Trehalose Treatment Alleviates Salt Toxicity in Wheat Seedlings: A benificial research attempt in agriculture sector of Pakistan

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Abstract

Osmoprotectants are small organic molecules that are synthesized and accumulate in plants which not only enhance growth parameters but also protect plants from damaging effects of abiotic stresses such as drought, heat, salt and metal toxicity. The most damaging being salinity stress, affecting every stage of wheat plant development. In the present study, the effect of an osmoprotectant compound commonly known as trehalose (Tre) on growth parameters of ten Pakistani wheat varieties (NIA Amber-10, Bhatoor, Bhittai, Borloug-16, DN-11, DN-84, Punjab-11, TJ-83, Zamindar-04and Zincol-16) were assessed. Their 7 days old seedlings were subjected to Tre (10 and 50mM) with and without (150 mM) NaCl for five days were investigated. In the NaCl treated group, a reduction in all four growth parameters i.e. root length (cm), shoot length (cm), fresh weight (g) and dry weight (g) were evident. However, Tre alone at 10 and 50 mM enhanced the growth of wheat cultivars. Furthermore, a combination of NaCl and Tre (10 and 50 mM) alleviated the harmful effects of NaCl by enhancing growth of all aforementioned parameters. Results of the present study led us to conclude that Tre act as an osmoprotective agent in wheat seedlings by reducing the damage caused by salinity.Thus, practical implications of such molecules cannot be undermined which may facilitate the growth of such cash crops also that will promote a global cultivation map for medicinal plants under such challenging or hostile salt affected areas thereby positively affecting the economic revenues in agriculture sector.

Keywords:

Wheat, Osmoprotectant, Trehalose, Salt stress.

1. INTRODUCTION

Around the globe, bread wheat (*Triticum aestivum L.*) is the leading grown food cereal, owing a wider adaptability as well as quality of nutritive values than other cereals. Equally in terms of production and land it also stands first. In the third world countries, it also serves as a strategic crop and has a substantial role on the national economy (Yadav *et al*., 2018). While, to meet the food security of increasing population its demand is increasing (Jahan *et al.*, 2019). At the same time several abiotic stresses such as heat, drought and salinity influence the productivity of wheat across the globe and among them the most important is soil salinity, particularly in arid and semi-arid regions (Out *et al.*, 2018). The primary environmental difficulties that negatively influence the development and growth of plants by altering the physio-biochemical process is soil salinity (Allakhverdiev *et al.*, 2000). Due to which 60% crop productivity is globally lost (Xie *et al*., 2016). Nearly 20% of the total cultivated land across the world is affected by salt stress Oproi and Madosa (2014).

It is well-established that under salt stress, owing to higher osmotic stress uptake of high concentrations of soluble salts limits the water uptake through the roots system. Consequently, membrane stability changes because of limited water uptake in plant cells that influences the turgor pressure (Sairam *et al*., 2002), as the uptake of essential nutrients is limited, high concentration of ions is absorbed by plant cells causing nutrient deficiency (Goudarzi and Pakniyat, 2008). Exposure of 2, 4, 6 and 8 ds m^{-1} salinity decreased the number of foliages, root growth and dry matter in *Aloe vera*. The reduced levels of total soluble solids (TSS) is the main limiting factor for these damages. When compared to the control this resulted in lower sprout production (30%) under salt stressed plants (Moghbeli *et al*., 2012).

In terms of cash crops, an attractive and economical approach is development of salt tolerant wheat varieties to enhance wheat production under saline areas. However, modern genomics technologies are required for discovery of salt tolerant genes and their precise mobilization into salt sensitive wheat varieties that are agronomically superior (Moose and Mumm, 2008). During osmotic and ionic stress osmoprotectant compounds play a vital role as membrane stabilizer with capabilities of protecting cell membrane, organelles and enzymes that are sensitive to dehydration and ionic damage (Sairam and Tyagi, 2004). They are a group of organic molecules also known as compatible osmolytes or compatible solutes, that have no charge, polar and have soluble nature (Fang and Xiang, 2015). These organic osmolytes are synthesized and accumulates in plants that protects them from salinity-induced damages and osmotic stress. Many efforts were made to use osmoprotectant compounds as a pre-sowing seed treatment or exogenous application as foliar treatment on plants at different growth stages to improve salinity tolerance of different crops. These compounds include proline, glycine betaine, or trehalose (Dawood and Sadak, 2014). One of these compounds trehalose, is a non-reducing disaccharide of glucose (Fig. 1) which plays an important role as a stress protectant in aquatic plants. Additionally, an energy source, protect biological structures from damage during desiccation, the unique physicochemical properties efficiently stabilize dehydrated enzymes, proteins and lipid membranes (Fernandez *et al.*, 2010).

