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# 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 needs considerable 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 conclusion of the present pot experiment was that foliar application of salicylic acid promotes the salt tolerance in two varieties of *Capsicum annuum* L.**

Key words: Agriculture; *Capsicum annuum* L.; Fluoride stress; Salicylic acid; Yield.

## INTRODUCTION

Chili (*Capsicum*) a crop, which belongs to solanaceae family, is of significant worth from an 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,. These are: *Capsicum frutescens* L., *Capsicum annuum* L., *Capsicum baccatum* L., *Capsicum chinense* L., and *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.[2]

Different biotic and abiotic factors influence the productivity and growth of the plants. Abiotic factors include cold, heat, drought, and salinity, etc. Biotic factors include insects, virus, bacteria, and fungi etc.[3] Each year loss of huge mass of crop occurs owing to these biotic and abiotic stresses.[4] Among all of these factors, soil salinity is the most disastrous factor.[5] 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.[6] The only solution

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concerning the growth of plants in saline soils is the selection of salt tolerant cultivars.[7]

In nature, fluoride is not present in the elementary state but is mostly found in the form of inorganic compounds that contain the ion fluoride. In terrestrial abundance, fluoride holds 13th position and its weight in earth's crust is 0.06–0.09%.[8] It possesses a strong electro negativity and is widely distributed in the environment being encountered in vegetation, water, air, and soil. [9]

Freshwater bodies have lesser concentration of fluoride as 0.0–0.3 ppm. Hot water springs in volcanic areas have higher concentration of fluoride.[10] Food items that we intake on daily basis also contains significant amount of fluoride.[11] Natural sources of fluoride accumulation in soil are weathering of minerals, volcanic ashes, and rocks.[12] Anthropogenic sources involve improper irrigation practices, excessive use of agricultural fertilizers, and treatment with phosphate fertilizers on agricultural soil.[13] 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.[14] Different industrial sources are also the source of fluoride accumulation in environment and as a result the yield of different valuable crops has been reduced.[15]

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 a higher amount of fluoride, such as 100 ppm.[16] However, fluoride toxicity affects all 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.[17]

Salicylic acid (SA) 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.[18] In the presence of low SA concentrations, antioxidant capacity is enhanced 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.[19]

In the earth crust, fluoride occurs in a 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.

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 annuum* (Magma and Zenia) and change the yield of chili plants.

## MATERIALS AND METHODS

Certified F1 hybrid chili pepper (*Capsicum annuum)* 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.[20] For this purpose, software package Costat (version 3.03) was employed using computer facility of the laboratory.

## RESULTS

**Number of Fruit**: Tables 1 and 2 show the number of fruit for the two varieties.

Table 1 shows 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, and 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, and NaF-300+SA-100. The maximum fruit number and reduction with was recorded as (9.68, 9.68, 16.13, 22.58, 35.48, and 51.61%), respectively, 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, and NaF-300+SA-200 (19.35, 25.81, 32.26, 41.94, 48.39, and 61.29%) respectively.

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**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. (Values are mean ± S.E; NaF=sodium fluoride; SA=salicylic acid; NaF-SA: sodium fluoride- salicylic acid)

| Treatments | Yield parameters | | |
|---|---|---|---|
| | Fruit length (cm) | No. of fruits per plant | Weight of fruit per plant (g) |
| Control | 8.50±0.17 | 10.33±0.27 | 83.19±0.61 |
| NaF-50 | 8.17±0.07 | 9.00±0.47 | 79.67±0.69 |
| NaF-100 | 7.57±0.28 | 8.00±0.47 | 77.77±0.38 |
| NaF-150 | 7.37±0.24 | 7.67±0.72 | 76.07±0.31 |
| NaF-200 | 6.83±0.27 | 6.67±0.27 | 71.73±0.37 |
| NaF-250 | 6.83±0.27 | 6.00±0.47 | 68.63±0.33 |
| NaF-300 | 6.03±0.17 | 3.67±0.72 | 65.53±0.33 |
| SA-100 | 8.67±0.20 | 11.33±0.54 | 84.60±0.54 |
| SA-200 | 7.70±0.21 | 8.00±0.47 | 78.80±0.45 |
| NaF-50+SA-100 | 8.33±0.18 | 9.33±0.54 | 81.13±0.48 |
| NaF-100+SA-100 | 8.33±0.17 | 9.33±0.27 | 80.00±0.08 |
| NaF-150+SA-100 | 7.97±0.12 | 8.67±0.27 | 78.04±0.44 |
| NaF-200+SA-100 | 7.63±0.30 | 8.00±0.47 | 74.00±0.31 |
| NaF-250+SA-100 | 7.07±0.46 | 6.67±0.54 | 71.30±0.29 |
| NaF-300+SA-100 | 6.77±0.32 | 5.00±0.47 | 69.70±0.29 |
| NaF-50+SA-200 | 7.47±0.23 | 8.33±0.27 | 75.56±0.28 |
| NaF-100+SA-200 | 7.27±0.26 | 7.67±0.72 | 67.57±0.69 |
| NaF-150+SA-200 | 6.80±0.26 | 7.00±0.47 | 61.87±0.77 |
| NaF-200+SA-200 | 6.73±0.22 | 6.00±0.47 | 56.50±0.34 |
| NaF-250+SA-200 | 6.67±0.24 | 5.33±0.72 | 53.83±0.83 |
| NaF-300+SA-200 | 5.63±0.19 | 4.00±0.47 | 51.93±0.69 |

