International Journal of Plant & Soil Science
9(5): 1-8, 2016; Article no.IJPSS.14284
ISSN: 2320-7035

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Effect of Different Salt Concentrations on Germination and Seedling Growth of DIchondra (*Dichondra repens*)

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Authors' contributions

This work was carried out in collaboration between both authors. Author YÖ designed the study, performed laboratory experiments and made measurements. Author SÇ managed the statistical analyses and wrote the manuscript. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2016/14284
Editor(s):
(1) Sławomir Borek, Faculty of Biology, Department of Plant Physiology, Adam Mickiewicz University, Poland.
Reviewers:
(1) Asghar Farajollahi, Gorgan University of Agriculture and Natural Resources, Iran.
(2) Mohamed Abdel-Ghany Aly Bekheta, National Research Centre, Giza, Egypt.
Complete Peer review History: http://sciencedomain.org/review-history/12576

Original Research Article

Received 25th September 2014
Accepted 13th November 2014
Published 5th December 2015

ABSTRACT

This experiment was conducted in the laboratory of the Department of Field Crops, Faculty of Agriculture, Akdeniz University in 2012. As a material the seeds of dichondra (*Dichondra repens*) which is a green area plant were used and the study was performed as randomized plots design with three replications in both plastic Petri dishes and peat media. Distilled water was used to prepare different NaCl concentrations (control, 5000, 7500, 10000, 15000, 20000 and 25000 ppm). The results showed that, germination was not observed in 20000 and 25000 ppm concentrations, so these doses were excluded from this study. While increasing salinity levels delayed the first germination day (first emergence day in peat experiment), germination rate (emergence rate in peat experiment), root length, shoot length, root weight, shoot weight and root/shoot ratio (both length and weight) characteristics decreased with increasing NaCl concentrations. This study shows that, although some plant characteristics of dichondra is effected negatively by application of salinity levels, the plant has tolerance to a certain amount of salinity (approximately 5000-7500 ppm) in germination and seedling growth stage.

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Keywords: Dichondra; salinity; germination; root; shoot.

1. INTRODUCTION

Salinity is one of the main factors which has negative effects on plant production in many districts in the world. Soil salinization is an important problem especially in arid and semi-arid regions [1,2]. About 800 million hectares of land which is over 6% of the world's total land area are suffered from salinity stress, either by salinity (397 million ha) or the associated condition of sodicity (434 million ha). Also, of the current 230 million ha of irrigated land, 45 million ha are salt-affected (20%). Of the 1.5 billion ha of land farmed by dryland agriculture, 32 million (2%) are affected by secondary salinity to varying degrees [3]. However, based on salinity and sodicity criteria used in Turkish Advanced Soil Map surveys, salinity and sodicity were detected on about 1.5 million ha of the land resource [4].

However, salinity is an important problem in coastal area of the world. Because most of the coastal aquifers in the world face to the problem of saltwater intrusion due to excessive exploitation of groundwater that is primarily used for urbanization, industrialization and agricultural purposes [5]. Also seawaters inflow to rivers which riverbeds in below sea levels. So, the use of river water or groundwaters which near to riverbeds cause important salinity problem [6]. Also salinity is an important problem in turf area. For example, soil salinity is one of the most important problem in golf areas particularly in Mediterannean region [7] and salinity problem reached to important level in golf areas which established in near the sea [8]. These areas are extremly important for tourism, so increasing of turf species which can adapt to salinity conditions is very important.

Plants in germination and seedling growth stages are more sensitive to high salt concentrations [9] and prevention of water uptake is important problem especially in germination stage. So, germination and seedling growth stages are more considered to determine effect of the salinity on plants [10]. The main objective of this study was to determine the effects of different NaCl concentrations on seed germination and seedling growth in dichondra (*Dichondra repens*) which is a turf area plant.

2. MATERIALS AND METHODS

Dichondra (*Dichondra repens*) seeds were used as material in study. Dichondra is belong to *Convolvulaceae* and it can grow in warm-rainy climate. Also this plant adapt to shadow and partially to arid area. But this plant is not resistant to step on and crush [11].