Trehalose being a signaling and antioxidant molecule has the added advantage. During detoxification and stress response it also acts as stress responsive element of genes (Bae *et al.*, 2005). However, to ameliorate stress induced adverse effects in most plants Tre production is not sufficient. On the other hand, external Tre application has been suggested as an alternative approach to induce stress tolerance that increases the internal level of this osmolyte (Chen and Murata, 2002). Different abiotic stresses including heat, water deficit, and salinity in wheat and drought in maize were alleviated by its exogenously application of Tre (Ali and Ashraf, 2011). It is an osmoprotectant that can enhance salinity stress tolerance of wheat plant through increasing some osmoprotectant compounds such as glucose, trehalose, proline, and free amino acids (Sadak, 2019). Therefore, the aim of the present study was to investigate the effects of exogenous application of Tre on different growth parameters such as root and shoot lengths and fresh and dry weights of different wheat cultivars with particular focus on their use for future wheat breeding programs.

2. MATERIALS AND METHODS

2.1. *Screening of Wheat Genotypes at Seedling Stage*

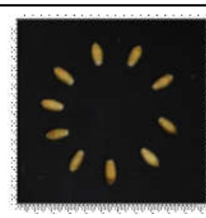
The experiment was carried out *in vitro* (petri dishes) at Department of Genetics, University of Karachi, Pakistan.

2.2. *Germplasm Collection*

Ten wheat varieties namely NIA Amber-10, Bhatoor, Bhittai, Borloug-16, DN-11, DN-84, Punjab-11, TJ-83, Zamindar-04 and Zincol-16 were collected from different provinces of Pakistan (Table 1).

Table 1. Sources of wheat germplasm from different provinces of Pakistan

S.No	Genotypes	Sources of Germplasm
1	NIA Amber-10	 Sindh
2	Bhatoor	 Sindh

3	Bhittai	 Sindh
4	Borloug-16	 NARC Islamabad
5	DN-11	 KPK
6	DN-84	 KPK
7	Punjab-11	 Punjab

8	TJ-83	 Sindh
9	Zamindar-04	 Balochistan
10	Zincol-16	 NARC Islamabad

2.3. *In vitro Experiment*

An experiment was conducted with completely randomized design (Three replications of each treatment) Control (dH_2O), Saline conditions (150mM NaCl) treated group (10 and 50mM) with Tre. Seeds from different wheat varieties were treated with sodium hypochlorite solution (1%) for 1h followed by repeat washing with distilled water. Seeds were germinated under normal condition for 7days at room temperature (15-20°C). Seven days old seedlings were subjected to Tretreatment (10 and 50mM) without and with NaCl (150mM) for consecutive five days. After twelve days old seedlings were harvested after stress period, root and shoot lengths and fresh weight were recorded. After drying all the seedlings using incubator (55°C) for 48 hours, dry weight was also noted.

2.4. *Statistical Analysis*

The data was analyzed by using the analysis of variance (ANOVA);genotypes and treatments were considered as fixed factors and replications as random factor. ANOVA was performed by Duncan's multiple range test (DMRT) for mean comparison using the statistical software SPSS version 16.

3. RESULTS AND DISCUSSION

Control (dH_2O), Saline conditions (150 mM NaCl) and treated group (10 and 50mM) with

Tre data was collected for root and shoot length of wheat seedlings also for fresh and dry weight from ten genotypes performed to statistical analysis i.e.(ANOVA). Mean squares revealed that main effect (genotypes and treatments) and their interaction was significant for root length, shoot length, fresh weight and dry weight (Table 2). Data was subjected to Duncan's multiple range test (DMRT) to evaluate significance of mean comparisons (Table 3).

Table 2. Mean squares for root, shoot length (cm), fresh and dry weight (g) of wheat genotypes under Control, NaCl and Tre treatments.

Sources of Variance	d.f	Root length (cm)	Shoot length (cm)	Fresh weight (g)	Dry weight (g)
Genotypes (G)	9	28.059^{***}	42.156^{***}	0.834^{***}	0.011^{***}
Treatments (T)	5	112.357^{***}	77.365^{***}	5.474^{***}	0.296^{***}
G×T	45	5.057^{***}	1.735^{***}	0.221^{***}	0.004^{***}

Note: d.f: degrees of freedom; *P< 0.05 level; **P < 0.01 level; ***P < 0.001 level

3.1 a) Root and shoot length of wheat seedlings

Salt stress caused a significant amount of reduction in shoot with a range of 5-39% and root length 6-52% of all wheat cultivars. Application of Tre as a foliar spray caused a significant increase in shoot (91%) and root length (13%) under non-saline conditions when compared to control group with means 14.3 and 12.8 cm respectively. Exogenous application of Tre appeared to be effective in increasing the shoot and root length of all cultivars with a range 8-34% and 6-33% under saline conditions. However, the maximum promotion was observed at 50 mM Tre compared to 10 mM (Fig. 2). Under saline condition exogenous Tre alleviated the adverse effect of NaCl by enhancing growth of shoot and root of wheat seedlings when compared to salt alone (Fig.3).

