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Screening Potato Genotypes for Salt Tolerance: Biochemical Markers and Physiological Responses

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ABSTRACT

This study examines the biochemical and physiological changes of potato (*Solanum tuberosum* L.) under salt stress to identify and select salt-tolerant varieties. The conditions of salinity stress are a major constraint to plant growth and production in arable farming. The screening experiments of the present study measured the capacity of various potato cultivars and Solanum species accessions using in vitro assessment under imposed NaCl-induced salt stress. Records developed in this context include TS, amino acids, protein contents, and enzymatic antioxidants. Hyperspectral data analyses showed that there are differences between genotypes in terms of salt tolerance also some biochemical traits showed strong relationship with salt tolerance. Outcome of the study demonstrate that biochemical markers can be incorporated into breeding programs and phytoremediation endeavors. This research links to increasing the sustainability of farming in saline conditions.

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Keywords: Salt Stress, Solanum Tuberosum, In Vitro Screening, Biochemical Markers, Antioxidant Enzymes, Phytoremediation

1. Introduction

This is the crossroad of agriculture, being charged with feeding an increasing global populace today while facing challenges from the physical world. Soil salinity, which reflects a major abiotic stress, is now being reported as a major threat to crop productivity in many areas of the world. Data of the present world suggests that around 800 million hectare of land is affected by salinity and around 20 percent of irrigated agriculture land is under the threat of salt stress (FAO, 2008; Ashraf et al., 2010a). Brought about by ill management of watering, intrusion of sea water, and climate change, salinity problems indicate that irrigation is still a very critical obstacle to food security around the globe (Munns & Tester, 2008; Martinez-Beltran & Manzur, 2005).

Major effects of salinity stress are osmotic stress which destabilizes plant cell and ionic toxicity, oxidative stress in general physiology of the plant. It causes ionic and osmotic stress through two ways: diminished water uptake, which causes cell dehydration; and ion toxicity from Na^+ and Cl^- that disturb enzymatic activities and imbalances the cell ions (Parida & Das, 2005). The follow-on oxidative stress produces ROS which lead to the formation of lipid peroxidation, protein aggregation and nucleic acid alteration, which in turn negatively affect plan growth and productivity (Mittler, 2002; Benavides et al., 2005).

Of all the staple crops around the world, the potato or scientifically known as Solanum tuberosum L. is highly valued for its economic and nutritive qualities. Potato, ranking as the fourth most important food crop provides carbohydrate, vitamin and mineral calories. However, owing to its low tolerance to salinity, the crop can only be grown in areas with little or no salinity stress which has often resulted in declining yields and poor quality tubers (Spooner & Salas, 2006; Horton & Sawyer, 1985). As salinity continues to H, a rise in production area there is need to breed and produce salt-tolerant potato cultivars where salinity limits the growing zones (Gichner et al., 2008).

This experiment reveals that salinity affects potato in some of its morphological, biochemical and physiological changes. Osmotic stress reduces water

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uptake which in turn decreases cell turgor pressure, which interferes with growth leading to poor tuber formation. Similarly, ionic toxicity reduces nutrient absorption and photosynthesis besides affecting enzyme activity causing plant vigor reduction (Ashraf & Foolad, 2007; Flowers & Flowers, 2005). These are compounded by the fact that accumulated ROS negatively affect cellular structures and interfere with most cellular metabolisms (Ashraf et al., 2008).

Modern techniques in plant biochemistry have now allowed the selection of salt tolerance characters through tissue culture tests. These techniques offer a controlled approach which may be used to ascertain plant reactions to saline tension as factor varies on to subfield (Chaudhary & Sharma, 2009). Shoot length, node number and internodal length are some of the important morphological descriptors used for phenotypic identification of salt tolerant genotypes (Goncalves et al., 2009). Moreover, other biochemical markers such as soluble protein content, osmotic solutes, and antioxidants activity provide evidence of tolerance processes (Gratao et al., 2005).

The results revealed that antioxidant defense mechanisms mainly contribute to reducing oxidative stress due to salinity. Many enzymes such as peroxidase (POD), polyphenol oxidase (PPO) and phenyl alanine ammonia lyase (PAL) play important roles in removal of ROS and maintaining cellular homeostasis. Increased activities of these enzymes are known to be associated with increased tolerance to salinity stress in several plant species such as the potato crop.

