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Effect of Salicylic Acid and Calcium on Growth, and Yield Components of Wheat Grown under Salinity

El- El-Saady, A.M.[1]; Hassoub, M.A[1]; Darwish, M.A.[1]; and Hussein M. M.[2];

[1-] *Fertilization Technology Department, National Research Centre, Dokki, Giza, Egypt*

[2-] *Water Relation and Field Irrigation Department, National Research Centre, Dokki, Giza, Egypt*

Abstract

In a pot experiment in the National Research Center's greenhouse, wheat (*Triticum aestavim* L.) grains of the variety Sakha-94 were sowed on November 15 (winter 2019/2020 season). The salinity treatments were started three weeks after sowing until harvest. Plants were sprayed with salicylic acid (0, 100-ppm, 200-ppm) plus calcium nitrate at three weeks and fifth weeks after sowing and the control plants were sprayed with distilled water. Data showed that the yield, and yield traits except spike length were decreased by salinity treatments. grains content of N, P, K, and Mn decreased as salinity increased but the reverse was true for Ca, Mg, Na, Cl, Fe, and Zn, which increased as salinity stress increased up to the highest level used. Data revealed that both chemicals increased the yield, and yield traits. Data cleared the synergistic effect of adding calcium plus salicylic acid on these criteria. Except for Na and Cl, percentages of different nutrients measured increased by both added compounds but the increment by combination of both exceeded those added solitary. Spraying salicylic acid or calcium improved the yield, and yield traits. The mineral status of wheat but adding these chemicals in combination was more effective under irrigation with saline water.

Keywords: Wheat-salinity-Salicylic acid-Calcium-Yield-Yield traits-Mineral status of grains.

1. Introduction

Field salinization is a global issue that is getting worse [1, 2]. One-third of the world's arable land resources affected by salinity, along with 10% of the cropland and up to 27% of the irrigated land that may already be affected [3]. Due to legislation restricting ground water pumping and the increasing competition for limited water resources, irrigated agriculture now uses low-quality water [4]. Utilizing the capacity of soil biology to preserve soil fertility, protecting against erosion, and managing water availability are some keys to agricultural success in semi-arid regions [5].

When thriving in saltwater circumstances, terrestrial plants must overcome severe obstacles. The cytosol must be kept free from excessive amounts of sodium ions (Na^+) and chloride ions (Cl^-), where high osmotic pressure can inhibit efficient water absorption. The question of how plants grow on saline soils is intriguing in and of itself, but it assumes added urgency in light of the fact that irrigation and sea level rises are increasing the amount of arable land that is salinized and that cultivation of marginal land is being encouraged by the need for more food globally [6].

Salicylic acid (SA) is a well-known naturally occurring signaling molecule responsible for inducing environmental stress tolerance in plants. Therefore, spraying of SA could provide protection against several types of stresses [7]. Treating grains with the right dose of a suitable hormone can effectively mitigate the negative effects of excessive salts on the early growth of wheat seedlings. Shakirova and Bezrukova, [8] shown that salicylic acid can increase wheat seedlings' salt resistance , as well as enhance plant defense mechanisms and improve tolerance towards abiotic stresses like salinity. Foliar application of salicylic acid has been proven an effective tool in mitigating the adverse effects of salinity stress on plants [9, 10].

Calcium plays a vital role in physiological functions and nutritional in plant, and essential in processes that preserve the structural and functional integrity of plant membranes, regulate ion transport, and control ion-exchange behavior as well as cell walls enzyme activities [11]. The requirement of plants for Ca^{2+} increases with salinity increases. Although Ca^{2+} concentrations usually increase as increased in concentration of total salt in saline soils, Ca^{2+} uptake from soil solution may be decreased due to ionic interactions, and increases in ionic strength reduce the activity of Ca^{2+}. These combined effects are at least

*Corresponding author e-mail: mhassoub@yahoo.com.; (M.A. Hassoub).
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responsible for reduced yields under saline conditions [12,13,14].

