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Screening of *Solanum tuberosum* Cultivars Salt Tolerences *In vitro* Condition

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MNJ and MSI designed the study, performed and followed the procedure. Author RA managed the literature searches and preparation of the manuscript. Author MMH performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

Aims: To evaluate the impacts of salinity on some physiological traits of potato cultivars under *in Vitro* conditions.
Study Design: Completely Randomized Design using two factors.
Place and Duration of Study: The Genetics and Plant Breeding Department, Sher-e-Bangla Agricultural University from October 2019 to January 2021.
Methodology: Ten varieties; eight were collected from Tuber Crops Research Centre (TCRC), Agricultural Research Institute (BARI), Gazipur, and two from Sylhet were used. The varieties were

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BARI 29 (V_1), Pechar Chokh (V_2), BARI 72 (V_3), Lal Shila (V_4), BARI 53 (V_5), BARI 25 (V_6), BARI 28 (V_7) and BARI 36 (V_8), BARI 7 (V_9) and BARI 73 (V_{10}). Four salinity treatments including T_1 (control), T_2 (5 dS/m), T_3 (10 dS/m), and T_4 (15 dS/m) were applied to the varieties.

Results: Varieties and salinity treatment were influenced individually in the interaction with the physiological traits of potatoes.V_8 showed higher chlorophyll content (63.892%) while a minimum of 27.5% was recorded in V_5. The chlorophyll content of potato varieties was increased at the lower level of salinity (T_0). The accumulation of proline was observed in all varieties and treatments; however, the V_7 cultivar (14.02 µmol-1FW) and T_4 salinity treatment had higher accumulation. In response to salinity, the content of Na^+ of potato plants rose at 0.26% in T_4 while the decreasing trend was found in K^+ due to salinity stress. Moreover, the highest Na^+ content (0.20%) was found in V_7 whereas the highest value of K^+ content (0.20 %) was reported in the V_4 variety.

Conclusion: From the experiment, it has been found that BARI Alu-72(V_3) performed well under 5 dS/m salinity level and 10 dS/m level because better yields were obtained from these varieties. So V_3 variety is recommended for mild to moderate saline-prone areas in Bangladesh.

Keywords: Variety; salinity; chlorophyll content; proline accumulation; Na^+ /K^+ Ion content.

1. INTRODUCTION

“Potato (*Solanum tuberosum* L.) is the fourth most important staple commodity consumed worldwide after rice, wheat, and maize” [1]. “It will help to ensure food and nutritional security for an increasing population of developing nations” [2]. In Bangladesh, potato is mainly consumed as a vegetable food and are widely cultivated in all regions. Meanwhile, there is a big gap between the average national yield of potatoes in Bangladesh compared to other potato-cultivated countries of the world like the Netherlands, the UK, France, the USA, and Germany [3].One of the most ecological threats to global agriculture is the salinity of soils [4]. It is reported that coastal or inland salinity is one of the major constraints on potato cultivation in southern and south-eastern Asia of the world [5-7], and in Bangladesh, the coastal area constitutes 20% of the country of which 53% are affected by different levels of salinity [8]. “It is undeniable that salinization occupies a prominent place among the soil issues that threaten the sustainability of agriculture in Bangladesh. Observations in the recent research reported that because of ascending degree in salinity of certain areas and expansion of salt remain in those locations, normal crop production becomes more restricted” [4]. “High levels of salt (greater than 50 mM NaCl) are observed to reduce potato output [9], nonetheless, the potato plant is considered to be fairly sensitive to salinity” [10]. “Salinity is one of the abiotic stresses that affect potato growth and productivity mostly in semiarid and growing areas, causing an imbalance in plant physiological processes. The accumulation of Na^+ and Cl^- in cells is extremely toxic and can affect all of the plant mechanisms and enzymatic actions” [11,12]. “Potatoes, especially in the early growth phases, are relatively sensitive to salinity and Photosynthesis is the most significant mechanism affected by salinity” [13]. “Moreover, by disturbing physiological processes, including ion balance change, mineral nutrition, and photosynthetic efficacy, high salt content lowers potato growth and production” [14]. Considering the constraints to cultivating potatoes in saline areas of Bangladesh,the aim of this study was to evaluate the impacts of salinity on some physiological traits of potato cultivars under *in Vitro* conditions.

2. MATERIALS AND METHODS

2.1 Plant Materials

For this experiment 10 varieties were used (Table 1).Total tuber size of potato is about 50-55 mm that was planted in each pot. Tuber were placed in 2-3cm depth and covered with soil in each pot(120 plastic pots) properly (Fig. 1A).

