Research Article

Salicylic Acid as a Potential Growth Regulator Under Salinity Stress in Pea (*Pisum sativum* L.) Plants

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Abstract | Salicylic acid (SA) is extensively documented for its ability to alleviate the detrimental impacts of abiotic stressors, such as salt, in plants. This study aims to assess the efficacy of SA foliar application in enhancing the growth and yield of pea (*Pisum sativum* L.) in response to the escalating challenge of soil salinity in agricultural regions. The experiment was executed at the ornamental nursery of the Department of Agriculture, University of Swabi, in 2019, utilizing a Randomized Complete Block Design (RCBD) with two components, duplicated thrice. Pea plants were cultivated from seeds and, after 30 days of germination, were exposed to varied doses of sodium chloride (0, 25, 50 and 75 mM) in conjunction with foliar application of salicylic acid at varying concentrations (0, 1, 2 and 3 mM). Salinity stress markedly diminished vine length, stem diameter, fresh pod weight, pod width, pod length, seeds per pod and total yield. Nonetheless, the foliar treatment of salicylic acid at 2 mM significantly alleviated these detrimental effects by improving plant growth metrics and production, while also facilitating early flowering and pod formation. The results underscore the viability of SA as a cost-effective and eco-friendly approach to improve pea cultivation in saline environments. Future study should investigate its wider uses across various crops and field circumstances to establish sustainable salinity control strategies that enhance agricultural production.

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Introduction

Pea (*Pisum sativum* L.) belongs to leguminous crop and it is highly nutritious for human consumption. Pea seeds contain I8-20% dry matter and carbohydrate 10- 12% and also contain protein 5-8%. Peas grow well and favor a cool season of mild climate (Gandhi, 2022). Thus, compared to hot dry areas in cold wet regions, it gives a higher yield. Its lowest germination temperature is up to I-6°C and it can live at low temperatures upto -5°C. Peas can develop in many soils; Maximum yield in clay-loam can be acquired, deep, productive, damp, marginally acid (pH 6.5-7.0) soils. Peas appear to be susceptible to salinity. The amount of salinity influences the rate of yield losses. Salt stress is a high threat to agriculture sector by affecting growth and development of agriculture yields and alternatively reducing per acre yield of plants (Devkota *et al*., 2022). It is projected that increased salinity of arable area would have universal consequences, resulting in a 30 percent loss of land in the next 25 years (Russ *et al*., 2020).

Salicylic acid is basic phenolic compound that has a role in the growth and development of plant, germination of seeds, plant yield, flowering of plants and physiological processes. It also plays an important role in fostering growth and inducing stress resistance in plants (Rahman *et al*., 2022; Yusuf *et al*., 2013).

Different physiological processes occur, such as stomata closure, somatic embryogenesis, flowering induction, stimulation of root development and thermogenesis. The use of SA does not only enhance the initiation process in angiosperms; however, they have a progress sieve impact on the chlorophyll rate, rate of photosynthetic and increase the absorption of minerals by plants increasing in conditions of stress. SA application has been reported to significantly reduce the inhibition of growth caused by drought in wheat (fresh mass, dry mass, plant height and root length) (Aziz and Kapoor, 2018; Rivas-San and Plasencia, 2011).

Salinity is a major factor in agriculture that causes soil infertility and the introduction of resistant plants to salt stress is worth researching. Irrigation is the biggest issue facing saline soils in the Mediterranean regions. Salinity is a significant problem and causes low legumes production both in semi-arid and arid cultivated area (Pessarakli and Szabolcs, 2019).

Salt stress is recognized to influence a variety of physiological and biochemical processes. Although some of the modifications found in salt-stressed plants are adaptive, many may simply be pathological consequences of stress injury. Stress of NaCl has two main adverse effects that affect plant growth and production. H_2O deficiency and ion toxicity combined with excess Cl and Na^+ uptake result in Ca^{+2} and K^+ and other nutritional imbalances being deficient (Barba-Espín *et al*., 2011).

Salinity of the soil is very important abiotic stress, which decreases growth and agricultural productivity more than many other related stress factors. It is major problem of soil toxicity in tropical Asia (Oshunsanya *et al*., 2019).

