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Impact of salinity on seed germination and seedling growth of tomato

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ABSTRACT

Salinity reduces tomato seed germination and lengthens the time needed for germination. The seed rate will be increase in the soils where the electrical conductivity (EC) of a saturated extract was equal to or above 8 dS m^{-1}. A study was conducted using fifteen genetically diverse genotypes under normal and salt stress conditions. The tomato genotypes were; 8 BARI varieties (BARI tomato-2, BARI tomato-8, BARI tomato-14, BARI tomato-15, BARI tomato-16, BARI tomato-17, BARI tomato-18 and BARI tomato-19) and 7 local varieties (Bonkim Ruby, Pusa Ruby, Suraksa, Patharkuchi, Ruma VF, Ruma 19 and Guli) were used as plant material. Although, tomato (Lycopersicon esculentum Mill.) was moderately sensitive to salinity but more attention to salinity is yet to be required in the production of tomato. In present study, germination (%), speed of germination, germination energy, germination capacity, seedling vigor index, fresh and dry weights of roots and root and shoot length, were the parameters assayed on five salinity levels. Increasing salt stress negatively affected germination and seedling growth. When salt concentration increased, germination of tomato seed was reduced and the time needed to complete germination lengthened. Among the varieties, BARI tomato 14 and BARI tomato 15 were found to be the more tolerant genotypes in the present study based on studied parameters.

Key Words: *Salinity, Seeds, Germination, Seedling growth and Tomato*

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I. Introduction

Salinity is currently one of the most severe abiotic factors, limiting agricultural production. Excessive salinity reduces the productivity of many agricultural crops including most of the vegetables. Knowledge of salt tolerance in vegetable plants is necessary to increase productivity and profitability of crops for coastal saline areas. The tomato plant can tolerably undergo salinity stress depending on cultivar or growth stage (Estan et al. 2005; Fernandez-Garcia et al. 2004; Santa-Cruz et al. 2002). The tomato cultivars significantly varied to different salinity levels (Kazemi et al. 2014). Some major processes are influenced by stress such as germination, growth and chlorophyll content (Parida and Das, 2005). Germination, emergence and early seedling growth are the three stages of establishment of the crop, which are particularly sensitive to salinity (Mariko et al. 1992; Jamil et al. 2005). Excessive

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uptake of the ions which causes toxicity for the plant, and reduced water availability between the seeds and the outer environment and so inhibits the primary root emergence (Delachiave and Dc Pinho 2003). The most critical stage is seed germination for seedling establishment and determining successful crop (Hosseine et al. 2003). Salinity also decreases the fresh and dry shoot and root weights of tomato seedlings (Shannon et al. 1987). Adding salt in nutrient solution adversely affected tomato shoot and roots, plant height, K concentration and K/Na ratio (Al-Karaki 2000). Salinity tolerance is important during the life period of any species. Tomato genotypes bear large number of genetic variation of tolerance to salt level. Most commercial tomato cultivars are insensitive to moderate levels of salinity (up to 2.5 dSm^{-1}) without significant yield reduction. Seedbed environment and varieties interaction greatly influence crop establishment at early seedling stages for successful crop production in a saline environment (Hakim et al. 2010). Correcting saline condition in field and greenhouse would be expensive and temporary while selection and breeding for salt tolerance can be a wise solution to minimize salinity effects as well as improve production efficiency. So breeding tolerant cultivars of tomato under saline conditions is needed. It is necessary to identify the sensitivity and tolerance level of a production (Bhattacharjee 2008). The least affected genotypes may be potential source of salinity tolerance for tomato breeding (Cuartero and Munoz, 1999; Hajer et al. 2006). These crops which are tolerant at seedling stage also show improved salinity tolerance at adult stage (Akinci et al. 2004). The objective of the present work was to investigate the response of 15 tomato genotypes to increasing salinity during the germination and seedling stages tried to find any level of tolerance to saline conditions.

II. Materials and Methods

Fifteen genetically diverse tomato including 8 BARI varieties were collected from Regional Agricultural Research Station (RARS), Jessore and 7 local varieties from coastal region's farmers by survey were evaluated in this experiment. This experiment was conducted in the Molecular Horticulture Lab, Agrotechnology Discipline, Khulna University during October 2017 to February 2018. The seeds of all the genotypes were surface sterilized with 0.1 % mercuric chloride solution for five minutes, then washed with sterilized distilled water. Fifty seeds of each genotype were placed in each Petridis at an equal distance from one another per salinity level. Salinity levels were created by Sodium chloride (NaCl, MW 58.44 g/mol, MERCK chemicals, AR grade) control (only distilled water), $4dsm^{-1}$, $8dsm^{-1}$, $12dsm^{-1}$ and $16dsm^{-1}$respectively. Each Petri dish was layered with Whatman's No.1 filter paper and irrigated with 5 ml of test solution. Whole set up was replicated thrice. Within the 18th days of the experiment, germination (%), speed of germination %, germination energy%, germination capacity%, seedling vigor index, root & shoot length of germinated seedlings, fresh and dry weight of germinated seedlings was measured. Seeds were considered germinated when the emergent root reached 2 mm length (Maggio et al. 2007).

