Preliminary study on the effect of temperature and salinity on germination and growth at the early seedlings stages of tomato (*Lycopersicon esculentum* Mill.).

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Abstract

Laboratory experiment in Petri dishes was conducted to know the effect of different temperatures C on seed germination of tomato varieties (Supermarimond and Castle)(15 , 20 , 25 , 30 and 35 Rock) . Results showed that , the appropriate temperature for germination was ranged between (20 - 30)C for both varieties seeds , and the highest percentages of seeds germination of Supermarimond %86) occurred after three days of the beginning -83 % %93) whereas , for Castle Rock was (-91 %(process of seed germination in distill water . The other experiment in Petri dishes also was adapted to study the effect of different salts NaCl , $CaCl_2$, Na_2SO_4 and a mixture of salts at a ratio of (1:1:1) weight basis of the concentrations (4 , 8 and 12) dS / m , in addition to distilled water as a control on the seeds germination and growth as lengths of plumules and radicles and their dry matter weights of tomato varieties seedlings . Results showed that , the increases of salts concentrations caused a decrease in seeds germination percentages , lengths of plumules and radicles and their dry matter weights . It was observed that , the germination and growth were more affected at the treatments of NaCl as compared with the other salt treatments , whereas salt mixture treatments have less effect . There were significant differences between varieties towards different salt concentrations treatments of the different salts .

المستخلص

أجريت تجربة مختبريه في أطباق بتري لمعرفة تأثير درجات الحرارة المختلفة (15 و 20 و25 و 30 و 35) مْ في إنبات بذور ضربي الطماطة (Supermarimond و Castle Rock) . أظهرت النتائج إن الحرارة المناسبة لإنبات البذور تراوحت بين (20 - 30) مْ ، وكانت النسب المرتفعة لإنبات بذور الضرب Supermarimond (91% - 93%) ، في حين كانت نسب الإنبات (83% - 86%) للضرب Castle Rock بعد ثلاثة أيام من بدء عملية إنبات البذور في الماء المقطر ، وأجريت كذلك تجربة أخرى في أطباق بتري لدراسة تأثير أملاح مختلفة من كلوريد الصوديوم و كلوريد الكالسيوم و كبريتات الصوديوم وخليط من الأملاح بنسبة (1 : 1 : 1) على أساس الوزن وبتراكيز (4 و 8 و 12) ديسيسمنز / م بالإضافة إلى الماء المقطر كمعاملة سيطرة في إنبات البذور والنمو وكما هو مقاس في أطوال الرويشات والجذور والأوزان الجافة لهما لبادرات ضربي الطماطة . أظهرت النتائج إن زيادة تركيز الأملاح سببت إنخفاضاً في نسب إنبات البذور وأطوال الرويشات والجذور والأوزان الجافة لهما . ولوحظ إن الإنبات والنمو تأثر كثيراً عند معاملات ملح كلوريد الصوديوم بالمقارنة مع بقية معاملات الأملاح الأخرى ، في حين كانت معاملات الخليط الملحي أقلها تأثيراً ، وكانت هناك فروق معنوية بين الضربين ولوحظت طرز مختلفة من الفروق المعنوية بين معاملات التراكيز الملحية المختلفة وللأملاح المختلفة .

Introduction

Tomato plant (*Lycopersicon esculentum* Mill.) was considered as an important vegetable crop in the world for the commercial and nutritional ways and comes in the first crop in the many arab and Asian countries , the importance of this crop comes from the nutritional , clinical and industrial values of their fruits (Hassen , 1989) . Tomato was classified as a sensitive crop to salinity , and this sensitivity considered the main problem which was faced the expansion of the agriculture and productivity of the crop in the world , especially , in the irrigated regions because of the high levels of salts in the soil (Matlob *et al.* , 1989) . Iraq was one of the countries that soils were highly affected by salinity in the large degrees as a result of