It has been discovered that the use of Salicylic Acid and Calcium can promote the growth of wheat crops in saline environments. Interestingly, when used together, they are even more effective in combating the negative effects caused by salinity. This is because they are instrumental in inducing an antioxidant response that safeguards the plant's membrane from oxidative harm [9,15]. Wheat is a major food crop in most of the countries of the world which suffer saline soils, and therefore increasing salinity tolerance in bread wheat is necessary [16]. Mikolajczyk, [17] indicated that SA is involved in various anti-stress mechanisms in plants. In view of these reports, the aim of this paper was to investigate the interactive effect of SA and Ca^{2+} on yield, yield component, and nutrient content in wheat grains (cv. Sakha-94) under salinity condition.

Materials and Methods

A pot experiment was conducted in the greenhouse of the National Research Centre, Dokki, Cairo, Egypt. Wheat (*Triticum aestavim L.*) grains var. Sakha-94 were sown at November, 15 (winter season of 2019/2020) in earthenware pots of 30 cm diameter and 30 cm depth, wich filled with clay loam soil. Calcium super phosphate (15.5 P_2O_5) and potassium sulphate (48.5% K_2O) in the rate of 1.5 g/pot for each fertilizer were added before sowing. Ammonium nitrate (33.5 N) added in the rate of 6 g/pot in two equal portions, the 1st at 21 days and the 2ndat 36 days after sowing. The salinity treatments were started three weeks after sowing until harvest. Plants were sprayed with 100 of salicylic acid and 200 ppm of salicylic acid plus calcium at three weeks and fifth weeks after sowing and the control plants were spray by distilled water. The physical and chemical analysis of investigated soil were determined and recorded in Table (1).Three weeks after sowing, plants were thinned to six plants per pot.

The experiment investigated the interaction between salinity water irrigation and salicylic acid exogenous application. The study included 9 treatments, with 3 salinity levels (0, 2000 and 4000 ppm) and 3 salicylic acid treatments (0, 100-ppm, 200-ppm) plus calcium nitrate. The experiment design was split plot in six replicates. The chemical properties of seawater used in this experiment were as follows: pH 8.4, EC (dSm^{-1}) 35.9, and cations and anions Ca, Mg, K, Na, HCO_3, Cl and SO_4 concentration were 0.44, 1.30, 0.40, 11.0, 0.13, 20.1 and 2.75 g/L, respectively. Grains from two plants picked from every treatment with three replicates, cleaned, washed, dried in an electric oven at 70 °C and ground with stainless steel mill. The determinations of nutrients were done as the methods described by [23]**.** Statistical analysis of Data was done as the methods described by [24]**.**

Table 1. Physico-chemical characteristics of the experimental soil

Variable	**2019/2020**		**Methods used for preparation evaluation and analysis**
Texture	Clay Loam		measured by hydrometer method [18]
pH	8.37	H	measured by pH meter [19]
EC dS/m	2.01	vH	measured by conductivity meter [19]
Calcium Carbonate %	1.16	L	measured by calcimeter [18]
Organic Matter %	0.37	vL	determined by Walkly and Black method [18]
K (mg/100g soil)	7.40	vL	**(NH_4OAC-Extractable**) and measured using Flame photometer [20]
Ca	240	H	
Mg	18.3	L	
Fe	2.1	vL	**(DTPA-Extractable)** and measured using Atomic absorption [21]
Mn (ppm)	3.8	vL	
Zn	2.3	M	
Cu	0.9	M	

vL=Very Low, L=Low, M= Moderate, H= High, v H=Very High [22]

Results and Discussion

Salinity effect on yield components:

