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Article

Some Ecological Impacts of Irrigated Water Type on Ornamental Pepper (*Capsicum annuum* L.)

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ABSTRACT
The ornamental pepper (*Capsicum annuum*) was planted in pots in Feb. 2019. When the plants were one month old, the pots were divided into three groups to irrigate: the first with tap water, the second with treated wastewater in Al Muamira station, and the third depended on textile wastewater (from the Hilla factory) in irrigation. The results showed that irrigation water caused effects on phenotypic traits and anatomy of leaves and stems. Each leaf area, plant's length, number of leaves, flowers and fruits and the highest numbers were in the second group—the plants within the third group characterized with significant variations in CAT, SOD, MDA and GSH. On the anatomical level, there are many variations in stomata frequency, length and width of stomata in both the upper and lower surfaces of the leaf.

Keywords: Capsicum annuum, irrigated water, phonological, physiological, stone cell.

INTRODUCTION

It has been known since ancient times that ornamental pepper (Capsicum sp.) has been used as an ornamental plant. This genus of Solanacea includes about twenty species distributed in tropic and sub-tropic countries[1], and its origin was the American tropics[2]. It is famous for its many uses because it is important in food and medicine and is seen as an ornamental plant [3,4]. Pepper is characterized by a high content of vitamins A, C and E [5], flavonoids, carotenoids, capsaicin [6], volatile oil and fixed oil[7], which are found in its fruits.
Ornamental peppers have all colors of the rainbow, so some plants can carry four or five colors at the same time [8], so the fruits range in their shapes [9]. These traits depend on genetic information from crosses in flowers [10] and the effect of environmental factors where plants grow. One of the important effecting factors is irrigation; water forms about 50-97% of plant body [11], and because the water resources are limited, ration water uses [12].

This work studied the effects of irrigation with textile wastewater, treated municipal wastewater and tap water on *Capsicum annuum*.

MATERIALS AND METHODS

In January 2019, the same *Capsicum annuum* plants were chosen at one month and then put in pots (plant/pot). These plants were divided into three groups to irrigate for three months: the first with tap water (control group) and the second with treated wastewater. By Al Muamira station, while the third depended on Hilla textile wastewater as irrigated water.

The nature of each type of water was identified by determining each pH, Electrical conductivity, Total dissolved Solids and salinity by multi-meter Type Hana, Oakton, US. The concentration of total hardness, Calcium, Magnesium, chloride, and sulfate was determined according to a standard method of water analysis [13]. At the same time, salinity was measured according to the 2003 Guild line of water analysis [14].

The essential features of soil were identification, which included pH, Electrical conductivity, Total dissolved Solids and Salinity, studied according to methods that deal with arid and semi-arid soil [15], while depending on titration method to calculate organic matter concentration [16].

After three months of irrigation, the morphological characteristics of *Capsicum annuum* were determined, which include the number of leaves, flowers and fruits, the length of the plant and the leaf area.

Some biochemical responses were studies which included concentration of each Catalase [17], super oxidase dismutase (SOD)[18], total protein[19], MDA [20], Glutathione [21], Proline [22]andChlorophyll content [23].

The study of anatomical variations of both stems and leaves depended on the handle method [24] of plant sample preparation, then studied microscopically.

RESULTS

Table (1) shows the main differences between the irrigated water types, which indicated high concentrations of all studies ions in treated wastewater for many reasons. First, returning to the nature of such water, it is used as a better alternate source to irrigate plants[25]. The second is related to the Hila textile factory, which, for many years, its main production stages were limited to finishing stages, and they did not use dyes or starch, which release ions and organic matter [26]. The soil was fertile, non-saline and suitable for growing ornamental plants, as its general features are explained in Table (2).

Plants' phonological responses are very affected by irrigation water type, as Table (3) shows. The treated wastewater caused an increase in shoot length, leaf area and the number of leaves, flowers and fruits.

Parameters	**Irrigated water**		
	1	2	**3**
pH	8.2	8.4	**8.8**
EC (µs/cm)	1180	2400	**1647**
TDS (mg/l)	937	1710	**1170**
Salinity (mg/l)	1123	2070	**1420**
Total hardness (mg/l)	680	880	**360**
Calcium (mg/l)	272.54	352.71	**144.38**
Magnesium (mg/l)	99.42	128.66	**52.634**
Chloride (mg/l)	339.89	479.85	**279.91**
Alkalinity (mg/l)	100	280	**200**
Sulphate (mg/l)	56.863	223.53	**109.8**
Organic matter (%)	0.06	0.27	**0.12**

Table 1. Characteristics of irrigated water types.

Parameters	**Concentration**
pH	**8.6**
EC (µs/cm)	**3000**
TDS (mg/l)	**2130**
Salinity (mg/l)	**2680**
Organic matter (%)	**1.76**

Table 2. Main characteristics of soil used in this experiment.

Treatment	**plant height cm)(**	**area of leaf (cm^2)**	**Number of**		
			leaves	Flowers	**Fruits**
1	10.5	3.6	21	9	**2**
2	19	9.1	41	15	**4**
3	15.5	4.8	28	12	**2**

Table 3. Main phonological studied responses of *Capsicumannuum*to the type of irrigated water.

