Effects of Salicylic acid on some yield characteristics of Capsicum annuum L. under Sodium Fluoride Stress

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ABSTRACT: Fluoride contaminated soil is one of the major concerns for agricultural industry as it has adverse effects on yield of economical crops, and it is high need of time to fulfill the requirements and meet the standards. Therefore, present research was conducted to check the effects of Salicylic acid on some yield characteristics of Capsicum annuum L. under Sodium Fluoride stress. Capsicum annuum L. is an edible crop used for human nutrition. It contains an alkaloid compound called as Capsaicin. Capsaicin has many benefits as it has bacterial growth inhibition effects, anti-carcinogenic, anti-mutagenic, antioxidant, and immunosuppressive characters. Keeping in view the present scenario there is a special need to increase the Capsicum production. Two varieties of Capsicum annuum L. (Magma and Zenia) were studied during the growth season 2018. To create stress condition, different concentrations of sodium fluoride i.e., 50, 100, 150, 200, 250 and 300 ppm were given as soil drench twice a week. The gradual accumulation of sodium fluoride created toxic effects on growth of plants. Significant reduction was observed with increased concentration of sodium fluoride in yield. The foliar applications of salicylic acid (100 ppm and 200 ppm) on C. annuum plants grown under sodium fluoride stress reduced the stress effect and increased the yield almost 50-70%. By observing the effects of salicylic acid, the present pot experiment was conducted to conclude that foliar application of salicylic acid promotes the salt tolerance in two varieties of Capsicum annuum L.

Key Word: Salicylic acid, Yield, Capsicum annuum L., Fluoride stress, Agriculture.

INTRODUCTION

Chili (Capsicum) a crop, which belongs to solanaceae family, is of significant worth depending on the economic point of view. The generic name Capsicum originated from word ‘capsa’ which is a Latin word. ‘Capsa’ meaning box or chest.¹ Genus Capsicum has 30 species. Out of 30
species, five are cultivated at domestic level, that are *Capsicum frutescens* L., *Capsicum annuum* L., *Capsicum baccatum* L., *Capsicum chinense* L., *Capsicum pubescens* as their common names are bird pepper, hot and sweet peppers, aji, aromatic chili pepper and Ruiz and Pav. (rocoto) respectively. This crop is native to Central and South America. It is considered that, the first spice used by human beings was Pepper.  

Different biotic and abiotic factors influence the productivity and growth of the plants. Abiotic factors include cold, heat, drought and salinity etc. While Biotic factors are insects, virus, bacteria and fungi etc. Each year loss of huge mass of crop occurs owing to these biotic and abiotic stresses. Among all of these factors, soil salinity is the most disastrous factor. Soil salinity not only affects the plant growth and metabolic processes but sustainability of agricultural products is also severely intimidated by it in semi-arid and arid areas of the world. The only solution concerning the growth of plants in saline soils is the selection of salt tolerant cultivars.

In nature, fluoride is not present in the elementary state, however it is mostly found in the form of inorganic compounds that contain fluoride. In terrestrial abundance, fluoride holds 13th position and its weight in Earth’s crust is 0.06-0.09%. It possesses a strong electro negativity and is widely distributed in the environment as encountered in vegetation, water, air and soil. Freshwater bodies have lesser concentration of fluoride as 0.0-0.3 ppm. Hot water springs in volcanic areas have higher concentration of fluoride. Food items that we intake on daily basis also contains significant amount of fluoride. Natural sources of fluoride accumulation in soil are weathering of minerals, volcanic ashes and rocks. Anthropogenic sources involve improper irrigation practices, excessive use of agricultural fertilizers and treatment of phosphate fertilizers on agricultural soil. Extreme use of fertilizers such as diammonium phosphate (DAP) on plants is the main cause of enhancing the fluoride level in soil and contaminates ground water and soil. Different industrial sources are also the source of fluoride accumulation in environment as a result yield of different valuable crops has been reduced.
Plants that grow in acidic soils have greater concentration of fluoride than the normal ones. There are examples of some plants such as tea plant (Camellia sinensis, syn. Thea sinensis) which have lesser amount of fluoride as 100 ppm. However, fluoride toxicity affects all the organisms, humans as well as plants. Different physiological processes such as chlorosis, necrosis and leaf tip burn have decreased plant growth. Crop growth especially at the beginning of seedling is adversely affected by fluoride contamination.

