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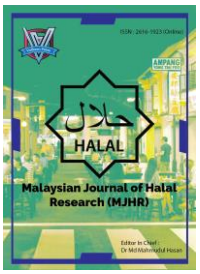

SALT TOLERANCE OF CHILI GENOTYPES DURING GERMINATION AND SEEDLING GROWTH

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ABSTRACT

Salinity is one of the major deleterious environmental problems that lead to a colossal deterioration of agricultural land and productivity globally. Due to lack of salinity tolerant varieties, farmers cultivate indigenous cultivars of chili consequences reduced yield. Therefore, the present research was performed to observe the effect of different levels of salinity on germination and growth at early seedling stage of chili plant. Hence, the effect of six different concentrations of NaCl (sodium chloride) (0, 50, 100, 150, 200 and 250 mM) on germination and seedling growth of seventeen chili genotypes was investigated. This experiment was performed in Petri dish lined with a layer of cotton consisting 10 ml of each test solution. Our results revealed that all investigated traits were impaired by salt stress and significantly affected the germination parameters, shoot and root length. Among the all investigated chili genotypes, Bogura (Local) and PARTEX PS-1711 were grown well up to 100 mM (NaCl) concentration and found to be the most tolerant genotype or variety to salt stress.

KEYWORDS

Chili Genotypes, Germination, Seedling growth and Salt tolerance.

1. INTRODUCTION

Salt stress is one of the most detrimental environmental factors involves in subsiding the productivity of crop plant, suppress a major environmental threat to agriculture and its repugnant impacts are getting more exaggerated in regions where saline water is used for irrigation. [1, 2]. It is one of the major abiotic stresses occupying approximately 800 million ha of land affected by high salt concentrations throughout the world [3]. Therefore, sustainable salinization of arable land is increasing dauntingly; thus decreasing the yield from formerly productive soil throughout the world. In Bangladesh, there are approximately 2.85 million ha of coastal land of which about one million ha are remarkably affected by varying degrees of salinity [4]. Investigation which endeavored at the effect of salt stress on growth transpired that there has been a outright connection between the decrease in plant length and the increase in the concentration of NaCl [5]. About 30-50% of net cropped areas in the coastal region of Bangladesh remains fallow in Rabi season, mainly due to soil and water (irrigation) salinity. The predominant salinity intrusion due to climate change has been dreadfully affecting the crop productivity in the saline regions of Bangladesh [6]. This situation demands an expeditious response to elevate the crop productivity. Introduction of chili genotypes; a high value spice crop, in the coastal saline soils could be most advantageous approach to improve food production as well as income of the farmers. In this regards, many other comprehensive studies have also pointed out that the fresh and dry weights of the shoot system and leaf number are affected with the unpredictability in salinity concentration, type of salt present, or type of plant species [7,8].

Chili (*Capsicum frutescens L.*) is a glycophyte plant which can't survive under high salt stress and produce affected yields. Seed germination is a ultimate factor limiting the establishment of plants under saline conditions [9]. Thus, salinity has been found one of the most crucial factors limiting plant growth and delaying seed germination as well as final germination percentage [10]. Salt stress can affect germination and seedling growth either by creating an osmotic pressure that prevents water uptake or by the toxic effects of sodium and chloride ions [11]. It generates low water potential in soil which vacillate the water and nutrients acquiring for the plants [12]. So, it is very important to know what extent of salinity a chili variety can tolerate at germination and early growth stage. Therefore; the present study was performed to evaluate the effect of different NaCl concentration treatments on germination and early

growth parameters in17 chili genotypes or variety in order to gain a better understanding of the reaction of young seedling to salt stress and to select tolerant genotypes or varieties.

2. METHODS AND MATERIALS

2.1 Experimental period and location

The experiment was conducted at the laboratory of the Department of Agricultural Botany, Patuakhali Science and Technology University, Dumki, Patuakhali during the period from March to July, 2016.

2.2 Study material

Seventeen genotypes of chili were collected from different location in Bangladesh and these genotypes are generally cultivated and abundant in Bangladesh.