Treatment	CAT(U/ml)	SOD (U/ml)	protein (mg/g. DW)	MDA nmol/ ml)(	GSH µg/ml) (	proline (µmole / g. DW)	Chloro-phyll con-tent (SPAD)	Mois-ture content (%)
1	51.54	3.343	24.2	4.37	13.1	4.838	23.1	**88.3**
2	46.19	3.683	23.92	3.88	33.74	6.941	32.4	**81.8**
3	58.9	2.89	23.15	3.03	49.31	5.364	24.2	**85.5**

Table 4. Physiological responses of *Capsicum annuum* to the type of irrigated water.

Treatment no.	lower surface			upper surface,		
	Stomata frequency	Stomata width	Stomata length	Stomata frequency	Stomata width	**Stomata length**
1	23	20-50 (35)	22.5-30 (26.25)	21	18.75-22.5 (20.625)	**27.5-30 (28.75)**
2	34	15-20 (17.5)	20-27.5 (23.75)	29	5-20 (17.5)	**20-32.5 (26.25)**
3	30	17.5-22.5 (20)	20-27.5 (23.75)	26	17.5-20 (18.75)	**22.5-27.5 (25)**

Table 5. The most important variations in the surface view of pepper plant leaves treated with different treatments, measured in mµ.

Character	1	2	3
cuticle thickness	7.5-10.5 (8.75)	2.5-10 (6.25)	5-10 (7.5)
Epidermis thickness	17.5-25 (21.25)	12.5-22.5 (17.5)	15-25 (20)
Collenchyma layers	1-6	1-7	1-7
Parenchyma layers	3-5	3-6	3-7
Vascular bundle length	175-450 (312.5)	325-425 (387.5)	175-500 (337.5)
Xylem diameter	22.5-37.5 (30)	22.5-55 (38.5)	20-47.5 (33.75)
Phloem length	50-87.5 (68.75)	30-75 (52.5)	55-112.5 (83.75)
Stone cells	+	+	-

Table 6. The most important variations in the cross-sections of the pepper plant stems, which were treated with different treatments, measured in mµ.

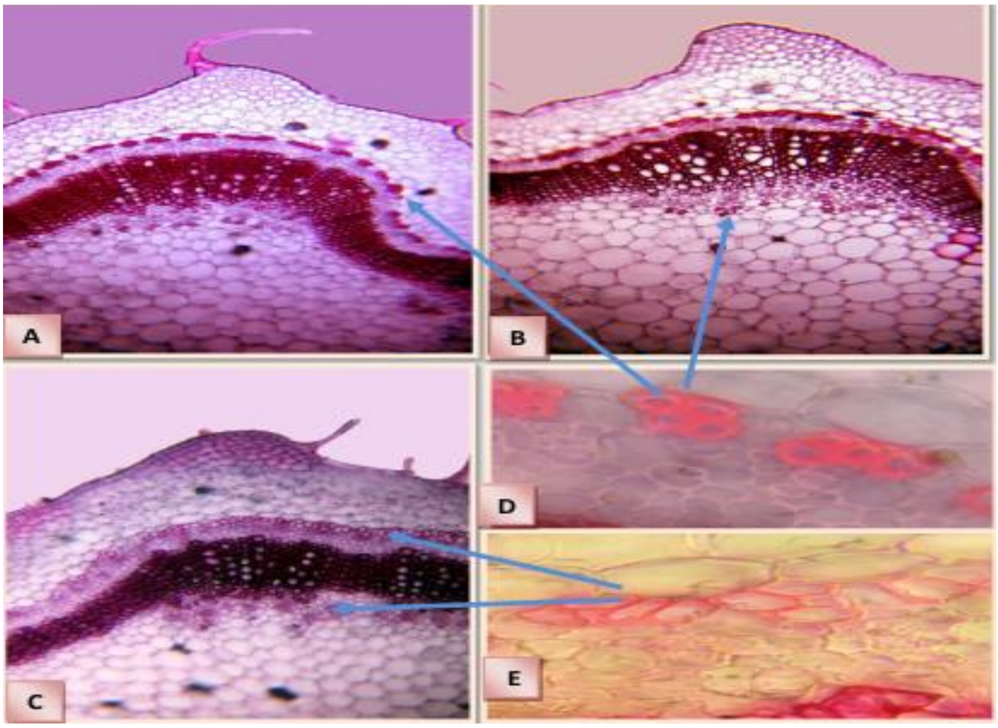

Figure 1. shows cross-sections of pepper stems treated with different treatments (A, B, C with a magnification of 20 X). (D, E with a magnification of 120 X) where:-A- Tap water, B-Al-Mmoamera treated wastewater, C- Textile wastewater, D-stone cells, E-sclerenchyma fibers

