GROWTH COMPONENTS AND PRODUCTIVITY OF EGGPLANTS IRRIGATED WITH TREATED WASTEWATER

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ABSTRACT

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In this study, secondary effluent was used to irrigate four experimental plots of Baby eggplants (Solanum melongena L.). Wastewater quality analysis indicated that few parameters do not meet the Lebanese water standards for crop irrigation and reuse. Results demonstrated that aboveground biomass increased by 16% for plants irrigated with treated wastewater, whereas aboveground biomass and fruit weight increased when treated wastewater and mulch were used. Further studies, such as chemical and microbial analysis, to evaluate the danger and risks on human health of using treated wastewater to irrigate eggplants were initiated.

Keywords: water reuse, secondary effluent, agriculture, contaminants.

INTRODUCTION

The use of wastewater for irrigation is a viable alternative to supply water and nutrients to plants, besides raising global awareness for a better use of this finite resource. Domestic sewage stands out for being rich in organic material and considered as sustainable for application in agriculture, especially treated sewage due to its composition and nutritional values. The utilization of treated sewage constitutes an effective measure to control pollution, because it avoids the disposal of sewage in water bodies and natural environment.

While the population in the Mediterranean Sea represent around 7% of the total world's population, this region has just 2% of the world fresh water reserves. The previously mentioned water reserves are distributed unequally and are concentrated in northern countries. Accordingly, water scarcity is a limiting factor for a variety of

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activities and especially for agriculture, which is the largest consumer of fresh water resources worldwide (Romanos-Vasileios, 2015).

Due to the irregular and uneven distribution, which describes the availability and the amount of water reserves, as well as the intensive use of the water resources, the reuse of treated wastewater in agriculture has recently became an attractive solution to reduce the quantities of water that are pumped form natural water resources.

Both wastewater treatment level and its use in irrigation vary among the Mediterranean countries. Northern Mediterranean countries treat around 90 % of their wastewater, yet utilize just a little portion for irrigation. Southern Mediterranean countries, which have much less water reserves, treat only a small portion of their wastewater, but tend to use almost all treated wastewater for irrigation.

Significant technological advances were recently made in wastewater treatment that meets health and environmental regulations which makes treated wastewater appropriate for different purposes including irrigation of crops.

Al-Abdoulqader and Al-Jaloud (2003) have stated, in their economic study of "The use of recycled sewage water in irrigation of field crops", that it saved up to 45% in fertilizers cost for wheat crop and 94% for alfalfa crop compared to irrigation with well water due to the fact that sewage water contains the essential elements needed by such crops. They also indicated that the usage of sewage water in irrigation of wheat and alfalfa crops increased their yield by 11 and 23%, respectively, and consequently increased the profit by 14 and 28%, respectively, as compared to irrigation with well water (Husseiki et al., 2017).

The objective of this study is to estimate the economic value of safe use of wastewater for crop production on farms, and its impact on the economic benefits for farmers in the Bekaa region of Lebanon. In addition, the effect of using mulch on growth and productivity of eggplant was also evaluated.

MATERIALS AND METHODS

Experimental design

Fruits of Baby eggplants, also called Continental or Lebanese eggplants, are slender elongated in shape with dark purple skin but can also be light green or white, and have spongy absorbent flesh that absorbs flavours well. They can be used in braises, roasted whole or in pieces, fried or grilled.

The experiment was carried in Ferzol village in the Bekaa valley, Lebanon. Twelve plots were selected for this experiment. Each plot was composed of 10 rows of eggplants, spaced at 1.0 m x 0.6 m, with 10 plants in each row. The total number of eggplants was 100 in each plot. Plants were watered by drip irrigation.