2.3 Salt concentrations treatment formulation

Six different salinity concentrations were formulated in this experiment. Each concentration was considered as an experimental treatment and different salinity concentrations were obtained by dissolving required amount of crude salt (collected from seashore) in distilled water. Before weighing salts were oven dried to remove moisture. The control (0 mM NaCl/L) was maintained using distilled water only.

Table 1: Formulation of different salt concentration treatments

Treatment number	Salt concentrations
T_1	0 mM NaCl/L (Control)
T_2	50 mM NaCl/L
T_3	100 mM NaCl/L
T_4	150 mM NaCl/L
T_5	200 mM NaCl/L
T_6	250 mM NaCl/L

2.4 Experimental design

The experiment was performed in Petri dishes of 12 cm diameter and thin layer of cotton was set at the bottom of the Petri dishes where 25 seeds were placed on cotton bed in a circle pattern. 10 milliliter of treatment solutions of different salinity concentrations were poured in each Petri dish to immerse the seeds partially for assuring the proper aeration. Then 3 replications were maintained for each salinity concentration. The seeds were allowed to germinate at room temperature (25±2°C) and required amount of distilled water was added to each Petri dish every day to maintain same level of water as in initial date. Seeds were considered germinated when radicles measured 2 mm size. A 100w power bulb was fixed using a stand on the Petri dishes. This lighting enhances photosynthesis of young seedlings and helps for normal plant growth.
Partial view of the experiment is shown in plate 3.1. The experiment was designed following the completely randomized design (CRD).

2.5 Data collection

2.5.1 Percent germination

The number of seeds germinated was recorded starting from 2 days after sowing (DAS) to 17 DAS and the results obtained in each day were converted into percentage.

2.5.2 Shoot length

Shoot length was recorded at 5, 9, 13 and 17 DAS. 5 randomly selected plants from each treatment and replication were used for data recording and shoot length was measured from the base to the tip of the longest leaf of the plumule. The Mean was calculated using data obtained from five seedlings.

2.5.3 Root length

Root length data was recorded at 17 DAS. Roots were carefully separated from the cotton and measured from the base to the top of radicles from 5 randomly selected seedlings.

2.5.4 Shoot elongation rate

Shoot elongation rate was determined using the following equation:

$$\text{Shoot elongation rate} = \frac{\text{Number of days at that specific date}}{\text{Shoot length at specific date}}$$

2.5.5 Root and shoot weight

Five seedlings were randomly selected for each treatment and replication, roots and shoots were separated, and the fresh weights were determined immediately. The root and shoot samples were then oven-dried at 65^0C for a period until a constant weight was obtained. Then the dry weight (g) of root and shoot of five seedlings was recorded. Because of very small value in single seedling root and shoot fresh and dry weight is expressed as gram per 5 seedlings.

2.5.6 Vigor index

Vigor index (VI) was performed according to the following formula:

$$\text{VI} = \text{Germination\%} \times (\text{Root length in cm} + \text{Shoot length in cm})$$

2.5.7 Speed of germination

Speed of germination (SG %) was calculated by the following formula, as given by Ellis and Roberts (1981**)**.

$$\text{SG} = \frac{\text{Number of germinated seeds}}{\text{Days of first count}} \quad \frac{\text{Number of germinated seeds}}{\text{Days of final count}}$$

2.6 Statistical analysis

Data recorded on crop characters were subjected to statistical analysis through computer based statistical program Mstat-C (Michigan State University, East Lansing, MI, USA) following the basic principles outlined by Gomez and Gomez (1984). Significant effects of treatments were determined by analysis of variance (ANOVA) and treatment means were compared at 5% level of significance by Duncan's Multiple Range Test (DMRT). Microsoft excel package (Microsoft Corporation, Pullman, WA, USA) was used for correlation and regression analysis.