To this end, this work will examine the biochemical and physiological changes in potato cultivars and Solanum species under NaCl stress conditions. Combining in vitro screening with biochemical assays aims to achieve the study identifies salt-tolerant genotypes and the biochemical pathways involved in tolerance. These results will be useful for plant breeding activities that focus on increasing the potato crop's ability to withstand saline conditions and, more broadly, support sustainable agriculture and food production given the challenges posed by global climate change and soil and water degradation.

2. Materials and Methods

2.1. Selection of Material

Diamant and Cardinal Potato varieties were selected for this study due to their high

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yield, market preference and past management practices. Certified seed potatoes were collected from Punjab Seed Corporation Sahiwal Farms. The seed tubers were thoroughly washed to minimize impacts of disease sources and maximize uniformity of the seeds. Firstly, they washed tubers with a detergent solution and then rinsed them with tap water to eliminate above-surface contaminants. This was done with autoclaved distilled water in order to keep sterile the site were implantation was to take place. It was then sown immediately and the tubers kept in absolute darkness at temperature within 18 – 22 °C to facilitate uniform sprouting. Through selection of healthy tubers with standard sprouting, reliability of the experiment was ensured during subsequent tissue culture tests. For all the experiments in the study, high-grade laboratory chemicals analytical grade as well as sterilized glassware was used. To avoid contamination of samples, strict aseptic measure was adopted, where all the instruments used were autoclaved at 121°C and 15 psi for 20 minutes.

2.2. Tissue Culture Procedures

2.2.1. Explants Preparation

These nodal segments were obtained from the tuber with sprouts. To control microbial infection the exterior of nodal explants was sterilized by 2% sodium hypochlorite for 20 min. This was done by rinsing (3-5) times with distilled water to wash out any traces of the sterilizing agent used. All steps were performed in a laminar flow hood to minimize bacterial contamination of the tissue culture preparations. Size and structure: All nodal segments of the 10 abaxial and 7 adaxial preparations were approximately 1.5 cm in length and there were no recorded pu and irregularities.

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2.2.2. Culture Media

The general growth medium that was used in tissue culture was Murashige and Skoog (MS) medium with sucrose at 3% as carbon source. The medium was set using 0.8% agar and the pH was brought to 5.7 – 5.8 before sterilization. To mimic different salinity levels within the tissue culture environment, sodium chloride (NaCl) was applied to the MS medium at 30, 60, 90, 120 and 150 mM as an indication of salt stress. A similarly prepared control medium, devoid of NaCl, was used in parallel. All media were sterilized by autoclaving and aseptically cooled prior to the inoculation.

2.2.3. Culture Conditions

Explants were grown in culture jars using the established media as described below. All cultures were grown in a growth chamber at 25 ± 1°C under controlled photoperiod of 16/8 (L/D) light. Light operations were controlled to a range of 2000–3000 lux with cool white fluorescent lamps. General morphological changes in the explants were monitored and recorded weekly for four weeks. Any form of interferences were observed and ceased so that uncontaminated data could be obtained.

2.3. Salt Stress Treatment

2.3.1. Experimental Setup

To investigate the effects of salinity, the explants were divided into six treatment groups based on the NaCl concentrations in the media:

1. Control (0 mM NaCl)
2. Low Stress (30 mM NaCl)
3. Moderate Stress (60 mM NaCl)
4. High Stress (90 mM NaCl)
5. Severe Stress (120 mM NaCl)
6. Critical Stress (150 mM NaCl)

Each treatment group consisted of three replicates, with 10 nodal explants per replicate. This experimental design ensured sufficient statistical power for subsequent analyses.

2.3.2. Application of Salt Stress

The nodal explants were grown on the treated MS media for a period of 28 days.

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During the experiment contamination was observed with explants and samples were removed if they were affected. Plant morphological attributes which include shoot length, number of nodes and internode length were recorded at one week interval using a measuring scale.

Treatment Group	NaCl Concentration (mM)	Replicates	Duration (weeks)
Control	0	3	4
Low Stress	30	3	4
Moderate Stress	60	3	4
High Stress	90	3	4
Severe Stress	120	3	4
Critical Stress	150	3	4

2.4. Morphological and Biochemical Analysis

2.4.1. Morphological Parameters

Phenotypic characterization was done at a biweekly interval to capture the effects of salinity on growth. Parameters measured included:

Shoot length (cm): Measured from the bottom of nodal segment to the apex of the shoot.

