Effect of Salinity and Soil Type on Physiological and Reproductive Growth of Zucchini (*Cucurbita pepo* L.).

Abdelnaser T. Abed

Department of Biology-Botany, Faculty of Arts & Science-Mesallata, Elmergib University, Al-khoms, Libya.

الملخص:

تمت معاملة نباتات الكوسة (*Cucurbita pepo* L.) صنف (Rceel F1) بتركيزات مختلفة من كلوريد الصوديوم كمصدر للملوحة بثلاثة مستويات: 2000 (ماء صنبور)، 4000، 6000 جزء في المليون والتي زرعت في نوعين من التربة (تربة طينية، تربة رملية)، وذلك لمعرفة تأثير نوع التربة على صفات النمو الخضري والتكاثري لنباتات الكوسة تحت ظروف الإجهاد الملحي. تم قياس كل من صفات النمو الخضري والتكاثري وتقدير محتوى الأوراق من عناصر النيتروجين (N) والفوسفور (P) والبوتاسيوم (K^+). ادت المعاملة بالملوحة (4000، 6000 جزء في المليون) إلى انخفاض في كل من عدد الأوراق (LN)، مساحة الورقة (LA)، الوزن الطازج للمجموع الخضري (FWS)، الوزن الطازج للجذر (FWR)، الوزن الجاف للمجموع الخضري (DWS)، الوزن الجاف للجذر (DWR) للنباتات لكل معاملة لنوعي التربة المستخدمة، كما ادت المعاملة بالمحلول الملحي لخفض محتوى الأوراق من النيتروجين والفوسفور والبوتاسيوم مقارنة بمعاملة الشاهد. بينما ادت زيادة ملوحة مياه الري إلى الإضرار بالأزهار المذكرة (MF)، الأزهار المؤنثة (FF)، العدد الكلي للأزهار (TF)، نسبة الأزهار المؤنثة (PFF)، النسبة الجنسية للأزهار المؤنثة (SR) لجميع التركيزات المستخدمة سواء كانت مع التربة الطينية أو الرملية. في حين كان تأثير الإجهاد الملحي أكثر شدة على نباتات الكوسة المزروعة في التربة الرملية مقارنة بالتربة الطينية. من ناحية أخرى، كانت النباتات المزروعة في التربة الطينية أقل حساسية لتركيزات الملوحة المتزايدة من النباتات المزروعة في التربة الرملية في قياسات النمو الخضري والتكاثري.

Abstract

Zucchini plants (*Cucurbita pepo* L. cv. Rceel F1) were subjected to different types of soil and NaCl as a source of salinity with irrigation to investigate the effect type of soil on vegetative growth and reproduction under salinity conditions. Two types of soil (clay soil, and sandy soil) were used with three levels of salinity: 2000 (tap water), 4000, and 6000 ppm. Leaves number (LN), leaf area (LA), fresh weight of shoot (FWS), fresh weight of root (FWR), dry weight of shoot (DWS), and dry weight of root (DWR) of the plant were measured for each treatment. Leaf contents of nitrogen (N), phosphorus (P), and potassium (K^+) in leaves were determined. Treatment with salinity (4000 and 6000 ppm) reduced (LN), (LA), (FWS), (FWR), (DWS), and (DWR) for all types of used soil. The saline treatment reduced the leaf content of N, P, and k^+ compared to the control. While, increasing the salinity of irrigation water harmed the male flower (MF), female flower (FF), the total number of flowers (TF), the percentage of female flowers (PFF), and the sex ratio of female flowers (SR) in all the concentrations used, whether clay or sandy soil. Whereas, the effect of salt stress was more severe on zucchini plants grown in sandy soil compared to clay soil. On the other hand, plants grown in clay soils were less sensitive to increased salinity concentrations than plants grown in sandy soils in the measurements of vegetative growth and reproductive stage

Keywords: Zucchini, *Cucurbita pepo* L., Soil type, NaCl, Salinity.

