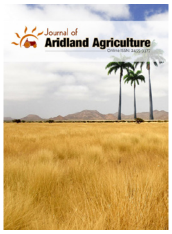
Journal of Aridland Agriculture 2021, 7: 76-82
doi: 10.25081/jaa.2021.v7.6588
http://updatepublishing.com/journal/index.php/jaa

Research Article



ISSN: 2455-9377

Effect of salinity on seed germination of some tomato (*Lycopersicon esculentum* Mill.) varieties

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Received: November 12, 2020
Revised: May 20, 2021
Accepted: May 22, 2021
Published: June 11, 2021

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ABSTRACT

Salinity adversely affects 20-30% of the irrigated area in the world. Tomato is sensitive to salinity. It is one of the most severe abiotic factors of many agricultural crops and it becoming the main problem in Ethiopia. This study was conducted to evaluate the effects of different salinity levels on the seed germination parameters of tomato varieties. It was laid out in a completely randomized design with three replicates. The treatment included four tomato varieties (Sirinka, Weyno, ARP D2, and Roma VF) and five salinity levels (1 dS m^{-1}, 2 dS m^{-1}, 3 dS m^{-1}, 4 dS m^{-1} and control). Fifty seeds were placed in a Petri dish over a moistened germination paper for germination and seedlings and allowed to grow for 14 days. The germination rate, speed and energy of tomato seeds were significantly ($p < 0.001$) affected by the combined effect of variety and salinity. The shortest mean germination time, the highest mean germination rate, and the highest speed of germination were recorded in the ARP D2 variety in the control treatment. The lowest first and last days of germination, and the uncertainty of germination were recorded from ARP D2. However, an increase in the days of germination and in the uncertainty of germination, and a decrease in the germination index and total germination percentage trends were observed with increasing salinity levels. The highest level of salinity (4 dS m^{-1}) affected the germination of tomato varieties. Among the four tested tomato varieties, ARP D2 and Roma VF were tolerant to salinity.

KEYWORDS: Germination index, Germination percentage, Mean germination time, NaCl, Rate of germination, Uncertainty of germination

INTRODUCTION

It is assumed that ten percent of the world croplands are affected by salinity. About 20-30% of the irrigated area maybe salt-affected (El-Zanaty *et al*., 2006) and up to 37% may be saline, sodic, or waterlogged (Ozcoban & Demir, 2006). Salinity in agricultural soils refers to the presence of a high concentration of soluble salts in the soil moisture of the root zone (El-Zanaty *et al*., 2006). Currently, it is one of the most severe abiotic factors in many agronomic and horticultural crops (Nasrin & Mannan, 2019). This resulted in a reduction in cultivated land size, crop productivity, quality and biomass, especially in arid and semi-arid irrigated areas (Shahbaz & Ashraf, 2013).

Salt in the soil affects plant growth by restricting the uptake of water and interfering with the balanced absorption of essential mineral ions by plant roots (El-Zanaty *et al*., 2006). Salt tolerance is a developmentally regulated stage-specific phenomenon. Assessment of salt tolerance should be evaluated separately for every developmental stage of the plant; where seeds germination is the first exposure of the crop to salinity stress (Ozcoban & Demir, 2006). Germination, emergence, and early seedling growth are salinity sensitive stages of crop development (Jamil *et al*., 2005). Salinity disrupts crop establishment by decreasing the germination percentage and delaying seedling emergence (Siddiky *et al*., 2014) and decreases the yield at a later stage (Rahman *et al*., 2018). Excessive uptake of ions causes toxicity, and reduced water availability between the seeds and the outer environment thereby inhibiting primary root emergence (Delachiave & dc-Pinho, 2003). Chloride and sulfate (Khajeh-Hosseini *et al*., 2003) salts of sodium and calcium (mainly NaCl and $CaSO_4$) are the major soluble salts contributing to the very high salinity level of soils (Auge *et al*., 2018).

The management of saline conditions in the fields and greenhouses would be expensive and temporary, while the selection for salt tolerance is a wise solution to minimize salinity effects and improve production efficiency (Nasrin & Mannan, 2019). Screening of varieties during seed germination is commonly used because the process is rapid and is easily quantifiable. It allows the identification of genotypes that are able to germinate and emerge rapidly in salt-affected soils (Ketema & Dessalegne, 2006). The tolerance of crops to salinity varies among species and genotypes (Campos *et al.*, 2006).