Salicylic Acid is present in plants either in free state or conjugated form e.g., methylated, amino acid, glucose–ester or glycosylated. Pathogenesis-related protein expressions are regulated by salicylic acid. It enhances the resistance from biotrophic pathogens in plants. In the presence of low SA concentrations antioxidant capacity enhances in plants. Vulnerability to abiotic conditions and cell death in plants occur due to high salicylic acid concentrations. Response to abiotic conditions, development, flowering, ripening and plant growth regulation are important factors that are controlled by SA.

The main objective of present study was to understand whether foliar application of salicylic acid could increase the NaF stress tolerance in the two varieties of Capsicum annum (Magma and Zenia) and observed various changes in the yield of chili plants.

MATERIALS AND METHODS

Certified F1 hybrid chili pepper (Capsicum annum) seeds of two varieties Magma and Zenia were purchased from Roshan Centre Zarai Markaz Lahore and were compartmentalized based on healthy equal sized seeds which were packed properly in polythene bags for further experimental work and unhealthy wrinkled seeds that were discarded. During experiment, the chemicals used according to analytical grades are as: Salicylic acid (SA), Sodium fluoride (NaF). Botanical Garden that is situated in University of the Punjab, Quaid-e-Azam Campus, Lahore was the site of field experiment. March 18, 2018 to June 2018 was the duration of experiment. It was conducted in enclosed wire-netting for protecting the plants from animal attack. Mixture of loamy
and sandy soil in 1:3 was used during the experiment with properly washed and cleaned earthen pots having a diameter and length of 25 cm and 30 cm respectively. Three pots per treatment were arranged according to Randomized Complete Block Design (RCBD). Each pot was filled with 7 kg soil and small pebbles were arranged at the bottom for closure of drainage hole. This closure of drainage hole is compulsory to reduce the excessive drainage of soil and water. Pots were organized depending on the plant variety, number of replicates and application of treatments on plants. Different concentrations of salicylic acid (100 and 200 ppm) and sodium fluoride (50, 100, 150, 200, 250 and 300 ppm) were prepared for the experiment. Calculated quantities of solutes were mixed in distilled water for the preparation of a particular solution. Different dilutions of salicylic acid and sodium fluoride in ppm were made and applied twice a week throughout the experimental season on Capsicum cultivars as foliar spray (SA) and soil drench (NaF) to alleviate NaF stress. 150 ml of sodium fluoride solution was applied as soil drench method in each pot to create stress.

Data obtained from the pot experiment was then used to calculate treatment mean, standard error and Duncan’s Multiple Range Test, as described by Steel and Torrie. For this purpose, Software package Costat (version 3.03) was employed using computer facility of the laboratory.

RESULTS

In Earth crust, fluoride occur in very little amount, but commonly acts as an environmental pollutant. It significantly affects various physiological processes of plants like decreasing plant growth, chlorosis, leaf tip burns and necrosis. Salicylic acid (SA) a naturally occurring plant hormone is an important signal molecule known to have diverse effects on biotic and abiotic stress tolerance. Exogenous applications of SA enhance plant growth and photosynthetic capacity in crop plant under stress conditions.
Keeping in view the productive effects of salicylic acid in stress tolerance of plants, current pot experiment was carried out to determine whether application of salicylic acid could promote stress tolerance of NaF in two different varieties of Capsicum annuum plants or not and to assess the connotation of yield characteristics.

**Number of Fruit:** Table 1 showed that in var. Magma, control and SA-100 gave the maximum result and total fruit number was increased. Gradual reduction was recorded under sodium fluoride stress NaF-50, NaF-100, NaF-150, NaF-200, NaF-250, NaF-300 ppm as (12.56, 22.58, 25.81, 35.48, 41.94 and 64.52%) respectively. Application of foliar salicylic acid e.g., SA-100 enhanced fruit number per plant significantly and reduction was recorded (-9.68%). SA-100 with different concentrations of sodium fluoride e.g. NaF-50+SA-100, NaF-100+SA-100, NaF-150+SA-100, NaF-200+SA-100, NaF-250+SA-100, NaF-300+SA-100 gave maximum fruit number and reduction was recorded as (9.68, 9.68, 16.13, 22.58, 35.48 and 51.61%) in contrast to NaF-50+SA-200, NaF-100+SA-200, NaF-100+SA-200, NaF-150+SA-200, NaF-200+SA-200, NaF-250+SA-200, NaF-300+SA-200 (19.35, 25.81, 32.26, 41.94, 48.39 and 61.29%) respectively.

