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EFFECTS OF SODIUM CHLORIDE SOLUTION STRESS ON GERMINATION AND GROWTH OF PASSION FRUITS SEEDLINGS

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ABSTRACT

Soil salinity can lead to reduced emergence and poor seedling growth. A study was conducted to investigate on the effect of NaCl salinity treatment on germination and seedling growth of passion fruit *(Passiflora edulis)* under different NaCl concentrations 0 (control), 1.8, 3.6, 5.4 and 7.2 dSm^{-1}). Germination of seeds was determined under different NaCl concentrations. Fifty seeds were germinated at room temperature in Petri dish lined with two layers of whatman No.1 filter paper, moistened with 7.5 ml of each of the NaCl solutions (0 (control), 1.8, 3.6, 5.4 and 7.2 dSm^{-1}) and replicated four times in a completely randomized design. The Petri dishes were placed on benches in Botany laboratory. Number of seeds germinating every day after the initiation of the NaCl treatments was counted, and final germination percentage established .The radicle and plumule length was determined at the end of the experiment. Data obtained from the study was subjected to analysis of variance (ANOVA) using COSTAT statistical computer package and treatment means compared for any significance difference at ($P = 0.05$). The results indicated significant differences among treatments. Sodium chloride solution treatment reduced germination percentage of passion fruit seeds, radicle growth and plumule growth. There was no germination at NaCl concentration levels 3.6, 5.4 and 7.2 dSm^{-1}. The control treatment had higher germination percentage, plumule growth and radical growth compared to NaCl concentration level, 1.8 dSm^{-1}. The findings from the study indicate that Passion fruits seeds are very sensitive to salt stress. It is recommended that the cultivar used in the study should not be grown in saline environments since it will give poor germination and seedlings growth.

Keywords: passion fruits, germination, NaCl solution treatment, seedling growth.

INTRODUCTION

The passion fruit (*passiflora edulis)* is a vigorous, climbing vine that clings by tendrils to almost any support. It can grow 15 to 20 ft per year once established. Passion fruit grow on light to heavy sandy loam of medium texture, 60 cm deep, a pH of 5.5-7.0, well drained soil and rainfall distributed well throughout the year (www.infoner-biodivision .org-passion fruit).

Passion fruits are good sources of Vitamin A and C in the African diet and as a possible export in the form juice and syrup for flavouring (Rice *et al*., 1987). Tender leaves of the passion fruits are consumed as a leafy vegetable; give oil used for domestic and industrial purposes. It can also be used as medicinal plant: Help urinary tract infections, fight chronic inflammation and help in asthma (www.infoner-biodivision.org-passion fruit).

Soil salinity is a global problem that limits crop production, especially on irrigated area of the world. It is one of the major factors reducing plant growth and productivity worldwide and affects about 7% of the world's total land area (Musyimi, 2005). Salinity is a limitation where plant growth is reduced due to presence of the soluble salts in the soil, which are high enough to affect plant growth and development, as they are unproductive and unmanageable.

Modern agriculture management practices also worsen the extent of salinity by remobilizing salts from deep soil layers, salinity also occur in non-irrigated environments (Musyimi, 2005). The problem of soil salinity can be combated through two approaches. One is to make the available technology for reclaiming these soils, while the other is based on biological exploitation of such soils through cultivation of salt tolerant plant species (Guasmi *et al*., 2007).

Plants exposed to salt stress undergo changes in their metabolism in order to cope with changes taking place in their environment .This makes water unavailable to plant, which results in reduced water up take (Mwai, 2001).

The stresses imposed by salinity are mainly due to ion compositions and concentrations in rhizosphere and in plant tissues (Hossein and Thengane, 2007). Saline solutions (salinity stress), affect plant growth by water deficits (osmotic stress), ion toxity and ion imbalance (ionic stress) or a combination of these factors (Reinhardt *et al.,* 1995). Irrigation systems are particularly prone to salinization, and about half of the existing irrigation system of the world is under influence of salinization (Munns *et al.,* 2002). In general, glycophytic (salt-sensitive) plants suffer a decline in growth and productivity when exposed to saline conditions (Reinhardt *et al.,* 1995).

