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EFFECT OF SALT STRESS ON GROWTH AND BIOCHEMICAL PROPERTIES OF LITTLE MILLET (*PANICUM MILIARE* L.)

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Abstract

The major proportion of chloride salts have been observed in the saline soils of Pakistan in the forms of chlorides of Na^+, Ca^{2+} and Mg^{2+}. The saline soils of coastal areas have plenty of chloride salts, which create physiological drought, osmotic imbalance and ion toxicity to various plant species. Nonetheless, the adverse effect of Cl^- may vary with types of salt and species of plant. This pot experiment reports the effect of 120 mol m^{-3} concentration of different salts of Cl^- on the growth, ion contents and yield of little millet crop. The salinity treatments consist of S_0: Control (No salts), S_1: NaCl, S_2: $MgCl_2$, S_3: $CaCl_2$, S_4: mixture of NaCl, $MgCl_2$ and $CaCl_2$, (1:1:1) and S_5: salt efflorescence. The results indicate the adverse impacts of all chloride salts on plant growth, yield and internal chemical compositions of plant biomolecules. In comparison of control treatment (S_0), the maximum decrease in plant height by 13.97%, number of tillers by 27.42%, root biomass by 45.92% and grain and straw yield by 31.78% and 14.83% respectively was observed in treatment S_1. Moreover, the concentration of toxic elements like sodium and chloride were observed significant at ($p<0.05$) in S_1 and S_5 treatments. Similarly, the concentration of effective ion nitrogen, phosphorus and potassium were suppressed and found lowest in S_1, S_2, S_4 by 74.21%, 40.21%, 35%% respectively. It is concluded that, the chlorides of sodium at the concentration of 120 mol m^{-3} are highly toxic for growth and biochemical properties in comparison to other salts of the chlorides and salt efflorescence.

Key words: Little millet, Salts stress, Growth and yield, Biochemical properties.

Introduction

Salinity has long been considered as a great threat to crop productivity, physico-chemical properties of arable soil on large scale especially in arid and semi-arid regions (Marschner, 1995; Lashari *et al*., 2013), which is going to be very severe for fertile soil; as the world's climate is getting warmer and drier day by day (Wang *et al.*, 2003; Lu. *et al.*, 2015). It is estimated that about 1128 Mha of land on the globe is affected by salinity and sodicity (Wicke *et al*., 2011). Salinity threats global food security and up to 1.5 Mha is losing crop production every year (Munns & Tester, 2008). Yet, this will definitely raise the risk of world food production capacity under climate change as the increasing salt stress would result in a decline in crop productivity up to 50% of total arable lands in mid of the 21st century (Mahajan & Tuteja, 2005; Turan *et al*., 2009).

Soil salinity impacts on water and nutrient uptake by plant due to the high osmotic potential by salt (Lashari *et al*., 2015), damaging crop growth and development (Munns & Tester, 2008; Yasir *et al*., 2021). Again, soil salinity impacts on the quantity, restricting soil biochemical functionality (Rietz & Haynes, 2003; Lu *et al*., 2015). Reduction in soil microbial biomass and community structure have also been reported in salt-stressed soils due to salt-stress and associated degradation of bio-physical properties (Lashari *et al*., 2018). Among the all phyto-toxic ions, excess concentration of chloride ions (Cl^-) has been claimed as one of the most dominant and toxic anions present in the saline soils of Sindh (Sial, 1985; Rajpar & Sial, 1997). Chloride disturbs the physiological mechanisms of plant especially reduce the uptake of essential anions such as nitrates, phosphate and sulphates which are required to plant for progressive growth and development (Sairam *et al*., 2002; Yang *et al*., 2018). Infact excessive chloride concentration in soil/root medium induces adverse impacts on plant photosynthesis processes, nutrient quality, chlorophyll content, respiration, transpiration, pre-dawn leaf water potential, stomatal density and conductance, leaf area index and yield (Nan *et al*., 2016).

In case of salt study, chlorides of Na^+ may become more toxic and injurious to plants compared to other salts of chloride such as chlorides of calcium, magnesium, barium and lithium. At equal concentrations the mixture of chloride salts can be non-effective, nonreactive to plants compared with pure concentration of sodium chloride salt. However, some findings indicate that every plant has its own tolerance levels to the variety of salts and ecosystem of the environment (Kumar *et al*., 2005; Rajpar *et al*., 2018).