Salinity in soil has adverse effect on plant productivity. Problem of salinity is increasing day by day. It is investigated that more than forty-five (45M ha) of irrigated land have been damaged by salinity worldwide which is almost 20 percent of the total land. The current increasing in soil salinity may results in 50% loss of the cultivated land till mid of 21stcentury (Hassani *et al*., 2021). Salinity add Na and Cl ion to the soil and hence negatively affect plant membrane damage, imbalance of plant nutrients and growth regulators, including photosynthesis. Salinity declines plant performance and causes physiological disorders which leads to death of the plants. Soil salinity enhances the oxidative stress in plants and increases significantly ROS, H_2O_2, O_2 and OH. Salt stress effect depends on various factors like concentration of salts, plant exposure to salt stress, genotype and environment (Ahmad *et al*., 2019).

Keeping in view, the importance of Salicylic acid (SA) and negative impact of salinity on growth and development of Pea, the current study was designed for the following objectives.

Objectives

- To study the performance of pea against salinity stress.
- To find out the best concentration of Salicylic acid for pea growth and flowering

Materials and Methods

The current analysis "influence of salinity stress and SA on growth and flowering of pea" was held at an ornamental nursery, Department of Agriculture, University of Swabi in the year 2019. Plants were grown through seeds in pots. Media in pots was consisted of clay, sand and silt in ratio (1:1:1). The pots were kept in a greenhouse at the ornamental nursery, Department of Agriculture, University of Swabi and irrigated every 1–2 days alternately with distilled water. Recommended doses of N (Urea), P (SSP), K (SOP) was applied at required time. The plants were grown in a greenhouse in order to avoid a dilution of NaCl applied to the containers by the rainfall. The project was designed with four treatments and three replications using Randomized Complete Block Design (RCBD) with 2 factors. Treatments of SA (0, I, 2- and 3-mM^{-1}) and sodium chloride (0-, 25-, 50- and 75-mM) were applied after 30 days of pea seed sowing. The trial was protected from insect, pest attacks and other abiotic stresses.

Table 1: *Salinity stress and salicylic acid.*

Factor A, Salinity stress (NaCl)	Factor B: salicylic acid (SA)
NaCl t_1= 0 mM	SA_1: 0 mM
NaCl t_2= 25 mM	SA_2: 1 mM
NaCl t_3= 50mM	SA_3: 2 mM
NaCl t_4= 75mM	SA_4: 3 mM

The following parameters studied during the experiment are summarized in Table 1:

Vine length (cm)

The vine length was recorded through measuring tape (cm) in each treatment for all replication after treatment application and then the average will be calculated.

Stem diameter (mm)

Stern diameter was recorded through vernier caliper (cm) in each treatment for all replication after treatment application and then average was calculated.

Days to flowering

Days to flowering were recorded at 50 % blooming of plants in each treatment then average was measured.

Days to pod formation

Days to pod formation were recorded in each treatment for all replication after treatment application and then average was calculated.

Fresh weight of pod

Weight of fresh pod were recorded in each treatment for all replication and then average of single pod fresh weight was calculated.

Pod width (mm)

Pod weight was observed with help of Vernier caliper in each treatment for all replication after treatment application and their average were taken.

Pod length(cm)

Pod length was recorded through measuring tape (cm) in each treatment for all replication after treatment application and then average were calculated.

Seeds pod^{-1}

Number of pods were counted visually by hand in each treatment for all replication and then average plant^{-1} was calculated.

Yield per plant(g)

Yield per plant was taken in each treatment for all replication and then average were measured ingrams.

Statistical analysis

The indicated data was subjected to (ANOVA) appropriate for RCBD design using statistic 8.1 software package (Statistix®, Analytical Software Inc, Tallahassee FL, USA). Significant (P< 0.05) the results as experienced by LSD.

Lay out of experiment

N_1S_1	N_2S_1	N_3S_1
N_1S_2	N_2S_2	N_3S_2
N_1S_3	N_2S_3	N_3S_3
N_1S_4	N_2S_4	N_3S_4
N_2S_1	N_1S_1	N_4S_1
N_2S_2	N_1S_2	N_4S_2
N_2S_3	N_1S_3	N_4S_3
N_2S_4	N_1S_4	N_4S_4
N_3S_1	N_4S_1	N_2S_1
N_3S_2	N_4S_2	N_2S_2
N_3S_3	N_4S_3	N_2S_3
N_3S_4	N_4S_4	N_2S_4
N_4S_1	N_3S_1	N_1S_1
N_4S_2	N_3S_2	N_1S_2
N_4S_3	N_3S_3	N_1S_3
N_4S_4	N_3S_4	N_1S_4

Results and Discussion

Vine length (cm)