Data of this study was measured by these equations:

Germination energy = Percentage of seeds germinated at 72 h (Bam et al. 2006).
Germination capacity = Percentage of seeds germinated at 168 h (Bam et al. 2006).
Seedling vigor index = Total length of seedling (m) × Germination % (Abdul and Anderson, 1973).

$$\text{Germination (\%)} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds placed in petridish}} \times 100$$ (Bam et al. 2006).

$$\text{Speed of germination (\%)} = \frac{\text{Number of seeds germinated at 72 h}}{\text{Number of seeds germinated at 168 h}} \times 100$$ (Krishnaswamy and Seshu, 1990).

The data in respect of germination and seedling growth were statistically analyzed using STAT statistical program to find out the statistical significance of the experimental results. Significance of differences between pairs of treatment means were evaluated by Duncan's New Multiple Range Test (Gomez and Gomez, 1984).

III. Results and Discussion

Germination parameters

There were significant variations due to different salinity levels in respect of germination %, germination energy %, germination capacity % and germination speed of tomato seeds. All germination parameters shows highest value in control followed by 4 dSm^{-1} and the lowest was found in 16 dSm^{-1} (Figure 01). It represented that increasing salinity make adverse effect on germination. Germination speed, germination capacity and germination energy was more affected by salinity. When salt concentration increased, the time needed to complete germination lengthened and the final germination of tomato seed was reduced. The result was in support with Parida and Das (2005).

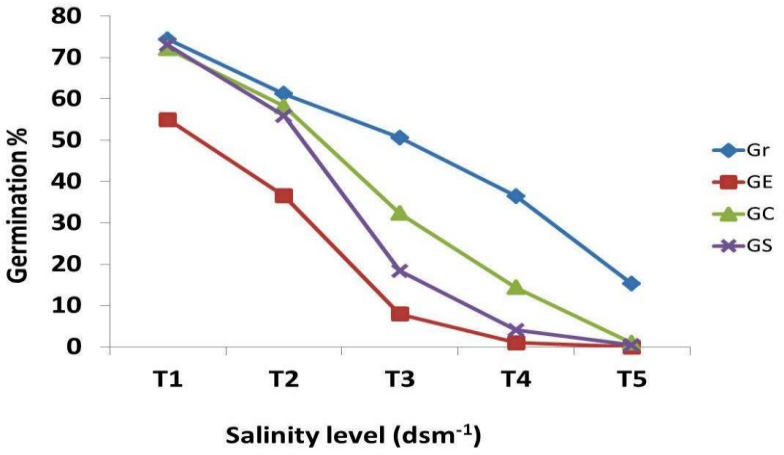

Figure 01. Impact of salinity Levels in respect of germination of tomato seeds. Gr (germination %), GE (germination energy %), GC (germination capacity %), GS (germination speed %), T1 (Control), T2 (4 dsm^{-1}), T3 (8dsm^{-1}), T4 (12 dsm^{-1}) and T5 (16dsm^{-1}).

Table 01. Effect different levels of salinity on selected varieties of tomato in respect of Germination Energy

Genotypes	Germination energy					Mean Germination Energy (%)
	Salinity levels					
	control	4 dsm^{-1}	8 dsm^{-1}	12 dsm^{-1}	16 dsm^{-1}	
BARI tomato 2	91.33 a	32.33n	2.33 y	0.00A	0.00A	25.20d
BARI tomato 8	45.0 h	12.33s	0.00 A	0.00 A	0.00A	11.47j
BARI tomato 14	91.66ab	85.00 bc	37.33k	0.00 A	0.00A	42.80a
BARI tomato 15	84.66b	78.66c	15.33q	3.33 x	0.00 A	36.40b
BARI tomato 16	78.00 c	64.66 d	14.00 r	0.00A	0.00 A	31.33c
BARI tomato 17	61.33e	35.00 l	2.33 y	0.00A	0.00 A	19.73g
BARI tomato 18	50.33 gh	43.33i	15.66q	7.00v	0.00 A	23.27e
BARI tomato 19	43.0 hi	8.33uv	0.00 A	0.00A	0.00A	10.27k
Bonkim Ruby	12.00 st	3.66x	0.00A	0.14z	0.00A	3.13 l
Pusa Ruby	53.33 g	29.66o	1.00 z	0.00 A	0.00A	16.8h0
Suraksa	34.66m	21.66p	5.66 w	0.00 A	0.00 A	12.40i
Patharkuchi	50.00 gh	41.00 j	11.67st	2.33 y	0.00 A	21.00f
Ruma VF	60.66e	53.00 g	7.66 v	2.33 y	0.00A	24.73d
Ruma 19	56.00f	35.66 l	6.33 vw	0.00A	0.00 A	19.60g
Guli	12.33s	3.66 x	0.00 A	0.00 A	0.00 A	3.20 l
LS	**					
CV	3.85					

LS=Level of significant, CV= Coefficient of variation, ** = Significant at 1% level.

Germination energy

The variation in germination energy of tomato seed among the varieties was statistically significant (Table 01). The maximum germination energy (42.80%) was found in BARI tomato-14 followed by BARI

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tomato-2(36.40%). The lowest germination energy of tomato seed was observed from Bankim Ruby (3.13%) proceeded by Guli (3.20%).