Little millet throughout crop history known as an ancient and important cereal crop botanically named (*Panicum miliare* L.) belongs to the family *Poaceae*. Minor millets were observed important food crops of the past century and presently claimed as the future food security, considering ill effects of global warming and climate change. Millets crop has the potential to be adopted in wide range of temperatures, humidity, soil moisture regimes and input conditions. It can be a potential option for providing food and feed to millions of small holders of dry land and domestic animals. Moreover, little millet as a C_4 plant has the ability of carbon sequestration and improves agro-biodiversity (Brahmachari *et al*., 2019). Grain product of little millet is highly value added food and beverages in developing countries. However, millets do not contain gluten and therefore advisable for stomach (abdominal) patients (Chandrasekara and Shahidi 2010). This crop can be grown around the year for fodder purpose and especially in summer for grain purpose. Byproduct grain used is a rich source of food containing mineral and dietary elements, malting and beverages. However, some considerable findings related salt-tolerance and pure line selection of little millet under dry land farming system has already been studied by (Pradhan *et al.*, 2011). Little millet is a highly important crop but which is less cultivated in tropical and sub-tropical regions of the world. However, having greater resistance to pests and diseases, it can tolerate salinity, drought, water logging and has high adoptability to the wide range of environment and produce good yield even at low inputs. Some relevant literature also indicates that it can survive under drought and salinity stress (Zhu, 2001). In lower regions of Pakistan especially in Sindh province little millet crop grown randomly in different areas. But most of growers are unaware to get potential yield through the utilization of their degraded land resources. Keeping these views, the study was designed to focus the salt variability, crop response and bioaccumulation, which is not reported before on priority bases.

Materials and Methods

To evaluate the effects of chloride salts on growth and biochemical properties of Little millet, a pot experiment was conducted at Greenhouse Centre for Bio-saline Agriculture, Department of Soil Science, Sindh Agriculture University Tandojam (25°25’35.68′N, 68°32’22.31′E). Experiment was organized with six treatment (S_0=control, S_1= NaCl, S_2= $MgCl_2$, S_3= $CaCl_2$, S_4= mixture of chloride salts Na, Mg and Ca and S_5= salt extract at 120 mM). The salts of chloride (NaCl, $MgCl_2$ and $CaCl_2$) laboratory grade were purchased from Merck Germany. Salt solutions were prepared using chlorides of sodium, magnesium, calcium and mixture of three salts at (120 mM). And also salt was extracted from the salt efflorescence having 120 mM concentration. Physical growth; yield, ion uptake in leaf cells and salt accumulation in soil was recorded.

Soil used for pot experiment: Fresh fertile plough layer of soil (0-20 cm) was collected from experimental site of Sindh Agriculture University Tando Jam. Initially soil was air-dried, pulverized and sieved from 5 mm sieve and filled in plastic pots having height 30 cm and diameter 18.5, filled with approximately 10 kg dry soil. After filling these pots were organized in a randomized complete block design in the experimental area of Greenhouse.

Physico-chemical properties of soil: The soil used for experiment purpose was clayey loam in texture (26.30% sand, 35.09% silt and 38.61% clay), non-saline ECe < 2.12 dS m^{-1}, slightly alkaline pH 7.8, non-sodic ESP < 4.89, moderately calcareous $CaCO_3$ 93.2 g kg^{-1}, having normal range of basic cations and anions (Calcium 6.50, magnesium 3.80 and sodium 4.34 meq L^{-1}). Organic matter 10.27 g kg^{-1}, total nitrogen 0.51 g kg^{-1}, available phosphorus 0.039 g kg^{-1} and with adequate concentration of potassium 0.1783 g kg^{-1}. At the time of harvest, soil sample was collected from all experimental pots for the analysis of soil chemical properties.

Raising of plants: Initially, all the filled pots with fertile soil were irrigated to reach field capacity. After that, surface of filled soil was opened up to 20 cm with the help of hand tools and then pulverized thoroughly and leveled equally in the filled pots. After that fifteen pre-soaked seeds of little millet were sown in pots up to a depth of 2 cm. After sowing, all pots were covered with green fiber net to avoid the quick loss of soil moisture from the soil due to increasing degree of day temperature. Twenty days later, when all seedlings were completely grown up, the rouging was done to keep five plants in each pot for further observation and application treatments.