Based on the data presented in Table (2), it appears that using saline water for irrigation had a negative impact on yield, and yield traits of wheat plants. However, it is worth noting that spike length was not affected by the saline water irrigation. These findings are coincide with those obtained by [25]**,** who, found that irrigation of wheat plants with saline water led to significant decrease of plant height, number of litters / plants, number of spikes per plant, spikes weight / plant, grains and straw weight / plant, as compared with non-saline water. In addition, **Mohamed *et al.*, [26]** detected negative relationship between vegetative growth parameters and the increase in salt concentration in irrigation water on wheat. The area of green leaves was decreased (53.18 %) from 5102 cm^2 in the plants irrigated by water contains 250 ppm salts (control) to be 2389 cm^2 in those irrigated by water contained 4000 ppm. Moreover, dry weight of stem, leaves and whole plant showed approximately similar response. The depression on stem, leaves and whole plants dry weight when irrigated by saline water of 4000 ppm amounted by 57.29, 47.43 and 51.43 % compare to the control [27] confirmed these results. **Hussein, *et al.*,** [28] reported that dry mater of stem and spikes of wheat decreased with the increase in salts concentration up to the highest level used but differences in leaves and vegetative parts dry matter was not significant. The salinity deleterious effects led to affect different physiological and metabolic processes of plants. The responses to these mentioned changes are often accompanied by many varieties of symptoms, such as the increase of leaf thickness and succulence, leaves abscission, necrosis of root and shoot, and decrease the internode lengths and leaf area, [29]**.** Such, depressive effect of salinity in wheat growth may be attributed to the adverse effect on enzymatic processes through some interactions of salts and some organic substances of the cell [30]**.** Moreover, crop reduction due to salinity is generally related to the osmotic potential increase of the root-zone soil solution, which leads to certain phonological changes and substantial reduction in productivity [31]**.** In addition, the reduction in growth and grain yield under salt stress has been attributed to reduction in dry matter production through a feedback of photosynthesis during reproductive phase of growth [32]**.**

Table (2) Effect of salinity on growth and yield traits of wheat plants cv Sakha 94.

Growth parameters			**Yield traits**					
Treatments	**Total Weight (g/plant)**	**Plant Height (cm)**	**No of Spike/ plant**	**Spike length (cm)**	**Spike Weight (g)**	**G.W. of Spike (g)**	**1000 grains weight (g)**	**Grains weight/ plant (g)**
S_0	5.78	67.78	1.50	7.46	3.32	2.13	55.0	3.20
S_1	4.40	62.59	1.28	7.55	2.81	1.62	40.7	2.07
S_2	3.96	57.26	1.13	8.10	2.87	1.24	41.1	1.40
$LSD_{0.05}$	0.25	1.32	0.08	0.36	0.09	0.07	7.81	0.15

S_0= Control (tap water), S_1= 2000 ppm, S_2= 4000 ppm

Salinity effect on macro and micronutrients in wheat grains:

Table (3) shows that the content of N, P, K, and Mn in grains decreased with increasing salinity levels. On the other hand, Ca, Mg, Na, Cl, Fe, and Zn increased as salinity stress increased. Wheat's straw and grain uptake of N, P, and K decreased as soil salinity increased. This trend was consistent across all foliar sprays with salicylic and ascorbic acids at different rates. It is worth noting that untreated plants without foliar spray died off at maturity due to extremely high salinity levels in the two seasons. These findings suggest that salinity stress negatively affects the nutrient content of wheat and its uptake of essential nutrients [33]**.**