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**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. (Values are mean ± S.E; NaF=sodium fluoride; SA=salicylic acid; NaF-SA: sodium fluoride- salicylic acid)

| Treatments | Yield parameters | | |
|---|---|---|---|
| | Fruit length (cm) | No. of fruits per plant | Weight of fruit per plant (g) |
| Control | 5.23±0.12 | 8.67±0.27 | 56.92±0.45 |
| NaF-50 | 4.80±0.12 | 7.33±0.54 | 52.46±0.55 |
| NaF-100 | 4.57±0.05 | 6.33±0.54 | 51.39±0.62 |
| NaF-150 | 4.17±0.07 | 6.00±0.82 | 49.66±0.77 |
| NaF-200 | 3.77±0.05 | 5.33±0.27 | 45.34±0.64 |
| NaF-250 | 3.73±0.07 | 4.33±0.27 | 42.21±0.88 |
| NaF-300 | 3.47±0.21 | 3.00±0.47 | 39.08±0.95 |
| SA-100 | 5.47±0.21 | 9.67±0.72 | 57.80±0.21 |
| SA-200 | 4.63±0.19 | 6.33±0.27 | 52.33±0.40 |
| NaF-50+SA-100 | 5.07±0.10 | 7.67±0.72 | 54.18±0.38 |
| NaF-100+SA-100 | 4.87±0.07 | 7.67±0.27 | 53.37±0.65 |
| NaF-150+SA-100 | 4.77±0.05 | 7.00±0.47 | 51.72±0.66 |
| NaF-200+SA-100 | 4.27±0.12 | 6.33±0.54 | 47.53±0.56 |
| NaF-250+SA-100 | 3.83±0.05 | 5.00±0.47 | 44.73±0.98 |
| NaF-300+SA-100 | 3.73±0.07 | 3.33±0.27 | 43.27±0.81 |
| NaF-50+SA-200 | 4.53±0.03 | 6.67±0.27 | 49.43±0.88 |
| NaF-100+SA-200 | 4.23±0.03 | 6.00±0.94 | 40.46±0.29 |
| NaF-150+SA-200 | 4.00±0.05 | 5.33±0.27 | 33.82±0.82 |
| NaF-200+SA-200 | 3.63±0.12 | 4.33±0.72 | 30.60±0.70 |
| NaF-250+SA-200 | 3.60±0.12 | 3.67±0.98 | 27.78±0.52 |
| NaF-300+SA-200 | 3.70±0.09 | 2.33±0.54 | 24.11±0.70 |

As shown in Table 2, 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, and 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, and 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%, respectively, 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, and NaF-300+SA-100 and percentage reduction was (1.96, 1.96, 6.27, 10.20, 16.86, and 20.39%), respectively, to NaF-50, NaF-100, NaF-150, NaF-200, NaF-250, and NaF-300 (3.92, 10.98, 13.33, 19.61, 19.61, and 29.02%), respectively, 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, and NaF-300+SA-200 (12.16, 14.51, 20.00, 20.78 21.57, and 33.73%), respectively.

Table 2 shows 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, and 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 Tables 1 and 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, and 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 higher results compared to SA-200 which showed a greater reduction in fruit weight.

## DISCUSSION

Fluoride is a well-known toxic substance which is present in small amounts in the earth's crust and can cause damaging effects on growth and developmental processes in plants. It is also recognized as a non-essential plant element. High levels of fluoride in acidic soil enhances the toxicity of soil making it difficult for plants to survive. The fluoride in the soil, air, and water is a 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*. In a study by Martin-Mex et al. exogenously applied salicylic acid enhanced the flowering in *Sinningia speciosan* in relation to control plants.[21] The plant heights and yields of different varieties of pea plant (*Pisum sativum*) decreased under sodium fluoride stress and this decline was overcome by salicylic acid applied exogenously.[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.[23]

## CONCLUSIONS

Fluoride is being added to agricultural soil day by day from various anthropogenic sources, i.e., improper irrigation practices, excessive use of agricultural fertilizers, and treatment of phosphate fertilizers. This is causing a drastic effect on the yield of crops. However, the foliar applications of salicylic acid have reduced the sodium fluoride stress in soil and proved very effective in helping plants respond to NaF stress conditions. The exogenously applied salicylic acid increased the yield of two varieties of *Capsicum annuum* by reducing the sodium fluoride stress. Salicylic acid in very high concentrations however also caused a high level of plant stress. Hence high doses of salicyclic acid proved to be less effective than the standard dose which is therefore the recommended dose.

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