The combined effect of variety and salinity levels also found significant in respect of germination energy of tomato seeds. The highest germination energy of tomato seeds was recorded from the variety BARI tomato-14 and BARI tomato-2 with control and the lowest germination energy of tomato seeds (0.00) was found in all the varieties with 16 dsm^{-1}. BARI tomato 14 and BARI tomato 15 gave higher value in 4 dsm^{-1} and BARI tomato 14 gave higher value in 8 dsm^{-1} than others (Table 01). Genotypes which germinate earlier at higher salinity are supposed to be more vigorous and may be used as parents or potential donor in salinity tolerance crop breeding programs (Cuartero and Munoz, 1999; Amir et al. 2011; Hamed et al. 2011).

Germination capacity

The variation in germination capacity of tomato seed among the varieties was statistically significant (Table 02). The maximum germination capacity (60.87%) was found in BARI tomato-14 followed by BARI tomato-15 (56.73%), BARI tomato-2 (49.27%) and BARI tomato-16 (48.20%). The lowest germination capacity of tomato seed was observed from Bankim Ruby (11.33%) proceeded by the variety Guli (15.33%), BARRI tomato-19 (23.40%) and BARRI tomato-8 (25.07%).

The combined effect of variety and salinity levels also found significant in respect of germination capacity of tomato seeds. The highest germination capacity of tomato seeds (96.33%) was recorded from the variety BARI tomato 15 with control salinity level which was statistically similar to BARI tomato-14 with control (95.00%) and the lowest germination capacity of tomato seeds (0.00) was found in the variety Guli with the highest level of salinity (16 dsm^{-1}) (Table 02).

Table 02. Effect different levels of salinity on selected varieties of tomato in respect of germination capacity of seeds

Genotypes	Germination capacity					Mean Germination capacity (%)
	Levels of salinity					
	control	4 dsm^{-1}	8 dsm^{-1}	12 dsm^{-1}	16 dsm^{-1}	
BARI tomato 2	93.00 bc	86.67 e	57.00 lm	9.67 [/]	0.0 A	49.27c
BARI tomato 8	67.33 jk	46.00 o	9.66 [/]	2.33 -	0.0 A	25.07i
BARI tomato 14	95.00 ab	92.33 cd	90.33 d	23.67 wx	3.0 -	60.87a
BARI tomato 15	96.33 a	87.33 e	66.66 jk	33.33 r	0.00A	56.73b
BARI tomato 16	95.00 ab	90.66 d	42.33 p	9.33 /]	3.67^	48.20d
BARI tomato 17	81.66 g	58.66 l	11.33 [/	8.33]	0.00A	32.00h
BARI tomato 18	65.67 jk	56.00 m	32.0 rs	25.00 w	2.00 -A	36.13f
BARI tomato 19	74.66i	38.33q	4.00^-	0.00A	0.00A	23.40j
Bonkim Ruby	21.66xy	19.67y	9.66[/]	5.66^	0.00A	11.33l
Pusa Ruby	77.00h	53.33n	21.33y	11.66[	2.33-	33.13g
Suraksa	73.66i	44.30o	31.33rst	15.66z	0.00A	11.00g
Patharkuchi	56.33m	52.66n	30.33stu	27.66v	0.66A	33.40g
Ruma VF	67.66j	65.33k	29.00uv	15.66z	0.66A	35.67f
Ruma 19	84.67f	52.33n	37.67q	23.67wx	2.33-	40.13e
Guli	32.0rs	29.33tuv	11.67[	3.67^-	0.00 A	15.33k
LS	**					
CV	2.56					

LS=Level of significant, CV= Coefficient of variation, ** = Significant at 1% level.

Germination speed

The variation in germination speed of tomato seed among the varieties was statistically significant (Table 03). The maximum germination speed (46.17%) was found in BARI tomato-18 followed by BARI tomato-14 (45.96%), Patharkuchi (42.67%) and Ruma-VF (42.55%). The lowest germination speed of tomato seed was observed from Guli (10.17%) preceded by Bankim Ruby (14.81%), BARI tomato-19 (15.85%) and BARI tomato-8 (18.70%).

The combined effect of variety and salinity levels also found significant in respect of germination speed of tomato seeds. The highest germination speed of tomato seeds (98.17%) was recorded from the variety BARI tomato- 2 with control salinity level, which was statistically similar to BARI tomato-14 with the control (96.47%) and the lowest germination speed of tomato seeds (0.00) was found in the variety Guli with 16 dsm^{-1} (Table 03). The salinity notably affects germination in many species but also lengthens the time needed to complete germination (Amir et al. 2011). In the present study the speed of germination was reduced i.e. it took more days to complete the germination under salinity. The stimulation of germination and days required for its completion, depend upon Gibberellic Acid content in seed. A low level of GA in seed in saline medium was unable to break the mechanical resistance of endosperm against imbibition of water by seed and this leads to the reduction in speed of germination (Groot and Karssen, 1992; Groot et al. 1988).