Observed results are similar to those reported by **Ahmad** [34] who stated that the N, P and K content of wheat plants were significantly decreased with increasing soil salinity stress in sandy loam soils. Salts might inhibit plant growth and nutrient uptake by increasing the osmotic stress, nutrition and specific ion toxicity. The extent of damage depends on the severity of stress, growth conditions and plant sensitivity to salinity. In addition, Salt stress markedly decreased the plant fresh, dry biomasses and nutrient uptake of rice plants [35]**.** Research has shown that using saline water for irrigation can lead to a decrease in nutrient content in grains, specifically N, P, K, and Mn. This is due to a competition for cation uptake and the impact of salinity on root growth and distribution in soil. It's worth noting that even foliar sprays with salicylic and ascorbic acids failed to counteract the negative effects of salinity stress on nutrient content and uptake in wheat plants. Plants grown under saline conditions accumulate more Na^+ and Cl^- contents resulting in ionic imbalances, specific ion effects and nutrient deficiency symptoms in plants [36], **Siringam, *et.al.*,** [37] reported that as increasing Na concentration in the root media Na% in grains increased, also N, Fe, and Cu concentrations increased up to the highest salt concentration used. P and Mn concentration were increased with the 1st level of salinity and then decreased with the 2nd concentration used. However, K concentration was decrease by the 1st level of salinity and tended to increase by the 2nd level of salinity (500ppm) but still less than the control. Lowering of soil osmotic potential, creation of nutritional imbalance, enhancing specific ionic toxicity (salt stress) or one or more combination of these factors, are some of the common implications of salinity stress experienced by plants [38,39]. Salinity stress increased the total soluble solids that might be due to more accumulation of Na^+, K^+ and Cl^- ions in the fruit [40]**.**

Salicylic acid effect on yield component:

After examining the data in Table (4), it found that the use of foliar spraying with salicylic acid (SA) or with calcium (Ca) led to a significant increase in all yield, and yield components when compared to the control. The data also showed that there was a synergistic effect when using both calcium and salicylic acid together, resulting in the highest values for yield components. This information could be useful for farmers looking to improve their crop yields and overall plant health.

Table (3) Effect of salinity on nutrient concentration of grains.

	N	P	K	Ca	Mg	Na	Cl	Fe	Mn	Zn
	(%)							(ppm)		
S_0	2.41	0.48	0.74	0.74	0.29	0.030	1.80	102.0	43.2	20.9
S_1	2.27	0.36	0.71	0.76	0.28	0.031	1.84	108.0	40.9	22.6
S_2	2.25	0.39	0.68	0.82	0.31	0.032	1.95	115.2	38.3	26.6
LSD 0.05	**0.11**	**0.02**	**0.04**	**0.02**	**0.01**	**0.001**	**0.10**	**2.4**	**2.38**	**1.35**

S_0= Control (tap water), **S_1**= 2000 ppm, **S_2**= 4000 ppm

Table (4): Effect of salicylic acid and calcium on growth and yield traits of wheat plants

Growth parameters			**Yield traits**					
Treatments	**Total Weight (g/plant)**	**Plant Height (cm)**	**No of Spike/ plant**	**Spike length (cm)**	**Spike Weight (g)**	**G.W. of Spike (g)**	**1000 grains weight (g)**	**Grains weight/ plant (g)**
T0	3.36	57.26	1.11	7.12	2.35	1.28	37.44	1.42
T1	4.96	61.86	1.33	7.64	2.91	1.58	44.01	2.10
T2	5.83	68.51	1.46	8.36	3.75	2.14	55.32	3.12
LSD 0.05	0.06	0.74	0.08	0.25	0.11	0.06	5.75	0.11

T0= o SA, T1= 100ppm SA+Ca, T2= 200ppm SA+Ca

Treatment of plants with 0.5 mM salicylic acid resulted in a maximum decrease in the content of Na^+, Cl^-, H_2O_2, and thiobarbituric acid reactive substances (TBARS), and electrolyte leakage under saline conditions compared to the control. In contrast, this treatment increased N, P, K, and Ca content, activity of antioxidant enzymes, glutathione content, photosynthesis, and yield maximally under non-saline and saline conditions [41]**. Shakirova, *et.al,* [42]** Concluded that the SA treatment reduced the damaging action of salinity and water deficit on wheat seedling growth and accelerated a restoration of growth processes. Also, **Afzal, *et.al,*** [43] concluded that hormonal priming has reduced the severity of the effect of salinity but the amelioration was better due to 50 ppm SA and 50 ppm ascorbic acid treatments.