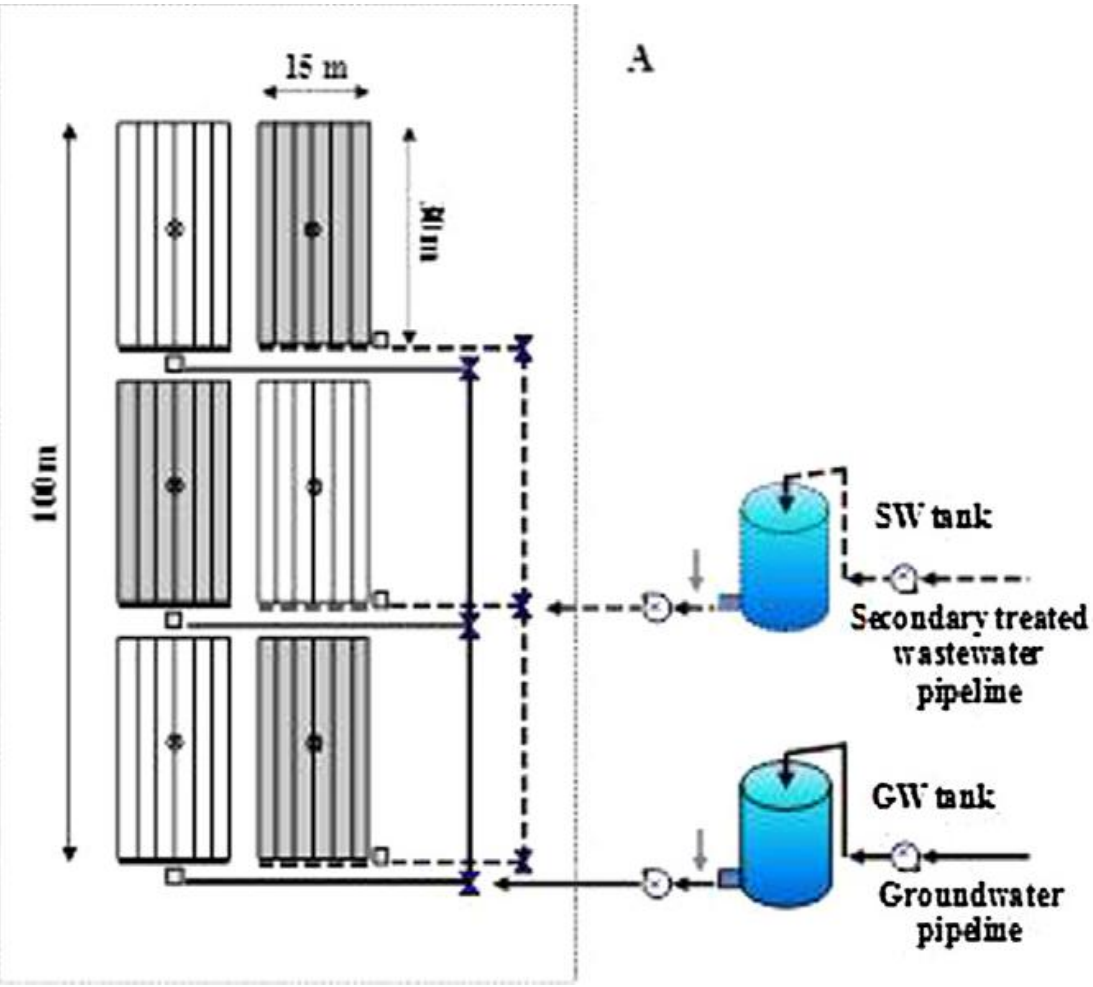

Figure 1. Layout of the experimental field and irrigation systems

Experimental plots were irrigated during the 2016 eggplant's growing season with both fresh water from a well and treated wastewater from the nearby Ferzol Wastewater Treatment Plant. Water was conveyed to the field via wastewater supply networks directly from the treatment plant.

Irrigation pipes were laid out above the soil to avoid direct water contact with crop foliage. The amount and frequency of irrigation were the same for every treatment, irrigation amount was 8mm/day during the first month after transplanting and 12mm/day afterwards.