INTRODUCTION

Squash (*Cucurbita pepo* L.) is moderately salt-tolerant but it is also an important crop in areas where salinity is commonly high Graifenberg *et al.*, (1996). Salinity affects more than 45 million hectares (20%) of irrigated soils accounting for one-third of worldwide food production areas (Machado and Serralheiro, 2017). Salinity is one of the most serious abiotic stresses that limit the productivity of crops, with adverse effects on germination, plant vigor, and crop yield. In general, soil salinity is known to affect plant growth in the form of osmotic stress which is then followed by ion toxicity (Munns and Tester, 2008).

Climate change, rise in evapotranspiration, intensive farming, excessive over-pumping of groundwater for irrigation (especially in coastal areas with consequent sea-water infiltration into fresh aquifers), and use of low-quality water (brackish water or treated wastewater) in irrigation contribute synergically to soil salinization (Daliakopoulos *et al.*, 2016).

Under high salinity, roots are unable to uptake water from the soil and toxic concentrations of sodium and chloride build up in the cytosol and organelles, resulting in plant nutritional disorders and oxidative stress (Tavakkoli *et al.*, 2010). Sodium interferes with potassium and calcium uptake, negatively affecting stomatal control; moreover, it can replace potassium in key enzymatic reactions. Therefore, the salt stress status of a crop depends mainly on the potassium-to-sodium ratio than on the absolute amount of sodium in the cytosol (Annunziata *et al.*, 2017).

Initially, the osmotic stress happened due to a reduction in soil water potential following the increase in root zone solute concentration. This will create low soil water potential around the root zone area and consequently interferes with the ability of the plants to extract water and remain turgid. Hence, in some species, salt stress may have similar symptoms to drought stress. When the salinity environment is prolonged or the concentration is increased, the ion toxicity phase will follow. The high concentration of Na^+ and Cl^- ions may disturb membrane integrity and function as well as interfere with the internal solute balance that also affects nutrient uptake; this gives the resemblance of nutrient deficiency symptoms similar to those that occur in the absence of salinity (Munns and Tester, 2008).

genetic diversity within the Cucurbitaceae family is tremendous, and the response against salinity stress may differ greatly among the species in the family. The mechanisms that glycophytes plants developed for absorbing, transporting, and utilizing mineral nutrients from non-saline substrates may not operate as efficiently or as effectively under saline compared to non-saline conditions. Na^+ and/or Cl^- concentrations often exceed those of most macronutrients by one or two orders of magnitude, and by even more in the case of micronutrients. Therefore, high concentrations of Na^+ and Cl^- ions in the soil solution may depress nutrient-ion activities and produce extreme ratios of Na^+/Ca^{2+}, Na^+/K^+, Ca^{2+}/Mg^{2+}, and $Cl^-/NO3^-$ (Shafieizargar *et al.*, 2015). The purpose of this research work is to study the influence of salinity and soil type on the physiological and reproductive growth of Zucchini.

MATERIALS AND METHODS

Plant material, growth conditions, and treatments:

factorial experiment using a randomized complete block design with three replications was conducted during the summer season of 2022 in an anti-aphid nylon greenhouse located in Amamra city, Mesallath, Libya (lat. 32°52′N, long.14° 12′ E, altitude 254m above sea level).

The tested vegetable species for the current experiment was squash (*Cucurbita pepo* L.) cv. Rceel F1. Zucchini plants were grown under natural light conditions and the daily air temperature inside the greenhouse. The factors in this experiment included three concentrations of sodium chloride (2000, 4000, 6000 ppm NaCl), as well as two types of soil (clay, sand). The description of the used soil type and chemical compositions applied are shown in (Table 1).

Table 1. Description of used soil type and chemical compositions

Test	Symbol	Units	Sandy soil	Clay soil
Hydrogen power	pH	-	8.0	8.2
Electrical conductivity	EC	µs/cm	87.0	140.5
Calcium	Ca	mg-kg	113.6	282.7
Potassium	K		54.2	89.3
Sodium	Na		98.6	175.6
Magnesium	Mg		9.9	29.8
Iron	Fe		0.7	0.3
Available phosphorus	P		41.6	27.3
Total nitrogen	N		11390	19477
Calcium carbonate	$CaCO_3$	wt%	3.6	16.2
Organic matter	O.M	mg/kg	986.6	742.0

Seeds were sowed in clay soil and sand soil in 25-liter plastic bags. Treatments were initiated when the plants reached the second leaf stage by adding different concentrations of NaCl with irrigation water. Plants were irrigated daily using two levels of salinity, tap water (the concentration of salts is about 2000 ppm) prepared by adding (0, 2000, and 4000mg.L^{-1}) of NaCl to tap water. Irrigation water was added according to the needs of the plants to reach field capacity. Treatments continued until 30 days after flowering.

