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Effects of Water Ozonated and Salinity on Some Properties of Cucumber

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ABSTRACT

The main objective of this study was to investigate the effects of water ozonated and salinity on some properties of cucumber. The treatments were defined by a two-factorial design of three water ozonated (0, 0.5 and 1 mg L^{-1}) and three water salinity levels (2, 4 and 6 dS m^{-1}). A greenhouse experiment was conducted and after germination, cucumber seeds were grown in pots containing soil, coco peat and perlite and were imposed with water ozonated and salinity treatments. The fruit yield, plant height, stem diameter, total soluble solids and some elements were determined. The results showed that salinity of irrigation water significantly reduced fruit yield and plant height of cucumber. However, statistical testing showed significant increase in total soluble solids with increasing water salinity. Ozonated water increased fruit yield, especially in water salinity 2 dS m^{-1}. Also, application of ozonated water caused significantly increases in the plant height. The results also indicated that salinity and ozonated water reduced stem diameter of cucumber, although there were not significant differences. The highest fruit yield (22.76 kg m^{-2}) and plant height (137.2 cm) were obtained at the third level of ozonated water (1 ppm) and 2 dS m^{-1} of salinity level. Statistical testing indicated significant increase in concentration of P and Na with increasing water salinity. The application of ozonated water and water salinity caused decreases in concentration of NH_4. The highest concentration of P (0.41%) and Na (2.76%) were obtained at the third level of ozonated water (1 ppm) and 6 dS m^{-1} of salinity level.

Key words: Saline, water ozonated, cucumber, elements, fruit yield

INTRODUCTION

Salinity is one of the most important significant environmental factors responsible for substantial losses in crop production in many parts of the world (Khoshbakht *et al*., 2014). The irrigation water salinity in Iran is the major factor limiting plant growths. Soil salinity is a serious constrain to crop production in many areas of Iran where the poor quality of the irrigation water is commonly associated with high temperature and reduced rainfall. Ozone had a potential for enhancing crop yield (Zheng *et al*., 2007). Chan *et al*. (2007) reported that irrigation by ozonated water increased the leaf area and fresh weight of spinach. Graham *et al*. (2011) reported that single applications of ozone had no effect on leaf area and shoot dry weight. However, pathogen levels were significantly reduced in all treatments aqueous ozone. Ohashi-Kaneko *et al*. (2009) suggested that ozonated water can be to sterilize of different source water (e.g., drain water, river water, rain water and underground water) in order to control pathogens during the early growth stage of plants. The effects of salt stress and ozonated water on the growth and productivity of vegetables have been studied separately by many authors but the combined effects of ozone and salt stress on cucumber are not yet available in the literature. Therefore, the present study aims to investigate combined ozone and salt stress effects on; fruit yield, plant height, stem diameter, total soluble solids and some elements of cucumber.

MATERIALS AND METHODS

A greenhouse experiment was conducted to study salt stress and ozonated water effects on cucumber yield and yield components. Some chemical and physical properties of experimental field soil listed in Table 1. Cucumber seeds (storm) were sown in a box of coco-peat substrate and young plants at four leaf stages were transferred in 10 L pots filled with soil (80%) and leca+perlite (20%). One cucumber plant was cultivated per pot. Modified Hoagland solution was used for irrigation of the pots. The treatments were defined by a two-factorial design of three irrigation water salinity levels (2, 4 and 6 dS m^{-1}) and three ozone concentrations (0, 0.5 and 1 ppm). The nine treatment combinations were replicated five times and arranged in a randomized complete block design. The salt solution was prepared by nutrient solution and NaCl and the electrical conductivity of different salinity levels was adjusted by a direct reading conductivity meter. Ozonated water was generated with an electrolytically ozonated water generator. The plants were exposed to ozone concentrations via irrigation with nutrient solution. For preparation of 0.5 and 1 ppm O_3, ozone was added to nutrient solution for 5 and 10 sec, respectively.

Soil analysis: Soil pH was measured in the soil saturation paste and Electrical Conductivity (EC) in saturated extracts. Soil organic carbon (Walkley and Black method), nitrogen (Kejldahl method), available K (with ammonium acetate) available P (Olsen's method) and Cation Exchange Capacity (CEC) with NH_4OAc method were determined via procedures described in Baruah and Barthakur (1997). Soil texture was performed using the hydrometer method (Gee and Bauder, 1986). Soil bulk density extracted by volumetric cylinder (Lestariningsih *et al*., 2013).