60 days after transplantation, plants height from soil surface to the insertion of the last leaf of the highest stem, stem diameter at 4 cm height from the plant base were measured. In each harvest, fruits were divided in two classes before counting and weighing:

1. Healthy, in terms of shape, weight and color
2. Un-marketable, such as small, multi-coloured and damaged fruits.

The average fruit weight, was measured by dividing total fruit weight by the number of fruits harvested. Yield was determined considering only healthy fruits. The last harvest was carried out 100 days after transplanting.

Irrigation water used

Secondary treated wastewater obtained from Ferzol Wastewater Treatment Plant (FWWTP) was used in this study. Results on the analyses of such water are presented in Table 1.

Table 1. FWWTP Wastewater analysis results conducted by LARI in 2016.

	Influent Ferzol Station	Effluents Ferzol station	Acceptable limits (FAO)
BOD5 (mg/l)	708	123	25
COD(mg/l)	1700	95	125
Total Suspended Solid Waste (mg/l)	6780	91	<60
Total Nitrogen (mg/l)	99	41	>5-<30
Total Phosphorus (mg/l)	1.93	1.67	10
Total Potassium (mg/l)	35	40	
pH	8.4	8.4	>6-<9

The 5 day biochemical oxygen demand, or BOD5, is water quality parameter.

BOD5 measures the quantity of biodegradable organic matter contained in water. This biodegradable organic matter is evaluated using the oxygen consumed by the microorganisms involved in natural purification mechanisms.

This parameter is expressed as the milligrams of oxygen needed to break down the organic matter contained in a litre of water over five days.

The chemical oxygen demand (COD) is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution. It is commonly expressed in mass of oxygen consumed over volume of solution which in SI units is milligrams per litre (mg/L).

As indicted in Table 1, some parameters, such as BOD5, TSS and total Potassium exceeded the FAO standards. Improper management and operation of the plant, as well as the very high level of BOD5, TSS and total Potassium at the inlet of the treatment plant could be behind such results. The amount of water used was 8 mm/day during the first month and 12 mm/day afterwards.

Treated wastewater as well as fresh underground water was stored in a 10^{m3} water reservoir before being used for irrigation. Both, ground water and treated wastewater were directly pumped to the drip irrigation system.

Evaluated treatments

In the first treatment, eggplants were cultivated using fresh underground water for irrigation in the absence of mulch. In the second treatment, eggplants were cultivated using fresh underground water, in addition to using black mulch. In the third treatment, eggplants were cultivated using treated wastewater from Ferzol treatment plant for irrigation in the absence of mulch. In the fourth treatment eggplants were cultivated using treated wastewater from Ferzol plant, in addition to using black mulch.

RESULTS AND DISCUSSION

In this study eggplants were irrigated with treated wastewater and fresh water from nearby wells as control, with the addition of mulch in order to evaluate the crop yield response to these factors.

Results represented in Figure 2 show that plants irrigated with treated wastewater with the use of mulch increased stem diameter by 21.4% compared to control plants.