Table 03. Effect different levels of salinity on selected varieties of tomato in respect of germination speed of seeds

Genotypes	Speed of germination					Mean Germination Speed (%)
	Levels of salinity					
	control	4 dsm^{-1}	8 dsm^{-1}	12 dsm^{-1}	16 dsm^{-1}	
BARI tomato 2	98.16a	37.26m	4.07yz	0.00z	0.00z	27.90e
BARI tomato 8	66.76h	26.73op	0.00z	0.00z	0.00z	18.70h
BARI tomato 14	96.47a	92.03b	41.30l	0.00z	0.00z	45.96a
BARI tomato 15	87.83c	90.03bc	22.96pq	9.83vw	0.00z	42.13b
BARI tomato 16	82.06d	71.26g	33.10n	0.0z	0.00z	37.29c
BARI tomato 17	75.06f	59.63i	20.40qrs	0.00z	0.00z	31.02d
BARI tomato 18	76.60f	77.33ef	49.00k	27.90o	0.00z	46.17a
BARI tomato 19	57.56ij	21.70qr	0.00z	0.00z	0.00z	15.85i
Bonkim Ruby	55.46j	18.57rst	0.00z	0.00z	0.00z	14.81i
Pusa Ruby	69.23gh	55.60j	4.83xy	0.00z	0.00 z	25.93f
Suraksa	47.0k	48.67k	18.00rst	0.00z	0.00z	22.78g
Patharkuchi	88.70bc	77.80ef	38.47lm	8.40wx	0.00z	42.67b
Ruma VF	89.63bc	81.10de	26.36op	15.00tu	0.66z	42.55b
Ruma 19	66.12h	68.13gh	16.76st	0.00z	0.00z	30.20d
Guli	38.40lm	12.43uv	0.00z	0.00z	0.00z	10.17j
LS	**					
CV	5.83					

LS=Level of significant, CV= Coefficient of variation, ** = Significant at 1% level.

Germination Percentage

The variation in germination of tomato seed among the varieties was statistically significant (Table 04). The maximum germination (74.27%) was found in BARI tomato-14 followed by BARI tomato-16 (70.53%), BARI tomato-15 (67.60%) and BARI tomato-2 (66.73%). The lowest germination was observed from the variety Bankim Ruby (15.07%) preceded by Guli (20.07%), BARI tomato-19 (35.93%) and BARI tomato-8 (37.40%).

The combined effect of variety and salinity levels also found significant in respect of germination of tomato seeds. The highest germination of tomato seeds (97.67%) was recorded from the variety BARI tomato 15 with 0 dsm^{-1} salinity level, which was statistically similar to BARRI tomato-14 with the control (96.00%) and the lowest germination of tomato seeds (0.00) was found in the variety Guli with 16 dsm^{-1} salinity levels (Table 04). The effect of salinity on seed germination may be effect on osmotic or ion toxicity, which can disturb physiological processes such as enzyme activities (Croser et al. 2001; Essa and Al-Ani, 2001).

Seedling vigour index

There were significant variations due to different salinity levels in respect of seedling vigour index of tomato. The highest seedling vigour index was found in 0 dsm^{-1} which was followed by 4 dSm^{-1} and the lowest seedling vigour index was found in 16 dSm^{-1}. (Figure 02).

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Table 04. Effect different levels of salinity on selected tomato varieties in respect of germination percentage of seeds

Genotypes	Germination (%)					Mean Germination (%)
	Levels of salinity					
	0 dsm^{-1}	4 dsm^{-1}	8 dsm^{-1}	12 dsm^{-1}	16 dsm^{-1}	
BARI tomato 2	94.66 bcd	87.00 f	74.33 i	56.00 lm	21.67z	66.73c
BARI tomato 8	73.00 i	50.00 qr	35.00 v	14.66 [	14.33[	37.40I
BARI tomato 14	96.00 ab	93.00 cde	91.66 e	63.67 k	27.0 x	74.27a
BARI tomato 15	97.66 a	91.33 e	75.00 hi	53.0 nop	21.00z	67.60c
BARI tomato 16	95.67 abc	92.00 de	80.33 g	69.0 j	15.67[	70.53b
BARI tomato 17	87.66 f	63.00 k	51.00 pqr	32.00 w	23.33yz	51.40e
BARI tomato 18	68.00 j	57.33 l	42.33 st	32.00 w	9.33/	41.80g
BARI tomato 19	75.00hi	49.3 qr	32.33 vw	23.00 yz	0.00^	35.93j
Bonkim Ruby	25.00 xy	21.66 z	14.66 [	10.33 /	3.67]	15.07l
Pusa Ruby	77.33 h	54.66 lmn	41.33 t	31.66 w	8.0 /	42.60g
Suraksa	74.33 i	49.66 qr	44.67 s	23.00 yz	9.67 /	40.27h
Patharkuchi	57.00 l	53.66 mnop	51.67opq	48.3 r	14.67[	45.07f
Ruma VF	68.0 j	67.6 j	49.3 qr	43.0 st	38.00u	53.20d
Ruma 19	85.3 f	54.0 mno	54.0 mno	43.3 st	21.67z	51.67e
Guli	41.6 t	33.6 vw	21.0 z	4.0]	0.00^	20.07k
LS	**					
CV	2.56					

LS=Level of significant, CV= Coefficient of variation, ** = Significant at 1% level.

