the process of the cell division. Leaf initiation, which is governed by cell division, (Papp *et al*., 1983) studied the effect of the salinity and found that the crop of sugar beet remains unaffected but the process of development of leaf is still noted to be get affected by the stress. Thus, cell division in leaves of sugar beet appears less salt sensitive than cell elongation. Munns and Termaat, 1986 found the contrary results of decrement in the cell numbers of the leaves of the grass. A detailed, quantitative study of the responses of leaf growth and development in sorghum to salt stress showed that the length of the growth zone was shortened by 20% under salt stress, and that salt stress also reduced the maximal relative elemental growth rate, particularly in the youngest region of the leaf (Bernstein *et al*, 1993a). Bernstein *et al*., (1993b) have also studied the effect of the external Ca supplementation again regrowth the length of the growth leaf zone and also speed up the relative growth process. External Ca supplementation has little effect on re-growing in the root of several crops, according to Zhong and Läuchli in 1993.

Reproductive growth

Läuchli and Epstein in 1990 and Maas and Grattan in 1999 and the many other have cited in their work that if the plants are grown under the salinity stress in the early stages of the vegetative phase has greater chances of becoming more tolerant as the crop leads to the final growth stage of the plant. There are many studies present which shown the different development process and growth phases of the crop. Several studies are present where results of different aspects of the crop development under the salinity stress which are studied under the various life growth stages till the maturity of the crop. The later stages of the growth is the higher chances of the partial favourism is very high which are indirectly proportional to the duration of the exposure to the stress and the amount of salt stress provided to them. In experiments with wheat (Maas and Poss, 1989a), sorghum (Maas *et al*., 1986) and cowpea (Maas and Poss, 1989) studied and concluded out with the behavior that those where having more higher responses to the stress in the early growth stages i.e. vegetative and early reproductive stages having moderate sensitiveness during the flowering stage and very less impact on later maturity stages in their life cycles. In all the studies which are carried out have emphasized on the parameter of seed weight for studying the yield character of the crop in both growing habit type of the crop i.e. determinate such as cereal crops and indeterminate such as cowpea.

Examples showing the impact of salinity on different types of crops

Legumes are very sensitive to abiotic stress and show negative responses in their early growth stages i.e, in early vegetative and reproductive stage, for eg., Amira M.S. Abdul Qados investigated the development and metabolic effects of beans grown in various concentrations of NaCl salt solution (0,60,120,240Mm) and discovered the varied influences of plant characteristics, such as an increase in the dry and fresh weight of the produce and a greater salinity will result in an increase in the chlorophyll A content, whereas the B type, total carotenoids present, and total chlorophyll reduction shows reduction as following contrary trend but the leaf area is unaffected. The plant height shows a particular trend of increasing or decreasing in measurement with the effect of salinity. Same type of the findings are concluded by Parvaiz Ahmed and Riffat Jhonn in the cultivar of pea naming EC33866 when treated with the different concentration (50,100,150,200 mM) of the stress For concluding the diversity of different genotypes of model legume M. truncatula, A.A. Amouri investigated the effect of many Algerian cultivars under the stress 137 mM. The main target in this study was focused on the measurement conclusion of the shoot and root system of the different ecotypes and concluded that variety naming as tru 11 (tru131) is the most resistant to the provided saline conditions and is favorable for semi-arid and saline soil present in the region thus the maximum output of the legume can be achieved.

Cereals has also shown sensitivity in various attributes for eg Noreen Zahra and Zulfiqar Ali Raza studied the salt sensitiveness in the two local cultivar of maize naming as sahiwal (2002) which is generally considered as salt tolerant type as compared to sadaf. The conclusion of this study is based on the application of the seed priming by phenyalanine compound also and is recorded that due to the increase in the application the tolerance toward the salt stress increases in the seedling stage of the crop. JK Datta and S NagA investigated the effect of salt on various wheat genotypes and discovered that when saline conditions and biochemical features such as sugar present increase, the length of the plant's root and shoot decreases, proline content as inversely proportion to conc. of the stress whereas the reduction in protein content is seen directly impacted by the increase salinity. Rice crop whereas shows the result of this stress very different and have a very different mechanism in terms of grain yield, rice is tolerant during germination (Heenan *et al*.1988), sensitive to salinity during emergence and early seedling growth, becomes more tolerant later on in vegetative development, and then can becomes sensitive again during reproductive growth (Pearson and Bernstein, 1959; Flowers and Yeo (1981) Khatun and Flowers, 1995; Abdullah *et al*., 2001). The vegetative shoot biomass of rice, on the other hand, is often affected much less than reproductivegrowth (except for young seedlings) (Khatun and Flowers, 1995; Munns *et al*. 2002). Field and greenhouse studies showed that salinity had a negative impacton stand establishment and adversely affected a number of yield components and even delayed heading (Grattan *et al.* 2002).

