Impact of Salinity on Chili Morphological and Physiological Characteristics

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Abstract

Salinity stress is one of the major abiotic stresses restricts agricultural production and influence the composition of bioactive vegetable compounds. High salt stress of the soil also leads to poor growth of plants, decreased plant growth, and poor yield of many crops, like peppers (*Capsicum annuum*). About 19.5% of all irrigated areas and 2.1% of dry land have been confirmed to be impacted by salinity stress, and those numbers continue to grow. The effects of NaCl Salinity stress on flowering, fruit production, and fruit- nutritious properties of chili were explored in this article. We examined the physiological reactions of chili during salinity (NaCl) pressure and defense mechanisms. Through increased salinity, dry weight and overall chlorophyll levels have reduced. Higher salinity levels led to higher salt levels across the roots. In this review, an article has discussed the major effects of saline stress on chili crops. Chili is a glycophyte and does not tolerate elevated salt concentrations in its cytoplasm for development contributing to a major question about the optimal saline tolerance limits of chili genotypes.

Keywords:- Salinity stress, Effects, Chilli, Yield, Chlorophyll.

INTRODUCTION

Chili is a member of the Solanaceae family, with the scientific name *Capsicum spp*. capsicum which includes 24 chromosomes with diploid condition mostly 2n=2x=24, but wild species with 2n = 2x = 26 chromosomes have been identified (Pickersgill, 1991). Chilli is a plant of glycophytes that cannot grow under heavy pressure of salt and develop affected outputs. Germination of seeds is an essential consideration that limits plant growth in salinity stress. Chilli cultivation began in Central America, most likely in Mexico, with secondary centers in Guatemala and Bulgaria (Salvador, 2002). The main chili-producing countries are India, Mexico, Japan, Ethiopia, Uganda, Nigeria, Thailand, Turkey, Indonesia, China, and Pakistan. It is also grown in Italy, Spain, and the United States to some degree. Paprika is a mild chili that is grown in Hungary, Spain, Romania, Bulgaria, and the Slovak Republic. Based on pungency, chilies are divided into two categories: hot and moderate. It is grown over an area of 1.98 million hectares worldwide, yielding 31.132 million tonnes per year and productivity of 1576.34 kg ha-1. India, China, Indonesia, Korea, Pakistan, Turkey, and Sri Lanka are the world's major chili leading producers.

Chilli (Capsicum annuum L.) is the world's second most common solanaceous vegetable after tomato, accounting for 170.03 MT from 19,83,000 ha in India with a productivity of 1900 kg per hectare (Horticultural Statistics, 2015). Chilli is cultivated all across India in various agro-climatic areas, but the region of riped dry chili is located in the southern states. This crop is grown on 287 thousand hectares in India, with a yearly output of 3406 thousand MT and a productivity of 2.1 kg ha-1 (National Horticulture board 2017). India only contributes roughly 50% of global production, 90% of which is consumed domestically and only 6% is transported to countries such as the United States, Bangladesh, Nepal, and Mexico.

What is salinity?

salinity is called as the level of salinity or the total amount of salt in a solution. Because of the increased use of low-quality water resources and soil salinization, salinity is significant abiotic stress restricting plant development and productivity in many parts of the world. Plant response to salinity stress requires a diverse set of physiological characteristics, metabolic mechanisms, and molecular or gene networks. A deep understanding of how plants react to salinity stress at various levels, as well as an integrated approach integrating molecular resources with biochemical and physiological techniques, are needed for the production of salt-tolerant plant varieties in salt-affected areas.

Per living organism needs proper nutrition to expand and evolve properly. To deal with a variety of environmental pressures while maintaining their production capacity. Abiotic stresses are likely to harm crop productivity and production. Salinity influences almost every aspect of plant physiology and biochemistry, greatly reducing yield. Every crop species' resistance to salinity is important throughout its lifespan (Munns and Tester, 2008). Since saline soils and saline waters are widespread in most parts of the world, considerable effort has been expended to understand the physiological responses of salinity tolerance in plants, as a foundation for plant breeders to grow salinity tolerant genotypes. Enhanced salt stress has hindered vegetable production, especially in water crop fields, which supply approximately 40% of the globe's food requirements. Too much salinity has a high effect on the quality of vegetables, like chili. High evapotranspiration due to dry and hot weather results in significant water depletion, trapping salt all-around plant roots, obstructing the plant's ability to absorb water. As per the FAO Soil and Plant Nutrition Management Service, sodicity or salinity affects more than 6% of the earth’s land surface. Salt-affected soils are salty or sodic soils that occupy over 400 million hectares, or more than 6% of the world's total area. Most of the world's soil is uncultivated, but a sizable amount of farming area is polluted by salt. Of the existing 230 million ha of irrigation water, 45 million ha are salt-affected (19.5%), and 32 million are salt-affected to different degrees of the 1,500 million ha in dryland agriculture (2.1 percent).