Table 1. Potato varieties used in the experiment

Sl. No.	Genotypes	Variety
01	V_1	BARI Alu-29
02	V_2	Pechar chokh
03	V_3	BARI Alu-72
04	V_4	Lal shila
05	V_5	BARI Alu-53
06	V_6	BARI Alu-25
07	V_7	BARI Alu-28
08	V_8	BARI Alu-36
09	V_9	BARI Alu-7
10	V_{10}	BARI Alu-73

Fig. 1. Activities during pot experiment; A) Placement of tuber in each pot, B) Adjusting salinity level by EC meter

2.2 Application of Salinity Treatments

Total ten varieties were treated under four treatment of salinity (Table 2). Plants in control treatments which was denoted by T_1, were not applied salinity. To make treatment solution, salt was mixed with water and EC value was measured for the accurate application. Plants which were under control treatments (T_1) were always irrigated with fresh (non-saline) water. The salinity levels in soil was adjusted by a direct reading conductivity meter (EC-meter) (Fig. 1B).

Table 2. Salinity treatment in the experiment

Sl. No.	Treatment	Salinity Level
01	T_1	Control
02	T_2	5 dS/m
03	T_3	10 dS/m
04	T_4	15 dS/m

2.3 Measuring of chlorophyll content

The leaves were used to measure chlorophyll content at different salinity treatments from four different leaf in the same plant and then they were averaged for analysis.SPAD-502 plus portable chlorophyll meter was used for the measurement.

2.4 Proline Content in Tuber

Free proline content in the tuber was determined according to the most well known method of Bates [15]. Free proline content in sample was evaluated by referring to a standard curve made from known concentrations of proline by taking following formula. Here,

FW = fresh weight of leaf tissue
D = Initial dilution
S = absorbance at 520 nm
115.5 = Molecular weight of proline
µ moles proline/g of fresh plant material = {(mg proline/ml×ml toluene)/115.5µg/µmoles} /g sample/5.

2.5 Determination of Na^+ and K^+ Content

Na^+ and K^+ content on the tuber samples were determined by Flame Photometer after processing the samples through some necessary procedures in the laboratory.

2.6 Statistical Analysis

The Collected data from the experiment were analysed statistically following CRD design by MSTAT-C computer package programme to figure out the significance of the difference among the treatments. Comparison among all treatments was assessed by Least Significant Difference (LSD) test at 5% level of significance [16].

3. RESULTS AND DISCUSSION

3.1 Chlorophyll Content

In case of chlorophyll content, the performances of varieties and treatments showed contradictory variation. Among the ten varieties of potatoes in the experiment, the highest content of chlorophyll was observed in BARI Alu-36 (V_8) while the minimum percentage of content 27.5% recorded in BARI Alu-53 (V_5) (Fig. 2). Chlorophyll content were significantly decreased in salinity level of the plant.From the Fig. 3, it showed that the maximum content recorded on control treatment i.e., null followed by 5 dS/m (T_2) salinity level.

“The significant values of chlorophyll attributed to an increased level of photosynthetic rate and higher yield productivity under salt stress” [17]. “The reduction in chlorophyll contents is to be expected under stress; being membranous bound, its stability is dependent on membrane stability, which under saline condition seldom remains intact” [18]. From the present experiment it was clear that chlorophyll content of potato varieties were increased at the lower level of salinity (Fig. 3).The study was in agreement with the reports by Ashraf et al. [18], and Khan at al. [17] who reported that “chlorophyll contents under saline conditions are decreasing.The decrease is significant in sensitive genotypes in comparison to tolerant”.

3.2 Proline Accumulation

The outcome of our experiment showed that there is a positive relationship between proline accumulation and performance of potatoes under salinity stress. “Although the ability of potato plants to respond to salinity by active accumulation of proline does not always correlate with their salt tolerance, elevation of proline content under stress undoubtedly contributes to cell homeostasis. This is suggested by the fact that, under stress, proline not only acts as an osmoregulator (although it is very important under salinity) but also performs many other protective functions, such as duties of a chemical chaperone, antioxidant, regulator of expression of stress-regulated genes, and source of carbon, nitrogen and reducing equivalents, participates in regulation of intracellular pH-stat, etc” [19,20].

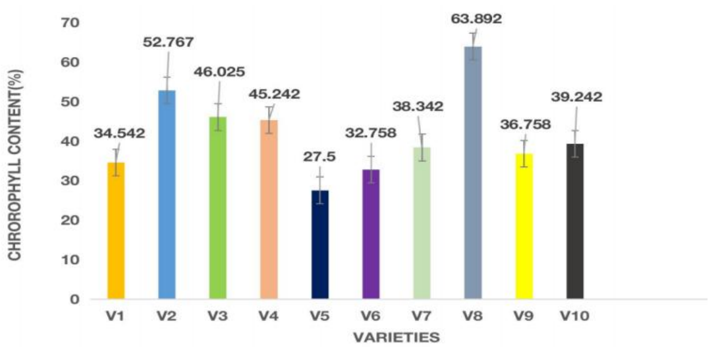

Fig. 2. Performances of varieties on chlorophyll content(%)