Number of nodes per plant: Included as the visible nodes on the primary axis of growth.

Internodal length (cm): As the ratio of total length of the path traversed by flow to the number of nodes actually encountered.

The dependability of the results was achieved by using accurate apparatus and method in taking the data.

2.4.2. Biochemical Parameters

To understand the physiological and biochemical responses to salt stress, the following assays were conducted:

Total Soluble Proteins: Concentration of protein was measured using Bradford Assay. A standard curve for the assay was generated using bovine serum albumin (BSA) and results were reported in mg/g fresh weight. Total Amino Acids: Determination of amino acids was carried out by colorimetry, employing ninhydrin

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chemical reagent. Measurement of absorbance was done spectrophotometrically and the concentrations were obtained from calibration plot with glycine.

Enzyme Activities: Specific enzymes participating in stress responses were examined:

Peroxidase (POD): Activity was assessed by detecting the extent of oxidation of guaiacol by hydrogen peroxide.

Polyphenol Oxidase (PPO): The rate of quinone formation from catechol was used as a measure of enzyme activity.

Nitrate Reductase (NR): Enzymatic assays were done to measure the decrease of nitrate to nitrite which is an essential process in nitrogen uptake.

Carbohydrate Content: Total soluble sugars were estimated according to the method of anthrone reagent. Absorbance was determined using spectrophotometry at 620 nm and sugar content was quantified as mg sugar per gram fresh weight of the tissue.

2.4.3. Antioxidant Analysis

Salt stress-induced oxidative stress was assessed by measuring the activity of antioxidative enzymes:

Superoxide Dismutase (SOD): Activity was defined operationally by its power to suppress the photochemical reduction of nitro blue tetrazolium (NBT).

Catalase (CAT): Catalase activity of the organism could be resolved by the rate of hydrogen peroxide breakdown.

Ascorbate Peroxidase (APX): APX activity was determined by recording changes in absorbance at 290 nm due to the oxidation of ascorbate.

Fluorescent probes were employed to determine the ROS levels and thereby understand the potential oxidative harm and standing of antioxidant functionalities.

2.5. Statistical Analysis

Data were statistically analyzed by Analysis of variance (ANOVA) to test the treatment effect on the morphological and biochemical variables. In the case of post treatment comparisons, Duncan's Multiple Range Test (DMRT) was used in order to determine whether the treatment means were significantly different at $p < 0.05$. Data was analyzed using SPSS (Version 25) with data presented as means with standard errors.

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Additional Experimental Considerations

Quality Control: All measurements were also undertaken thrice and averages of each measurement were used after omitting thee highest and lowest results from the averages. Replication: High biological and technical redundancy was maintained in the design of the experiment in order to boost stability of the statistics. Data Documentation: Visual records of plant growth under each treatment were taken weekly and photographed to show the impact of salinity stress.

This comprehensive methodological approach provided a robust framework for investigating the morphological, biochemical, and physiological responses of potato cultivars to salinity stress under controlled conditions.