In Ethiopia, the rainfall duration is short with erratic distribution; tomato production is based on the use of irrigation water. However, the quality of the irrigation water is unknown. Salt-affected soils are becoming the main problem in Ethiopia (Seid & Genanaw, 2013) which greatly hamper tomato production. Tomato is a cash crop, and widely produced by small-scale and commercial growers under irrigation (Ketema & Dessalegne, 2006). The tomato plant varies in its tolerance to salinity stress depending on the cultivar and growth stage (Estan *et al.*, 2005).

Tomato cultivars have significant variations in responses for salinity levels (Kazemi *et al.*, 2014). The germination percentages decline as salinity levels increase (Zhang *et al.*, 2010; Ratnakar & Rai, 2013). According to Maas and Hoffman (1977), the maximum soil salinity tolerated by the tomato is 2.5 dS m^{-1}, with a production reduction of 9.9% for each unit increase in salinity above this limit. On the other hands, the use of irrigation water with electrical conductivity of 1.7, 2.3, 3.4, and 5.0 dS m^{-1} resulted in 0%, 10%, 25% and 50% of the tomato yield reduction, respectively (Campos *et al.*, 2006).

The selection of cultivars and identification of tolerance levels is a paramount important intervention option for tomato production in saline soils. The least affected genotypes can be a potential source of salinity tolerance for tomato production and breeding. Therefore, the aim of this study was to evaluate the effects of different salinity levels on seed germination of tomato varieties under laboratory conditions.

MATERIALS AND METHODS

The study was conducted in the laboratory of the plant science department, College of Agriculture, Wollo University, Ethiopia, in 2020. The average temperature of the laboratory during the study was 19 °C. Seeds of tomato varieties were collected from the Sirinka Agricultural Research Center and Melkassa Agricultural Research Center (MARC); and the seeds of each released variety were multiplied in the Sirinka Agricultural Research center, Jari Branch, Ethiopia. Insects and disease-free and good-sized seeds were selected and are used in the experiment. Laboratory grade sodium chloride (NaCl) was used to induce salinity during seed germination, and salt concentration was expressed in millimoles (mM). A factorial experiment was conducted using four tomato varieties (Sirinka, Weyno, ARP D2, and Roma VF) and five levels of salinity (1 dS m^{-1}, 2 dS m^{-1}, 3 dS m^{-1}, 4 dS m^{-1} and control). Different salinity levels were prepared using different concentrations of NaCl solution. The experiment was laid out in a completely randomized design (CRD) with three replicates.

Under aseptic conditions, fifty seeds of each variety were placed on sterilized one layered Whatman No. 1 filter paper in a Petri dish, where seeds were evenly spaced. Then each filter paper was moistened once with 5 ml distilled water, and NaCl solutions according to the treatments. Thereafter, the filter paper was kept moist using distilled water until the experiment completed.

Data Collection

The germination process was monitored from the day of seed sowing to the 14th day. Seeds were considered to have germinated when the radicle was 2 mm in length (Maggio *et al.*, 2007). The germinated seeds were counted daily and completed on the 14th day after sowing. The following parameters were calculated based on the collected data.

The Mean germination time (days): was calculated using the equation described by Ranal *et al.*, (2009).

$$MGT = \frac{\sum n_i t_i}{\sum n_i}$$

Where, *ti*: days from the start of the experiment to the i^{th} observation; *ni* is the number of seeds germinated on the i^{th} day (not the cumulative number)

Mean germination rate (MGR): was the reciprocal of the mean germination time (Ranal *et al.*, 2009).

$$MGR = \frac{1}{MGT}$$

The Speed of germination (%): was calculated using the equation described by Krishanasamy and Seshu (1990).

$$SoG = \frac{Number\ of\ seeds\ germinated\ on 4th\ day}{Number\ of\ seeds\ germinated\ on 14th\ day} * 100$$

Germination energy (%): was recorded on the 4th day after sowing, as the percentage of germinating seeds on the 4th day after planting relative to the total number of seeds tested (Bam *et al.*, 2006).

$$GE = \frac{Total\ number\ of\ seeds\ germinated\ on 4th\ day}{Total\ number\ of\ seeds\ tested} * 100$$

The First day of germination (day): was the day on which the first germination event occurred.

Last day of Germination (day): was the day on which the last germination event occurred.