the use of a large quantities of irrigated water , and nothingness regulation of system neat , especially on the middle and southern regions , so salinity becomes a problem , that delay the development of agriculture in the country , also leads to a large decrease in the commercial feedback of agriculture production (Al-Zubaydi , 1989) . Plant seeds differs in their temperature requirements and the differences between seeds occurred in germination . In general the germination of seeds decreased at low or high temperature degrees (Mayer and Poljakoff - Mayber , 1975). Temperature affected seed water imbibition , high temperature causes the increase of seed water imbibition rate , and the rate of imbibition was increased at the optimum temperature (Maluf and Tigchelaar , 1982) . Seeds usually shows optimal germination in fresh water , but differ in their ability to germinate

at higher salinities (Ungar , 1995) . Plant seeds vary in their ability to tolerate salinity (Khan , 2002) , this variation could be due to a number of factors such as light , temperature , and water stress (Neo and Zedler , 2000) . Temperature interacts with salinity to affect the germination of seeds (Khan *et al*., 2001) . The adverse effect of high salinity is further aggravated by either an increase or decrease in temperature (Khan , 2002) . Non halophyte grown in saline environments are only within limits able to regulate their intercellular ionic composition in order to prevent growth reduction (Rathert and Doering , 1981) . The differences between plants are mainly dependent on differences in osmoregulation , especially at high external salt concentrations (Hellebust , 1976) and on differences in ion uptake by the roots and translocation into the shoot in response to the nature of salinization (Greenway and Munns , 1980) . In saline environments , plant adapted to salinity during germination and early stages of growth is crucial for the establishment of species (Ungar, 1995) . The seedling stage is the most vulnerable stage of the life cycle of plants , whereas , germination determines where and how seedling growth begins (Kigel , 1995) . Salinity has inhibitory effects on seed germination by limiting water uptake and arresting radical emergence , although the ion toxic influence of salt cannot be excluded (Sharma and Yamdagni , 1989) . Plant growth is affected by the interaction of Na^+ or Cl^- , as well as by other mineral nutrients , causing imbalance in nutrient availability , uptake , or distribution within plants (Grattan and Grieve , 1992). The aim of the following work was to investigate the effect of temperature and different concentrations from different salts on germination and growth at the early stage of tomato plant seedlings .

Materials and Methods

1- Effect of temperature on germination

Seeds of tomato verities (Supermarimond and castle Rock) were brought up from the local market in November - 2006 . Seeds had taken and washed by sterilized distilled water , (100) seeds of each variety were chosen and distributed in equal number (25) in four Petri dishes (10 cm diam.) and each dish contained two filter papers (Whatman's No.1) at the same diameter , then (6) ml of sterilized distilled water was added , seeds were covered by other filter paper to prevent the evaporation , replicated three times , then incubated at different temperatures (15 , 20 , 25 , 30 and 35) C to definition the prerequisite period of the beginning of germination at each temperature and the final percentage of germination of the each variety was calculated after (5) days of the beginning of germination .

2- Effect of salinity on germination

Salt solution was prepared from NaCl , $CaCl_2$, Na_2SO_4 and a mixture of the salts at a ratio (1:1:1) on the weight basis at a concentrations of (4 , 8 and 12) dS/m , seeds were distributed in Petri dishes as in the above experiment , then they put in incubator at temperature of (25) C (this temp. degree chosen from the other degrees to depression the effect of temperature on germination and evaporation percentages) for (7) days after adding (6) ml. from the concentration of each salt , in addition to sterilized distill water as a control treatment in three replication for the each treatment , at the end of the experiment the germination percentages were calculated as the following : -

Numbers of the germinated seeds
1 - percentage of germination = -- -------------------------------------- × 100

Total numbers of seeds

2 - Lengths of plumules and radicles : -

Five seedlings had chosen from each dish randomly , then , the lengths of plumules and radicles were measured from the seed contact point with seeds by a ruler , after the length mean of plumules and radicles of five seedlings from each replicate was calculated .