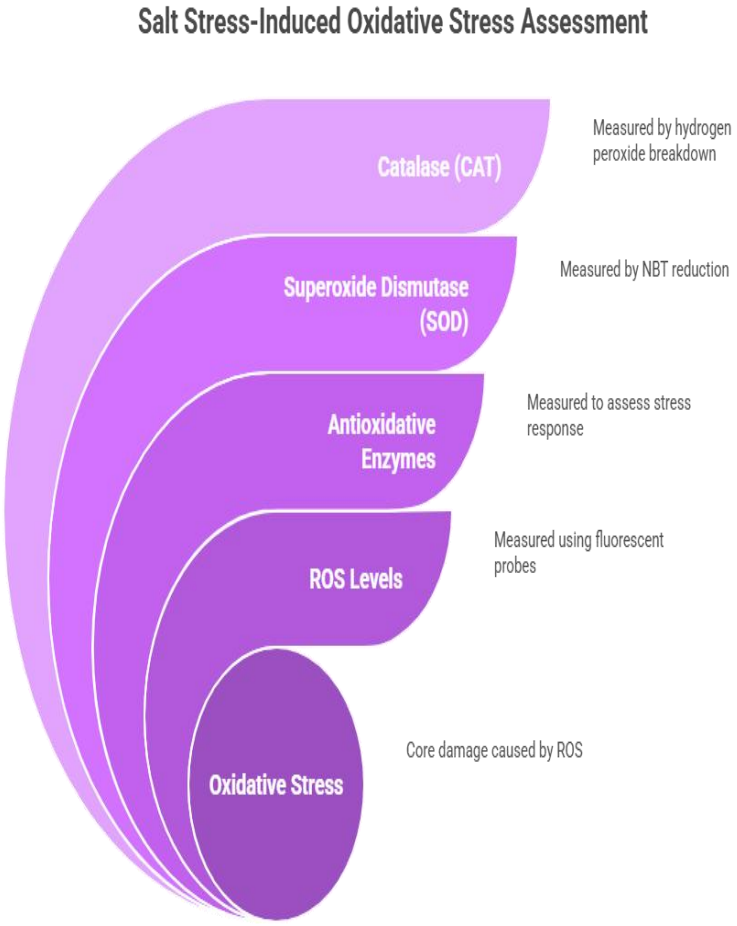


Diagram for the analysis of biochemical and physiological changes of potato (*Solanum tuberosum* L.) under salt stress

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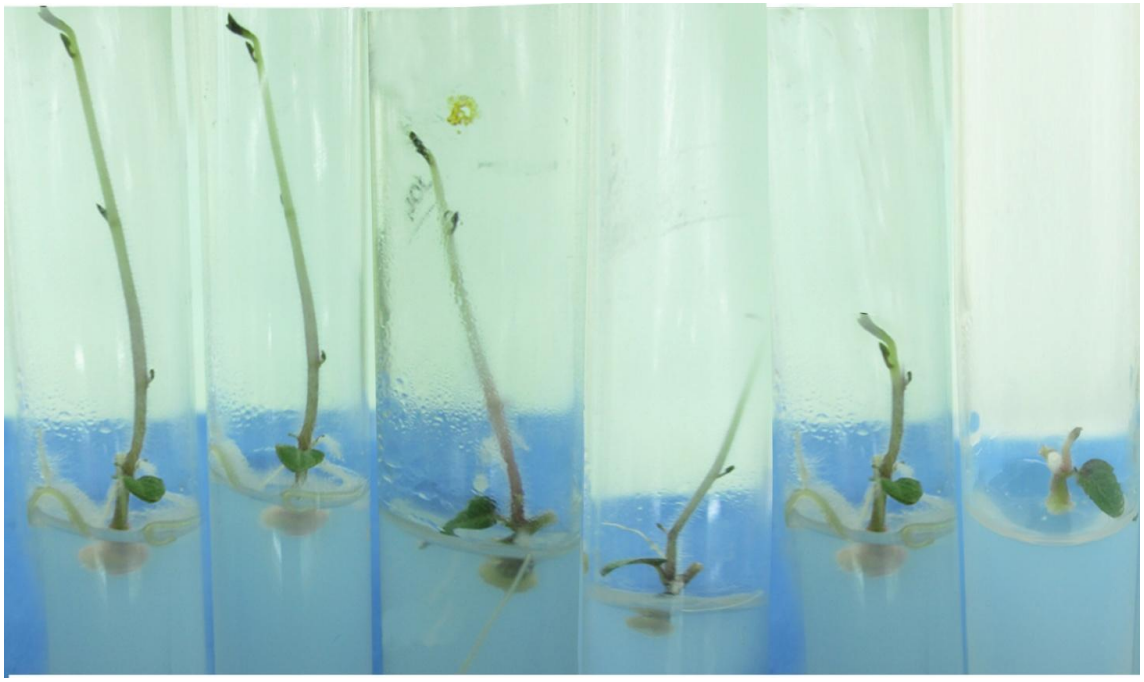
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3. Results

3.1. Morphological Responses to Salt Stress

3.1.1. Shoot Length

Effectiveness of NaCl on shoot length was significantly varied between the two cultivars, namely: the Diamant and Cardinal. When cultivated at a solution supplemented with a relatively low concentration of NaCl (30 mM), both the cultivars showed improvement in growth. Diamant's increase was recorded at 6.54 % of the shoot length and for Cardinal a higher rise of 13.41 % was observed. These effects indicate the ability of low salinity levels to be considered as mild stress indicators of the stunted fish muscles and the ability of the muscles to elicit adaptive mechanisms including water uptake and osmotic regulation.



30mM NaCl | Control | 60mM NaCl | 90mM NaCl | 120mM NaCl | 150mM NaCl

Figure 1: In vitro plants of potato (cv Diamant) in descending order after two weeks of treatment.

