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Salt Tolerance Screening of 26 Tomato Cultivars

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ABSTRACT
Tomato (*Lycopersicon esculentum* Mill.) is an economically important vegetable crop that is produced for consumption globally, including in Thailand. The northeast of Thailand has the greatest area for cultivating tomato in the country, but this area has problems with saline soil, which means farmers do not have enough space for cultivation. The objectives of the study were to screen the salt tolerance of tomato and study the effects of salt stress on the growth and physiology of 26 tomato cultivars. Tomato seeds were germinated on sponges for seven days, then they were moved to half-Hoagland's solution and grown for 28 days. Data was collect before adding salt, including salt tolerance score, height and proline content. There was then supplementation with sodium chloride solution at 200 mM concentration for five days. Then the 33-day-old plants had data collected, including salt tolerance score, height, proline content and dry weight at the end of the experiment. The results showed that the salt tolerance scores for the cultivars LE153 and LE001 were the most salt tolerant, while the most sensitive cultivars were LE029, LE095, LE141, LE164, wild type, Epe Chia Tai and Sida. In terms of height, LE153 had the greatest increase. In terms of dry weight, LE153 and LE003 had the least shoot dry weight, and LE153 had the lowest root dry weight. In terms of proline content, the LE153, LE164 and LE171 varieties had the lowest increase in proline content. These finding could enable the screening of tomato for saline soil tolerance in tomato breeding programs.

Keywords
Screening, Salt tolerance, Proline, Tomato

Introduction

Tomato (*Lycopersicon esculentum* Mill.) is in the family Solanaceae[1].Tomatoes are an economically important vegetable crop. It is produced for consumption around the world where it is both eaten fresh and processed into a wide variety of products. Tomatoes contain important substances that are beneficial for health, such as vitamin A, vitamin C, potassium, beta-carotene and antioxidants like lycopene. In addition, tomatoes are a type of vegetable that generates income for farmers, as they can produce for fresh markets, industrial processing and producing seeds [2].Tomatoes have a large variety of species. There are both native species and improved hybrid varieties for Thailand, which can enable suitable varieties to be chosen [3].Thailand has a total area of 5,832 ha suitable for tomato cultivation, comprising 1,846 ha in northern region, 1,094 ha in central region, 6 ha in southern region and the northeast region has the most cultivated area, which is 2886 ha, and the cultivated area is increasing. The main cultivation sites are Nakhon Phanom, Sakon Nakhon, Mukdahan and Bueng Kan Provinces [4].

Saline soils contain a large amount of salt, especially in the form ofNaCl, and this affects plant growth, which causes agricultural problems [5]. Salinity is caused by improper use of the agricultural area, such as invading and destroying flood plans. There is very little conservation and restoration of the soil and water [6]. In conjunction with limited rainfall, high evaporation and high temperature, these problems are related to water and soil management. Especially, the evaporation of salt water results in the deposition of sodium chloride in the soil at a high intensity. Areas with low rainfall means there is no leaching of the salt from the soil, which results in a stressful, salty soil condition and therefore deterioration. In addition, it makes it difficult for plants to absorb water from the soil. This causes slow or interrupted plant development and growth [7]. The presence of salts in the soil solution results in a low water potential, which makes it harder for the roots of plants to absorb water, which causes plants to lose water. If the water potential in the plant is lower than the water potential of the soil, the osmotic phase first occurs. This occurs as soon as the plant takes-up salt, which leads to a decrease in the root and leaf adhesion rate due to osmosis. This inhibition of osmotic growth may continue for several days, resulting in a decrease in the growth rate. The proliferation of new leaves is slower and branching is disrupted, etc., after the plant has been exposed to salinity for a long period of time. Growth inhibition is directly affected by salt (ionic phase), not osmosis. The effects are associated with salt being directly absorb by plants as it becomes toxic to cells. At the same time, sodium inhibits the absorption of potassium, causing plants to lack potassium, which is a nutrient necessary for metabolic processes [8]. Another problem of salinity, in addition to affecting agriculture, is that it affects the economic conditions and environment. Salinity problems in Thailand are found both in the northeast, central and coastal areas [9]. Saline soils

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in the northeastern region cover as much as 2.85 million ha, or 17% of the land area, and there is the potential for salt to affect another 3.1 million ha [8]the problem of saline soil will become more serious in the future [6].