Vegetative stage measurements:

Plants designated for the measurements were cut off at the end of the vegetative stage. Leaves number (LN), leaf area (LA), fresh weight of shoot (FWS), dry weight of shoot (DWS), fresh weight of root (FWR), and dry weight of root (DWR) were measured, then plants were dried for three days in an oven at 65 °C (until there was no decrease in weight) for determination of the dry weight of shoot (DWS), dry weight of root (DWR) were measured. Also, leaf contents of nitrogen (N), phosphorus (P), and potassium (K^+) leaves were determined.

Reproductive stage measurements:

At the reproductive stage; the male flower (MF), female flower (FF), the total number of flowers (TF), percentage of female flowers (PFF), and sex ratio of female flowers (SR), were calculated. Sex ratio was calculated by dividing the number of female flowers by the number of male flowers produced by a plant.

Experimental design and statistical analysis:

The data represent the mean values of the independent experiment performed during the summer season of 2022. The experimentation was conducted using three replicates for each treatment, using factorial experimental 3×2 in randomized complete block design, with the treatments of salinity and soil type. Data were subjected to analysis of variance using a two-way ANOVA test and means were compared by LSD means test ($P<0.05$) using the Statistics 10 software package.

RESULTS AND DISCUSSION

Vegetative growth:

The results of some vegetative parameters are shown in (Table 2). Salinity decreased leaves number (LN), leaf area (LA), fresh weight of shoot (FWS), dry weight of shoot (DWS), fresh weight of root (FWR), and dry weight of root (DWR), significantly. This result was consistent with those of other studies (Alasheebi *et al.*, 2020; Turan *et al.*, 2011). On the other hand, the sandy soil reduced vegetative parameters more than the clay soil regardless of the concentration of NaCl used (Table 2). Similar results were also reported by (Huihui *et al.*, 2020).

The salt level (4000 ppm) had an inhibitory effect on plant growth 5 weeks after treatment. In contrast, (6000 ppm) NaCl salinity showed its inhibitory effect on plant growth 3 weeks after treatment. On the other hand, the results showed that the effect of salinity on the fresh and dry weight of both shoot and root system was less in plants grown in clay soil compared to sandy soil, which may be due to the higher content of nutrients in clay soil compared to sandy soil (Table 2).

The primary physical processes associated with high sodium concentrations are soil dispersion. The forces that bind clay particles together are disrupted when too many large sodium ions come between them. Soil dispersion causes clay particles to plug soil pores, resulting in reduced soil permeability (Warrence *et al.*, 2002).

Table 2. Effect of salinity (NaCl) and soil types on leaves number (LN), leaf area (LA), fresh weight of shoot (FWS), dry weight of shoot (DWS), fresh weight of root (FWR), dry weight of root (DWR), of Zucchini plants

Salinity (ppm)	Soil types	LN (No.)	LA (cm^2)	FWS	DWS	FWR	DWR
				(g)			
Tap Water	Clay soil	10.55[a]	265.8[a]	242.6[a]	29.1[a]	9.8[ab]	0.83[a]
	Sandy soil	10.44[a]	205.3[b]	181.0[b]	21.7[b]	10.7[a]	0.76[a]
4000	Clay soil	10.33[a]	190.8[c]	161.7[b]	18.8[b]	7.9[b]	0.83[a]
	Sandy soil	8.88[ab]	147.6[d]	36.0[d]	5.2[cd]	1.7[d]	0.16[b]
6000	Clay soil	9.11[a]	133.6[e]	75.5[c]	9.0[c]	5.1[c]	0.30[b]
	Sandy soil	7.11[b]	105.2[f]	21.7[d]	3.4[d]	2.1[d]	0.11[b]

Means followed by the same letter in each column are not significantly different by LSD multiple range test at 5% level.