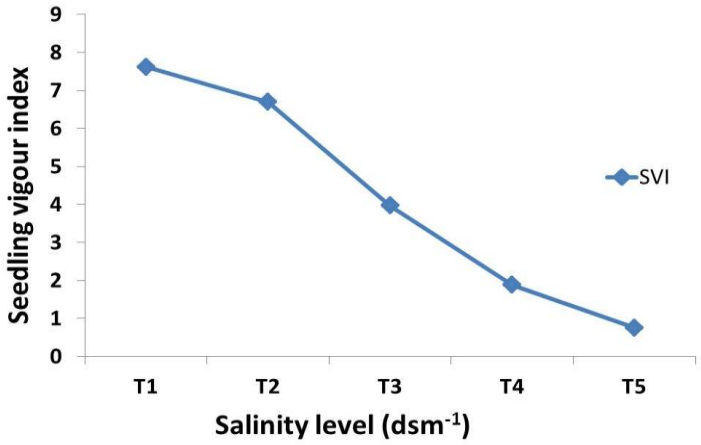

Figure 02. Impact of salinity levels in respect of seedling vigor index of tomato seeds. SVI (seedling vigor index), T1 (Control), T2 (4 dsm^{-1}), T3 (8dsm^{-1}), T4 (12 dsm^{-1}) and T5 (16dsm^{-1}).

The variation in seedling vigour index of tomato among the varieties was statistically significant (Table 05). The maximum seedling vigour index (6.83) was found in BARI tomato-18 followed by BARI tomato-16 (6.73), BARI tomato-2 (5.90) and BARI tomato-15 (5.41). The lowest seedling vigour index of tomato was observed from the variety Pusha Ruby (3.51) preceded by Ruma-VF (3.82), Surakkha (3.83) and BARI tomato-17 (3.92). The combined effect of variety and salinity levels also found significant in respect of seedling vigour index of tomato. The highest seedling vigour index of tomato (11.83) was recorded from the variety BARI tomato 16 with 0 dsm^{-1} salinity level which was followed by BARI tomato-15 with 4 dsm^{-1} (11.13) and the lowest seedling vigour index of tomato (0.00) was found in the variety Guli with 16 dsm^{-1} (Table 05). The result in agreement with Kazemi et al. (2014).

Seedling growth

Shoot length of seedlings

There were significant variations due to different salinity levels in respect of in length of shoots. The highest length of shoots (4.58 cm) was found in 4 dsm^{-1} which was statistically similar to 0 dSm^{-1} (4.54 cm) and the lowest length of shoots (0.20 cm) was found in 16 dSm^{-1} (Table 06).

Table 05. Effect different levels of salinity on selected varieties of tomato in respect of seedling vigour index

Genotypes	Seedling vigour index					Mean Seedling vigour index
	Levels of salinity					
	control	4 dsm^{-1}	8 dsm^{-1}	12 dsm^{-1}	16 dsm^{-1}	
BARI tomato 2	8.39ij	10.83c	6.78lm	3.17yz	0.33-A	5.90b
BARI tomato 8	7.70k	4.51qr	3.27yz	0.28A	0.00A	3.15i
BARI tomato 14	9.97de	10.23d	9.33g	4.23rs	0.40-	6.83a
BARI tomato 15	7.56k	11.13b	4.77q	3.64wx	0.00A	5.41c
BARI tomato 16	11.87a	9.75ef	7.47k	4.13st	0.40-	6.72a
BARI tomato 17	8.56i	6.53mn	3.96s-w	0.49^-	0.00A	3.92g
BARI tomato 18	8.11j	7.74k	3.89t-w	2.30[	0.00A	4.42d
BARI tomato 19	5.11p	3.63vwx	0.78^	0.00A	0.00A	1.91j
Bonkim Ruby	3.06z	2.50[	0.63^-	0.45-	0.00A	1.34l
Pusa Ruby	8.83h	4.59q	2.60[	1.43/]	0.00A	3.51h
Suraksa	8.49i	5.43o	3.98s-v	1.24]	0.00A	3.83g
Patharkuchi	6.43n	6.87l	4.81q	3.26yz	0.00A	4.28e
Ruma VF	6.57mn	7.63k	3.11yz	1.77/	0.00A	3.82g
Ruma 19	9.53fg	5.33op	3.77uvw	1.74/	0.00A	4.08f
Guli	4.00stu	3.41xy	0.40-	0.00A	0.00A	1.56k
LS	**					
CV	3.44					

LS=Level of significant, CV= Coefficient of variation, ** = Significant at 1% level.