Plant exhibit great variability in their capacity to tolerate salinity, they evolve adaptive mechanisms, which enable them to continue the various metabolic and physiological growth processes. Amongst salinity, resistances are maintaince of tugor through osmotic adjustment, and reduction of respiratory water loss through increased root and leaf resistances (Mwai, 2001).

The germination process comprises two distinct phases the first is imbibition, mainly dependent on the

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physical characteristics of the seeds (Araya, 2005), and the second is a heterotrophic growth phase between imbibitions and emergence (Almodares *et al.,* 2007).

Imbibition is a diffusion process of water in plants where the net movement of water is along a diffusion gradient (Devlin and Witham, 1983). Salinity inhibits the seed ability to imbibe (absorb) water thus germinating seed would become non-viable and die. High salt concentration causes a more negative water potential and this brings about a decrease in the rate at which water is imbibed and thus the amount of water taken up (Devlin and Witham, 1983).

Worldwide, the effects of salinity on plant growth and development are increasingly problematic (Musyimi *et al*., 2007). The mechanisms for salt damage during germination are not fully understood (Almodares *et al.,* 2007). However, the effect of the salinity on plant growth is a complex syndrome that involves osmotic stress, ion toxity and mineral deficiencies (Musyimi *et al.,* 2007). Soil salinity can lead to reduced emergence and poor crop establishment, thus diminishing yield potential (Almodares *et al.,* 2007).

Germination refers to emergence of the radical through the seed coat (Araya, 2005). Salinity affect germination by creating an osmotic potential to prevent water uptake or by providing conditions for the entry of the ions that may be toxic to embryo or developing seedlings (Almodares *et al.,* 2007).Also reduced germination in saline soil can be a consequence of either direct toxic effects of salts or osmotic stress resulting in longer exposure of seedling to biotic and abiotic hazards (Almodares *et al*., 2007). Most of salt normally accumulate at upper soil layer due to evaporation of water from soil surface and this where seeds are placed. Thus, most of germination takes place at higher salt concentration than in the whole soil profile, and plants with long taproot or fast growing root system will emerge. However, plants are most sensitive to salinity during germination and seedling growth (Reinhard *et al*., 1995). At the germination stage, the difference in tolerance may be due to genetic factors among cultivars (Almoderes *et al.,* 2007). Salt tolerance of crops may vary with their growth stage (Guasmi *et al*., 2007).

Salinity effects in plants have been observed with increasing salinity. These effects on plants include dwarfed, stunted plants, with colored leaves, coated with wax deposits. High salt concentrations in the rooting media results to loss of turgor , growth stops , and if stress is severe enough , killing of tissues in form of falling leaves, or death of whole plant(Mwai , 2001).Three major hazards associated with salinity are:-osmotic stress, ion toxicity and mineral deficiencies (Musyimi *et al*., 2007).

Many arid and semi arid regions in the world contain soil and water resources that are too saline for germination and growth of most important crops. Low germination rates of various crops occur due to high salinity of the irrigation water, thus poor crop establishment and reduced yield potential.

Passion fruit is salt sensitive crop, often grown in dry areas where irrigation is practiced. Due to its nutrition value, and economic importance, it is important to investigate the water salinity level suitable for good germination and emergence of passion fruits seeds. Lack of data on the effect of saline water irrigation on germination and growth of passion fruit which is a very important crop grown in Kenya for export and domestic markets demands for this study. This crop has a high potential in reducing poverty among resource, poor farmers in arid and semi arid areas in Kenya but very little research has been done on this fruit crop concerning its response to salinity especially during germination and seedling growth. The objective of this research was to investigate the effects of different concentration of NaCl solutions on germination and seedling growth of passion fruit *(Passiflora edulis Sims*).