Fruit crops Citrus is ranked among the most sensitive crops to salinity. This constraint affects plant morpho-physiology and may leads to yield declines. Singh *et al.* (2014) reported that the highest Membrane injury index (0.159) was recorded in Jatti khatti under 50 mM salinity followed by Attani-2 and Attani-1. The highest SOD (45.67 units mg-1 protein min-1) and CAT (5.34 ì molesH2O2 hydrolized mg^{-1} protein min^{-1}) activities was recorded in the Jatti khatti under 50 mM NaCl salinity followed by Attani-2 and Attani-1. Based on observations they concluded, the relative salt tolerance of citrus root stocks was adjudged to decrease in the following order: Attanni-1>Attanni-2> Jatti khatti. Pandey *et al*. (2014)

conducted experiment on six-month-old seedlings of seven mango (*Mangifera indica* L.) rootstocks namely Moovandan, Bappakai, Nekkare, Kurukkan, Olour, Terpentine and Chandrakaran with water containing 0, 50, 100, and 150 mM NaCl for 90 days. The decrease in growth was greatest in the salt-susceptible Chandrakaran rootstock (32.02%) at higher levels of salinity. However, in the salt-tolerant Olourand Nekkare, NaCl caused only a slight decrease in numbers of leaves and leaf area per plant.

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Flower crop

Significantly higher salt concentrations that could cause harm to susceptible species of plants. Rose plants are the most attractive plants in our world. Although, the rose face serious salt stress. Salinity is the main abiotic factor that decreases the vegetative growth and yield by causing hyperosmotic and hyper ionic effects on soil rhizosphere. Studied the influence of *Rosa rubiginosa* plant against saline environment and reported that the plants lose its ability of water uptake due to accumulation of salt in leaf water and leaves started to dry. The increase in salinity level leads to significantly reduction in height of cardinals (Rose). Pasquale Campi *et al*. conducted a trial to study the effects of different salinity conditions on Rosa geranium leaf (*Pelargonium graveolens* L) and reported that as salinity started plants immediately developed capitate trichome density however, rose geranium have some degree of resistance against salinity stress conducted a research to study the response of carnation plants against saline and reported that when plants were injected by different strains, *Glomus* intradices showed tolerance against saline environment. Furthermore, color of leaves, flowers, size of flower, number of flower and plant growth was also improved by the combination of injected mycorrhiza with adequate saline concentration. Ali E *et al*. investigated the resistance response of Taif Roses against the salinity in the presence of gibberellic acid and results indicated that relative water, plant height, leaf area, stem dry weight, number of branches and leaf area decreased due to saline conditions whereas application of gibberellic acid reduce the bad effect of saline conditions. Furthermore, gibberellic acid enhances the tolerance of plant against salinity and provides high activity of antioxidant enzyme preventing the ions homeostasis.

Fodder crop

Salinity was found to have a significant impact on the growth characteristics of fodder beet genotypes. Other fodder crops have a lower ability to thrive under salt stress, but fodder beet has the maximum biomass production. Overall, fodder beet plants developed well in saline soil with a salinity of up to 200 mM.

Fiber crop

Cotton is one of the most important fiber crop is studied by Nudrat Aisha Akram *et al*. under this type of constraint in addition of jute, hemp, flax, kenaf and concluded that salinity stress tolerance of the fiber crops can be improved via improvement in free radical scavenging, up regulation of antioxidants, potassium retention, enhanced osmolyte synthesis, and accumulation and better ion partitioning. Biotechnological approaches to increase tolerance and fiber quality under salt-affected areas include development of transgenic fiber crops for Na+ vacuolar sequestration and improvements in physio-biochemical attributes.

Conclusion

Plant in its whole life gets effected by various types of the stresses but due to the salinity stress several type of changes occur inside the plant in root zone area and shoot zone of the plant and their length also. The earlier stages of crops are higher effects as compared to the later stages. Different types of the crop respond in the different ways some showing the positive combination and whereas some are showing negative outcome. Therefore if the goal is to develop the transgenic species of the crop then the best way to combine two or more type of stresses together but the same scenario is not considered for testing or producing simple genotypes

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