Uncertainty of the germination process: This was calculated as described by Ranal *et al.*, (2009).

$$U = -\sum f_i log_2 f_i$$

Where $f_i = \frac{n_i}{\sum n_i}$ and n_i: number of seeds germinated on the i_{th} day

Germination index: This was calculated as described in the Association of Official Seed Analysts (Kader, 2005) using the following formula:

$$GI = \sum_{t=1}^{k} \frac{n_i}{t_i}$$

where *ti*: days from the start of the experiment to the i^{th} observation; *ni*: number of seeds germinated on the i^{th} day (not the cumulative number); *k*: last day of observation.

The Total germination percentage (%): was calculated as described by Ranal *et al.*, (2009)

$$FGP = \frac{Total\ number\ of\ seeds\ germinated}{Total\ number\ of\ seeds\ tested} * 100$$

Data Analysis

The collected data were statistically analyzed using the GenStat 12^{th} version of the computer package. The significance of treatment means differences were compared using the least significant difference at the 1% probability level.

RESULT

Mean Germination Time

The mean germination time was significantly influenced ($P < 0.001$) by the combined effects of tomato variety and salinity (Table 1). The maximum mean germination time (10.705 days) was recorded from the Sirinka variety at 4 dS m^{-1} followed by the same variety at 3 dS m^{-1} salinity level. The ARP D2 variety in the control treatment had the shortest mean germination time (4.676 days), but it was not significantly different from the same variety at 1 dS m^{-1} and Roma VF in the control treatment (Table 2). The Sirinka variety took more time to germinate than the other varieties. When the salinity level increased the mean germination time was increased in each variety. When compared to the control treatment, the 4 dS m^{-1} resulted in a significant delay in mean germination time by 25.7%, 36.1%, 45.8% and 34.8% for Roma VF, ARP D2, Sirinka and Weyno varieties respectively (Table 2).

Mean Germination Rate

The interaction effects of salinity and variety was significant difference ($p < 0.01$) in the mean germination rates (Table 1). In each variety, the germination rate gradually decreased as the salinity level increased. The highest mean germination rate (0.214) was recorded from ARP D2 in the control treatment followed by Roma VF in the control, and ARP D2 at 1 dS m^{-1}. The minimum mean germination rate (0.0934) was recorded from the Sirinka variety at the 4 dS m^{-1} salinity level, but it was not significantly different from the same variety at 3 dS m^{-1} (Table 2). The 4 dS m^{-1} treatment reduced the mean germination rate of the Sirinka variety by 46% compared to the control treatment.

Speed of Germination

The tomato seeds germination speed was significantly affected by the combined effects of variety and salinity (Table 1, $p < 0.001$). The ARP D2 variety in the control treatment showed the highest speed of germination (59.1 %), but it was not significantly different from Roma VF in the control treatment. The Weyno variety at the 4 dS m^{-1} salinity level did not show any germination speed. In addition, the Sirinka variety did not show

Table 1: ANOVA results of the effect of salinity on the Mean germination time (MGT), Mean germination rate (MGR), Speed of germination (SoG), Germination energy (GE), First day of germination (FDG), Last day of germination (LDG), Uncertainty of germination (UoG), Germination index (GI), and Total germination percentage (TGP) of tomato varieties

Source of variation	df	Mean squares								
		MGT	MGR	SoG	GE	FDG	LDG	UoG	GI	TGP
Varieties (V)	3	18.978***	0.00796***	2977.46***	2327.18***	0.6**	12.55**	1.49***	14.64***	378.13***
Salinity (S)	4	18.171***	0.00836***	1998.05***	1487.57***	0.72***	9.75*	1.59***	22.41***	137.60**
V x S interaction	12	1.086***	0.00016**	335.33***	219.79***	0.16ns	1.16ns	0.05ns	0.21ns	38.36ns
Error	40	0.116	0.00005	35.05	27.27	0.1	2.867	0.04	0.34	28.67

ns, not significant; *P<.05; **P<.01; ***P < .001.

Table 2: The interaction effect of salinity levels and varieties on mean germination time (days) and mean germination rate of tomato seed

Salinity (dS m^{-1})	Mean germination time (day)				Mean germination rate			
	Variety				Variety			
	Roma VF	ARP D2	Sirinka	Weyno	Roma VF	ARP D2	Sirinka	Weyno
0	5.093	4.676	5.798	5.689	0.1969	0.2140	0.1726	0.1759
1	5.452	5.148	6.841	6.407	0.1836	0.1947	0.1465	0.1564
2	5.769	5.621	7.615	7.371	0.1734	0.1780	0.1317	0.1364
3	5.928	6.526	9.638	8.093	0.1687	0.1532	0.1041	0.1236
4	6.854	7.312	10.705	8.721	0.1461	0.1371	0.0934	0.1149
LSD (1%)	0.752				0.0160			
CV (%)	5.0				4.7			

LSD: List significant difference; CV: Coefficient of variation any significant difference in the speed of germination among all treatments (Table 3). In all varieties as the salinity levels increased the speed of germination decreased.