3 - Dry weights determination of plumules and radicles : -

Plumules and radicles which their lengths were measured , separated from the contact point with seeds , put in the glass Petri dishes in an oven at (70) C for (48) hours , then dry weights were calculated by Sartorius balance (BL 210 S) of the five seedlings from each replicate . Data were subjected to statistical analysis of variance and T test values at ($P < 0.05$) level of significance were used . Test of significance was done according to the least significant differences (L.S.D) for each salt treatment by using the analysis statistical program (Spss - 11- 2003) .

Results and Discussion

Table (1) shows that , high percentages of seed germination were occurred with the increase of temperature , low percentages (18 and 37) were observed at the low temperature (15) C and high percentages (93 and 86) noticed at temperatures of (25 and 30) C for the two varieties . A significant difference ($P < 0.05$) on percentages of seed germination between two varieties was found at different temperatures and differences observed at different temperatures except at (25 and 30) C . The differences between varieties on the percentages of seed germination at different temperatures can be due to the difference on the genetic structures or a difference on the seeds viability . The depression on the percentages of seed germination at low temperature perhaps due to the increase of water viscosity which it was difficult for seeds to imbibition water (Bland , 1971) , whereas at high temperature , the depression perhaps due to the effect of temperature on the seed lipids and its transform to inhibitor compounds which were inhibited the seeds viability (Mayer and Poljakoff -Mayber, 1975) .The high percentages of germination at temperatures (25 and 30) C might be due to the increase of imbibition water by seeds and activation of some enzymes that catalysis the embryo of seeds for the beginning of germination .

Table (1) Effect of different temperature degrees on the seeds germination percentages of tomato varieties .

Temperature C / Tomato var.	15	20	25	30	35	Means
Supermarimond	37	84	93	91	76	78.20
Castle Rock	18	76	83	86	42	61.0
Means	27.5	80.0	88.0	88.5	59.0	

** Each number represents the means of three replications.*

L.S.D (P <0.05) Temp . = 5.53 , Var. =11.86 , Interaction (Temp. × Var.) = 2.91

Table (2) demonstrated the effect of salinity on the percentages of seeds germination of the two varieties . It was clear that , the best percentages of seeds germination occurred in the distill water at a control treatment , it was observed that seeds of Supermarimond excellence the seeds of Castle Rock in the percentages of germination at all salt treatments and significant differences between the two varieties were noticed . From the table , it was clear that , the increase of salt concentrations caused a decrease in the percentages of seeds germination at all different treatments of salts and the percentages of germination were more affected at the treatment (12) dS/m , especially at the NaCl treatment . There were different patterns of significant differences on the percentages of germination between salt treatments and kind of salts found . These results were in accordance with many authors (Ungar , 1995 ; Khan , 2002 ; Al-Seedi , 2004) . The reduction in the percentages of seeds germination with the increasing salt concentrations were due to the specific ion effect (Hassan , 1999) or to a limitation of water supply as a results of high osmotic

Table (2) Effect of salinity on the percentages of seeds germination of tomato varieties .

Tomato varieties	Treatments dS /m	Salts NaCl	$CaCl_2$	Na_2SO_4	Mixture	Means
Supermarimond	Control	93.0	93.0	93.0	93.0	93.0
	4.0	92.0	92.0	90.0	90.0	91.0
	8.0	75.0	84.0	85.0	82.0	81.5
	12.0	18.0	74.0	82.0	76.0	62.5
Means		69.5	85.75	87.5	85.25	
Castle Rock	Control	83.0	83.0	83.0	83.0	83.0
	4.0	82.0	83.0	72.0	75.0	78.0
	8.0	10.0	74.0	52.0	56.0	48.0
	12.0	3.0	5.0	47.0	32.0	21.75
Means		44.5	61.25	63.5	61.50	

L.S.D ($P <0.05$) Salinity = 2.67 , Variety = 3.39 , Interaction (Sal. × Var.) = 1.12

stress (Dutt , 1976) . The negative effect of salts during germination were due to toxic and osmotic effects of salt ions especially Na and Cl (Khan *et al.* , 1999 ; Tester and Davenport , 2003) and the effect variations between salts on the percentages of seeds germination were perhaps due to the effect variations of their ions in the seeds embryo .