Table 2 showed that Salinity Stress, SA and their interaction significantly affected the vine length of pea. Maximum vine length (59.91 cm) was recorded in control plants while minimum vine length (35.084

cm) was observed in plants subjected to salinity level 75 mM NaCl. Foliar application of salicylic acid significantly increased plant height of pea plant in control as well in plants grown under all salinity levels. The highest vine length (52.34 cm) was recorded in pea plants where 2 mM of SA was applied while the lowest (39.68 cm) was recorded in control plants. With regard to interaction maximum vine length (64.426 cm) was recorded in plants in control plants where 2 Mm SA was applied while minimum vine length (28.77 cm) was observed in plants subjected to salinity level of 75 mM NaCl without salicylic acid. Overall salicylic acid at 2 mM in treated and control plants produced maximum vine length where NaCl was not applied.

Table 2: *Vine length (cm) of pea plant as affected by salinity stress and Salicylic acid.*

Salinity stress (mM)	Salicylic acid (mM)				
	0	**1**	**2**	**3**	**Mean**
Control	54.761c	59.282b	64.426a	61.184b	59.91a
25 mM NaCl	40.940f	46.083e	54.137c	51.530d	48.172b
50 mM NaCl	34.274hi	37.962g	47.985e	41.121f	40.336c
75 mM NaCl	28.773j	32.794i	42.817f	35.953gh	35.084d
Mean	39.687d	44.030c	52.341a	47.447b	

Mean values in a single column or row followed by different letters are significantly different at P≤ 0.05. LSD value at 5% level of probability for salicylic acid (SA) = 1.1814, LSD value at 5% level of probability for salinity stress (NaCl)= 1.1814, LSD value at 5% for level of probability for SA× NaCl = 2.3628.

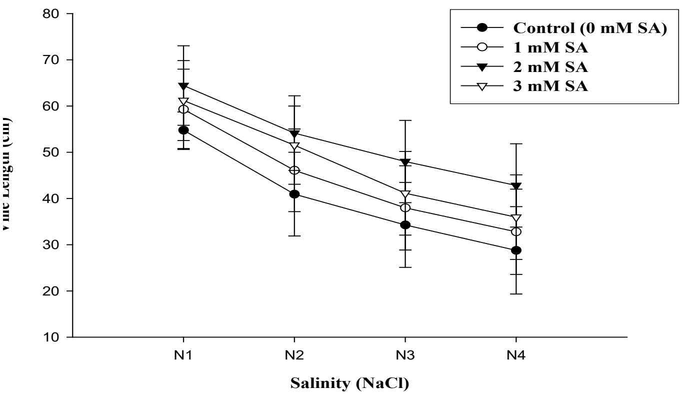

Figure 1: *Interaction for vine length (cm) as affected by salinity stress and salicylic acid.*

Figure 1 shows that salinity stress caused a significant reduction in plant height, as it inhibits protein synthesis and accelerates protein degradation, ultimately leading to reduced plant growth. The significant increase in plant height in current findings may be attributed to enhancing protein synthesis and cell anti-oxidation due to salicylic acid treatment (Gong *et al*., 2001). Under salt stress, salicylic acid enhanced the plant height of pea plants. Plant height may have increased as a result of lower transpiration and regulation of stomata and plant photosynthesis. The soluble sugars and various osmotic active substances, such as leaf proline and soluble proteins, also raised turgor pressure in the cells. Various internal and external factors control plant growth and development (Ahmad *et al*., 2024). SA control physiological and various biochemical processes of the plant, as well as regulating their development and production (Ashraf *et al*., 2010). The findings are in line with who reported that plant growth was increased in corn seedling under salinity stress by the application of salicylic acid (Naz *et al*., 2022; Sajid *et al*., 2016).

Stem diameter (mm)

Salinity stress and salicylic acid significantly affected the stem diameter of pea plant (Table 3) while their interaction was found non-significant. Maximum stem diameter (4.63 mm) was observed in untreated plants while less stem diameter (4.18 mm) was observed in those plants which were subjected to salinity level 75 mM NaCl. Foliar application of salicylic acid significantly increased the stem diameter of pea plant in control as well in plants grown under all salinity levels. The highest stem diameter (4.49 mm) was recorded in pea plants applied with 2 mM of salicylic acid while the lowest (4.26 mm) was recorded in control plants.