3. RESULTS

3.1 Effect of Variety

Genotypes had different response to the salinity. The traditional genotypes were sensitive to germination than the hybrid variety. At 5 DAS, the maximum germination (54.67%) was recorded from F1 hybrid hot pepper Angarika, while the lowest germination (23.78%) was recorded from Muladi (Table 1). At 9 DAS, significantly the highest germination (72.44%) was obtained from BRAC fire volcano and lowest (36.22%) germination was recorded from BARI-Chilli-1. Beyond 9 DAS, with the progress of time; the germination percentage increased very gradually. At 13th days of data recording it was observed that the germination percentage was the highest in the variety Supreme Sindu (78.22%) and minimum germination percentage was recorded in variety BARI-Chilli-1 (38.22%). After 13 DAS, with the advance of time, a few germination percentages increased. So it indicates that maximum seeds of chili germinate within 13 DAS. Among the genotypes, above 70 % germination of seed was found in Supreme sindu, Bogura (Local), GAVL pp-002, PARTEX PS-1711, BRAC fire volcano, Sonic chili F1, Hybrid Chili Lanka-1820, Amtoli (Local) and F1 hybrid hot pepper Sun drop that are statistically similar while remaining genotypes gave above 60% germination except Pirojpur (55.33%) and BARI-Chilli-1 (38.44%). The hybrid variety Sonic chili F1 had a higher germination speed (28.18) that was statistically similar with F1 hybrid hot pepper Sun drop, F1 hybrid hot pepper Angarika, Supreme sindu, GAVL pp-002, PARTEX PS-1711, BRAC

fire volcano, Hybrid Chili CH-1820, Bogura (Local), Hybrid Chili Lanka-1820 and Amtoli (Local) while lower speed of germination was found in BARI-Chilli-1 (15.72) (Table 3). It was observed from the table 2 that shoot elongation rate of seedlings of chili was maximum (7.0mm/day) in variety BARI-Chilli-1 and the minimum shoot elongation rate (4.93mm/day) was observed in variety Sonic chili F1. Shoot elongation rate was varied among the genotypes with the progress of time. Maximum shoot elongation rate at 5, 9, 13 and 17 DAS was recorded from Vhola (3.73mm/day), Vhola (5.53mm/day), Hybrid Chili CH-1820 (6.36mm/day) and Kolapara (7.0mm/day), respectively. It was observed from the table 2 that shoot elongation rate of seedlings of chili was maximum (7.0mm/day) in variety BARI-Chilli-1 and the minimum shoot elongation rate (4.93mm/day) was observed in variety Sonic chili F1. Shoot elongation rate was varied among the genotypes with the progress of time. Maximum shoot elongation rate at 5, 9, 13 and 17 DAS was recorded from Vhola (3.73mm/day), Vhola (5.53mm/day), Hybrid Chili CH-1820 (6.36mm/day) and Kolapara (7.0mm/day), respectively.

Table 2: Effect of different salt concentration treatments on germination percentage of chili genotypes

Genotypes	Germination (%)			
	5 DAS	9 DAS	13 DAS	17 DAS
BARI-Chilli	32.44 cde	36.22 e	38.22 e	38.44 g
Kolapara	38.22 bcd	58.89 a-d	65.33 a-d	65.56 b-f
Vhola	31.33 de	52.22 cd	61.56 bcd	63.11 def
Muladi	23.78 e	50.67 de	60.67 d	60.67 ef
Pirojpur	32.44 cde	46.22 de	53.78 d	55.33 f
Bagerhat	34.44 cde	53.33 bcd	64.89 a-d	64.89 c-f
BRAC fire volcano	44.22 a-d	72.44 a	74.00 abc	74.00 a-d
PARTEX PS-1711	48.67 ab	70.89 a	75.33 abc	75.33 a-d
Sonic chilli F1	51.56 ab	70.44 a	74.00 abc	74.00 a-d
GAVL pp-002	47.78 ab	68.22 abc	77.11 ab	75.56 abc
Supreme sindu	44.67 abc	72.22 a	78.22 a	78.22 a
Bogura (Local)	41.33 a-d	71.56 a	77.33 ab	77.33 ab
Hybrid Chilli Lanka-1820	44.89 abc	69.56 ab	73.33 abc	73.33 a-d
Hybrid Chilli CH-1820	50.67 ab	66.89 abc	68.67 a-d	68.89 a-e
F1 hybrid hot pepper Angarika	54.67 a	67.56 abc	68.22 a-d	68.22 a-e
F1 hybrid hot pepper Sun drop	54.00 a	69.56 ab	70.67 abc	70.67 a-e
Amtoli (Local)	52.22 a	70.22 a	71.11 abc	71.56 a-e
$S_{\bar{x}}$	0.86	0.89	0.73	0.94
Level of significance	0.01	0.01	0.01	0.01
CV (%)	3.04	3.26	3.36	3.45

Figures in a column followed by different letters differ significantly, but with common letter (s) do not differ significantly at 1% level of probability by DMRT.