From the table (3 and 4) it was observed that , lengths of plumules and radicles of tomato varieties seedlings were affected by salt treatments and the decrease

Table (3) Effect of salinity on the lengths (cm.) of seedlings plumules of tomato varieties .

Tomato varieties	Treatments dS /m	Salts NaCl	$CaCl_2$	Na_2SO_4	Mixture	Means
Supermarimond	Control	5.80	5.80	5.80	5.80	5.80
	4.0	5.30	5.60	5.30	5.60	5.45
	8.0	3.30	4.80	4.70	5.05	4.462
	12.0	1.86	4.40	3.70	4.25	3.552
Means		4.06	5.15	4.87	5.17	
Castle Rock	Control	5.60	5.60	5.60	5.60	5.60
	4.0	5.60	5.60	5.10	5.50	5.45
	8.0	2.60	4.70	4.50	5.35	4.287

	12.0	1.10	2.50	3.50	4.50	2.90
Means		3.72	4.60	4.67	5.23	

L.S.D (P <0.05) Salinity = 0.50 , Variety = 0.70 , Interaction (Sal. × Var.) = 0.23

Table (4) Effect of salinity on the lengths (cm.) of seedlings radicles of tomato varieties .

Tomato varieties	Treatments dS /m	Salts				Means
		NaCl	$CaCl_2$	Na_2SO_4	Mixture	
Supermarimond	Control	6.30	6.30	6.30	6.30	6.30
	4.0	5.30	6.80	5.50	6.50	6.02
	8.0	3.10	4.0	4.2	4.60	3.975
	12.0	2.20	3.20	3.7	3.60	3.175
Means		4.22	5.07	4.92	5.25	
Castle Rock	Control	6.60	6.60	6.60	6.60	6.60
	4.0	5.50	6.90	6.30	6.80	6.375
	8.0	2.20	3.90	4.30	4.30	3.675
	12.0	1.0	1.10	2.60	3.8	2.125
Means		3.82	4.62	4.95	5.37	

L.S.D (P <0.05) Salinity = 0.498 , Variety = 0.904 , Interaction (Sal. × Var.) = 0.282

was clearly observed at high salt concentrations , it was clear , the variety Castle Rock was more affected at the treatment(12) dS/m . Significant differences between two varieties were noticed . The high means values of lengths of plumules and radicles of tomato seedlings occurred in the distilled water at a control treatments , whereas the low means values occurred at the high salt treatments (12) dS/m . There was a gradual decrease in the lengths of plumules and radicles of seedlings with the increase of salt concentrations and significant differences between salts treatments and the kinds of salts noticed .

From the preceding tables , it was clear , salts differ in their effect on the lengths of plumules and radicles , the low affect observed at a mixture which was due to the antagonism phenomenon between salts which causes a depression in salt toxicity when salts found as mixture and the marked effect observed at NaCl treatments was due to the toxicity of Na and Cl ions (Al- Seedi , 1992) . These results were in accordance with many authors (Greenway and Munns , 1980 ; Huang and Redman , 1995 ; Al-Rahmani *et al.* , 1997) .

Table (5 and 6) demonstrates the effect of salts on the dry matter weights of plumules and radicles of tomato seedlings , it was observed that , the variety Supermarimond was less affected than Castle Rock and significant differences between two varieties were noticed . The dry weights of plumules and radicles of tomato varieties seedlings were decreased with the increasing of salt concentrations , the variation of the dry weights at the salts treatments occurred and different patterns of significant differences between treatments noticed. From the preceding tables , it was observed that , the dry weights of plumules and radicles of tomato seedlings were less affected at the treatments of ($CaCl_2$ and a mixture) , whereas the dry weights were more affected at the treatments of (NaCl and Na_2SO_4) , it was due to the specific toxicity of Na ions . The results were in accordance with many authors (Tal , 1971 ; Al-Zubaydi ,1994 ; Al-Seedi , 2004) . Increasing salinity of the plant growth medium caused a reduction in plant selective ability to absorb the other important ions for the growth especially potassium , that was resulted from a toxic accumulation of sodium ions on the plant tissues (Torres , 1972) . The reduction of plant growth under salinity was due to the effect of salinity on the different vital activities of plants , such as a depression of the enzymes activities , metabolism , cell division and photosynthesis (Mayer *et al.* , 1973) . The depression of the lengths of plumules and radicles of tomato seedlings and their dry matter weights perhaps due to the water stress which was caused the water deficit in the cells during the growth period (Greenway and Munns , 1980) , the increase of water stress on the growth medium leads to the decrease of absorbed water by roots