This study, involved 7 different salt concentration were applied (5000, 7500, 10000, 15000, 20000 and 25000 ppm) in addition to control (distile water). Distile water and common salt (no-iodine and 99.5% purity) were used to prepare salt concentrations and 500 ml solution was prepare for each concentrations. Also electrical conductivity (EC) value of solutions were determined by using condactivity device (EC meter) in 20-21ºC. Salt amount and EC value of solutions and salinity classification of this EC values according to Aydemir [12] are shown in Table 1.

Study was conducted in laboratory conditions both petri dish and peat. The experimental design was a Random-Parcel design with three replications. In petri experiments, plastic petri dishes (diameter is 9 cm) which were placed blotting paper were used. After this process, 4.5 ml solutions apply to petri dishes 3 replication for each salt concentrations and fifty seeds were placed in to petri dishes. Petri dishes were closed and wrapped with paraffin and placed in an incubator with the temperature of 20ºC.

In peat experiment, the styrofor viols were filled with thin-textured peat. Its pH, salt concentration, nitrogen rate, phosphorus rate and potassium rate is 5.2-6, 0.3 $mg.lt^{-1}$, 30-80 $mg.lt^{-1}$, 20-40 and 30-90 $mg.lt^{-1}$, respectively. For each salt concentration, 3 lines of viol were splited up and each line included 8 seed bed and 9 ml solution was applied to each seed bed. After solution application, 1 seed were sown in each seed bed with 1 cm sowing depth and viols placed in an incubator with the temperature of 20ºC.

In this study, measured germination properties and seedling growth are including: First germination day (day), germination percentage (%), root and shoot lenght (cm), root and shoot weight (g) and root/shoot rate (for lenght and weight). Germination was calculated as the number of seeds germinated (coleoptile emerged) as a percentage of the total number of seeds pleaced in each petri. Germination observations were made in the same time everyday and when least 5 seeds were fully germinated, this time was recorded as first germination day in petri experiment. Also, emergence day was determined instead of first germination day in peat experiment and when 3 seedlings were emerged on the peat, this time was recorded as first emergence day in peat experiment. At the end of the study, seedlings were cut at root crown parts, when they are 3 leaves stage and height and weight of roots and shoots were determined.

Data were analysed with PROC ANOVA procedure in SAS statistical programe and differences between applications were statistical tested. Duncan Multiple Range Test (DMRT) was used for comparison of means.

3. RESULTS AND DISCUSSION

In experiment, 7 different NaCl concentrations were applied as specified in material and methods divisions, but germination didn't observation or germination physiology couldn't complation at 20000 and 25000 ppm concentrations. So these concentrations were excluded in evaluation of results. Results of petri and peat experiments are shown in Tables 2 and 3, respectively.

Acorrding to results, first germination day and germination rate were significantly influenced by different NaCl concetrations. First germination day delayed depend on increasing of NaCl concentration. While the earliest germination were determined at control and 5000 ppm applications with 2 days, first germinations were in third days in other applications. Significant differences were observed for germination rate between applications. The highest germination rate was observed from control applications with 92%, while the lowest germination rate was obtained from 15000 ppm application with 54%. Also similar effects were observed on germination rate in other applications (5000, 7500 and 10000 ppm).

Similar results were obtained from peat experiment and earliest emergence was determined in control application with 3 days. Emergences were delayed depend on increasing of NaCl concentration and latest emergence were obtained from 15000 ppm application with 6 days. Also, in peat experiment, while highest germination rate were determined in control application with 100%, rates were reduced in high NaCl concentrations and lowest germination rate was observed at 15000 ppm application.

The results showed that high NaCl concentrations have negative effect on germination which is first grown stage of plants. Because water uptake prevented by osmotic pressure in high NaCl concentration. Nizam [13] recorded that water uptake rate of perennial grass (*Lolium perenne*) seeds decreased in case of NaCl concentration of solution in over 4 dS.m-1. Also in the same experiment, while highest germination rate was determined as 96.5% in control group, lowest rate was obtained as 20% in 24 dS/m. In another study, Camberato and Martin [14] reported that germination percentage of rought bluegrass (*Poa trivialis* L.) seeds decreased with increasing of NaCl concentration. The similar results were determined by Taiz and Zeiger [15] and Dai et al. [16] in different plants.