Saline soil has negative effects on many important physiological processes, and this leads to the inhibition of growth, which means economic crops, such as tomatoes have decreased yield. The knowledge of the differences between salt-tolerant and susceptible varieties is useful information for plant breeders to use in the selection of salt tolerant plants. The physiological characteristics commonly used in the selection of salt tolerant plants are the ability to maintain potassium ions in the tissue and the ability to balance osmosis by accumulation of compatible solutes, etc. [8], which results in osmotic balance by deposition of the compatible solute substances, so when the plants are given salt, the salt solution would reduce the water potential of the soil. The roots will not be able to absorb water from the soil; therefore, the plant adapts by accumulating compatible solute in the roots. This reduces the water potential of the roots and allows the plant to absorb the water. In addition to accumulating in the roots, the plant also collects them in other areas, such as stems or leaves, which gives continuous water availability [10].

The northeastern region of Thailand has the greatest tomato cultivation area in Thailand. At the same time, the northeast has the greatest salt-affected area in the country. As a result, farmers do not have enough space for cultivation, which causes both economic and social problems. Therefore, this research aimed to select the most salt-tolerant tomatoes from 26 varieties, which will give useful information for plant breeders to use when selecting salt tolerant tomatoes, which can be planted in saline soils in the future.

Material

Plant material and growing conditions

The plants used for the experiment were 26 cultivars of tomatoes, of which 20 were provided courtesy of the Center for Research and Development of Tropical Plants, Kasetsart University (LE001, LE002, LE003, LE004, LE017, LE027, LE029, LE043, LE054, LE076, LE089, LE095, LE104, LE107, LE122, LE141, LE153, LE159, LE164 and LE17). Two cultivars were provided courtesy of the Sisaket Horticultural Research Center, consisting of Sisaket 2 and Sisaket 19. There were four commercial cultivars: Epe-Chia Tai, Sida, Sweet Girl and Wild type. A Completely Randomized Design (CRD) trial was planned with two factors: factor 1, 26 tomato varieties and factor 2: the concentration of the sodium chloride solution at concentrations of 0 mmolar (before salt added) and 200 mmolar (after salt added). In total, three replicates were performed. Seeds were germinated on a sponge for seven days. Transferred to half-Hoagland's solution (modified) in a three litterpot. Air was add, via a pump, to the roots at all times to provide oxygen. Light was maintained at 16 hours a day, and the temperature was room temperature. The tomato seedlings were grown in a nutrient solution for 28 days, and data were collected on salt tolerance score, height and proline content. Then on day 29 the tomato seedlings were divided into two groups: control group and with sodium chloride added at a concentration of 200 mM for five days until the plants were 33 days, and the data collected after adding salt were salt tolerance score, height, proline content and dry weight.

Methodology

Salt tolerance score

The rating for the plant salinity tolerance, was expressed when receiving salt as scored 1-4, which was modified from Desgan et al. [11]; the salt tolerance score was 1-1.9: plants show no signs of damage, or show slight bending of the leaf edges. The salt tolerance score was 2-2.9: the old leaves are still green but the young leaves are slightly bent. The salt tolerance score was 3-3.9: almost all leaves, about 70-90 percent, are kinked and shriveled. The salt tolerance score was 4: the plant was wilting and dead (Figure 1).

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Figure 1 Scoring salt tolerance of tomato plants affected by sodium chloride salt.

Height and dry weight analysis

The height of the tomato stems were measured from above the root to the highest tip of the tomato plant. The plants were separated into shoots and roots, dried at 60 ° C for 48 hours and weighed with a fine balance.