Preparation of different Cl^- salts and salt efflorescence solutions: For the application of chloride water, salts of NaCl, $MgCl_2$, $CaCl_2$ and mixture of all three salts solution were prepared by calculating molecular weight of salt at 1M in distilled water. The solution were further diluted and prepared 120 mM before application. For salt efflorescence, salt crust of saline soil was collected and extracted using distilled water, obtained initial salt concentration throughout extracting process were further diluted up to the concentration of 120 mM under laboratory conditions and were applied to crop. Applications of all chlorides salts were applied twice in week as per field capacity levels and followed by once with non-saline water to all treatments for refreshing the soil properties.

Fertilizers applications: Recommended rate of nitrogen 180 kg ha^{-1} and phosphorus 90 kg ha^{-1} was applied to each pot by using the fertilizer urea and di-ammonium phosphate. The di-ammonium phosphate fertilizer was grinned in a pestle mortar and dissolved in distilled water, filtered from cotton cloth and equally distributed to all pots at the time of sowing. One third of urea was applied at the time of sowing and remaining quantity of urea fertilizer was applied in three splits.

Plant sampling and analysis for ion content: Plants leaf samples at the maturity stage were collected for the analysis of ion content in leaf sap. A portion about 4.0 g of fresh green leaves were chopped into small pieces, placed in a plastic centrifuge tube and frozen at -16 ^{0}C for the two of weeks (Cuin & Shabala, 2007). The frozen leaf samples were further homogenized using glass rods and then centrifuged at 10000 × *g* for 25 minutes to obtain the clear supernatant leaf sap. For total nitrogen and phosphorus determination, 6 mL of the supernatant leaf sap was digested with concentrated H_2SO_4 at 280°C on an electric hot plate few drops of H_2O_2 were added to increase the rate of digestion. For determination of ion contents of Na^+, K^+ and Cl^-, the leaf sap was diluted 1:50 with deionized water and measured directly using methods (Cuin & Shabala, 2007; Chen *et al.*, 2007). At the same time for all mentioned analysis, a blank sample was processed with the same procedure.

Data processing and analysis: All recorded data from pot experiments including soil and plant were expressed as mean ± SD. Observed data were processed using Microsoft Excel 2007 and statistical analysis was done with SPSS, version 16.0, 2001 (SPSS Institute, Chicago, IL, USA). Significance for differences between the treatment means was examined by one-way analysis of variance (ANOVA), with a probability defined at (p<0.05).

Results

Soil properties: The soil treated with chloride of Na^+, Mg^{2+}, Ca^{2+}, mixture of chloride salts and salts efflorescence solutions were shown a typical condition as represented by saline soils at the time of plant harvesting v/s control (not added chloride salts), data presented in (Table 1). In compression with control treatment the plants of little millet under pot experiment were treated with chloride salts of Na^+, Mg^{2+}, Ca^{2+}, mixture of chloride salts of (Na, Mg, Ca) and salt efflorescence appeared to be slightly increased soil salinity. Comparatively the maximum soil salinity was observed in treatment S_1 followed by S_4 and it was higher by 65% and 50% respectively compared to other chloride salts and salts efflorescence. 50% where the soil was treated with 120 mM NaCl and salt mixture as compared to other chloride salts solution and salt efflorescence extract. Similarly, the soil pH was increased in treatment S_2, S_3 and S_4. The maximum soil pH was increased 7.32%, 6.20% and 3.79% where the 120 mM $CaCl_2$, $MgCl_2$ and mixture of chloride salt were used for irrigation purpose. The significant accumulation of Na^+ (94.03% and 92.02%), Cl^- (83.01% and 75.04%) was observed in experimental soil after the harvest of little millet in treatment S_1 and S_4 respectively, where the experimental soil was treated with the salt of NaCl and mixture of chloride salts in comparisons of other salts treatment. Soil bicarbonates (HCO_3^-) were increased up to toxic limits in S_5, where the sources of salts to plants were used salt efflorescence extract.