In Table 1, Zenia variety showed different fruit number under different treatments as control, SA, NaF and combined SA & NaF doses. Maximum fruit number was recorded under control and SA-100 doses and recorded percentage reduction was -11.54%. Progressive reduction in fruit number was observed under sodium fluoride treatments NaF-50, NaF-100, NaF-150, NaF-200, NaF-250, NaF-300 ppm (15.38, 26.92, 30.77, 38.46, 50.00 and 65.38%) and NaF-50+SA-200, NaF-100+SA-200, NaF-100+SA-200, NaF-150+SA-200, NaF-200+SA-200, NaF-250+SA-200, NaF-300+SA-200 (23.08, 30.77, 38.46, 50.00, 57.69 and 73.08%) respectively.

**Fruit Length:** In Table 1, Magma variety showed maximum fruit length. Plants grown in control conditions and SA-100 have maximum fruit length. Significant percentage reduction in fruit length was observed 3.92, 10.98, 13.33, 19.61, 19.61 and 29.02% under 50, 100, 150, 200, 250
and 300 ppm NaF treatments. However, salicylic acid (100 ppm) in foliar spray significantly enhanced the length of fruits per plant under NaF stress conditions. Percentage reduction observed at SA-100 ppm was -1.96% in comparison to SA-200 ppm (9.41%). Increase in fruit length was observed under NaF-50+SA-100, NaF-100+SA-100, NaF-150+SA-100, NaF-200+SA-100, NaF-250+SA-100, NaF-300+SA-100 and percentage reduction was (1.96, 1.96, 6.27, 10.20, 16.86 and 20.39%) irrespective to NaF-50, NaF-100, NaF-150, NaF-200, NaF-250, NaF-300 (3.92, 10.98, 13.33, 19.61, 19.61 and 29.02%) and NaF-50+SA-200, NaF-100+SA-200, NaF-100 + SA-200, NaF-150+SA-200, NaF-200+SA-200, NaF-250+SA-200, NaF-300+SA-200(12.16, 14.51, 20.00, 20.78 21.57 and 33.73%).

Table 2 showed fruit length of variety Zenia grown under control, SA, NaF and in combined SA & NaF treatments. Maximum fruit length was observed under SA-100 and percentage reduction was (-4.46%). In the same manner NaF-50+SA-200, NaF-100+SA-200, NaF-100 + SA-200, NaF-150+SA-200, NaF-200+SA-200, NaF-250+SA-200, NaF-300+SA-200 showed maximum percentage reduction (13.38, 19.11, 23.57, 30.57, 31.21 and 29.30%) respectively as compared to other treatments.

**Fruit Weight:** For variety Magma and Zenia, increase in fruit weight (-1.70 and -1.55%) was studied by applying SA-100 ppm in foliar form as shown in Table 1-2. Sodium fluoride stress minimized the fruit weight and hence, gradual reduction was noted under NaF-50, NaF-100, NaF-150, NaF-200, NaF-250, NaF-300 ppm as 4.23, 6.52, 8.56, 13.78, 17.49 and 21.22% in var Magma and 7.84, 9.71, 12.76, 20.33, 25.84 and 31.34% in var Zenia respectively. Different sodium fluoride concentrations with SA-100 gave maximum results irrespective to SA-200 that showed maximum reduction in fruit weight.
Table 1: Yield parameters of *Capsicum annuum* L. var. Magma 103 DAS by using different sodium fluoride and salicylic acid concentrations during the growth season 2018

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Yield Parameters</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Fruit length (cm)</td>
<td>No. of fruits per plant</td>
<td>Weight of fruit per plant (g)</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>8.50 ±0.17</td>
<td>10.33 ±0.27</td>
<td>83.19 ±0.61</td>
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<tr>
<td>NaF-50</td>
<td>8.17 ±0.07</td>
<td>9.00 ±0.47</td>
<td>79.67 ±0.69</td>
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<tr>
<td>NaF-100</td>
<td>7.57 ±0.28</td>
<td>8.00 ±0.47</td>
<td>77.77 ±0.38</td>
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<tr>
<td>NaF-150</td>
<td>7.37 ±0.24</td>
<td>7.67 ±0.72</td>
<td>76.07 ±0.31</td>
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<tr>
<td>NaF-200</td>
<td>6.83 ±0.27</td>
<td>6.67 ±0.27</td>
<td>71.73 ±0.37</td>
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<tr>
<td>NaF-250</td>
<td>6.83 ±0.27</td>
<td>6.00 ±0.47</td>
<td>68.63 ±0.33</td>
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<tr>
<td>NaF-300</td>
<td>6.03 ±0.17</td>
<td>3.67 ±0.72</td>
<td>65.53 ±0.33</td>
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<tr>
<td>SA-100</td>
<td>8.07 ±0.20</td>
<td>11.33 ±0.54</td>
<td>84.60 ±0.54</td>
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<tr>
<td>SA-200</td>
<td>7.70</td>
<td>8.00</td>
<td>78.80</td>
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</table>
Table 2: Yield parameters of Capsicum annuum L. var. Zenia 103 DAS by using different sodium fluoride and salicylic acid concentrations during the growth season 2018