Table 3: *Stem Diameter (mm) of pea plant as affected by salinity stress and salicylic acid.*

Salinity stress	Salicylic acid (mM)				
	0	**1**	**2**	**3**	**Mean**
Control	4.58	4.61	4.67	4.64	4.63 a
25 mM NaCl	4.30	4.36	4.51	4.42	4.40 b
50 mM NaCl	4.22	4.28	4.41	4.34	4.31 c
75 mM NaCl	3.96	4.21	4.36	4.19	4.18 d
Mean	4.26 c	4.36 b	4.49 a	4.40 b	

Mean values in a single column or row followed by different letters are significantly different at P≤0.05. LSD value at 5% level of probability for salicylic acid (SA) = 0.07, LSD value at 5% level of probability for salinity stress (NaCl)= 0.07

Salinity drastically reduced the stem diameter of pea plants that might be due to the degradation of cell wall. The current research is further supported (Naz *et al*., 2022) by that salts stress reduces the activity of various enzymes that work during nitrogen metabolism and ultimately reduce the level of nitrogen in plant body which causes the reduction of stem diameter. In our experiment stem diameter was significantly increased under salinity might be due to the reduction of lipid per-oxidation by the foliar application of salicylic acid supported the findings of (Naz *et al*., 2022). Results are further in agreement with who reported that salicylic acid enhances the protection of photosynthetic pigments which work in photosynthesis which increases assimilates in plant stem diameter and increases its width (Barba-Espín *et al*., 2011).

Days to flowering

The mean table for days to flowering of pea plant is shown in Table 4. Days to flowering showed significance under salinity levels and SA levels while the interaction was found non-significant. Maximum days to flowering (59.84) was observed in plants subjected to salinity stress at rate of 75 mM while the lowest (48.27) in control plants. Similarly, the highest days to flowering (57.54) was noted in plants under control, where as a minimum (51.17) was resulted in plants treated with 2 mM Salicylic acid.

Table 4: *Days to flowering of pea plant as affected by salinity stress and salicylic acid.*

Salinity stress (mM)	Salicylic acid (mM)				
	0	1	2	3	Mean
Control	50.38	48.09	46.70	47.91	48.27 c
25 mM NaCl	56.97	55.74	50.58	54.31	54.40 b
50 mM NaCl	57.97	56.24	52.64	54.84	55.42 b
75 mM NaCl	64.84	61.3	54.77	58.41	59.84 a
Mean	57.54 a	55.35 b	51.17 d	53.87 c	

Mean values in a single column or row followed by different letters are significantly different at $P \leq 0.05$. LSD value at 5% level of probability for salicylic acid (SA) = 1.29, LSD value at 5% level of probability for salinity stress (NaCl)= 1.29

Salinity delayed the flowering of pea plants might be due to the weak antioxidant enzymatic activity and weak accumulation in secondary metabolites. Results are further supported by (Chavoushi *et al*., 2020) that NaCl causes a reduction in carbohydrates that are important for growth and also imbalance the nutrient uptake by plant which may result in delayed flowering. Foliar application of salicylic acid reduced the delay in flowering might be the enhancement of antioxidant enzymes and accumulation of secondary metabolites in saline conditions supported the findings of (Chavoushi *et al*., 2020).

Days to podding

Days to podding showed significance with salinity levels and SA levels and its interaction was observed non-significant which is clearly shown in mean Table 5. Maximum days to podding (64.06) was observed in plants subjected to salinity stress at the rate of 75 mM while the lowest days to podding (51.93) was recorded in control plants. Similarly, the highest days to podding (61.59) was noted in plants under control, whereas minimum (54.90) was resulted in plants treated with 2 mM Salicylic acid.

Table 5: *Days to Podding of Pea plant as affected by salinity stress and salicylic acid.*

Salinity stress (mM)	Salicylic acid (mM)				
	0	1	2	3	Mean
Control	53.77	52.09	49.63	52.24	51.93 c
25 mM NaCl	60.97	59.74	54.58	58.98	58.57 b
50 mM NaCl	61.97	60.24	56.64	59.17	59.51 b
75 mM NaCl	69.65	66.46	58.77	61.36	64.06 a
Mean	61.59a	59.63 b	54.90 d	57.93 c	

Mean values in a single column or row followed by different letters are significantly different at $P \leq 0.05$. LSD value at 5% level of probability for salicylic acid (SA) = 1.64, LSD value at 5% level of probability for salinity stress (NaCl)= 1.64

Days to podding of pea plant was significantly delayed by salinity stress that might be due the fact that salinity reduced nutrients uptake like phosphorus and calcium. In current findings, foliar application of salicylic acid causes earliness in days to podding of pea plant might be due the increased in nutrient uptake reported by. Current findings are in agreement with previous study who investigated that spraying SA on stressed plants increased the uptake of macronutrients, phosphorous and calcium which ultimately cause earliness in days to podding of pea plant (Naz *et al*., 2022).