Crop growth and yield: The applications of chloride salts solutions significantly and adversely affected plant growth related components such as plant growth, root biomass, number of tillers plant^{-1}, biomass production grain and straw plant^{-1}. The maximum decrease over the control treatment in plant height by 13.97%, tillers plant^{-1} by 27.42, root biomass by 45.92%, straw and grain yield by 31.78 and 14.83% was observed in treatment S_1, where the plants were treated with120 mM NaCl (Table 2).

Ion accumulation in leaf sap: Majority of chloride salts caused ion toxicity and suppressed effective nutritional transport in plant biomolecules. Data presented (Table 3) indicates significant decrease in major nutrient content in plant leaf cell sap. The maximum decrease in plant cell sap nitrogen, potassium and K/Na ratio was observed in treatment S_1 by 75.21, 35.00 and 85.37% respectively, while the maximum cell sap phosphorus was decreased in treatment S_3. Moreover, the magnesium content was significantly increased in all over treatment except control treatment S_0, while high content of leaf cell sap calcium by 40.94% and low content of leaf sap phosphorus by 40.21% was observed where 120 mM $CaCl_2$ solution was source of irrigation for plants. Meanwhile, sodium Na^+ and chloride Cl^- content in leaf sap was significantly increased in all treatment v/s control (Fig. 1A). The maximum leaf sap Na^+ content was observed in treatment S_1 and S_5 by 78.80% and 75.21% respectively, where 120 mM NaCl and salt extract was applied to plant as a source of irrigation. While the content of cell sap Cl^- was variable in all treatments shown (Fig. 1B). However, the maximum concentration of leaf sap chloride by 75.02% was observed in treatment S_4, where the mixture of chloride salts of (Na^+, Ca^{2+}, Mg^{2+}) was applied to crop as a source of irrigation.

Table 1. Effect of Chloride salts and salt extract on chemical properties of soil after harvesting of little millet (*Panicum maliare* L.)

Treatments	ECe (dS m^{-1})	pH	Cl^-	HCO_3^-	Ca^{2+}	Mg^{2+}	Na^+
S0	2.03 ± 0.21d	7.60 ± 0.12c	12.93 ± 1.08d	5.16 ± 0.13c	5.80 ± 0.87d	3.60 ± 0.08f	4.12 ± 0.91d
S1	5.80 ± 0.13a	7.80 ± 0.20b	76.66 ± 1.13a	6.18 ± 0.08bc	13.90 ± 0.73c	10.70 ± 0.14d	73.00 ± 1.33a
S2	3.32 ± 0.32c	8.20 ± 0.22a	43.16 ± 0.79bc	6.33 ± 0.04bc	15.70 ± 0.65b	33.00 ± 0.96a	13.33 ± 0.13c
S3	3.47 ± 0.22c	8.10 ± 0.46a	45.15 ± 0.67bc	7.00 ± 0.32b	29.00 ± 0.32ab	13.70 ± 0.11cd	15.33 ± 0.40c
S4	4.06 ± 0.51ab	7.90 ± 0.23b	52.78 ± 0.86b	7.12 ± 0.65b	29.00 ± 0.51ab	21.00 ± 0.19b	52.78 ± 0.96b
S5	3.83 ± 0.11bc	7.80 ± 0.17b	49.83 ± 1.04b	13.00 ± 0.41a	31.00 ± 0.71a	16.00 ± 0.05c	49.83 ± 0.41bc

S_0=control (00 mM salt), S_1= NaCl, S_2= $MgCl_2$, S_3= $CaCl_2$, S_4= Mixture of chloride salts (Na^+, Mg^{2+} and Ca^{2+}) and S_5= Salt extract at 120mM
EC= Electrical conductivity, Chloride (Cl^-), Bi-carbonates (HCO_3^-), Calcium (Ca^{2+}), Magnesium (Mg^{2+}) and Sodium (Na^+) meqL^{-1}
Different letters next to the mean value indicate significant differences at p≤0.05

Table 2. Effect of Chloride salts and salt extract on growth and yield of little millet (*Panicum maliare* L.)