Table 3a: Mean comparisons for root length (cm) in wheat genotypes under Control, NaCl and Tre treatments

Genotypes	Control	T1	T2	T3	T4	T5
NIA Amber-10	10^{cd}±0.45	9.3^{a}±0.17	11.1^{bc}±0.35	11.7^{g}±0.17	10.5^{a}±0.32	11.5^{bc}±0.26
Bhatoor	12.1^{b}±0.03	9^{d}±0.09	11.2^{bc}±0.12	13.2^{de}±0.45	10^{a}±0.03	12^{a}±0.03
Bhittai	10.4^{c}±0.46	9.6^{a}±0.30	11.8^{b}±0.15	12.2^{fg}±0.31	10.6^{a}±0.31	11.2^{bc}±0.34
Borloug-16	13.4^{a}±0.30	8.5^{b}±0.29	11.1^{bc}±0.20	14.6^{c}±0.28	8.6^{b}±0.31	9.1^{c}±0.18
DN-11	10.6^{c}±0.30	9.5^{a}±0.29	11.6^{b}±0.22	16.8^{b}±0.15	10.2^{a}±0.44	11.6^{bc}±0.35
DN-84	8.8^{de}±0.18	7.1^{c}±0.23	9.3^{d}±0.15	12.6^{ef}±0.21	7.3^{c}±0.15	7.8^{d}±0.22
Punjab-11	13.3^{a}±0.44	9.1^{bc}±0.06	10.5^{c}±0.29	14.5^{c}±0.29	10.1^{a}±0.24	10.8^{b}±0.12
TJ-83	14.2^{a}±0.67	9.5^{a}±0.29	16.6^{a}±0.30	18.6^{a}±0.21	10.6^{a}±0.30	11.6^{bc}±0.30
Zamindar-04	11.0^{bc}±0.59	9.6^{a}±0.22	11.1^{bc}±0.06	15.0^{c}±0.50	10.4^{a}±0.32	11.2^{b}±0.27
Zincol-16	8.1^{e}±0.30	8.5^{b}±0.29	11.2^{bc}±0.44	13.6^{d}±0.24	8.0^{bc}±0.03	8.2^{d}±0.03
Average	**11.19**	**8.97**	**11.54**	**14.26**	**9.62**	**10.49**

3.1 b) ***Fresh and dry weight of wheat seedlings***

Wheat seedlings were supplemented with Tre increased fresh and dry weight (13% and 85%) when compared to control seedlings with values of mean 2.35 and 0.49g, respectively. Supplementation with Tre (50 mM) markedly increased fresh and dry weight as compared to 10 mM which caused a slight increase in fresh weight. Salt stress caused a significant reduction in shoot, fresh and dry weights with a range of 4-46% and 13-26% of all ten cultivars. Under salt stress, exogenous Tre promoted growth of wheat varieties with a range of 2-27% and 12-14% as compared to stress alone. Fresh and dry weight of seedlings supplied with 50 mM Tre increased significantly, as compared to salt-stressed seedlings without osmoprotectant. Tre 10 (mM) demonstrated a slight increase in fresh and dry weight presented in Fig.4.

Table 3b. Mean comparisons for shoot length (cm) in wheat genotypes under Control, NaCl and Tre treatments.