Fresh weight of pod

Salinity stress, salicylic acid and their interaction significantly affect the fresh pod weight of pea plant as shown in Table 6. Maximum fresh weight of pod (9.13 g) was recorded in control plants while minimum fresh weight of pod (6.95 g) was observed in plants subjected to salinity level 75 mM NaCl. Nonetheless, foliar application of salicylic acid significantly increased the fresh pod weight of pea plants in control as well in plants grown under all salinity levels. The highest pod fresh weight (9.23 g) was observed in pea plants treated with 2 mM of salicylic acid while the lowest (6.71 g) was recorded in control plants (Figure 2). With regard to interaction maximum Fresh weight of pod (10.79 g) was calculated in plants treated with salicylic acid at 2 mM in control, while lowest Fresh weight of pod (5.85 g) was observed in plants subjected to salinity level of 75 mM NaCl without salicylic acid (Figure 4). Overall salicylic acid at the rate of 2 mM under control and stress conditions produced maximum Fresh weight of pod with respect to treatments where salicylic acid was not added.

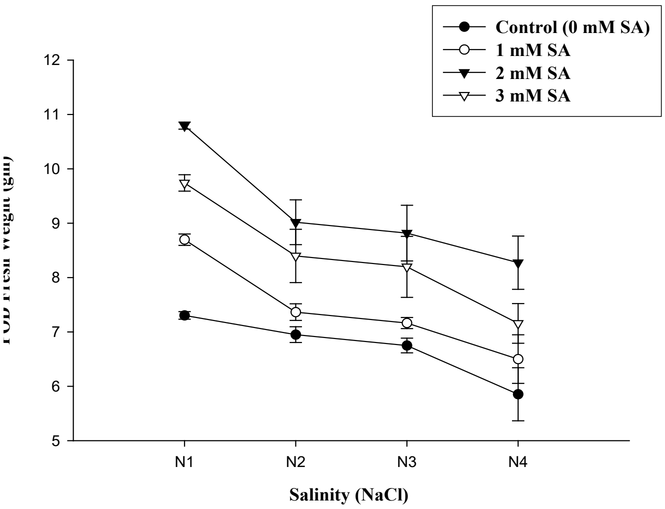

Figure 2: *Interaction for pod fresh weight (g) as affected by salinity stress and salicylic acid.*

Table 6: *Pod fresh weight of pea plant as affected by Salinity stress and salicylic acid.*

Salinity stress	Salicylic acid (mM)				
	0	1	2	3	Mean
Control	7.30	8.70	10.79	9.74	9.13 a
25 mM NaCl	6.95	7.36	9.02	8.40	7.93 b
50 mM NaCl	6.75	7.16	8.82	8.20	7.73 b
75 mM NaCl	5.85	6.50	8.27	7.16	6.95 c
Mean	6.71 d	7.43 c	9.23 a	8.37 b	

*Mean values in a single column or row followed by different letters are significantly different at P≤0.05. LSD value at 5% level of probability for salicylic acid (SA) = 0.2876, LSD value at 5% level of probability for salinity stress (NaCl)= 0.2876, LSD value at 5% level of probability for interaction (Sa*NaCl) = 0.56*

Fresh pod weight was reduced in plants under salinity stress might be due to the overproduction of ROS activity and less accumulation of phenolic compounds that hampered fresh pod weight reported by under abiotic stress. also reported that moisture content of pod simultaneously decreased by NaCl treatment and hence decrease the pod fresh weight. The foliar spray of salicylic acid greatly enhanced fresh pod weight by reducing ROS generation and protecting the photosynthetic pigment from oxidation. which might explain SA-treated plants had the highest fresh pod weight in our experiment as compared to control plants. Similar mechanisms were also reported in other studies (Ahmad *et al*., 2024; Hossain *et al*., 2024).