Treatments	Plant height	Tillers plant^{-1}	Grain yield	Straw yield	Root biomass	Root length
S0	77.40 ± 3.28a	5.47 ± 0.61a	3.80 ± 1.75a	10.70 ± 1.12a	2.94 ± 0.32a	26.67 ± 2.04ns
S1	66.27 ± 1.92d	3.97 ± 0.48c	3.31 ± 0.36d	7.30 ± 1.40cd	1.59 ± 0.43d	22.98 ± 1.98
S2	73.67 ± 1.48b	5.13 ± 1.61a	3.72 ± 1.01b	8.90 ± 2.21b	1.84 ± 0.26c	24.33 ± 1.89
S3	72.00 ± 2.87b	4.00 ± 0.53bc	3.67 ± 3.06c	8.50 ± 1.97bc	2.76 ± 0.11b	22.33 ± 3.55
S4	68.42 ± 1.97c	4.05 ± 0.47bc	3.41 ± 3.04cd	7.97 ± 0.35c	2.66 ± 0.21b	25.00 ± 1.00
S5	70.81 ± 2.31bc	4.41 ± 0.38b	3.45 ± 1.98cd	9.56 ± 0.89b	2.62 ± 0.31bc	25.47 ± 1.87

S_0= Control (00 mM salt), S_1= NaCl, S_2= $MgCl_2$, S_3= $CaCl_2$, S_4= Mixture of chloride salts (Na^+, Mg^{2+} and Ca^{2+}) and S_5= Salt extract at 120mM
Plant height, Root length (cm), Number of tillers plant^{-1}, Grain yield, straw yield and root biomass plant^{-1} (g)
Different letters next to the mean value indicate significant differences at p≤0.05

Table 3. Effect of Chloride of Na^+, Mg^{2+}, Ca^{2+}, mixture of salts and salt extract (efflorescence) on ion content in cell sap of little millet (*Panicum maliare* L.).

Treatments	N mM	K^+ mM	K/Na	Ca^{2+} mM	Mg^{2+} mM	P mM
S0	796.34 ± 11.35a	314.50 ± 1.36a	29.09 ± 0.43a	20.67 ± 0.29c	2.22 ± 1.42e	78.57 ± 3.86a
S1	675.45 ± 17.28e	216.55 ± 0.33d	4.24 ± 0.29d	18.33 ± 0.33d	10.55 ± 0.48d	53.71 ± 2.89c
S2	721.34 ± 9.56c	261.28 ± 0.69b	15.95 ± 0.19bc	17.50 ± 0.00d	58.33 ± 0.81a	56.82 ± 5.32c
S3	732.34 ± 13.24b	243.68 ± 2.15c	18.28 ± 0.77b	35.00 ± 0.00a	21.11 ± 0.00c	46.98 ± 3.80d
S4	697.84 ± 8.86d	230.28 ± 0.93cd	7.18 ± 0.32c	31.00 ± 0.41ab	43.61 ± 0.36b	59.23 ± 4.11b
S5	711.76 ± 17.46cd	239.45 ± 0.77c	5.49 ± 0.52d	29.16 ± 0.27b	60.83 ± 0.72a	61.28 ± 2.67b

S_0= Control (00 mM salt), S_1= NaCl, S_2= $MgCl_2$, S_3= $CaCl_2$, S_4= Mixture of chloride salts (Na^+, Mg^{2+} and Ca^{2+}) and S_5= Salt extract at 120mM
N= Nitrogen, P= Phosphorus, mM= Milimolar. Different letters next to the mean value indicate significant differences at $p \leq 0.05$