There is a lot of genetic variance in chili genotypes when it comes to salinity tolerance. However, breeding programs on salt tolerance have been hampered by the trait's nature, a lack of genetic and physiological knowledge of tolerance-related features, and a lack of an effective selection domain.

Rectify saline conditions in the field and greenhouse will be costly and ineffective while selecting and breeding for salt tolerance can be a feasible option to reduce salinity effects and increase production quality.

Impacts of salinity:

Iqbal *et al.,* (2015) mentioned that excessive salinity has a high effect on the quality of vegetables, including chili. High evapotranspiration due to dry and hot weather results in significant water depletion, leaving salt around the plant roots, obstructing the plant's ability to absorb water. Plant salinity exposure results in turgor degradation, reduced growth, wilting, epinasty, and leaf curling, reduced photosynthesis, changes in respiration, loss of cellular integrity, tissue necrosis, and eventually plant death

Munns and Tester (2008) suggested three major salinity resistance mechanisms:

1.Tissue resistance – the partitioning of radioactive ions into subcellular organelles, cells, and various tissues. 2. shoot ion-independent resistance – the ability to maintain growth and water absorption regardless of the amount of $Na+$ accumulated in the shoot. 3. Ion elimination – refers to the net removal of radioactive ions from the shoot. Niu *et al*, (2010) stated that the extent of salinity impact, however, differed according to species of plants, form, and salinity level. Wei *et al*., (2003) stated that Saltiness is among the great environmental restrictions restricting productivity in agriculture. Kpinkoun *et al*., (2019) explained that flowering and fruit ripening disturbed by salinity stress; decreased fruit quantities, size, and weight; reinforced fruit sharpness, and diminished chili pepper nutritional values. Grattan *et al*, (1992) have told that however, several experiments have demonstrated, under non-saline circumstances, that an optimum concentration or action of a certain nutrient could be insufficient, or excessive in certain instances in salinity stress.

Impact on flowering

According to Kpinkoun *et al*., (2019), the influence of NaCl on the date of arrival of the first flowers increased from 23.66 days for the control to 31.66, 39.66, and 40.33 days at 60, 90, and 120 mM NaCl, leading to a delay of 8, 16, and 17 days of flowering in contrast to the control; however, no change was detected at 30 mM NaCl. As a consequence of the NaCl impact on the chili plant, flowering was delayed. Van Zandt and Mopper (2002) stated in Iris hexagona where salinity delayed flowering phenology significantly, particularly in the second year when less than 4 g/L NaCl delayed flowering for up to 3 days. Zapryanova and Atanassova (2014) confirmed that treated NaCl plants are flowering earlier and shorter than untreated plants show that salinity condition accelerates flowering of these species. Shrivastava and Kumar (2015) report that salinity negatively impacts reproductive growth by hindering stamen filament elongation and microsporogenesis, increasing apoptosis in some types of tissues, senescence of fertilized embryos, and ovule abortion. Shannon *et al.*, (1994) confirmed that soil porosity affects the absorption of salt into the root area and thus causes variations in plant retaliation to salt stress. Capiati *et al.*, (2006) explained that salinity is a key factor for the yield and growth of crops among abiotic stress conditions.