Pod width

Salinity stress, salicylic acid and their interaction significantly affect the pod width of pea plant as shown in Table 7. Maximum pod width (15.96 mm) was recorded in control plants while minimum Pod width (14.05) was observed in plants subjected to salinity level 75 mM NaCl (Figure 3). Nonetheless, foliar application of salicylic acid significantly increased pod width of pea plant in control as well in plants grown under all salinity levels. Highest Pod width (15.49 mm) was observed in pea plants treated with 2 mM of salicylic acid while the lowest (14.01 mm) was recorded in control plants (Figure 5). With regard to interaction maximum pod width (16.34 mm) was observed in plants treated with salicylic acid at the rate of 2 mM in control, while lowest Pod width (11.88 mm) was observed in plants subjected to salinity level of 75 mM NaCl without salicylic acid. Overall salicylic acid at the rate of 2 mM under control and stress conditions produced maximum Pod width with respect to treatments where salicylic acid was not added.

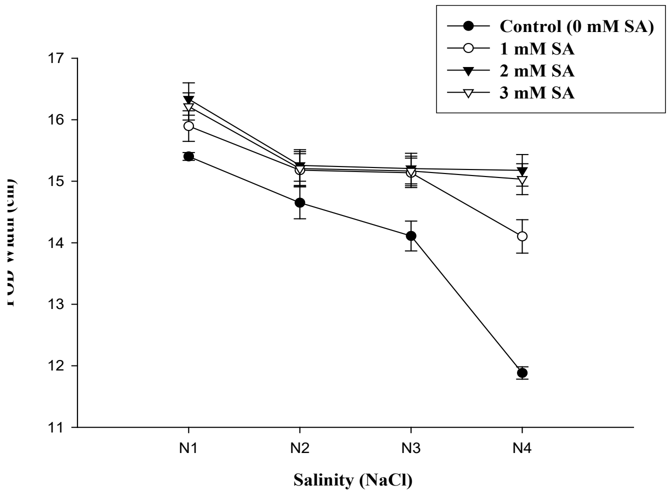

Figure 3: *Interaction for pod width (mm) as affected by salinity stress and salicylic acid.*

Pod width was significantly decreased by drought stress as saline conditions reduces the accumulation of proline and less increase in the activation of antioxidants. Saline condition restricted water availability to plant and also decreases photosynthesis and translocation as well as ion uptake which causes reduction in pod fresh weight. Foliar application of SA significantly increased the pod width due to increase of water ratio, pigments and proline and antioxidant activity. under saline stress. Our results are also supported by (Sajid *et al*., 2016). The increase in pod width may also be due to more availability of foods due to photosynthesis and transport as well as membrane permeability.

Table 7: *Pod width (mm) of pea plant as affected by salinity stress and salicylic acid.*

Salinity stress	Salicylic acid (mm)				
	0	1	2	3	Mean
Control	15.40 c	15.90 b	16.34 a	16.22 a	15.96 a
25 mM NaCl	14.65 f	15.18 d	15.26 d	15.21 d	15.07 b
50 mM NaCl	14.11 g	15.14 de	15.21 d	15.17 d	14.91 c
75 mM NaCl	11.88 h	14.10 g	15.18 d	15.03 e	14.05 d
Mean	14.01 d	15.08 c	15.49 a	15.41 b	

Mean values in a single column or row followed by different letters are significantly different at P≤ 0.05. LSD value at 5% level of probability for salicylic acid (SA) = 0.06, LSD value at 5% level of probability for salinity stress (NaCl)= 0.06, LSD value at 5% level of probability for SA× NaCl = 0.12

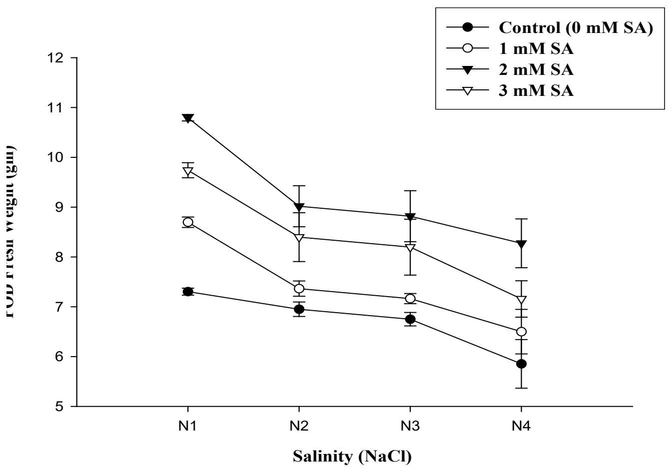

Figure 4: *Interaction for pod fresh weight (g) as affected by salinity stress and salicylic acid.*