Table 3: Effect of different salt **concentration** treatments on shoot elongation rate of chili genotypes

Genotypes	Shoot Elongation Rate(mm/day)			
	5 DAS	9 DAS	13 DAS	17 DAS
BARI-Chilli	3.500 bcd	5.400 abc	6.033 bcd	7.000 a
Kolapara	3.167 f	4.433 g	5.733 ef	6.567 bc
Vhola	3.733 a	5.533 a	5.933 cde	5.933 fgh
Muladi	3.433 cd	5.500 ab	6.300 a	6.400 cd
Pirojpur	3.367 de	4.967 e	5.667 f	5.833 h
Bagerhat	3.367 de	4.433 g	5.033 h	5.100 j
BRAC fire volcano	3.400 de	5.267 cd	5.833 def	5.900 gh
PARTEX PS-1711	3.267 ef	4.967 e	5.733 ef	5.833 h
Sonic chilli F1	3.000 g	4.400 g	4.900 h	4.933 j
GAVL pp-002	3.400 de	4.733 f	5.400 g	5.433 i
Supreme sindu	3.167 f	3.800 h	4.900 h	4.967 j
Bogura (Local)	3.600 ab	5.133 de	5.900 def	6.100 efg
Hybrid Chilli Lanka-1820	3.600 ab	5.133 de	5.967 cde	6.067 fgh
Hybrid Chilli CH-1820	3.500 bcd	5.267 cd	6.367 a	6.667 b
F1 hybrid hot pepper Angarika	3.567 bc	5.300 bcd	6.000 bcd	6.167 def
F1 hybrid hot pepper Sun drop	3.433 cd	5.033 e	6.233 ab	6.500 bc
Amtoli (Local)	3.633 ab	5.367 abc	6.167 abc	6.333 cde
$S_{\bar{x}}$	0.035	0.052	0.061	0.063
Level of significance	0.01	0.01	0.01	0.01
CV (%)	3.43	4.51	4.54	4.56

6.24, 3.45 to 7.51 and 3.52 to 7.81 mm/day, respectively. At 5 DAS highest elongation rate was found at control treatment that was statistically similar with 50 mM NaCl concentration, followed by 100 (3.67 mm/day) and 150 mM (3.36 mm/day) NaCl concentration. At 9 DAS highest position was ranked by 0 mM NaCl concentration, second (12.09 mm/day) and third position was recorded in 50 and 100 mM NaCl concentration, respectively.

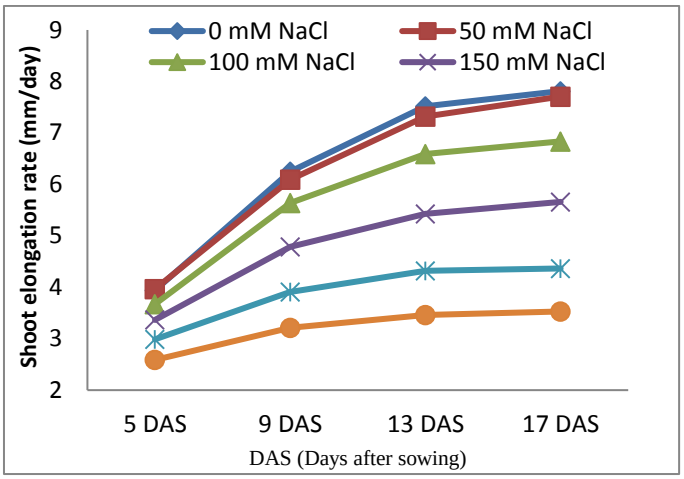

Figure 2: Shoot elongation rate of chili genotypes at different levels of salt treatments

Speed of germination was significantly influenced by different levels of salt stress and the speed of germination ranged from 19.97 to 29.46; highest in control and lowest in 250 mM NaCl concentration (Table 4). The second highest position was ranked by the 50 mM NaCl concentration which was statistically similar with 100 mM NaCl concentration.