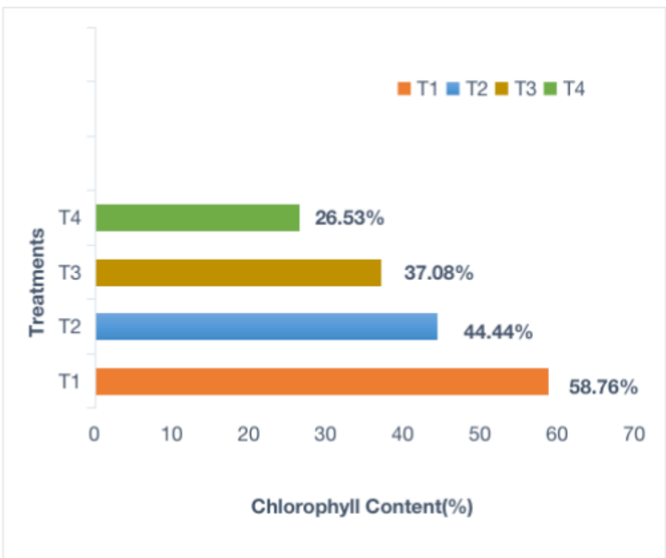

Fig. 3. Effects of salinity on chlorophyll content (%)

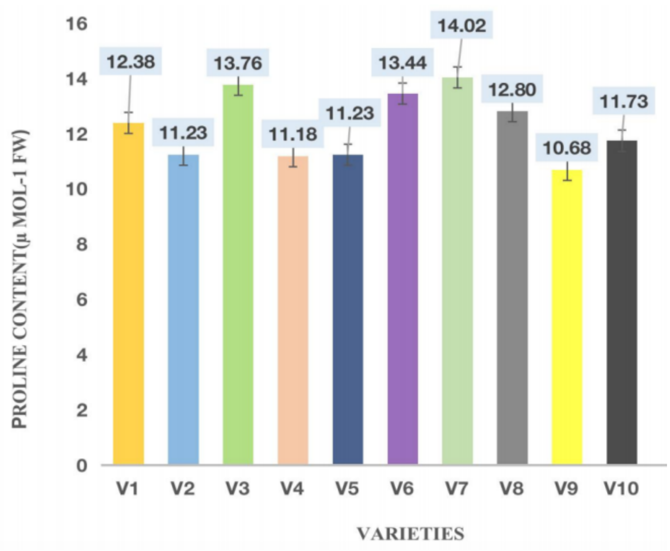

Fig. 4. Proline accumulation on potato varieties

In our experiment, the accumulation of proline was commonly observed in all varieties and treatments; however, the BARI Alu-28 ,V_7 (14.02 µmol-1FW) which was similar to BARI Alu-72,V_3 (13.76 µmol-1FW) (Fig. 4) and T_4 (21.63µ mol-1FW) had higher proline accumulation (Table 3) whereas the lowest value of proline content was found in T_1 (0.49µmol-1 FW) treatment. Similar observations were recorded by other workers [21] in different crops. Proline content showed statistically significant result with the interaction of variety and salinity treatments as well.

Table 3. Effects of treatments on proline accumulation (µmol-1FW)

Treatment	Proline content
T_1	0.494 d
T_2	10.513 c
T_3	16.353 b
T_4	21.637 a
CV(%)	6.72
LSD(0.05)	0.422

3.3 Na^+ Ion Content

Unlike halophytes, glycophytes may accumulate much sodium in the assimilating organs, and this is a sign of poor salt tolerance [22,23]. Statistically significant variation was found in experimented varieties of potato tuber in terms of Na^+ content (Fig. 5). The lowest Na^+ content (0.11%) was found in V_2 Variety (Pechar chokh) in where the highest Na+ content (0.20%) was found in BARI Alu-28 (V_7). "The low Na accumulation of V_1,V_2,V_8 and V_9 varieties were more tolerant than those which translocated maximum Na in leaves. It is found that Na is a toxic element whose higher concentration disturbs some of the metabolic activities" [24]. "The varieties which were successful in retaining the Na were tolerant" [25,24].

Reduction in osmotic potential of the cell contents occurring at salinity depends on plants ability to first of all uptake sodium and potassium ions from the nutrient medium [26]. The obtained results indicate that, in response to salinity, the content of sodium ions of potato plants rose at 0.26%) in T_4 salinity treatment while recorded 0.03 %) was observed under T_1 salinity treatment (Fig. 6). Potato grown under high salinity (8.90 dS/m) accumulated the highest level of Na^+ in their leaves and roots;so the growth of these plants was affected due to high concentration of Na^+ and low K^+ content [27,28] which was similar to our findings.