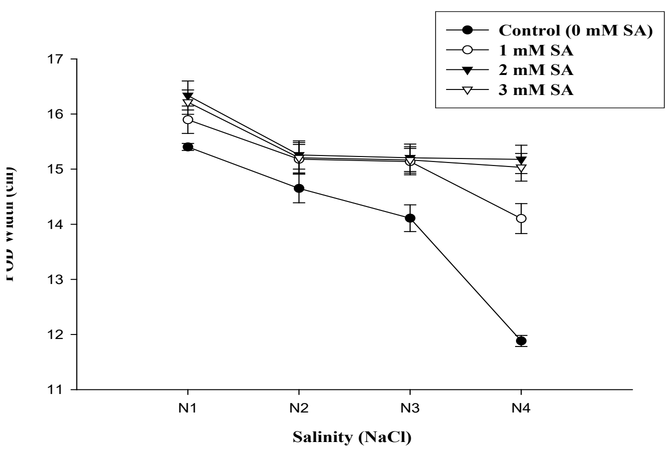

Figure 5: *Interaction for Pod Width (mm) as affected by salinity stress and salicylic acid.*

Pod length

Salinity stress and salicylic acid had significantly affected Pod length of pea plant as shown in mean Table 8. Maximum pod length (10.14 cm) was recorded in control plants while minimum pod length (6.30 cm) was observed in plants subjected to salinity level 75 mM NaCl. Nonetheless, foliar application of salicylic acid significantly increased pod length of pea plant in control as well in plants grown under all salinity levels. Highest Pod length (9.29 cm) was observed in pea plants treated with 2 mM of salicylic acid while the lowest (7.12 cm) was recorded in control plants. With regard to interaction maximum pod length (10.27 cm) was observed in plants treated with salicylic acid at the rate of 2 mM in control, while lowest pod length (4.85 cm) was observed in plants subjected to salinity level of 75 mM NaCl without salicylic acid. Overall salicylic acid at the rate of 2 mM under control and stress conditions produced maximum Pod length with respect to treatments where salicylic acid was added.

Table 8: *Pod length of pea plant as affected by salinity stress and salicylic acid.*

Salinity stress	Salicylic acid (cm)				
	0	1	2	3	Mean
Control	9.99	10.15	10.27	10.14	10.14 a
25 Mm NaCl	7.49	8.52	10.13	9.74	8.97 b
50 Mm NaCl	6.15	6.89	8.90	7.66	7.40 c
75 Mm NaCl	4.85	5.86	7.86	6.66	6.30 d
Mean	7.12 d	7.86 c	9.29 a	8.54 b	

Mean values in a single column or row followed by different letters are significantly different at P≤0.05. LSD value at 5% level of probability for salicylic acid (SA) = 0.2429, LSD value at 5% level of probability for salinity stress= 0.2429

Salinity reduced the pod length of the pea plant might be due the poor uptake and accumulation of nutrients due the high level of salts in soil, our experiment is similar with the findings of (Farooq *et al*., 2017). Decline in pod length was significantly recovered by the application of salicylic acid could be due to its work in nutrient uptake to the plant, plant water relations, regulation of stomata, plant photosynthesis and growth.

Seed pod^{-1}

Salinity Stress and Salicylic acid had significantly affected seed per pod of pea plant shown in mean Table 9. Maximum Seed per pod (8.57) was recorded in control plants while minimum seed per pod (5.28) was observed in plants subjected to salinity level 75 mM NaCl. Nonetheless, foliar application of salicylic acid significantly increased seed per pod of pea plant in control as well in plants grown under all salinity levels. Highest Seed per pod (7.54) was observed in pea plants treated with 2 mM of salicylic acid while the lowest (5.87) was recorded in control plants.

Table 9: *Seed per pod of pea plant as affected by salinity stress and salicylic acid.*

Salinity stress	Salicylic acid				
	0	1	2	3	Mean
Control	7.93	8.47	9.16	8.72	8.57 a
25 Mm NaCl	6.03	6.71	7.78	7.44	6.98 b
50 Mm NaCl	5.14	5.63	6.96	6.05	5.94 c
75 Mm NaCl	4.40	4.94	6.28	5.52	5.28 d
Mean	5.87 d	6.43 c	7.54 a	6.93 b	

Mean values in a single column or row followed by different letters are significantly different at P≤0.05. LSD value at 5% level of probability for salicylic acid (SA) = 0.18, LSD value at 5% level of probability for salinity stress= 0.18

Salinity minimized seeds pod^{-1} might be due reduced viability of pollen under stress condition could results in failure of seed set. the decrease seed pod^{-1} may also be due to lees nutrient availability, competitive uptake transport and distribution in the plant and the impaired cell division and cessation of protein synthesis reported by (Mitra, 2017). The experimental results indicate that the number of seeds per pod was significantly influenced by salicylic acid, which may be attributed to its role in enhancing IAA and cytokinin levels that salicylic acid increases the synthesis IAA and cytokinin which increased seeds production under stress environment. The current results are further supported by (Ali and Mahmoud, 2013) that salicylic acid significantly increased seed per pod in mung bean. The results are also in line with the results of (Sadeghipour and Aghaei, 2012) that salicylic acid improve relative water content and plant photosynthesis which increases seed production on common bean plant.