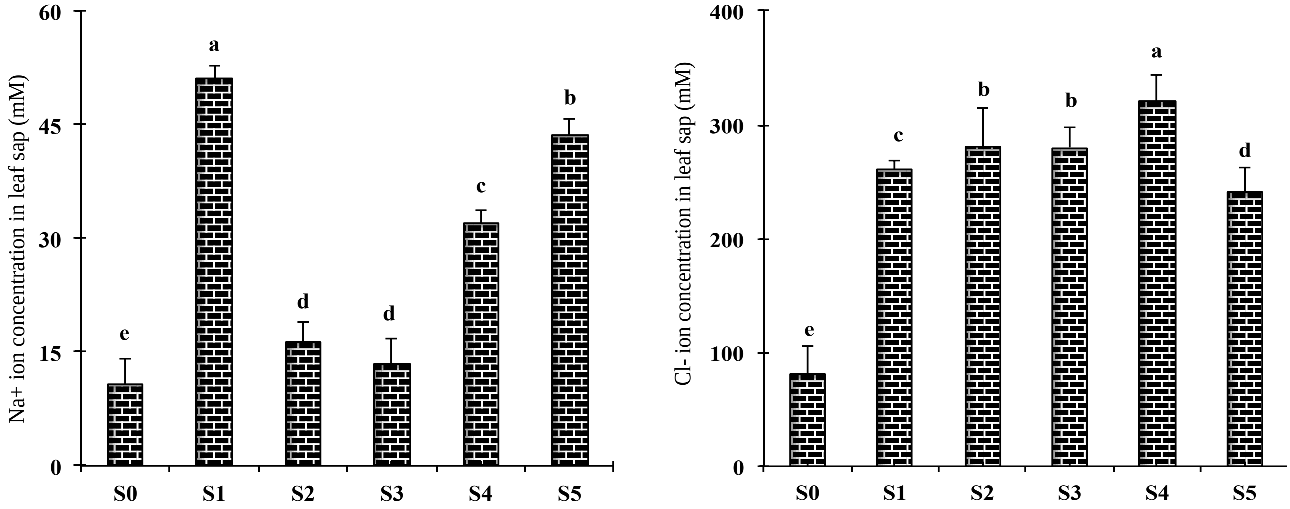

Fig. 1. A and B. Sodium (Na^+) and Chloride (Cl^-) ion concentration in leaf sap of little millet (*Panicum maliare* L.).

Discussion

Impacts of chloride salts on soil properties: Addition of chloride salts into soil raise the electrical conductivity of soils and may produce adverse effects on soil physico-chemical properties as well as on soil biota (Munns *et al*., 2006; Lashari *et al*., 2018). In case of salinity, surplus chloride salts in soil adversely affect the growth and development of the numerous crop species excluding halophytes (Pascale *et al*., 2005; Wittyngham *et al*., 2019). However, the intensive effects of chloride salts addition to plant species in very small quantity may be required for physiological responses (Li *et al*., 2000). But this study demonstrated significant interaction of various chloride salts on growth and development of little millet. The majority of growth and development processes were retarded due to the addition of chloride salts at 120 mM. While our findings showed that the plant suffered most particularly growth and permanent negative effects on soil properties were due the addition of NaCl and mixture of chloride salts at 120 mM in the term to raise the soil electrical conductivity, fluctuate soil pH and perfectly add high content of Na^+ and Cl^- ion soil proportion. The increasing proportion of salts such as having higher quantity of chlorides of sodium may cause salinity problem anywhere accumulated in soil layers. Such as the addition or accumulations of these salts through other source may cause negative impacts on soil properties (Lutts *et al*., 2004). It has been reported major losses of arable lands due to accumulation of salts, changing soil environment due to climatic conditions (Khan & Gulzar, 2003).

Impacts of chloride salts plant growth: Chloride salts induce biotic stress in living organism including plants and also disperse the physical condition of soils by producing highly negative effects on soil physical and biological properties (Rietz & Haynes 2003). In this study the addition of chloride salts of sodium (S_1) and chloride mixture (S_4) reduced seedling growth, including plant height, number of tillers, above ground biomass and grain yield at the time of harvest (Table 2), similar impact on maize growth and yield were also observed and had been reported due to soil salinity at central great plain of China (Lashari, 2014). Chloride salt accumulation adversely impacts on soil nutritional components due to the less soil biological function and microbial activity. The present results clearly indicated the negative effects of chloride salts on growth inhibition, development process such as number of tillers low uptake of essential growth forming nutrients in plant leaf sap whereas the salt of sodium chlorides was applied (120 mM) to the little millet in compression of other chloride salts (Table 3). These findings were correlated with the findings of (Muhammad & Hassan 2010; Adhikari *et al*., 2019; Yousif *et al.,* 2021) who concluded that the salt of sodium chloride was highly toxic compared to other chloride salts. Our results reveled a clear negative effect on crop growth, with low biomass and yield in compression of control treatment. Meanwhile, the variety of chloride salts showed variable negative impacts on plant growth, biomass and yield in similar sense.