Table (5) Effect of salinity on the dry weights of seedlings plumules (mg / 5 plants) of tomato varieties .

Tomato varieties	Treatments dS /m	Salts				Means
		NaCl	$CaCl_2$	Na_2SO_4	Mixture	
Supermarimond	Control	7.60	7.60	7.60	7.60	7.60
	4.0	7.10	7.40	7.0	7.20	7.175
	8.0	4.40	6.40	6.0	6.60	5.85
	12.0	2.60	5.70	4.60	5.60	4.625
Means		5.42	6.77	6.30	6.75	
Castle Rock	Control	6.80	6.80	6.80	6.80	6.80
	4.0	6.80	6.80	5.80	6.50	6.475
	8.0	3.35	5.60	4.90	5.90	4.937
	12.0	1.60	2.90	1.90	5.00	2.85
Means		4.63	5.52	4.85	6.05	

L.S.D ($P < 0.05$) Salinity = 0.618 , Variety = 0.860 , Interaction (Sal. × Var.) = 0.276

Table (6) Effect of salinity on the dry weights of seedlings radicles (mg / 5 plants) of tomato varieties .

Tomato varieties	Treatments dS /m	Salts				Means
		NaCl	$CaCl_2$	Na_2SO_4	Mixture	
Supermarimond	Control	1.90	1.90	1.90	1.90	1.90
	4.0	1.70	2.10	1.60	2.15	1.887
	8.0	1.20	1.36	1.30	1.70	1.39
	12.0	0.90	1.10	1.0	1.40	1.10
Means		1.42	1.61	1.45	1.78	
Castle Rock	Control	1.30	1.30	1.30	1.30	1.30
	4.0	1.20	1.50	1.30	1.45	1.362
	8.0	0.90	0.90	1.10	1.0	0.975
	12.0	0.60	0.60	1.0	0.9	0.775
Means		1.0	1.07	1.17	1.16	

L.S.D ($P < 0.05$) Salinity = 0.360 , Variety = 0.434 , Interaction (Sal. × Var.) = 0.135

and causes an imbalance in the biochemical reactions of cells (Huang and Redman , 1995) . Also salinity affected the growth by the affecting of cell division and cell elongation and causes a decrease in the number of divided cells and increased the division time (Al-Rahmani *et al.* , 1997) . The variation in the plant tolerance to salinity stress might be in consequence of a multitude of physiological process including a difference in regulation of mineral uptake and

translocation , particularly of Na^+ and Cl^- (Greenway and Munns , 1980) . The regulation of mineral nutrient uptake by plant organisms seems to be controlled genetically (Epstein , 1972) and at least one explanation for the differences in salt tolerance of tomato varieties (Tal , 1971) . The imbalance of cells ionic content as a result of the increase of Na ions and a decrease of the concentration of essential elements for the growth especially K^+, leads to an imbalance in cells metabolisms and causes a reduction in plant growth (Lauchli , 1990) . The low effect of ($CaCl_2$ and a mixture) might be explained due to the role of Ca^{++} for the conservation of the cells membranes that causes an increase of the cells capacity to control the entrance of different materials to the cells and finally improve the growth characters of tomato seedlings by the increase of seedlings lengths and their dry matter weights , also the depression of salts effect as a mixture perhaps due to the antagonism phenomenon and its role to decrease the toxicity of salts when were found as a mixture , so the increase of tomato seedlings lengths and their dry matter weights due to this reasons (Al-Seedi , 1992) .
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