In study, better results were obtained generally in low NaCl concentrations for root and shoot features. Root lengths were determined between 2.91 cm and 0.51 cm depend on NaCl concentration in petri experiment. While the biggest root length was determined at control with 2.91 cm, lowest value was recorded at 15000 ppm application with 0.51 cm. Similarly, high shoot lengths were determined at control and 5000 ppm with 2.99 cm and 3.05 cm, respectively, shoot length was reduced to 1.23 cm at 15000 ppm.

Root length was influenced by NaCl concentrations and the highest root lengths was

Table 1. Salt amount for concentrations, EC values of concentrations and classification

Salt concentration (ppm)	Salt amount (g.500 ml^{-1})	Electrical conductivity (EC) values ($mS.cm^{-1}$)	Salinity classification
Distilled water		0.002	Non saline
5000	2.50	9.15	Highly saline
7500	3.75	13.61	Highly saline
10000	5.00	17.41	Severely saline
15000	7.50	25.4	Severely saline
20000	10.00	33.4	Severely saline
25000	12.50	39.3	Severely saline

Table 2. Effect of different NaCl concentration on some traits (Petri experiment)

	First germination (day)	Germination percentage (%)	Root length (cm)	Shoot length (cm)	Root weight (g)	Shoot weight (g)	Root/Shoot rate (for length)	Root/Shoot rate (for weight)
Distilled water	2 A	92 A	2.91 A	2.99 A	0.0053 A	0.014 BC	0.97 A	0.37 A
5000 ppm	2 A	83 B	2.53 AB	3.05 A	0.0056 A	0.018 A	0.83 A	0.31 A
7500 ppm	3 B	81 B	2.45 AB	2.76 AB	0.0049 A	0.017 AB	0.88 A	0.31 A
10000 ppm	3 B	79 B	2.06 B	2.48 B	0.0047 A	0.016 AB	0.83 A	0.31 A
15000 ppm	3 B	54 C	0.51 C	1.23 C	0.0027 B	0.012 C	0.42 B	0.23 B
F value	0.000…..	69.20**	19.31**	63.59**	10.63**	6.68**	15.52**	5.14*

*Mean differences with different letter within the same column are statistically significant *: p<0.05, **: p<0.01*

Table 3. Effect of different NaCl concentration on some traits (Peat experiment)

	First germination (day)	Germination percentage (%)	Root length (cm)	Shoot length (cm)	Root weight (g)	Shoot weight (g)	Root/Shoot rate (for length)	Root/Shoot rate (for weight)
Distilled water	3 A	100 A	5.01 A	3.41 A	0.0057 B	0.019 BC	1.48 A	0.30 A
5000 ppm	4 AB	92 AB	5.21 A	3.49 A	0.0066 A	0.023 A	1.49 A	0.21 A
7500 ppm	4 BC	84 BC	4.41 B	3.50 A	0.0055 BC	0.022 AB	1.26 B	0.25 A
10000 ppm	5 CD	75 DC	4.25 B	3.09 A	0.0048 C	0.021 AB	1.38 AB	0.23 A
15000 ppm	6 D	71 D	1.95 C	2.52 B	0.0038 D	0.017 C	0.77 C	0.22 A
F value	12.17**	14.02**	62.18**	8.20**	18.50**	6.71**	29.08**	0.83

*Mean differences with different letter within the same column are statistically significant *: p<0.05, **: p<0.01*

determined at 5000 ppm with 5.21 cm and in control with 5.01 cm in peat experiment. While the lowest root length were recorded at 15000 ppm with 1.95 cm, there was no differences between 7500 ppm and 10000 ppm in consideration of root lenght (Table 4). Shoot lengths were determined between 2.52 cm and 3.50 cm and while the lowest shoot length was obtained at 15000 ppm, there wasn't statistic difference between other NaCl concentration.