Genotypes	Control	T1	T2	T3	T4	T5
NIA Amber-10	10^{e}±0.25	9.5^{c}±0.29	11.1^{e}±0.43	11.5^{e}±0.25	9.8^{c}±0.06	9.5^{d}±0.09
Bhatoor	12.5^{c}±0.09	8.5^{d}±0.23	12.6^{c}±0.07	13^{d}±0.06	8.8^{d}±0.25	9.5^{d}±0.38
Bhittai	14.3^{a}±0.12	10.7^{a}±0.15	15.1^{a}±0.66	15.2^{b}±0.28	11.4^{a}±0.36	12.2^{a}±0.23
Borloug-16	10.1^{e}±0.06	7.0^{d}±0.20	11.6^{de}±0.09	12.5^{d}±0.29	7.5^{e}±0.50	9.4^{d}±0.47
DN-11	10^{e}±0.12	8.6^{c}±0.20	10^{f}±0.15	10.6^{e}±0.09	8.9^{cd}±0.32	9.9^{cd}±0.46
DN-84	10^{c}±0.12	9^{bc}±0.06	12.2^{cd}±0.15	12.9^{d}±0.39	10.3^{b}±0.25	10.7^{bc}±0.15
Punjab-11	12.1^{c}±0.19	8.7^{c}±0.15	13.7^{c}±0.18	14^{c}±0.09	9.4^{c}±0.38	9.5^{d}±0.12
TJ-83	11.5^{d}±0.18	9.6^{c}±0.23	12.5^{c}±0.21	13^{d}±0.30	10.4^{b}±0.40	11^{b}±0.06
Zamindar-04	14.1^{b}±0.05	10.5^{b}±0.29	14.6^{b}±0.09	16.1^{a}±0.58	11.4^{a}±0.32	12.5^{a}±0.17
Zincol-16	8.2^{f}±0.24	7.3^{d}±0.14	9.0^{g}±0.10	9.7^{f}±0.09	7.6^{e}±0.55	8.4±^{e}0.20
Average	**11.58**	**8.96**	**12.27**	**12.86**	**9.52**	**10.28**

Table 3c. Mean comparison for fresh weight (g) in wheat genotypes under Control, NaCl and Tre treatments

Genotypes	Control	T1	T2	T3	T4	T5
NIA Amber-10	1.33^{d}±0.05	1.27^{d}±0.01	1.40^{d}±0.03	2.24^{d}±0.09	1.30^{d}±0.01	1.34^{b}±0.03
Bhatoor	1.40^{d}±0.01	0.82^{f}±0.01	1.29^{e}±0.03	1.61^{f}±0.06	0.90^{d}±0.05	1.05^{d}±0.03
Bhittai	1.40^{b}±0.03	1.24^{d}±0.02	2.37^{a}±0.03	2.84^{b}±0.08	1.34^{d}±0.04	1.41^{b}±0.03
Borloug-16	1.57^{c}±0.00	1.34^{bc}±0.01	1.62^{c}±0.03	2.36^{d}±0.08	1.36^{d}±0.02	1.41^{b}±0.03

DN-11	$1.60^{bc}\pm0.03$	$0.86^{f}\pm0.02$	$1.22^{e}\pm0.05$	$1.33^{g}\pm0.05$	$0.91^{d}\pm0.02$	$1.02^{d}\pm0.04$
DN-84	$1.66^{abc}\pm0.03$	$1.29^{cd}\pm0.01$	$1.57^{c}\pm0.04$	$2.80^{b}\pm0.04$	$1.34^{d}\pm0.01$	$1.37^{b}\pm0.03$
Punjab-11	$1.72^{ab}\pm0.04$	$1.36^{b}\pm0.02$	$1.41^{d}\pm0.04$	$2.29^{d}\pm0.03$	$1.42^{d}\pm0.07$	$1.39^{b}\pm0.01$
TJ-83	$1.64^{abc}\pm0.03$	$1.13^{e}\pm0.03$	$1.76^{b}\pm0.03$	$2.66^{c}\pm0.10$	$1.14^{c}\pm0.03$	$1.24^{c}\pm0.03$
Zamindar-04	$1.75^{a}\pm0.07$	$1.11^{e}\pm0.00$	$1.80^{b}\pm0.03$	$3.34^{a}\pm0.02$	$1.15^{c}\pm0.03$	$1.25^{c}\pm0.03$
Zincol-16	$1.58^{c}\pm0.00$	$1.41^{a}\pm0.03$	$1.49^{d}\pm0.01$	$2.05^{e}\pm0.01$	$1.70^{a}\pm0.04$	$1.84^{a}\pm0.04$
Average	**1.56**	**1.19**	**1.59**	**2.35**	**1.26**	**1.33**

Table 3d: Mean comparison for dry weight (g) of wheat genotypes under Control, NaCl and Tre treatments