Plant analysis: Some plant properties including fruit yield (kg m^{-2}), plant height, stem diameter and total soluble solids were determined at the end of growth period. The fruit weight (for determination of fruit yield) was determined by weighting theses in the air on a precision digital balance with an accuracy of 0.001 g. Plant density was 2.5 plant in m^2. The plant height and stem diameter was measured with a Meter and digital vernier caliper, respectively. The Total Soluble Solids (TSS) were measured with a digital refractometer (Erma, Tokyo, calibrated using distilled water). The concentrations of some elements in plant, such as P, K, Ca, Mg and Na were determined by drying samples at 100°C and then ashed at 550°C under a gradual increase in temperature (Caballero *et al*., 2009). The concentrations of P (colorimetrically method), Na and K (flame photometry method) were measured. Also, the concentrations of Ca and Mg were measured either by atomic absorption spectrophotometry. The concentration of NH_4 and NO_3 was determined by Kjeldhal method.

Table 1: Some chemical and physical properties of experimental field soil

Properties	Values
EC (dS m^{-1})	1.42
pH (-)	8.22
N (%)	0.08
P (mg kg^{-1})	28
K (mg kg^{-1})	153
OC (%)	1.7
CEC (cmol+/kg)	19
$CaCO_3$ (%)	42
Texture (-)	Sandy loam
ρb (g cm^{-1})	1.5
Porosity (%)	56

EC: Electrical conductivity, OC: Organic matter, CEC: Cation exchange capacity, ρb: Bulk density

Statistical analysis: Two-way analysis of variance (ANOVA) was applied to estimate the effects of ozonated water and water salinity on studied properties of plant. Means were compared by Least Significant Difference (LSD) test ($p<0.05$). Statistical procedures were carried out using the software package SAS 9.1.

RESULTS

Fruit yield: Results showed that fruit yield were increased at high ozonated water levels. A decrease in fruit yield was noted as the salinity of irrigation water increased (Fig. 1). There was a significant ozonated water × salts stress interaction on the fruit number contents indicating that the highest fruit yield was obtained at the third level of ozonated water (1 ppm) and 2 dS m^{-1} of salinity level (Fig. 1).

Stem diameter: The results also indicated that salinity and ozonated water reduced stem diameter of cucumber, although there were not significant differences (Fig. 2).

Plant height: As shown Fig. 3, a significant increase in plant height was noted as the ozonated water levels increased. Results showed that with higher levels of water salinity the plant height was significantly decreased (Fig. 3). The highest plant height was obtained at the third level of ozonated water (1 ppm) and 2 dS m^{-1} of salinity level (Fig. 3).

Total soluble solids: There was a not significant ozonated water×salts stress interaction on total soluble solids. There were not significant differences between 0, 0.5 and 1 ppm ozonated water in total soluble solids. However, statistical testing showed significant increase in total soluble solids with increasing water salinity (Fig. 4).

Concentrations of P, K, Ca, Mg, Na, NH_4 and NO_3 in plant: Statistical testing indicated significant increase in concentration of P and Na with increasing water salinity. Also, application of ozonated water caused increases in concentration of P (across three salinity levels), Na

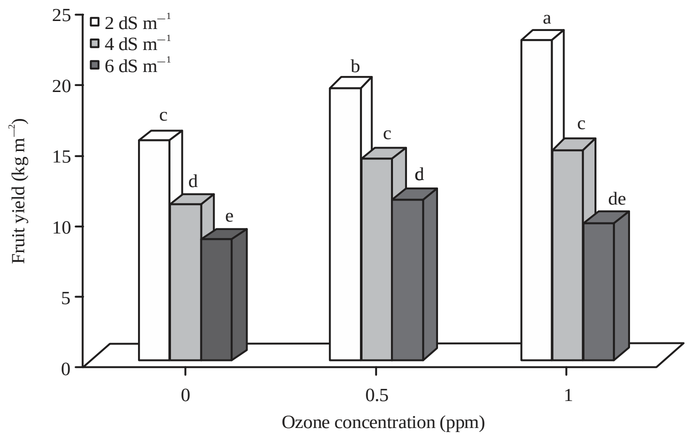

Fig. 1: Fruit yield in three ozone concentrations at the different salinity levels. The values followed by at least one common character are not statistically different at 5% probability level, according to LSD test