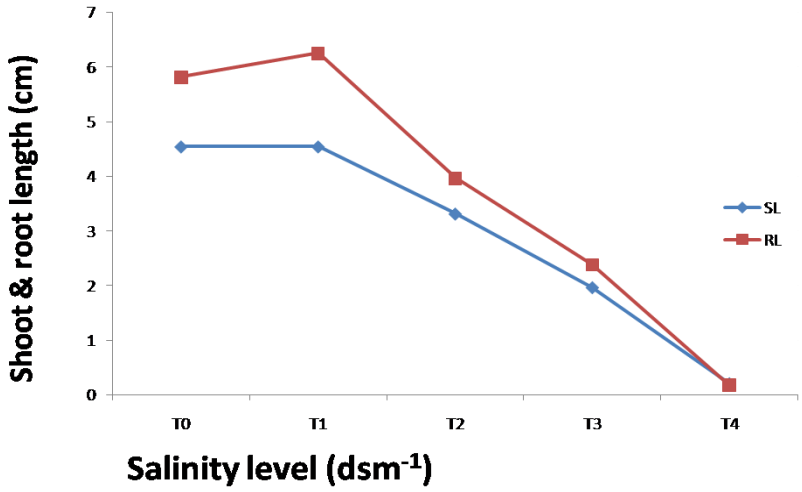

Figure 03. Impact of salinity Levels in respect of shoot length and root length of tomato seedlings. SL (Soot length), RL (Root length), T1 (Control), T2 (4 dsm^{-1}), T3 (8 dsm^{-1}), T4(12 dsm^{-1}) and T5 (16 dsm^{-1}).

The variation in shoot length of seedlings among the varieties was statistically significant. The highest length of shoots (3.85 cm) was found in BARI tomato -18 followed by BARI tomato -14 (3.37 cm), BARI tomato -16 (3.35 cm) and Bankim Ruby (3.31 cm). The lowest length of shoots was observed from BARI tomato -19 (1.71 cm) preceded by Guli (1.83 cm), Ruma-19 (2.47 cm) and BARI tomato -17 (2.69 cm) (Table 07). The combined effect of variety and salinity levels also found significant in respect of length of shoots. The highest length of shoots (6.04 cm) was recorded from the variety BARI Tomato-18 with 4 dsm^{-1} salinity level which was statistically similar to Bankim Ruby with control. The lowest length of shoots (27.94 cm) was found in Guli with 16 dsm^{-1} (Table 07). The result was in support with Al-Karaki (2000).

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Table 06. Effect different levels of salinity on selected varieties of tomato in respect of shoot length of seedling

Genotypes	Shoot length (cm)					Means of Shoot length (cm)
	Salinity levels					
	control	4 dsm^{-1}	8 dsm^{-1}	12 dsm^{-1}	16 dsm^{-1}	
BARI tomato 2	3.50rst	5.30bc	3.90m-r	2.80wx	0.73[	3.26bc
BARI tomato 8	5.08c-f	4.50h-l	4.63f-j	1.23-	0.00A	3.09cd
BARI tomato 14	4.20i-o	5.20bcd	3.60p-t	2.94vwx	0.76[	3.37b
BARI tomato 15	4.16j-p	4.70e-i	2.90vwx	2.83wx	0.00A	2.94de
BARI tomato 16	4.57g-k	4.45h-m	3.90n-s	2.20yz[	1.50]^-	3.35b
BARI tomato 17	3.86n-s	4.20i-o	4.20i-n	1.10-	0.00A	2.69f
BARI tomato 18	5.56b	6.04a	4.10k-p	3.54q-t	0.00A	3.85a
BARI tomato 19	3.54q-t	3.52q-t	1.50^-	0.00A	0.00A	1.71h
Bonkim Ruby	6.03a	5.12b-e	2.93vwx	2.50xyz	0.00A	3.34b
Pusa Ruby	4.90c-h	4.00l-q	3.03uvw	1.83[/]^	0.00A	2.75ef
Suraksa	4.60f-k	4.46h-l	3.40stu	1.90[/]	0.00A	2.90de
Patharkuchi	5.05c-g	4.64e-j	4.10j-p	2.50xy	0.00A	3.28bc
Ruma VF	4.76d-h	4.26i-n	3.31t-v	2.06z[/	0.00A	2.88ef
Ruma 19	4.47h-l	3.46stu	2.62wxy	1.76/]^	0.00A	2.47g
Guli	3.75o-t	4.23i-o	1.15-	0.00A	0.00A	1.83h
LS	**					
CV	6.9					

LS=Level of significant, CV= Coefficient of variation, ** = Significant at 1% level.

Table 07. Effect different levels of salinity on selected varieties of tomato in respect of root length of seedling

Genotypes	Root length (cm)					Means of Root length (cm)
	Salinity levels					
	control	4 dsm^{-1}	8 dsm^{-1}	12 dsm^{-1}	16 dsm^{-1}	
BARI tomato 2	5.36l	7.12d	5.15m	2.86xy	0.79^-	4.26d
BARI tomato 8	5.46l	4.53op	4.70o	0.69-	0.00 A	3.08i
BARI tomato 14	6.15j	5.76k	6.49gh	3.71st	0.73^-	4.57b
BARI tomato 15	3.58tu	7.46c	3.33vw	4.04r	0.00A	3.68f
BARI tomato 16	7.78b	6.14j	5.40l	3.76st	1.05]	4.83a
BARI tomato 17	5.90k	6.20ij	3.50uv	0.45A	0.45^	3.21h
BARI tomato 18	6.36hi	7.46c	5.10m	3.86rs	0.00A	4.55b
BARI tomato 19	3.26w	3.90rs	0.90]^	0.00A	0.00A	1.62k
Bonkim Ruby	6.23ij	6.64efg	1.45/	1.90[	0.00A	3.25h
Pusa Ruby	6.60fg	4.40pq	3.26w	2.71y	0.00A	3.40g
Suraksa	6.83e	6.46gh	5.43l	3.4uvw	0.00A	4.43c
Patharkuchi	6.19ij	8.20a	5.16m	4.23q	0.00A	4.76a
Ruma VF	4.90n	7.10d	2.99x	1.90[	0.00A	3.38g
Ruma 19	6.70ef	6.46gh	4.30q	2.25z	0.00A	3.94e
Guli	5.86k	5.90k	0.76^-	0.00A	0.00A	2.51j
LS	**					
CV	2.6					

LS=Level of significant, CV= Coefficient of variation, ** = Significant at 1% level.