Proline content analysis

Tomato leaves were collected and analyzed for proline content (µMol/g fresh weight) using a method adapted from Bates et al. [12] by weighing approximately 0.05 g of fresh leaves, crushed with 5 ml of 3% sulfosalicylic acid and filtered several times using number 2 filter paper. Then, 0.5 ml of the filtered solution was put into a test tube and 0.5 ml of acid ninhydrin and 0.5 ml of glacial acetic acid were added. It was heated at 100 ° C for 1 h, cooled to 0 ° C for about 10 min and then 2 ml of toluene was added. Then the reaction mixture with 2 ml of toluene was shaken for 15-20 seconds with a vortex mixer. The solution should separate. The upper solution was removed and used to measure the absorbance at 520 nm wavelength with a UV-Vis spectrophotometer.

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Analytical Statistics

Analysis of variance was used with the data, and the mean differences were tested using Tukey's HSD test with the SPSS program at the 95% confidence level.

Results

The salt tolerance score and characteristics of tomato plants (phenotype) were expressed after being exposed to salt. The experiment evaluated the damage symptoms of tomatoes under salt stress at a concentration of 200 mM for five days. It was found that the cultivars LE153 and LE001 tolerated salinity the best. The salt tolerance scores were 1.33 and 1.67, respectively. The plants showed no signs of damage or showed only slight leaf margin impacts, which was not different from before receiving salt. Cultivars LE003, LE104, LE002, LE004, LE122 and LE159 had salt tolerance scores of 2, 2, 2.33, 2.33, 2.67 and 2.67, respectively. Under which the plant shows signs of aging but remains green and the young leaves are bent in part. Cultivars LE029, LE095, LE141, LE164, wide type, Epe-Chia Tai and Sida had salt sensitive scores of 4. Under which the plant exhibited very severe damage, wilting leaves and death (Table 1).

Table 1 Salt tolerance score and phenotypes of tomatoes for each cultivar.

No.	Cultivar	Score	Phenotypes
1	LE153	1.33	Normal
2	LE001	1.67	Edge of leaf is slightly bent.
3	LE003	2	Old leaves withered but remain green. Young leaves are bent in part.
4	LE104	2	Old leaves withered but remain green. Young leaves are bent in part.
5	LE002	2.33	Old leaves withered but remain green. Young leaves are bent in part.
6	LE004	2.33	Old leaves withered but remain green. Young leaves are bent in part.
7	LE122	2.67	Old leaves withered but remain green. Young leaves are bent in part.
8	LE159	2.67	Old leaves withered but remain green. Young leaves are bent in part.
9	LE017	3	Almost 70-80% of leaves are kinked and withered.
10	LE076	3	Almost 70-80% of leaves are kinked and withered.
11	LE054	3	Almost 70-80% of leaves are kinked and withered.
12	LE107	3	Almost 70-80% of leaves are kinked and withered.
13	Sweet Girl	3	Almost 70-80% of leaves are kinked and withered.
14	Srisaket2	3.33	Almost 80-90% of leaves are kinked and withered.
15	Srisaket19	3.33	Almost 80-90% of leaves are kinked and withered.
16	LE171	3.33	Almost 80-90% of leaves are kinked and withered.
17	LE043	3.33	Almost 80-90% of leaves are kinked and withered.
18	LE089	3.33	Almost 80-90% of leaves are kinked and withered.
19	LE027	3.67	Almost 90% of leaves are kinked and withered.
20	LE029	4	Dead
21	LE095	4	Dead
22	LE141	4	Dead
23	LE164	4	Dead
24	Wild type	4	Dead
25	Epe-Chia Tai	4	Dead
26	Sida	4	Dead

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To establish the effect of salt on tomato heights, 26 tomato seedlings were transplanted into nutrient solution and grown for 28 days, and height data was collected before adding the sodium chloride salt solution the next day at a concentration of 200 mM. The plants were exposed to salt stress for five days until the plants were 33 days old. Height data was collected after adding the NaCl solution. The obtained data were used to compare the percentage increase in height between the different species. Comparing before and after NaCl was added, it was found that the cultivars with the greatest increases were LE153, LE095 and LE002 at 9.40, 7.46 and 6.42 percent, respectively. The cultivar with the lowest increase was LE027 at 1.76 percent. At 28 and 33 days, the highest cultivar was LE001 at 15.17 and 15.87 cm, respectively. The height was different statistically for the tomatoes before and after NaCl was added, as shown in Table 2.