Genotypes	Control	T1	T2	T3	T4	T5
NIA Amber-10	$0.29^{bc}\pm0.01$	$0.24^{a}\pm0.01$	$0.30^{c}\pm0.02$	$0.39^{d}\pm0.02$	$0.35^{bc}\pm0.00$	$0.41^{bc}\pm0.02$
Bhatoor	$0.23^{f}\pm0.01$	$0.20^{de}\pm0.01$	$0.34^{bc}\pm0.01$	$0.48^{bc}\pm0.02$	$0.32^{c}\pm0.00$	$0.40^{bc}\pm0.01$
Bhittai	$0.25^{de}\pm0.01$	$0.22^{cd}\pm0.01$	$0.43^{ab}\pm0.01$	$0.57^{a}\pm0.02$	$0.41^{ab}\pm0.01$	$0.49^{a}\pm0.02$
Borloug-16	$0.33^{a}\pm0.01$	$0.24^{a}\pm0.01$	$0.35^{bc}\pm0.02$	$0.47^{bc}\pm0.02$	$0.36^{ab}\pm0.00$	$0.41^{bc}\pm0.03$
DN-11	$0.24^{ef}\pm0.01$	$0.18^{e}\pm0.00$	$0.39^{abc}\pm0.01$	$0.52^{ab}\pm0.02$	$0.41^{a}\pm0.01$	$0.45^{abc}\pm0.02$
DN-84	$0.26^{de}\pm0.01$	$0.18^{e}\pm0.00$	$0.34^{bc}\pm0.03$	$0.44^{cd}\pm0.02$	$0.34^{bc}\pm0.01$	$0.41^{bc}\pm0.02$
Punjab-11	$0.25^{de}\pm0.01$	$0.20^{cd}\pm0.01$	$0.31^{c}\pm0.01$	$0.56^{a}\pm0.02$	$0.36^{bc}\pm0.00$	$0.45^{abc}\pm0.02$
TJ-83	$0.24^{f}\pm0.01$	$0.21^{cd}\pm0.00$	$0.37^{abc}\pm0.02$	$0.43^{cd}\pm0.02$	$0.33^{c}\pm0.01$	$0.39^{bc}\pm0.02$

Zamindar-04	$0.30^{ab}\pm0.01$	$0.24^{ab}\pm0.01$	$0.36^{abc}\pm0.05$	$0.49^{bc}\pm0.02$	$0.33^{c}\pm0.00$	$0.38^{c}\pm0.04$
Zincol-16	$0.27^{cd}\pm0.01$	$0.22^{bc}\pm0.01$	$0.46^{a}\pm0.02$	$0.51^{ab}\pm0.02$	$0.42^{a}\pm0.01$	$0.46^{ab}\pm0.03$
Average	**0.27**	**0.21**	**0.38**	**0.49**	**0.36**	**0.42**

Wheat genetically consists of 2n = 6x = 42 chromosomes composed of three distinctive genomes A, B and D namely allohexaploid (AABBDD). Each genome has 7 pairs of chromosomes (1-7A, 1-7B and 1-7D) (Shaista *et al*., 2010). For global food security it constitutes one of the most pivotal cereal crops(Chairi *et al*., 2020). It is one of the principal sources of calories and protein. The world's 82-85 percent population mainly rely wheat crop (Caverzan *et al*., 2016). It also serves as a mainfood component for the population of Pakistan (Zafar *et al*., 2015) and ranked 2^{nd} after maize (Zeb *et al*., 2009).According to a Global Agricultural Information Network report from the US Department of Agriculture (USDA) the current year's wheat production forecast in Pakistan is 25.5 million tonnes, a 1.2-million-tonne increase over the previous year. Pakistan procured 6.5 million tonnes of wheat from this year's harvest, about 80% of its goal. Salinity or sodicity affects more than 6 percent of the world's land (Priyanka and Arun, 2015). An estimated value affected by salinity in irrigated areas of Pakistan is 20% (Asian Water Development Outlook, 2013). As a result, plant growth and development are adversely affected by salt stress (Li *et al*., 2011; Mahmood *et al*., 2012).

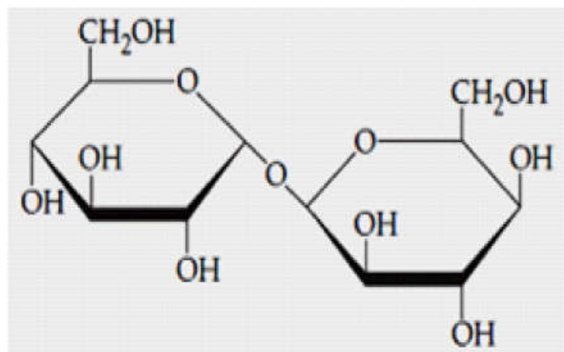


Fig.1: Trehalose, a disaccharide consisting of two glucose units linked by α-(1'!1) glycosidic bond.