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Fruit length (cm)</th>
<th>No. of fruits per plant</th>
<th>Weight of fruit per plant (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>5.23 ±0.12</td>
<td>8.67 ±0.27</td>
<td>56.92 ±0.45</td>
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<tr>
<td>NaF-50</td>
<td>4.80 ±0.12</td>
<td>7.33 ±0.54</td>
<td>52.46 ±0.55</td>
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<tr>
<td>NaF-100</td>
<td>4.57 ±0.05</td>
<td>6.33 ±0.54</td>
<td>51.39 ±0.62</td>
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<tr>
<td>NaF-150</td>
<td>4.17 ±0.07</td>
<td>6.00 ±0.82</td>
<td>49.66 ±0.77</td>
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<tr>
<td>NaF-200</td>
<td>3.77 ±0.05</td>
<td>3.33 ±0.27</td>
<td>43.34 ±0.64</td>
</tr>
<tr>
<td>NaF-250</td>
<td>3.73 ±0.07</td>
<td>4.33 ±0.27</td>
<td>42.21 ±0.88</td>
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<tr>
<td>NaF-300</td>
<td>3.47 ±0.21</td>
<td>3.00 ±0.47</td>
<td>39.08 ±0.95</td>
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<tr>
<td>SA-100</td>
<td>5.47 ±0.21</td>
<td>9.67 ±0.72</td>
<td>57.80 ±0.21</td>
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<tr>
<td>SA-200</td>
<td>4.63 ±0.19</td>
<td>6.33 ±0.27</td>
<td>52.33 ±0.40</td>
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<td>NaF-50+SA-100</td>
<td>5.07 ±0.10</td>
<td>7.67 ±0.72</td>
<td>54.18 ±0.38</td>
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<tr>
<td>NaF-100+SA-100</td>
<td>4.87 ±0.07</td>
<td>7.67 ±0.27</td>
<td>53.37 ±0.65</td>
</tr>
<tr>
<td>NaF-150+SA-100</td>
<td>4.77 ±0.07</td>
<td>7.00 ±0.27</td>
<td>51.72 ±0.21</td>
</tr>
</tbody>
</table>
DISCUSSION

Fluoride is a well-known substance offering very little amount of it in the earth’s crust but can causes damaging effects on growth and developmental processes and is also recognized as non-essential plant element. High levels of fluoride in acidic soil enhanced the toxicity of soil so it is difficult for plants to survive in such toxic conditions. Different kinds of fluoride are there in the soil, air and water and are continuous source of environmental pollution.

The yield parameters are highly affected by sodium fluoride stress. The increased concentrations of sodium fluoride decreased the number of flower and fruits in both varieties of *Capsicum*. The exogenously applied salicylic acid enhanced the flowering in *Sinningia speciosan* in relation to control plant studied by Martin-Mex et al.\textsuperscript{21} The plants heights and yields of different varieties of pea plant (*Pisum sativum*) decreased under sodium fluoride stress while this decline was overcome by the salicylic acid applied exogenously.\textsuperscript{22} The application of salicylic acid led to a decline in the adverse effects of salt stress which ultimately improves the growth characteristics and fruit yields of sweet pepper plants.\textsuperscript{23}
CONCLUSION

Fluoride is being added to agricultural soil day by day due to anthropogenic sources i.e., improper irrigation practices, excessive use of agricultural fertilizers and treatment of phosphate fertilizers and causing drastic effects on yield of crops. However, the foliar applications of salicylic acid have reduced the sodium fluoride stress in soil and proved much effective in response to NaF stress conditions. The exogenously applied salicylic acid increased the yield of two varieties of *Capsicum annuum* by reducing the sodium fluoride stress. The salicylic acid in very high concentration also caused high level of plant stress hence proved less effective therefore recommended with standard dose.

REFERENCES