Germination Energy

The germination energy of tomato seeds was significantly affected by the combined effects of variety and salinity (Table 1, $p < 0.001$). The highest germination energy was recorded from the Roma VF variety (52.67 %) in the control treatment, but it was not significantly different from ARP D2 in the control treatment. The Weyno variety at the 4 dS m^{-1} salinity level did not show any germination energy. In addition, the Sirinka variety did not show any significant difference in germination energy among all treatments (Table 3).

First and Last Days of Germination

Based on ANOVA results, varieties and salinity significantly affected the first and last days of tomato seed germination while the interaction between them was insignificant (Table 1). The variation in the first and last days of germination of the tomato varieties was significant difference (Table 1, $P < 0.01$). The Roma VF variety had the shortest first day (4) of germination, but it was not significantly different from the ARP D2 variety (Table 4). The ARP D2 variety had the shortest last day (10.93) of germination. This indicates that the ARP D2 variety has a faster initiation and ending of germination than the other varieties. Salinity significantly affected both the first and last days of germination of tomato seeds at $p < 0.001$ and $P < 0.05$ respectively (Table 1). Tomato seeds in the control treatment showed the shortest first and last days of germination, but they were not significantly different with tomato seeds at 1-3 dS m^{-1}. Both the first and last days of germination increased as salinity level increased.

Table 3: The interaction effect of salinity and varieties on speed of germination (SoG) and germination energy (GE) of tomato seeds

Salinity (dS m^{-1})	Speed of germination (%)				Germination energy (%)			
	Variety				Variety			
	Roma VF	ARP D2	Sirinka	Weyno	Roma VF	ARP D2	Sirinka	Weyno
0	56.62	59.10	6.43	16.44	52.67	44.67	6.00	15.33
1	45.76	30.16	3.02	8.36	42.67	24.00	2.67	7.33
2	31.55	11.39	2.17	2.17	28.00	9.33	2.00	2.00
3	21.76	3.37	0.74	0.68	18.00	2.67	0.67	0.67
4	8.48	0.95	0.83h	0.00	7.33	0.67	0.67	0.00
LSD (1%)	13.073				11.531			
CV (%)	38.2				39.1			

LSD: List significant difference; CV: Coefficient of variation

Table 4: Effect of Varieties on First day of germination (FDG), Last day of germination (LDG), Uncertainty of germination (UoG), Germination index (GI) and Total germination percentage (TGP) of tomato seeds

Variety	FDG (day)	LDG (day)	UoG	GI	TGP (%)
ARP D2	4.133	10.93	1.970	7.227	78.67
Sirinka	4.400	12.33	2.616	6.224	89.87
Weyno	4.400	12.93	2.639	6.561	85.73
Roma VF	4.000	12.80	2.302	8.463	88.67
LSD (1%)	0.312	1.67	0.194	0.581	5.28
CV (%)	7.5	13.8	8.3	8.3	6.2

LSD: List significant difference; CV: Coefficient of variation

Uncertainty and Index of Germination

The uncertainty and index of germination were significantly affected ($p < 0.001$) by both variety and salinity (Table 1). Variety ARP D2 had the lowest uncertainty of germination (1.970) followed by Roma VF. In terms of the germination index, the highest (8.463) was recorded in the Roma VF followed by the ARP D2 variety (Table 4). The highest uncertainty of germination was recorded at 4 dS m^{-1} salinity level but not significantly different from 3 dS m^{-1}. However, the lowest uncertainty of seeds germination was recorded in the control. In contrast, the control recorded the maximum germination index, while 4 dS m^{-1} showed the lowest germination index (Table 5). The uncertainty and index of germination decreased as salinity level increased.

Total Germination Percentage

The analysis of variance showed that the total germination percentage was significantly ($p < 0.001$) affected by variety (Table 1). The highest total seed germination percentage (89.87%) was recorded in the Sirinka variety, but it was not significantly different from the Roma VF and Weyno. The lowest total germination percentage (78.67%) was observed in the ARP D2 variety (Table 4).