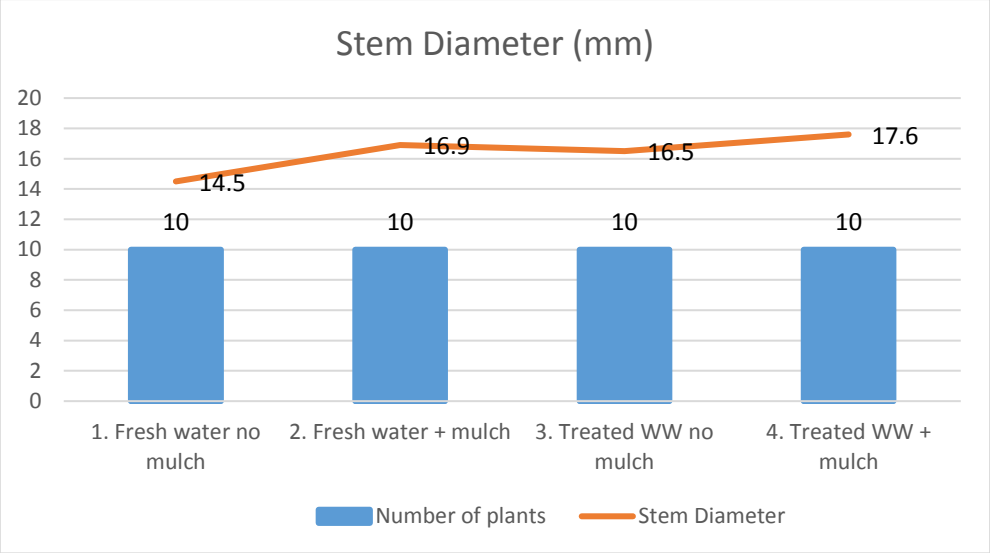

Figure 2. Effect of using mulch and treated wastewater on stem diameter of eggplants.

Results (Figure 3) showed that plant height was increased by only 14.5 % compared to the control plants. In this case, the use of 'treated wastewater/mulch' combination increased the stem diameter but and from negatively affected the height of eggplants.

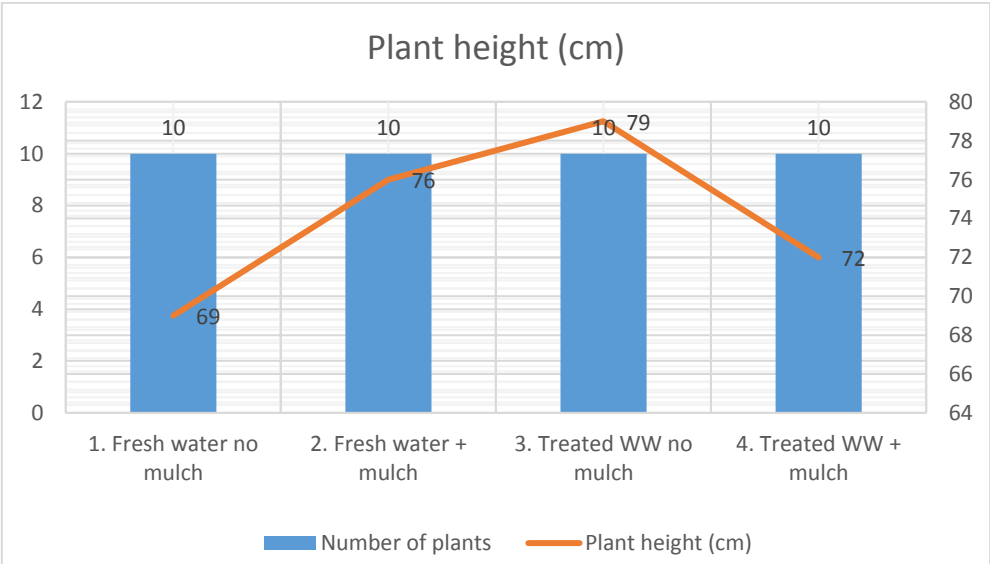

Figure 3. Effect of using mulch and treated wastewater on plant height of eggplant.

Mulching does not perform instant miracles, but it encourages better plant growth and development, and makes all landscape maintenance operations easier. These benefits accrue whether plants are growing in the coolest or hottest climates or in the wettest or driest weather.

The field production of eggplant in moderate climates is difficult as it depends heavily on thermal conditions. Eggplant is a species that is sensitive to low temperatures, and temperatures below 16ºC constrain the growth of young plants. Other disadvantageous factors include: temperatures that are too high, water shortage and excessive soil humidity. The growth conditions for eggplant can be improved by using mulches.

Mulches break the force of rain and irrigation water thereby preventing erosion, soil compaction and crusting. Mulched soils absorb water faster. Mulches prevent splashing of mud and certain plant disease organisms onto plants and flowers during rain or overhead irrigation. The mulch covering excludes light which prevents germination of many weed seeds. Fewer weeds provide less competition for available moisture and nutrients. Using mulches to control weeds is safer than applying herbicides or cultivating which can damage tender, newly formed roots. Mulches also add attractive features to landscape.