Hussein, *et.al,* [44] mentioned that spraying maize plants with salicylic acid in the rate of 200 ppm improved all growth characters i.e. plant height, number and area of green leaves, stem diameter and dry weight of stem, leaves and whole plant. The highest increment was shown in stem dry weight and the lowest in stem diameter. As well as, foliar application of salicylic acid had a valuable effect on this parameter and elevated the harm-ful effect from stressed plant which possibly may lead to a possible increase of quality parameters such as TSS and vitamin C content [45,46]**.**

Jini and Joseph [47] reported that the exogenous application of SA increased the endogenous level of SA under salt and non-salt stress conditions in rice both the ASD16 and BR26 rice varieties. This increased endogenous level of SA might change all the physiological changes in the plant

Salicylic acid application affected the content of ascorbic acid vitamin C is a ubiquitous molecule proves effective in improving abiotic and biotic stress tolerance in plants [48,49 ,50]**.** It can improve tolerance against abiotic stresses by enhancing plant growth, rate of photosynthesis, transpiration; oxidative defense potential and photosynthetic pigments [51]**.**

Salicylic acid effect on macro and micronutrients in wheat grains:

Under salt stress condition, the use of salicylic acid (SA) led to a significant increase in the accumulation of different nutrients, except for Na and Cl, as shown in Table (5). The data also revealed that using a combination of SA and calcium resulted in higher percentages of nutrient accumulation compared to using either compound alone. These findings suggest that using SA and calcium together could be an effective strategy for improving nutrient accumulation in plants under salt stress conditions. **Hussein, *et.al.*, [52]** Reported that N, K, Mg, Ca and micronutrients concentration was increased by spraying salicylic acid in the rate of 200 ppm where P concentration was not affected. On the other hand, Na concentration was decreased by spraying salicylic acid. These results are consistent with those of [53] for cucumber and [54] for strawberry who found that exogenous SA application inhibited Na accumulation, but stimulated N, P, K, Mg, Fe, Mn and Cu uptake.

Table (5): Effect of salicylic acid and calcium on nutrient concentration of wheat grains.

	N	P	K	Ca	Mg	Na	Cl	Fe	Mn	Zn
	(%)							(ppm)		
T0	2.19	0.36	0.58	0.61	0.25	0.032	1.96	97.80	32.67	18.90
T1	2.28	0.45	0.74	0.84	0.31	0.030	1.76	111.90	44.22	24.45
T2	2.46	0.41	0.82	0.87	0.33	0.030	1.87	115.50	45.54	26.60
LSD $_{0.05}$	**0.1**	**0.01**	**0.03**	**0.01**	**0.02**	**0.001**	**0.06**	**2.1**	**1.97**	**1.32**

T0= o SA, T1= 100ppm SA+Ca, T2= 200ppm SA+Ca

Also, **Hussein and Nesreen** [55] confirmed these results on Moringa. An increase in concentration of K and Ca in plants under salt stress could ameliorate the deleterious effects of salinity on growth and yield [56]. Alteration of mineral uptake from SA applications may be one mechanism for the alleviation of salt stress. Application of SA might improve physiological performance in terms of production of photosynthesis, total oil and dry matter accumulation, which can be related to increased nutrient uptake by SA-treated, plants [54]. In addition, **Hussein, *et.al,***[57] found that P concentration in Cotton plants not affected significantly with spraying salicylic acid while other minerals concentrations were significantly affected under salt stress.

The interaction effect of Salicylic acid and calcium on yield component:

It could be seen from data of Table (6) that plant height as well as total weight/plant, spikes weight, and grains weight/plant were significantly increased by both chemical compounds (salicylic acid as antioxidant and calcium nitrate as fertilizer). Similar response was shown in yield components as number and weight of spike, grains weight of spike and 1000 grains weight.

The application of salicylic acid (SA) improved the growth and yield under salt stress conditions [47]**.** The treatment of SA to the high and low saline soils enhanced the growth, yield and nutrient values of rice. They concluded that the application of SA could alleviate the adverse effects of salt stress by the regulation of physiological mechanism in rice plants.