Table 2.Heights of 26 tomato cultivars grown in nutrient solution compared before adding NaCl (28 day old plants) and after adding 200 mM of NaCl (33 day old plants).

Cultivar	**Height (cm)**		**Percentage increase**
	Before adding NaCl	After adding NaCl	
LE001	15.17 ± 1.64^{Aa}	15.87 ± 1.68^{Aa}	4.41
LE002	6.27 ± 0.43^{Afg}	6.70 ± 0.52^{Ae}	6.42
LE003	$8.67\pm1.20^{Ab-g}$	$9.07\pm1.22^{Ab-e}$	4.41
LE004	$10.43\pm0.92^{Ab-e}$	$11.10\pm0.97^{Ab-d}$	6.04
LE017	$10.30\pm1.23^{Ab-f}$	$10.60\pm1.35^{Ab-e}$	2.83
LE027	$11.33\pm0.44^{Aa-c}$	11.53 ± 0.46^{Bbc}	1.73
LE029	$8.80\pm0.44^{Ab-g}$	$9.30\pm0.38^{Ab-e}$	5.38
LE043	$11.77\pm0.67^{Aa-b}$	12.27 ± 0.78^{Aab}	4.07
LE054	$9.43\pm0.32^{Ab-g}$	$9.93\pm0.30^{Ab-e}$	5.04
LE076	$8.97\pm0.24^{Ab-g}$	$9.30\pm0.30^{Bb-e}$	3.55
LE089	$6.93\pm0.30^{Ae-g}$	7.23 ± 0.34^{Ade}	4.15
LE095	6.20 ± 0.12^{Ag}	6.70 ± 0.15^{Ae}	7.46
LE104	$8.93\pm0.64^{Ab-g}$	$9.23\pm0.69^{Ab-e}$	3.25
LE107	$8.53\pm0.90^{Ab-g}$	$9.00\pm0.96^{Ab-e}$	5.22
LE122	$8.83\pm0.78^{Ab-g}$	$9.33\pm0.81^{Ab-e}$	5.36
LE141	$6.43\pm0.30^{Ae-g}$	6.63 ± 0.34^{Be}	3.02
LE153	$7.13\pm0.47^{Ad-g}$	$7.87\pm0.55^{Ac-e}$	9.40
LE159	$8.97\pm0.52^{Ab-g}$	$9.40\pm0.58^{Ab-e}$	4.57
LE164	$9.60\pm0.70^{Ab-g}$	$9.80\pm0.71^{Bb-e}$	2.04
LE171	$8.93\pm0.80^{Ab-g}$	$9.13\pm0.86^{Bb-e}$	2.19
Srisaket2	$7.23\pm0.82^{Ad-g}$	$7.67\pm0.84^{Ac-e}$	5.74
Srisaket 19	$8.37\pm0.45^{Ab-g}$	$8.83\pm0.52^{Ab-e}$	5.21
Epe-Chia Tai	$7.33\pm0.72^{Ac-g}$	$7.60\pm0.70^{Ac-e}$	3.55
Sida	$6.80\pm0.40^{Ae-g}$	7.00 ± 0.40^{Bde}	2.86
Sweet Girl	$11.13\pm0.43^{Aa-d}$	11.57 ± 0.50^{Abc}	3.80
Wild type	$9.07\pm1.02^{Ab-g}$	$9.63\pm1.09^{Ab-e}$	5.82

*Means followed by uppercase letters for the same cultivarbetween before and after adding NaCl were statistically significantly different at the 95% confidence level.Lowercaseletters in the same column were statistically significantly different at the 95% confidence level.