Sufficient evidence for the negative influence of salinity on shoot length was identified once the specific levels of salinity were defined. Amounts of NaCl: Diamant reduced shoot length to 35.81% by 120 mM / 100% whereas Cardinal reduced shoot length to 25.18% by 120 mM / 100%. This decrease clearly shows the injury that

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high salinity imposes on the capacity to elongate or divide cells through osmotic stress and disturbance in proper sharing of ions. High salinity stress affects plant growth vigor and productivity and in extreme cases it reduces yield in terms of agricultural production.

Table 2: ***Shoot Length At Various Treatments To Turnip***

Treatment	Diamant (Shoot Length, cm)	% Change	Cardinal (Shoot Length, cm)	% Change
Control	9.48 ± 0.74	---	9.32 ± 0.75	---
30 mM NaCl	10.10 ± 0.86	+6.54%	10.70 ± 0.98	+13.41%
120 mM NaCl	3.30 ± 0.85	-65.19%	2.72 ± 0.85	-70.82%

3.1.2. Number of Nodes

Thus, salt stress influenced the nodes count in a twofold manner. Thus at 30 mM NaCl Diamant had 32 % increase in node count and Cardinal increase in node count as compared to their control was only 18%. This can be an implication that low salinity increases nodal development as a result of enhanced nutrient and water assimilation. This is probably because of increased auxin distribution and localized stress signaling which somewhat increases nodal development under mild stress. Severe stress (150 mM NaCl) showed a similar decline in Diamant by 56% and in Cardinal by 62% for NA-6, suggesting a decrease in, meristematic activity and energy used for growth divergence. These results indicate that the effects of salinity are threshold dependent at the cellular and tissue level.

Table 3: ***Number Of Nodes Under Various Treatments***

Treatment	Diamant (Nodes per Plant)	% Change	Cardinal (Nodes per Plant)	% Change
Control	15.8 ± 0.8	---	14.3 ± 0.7	---
30 mM NaCl	20.9 ± 1.2	+32%	16.8 ± 1.0	+18%
150 mM NaCl	6.9 ± 0.6	-56%	5.4 ± 0.5	-62%

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3.1.3. Internodal Length

As shoot length internodal length also followed the same trend. The impact of saline stress was significant for both cultivars, with a minor stress treatment (30 mM NaCl) enhancing productivity in both Diamant which rose by a 10.4%, and Cardinal rose by a 14.2%. Cultivar stress well-tolerance to moderate stress but severe stress led to reduction more than 60 % both the cultivars. These results are well in synchrony with previous reports on the negative impacts of high salinity on elongation growth probably through a reduction in cell wall extensibility and turgor pressure. High stress results in decreased internodal length meaning that, although an increase in internods is desirable for plants in terms of elongation, stress impedes growth and emphasizes the plant's means of survival.

Table 4: ***Internodal Length At Various Treatments***

Treatment	Diamant (Internodal Length, cm)	% Change	Cardinal (Internodal Length, cm)	% Change
Control	1.34 ± 0.05	---	1.38 ± 0.06	---
30 mM NaCl	1.48 ± 0.08	+10.4%	1.58 ± 0.09	+14.2%
150 mM NaCl	0.52 ± 0.03	-61.2%	0.49 ± 0.02	-64.5%

3.2. Biochemical Responses to Salt Stress

3.2.1. Soluble Protein Content

Challenges: Proteins act in stress response as structural and functional molecules in the plants. They found in Diamant, protein content of organisms reduced with increasing salinity, they presumed this was due to protein degradation under stress. This degradation could be due to increased protease activity which is a well-known indicator of stress for quite a long time. On the other hand, Cardinal also showed an increased protein content under different stress levels but more significantly under higher stress levels of NaCl at 150mM stress level the protein content was 14.64% higher than the control. This implies that Cardinal may rely on stress-responsive protein synthesis for counteraction of the impacts of marginal salinity levels. Increased synthesis of proteins under stress condition is seen to involve measures

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that serve as protective steps, such as chaperone activity as well as stabilization of the enzymes.