Root length of seedlings

There were significant variations due to different salinity levels in respect of length of roots. The highest length of root was found in 4 dsm^{-1} which was statistically similar to control the lowest length of shoots was found in 16 dSm^{-1} (Table 06). The variation in root length of seedlings among the varieties was statistically significant .The highest length of roots (4.83 cm) was found inV5 followed by Patharkuchi (4.76 cm), BARI tomato -14 (4.57 cm) and BARI tomato -18 (4.45 cm). The lowest length of roots was

observed from Bankim Ruby (1.66 cm) preceded by Guli (2.51 cm), BARI tomato -8 (3.08 cm) and BARI tomato -17 (3.21 cm) (Table 08). The combined effect of variety and salinity levels also found significant in respect of length of roots. The highest length of roots (8.20 cm) was recorded from the variety Patharkuchi with 4 dsm^{-1} salinity level which was followed BARI tomato -16 with control treatment. The lowest length of roots (0.00 cm) was found in Guli with 16 dsm^{-1} (Table 08). The similar result was reported by Al-Karaki (2000).

Fresh weight of seedling

There was significant effect of different salinity levels on the fresh weight of seedlings (Figure 04). The maximum fresh weight of seedlings was observed in 0 dsm-1 which was followed by 4 dsm^{-1}. The minimum fresh weight of seedlings was found in 16 dsm^{-1}.

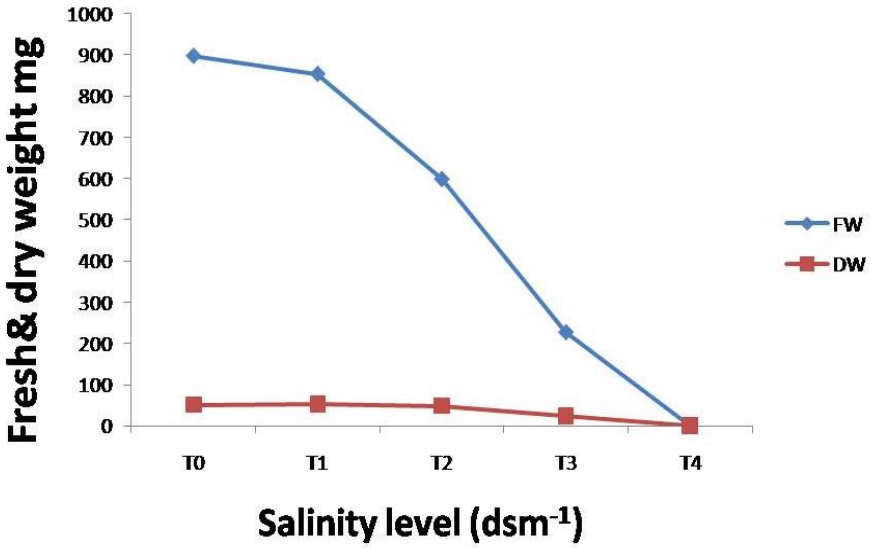

Figure 04. Impact of salinity levels in respect of fresh and dry weight of tomato seedlings. FW (Fresh weight), DW (Dry weight), T1 (Control), T2 (4 dsm-1), T3 (8dsm-1), T4 (12 dsm-1) and T5 (16 dsm-1).

Table 08. Effect different levels of salinity on selected varieties of tomato in respect of seedlings fresh weight

Genotypes	Fresh weight of seedling (g)					Means of fresh weight of seedling (g)
	Salinity levels					
	control	4 dsm^{-1}	8 dsm^{-1}	12 dsm^{-1}	16 dsm^{-1}	
BARI tomato 2	1306.66c	1311.66c	1058.3fg	724.3lm	0.00[	880.2b
BARI tomato 8	773.00k	597.33o	352.66st	0.00[	0.00[	344.6i
BARI tomato 14	1321.33c	1722.66a	1455.30b	556.6p	0.00[	1011.a
BARI tomato 15	1032.6gh	1062.0fg	881.00j	404.66r	0.00[	676.1d
BARI tomato 16	1443.30b	1051.6fgh	1084.30f	312.0u	0.00[	778.3c
BARI tomato 17	1128.33e	1050.6fgh	715.33m	0.00[	0.00[	578.9e
BARI tomato 18	758.00kl	426.00qr	360.66s	0.00[	0.00[	308.9j
BARI tomato 19	1040.0gh	558.33p	191.00xy	0.00[	0.00[	357.9i
Bonkim Ruby	429.00qr	157.66yz	161.33yz	129.6z	0.00[	175.5k
Pusa Ruby	581.00op	657.00n	320.00tu	217.0wx	0.00[	355.0i
Suraksa	599.00o	752.00kl	608.66o	260.33v	0.00[	444.0h
Patharkuchi	913.00ij	922.33i	737.33lm	348.6st	0.00[	584.3e
Ruma VF	913.00ij	1177.33d	448.33q	244.0vw	0.00[	556.5f
Ruma 19	892.30ij	1022.00h	563.33p	210.3x	0.00[	537.6g
Guli	320.60tu	329.0stu	37.00[	0.00[	0.00[	137.3l
LS	**					
CV	2.93					

LS=Level of significant, CV= Coefficient of variation, ** = Significant at 1% level.