Dry weights of tomato plants exposed to salinity stress for five days until they were 33 days old were recorded.The cultivar with the highest shoot dry weight was LE003 (0.1573 g) and highest root dry weight was LE159 (0.0197 g). The two cultivars with the lowest shoot dry weight when compared to the control (33 day old plants without NaCl added) were significantly different ($p \leq 0.05$), LE153 and LE003 had decreases of 7.69 and 8.01 percent, respectively. While the shoot dry weight with the highest drop was LE095 with a decrease of 72.85 percent. The percentage of root dry weight compared to the control group with the least decreasein the cultivar was LE153 at 7.69

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percent. The dry weight of the root had the greatest decrease at 70.84 percent (LE107). The top cultivar with shoot and root weight loss were closely related to LE153 (Tables 3 and 4).

Table 3. Shoot dry weight of 26 tomato cultivars comparing between control groups and the group receiving NaCl 200 mM when plants were 33 days old.

Cultivar	**Shoot dry weight** (g)		**Percentage decrease**
	Control	**NaCl 200mM**	
LE001	0.1973 ± 0.0012^{c}	0.1540 ± 0.0026^{ab}	21.95
LE002	0.1767 ± 0.0015^{ef}	0.0853 ± 0.0018^{i}	51.73
LE003	0.1710 ± 0.0012^{fg}	0.1573 ± 0.0022^{a}	8.01
LE004	0.2443 ± 0.0015^{b}	0.1437 ± 0.0023^{cd}	41.18
LE017	0.0653 ± 0.0009^{p}	0.0553 ± 0.0009^{k}	15.31
LE027	0.0853 ± 0.0015^{lm}	0.0760 ± 0.0012^{j}	10.90
LE029	0.1460 ± 0.0012^{h}	0.1260 ± 0.0012^{fg}	13.70
LE043	0.1153 ± 0.0015^{j}	0.0950 ± 0.0017^{h}	17.61
LE054	0.1350 ± 0.0012^{i}	0.0993 ± 0.0007^{h}	26.44
LE076	0.1147 ± 0.0009^{j}	0.0953 ± 0.0015^{h}	16.91
LE089	0.1050 ± 0.0017^{k}	0.0923 ± 0.0015^{hi}	12.10
LE095	0.1853 ± 0.0015^{ed}	0.0503 ± 0.0019^{k}	72.85
LE104	0.1863 ± 0.0022^{d}	0.1250 ± 0.0012^{g}	32.90
LE107	0.2850 ± 0.0012^{a}	0.1460 ± 0.0021^{bc}	48.77
LE122	0.1643 ± 0.0026^{l}	$0.1270\pm0.0012^{e-g}$	22.70
LE141	0.1390 ± 0.0017^{hi}	0.0747 ± 0.0023^{j}	46.26
LE153	0.1470 ± 0.0012^{h}	0.1357 ± 0.0019^{de}	7.69
LE159	0.2523 ± 0.0015^{b}	$0.1350\pm0.0017^{d-f}$	46.49
LE164	0.1333 ± 0.0027^{i}	0.0683 ± 0.0018^{j}	48.76
LE171	0.0923 ± 0.0015^{l}	0.0490 ± 0.0017^{k}	46.91
Srisaket2	0.1180 ± 0.0018^{j}	0.0567 ± 0.0015^{k}	51.95
Srisaket 19	$0.0723\pm0.0018^{n-p}$	0.0540 ± 0.0017^{k}	25.31
Epe-Chia Tai	0.0780 ± 0.0018^{mn}	0.0477 ± 0.0015^{k}	38.85
Sida	0.0753 ± 0.0018^{no}	0.0360 ± 0.0012^{l}	52.19
Sweet Girl	0.0670 ± 0.0018^{op}	0.0530 ± 0.0017^{k}	20.90
Wild type	0.1730 ± 0.0018^{fg}	0.1423 ± 0.0018^{cd}	17.75

*For the same cultivar between before and after adding NaClthat were not statistically significantly different at the 95% confidence level as shown bylowercaseletters in the same column.