Table 5: ***Soluble Protein Content under Various Treatments***

Treatment	Diamant (Protein Content, mg/g tissue)	% Change	Cardinal (Protein Content, mg/g tissue)	% Change
Control	0.478 ± 0.002	---	0.478 ± 0.002	---
30 mM NaCl	0.454 ± 0.021	-5.02%	0.481 ± 0.003	+0.63%
150 mM NaCl	0.548 ± 0.074	-14.64%	0.497 ± 0.031	+14.64%

3.2.2. Total Soluble Sugars

In conditions of salinity stress, osmotic adjustment is usually associated with the accumulation of soluble sugars as osmoprotectants. Diamant had the highest sugar content increase with 28.6% at 90 mM NaCl and cardinal followed this with a 31.2% at 60 mM NaCl. Thus, the data presented here show that spread of sugar accumulation can prevent weaknesses in osmotic stress. Sugars also act as communication molecules and influence stress-sensitive processes to increase a chance for survival. When salinity increased, sugars decreased because of loss of metabolic energy during long term stress condition.

Table 6: ***Total Soluble Sugars Under Various Treatments***

Treatment	Diamant (Total Sugars, mg/g tissue)	% Change	Cardinal (Total Sugars, mg/g tissue)	% Change
Control	0.212 ± 0.008	---	0.208 ± 0.009	---
60 mM NaCl	0.273 ± 0.011	+28.6%	0.272 ± 0.010	+31.2%
150 mM NaCl	0.141 ± 0.007	-33.5%	0.132 ± 0.006	-36.5%

3.3.3. Enzyme Activities

Phenylalanine Ammonia-Lyase (PAL): PAL activity was at its highest in 60 mM

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NaCl treatment with a 2114% enhancement of Diamant callus and 1207% increase of Cardinal callus to the control. This might mean enhanced secondary metabolite synthesis in stressed zones of the plant, which, in turn might serve functions of fortifying the cell wall and antioxidant protection.

Superoxide Dismutase (SOD): A key antioxidant enzyme was SOD and HU and SU cultivars exhibited enhanced SOD activity with increasing salinity to 120 mM NaCl. This increase can be attributed to efforts made at the plant level to prevent the accumulation of Reactive Oxygen Species (ROS).

Catalase (CAT): CAT activity was also found to be exhibited a biphasic manner and it showed increase only at moderate level of stress but decrease at severe stress confirming that high salinity is causing oxidative damage. The descrease of CAT activity at the most severe stress level indicates the over accumulation of ROS that can not be detoxified by the enzymes.

Table 7: ***Phenylalanine Ammonia-Lyase (PAL) Activity under Different Treatments to Turnip***

Treatment	Diamant (PAL Activity, U/mg protein)	% Change	Cardinal (PAL Activity, U/mg protein)	% Change
Control	0.023 ± 0.002	---	0.025 ± 0.001	---
60 mM NaCl	0.523 ± 0.031	+2114%	0.328 ± 0.026	+1207%
150 mM NaCl	0.478 ± 0.024	+1978%	0.310 ± 0.020	+1140%

4. Discussion

The observed variation in the morphology of potato cultivars Diamant and Cardinal treated with NaCl compared to the control group effectively points to the difference in the cultivars' sensitivity to salinity stress. Cardinal cultivar responded to low salinity levels (30mM NaCl) with relatively higher adaptive response where shoot length and node numbers improved significantly across the two cultivars. This goes in consonance with earlier reports that mild osmotic stress resulting from the salinity can actually be growth promoting by increasing the efficiency of osmotic

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adjustment and promoting water uptake (Farhatullah & Raziuddin, 2002). However, all the growth parameters like shoot length, internodal length, node numbers etc. were generally reduced significantly when salinity reached up to 120mM and further this showed the negative impacts of both ionic and osmotic stresses on plant growth and development. The same trends have also been identified in other researches on salinity effects in other crops: these are consistent with the notion of Salinity stress effect on morphological traits being a function of threshold level.

That several measured features such as shoot and internodal lengths decreased considerably under the salinity stress would be attributed to the decreased cell elongation and division because of ionic toxicity and water deficit. This response supports Turhan et al. (2010), the pot experiment authors, who reported that salinity destabilises the cytoskeleton, which interferes with cell wall flexibility and growth. Additionally, the observed slight superiority of Diamant under intense stress has indicated for strong ion exclusion mechanisms or superior osmotic adjustment potentialities in this genotype.