Table 5: Speed of germination, vigor index, shoot length, root length, shoot dry weight and root dry weight of chili genotypes at different levels of salt treatments

Salinity levels (%)	Speed of germination	Vigor index	Shoot length (cm)	Root length (cm)	Shoot dry weight (mg)	Root dry weight (mg)
0 mMNaCl	29.46 a	6.727 a	3.907 a	4.507 a	7.929 a	4.753 a
50 mMNaCl	27.81 ab	6.259 b	3.854 a	4.265 b	7.806 a	4.265 b
100 mMNaCl	25.94 b	5.295 c	3.420 b	3.777 c	6.706 b	3.688 c
150 mMNaCl	23.50 c	3.880 d	2.831 c	3.118 d	5.806 c	3.018 d
200 mMNaCl	21.78 cd	2.813 e	2.183 d	2.518 e	5.059 d	2.718 e
250 mMNaCl	19.97 d	1.641 f	1.766 e	1.360 f	6.647 b	2.076 f
$S_{\bar{x}}$	0.56	0.122	0.19	0.21	0.48	0.22
Level of significance	0.01	0.01	0.01	0.01	0.01	0.01
CV (%)	4.26	3.68	4.61	4.72	3.13	3.59

Figures in a column followed by different letters differ significantly, but with common letter (s) do not differ significantly at 1% level of probability by DMRT.

The effects of salinity stress on vigor index of genotypes were showed in (table 4). and the results showed a decrease in vigor index with increase in salt concentrations. Vigor index was found maximum in controlled condition (6.72) whereas minimum was found in 150 mM NaCl solution (1.64). Maximum root length, shoot length, shoot dry weight and root dry weight of chili were found in 0 mM NaCl concentration (Table 4). With increasing the salt concentrations levels all these three characters of chili diminished.

3.3 Interaction effect

There was significant influence due to the interaction effects of genotypes and different levels of NaCl solution (Table 6). The combination of Kolapara and 0 mM NaCl solution gave the maximum germination at 90 DAS.Above 80% germination was found from BRAC fire volcano, PARTEX PS-1711, Sonic chili F1, GAVL pp-002, Supreme sindu and Amtoli (Local)grown up to 100 mM NaCl concentration. The highest speed of germination was obtained from BRAC fire volcano when germinated at 0 mM NaCl solution that was statistically similar with BARI Chilli-1 germinated at 0 mM NaCl solution. PARTEX PS-1711, Sonicchilli F1, Supreme sindu, F1 hybrid hot pepper Angarika, F1 hybrid hot pepper Sun drop and Amtoli (Local) had higher speed of germination having upto 100 mM NaCl concentration. Highest vigor index was recorded from PARTEX PS-1711 and Bogura (Local) with upto 100 mM NaCl concentration. The interaction of BARI-Chilli-1, Kolapara, Bogura (Local), Hybrid Chili CH-1820, F1 hybrid hot, pepper Sun drop and Amtoli (Local) and upto 50 mM NaCl concentration produced significantly the higher shoot.Bogura (Local), PARTEX PS-1711 and GAVL pp-002 produced well root up to 100 mM NaCl concentration. BRAC fire volcano, PARTEX PS-1711, Bogura (Local), Sonic chili F1 and Hybrid Chili CH-1820 accumulated maximum dry matter in shoot with upto 100 mM NaCl concentration. PARTEX PS-1711, Bogura (Local), Hybrid Chili Lanka-1820, Hybrid Chili CH-1820, F1 hybrid hot, pepper Angarika, BARI-Chilli-1 and Kolapara accumulated maximum dry matter in root with upto 100 mMNaCl concentration. BARI-Chilli-1, Kolapara, F1 hybrid hot pepper Sun drop and Amtoli (Local)had higher shoot elongation rate with up to 100 mM NaCl concentration.