Black plastic mulch can capture and reflect excessive heat around plants. They can also work their way down into the soil, making cultivation difficult, thus negatively affect some of the growth parameters, such plan height. Mulching can capture moisture and control weeds which should have positive effect on plant growth.

Figure 4 showed a significant difference in fruit weight from plants mulched with black polythene compared to the control. This was probably because of trapped moisture under the plastic mulch, the warmth which provided the root zone with favourable temperatures for nutrient absorption. In the plastic mulch there was probably less nutrient volatilization, thus most of the time the available nutrients were used for vegetative growth by the plant, this could explain why fruit weight was significantly increased by 46.5 % compared to the control.

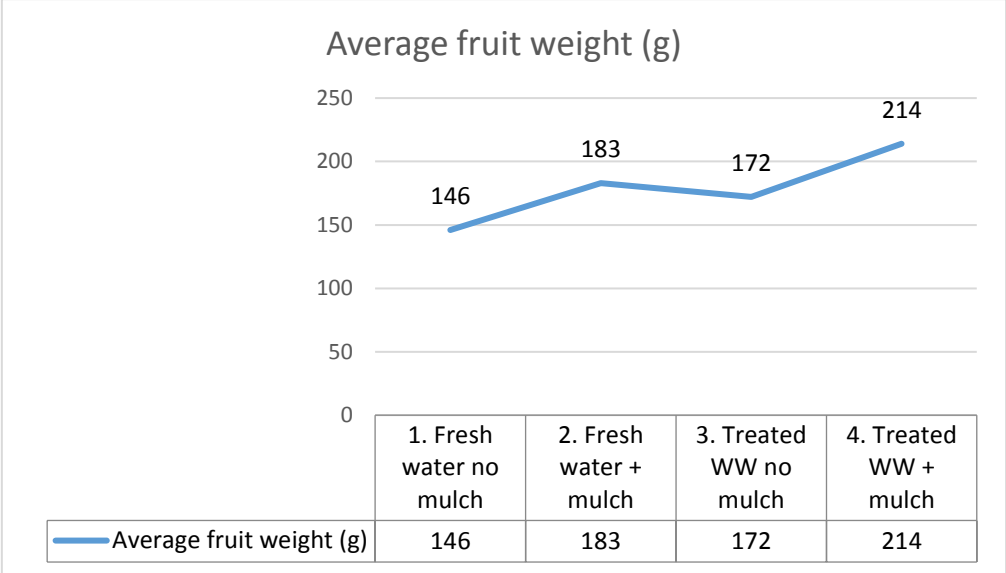

Figure 4. Effect of using mulch and treated wastewater on average fruit weight of eggplants.

Figures 5 and 6 report eggplant fruit production features in terms of total fruit weight and number of fruits per plant. Results showed an increase of 14.4 % of fruit weight and 28.5 % decrease in number of fruits per plant.