As shown in (Table 3), the saline treatment reduced the leaf content of nitrogen (N), phosphorus (P), and potassium (K^+) compared to the control. Whereas, the leaf content of the nutrients of plants grown in clay soil was higher than the content of leaves of plants grown in sandy soil in all salinity concentrations. Similar results were also reported by (Villora *et al.*, 1997).

Table 3. Effect of salinity (NaCl) and soil types on the content of nitrogen (N), phosphorus (P), and potassium (K^+) in leaves of Zucchini plants

Salinity (ppm)	Soil types	N	P	K^+
			(mg /g)	
Tap Water	Clay soil	20.77[a]	29.44[a]	35.49[a]
	Sandy soil	19.23[b]	23.20[b]	28.69[b]
4000	Clay soil	17.99[c]	18.96[c]	24.12[c]
	Sandy soil	14.56[d]	13.82[d]	21.62[c]
6000	Clay soil	11.95[e]	11.79[de]	15.65[d]
	Sandy soil	10.16[f]	10.67[e]	9.60[e]

Means followed by the same letter in each column are not significantly different by LSD multiple range test at 5% level.

Reproductive growth:

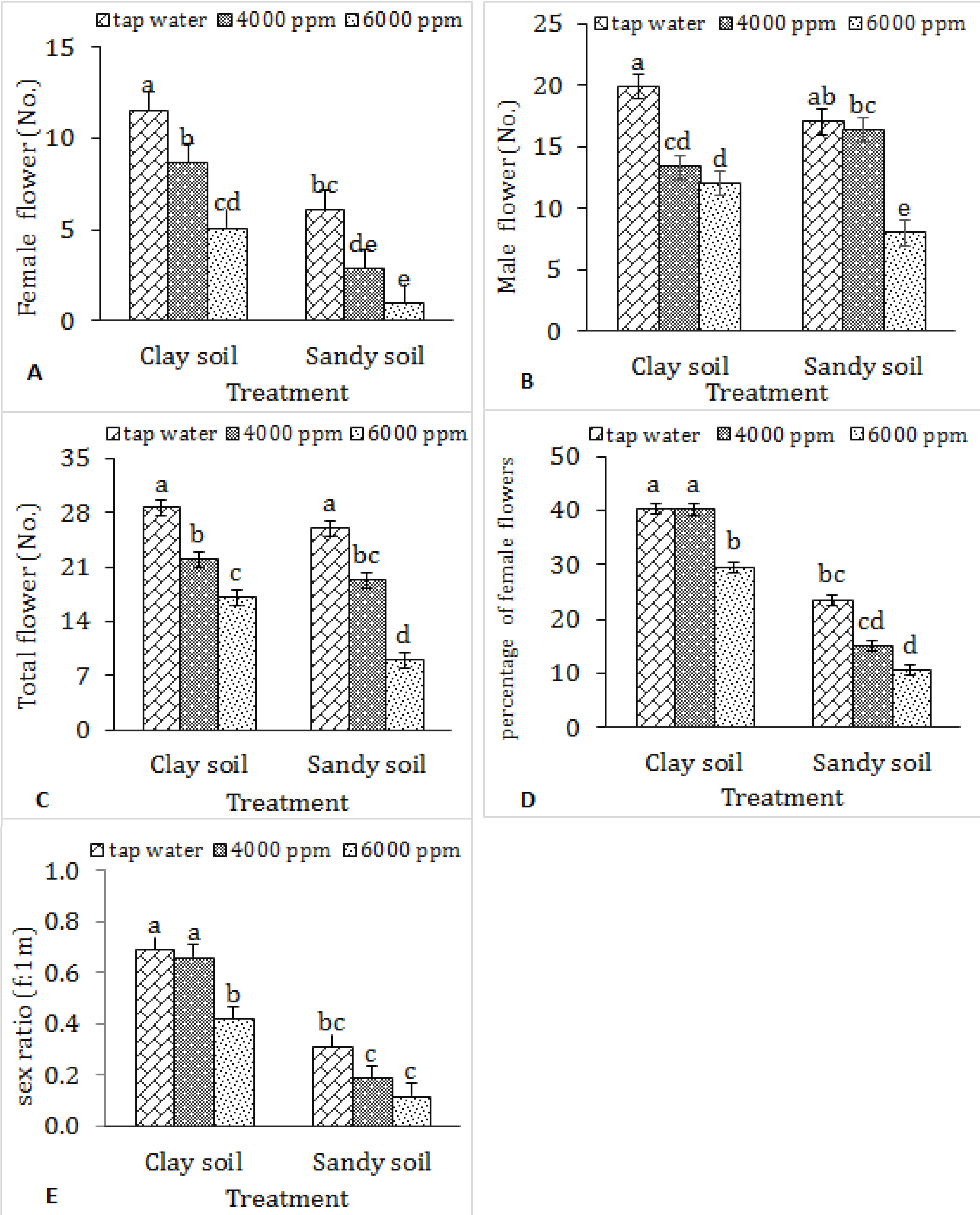
(Figure 1.) shows the effect of salinity and soil types on the reproductive growth parameters of Zucchini. Salinity decreased the male flower (MF), female flower (FF), the total number of flowers (TF), and the percentage of female flowers (PFF) and sex ratio of female flowers (SR) regardless of the concentration of salinity treatment. This is consistent with the results of (Al Gehani *et al.*, 2020).