Regarding in interaction both salinity and salicylic acid significantly affected all the variables except fruit firmness, total soluble solids, pH and vitamin C. From the present study, it can be concluded that salinity reduced the quantitative attributes while it increased the qualitative attributes except pH. Therefore, salicylic acid at 0.5mM might be applied to the tomato plant under saline condition up to 90mM, which could effectively alleviate the deleterious effect of salt stress [58]**.**

Hussein, *et.al,* [44] reported that Number and area of leaves and whole maize plant dry weight were significantly affected by the interaction, while, differences in plant height, stemdiameter and dry weight of leaves and stem were not significant. Similar responses were detected in number and area of leaves and dry weight of whole plant in which salicylic acid treatment increased both characters under saline irrigation water of 4000 ppm salinity level as well as the unstressed plants but the percentage of increment under the high salt stress used slightly more than that caused under non stress condition. However, this organic acid did not exert any significant differences.

Table (6): Effect of interaction between salicylic acid and salinity on growth and yield traits of wheat plants grown under salinity levels

Growth parameters				**Yield traits**					
Treatments		**Total Weight (g/plant)**	**Plant Height (cm)**	**No of Spike/ plant**	**Spike length (cm)**	**Spike Weight (g)**	**Spike grain Wt. (g)**	**1000 Grains weight (g)**	**Grains weight/ plant (g)**
	T0	3.00	66.1	1.12	6.8	2.25	1.57	34.9	1.76
S_0	**T1**	6.28	67.6	1.67	7.3	3.20	2.08	50	3.47
	T2	8.05	69.6	1.72	8.4	4.52	2.75	80	4.73
	T0	3.50	54.4	1.22	6.7	2.30	1.38	37.1	1.68
S_1	**T1**	4.57	65.8	1.22	7.7	2.88	1.55	40.9	1.89
	T2	5.15	67.6	1.38	8.3	3.27	1.93	44	2.66
	T0	3.58	51.3	1.00	7.9	2.50	0.90	40.3	0.90
S_2	**T1**	4.02	52.2	1.12	8	2.65	1.10	41.1	1.23
	T2	4.28	68.3	1.28	8.4	3.45	1.72	42	2.20
	LSD $_{0.05}$	**0.11**	**1.28**	**0.14**	**0.44**	**0.18**	**0.11**	**9.96**	**0.13**

S_0= Control (tap water), **S_1**= 2000 ppm, **S_2**= 4000 ppm, T0= o SA, T1= 100ppm SA+Ca, T2= 200ppm SA+Ca

The interaction effect of Salicylic acid and Calcium on macro and micronutrients in wheat grains:

Upon examining the data presented in Table (7), it is evident that nutrient concentration levels were significantly improved with the application of salicylic acid, or +calcium salicylic acid, except for Na. However, combining salicylic acid with calcium resulted in an even more impressive effect, enhancing nutrient concentration levels even in the face of varying water salinity conditions. It is noteworthy that the organic acid added plus calcium caused a greater increment in nutrient concentration levels as compared to the antioxidant alone. These observations were consistent across different levels of water irrigation salinity.

Table (7) Effect of interaction between salicylic acid and calcium on nutrient concentration on grains of wheat plants cv Sakha 94 grown under salinity

		N (%)	P	K	Ca	Mg	Na	Cl	Fe (ppm)	Mn	Zn
S_0	**T0**	2.3	0.45	0.58	0.70	0.28	0.030	1.85	99.9	41.7	19.1
	T1	2.4	0.54	0.75	0.77	0.28	0.030	1.73	102.6	43.7	21.2
	T2	2.5	0.45	0.88	0.77	0.31	0.029	1.82	103.5	44.3	22.4
S_1	**T0**	2.2	0.31	0.58	0.65	0.24	0.034	1.90	99.0	32.7	19.2
	T1	2.2	0.37	0.74	0.80	0.30	0.032	1.75	110.7	44.0	23.1
	T2	2.4	0.39	0.82	0.82	0.31	0.026	1.87	113.4	46.0	25.4
S_2	**T0**	2.1	0.32	0.59	0.48	0.24	0.032	2.13	95.6	23.7	18.5
	T1	2.3	0.45	0.71	0.95	0.33	0.030	1.80	122.4	45.0	29.1
	T2	2.4	0.39	0.75	1.02	0.36	0.034	1.91	129.6	46.3	32.1
LSD $_{0.05}$		**n.s**	**0.02**	**0.05**	**0.02**	**0.03**	**0.001**	**0.11**	**3.59**	**3.42**	**2.29**