In plant's life cycle, seedling has been considered as the most vulnerable stage. In *Thymus maroccanus* (an antibacterial plant) salinity caused a significant reduction in the seedling growth by suspending cell division, inhibiting reserve food mobilization, enlarging and injuring hypocotyls. Similar results were noticeable for *basil, chamomile* and *marjoram* (Said-Al Ahl and Omer, 2011). Our study demonstrated that seedling growth under stress condition with 150 mM NaCl was drastically inhibited. During the experimental period salt stress induced a significant variation in plant growth conditions. All wheat varieties showed considerable reductions in all studied growth parameters. Statistical analysis stated that varieties, treatments and their interaction were significant at $P < 0.001$ level for all the growth parameters such as Root, shoot, fresh and dry weight. Under stress condition, Zamindar-04 showed maximum root length (9.6 cm) (Fig. 2a) where as DN-84 had minimum root length (7.1 cm). In Bhittai maximum shoot length (10.7 cm) (Fig. 2b) while Zincol-16 showed minimum shoot length (7.3 cm).The overall reduction in root length was 18.0%and shoot length was 21% conûrmed the negative effect of NaCl treatments on plant growth at early seedling stage. Similar results were obtained for fresh (24%) and dry weight (20%). When compared with control group these parameters were highly affected by salt stress with greater amount of reduction. Decrease in root and shoot development is due to the higher level of NaCl toxic effects as well as unbalanced nutrient uptake by seedlings. Under high salt stress condition initially inhibition of the root and shoot elongation occurs which further slowing down the water uptake for overall osmotic adjustments of the plant structure making it difficult for further plant to grow and develop. The reduction of these growth parameters was reported previously (Singh *et al*.,1994) that salt stress reduces dry matter accumulation, leaf area and photosynthetic ability. Salt effect mainly makes plant growth processes sensitive, thus biomass production and growth rates provide reliable criteria for assessing the degree of salt stress and the ability of a plant to survive (Amor *et al*.,2005).

a) Bhittai

C T1 T2 T3 T4 T5

b) Zamindar-04

C T1 T2 T3 T4 T5

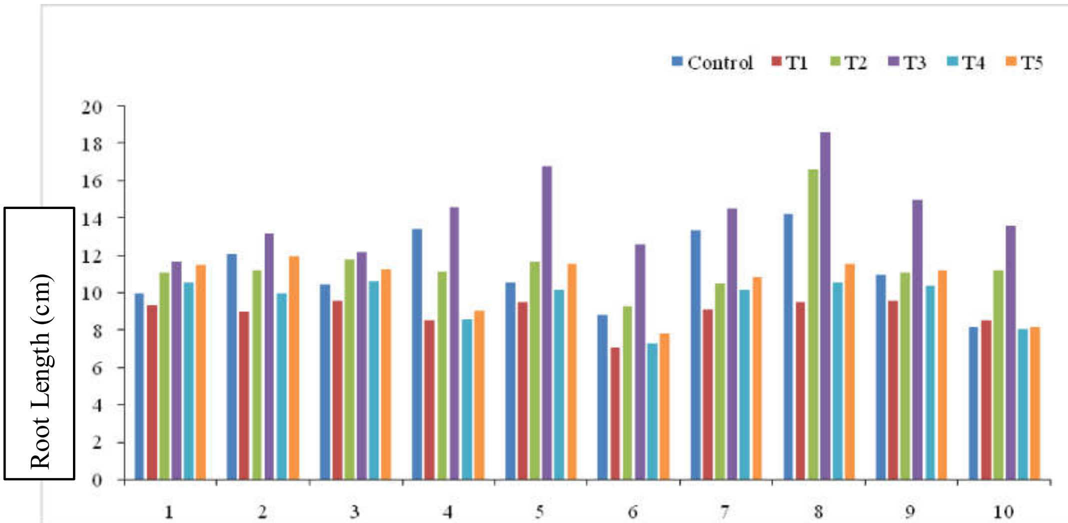
Fig.2: The effect of sodium chloride and trehalose on wheat varieties at seedling stage.

Control (C) and treatments: Sodium chloride (T1,150 mM), Trehalose (T2, 10mM and T3, 50mM), T1 + T2 (T4) and T1 + T3 (T5).
The scale on the right hand was used to measure the shoot and root lengths (cm).

Under normal condition addition of Tre to promote seedling growth of wheat cultivars as compared to control group. Tre treatment alone played a significant role in improved growth condition.All ten wheat cultivars performed adequately at both concentrations of Tre (10 and 50mM) which predominantly enhanced the overall growth conditions. In foliar application of Tre Zamindar-04 and Bhittai showed maximum shoot length (15.1 cmand 14.6 cm) (Fig. 4a and b). Maximum root length was observed in TJ-83 (18. 6 cm) and minimum NIA Amber-10 (11.7 cm). The Tre at 50 mM was more beneficial to improve the length and weight of root and shoot with overall promotion 92%, 13%, 51% and 85% respectively.