Table 4. Root dry weight of 26 tomato cultivars compared between control group and group receiving NaCl 200 mM when plants were 33 days old.

Cultivar	**Root dry weight** (g)		**Percentage decrease**
	Control	**NaCl 200mM**	
LE001	$0.0223\pm0.0009^{Ac-e}$	0.0203 ± 0.0009^{Ba}	8.97
LE002	0.0247 ± 0.0015^{Acd}	$0.0090\pm0.0006^{Ad-h}$	63.56
LE003	$0.0183\pm0.0009^{Ad-g}$	$0.0077\pm0.0003^{Ad-i}$	57.92
LE004	0.0333 ± 0.0015^{Aab}	0.0177 ± 0.0009^{Aab}	46.85
LE017	0.0093 ± 0.0009^{Ahi}	$0.0043\pm0.0003^{Ah-j}$	53.76
LE027	0.0063 ± 0.0009^{Ai}	0.0023 ± 0.0003^{Aj}	63.49
LE029	$0.0203\pm0.0015^{Ac-f}$	$0.0110\pm0.0006^{Ac-e}$	45.81
LE043	0.0093 ± 0.0012^{Ahi}	$0.0067\pm0.0009^{Be-j}$	27.96
LE054	0.0080 ± 0.0017^{Ahi}	$0.0060\pm0.0012^{Bf-j}$	25.00
LE076	$0.0140\pm0.0021^{Af-h}$	$0.0097\pm0.0012^{Bc-g}$	30.71
LE089	$0.0123\pm0.0009^{Ag-i}$	$0.0103\pm0.0009^{Bc-f}$	16.26

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LE095	$0.0123\pm0.0009^{Ag-i}$	$0.0053\pm0.0003^{Ag-j}$	56.91
LE104	$0.0170\pm0.0017^{Ae-g}$	0.0143 ± 0.0015^{Bbc}	15.88
LE107	0.0367 ± 0.0015^{Aa}	$0.0107\pm0.0009^{Ac-f}$	70.84
LE122	$0.0110\pm0.0015^{Ag-i}$	$0.0087\pm0.0012^{Bd-i}$	20.91
LE141	$0.0137\pm0.0012^{Af-i}$	$0.0043\pm0.0003^{Ah-j}$	68.61
LE153	$0.0130\pm0.0006^{Af-i}$	0.0120 ± 0.0006^{Bcd}	7.69
LE159	0.0263 ± 0.0018^{Abc}	0.0197 ± 0.0015^{Aa}	25.10
LE164	0.0063 ± 0.0024^{Ai}	0.0040 ± 0.0015^{Bij}	36.51
LE171	$0.0113\pm0.0015^{Ag-i}$	$0.0063\pm0.0009^{Be-j}$	44.25
Srisaket2	0.0093 ± 0.0009^{Ahi}	$0.0060\pm0.0006^{Af-j}$	35.48
Srisaket 19	0.0073 ± 0.0009^{Ahi}	$0.0063\pm0.0009^{Be-j}$	13.70
Epe-Chia Tai	0.0067 ± 0.0012^{Ahi}	$0.0053\pm0.0009^{Bg-j}$	20.90
Sida	$0.0113\pm0.0009^{Ag-i}$	$0.0043\pm0.0003^{Ah-j}$	61.95
Sweet Girl	0.0070 ± 0.0012^{Ahi}	$0.0053\pm0.0009^{Bg-j}$	24.29
Wild type	$0.0240\pm0.0017^{Ac-e}$	0.0170 ± 0.0012^{Aab}	29.17

*Means followed by uppercase letters for the same cultivarbetween before and after adding NaCl were statistically significantly different at the 95% confidence level.Lowercaseletters in the same column were statistically significantly different at the 95% confidence level.