On the other hand, the effect of salinity on plants grown in clay soil was less than on plants grown in sandy soil (number of male flowers, number of female flowers, total number of flowers, percentage of female flowers, and sex ratio of female flowers). It may be due to the ability of clay soil to retain nutrients and make it easier for plants than sandy soil (Figure 1.). Similar results were also reported by (Huihui *et al.*, 2020).

The interaction between the effect of salinity and soil type on reproductive growth traits shows that there is a significant difference in the number of female flowers between clay soil and sandy soil for all salinity treatments used (2000, 4000, 6000 ppm) (Fig.1A). On the other hand, (Fig.1B, C) shows that there is no significant difference in the number of male flowers and the total number of flowers between the two types of soil treated with tap water (2000 ppm). As well as the second treatment (4000 ppm) for the two types of soil (clay, sandy) within the same concentration of salinity, while there was a significant difference between the two types of soil used in the third treatment of salinity (6000 ppm). As for the percentage of female flowers, a significant difference is observed within the treatments (2000, 4000, 6000 ppm) between clay and sandy soils, while there is no significant difference in clay soil between the first and second salinity treatments. On the contrary, a difference is noted. Significant when compared to the third treatment (Fig.1D). It is noted from (Fig. 1 E) of the sex ratio of female flowers, that there is no significant difference in clay soil between the salinity treatments (2000, 4000 ppm), which differed significantly from the treatment (6000 ppm). While in the sandy soil, there were no significant differences between all salinity treatments used in the sex ratio of female flowers.

In general, we notice that the higher the salinity concentration, the more negatively affected all reproductive growth characteristics (the number of male flowers, the number of female flowers, and total number of flowers) for both clay and sandy soils alike due to changing the structure of the soil and increase in the osmotic potential of the soil solution as a result of the accumulation of salts, which had a negative effect, The ability of the roots to absorb water and the nutrients dissolved in it, which in turn negatively affected the reproductive growth characteristics of the plant, This is consistent with the results of (Levy *et al.*, 2003).

Fig.1. Reproductive growth characters of Zucchini plants affected by interaction salinity (NaCl) and soil types


tap water
4000 ppm
6000 ppm
Female flower (No.)
15
10
5
0
a
b
cd
bc
de
e
Clay soil
Sandy soil
Treatment
A
Male flower (No.)
25
20
15
10
5
0
a
cd
d
ab
bc
e
B
Total flower (No.)
35
28
21
14
7
0
a
b
c
a
bc
d
C
percentage of female flowers
50
40
30
20
10
0
a
a
b
bc
cd
d
D
sex ratio (f:1 m)
1.0
0.8
0.6
0.4
0.2
0.0
a
a
b
bc
c
c
E

CONCLUSION

From this study, we conclude that the effect of salinity was more on plants growing in sandy soil compared to clay soil, and this may be due to the ability of clay soil to retain nutrients more than sandy soil, and the increase of sodium led to change in soil structure. On the other hand, the negative effect on vegetative and reproductive growth characteristics increased when the salinity concentration increased. It is clear from these results that zucchini plants are medium tolerant to salinity and prefer to be grown in clay soil compared to sandy soil.

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