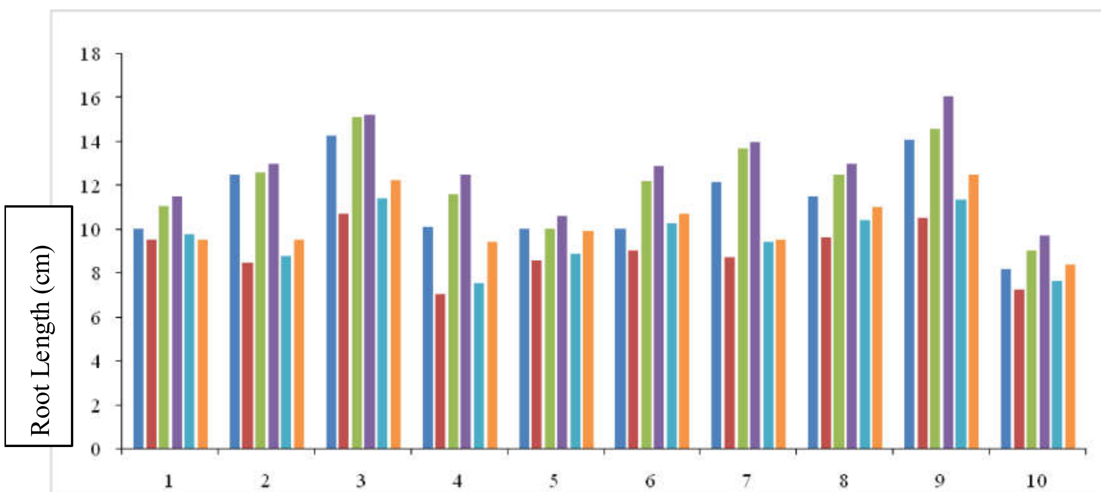
These results were similar with earlier report that Tre applied exogenously mainly protects plants from desiccation by water recovery, maintains enzymes level, proteins and lipid membranes from aggregation also causes the changes in the metabolism of sugar. Zeid (2009) mentioned the effect of Tre in maize. According to his observation before exposure to salt treatment exogenous accumulation of Tre was able to improve growth of salt-stressed and unstressed maize plants. Furthermore, under stress condition exogenous supply of Tre dramatically supply of Tre dramatically reversed the negative effects of salt and significantly improved the overall growth of the wheat seedlings. Combined effect of Tre and NaCl, Zamindar-04 demonstrated maximum shoot length (12.5 cm) whereas Zincol-16 showed minimum length (8.4 cm). Maximum root length was noticed in Bhatoor (12 cm) and minimum in DN-84 (7.8 cm).

a) Root length (cm)



Wheat genotypes (cm)

a) Shoot length (cm)

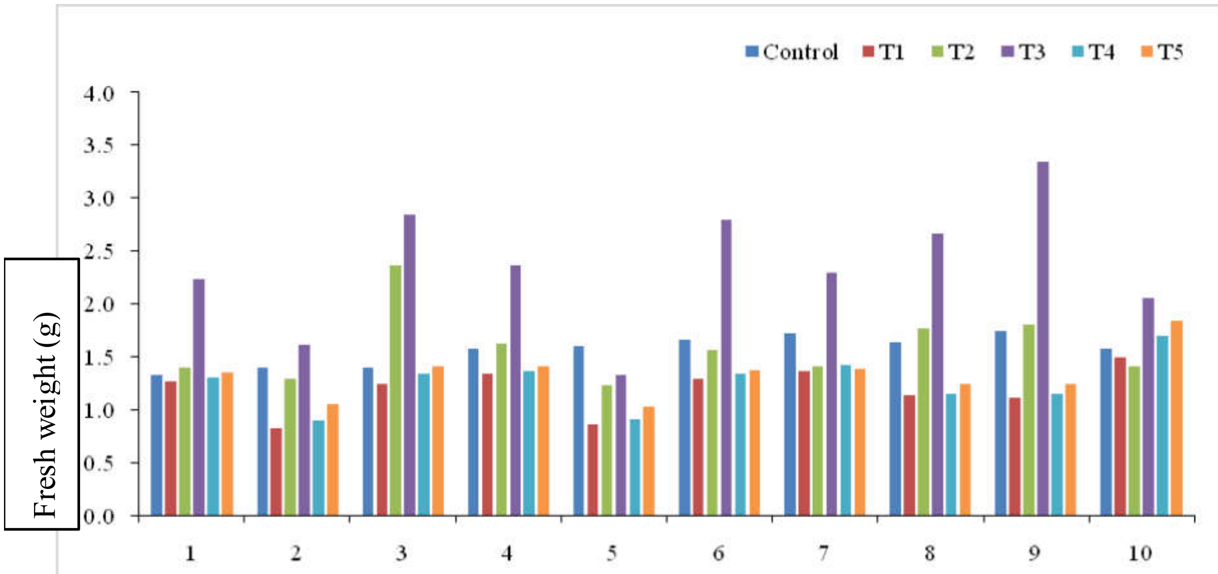


Wheat genotypes (cm)

Fig. 3: Root and shoot length of wheat seedling of various wheat genotypes.