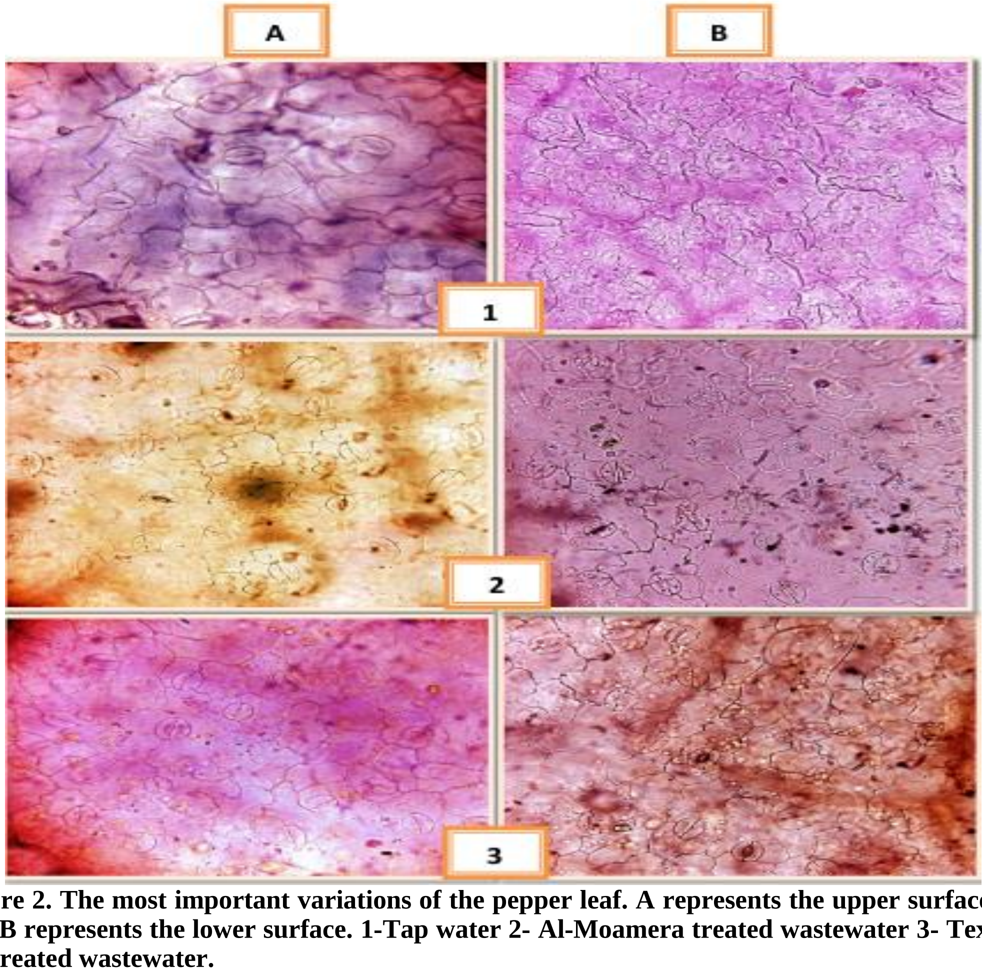

Figure 2. The most important variations of the pepper leaf. A represents the upper surface, and B represents the lower surface. 1-Tap water 2- Al-Moamera treated wastewater 3- Textile treated wastewater.

DISCUSSION

This increase returns to high organic matter and essential elements like Calcium, Magnesium and other dissolved ions like Phosphorus and nitrate[27]. In contrast, the textile wastewater gives better growth when compared with the control group; this result may be due to moderate concentrations of ions, and these results agree with other studies on the effect of diluted textile wastewater [28, 29].

The results in Table (4) explained that both treated and textile wastewater caused non-significant variations in the level of biochemical responses.

These results mean such irrigated water did not cause high stress on plants; compared to groups, we can see the highest chlorophyll content was in group 2 due to the high organic matter and Magnesium in this water. The Catalase and Glutathione recorded higher concentrations in leaves of *Capsicum annu*m group 3 as a part of an adaptive strategy of plants as a manifestation of initiation of anti-oxidant defenses[30].

The exposure to different environmental factors caused different anatomical responses in plants. Leaf areas, for example, are less under poor supply of essential requirements like water and minerals [30]. Leaves anatomical responses are shown in Table (5) and Plat (1).

The width and length of stomata were decreased with high stomata frequencies in leaves of plants watered with treated wastewater but without significant variations among the three groups.

Table (6) and plate (2) explain the main stem anatomical variations induced by irrigation water type. The thickness of the cuticle and epidermal layer was higher in plants irrigated with tap water due to the high need to reduce water loss, while the lower thickness was in plants irrigated with treated wastewater due to high organic matter in the soil. The cuticle is thought to have an important role in plant tolerance due to its ability to potstone the onset of cellular dehydration in stress conditions [32]. Each of[,33]and, 34, and [34] found that salinity increased the diameter of the xylem in the stem; this result agrees with a current study on pepper.

The stone (sclerenchyma toes) cells were missed from the chlorenchyma of the stem in the group irrigated with textile-treated wastewater. These cells can used as a bio indicator of the ability of plants to tolerate environmental pollutants, especially heavy metals [31].

CONCLUSIONS

The type of irrigated water caused changes in the stem's anatomy, like stone ́s cells disappearance in the third group, so the length of the vascular bundle and the diameter of the xylem vessel increased.

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