S_0= Control (tap water), S_1= 2000 ppm, S_2= 4000 ppm

Dry matter of straw and grain and yield quality, straw and grains N, P and K-uptake were decreased with increasing the soil salinity level. This trend was found true under all foliar sprays with salicylic and ascorbic acids at different rates. straw and grains N, P and K-uptake of wheat plants occurred with ascorbic acid 0.2% "AA2" treatment followed by ascorbic acid 0.1% "AA1", salicylic acid 0.2% "SA2", salicylic acid 0.1% "SA1" and untreated plants that descending order in the two seasons [61].

Hussein, *et.al,* [62] revealed that N, P, K, Na and Ca were decreased by salt stress. Na/K ratio increased as salt concentration increased but Ca: (Na+K) showed the opposite response. Salicylic acid application of 200 ppm showed the highest improve in uptake of the macronutrients and Ca:(K+Na) compare to the control plants. Salicylic acid application lowered the adverse effect of salt stress and can use for amelioration of salt stress in cotton plants, [63] noted a decrease in the amount of K in the root and shoot part in salt-stressed plants. Interestingly, it has been reported that salinity induced Na^+ damage, which affects K^+ uptake by root cells [64].

Essbihi, *et.al,* [7] stated that the application of SA led to an improvement in these mineral (K, P and Ca) contents in the Salvia officinal is plant. Salicylic acid application increased P content in leaves and roots, by surpassing control group levels. K and Ca levels also recovered and exceeded control group levels. Salicylic acid, combined with calcium, may improve plant health and nutrient levels despite varying water salinity.

Jayakannan, *et.al,* [65] proved that the application of salicylic acid had a positive impact on nutrient concentration levels, as evidenced by an increase in K^+ content and a decrease in Na^+ accumulation in the shoot of Arabidopsis under salt stress condition. These findings suggest that salicylic acid may be a helpful tool in promoting plant health and improving nutrient levels, particularly when used in combination with calcium. Moreover, these results were consistent across different levels of water irrigation salinity, indicating that salicylic acid may be effective in a variety of growing conditions. **Khan, *et.al,*** [41] also found that the application of 0.5 mM/L SA enhanced salinity tolerance of mungbean by reducing Na^+ and increasing K^+ content. It happens because Na+ may influence the transport of K+ within the plant cells because of the chemical resemblance [66].

The experiments conducted showed that electrolyte leakage increased significantly due to salinity treatments. However, cucumber plants treated with foliar SA exhibited lower levels of electrolyte leakage compared to those that were not treated. Moreover, foliar SA applications resulted in a significant increase in nutrient content in both the leaves and roots of cucumber plants under salt stress. Notably, the plants treated with 1.00 mM SA showed the most significant increase. These findings suggest that SA treatments may be an effective solution to mitigate the negative impact of salinity on the growth of cucumber [53].

Conclusion

The study examined the effects of salicylic acid and calcium nitrate foliar application on wheat growth, yield and yield traits under different salinity levels. The results showed that both salinity levels had a negative impact on the growth and yield of wheat plants. However, when organic acid, calcium, and salicylic acid were applied, the plants showed improved growth and yield components. In conclusion, the application of salicylic acid and calcium or both together can help improve the growth, yield, and yield components of wheat plants irrigated with fresh or saline water.

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