Yield per plant

Salinity stress and salicylic acid has significant effect on yield of pea plant as shown in Table 10. Maximum Yield (79.81 g) was recorded in control plants while minimum yield (55.30 gm) was observed in plants subjected to salinity level 75 mM NaCl. Nonetheless, foliar application of salicylic acid significantly increased yield of pea plant in control as well in plants grown under all salinity levels. Highest yield (72.48 g) was observed in pea plants treated with 2 mM of salicylic acid while the lowest (59.24 gm) was recorded in control plants.

Table 10: *Yield of pea plant as affected by salinity stress and salicylic acid.*

Salinity stress (mM)	Salicylic acid (mM)				
	0	1	2	3	Mean
Control	74.76 a	78.78 b	84.99 a	79.68 b	79.55 a
25 Mm NaCl	60.94 e	66.08 d	74.14 c	72.24 c	68.35 b
50 Mm NaCl	53.62 gh	57.96 f	67.99 d	61.12 e	60.17 c
75 Mm NaCl	47.64 i	52.79 h	62.82 e	55.95 fg	54.80 d
Mean	59.24 d	63.90 c	72.48 a	67.25 b	

Mean values in a single column or row followed by different letters are significantly different at P≤0.05. LSD value at 5% level of probability for salicylic acid = 1.30, LSD value at 5% level of probability for salinity stress = 1.30, LSD value at 5% level of probability for interaction = 2.61

Salinity retarded yield of pea plant may be due to salinity which causes significant reduction in yield. The decrease yield may also be attributed due to the reduction in photosynthesis due to accumulation of higher Na and Cl in the chloroplast. The decrease in yield may also be due to the reduce activity of Rubisco enzyme which is highly affected by increase concentration of chlorine in the leaves. The decrease in yield may also be due to the retardation of proline accumulation under salinity stress. On the other hand; Salicylic acid enhances the yield of pea plant which might be due to protection of plant from salinity and osmotic stress and it also enhance protection of photosynthetic pigment in barely which may also be the reason of increase yield per plant. The increase in yield may also be due to exogenous application of salicylic acid which causes considerable amount of net photosynthesis rate. Results are further supported by in maize and in mustard. reported that salicylic acid has both qualities to inhibit or promote the growth of plant. The increasing concentration of salicylic acid decreases plant water content, chlorophyll content and plant soluble protein (Loutfy *et al*., 2012). Higher SA concentration has a toxic effect, based on the sharp increase in phenylalanine ammonia-lyase (PAL) activity (24h after application), which is followed by an increase in total soluble phenolics, lignin accumulation and the majority of the 11 detected phenolic acids.

Links Researchers

Conclusions

It can be concluded from the results obtained during study that the optimum level of foliar application of salicylic acid at the rate of 2 mM enhanced vine length, stem diameter, pod fresh weight, pod width, pod length, seed pod^{-1} and yield pod^{-1} while decreased days to flowering of pea and days to podding of pea of pea under saline soil. Salinity (NaCl) affected negatively all growth and yield parameters of pea while increasing level of salinity from 0 mM to 75 mM causes more adverse effect on pea growth and yield attributes.

Recommendations

Foliar application of salicylic acid at the rate of 2 mM decreases the adverse effect of salinity and improved most of the growth and yield attributes of pea under saline conditions and hence could be recommended for getting significant growth and yield of pea under saline condition.

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Novelty Statement

This study demonstrates that foliar application of salicylic acid at 2 mM effectively mitigates salinity-induced growth and yield losses in pea.

Author's Contribution

All authors contributed equally to all the activities of the manuscript. All authors have read and agreed to the published version of the manuscript.

Generative AI and AI-assisted technology statement
The authors declare that no generative AI or AI-assisted technologies were used in the preparation of this manuscript.

Conflict of interest
The authors have declared no conflict of interest.

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