The tendency for the buildup of soluble proteins and sugars differ significantly between Diamant and Cardinal; thus providing an insight into their biochemical response to stress induced by salinity. Cardinal also confirmed the result for soluble protein content to be significantly higher among exposed organisms under high salinity linked to stress induced proteins such as enzymes and molecular chaperones. This work is in concord with earlier reports made by Farhad et al. (2001) who suggested that stress-responsive proteins were proved to have immense proactive action on the negative impacts of salinity by maintaining cellular homeostasis. On the other hand, Diamant's protein decreased with increased salinity potentially through protein degradation due to oxidative stress of salinity or suppression of protein synthesis stress factors as noted by Ashraf and Harris, (2004). Ethanol precipitation of soluble sugars indicated their function as osmolytes; this fraction was higher in the specimens obtained from moderate levels of salinity. Severe stress led to the decrease in sugar content in both cultivars probably due to utilization of the available metabolic reserves and reduced ability of the plants to perform photosynthesis. The same authors, Parida and Das (2005) also noted that sugars on one hand serves as osmoprotectant and on the other as a source of energy

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under abiotic stress conditions.

The observed higher activity PAL, SOD, and CAT under salinity stress suggest that the plant regulates antioxidant system to combat the increased control oxidative stress. Maximum PAL activity matched the allosteric regulation of the phenylpropanoid pathway at 60 mM NaCl, generating lignin and other secondary metabolites contributing to an increased cell wall rigidity and oxidative stress shield. The higher PAL activity in Diamant implies that the pathway for secondary metabolite biosynthesis is better developed than that found in Cardinal, as deduced from Vinocur and Altman, 2005.

The SOD activity rose gradually with the increase in salinity, thus confirming works of the enzyme in the dismutation of the superoxide radicals to less dangerous hydrogen peroxide. Though CAT activity reduced at the higher salinity level, there is marked increase in the level of ROS, which in turn cross the detoxification limit of the enzymatic defense mechanism. These results are in line with other studies done by Mittler (2002), which stated that stress tolerance is determined by a well-balanced system of ROS scavengers.

Dissection of the two plants to salinity stress offers a rich insight into the breeding initiatives toward the development of the salt tolerant potatoes by Diamant and Cardinal. The overall better morphological fitness and higher antioxidant enzyme activity of Diamant under moderate salinity level may suggest its possibility to be grown in slightly saline zone. On the other hand, to generate less ATP under stress while being capable of sustained protein synthesis at the same time makes Cardinal better suited for environments that can sharply change the salinity levels.

As used in this study, in vitro screening techniques are a 'fast' and 'economic' means of assessing the levels of tolerance to salinity among various cultivars. Since biochemical and morphological features responsive to salinity stress are known, breeders can choose genotypes higher in salinity tolerance to get them to the next stage of field testing. Moreover, implementation of these insights within the framework of precision agriculture to include irrigation and nutrient management can help to minimise detrimental impacts of salinity, as well as increase yields..

5. Conclusion

It was revealed that salt stress provokes changes at the morphological, biochemical,

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and enzymatic levels in the potato cultivars Diamant and Cardinal. Light microscopy analyses showed that low salinity (30 mM NaCl) increased growth factors while high salinity levels (120–150 mM NaCl) reduced shoot length, node and internode number tremendously. This decline was as a result of ionic toxicity and osmotic stress whereby normal metabolic and cellular functioning were interfered with. Cultivars displayed differential sensitivity to the extract based on biochemical analysis. Whereas, under stress conditions, the soluble protein content in Diamant was found to be lower, in Cardinal it has been increased perhaps due to expression of stress-inducible proteins. Soluble sugars offered optimum adjustment at moderate salinity for osmotic purpose but depleted under severe stress condition. PAL and SOD are critical in alleviating oxidative stress damage since their activities were upregulated in both the cultivars. Nevertheless, the authors found that, under severe stress, CAT activity declined, indicating that ROS build-up exceeded the capability of the enzymatic detoxification system to neutralize it. The results presented in this paper serve to underscore an intricate interdependence of the structural and chemical processes in plant response to salinity stress. Comparing the differential responses between Diamant and Cardinal, it supports the genetic basis of the rice varieties, and the stress tolerance mechanism shown where Diamant performed higher in moderate stress condition while Cardinal has comparative biochemical techniques under severe stress. Further investigations carried out at the molecular level should be directed toward the identification of stress-inducible genes and their networks. Field trials are also suggested to confirm in vitro results with a common procedure to study the effects of salinity stress in natural settings. The outcome of this study will be of immense value to future breeding initiatives aimed at increasing salinity tolerance in potato and other crops as well as for the development of sustainable production practices in areas affected by salinity.

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