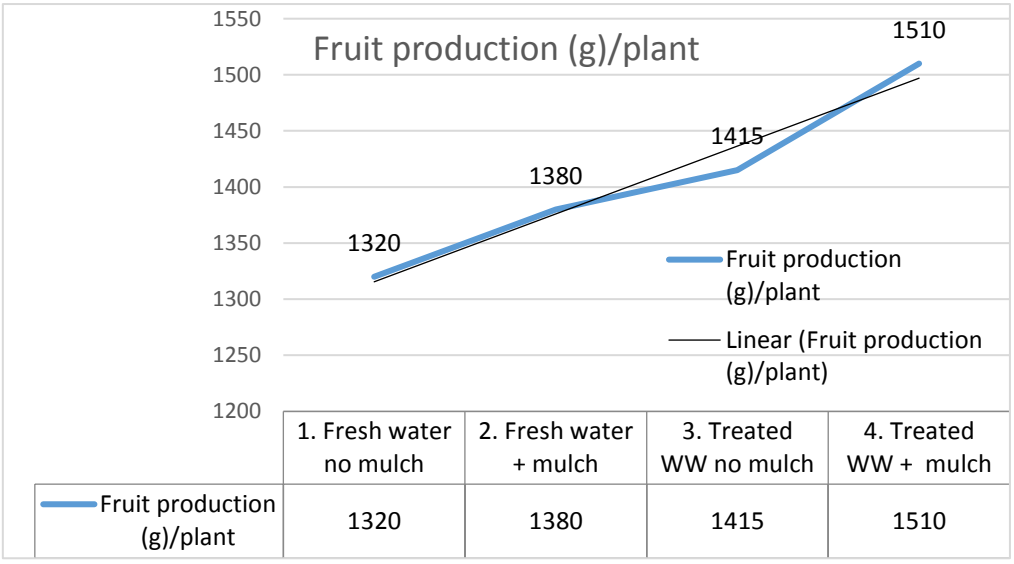

Figure 5. Effect of using mulch and treated wastewater on eggplant fruit production.

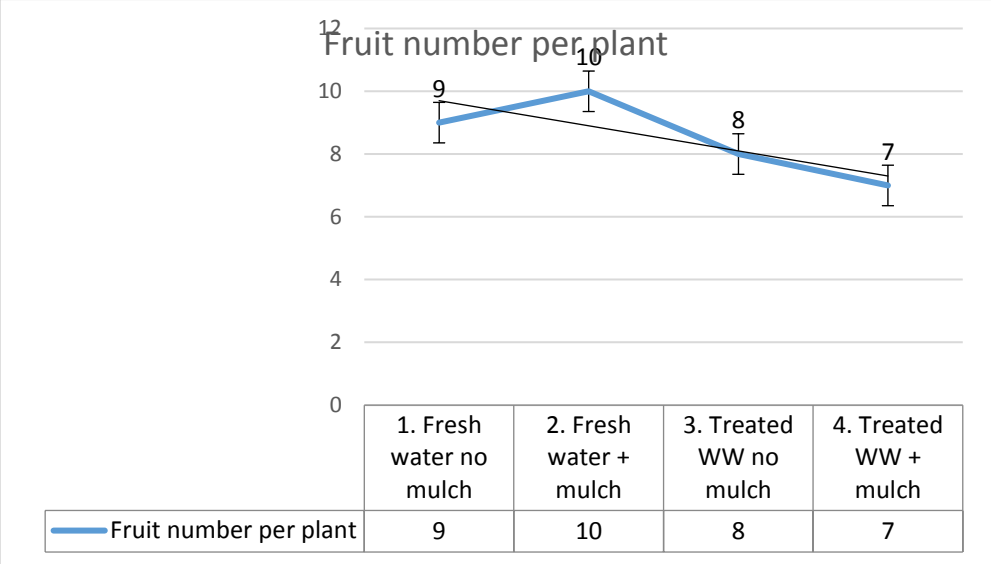

Figure 6. Effect of using mulch and treated wastewater on eggplant fruits number per plant.

Among various water conservation practices, the use of non-conventional water resources, such as treated waste-water must be probed. Wastewater reuse for agriculture offers the greatest scope for application because it usually has the potential to meet increasing water demands, conserve potable supplies, reduce disposal of pollution effluent into surface water bodies, allow lower treatment costs and enhance economic benefits to growers due to reduced fertilizers application rates.

Presently farmers who reuse wastewater don't practice more precaution measures, such as direct foliage watering technique to avoid/minimize pathogen contamination risk or no irrigation prior to harvesting. Thus, proper disinfection and good cooking by the consumers are still necessary to eliminate any kind of pathogen health risk of using treated wastewater.

The study showed that the usage of mulches of black polythene, along with treated wastewater have improved eggplants yields, reduced weed infestation and preserved soil moisture. It is recommended that farmers use black polythene and treated wastewater for irrigation of eggplants and other vegetables that are usually consumed after cooking. The use of locally available mulch materials is recommended. Monitoring residue of some chemicals, especially heavy metals, should be investigated in future research.

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