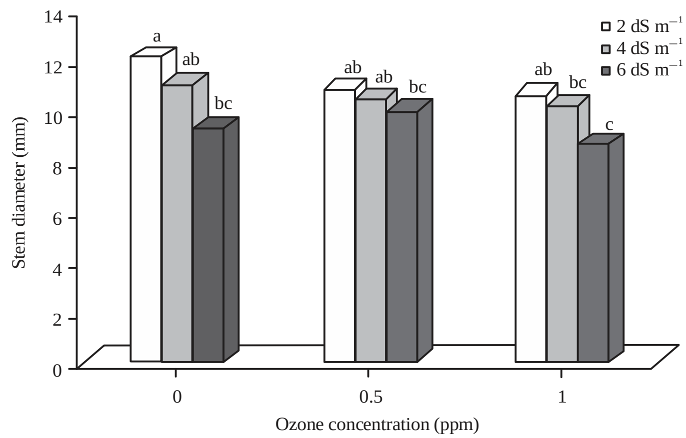

Fig. 2: Stem diameter in three ozone concentrations at the different salinity levels. The values followed by at least one common character are not statistically different at 5% probability level, according to LSD test

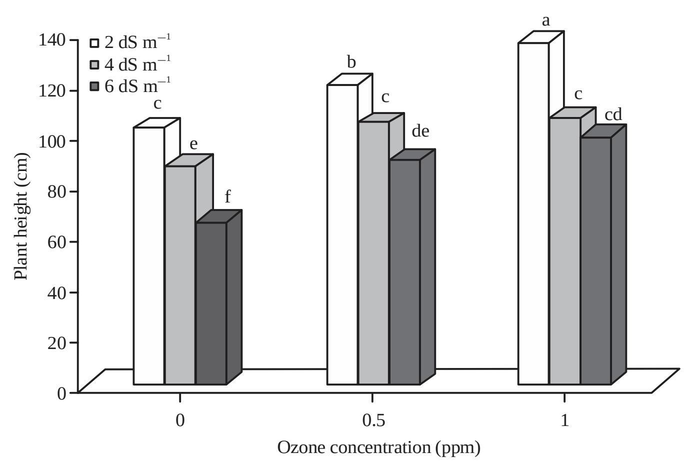

Fig. 3: Plant height in three ozone concentrations at the different salinity levels. The values followed by at least one common character are not statistically different at 5% probability level, according to LSD test

(only 6 dS m^{-1} of salinity level) and Mg (in 2 and 6 dS m^{-1} of salinity level) (Table 2). The highest concentration of P and Na were obtained at the third level of ozonated water (1 ppm) and 6 dS m^{-1} of salinity level. The concentration of Ca in 4 dS m^{-1} of salinity level was significantly higher than that other salinity levels (Table 2). Results indicated that, application of ozonated

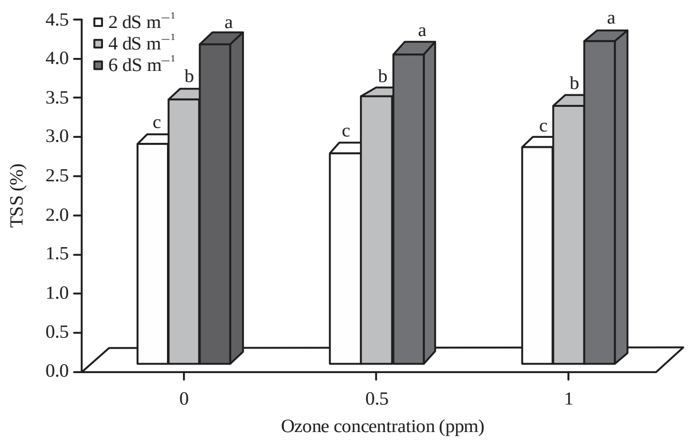

Fig. 4: Total soluble solids in three ozone concentrations at the different salinity levels. The values followed by at least one common character are not statistically different at 5% probability level, according to LSD test