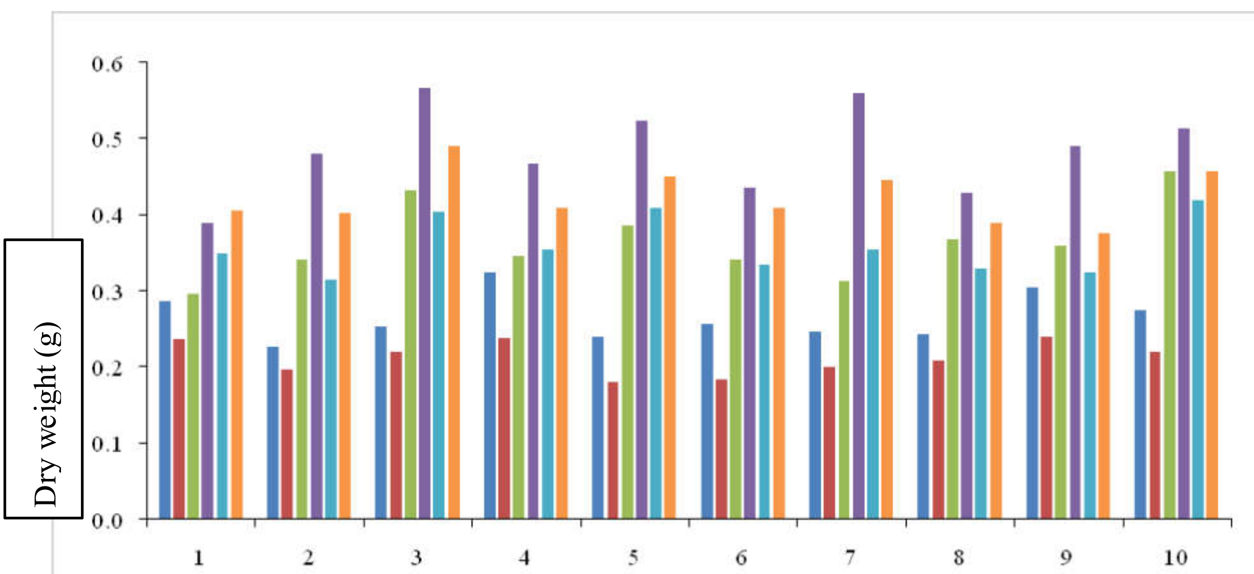
(1) NIA Amber-10,(2) Bhatoor, (3) Bhittai, (4) Borloug-16, (5) DN-11, (6)DN-84,(7) Punjab-11, (8) TJ-83, (9) Zamindar-04, (10) Zincol-16.Control (C) and treatments: Sodium chloride (T1,150 mM), Trehalose (T2, 10mM and T3 50mM), T1 + T2 (T4) and T1 + T3 (T5).

a) Fresh weight (g)



Wheat genotype

b) Dry weight (g)



Wheat genotype

Fig. 4: Fresh and dry weights of wheat seedling of various wheat genotypes

The adverse effect of salt stress was alleviated significantly by foliar-applied trehalose resulting increase in seedling root length up to 17% and shoot length15% fresh weight and dry weight12% and 13% atTre 50 mM. These results were similar to the previously report (Shahbaz *et al*.,2016) where shoot length and dry weight were enhanced by foliar-applied trehalose in rice. It was also confirmed that Tre is applied exogenously plants are better condition to recover from stress. (Djilianov *et al*.,2005). It was also suggested that Tre accumulation influences the alteration of sugar metabolism leading to an osmoprotectant effect under stress condition. During high levels of salt accumulation and drought condition Tre could be used as a stress reducing approach as it promotes plant growth (Mosquera *et al*., 2019).

4. CONCLUSION

Under saline medium, the growth rate of all wheat cultivars was significantly affected. However, foliar-applied Trehalose a protective role under saline conditions. Furthermore, Tre alone provided substantial attributes to growth parameters such as root length (cm), shoot length (cm), fresh weight (g) and dry weight (g). Moreover, this appears to be promising strategy for breeders to use this osmoprotectant as a beneficial source to reduce stress in plants to screen best yielded salt tolerant varieties at early stages with positive impact Tre. Positive aspect of this research will also impact on revenue generation in agriculture practice of this common food ceral. However further investigations on other stress parameters such as heat, drought and metal toxicity of different crops needs to be included in future breeding programs.

Conflict of interest

The is no conflict of interest

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