For the proline content of tomatoes growing in salinity, the cultivar LE029 had the highest levels (35.62 µmole/g FW) after plants were exposed to salinity stress for five days until the plants were 33 days old. This level was followed by LE054 (24.22 µmole/g FW) and LE043 (10.12 µmole/g FW), while Srisaket2 had the lowest levels of proline content (1.23 µmole/g FW). LE029 had 28.96 times the proline contentof LE043. The cultivarsLE029, LE107 and LE141 had the greatest increase in the proline content compared to the control at 64.76, 63.45 and 63.25 times, respectively. The tomato cultivars LE153, LE164 and LE171 had the lowest increase in proline content when compared to the control at 5.55, 5.90 and 6.00 times, respectively (Table 5).

Table 5.Proline content of 26 tomato cultivars grown in nutrient solution comparing before adding NaCl (28 day old plants) and after adding 200 mM of NaCl (33 day old plants).

Cultivar	Proline content (µmole/g FW)		**Change (times)**
	Before adding NaCl	After adding NaCl	
LE001	$0.271\pm0.066^{b-d}$	2.672 ± 0.044^{kl}	9.89
LE002	$0.201\pm0.017^{c-e}$	$3.602\pm0.026^{j-l}$	18.00
LE003	$0.191\pm0.026^{c-e}$	$3.794\pm0.208^{i-l}$	19.95
LE004	$0.231\pm0.035^{c-e}$	1.461 ± 0.245^{l}	6.35
LE017	0.501 ± 0.017^{a}	$8.635\pm0.200^{c-e}$	17.28
LE027	0.531 ± 0.017^{a}	9.167 ± 0.096^{cd}	17.30
LE029	0.553 ± 0.027^{a}	35.624 ± 2.652^{a}	64.76
LE043	0.511 ± 0.036^{a}	10.121 ± 0.336^{c}	19.84
LE054	0.501 ± 0.017^{a}	24.218 ± 0.693^{b}	48.44
LE076	0.421 ± 0.056^{ab}	$6.694\pm0.054^{d-i}$	15.93
LE089	$0.231\pm0.017^{c-e}$	$8.454\pm0.017^{c-f}$	36.74
LE095	0.098 ± 0.009^{e}	$5.453\pm0.096^{f-k}$	54.50
LE104	$0.184\pm0.009^{c-e}$	$4.222\pm0.046^{h-l}$	23.44
LE107	0.081 ± 0.005^{e}	$5.062\pm0.065^{g-k}$	63.25
LE122	0.117 ± 0.012^{e}	$7.494\pm0.395^{c-g}$	62.42
LE141	0.111 ± 0.006^{e}	$6.984\pm0.046^{d-h}$	63.45
LE153	0.308 ± 0.050^{bc}	1.723 ± 0.101^{l}	5.55
LE159	$0.211\pm0.026^{c-e}$	1.534 ± 0.018^{l}	7.29
LE164	0.301 ± 0.026^{bc}	1.771 ± 0.017^{l}	5.90
LE171	$0.221\pm0.026^{c-e}$	1.322 ± 0.018^{l}	6.00
Srisaket2	$0.171\pm0.017^{c-e}$	1.233 ± 0.017^{l}	7.24
Srisaket 19	0.141 ± 0.017^{de}	1.262 ± 0.017^{l}	9.00

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Epe-Chia Tai	$0.201\pm0.017^{c-e}$	1.431 ± 0.027^{l}	7.15
Sida	$0.171\pm0.017^{c-e}$	1.352 ± 0.017^{l}	7.94
Sweet Girl	$0.201\pm0.017^{c-e}$	$3.384\pm0.017^{j-l}$	16.90
Wild type	0.144 ± 0.015^{de}	$5.765\pm0.037^{e-j}$	41.21

*For the same cultivars between before and after adding NaClwith no statistically significantly differences at the 95% confidence level were shown bylowercaseletters in the same column.