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The variation of fresh weight of seedlings was found significant among the varieties (Table 09). The maximum fresh weight seedlings (1011.0 g) was found in the variety BARI tomato -8 followed by BARI tomato-2 (880.2 g) and BARI tomato -16 (778.3 g) and that was the minimum (137.30 g) in Guli. The combined effect of variety and salinity levels also found significant in case fresh weight of seedlings (Table 09). The maximum fresh weight of seedlings (1723 g) was found in BARI tomato-15 with 8 dsm-1 which was followed by BARI tomato-16 with 0 dsm-1 (145 g) and BARI tomato-14 with 0 dsm-1 (1321 g) and that was the minimum (0.00 g) in the variety Guli with 16 dsm-1.The result consented with Parida and Das (2005).

Dry weight of seedling

There was significant effect of different salinity levels on the dry weight of seedlings (Figure 04). The maximum dry weight of seedlings was observed in 4 dsm^{-1} which was followed by control. The minimum fresh weight of seedlings was found in 16 dsm^{-1}. The variation of dry weight of seedlings was found significant among the varieties (Table 09). The maximum dry weight seedlings (69.59 g) were found in the variety BARI tomato-8 followed by BARI tomato-2 (60.83 g) and Patharkuchi (47.84 g) and that was the minimum (11.72 g) in the variety Bankim Ruby. The combined effect of variety and salinity levels also found significant in case dry weight of seedlings (Table 09). The maximum dry weight of seedlings (114.2 g) was found in BARI tomato-14 with 4 dsm^{-1} which was followed by BARI tomato-2 with control (95.77 g) and BARI tomato-14 also control (89.97 g) and that was the minimum (0.00 g) in the variety Guli with 16 dsm^{-1}.

Table 09. Effect different levels of salinity on selected varieties of tomato in respect of seedlings dry weight

Genotypes	Dry weight of seedling (g)					Means of dry weight of seedling (g)
	Salinity levels					
	control	4 dsm^{-1}	8 dsm^{-1}	12 dsm^{-1}	16 dsm^{-1}	
BARI tomato 2	49.46n	95.76b	79.73e	79.16e	0.00\	60.83b
BARI tomato 8	35.76t	38.33s	26.93v	0.00\	0.00\	20.21l
BARI tomato 14	88.36d	89.96c	114.2a	55.40jk	0.00\	69.59a
BARI tomato 15	42.43pq	59.96i	63.90h	25.96v	0.00\	38.45g
BARI tomato 16	67.76g	40.36r	75.10f	17.70x	0.00\	40.19f
BARI tomato 17	59.60i	58.83i	47.46o	0.00\	0.00\	33.18h
BARI tomato 18	63.56h	51.93m	35.86t	0.00\	0.00\	30.27j
BARI tomato 19	60.20i	35.13t	10.36[	0.00\	0.00\	21.14k
Bonkim Ruby	22.00w	9.93[	14.70y	11.96z	0.00\	11.72n
Pusa Ruby	49.46n	56.33j	30.56u	21.10w	0.00\	31.49i
Suraksa	34.83t	41.46qr	43.66p	30.33u	0.00\	30.06j
Patharkuchi	58.60i	64.70h	75.10f	40.80r	0.00\	47.94c
Ruma VF	59.40i	75.70f	59.86i	30.73u	0.00\	45.14d
Ruma 19	59.60i	53.43l	54.06kl	37.73s	0.00\	40.97e
Guli	21.66w	30.36u	10.33[	0.00\	0.00\	12.47m
LS	**					
CV	*1.96*					

LS=Level of significant, CV= Coefficient of variation, ** = Significant at 1% level.

IV. Conclusion

Germination parameter are negatively influenced with the increasing salinity and salt tolerance of the varieties varied significantly with salinity level. This investigation showed that BARI tomato-14 perform better in germination (%), germination capacity, Germination speed, germination energy, and fresh and dry weight up to 8 dsm^{-1} salinity level. BARI tomato-15 and BARI tomato-18 showed moderately resistance up to 12 dsm^{-1}. Ruma VF gave highest germination (%) in case of 16 dsm^{-1} and patharkuchi in case of 12 dsm^{-1}. Guli is lower performer based on studied parameter. BARI tomato-15 gave the highest fresh weight with 8 dsm^{-1}. Therefore, BARI tomato-14 was more successful than the other varieties in the seed germination and growth stage up to 8 dsm^{-1}. On the other hand, Ruma VF and patharkuchi is suitable varieties where the salinity is high (12 dsm^{-1}-16 dsm^{-1}).

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