Table 6: Analysis of variance of effects of different salt concentrations level on Chili genotype's germination percentage and shoot elongation rate

Paremeters	Sources of variation	Degree of freedom	5 DAS	9 DAS	13 DAS	17 DAS
Germination (%)	Factor A	16	1533.791***	2185.458***	1852.275***	1744.614***
	Factor B	5	1676.643***	5018.562***	5736.617***	5573.354***
	AB	80	141.265*	122.940 *	114.439*	118.465*
	Error	204	165.229	146.092	138.510	140.654
Shoot Elongation Rate	Factor A	16	0.650 ***	4.058 ***	3.852***	6.448 ***
	Factor B	5	15.427***	77.451***	139.637***	160.988***
	AB	80	0.293***	1.009***	1.225***	1.320 ***
	Error	204	0.023	0.050	0.069	0.074

*= Significance at 5% level, **= Significance at 1% and ***= Significance at 0.1%

4. DISCUSSION

There have been numerous investigations concerning the crops growth transpired that in the adverse environmental condition such high soil salinity can lead to reduction in the plant growth due to the toxicant effects of Na+ and Cl^- ions on the metabolism condition. In this regard an attempt was made to evaluate the performance of the chill genotypes under different salt concentration. In this investigation, it was observed that salt stress had a significant effect on germination and growth characters of chili and chili genotypes differed significantly in terms of characters studied. The cultivar supreme sindu had maximum germination that was statistically similar with Bogura (Local), GAVL pp-002, sonic chili F1 and PARTEX PS-1711.Bogura (Local) had highest vigor index and length root than of all other genotypes. The probable reason of the differences in vigor index and length of root is the genetic make-up of the cultivar which is primarily influenced by heredity. Salt stress exercised a remarkable effect on germination and growth characters of chili genotypes. All characters of chili investigated decreased gradually with the increasing of salt concentration and the interaction of genotypes and salt significantly predominantly impacted the germination and growth characters of chili genotypes. Among the genotypes, Bogura (Local) and PARTEX PS-1711were found grown well up to 100 mM NaCl concentration in the growth medium. Under conditions of salt stress Na+ influx into the root cells ameliorate the cytoplasm Na+ concentration and contrivances the toxicity symptoms; therefore lead to the progress of some metabolic disorders curtailing the reduction in total seed germination. [13] Another study reported that there has been a outright correlation between the water absorption of plant and elevation in total germination percentage. Salt stress has been found a crucial factor which can lead to the deterioration in water absorption into seeds [14, 15]. Our findings also resemble with other two research investigation which has focused on some savory and spinach genotypes found that the salt stress imposes adverse effect. Four vegetables species were treated with different concentration of salt solution to study salt effect and the results indicated that salinity caused remarkable reduction in germination percentage and root and shoot lengths. Two researchers have found the same result respectively on some savory and spinach genotypes [16,17]. Salinity affects the germination in different ways- first by diminishing the osmotic potential which hinder the uptake of water and second by a noxious accumulation of ions which leads to the damages in the embryo [18]. Studies showed that plumule was more suppressed than radicle by salinity in salt concentration levels and shoots of seedlings are more sensitive to salt stress than roots [19].The gradual decrease in plumule length with increase in NaCl stress render due to an inhibitory effect of NaCl salt in shoot growth and the reduction in seedling fresh weight might be due to decrease in water uptake imposed by seedling under salinity [20, 21]. Unfortunately, the mechanism of tolerance to salinity is yet to be fully developed. Moreover the Salinity has both osmotic and specific ionic effects on seedlings growth which can be executed through the toxic ion accumulation leading to a suppression in the uptake of essential nutrients like phosphorus (P) and potassium (K) in plants [22,23]. Chili is a glycophyte plants sensitive and cannot survive high concentrations of salt in their cytoplasm during growth leading to an urgent concern to investigate the optimum salt tolerances of chili genotypes. However, based in these calculated parameters, the "Anaheim Chili" is the most tolerant genotype and can be used in next selection programs.

5. CONCLUSION

This study demonstrated that the seed germination and growth of chili differed according to the change in NaCl concentration levels and the increase of salt stress diminished all studied parameters on germination and seedling growth. We found that "Bogura (Local) and PARTEX PS-1711" genotype are the most resistant genotype to salt stress on germination and early growth stage. However, further studies are needed to evaluate the agronomic behavior of those genotypes during the later stages of the culture. Results of this experiment can be efficacious to provide a better understanding of chili salt tolerance to the local farmers to cultivate chili genotypes with improved germination under salt stress.

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