3.4 K^+ Ion Content

From the Fig. 7, it showed the statistically non-significant variation among ten potato varieties in terms of K^+ ion content. The highest value of K^+ content (0.20%) was reported in Lal shila i.e.,V_4 variety whereas the lowest value of K^+ content (0.08 %) was found in BARI Alu-53 (V_5) variety.In the present study all potato varieties showed decreasing trend in K content due to salinity stress. The highest (0.20%) value of K+ ion was reported in T_1 and the lowest value (0.05%) was found in T_4 treatment (Fig. 7). This statement was supported by several authors experiments.The decrease in K was happened because of the presence of excessive Na in the growth medium because high external Na content is known to have an antagonistic effect on K uptake in plant [29]. It is also reported that salt tolerance is associated with K contents [30], because of its involvement in osmotic regulation and competition with Na ion [18].

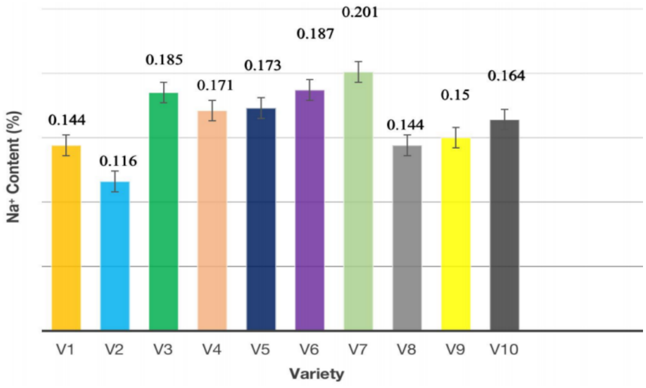

Fig. 5. Concentration of Sodium ion (%) on potato varieties under saline conditions

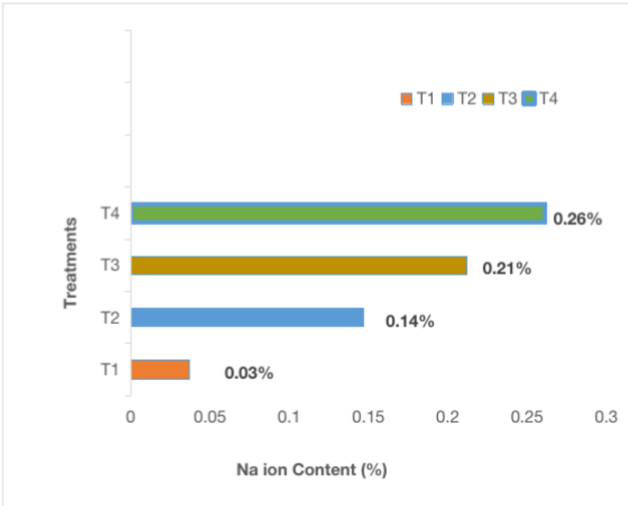

Fig. 6. Effects of salinity on Na^+ Ion content (%)

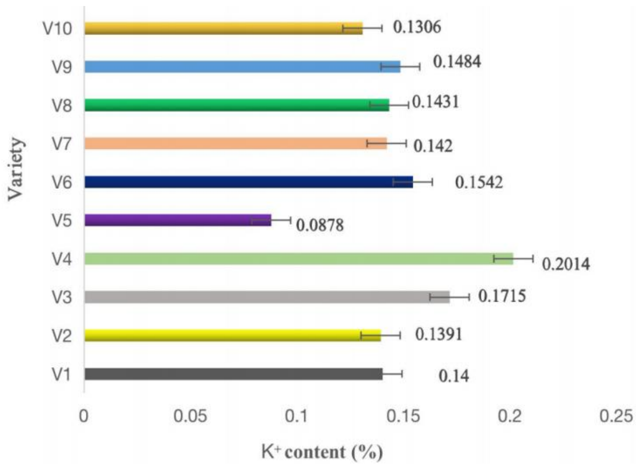

Fig. 7. Potassium (K^+) ion content on (%) the potato varieties under salinity

4. CONCLUSION

From the outcome of this experiment, it has been found that BARI Alu-72 (V_3) performed well under T_2 i.e., 5 dS/m salinity level and T_3 (10 dS/m) level because better yield were obtained from these varieties. So BARI Alu-72 (V_3) variety is recommended for mild to moderate saline prone area in Bangladesh. Thus, the varieties of potato, exposed to salinity showed a strong inhibition of a decrease in the content of K^+ ion, and increase of Na+ ion content. At the same time, under mild and moderate salt stress, the cultivars actively accumulated proline that possesses stress protective properties, and showed hardly any signs of oxidative stress, which points to the operation of important stress-induced mechanisms.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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