Impact on Fruitification

Impact of NaCl on fruit ripening. At 90 and 120 mM NaCl, no fruit was collected. Under salt tension, the time for the arrival of the first ripe fruit increased, causing a delay of 4 and 18 days, respectively, for 30 and 60 mM NaCl in contrast to the regulation. This rise was only meaningful at 60 mM NaCl, indicating that the NaCl effect on chili fruit resulted in a significant delay in fruit ripening the impact of NaCl on the number of ripe fruits. At 30 and 60 mM NaCl, the number of ripe fruits decreased from 6.33 in the control to 3.66 and 2.33, respectively. At 30 and 60 mM NaCl, the reduction in fruit fresh number due to salt stress was 42 and 63 percent, respectively, compared to the control. Thus, the NaCl effect on chili fruit resulted in a substantial decrease in the number of mature fruits (Kpinkoun *et al.*, 2019). As opposed to the control, all salinity treatments improved fruit dry matter and total soluble solids. Total phenol content increased marginally (10%) with NaCl salinity, while carotenoids concentration increased by 40% with NaCl salinity relative to the regulation and nutrient salinity (Giuffrida *et al.*, 2014). Salinity decreasing the fruit set rate, production, and mean weight of the fruit (R'him *et al.*,2013). In chili pepper variety Sandia, the number of fruits is most impacted by the salinity compared to the weight of the single fruit (Huez-López *et al.*,2011)

Impact on morpho-physiological characters

Ramanjulu and Sudhakar, (2001) have mentioned in their paper that plants attempt to compensate for the nutritional and osmotic shocks caused by salinity by producing natural chemical solutes (polyamines, proline, glycine betaine, etc.) in their tissues. Yang *et al*., (2003) mentioned that however, proline and glycine betaine (GB) compounds were formed in higher plants as a result of salinity so it is also thought to be an adjustment to saline environments. Mustafa *et al*, (2014) reported that with increasing NaCl salinity, total chlorophyll content and net photosynthesis rate were decreased. In the current research, salinity-induced photosynthetic limitations may be attributed to lower overall chlorophyll contents `and under stress conditions. Kpinkoun *et al*, (2019) confirmed that the content of capsaicinoids risen considerably for approximately 389% compared with the regulation of 60 mM NaCl, compared to B6, B12, and C content substantially reduced as the concentration of NaCl raised. The physiological consequences of salinity include the preliminary water deficiency state caused by comparatively high solute ratios in the soil, which induces ion toxicity caused by skewed K+ /Na+ ratios and directs to increase the Cl- and Na+ that are harmful to crop plants (Yamaguchi and Blumwald, 2005). The findings revealed that pepper's reaction to salinity is both osmotic and ion-specific, with a more negative effect observed under NaCl stress. Furthermore, the presence of the most antioxidant compounds in NaCl-treated fruits may mean that NaCl triggered increasingly stressful circumstances than nutrient salinity. (Giuffrida *et al*, 2014)Salinity harmed the morpho-physiological characteristics of chili genotypes by inducing osmotic stress, ionic toxicity, altered stomatal functionality, disrupted photosynthesis, and reduced K+ supply (Mustafa *et al*, 2014)The main causes of decreased photosynthesis are a decline in photochemical ability, stomatal conductance, metabolism and carbon absorption under salt stress according to (Mundree *et al*, 2002), Since the earth's water contains significant concentrations of salts (30 g NaCl L-1) it is referred to as a saline world, and this NaCl influences soil quality and crop production (Flowers, 2004). Both sodium and chloride cause several physiological problems, but chloride is the most harmful since NaCl releases nearly 60% more ions into soil solution than Na2SO4 (Cedra *et al*., 1982). Furthermore, the Salinity does have an osmotic and ionic impact on seedlings growing that can be achieved by aggregation of toxic ions resulting in a degradation of vital nutrients, such as potassium(K) and phosphorus(P) in plants (Munns, R. 2005) and (Vicente *et al*, 2004). Disrupted biosynthesis of chlorophyll is a normal function causing chlorophyll reduction and chlorosis in plants (Parida and Das, 2005). The raise in salt concentrations with K+ may also be a genotypical Osmo-controlled reaction in challenging situations in quest of advantageous plant balance to water (Taiz and Zeiger, 2006)

Conclusion

This study suggested that high levels of NaCl delayed significantly the flowering and ripening of fruit and significantly decreased the number of the fruits, size, fresh weight, and vitamins B6, B12, and C levels. And this article also observed the impact of salinity on biochemical parameters like a lowered in chlorophyll content of the leaves which leads to reduced photosynthesis, stomatal closure which impacts evapotranspiration, a saline condition that also increases the percentage of capsaicinoids present in the fruit. This saline stress induces many morpho-physiological effects on the chili-like reduced growth, reduces yield, and also higher concentrations may cause the death of the plant also. chili plant releases some natural chemical solutes as a defense mechanism to withstand the osmotic shock produced by the NaCl on chili plant-like proline, glycine betaine, polyamines, etc., in the tissues. Some of the plants will cause programmed cell death to withstand this.

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