Characteristics related root and shoot are two of the most important selection criteria for determining of resistance of plants to different salinity conditions. Because roots which are directly contact with soil are uptake water and sent it to other organs of plant. Toxic effect of sodium chloride causes reduction in shoot growth through unbalanced nutrient uptake under the NaCl stress. Elongation of root and shoot can be decelerated by high salt concentrations because of prevent water and nutrient element uptake of plants [17]. This status explains results which about root and shoot length in our study. Also, similar results were reported in different plants such as wheat [18], Indian mustard [19], Kentucky bluegrass and tall fescue [20].

In study, the lowest root weigth was determined at 15000 ppm application with 0.0027 g. But a statistically significant difference was not found between other application and root weigth varied between 0.0047g and 0.0056 g. Results obtained from our study are consistent with results of study conducted by Pessarakli et al. [21] Because these researchers reported that variations in root dry weight were not statistically significant up to certain point in some turfgrass plants which are exposed to increased NaCl concentrations. We also found that root weight was affected by different NaCl concentrations. While highest root weight was determined at 5000 ppm application with 0.0066 g, root weight was affected negatively at higher concentrations and it was reduced to 0.0038 g at 15000 ppm.

While the highest shoot weight were recorded as 0.018 g at 5000 ppm application, shoot weight of seedlings were decreased in higher doses than 5000 ppm. Shoot weight values were determined as 0.022 g and 0.021 g at 7500 ppm and 10000 ppm, respectively, and finally, lowest shoot weight were obtained at 15000 ppm with 0.012 g. Similar results were observed in peat experiment and highest shoot weight value (0.023 g) was calculated at 5000 ppm application. Growth restriction can be appear in plants exposed to high salt concentrations depend on decreasing energy and reducing turgor which are required for growth [22]. In high salinity conditions, ion stability in protoplasma disrupts due to reducing water uptake of plant and competition occurs between ions and plant nutrient element and nutrient element uptake can be precluded. So high salt stress causes scrubby growth and declining root growth [23]. Both fresh and dry weights of root, shoot and leaves decrease under salt stress and this status determined in many study [24-26]. Dudeck and Peacock, [27] determined that shoot weight decreased by 50% in bermuda grass (*Cynodon dactylon*) which grown at 33 dS.m-1. Similarly, Uddin et al. [28] reported that shoot growth decreased by 50% in 8 different turfgrass plants in high salt concentrations. Also in the same study determined that significant reduction occured in root growth with increasing salt concentrations.

Generally, root/shoot ratios reduced in both petri and peat experiments with increasing NaCl concentrations. In petri experiment, while the lowest root/shoot ratio for length and weight were determined at 15000 ppm with 0.42 and 0.23 respectively, there was no statistically difference between other applications to both length and weight. According to root/shoot ratios of peat experiment, ratios for length reduced with increasing salt concentrations and lowest ratio was recorded as 0.77 at 15000 ppm. Also ratios for weight were varied between 0.30 and 0.22, but significant differences were not determined between means of different salt concentratios.

Sodium (Na+) and chlorine (Cl-) ions accumulate in higher rates in leaves compared to root. So roots are more sensitive to salinity (especially sodium ion) compared to leaves. Thus root/shoot ratio increase plants which are grown in salinity conditions [29]. But in contrast, roots are more sensitive to salinity in comparison to leaves in seedling stage and they are more affected. So in seedling stage of plants, reductions occur in root/shoot ratio in case of salt stress. This status explains reductions in root/shoot ratio obtained in our study. Kaya et al. [30] reported that root/shoot ratios of safflower (*Carthamus tinctorius* L.) seedlings were decreased with increasing salt concentrations. Similar results were recorded by Ghorashy et al. [31] in safflower, by Hussain and Rehman [32] in sunflower, by Bandeh-hagh et al. [33] in canola, Zhang et al. [34] in tall fescue and Zhang et al. [35] in buffalograss and blue grama grass.

A correlation analysis was conducted to determine the relationships among the variables. As a result of the analysis, significant relationships were recorded between characterisitcs and results are shown at Tables 4 and 5.