Salinity also significantly affected the total germination percentage of tomato seeds (Table 1, $P < 0.01$). Tomato seeds germinated better in the absence of salt stress, with germination percentages ranging from 80.00% to 88.00%. The lowest total germination percentage was recorded at 4 dS m^{-1} salinity level, but it was not significantly different with 3 dS m^{-1} (Table 5). The results indicated that, the 4 dS m^{-1} reduced the total germination percentage by 9.1%, 8.3%, 9.1%, and 6.1% compared to the control, 1 dS m^{-1}, 2 dS m^{-1}, and 3 dS m^{-1} salinity levels respectively. This shows that as the salinity level increased the total germination percentage decreased.

Table 5: Effect of salinity levels on First day of germination (FDG), Last day of germination (LDG), Uncertainty of germination (UoG), Germination index (GI) and Total germination percentage (TGP) of tomato seeds.

Salinity (dS m^{-1})	FDG (days)	LDG (day)	UoG	GI	TGP (%)
0	4.000	10.92	1.823	8.799	88.00
1	4.000	12.00	2.261	7.936	87.33
2	4.250	12.17	2.430	7.270	88.00
3	4.333	13.00	2.671	6.268	85.33
4	4.583	13.17	2.725	5.321	80.00
LSD (1%)	0.349	ns	0.217	0.650	5.91
CV (%)	7.5	13.8	8.3	8.3	6.2

LSD: List significant difference; CV: Coefficient of variation

DISCUSSION

Salinity is a major environmental factor that adversely affects the germination, growth and yield of tomato plants. Germination is a critical process in a plant's life cycle and is highly sensitive to adverse environmental factors. The use of salt-tolerant varieties can be an alternative strategic approach to minimize production problems in saline arable lands. Hence, in this study the responses of four tomato varieties were evaluated for germination at four different salinity levels (1 – 4 dS m^{-1}).

The combined effects of tomato varieties and salinity levels were significantly affected by the mean germination time, mean germination rate, speed of germination and germination energy. The highest mean germination time was recorded from the Sirinka variety at 4 dS m^{-1} salinity level. The highest mean germination rate, speed of germination and germination energy were recorded in the ARP D2 and Roma VF varieties in the control treatment. This indicates that the Sirinka variety is more sensitive to salinity than the other varieties. The combined effect of variety and salinity had a significant effect on the mean germination rate (Cunhua *et al.*, 2012; Sardoei and Mohammadi, 2014; Moles *et al.*, 2019), mean germination time (Sholi 2012; Chakma & Hossain, 2019), speed of germination (Nasrin & Mannan, 2019; Moles *et al.*, 2019) and germination energy (Nasrin & Mannan, 2019), which supports the findings of this study.

In this study, variations were observed among the tested tomato varieties in terms of mean germination time, mean germination rate, speed of germination and germination energy. These results are in agreement with the findings of Sardoei and Mohammadi (2014) on the mean germination rate and Nasrin and Mannan (2019) on the germination energy of tomato varieties. In tomato, the speed of germination, mean germination time, mean germination rate and germination energy under osmotic conditions depend on the genetic background (Foolad *et al.*, 2007).

When the salinity level increased the mean germination rate, speed of germination and germination energy was decreased, but the mean germination time was increased. This negative correlation varies depending on the salt concentration. A low level of salt stress induce seed dormancy while, a high level inhibit seed germination. This is due to the effects of high osmotic potential and specific ion toxicity (accumulation of Na^+ and Cl^- ions) (Khan & Weber, 2008). The present findings are in line with previous reports on the mean germination rate (Cunhua *et al.*, 2012; Sardoei & Mohammadi, 2014), speed of germination (Nasrin & Mannan 2019), germination energy (Nasrin & Mannan, 2019) and mean germination time (Chakma & Hossain, 2019) of the tomato seeds. Salinity notably affects germination in many species but also increases the time required to complete germination (Nawaz *et al.*, 2011). The germination rate was significantly inhibited by salt stress, and the degree of inhibition increased with increasing salt concentration. The rate of seed germination under salt stress can be recognized as the basis for determining the salt-tolerance of plants (Cunhua *et al.*, 2012).