Table 2: Some concentration elements in three ozone concentrations at the different salinity levels

Ozone concentration (ppm) and salinity level (dS m^{-1})	Concentration in plant (%)						
	P	K	Ca	Mg	Na	NH_4	NO_3
Control							
2	0.20^{h}	1.60^{b}	1.50^{c}	0.98^{e}	1.22^{d}	0.29^{a}	0.24^{c}
4	0.23^{g}	0.80^{e}	3.82^{a}	1.31^{a}	1.78^{c}	0.27^{b}	0.19^{e}
6	0.28^{f}	0.74^{e}	1.90^{c}	0.94^{e}	1.96^{c}	0.25^{c}	0.03^{g}
0.5							
2	0.30^{e}	1.82^{a}	1.70^{c}	1.05^{d}	1.05^{d}	0.26^{bc}	0.20^{e}
4	0.35^{d}	1.50^{b}	3.01^{b}	1.30^{a}	1.83^{c}	0.22^{d}	0.27^{b}
6	0.37^{c}	1.22^{c}	1.94^{c}	1.16^{c}	2.43^{b}	0.20^{ef}	0.01^{h}
1.0							
2	0.36^{cd}	1.80^{a}	1.86^{c}	1.15^{c}	1.07^{d}	0.21^{de}	0.22^{d}
4	0.39^{b}	1.00^{d}	3.17^{b}	1.30^{a}	1.87^{c}	0.19^{f}	0.30^{a}
6	0.41^{a}	1.92^{a}	1.96^{c}	1.23^{b}	2.76^{a}	0.18^{g}	0.07^{f}

In each column, the means followed by at least one common character are not statistically different at 5% probability level, according to LSD test

water decreased the concentrations of in the leaf tissues of tomato than control. Increasing water salinity levels resulted in a significant reduction in NH_4 and these reductions reached the highest values at 6 dS m^{-1} water levels compared with control plants. The highest concentration of NH_4 was obtained at the water without O_3 and 2 dS m^{-1} of salinity level (Table 2). However, the highest concentration of NO_3 was observed at 1 ppm O_3 and 4 dS m^{-1} of salinity level (Table 2).

DISCUSSION

It can be concluded that the application of ozone concentration (especially 1 ppm) increased, the fruit yield and plant height of cucumber. These findings are in alliance with the observations of Ohashi-Kaneko *et al*. (2009) and Chan *et al*. (2007), who found that growing properties of plant were greater in plants, treated with ozonated water than for control. The root respiration by ozonated water might be related to increased biomass productivity of cucumber plants. On the other hand, the exposure of roots with high level of oxygen is probably associated with the promotion of biomass productivity. Abdel Nasser (2002) reported that exposure to high ozone concentration (100 ppb) decreased the number and weight of root nodules, water content and leaf area. According to the study on the tomato reported by Ohashi-Kaneko *et al*. (2009), ozonated water did not harm plants (tomato) but did promote their growth. Sterilization by ozonated water might have decreased root rot, consequently increase water and mineral uptake by plant root (Ohashi-Kaneko *et al*., 2009). However, Graham *et al*. (2011) found that the applications of ozone had no significant impact on plant properties. Electrical conductivity of 1.8 dS m^{-1} may be generally armful to vegetable crops due to salt stress (De Pascale and Barbieri, 1995). Many studies reported that the yields components of vegetables decreased with increase in water salinity (Malash *et al*., 2002; Rameeh *et al*., 2004; Huang *et al*., 2009). Al-Busaidi *et al*. (2009) found that under saline condition all plant parameters of different varieties (except for the number of fruits) were reduced compared to the control. The findings of present study indicated that with higher levels of water salinity the studied properties of cucumber were significantly decreased. These results are concurred with the results of Huang *et al*. (2009) who found that water salinity significantly reduced fruit yield of cucumber owing to a decrease both in mean fruit weight and fruit number. Also, salinity caused a reduction in the number of fruits (Trajkova *et al*., 2006).

CONCLUSION

In this study, we found that ozonated water can be to use for irrigation of cucumber plant. Overall, the use of ozonated water could provide a useful tool to improve fruit yield of cucumber under salinity stress.

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