Discussion

For the plants that were least affected by salt, there was a phenotypic expression that had the least differences from plants not exposed to salt stress. Some plants exhibited a strong response to salt, such as the leaves becoming kinked and withered with theplant wilting until the plant dies. The old leaves began to die due to the accumulation of salt that is toxic as the salts are dissolved in the liquid in the xylem and move into the leaves all the time.

When a plant has a high rate of transpiration, it results in increasing the salt that enters the plant. The accumulated salt content is thus increasing until the leaves wither and die [11]. In plants susceptible to salinity (salt sensitive), leaf death can occur within a few days after exposure to high concentrations of salt, but in a salt tolerant plant, it can take several weeks. For salt sensitive plants, the death rate of mature leaves is faster than the growth rate of young leaves. The photosynthesis rate will continue to decline until the plant dies [8]. Different plant cultivars have different salt tolerances [13]. Therefore, thesalt tolerance score is a factor for the selection of salt tolerant plants.

Salt also affects the growth of plants, such as the height,shoot dry weightand root dry weight, thereby reducing the plant growth. This is consistent with the research by Ghars et al. [14], who studied tomato and found that a high concentration of sodium chloride solution resulted in the height and weight of the plant decreasing. The decrease in the plant growth rate was due to the change in thewater potential in the soil. Salt reduces the water potential. Therefore, plant roots absorb less water while the plants are transpiringand a loss of water occurs. When the water content of a plant is insufficient, mechanisms are disrupted and they affect both the heightand weight of the plant [15]. It also results in an imbalance in the water potential between the apoplasts and the symplasts of the plant cells. Water will move outside the cells. This causes a loss of water from the cells, resulting in a loss of firmness in the cells, which causes a decrease in plant growth [16].

Plants in saline soils tend to accumulatecompatible solutes, such as proline, sugar and glycine betaine, etc. Plants adapt by accumulating compatible solutes in the roots. This reduces the water potential of the roots and allows the plant to absorb water. In addition to accumulating in the roots, the plant also collects them in other areas, such as the stems or leaves, which helps maintain constant water availability [10]. This substance, although it is deposited in high amounts in the cell, does not interfere with cell processes and enzymes and does not cause a change in the pH in the cell [17]. The level of proline content deposition is different, as it depends on the type of plant, it may increase by only two to many times that of control plants that do not receive salt. In addition, different cultivars of the same plant have different levels of proline content accumulation. Salt tolerant cultivars accumulated proline more than sensitive cultivars, such as sunflower or wheat, etc. However, in some plants the opposite was found where sensitive cultivars accumulated proline more than the salt tolerant ones, such as in tomatoes and green beans, etc.[18]. In which plants may accumulate a compatible solute to form substances other than proline.

Conclusion

For the selection of 26 cultivars of salt tolerant tomatoes, they were grown in a nutrient solution until 28 days old, and then 200 mM of sodium chloride concentrate was added. After five days, the salinity tolerance score of the tomato plant was assessed after exposure to salt. It was found that the plants had a range of salt tolerance scores from 1 to 4, and the salt tolerance score for the phenotype of the plants showed slight bending of the leaf edgesto dead. The cultivars LE153 and LE001 tolerated salinity the best.Height,shoot dry weightand root dry weight, thereby reducing the plant growth. It was found that the cultivars with the highest increase were LE153, LE095 and

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LE002.In addition, the percentage of shoot and root dry weight compared to the control group,slightest decreasedin cultivar LE153.From this research, it was found that the measurement of proline in tomatoes in cultivar LE029 was the highest levelsand cultivars LE153, LE164 and LE171 had the lowest increases in proline content, when compared to the control.It was found that the cultivar LE153 had the best salinity tolerance. This cultivar has the highest score and best growth rate, but the lowest accumulation of proline, so it may accumulate another substance.This cultivar is therefore an alternative for farmers to grow tomatoes in saline areas.

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