MATERIALS AND METHODS

Experimental materials and growth conditions

A germination experiment was conducted at Maseno University, Botany laboratory. Passion fruits were purchased from passion fruit growers, and seeds extracted using the established procedures. Both dry and fresh clean seeds of Passion fruits were surface sterilized with 70% ethanol for five seconds .The seeds were then rinsed with distilled water and imbibed for 24 hours. After imbibition, fifty seeds were germinated at room temperature, in 9cm Petri dishes, lined with two layers of whatman No. 1, filter papers, moistened with 7.5 ml of NaCl solutions whose concentration was (0 (control) ,1.8 ,3.6, 5.4 and 7.2 dSm^{-1}) respectively and were replicated four times. The Petri dishes were completely randomized on a bench in the Botany laboratory. The numbers of seeds germinating every day after treatments were counted and final germination percentage in each treatment calculated. The radical and plumule length of the seedlings were also measured using a transparent plastic ruler.

Experimental design and layout

The experimental design was a completely randomized design with five treatment (0 (control), 1.8, 3.6, 5.4 and 7.2 $dSm^{-1)}$ replicated four times. Data was taken daily up to the end of week 7.

Sampling procedure

Data collected included number of days to germination, number of seeds germinating daily, the radicle and plumule length.

Data analysis

The data from the various seed treatments were pooled together and subjected to analysis of variance (ANOVA) using Costat statistical package to determine the statistical significance difference of the mean of the treatment in the final germination percentage and growth parameters.

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RESULTS

Germination percentage (%)

There were significant differences ($p \leq 0.05$) among salinity treatments for this parameter (Tables 1 and 2). There was no germination observed for the salt treatments 3.6, 5.5 and 7.3 dSm^{-1}. The highest germination percentage was noted on control treatment, which was 39.5% compared to 21.5% at 1.8 dSm^{-1} NaCl concentration.

Plumule length

There were significant differences ($p \leq 0.05$) between control treatment and 1.8 dSm^{-1} NaCl salinity level for this parameter (Tables 1 and 2). The highest plumule length measured on control seedlings was 24.8 mm compared to 11.6 mm at 1.8 dSm^{-1} NaCl concentrations.

Radicle length

There was no significance difference between control treatment and seeds receiving 1.8 dSm^{-1} NaCl solution treatment ($p \leq 0.05$).The radicle length in control treatment was 23.0 mm while that for 1.8 dSm^{-1} salinity level was 21.8 mm (Tables 1 and 2).

Days to germination

Germination occurred after 15 days for control treatment and 22 days for seeds under 1.8 dSm^{-1} NaCl solution treatment. There was no germination at all for treatments 3.6, 5.4 and 7.2 dSm^{-1} (Table-1 and Figure-1).

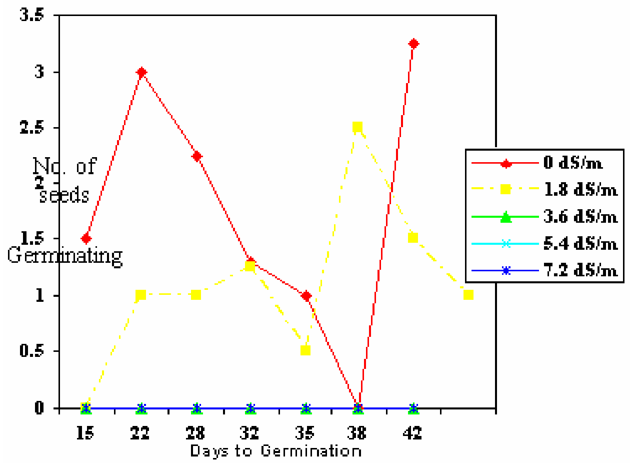

Figure-1. The effect of NaCl solution treatment on germination of passion fruits seeds. Means of four replicates.

Table-1. Effects of NaCl solution treatment on germination percentage and growth of fresh Passion fruit seeds 53 days after treatment means of four replicates.

	Parameters		
Treatment	**Germination** (%)	**Radicle length** (mm)	**Plumule length** (mm)
0 dSm^{-1}	39.5a	23a	24.7575a
1.8 dSm^{-1}	21.5b	21.75a	115625b
3.6 dSm^{-1}	0c	0b	0c
5. dSm^{-1}	0c	0b	0c
7. dSm^{-1}	0c	0b	0c
LSD	9.8908	6.2597	3.4945

Means followed by same letters down the column are not significantly different at $p \leq 0.05$.