At the active stages of seed germination, the inhibitory effects of toxic salts showed primary injury that lead to other technical symptoms such as programmed cell death might also occur under extreme salinity shock (Rajpar & Sial 2002; Satish *et al.*, 2016). Excessive sodium ions at the surrounding rhizosphere disturb plant potassium nutrition and its availability (Tester & Davenport, 2003). Because of the similar chemical nature of sodium and potassium ions, sodium has a strong inhibitory effect on potassium uptake by the root. Plants use both low and high affinity systems for potassium uptake. Sodium ions have a more damaging effect on the low-affinity system, which has low K/Na selectivity in plant bio-molecule. Under sodium stress, it is necessary for plants to operate the more selective high-affinity potassium uptake system in order to maintain adequate potassium nutrition source like as bio-fertilizer and biochar to improve nutritional affinity in plant system (Lashari *et al*., 2018). Potassium deficiency inevitably leads to growth inhibition because potassium, as the most abundant cellular cation, plays a critical role in maintaining cell turgor, membrane potential and enzyme activities.

Once sodium gets into the cytoplasm, it inhibits the activities of many enzymes. This inhibition is also dependent on how much potassium is present. High Na/K ratio is the most damaging plant metabolic processes (Rajpar *et al*., 2018; Hu *et al.,* 2021). Even in the case of halophytes they accumulate large quantities of sodium inside the cell, their cytosolic enzymes are just as sensitive to sodium as enzymes of glycophytes. This implies that halophytes have to compartmentalize the sodium into the vacuole, away from cytosolic enzymes. An important factor in the battle between sodium and potassium ions is calcium (Shabala, 2009). Increased calcium supply has a protective effect on plants under sodium stress. Calcium sustains potassium transport and K/Na selectivity in sodium-challenged plants. This beneficial effect of calcium is mediated through an intracellular signaling pathway that regulates the expression and activity of potassium and sodium transporters. Calcium may also directly suppress sodium import mediated by nonselective cation channels. Finding of this study indicated that less suppression of calcium ion in plant leaf sap in treatment (S_4), where the salt of calcium chloride was applied.

Chloride salts and ionic imbalance: Ionic imbalance is a major threat to many crops under any types stress caused under field conditions. While the salt stress is one of them disturb balanced uptake of ion for the growth of plant. Ion disturbances under salt-stress environment specially reduce plant growth by affecting the availability, transportation and compartmenting of nutrients in plant (Baghalian *et al*., 2008). However, salt-stress can differentially affect the mineral nutrition of plants during different growth stages. Salt-stress may cause insufficient supply of nutrient or imbalances, due to the competition of Na^+ and Cl^- with nutrients such as K^+, Ca^{2+}, and NO_3^- (Bhaskaran & Panneerselvam, 2013; Hu *et al.,* 2021), mainly the reduced plant growth observed under salt stressed environment due to specific ion toxicity i.e. chlorides of sodium and ionic disorders directly act on biophysical and metabolic functions of plant growth (Tester & Davenport, 2003). However, present results indicated prominent negative changes in plant growth due the application of chlorides salts. Even more ionic disorder was observed due to the addition of sodium chloride at 120 mM^{-1}. Overall, our results co-related with the findings of (Li *et al*., 2002; Jaleel *et al*., 2007). In comparison to control treatment (S_0), all specific ions (N, P, K, Ca and Mg) were suppressed (Table 3) due to toxic concentration of chloride observed in little millet leaf sap.

Conclusion

The present study showed that all chloride salts and salt efflorescence are highly harmful for little millet plants due to their toxic effects. Overall, studies showed that the toxic limits vary from species to species and plant to plant. Moreover, it was observed that chlorides of sodium are highly toxic for the growth of little millet plants, which caused reduction in grain yield and early crop maturity in comparison to the control treatment. It was further observed that, the addition of chloride salts of Na^+ created specific ion imbalance, induced salt stress and reduced quality and quantity of little millet, which became toxic for plant health and responsible for producing negative impact on soil quality. It is recommended that, the little millet crop should be cultivated under moderate levels of soil salinity to ensure good crop growth and quality grains as well as to avoid hazardous residual effects on plant parts being consumed by humans and animals.

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