In petri experiment (Table 4), it was found out that germination day (GD) correlated with germination percentage (GP), root lenght (RL), shoot lenght (SL) and root weight (RW), negaitive and significant ($p<0.05$); whilst GD correlated with root/shoot ratio (R/SRW for weight), positive and significant ($p<0.05$). Also GP was positively correlated with RL, SL, RW (at 0.01) and shoot weight (SW) (at 0.05), but GP negatively correlated with root/shoot (R/SRL for length) and R/SRW at 0.01. A significantly posititive correlation ($p<0.01$) was found between RL and SL, RW and SW; R/SL was correlated negatively with R/SRW. Relationships of SL with RW and SW was determined as singnificant and positive, SL was correlated negatively with R/SRL and R/SRW. Both R/SRL and R/SW were correlated negatively with RW, positive correlation was determined between RW and SW. While there was a highly significant negative correlation between RW and R/SRL, correlation between R/SRL and R/SRW was determined as significant and positive.

Similar results to petri experiment were obtained from peat experimet for correlations and significant relationships were determined between variables (Table 5).

Table 4. Correlation coefficients between the factors among all characteristics (Petri experiment)

	FGD	GP	RL	SL	RW	SW	R/SRL
GP	-0.617*						
RL	-0.577*	0.911**					
SL	-0.622*	0.918**	0.951**				
RW	-0.574*	0.867**	0.874**	0.882**			
SW	-0.287	0.523*	0.671**	0.744**	0.685**		
R/SRL	0.418	-0.876**	-0.916**	-0.870**	-0.803**	-0.540*	
R/SRW	0.537*	-0.816**	-0.690**	-0.677**	-0.839**	-0.209	0.723**

*(FGD: First germination day, GP: Germination percentage, RL: Root length, SL: Shoot length, RW: Root weight, SW: Shoot weight, R/SRL: Root/Shoot rate (for length), R/SRW: Root/Shoot rate (for weight)); *: p<0.05, **: p<0.01*

Table 5. Correlation coefficients between the factors among all characteristics (Peat experiment)

	FGD	EP	RL	SL	RW	SW	R/SRL
GP	-0.822**						
RL	-0.731**	0.716**					
SL	-0.670**	0.642**	0.874**				
RW	-0.654**	0.762**	0.892**	0.870**			
SW	-0.400	0.306	0.697**	0.808**	0.741**		
R/SRL	0.551*	-0.530*	-0.927**	-0.712**	-0.734**	-0.541*	
R/SRW	0.607*	-0.824**	-0.754**	-0.621*	-0.831**	-0.254	0.691**

(FGD: First germination day, EP: Emergence percentage, RL: Root length, SL: Shoot length, RW: Root weight, SW: Shoot weight, R/SRL: Root/Shoot rate (for length), R/SRW: Root/Shoot rate (for weight))
**: p<0.05, **: p<0.01*

Emergence day (ED) was correlated singnificant and negatively with emergence percentage (EP), RL, SL and RW, singnificant and positively with R/SRL and R/SRW. Also while strong positive correlations were found between EP and RL, SL and RW, EP was correlated negatively with R/SRL ($p<0.05$) and R/SRW ($p<0.01$). According to another result, while RL was positively correlated with SL, RW and SW and negatively correlated with R/SRL and R/SRW. SL was significant and positively correlated with RW and SW, and negatively correlated with R/SRL and R/SRW. RW was positively correlated with SW and negatively correlated with R/SRL and R/SRW. Also while a significant negative correlations determined between SW and R/SRL, R/SRL was positively correlated with R/SRW.

4. CONCLUSION

According to the obtained results of the study, seeds and seedlings of dichondra plant are partially (approximately 5000-7500 ppm) resistant to salinity conditions, but germination percentage and growth parametres were reduce with increasing NaCl concentrations. So dichondra has a turfgrass potential in coastal areas of Aegean and Mediterranean regions which have intensive turf and golf areas and it can be use especially in salinity soils and shadow conditions.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/12576