Table-2. Analysis of variance on the effect of NaCl salinity on germination percentage, plumule length and Radicle length of passion fruit seeds and seedlings.

Parameter	Source	Df	Ms	F	P
Germination (%)	Treatment	4	1278.3	29.6819	0.00***
	Error	15	0.6667<-		
	Total	19	5759.2		
	Model	4	1278.3	29.6819	0.0***
	Coefficient of Variation = 53.7911				
Plumule Length	Treatment	4	482.80	89.80	0.00***
	Error	15	5.37<-		
	Total	19			
	Model	4	482.80	89.80	0.00***
	Coefficient of Variation = 31.9188				
Radicle Length	Treatment	4	601.555	34.872	0.00***
	Error	15	17.25<-		
	Total	19			
	Model	4	601.55	34.8724	0.00***
	Coefficient of Variation = 46.4057				

DISCUSSIONS

Effects of salinity on seed germination

Salinity had a significant effect on the germination of the passion fruits seeds. Salinity prolonged the germination period of the seeds especially seedlings receiving NaCl solution treatment (Figure-1; Tables 1 and 2). Sodium chloride solution may have created an osmotic potential which prevented water uptake .It is also possible that solution provided the entry of the ions to the seeds that might have been toxic to the embryo or the developing seedlings (Almodares *et al.,* 2007). According to Reinhard *et al*. (1995), most plants are more sensitive to salinity during germination and seedling growth; this is in agreement with our study. There was no germination at NaCl concentration levels (3.6, 5.4 and 7.2 dSm^{-1}). A higher germination percentage at control treatment could have been due to absence of salts in the medium and therefore seeds were able to imbibe water. Sodium chloride treatment decreased germination percentage, the germination processes might have been stopped as a result of contact of the seeds with high concentration of Na^+ and Cl^- ions (Almodares *et al.,* 2007). High concentration of NaCl in the solution might have increased osmotic potential; hence the seeds were unable to imbibe the water required for germination. Passion fruits seeds were demonstrated to be more sensitive to salinity with respect to lower germination percentage at low salinity level and no germination at high salinity levels 3.6, 5.4 and 7.2 dSm^{-1}.

Effect of salinity on seedling growth

Sodium chloride solution treatments reduced the growth of the plumule and radicle. There is a direct relation between salt concentration and reduction in growth (Plumule and radicle), because as the NaCl concentration level increased, the plumule and radicle length decreased (Table-1). The results indicate that passion fruit seedlings are sensitive to salinity. It has been reported that during imbibition, the effect of salt is merely osmotic until a hydration threshold is surpassed (Almodares *et al.,* 2007).The combined toxic and osmotic effects could be lethal at high NaCl concentration levels (3.6, 5.4 and 7.2 dSm^{-1}) leading to lack of germination at these levels. Some plants are sensitive to salinity at the seedling stage, because the mechanism of the tolerance to salinity is not yet fully developed. (Almodares *et al.,* 2007).Some other plants may also show tolerance to salinity at the seedling stage (Netondo, 1999; Mwai, 2001)

Based on these results, it seems that the passion fruits seeds are sensitive to salinity and therefore cannot tolerate high salinity levels 3.6, 5.4 and 7.2 dSm^{-1}.It is highly recommended that water for irrigating passion fruits seeds and seedlings should be of low salt concentration, not more than 1.8 dSm^{-1}.It was clearly evident from the study that NaCl stress reduced the general germination and growth of passion fruits seeds. Seeds failed to germinate at NaCl concentration levels 3.6, 5.4 and 7.2 dSm^{-1}. The results indicate that passion fruits seeds and seedlings are sensitive to salinity.It is recommended that water of low salinity level not exceeding 1.8 dSm^{-1} should be used on this cultivar. The cultivar used in this study should not be grown in areas with salinity problem.

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