The tested tomato varieties also varied in their responses to salinity. Hence, the ARP D2 variety had the lowest total germination percentage, the last days of germination, and the uncertainty of germination. Roma VF had the lowest first day of germination and the highest germination index. According to different authors, tomato varieties respond differently to total germination percentage (Sardoei & Mohammadi, 2014; Chakma & Hossain, 2019; Moles *et al.*, 2019; Nasrin & Mannan, 2019) and germination index (Chakma & Hossain, 2019) which supports these findings. These observed variations in seed germination responses over different salinity levels indicate the different behaviors of individual tomato varieties. This can be due to the genetic makeup of tomato varieties or the somatic quality of seeds. Genotypes that germinate earlier at higher salinity are supposed to be more vigorous and may be used as parents or potential donors in salinity tolerant crop breeding programs (Nawaz *et al.*, 2011) or to survive in highly fluctuating salinity.

These results demonstrated that, the total germination percentage and germination index decreased with increased salinity levels. However, the first day of germination, last days of germination and uncertainty of germination increased. High salinity has been reported as an environmental constraint that adversely affects crop productivity (Sardoei & Mohammadi, 2014). This is in agreement with the present findings, where the germination parameters of tomato seeds were affected at 4 dS m^{-1} but not completely arrested. This showed that tomato seeds exhibited some degree of tolerance at these concentrations, and this tolerance tended to decreases with an increase in salinity. It has also been reported that salinity decreases the germination percentage (Cunhua *et al.*, 2012; Chakma & Hossain, 2019; Moles *et al.*, 2019; Nasrin & Mannan, 2019) and germination index (Chakma & Hossain, 2019) of tomato seeds and increases the duration of germination of sweet sorghum (Sholi, 2012). The salinity notably affects germination in many species by lengthening the time needed to complete germination (Nawaz *et al.*, 2011) which conforms with this study. The present study also revealed an extended period of the first and last days of germination under saline conditions. The negative effect of salinity on seed germination might be due to salinity-induced ionic imbalance or toxicity (Panuccio *et al.*, 2014).

There was no significant difference between the control and lower salinity levels (1 – 3 dS m^{-1}) on the total germination percentage, germination energy and first days of germination. However, the other germination parameters (mean germination time, mean germination rate, speed of germination, last day of germination, the uncertainty of germination and germination index) were significantly affected. Salinity can influence the germination process by altering the imbibition of water by the seeds (Khan & Weber, 2008). The high accumulation of Na^+ in the medium causes osmotic and pseudo-drought stress, leading to a decrease in water absorption by the seeds (Farhoudi & Tafti, 2011). Moreover, salinity can cause changes in physiological processes such as changes in the metabolism of nucleic acids and proteins (Gomes-Filho *et al.*, 2008); disturbance of hormonal balance (Ryu & Cho, 2015), and reduction in the use of seed reserves (Othman *et al.*, 2006).

Under saline conditions, genotypes that maintain higher germination responses are salt-tolerant and produce higher biomass and yield (Zhang *et al.*, 2010). In the present study, the Sirinka variety had more time to germinate than the other varieties. Even in the control treatment, it took equal mean germination time with ARP D2 and Roma VF varieties at 3 dS m^{-1}. Hence, based on most germination parameters, ARP D2 and Roma VF can be supposed to be salt-tolerant, while Sirinka is supposed to be a salt-sensitive variety. It seems that the differences in germination parameters of tomato varieties may be due to genetic makeup and inherent variations among them (El Naim *et al.*, 2012).

Germination rate, germination potential, germination speed and germination index are important indicators for evaluating the plant's salt tolerance during seed germination (Li *et al.*, 2020). The mean germination time and germination index are known indicators of the seed germination rates. A higher germination index and lower mean germination time represent faster seed germination (Panuccio *et al.*, 2014). The results of this study indicated that high salinity negatively affected the mean germination rate, germination index, germination energy and germination time of tomato varieties. Similar results have been reported for spinach (keshavarzi *et al.*, 2011).

CONCLUSION

The germination parameters of tomato varieties were significantly affected by salinity levels and salt tolerance of the varieties were varied significantly with salinity levels. The tomato varieties responded differently to increased levels of salinity. Based on most of the germination parameters, the ARP D2 and Roma VF showed tolerance to an increased level of salinity. The total germination percentage, germination energy and first days of germination were not significantly difference between the control and lower salinity levels (1 – 3 dS m^{-1}). The mean germination time, mean germination rate, speed of germination, last days of germination, uncertainty of germination and germination index were all significantly affected by high salinity levels. Hence, the highest salinity level (4 dS m^{-1}) significantly affected most of the germination parameters.

ACKNOWLEDGEMENT

We would like to acknowledge Wollo University for the financial support to conduct this study.

Data Availability Statement

All data are included in the manuscript, but we can provide any inquiry up on request.

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