RESEARCH ARTICLE Legume Research- An International Journal, Volume 45 Issue 5: 626-630 (May 2022)

Effect of Short-term Irrigation of Treated Wastewater on Vetch (*Vicia sativa* L.) and Alfalfa (*Medicago sativa* L.) Growth

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10.18805/LRF-654

ABSTRACT

Background: This study was conducted to evaluate the production of two fodder crops; common vetch (*Vicia sativa* L.) and Alfalfa (*Medicago sativa* L.) irrigated with treated wastewater. The study was implemented during summer 2015.

Methods: Four water regimes were used in the experiment including: Irrigation with fresh water (control), fresh water supplied by 10 ppm N-P-K fertilizer, treated wastewater and treated wastewater supplied with 10 ppm N-P-K fertilizer. The crops were planted in 5 liters plastic pots in 4:1 v/v sandy to clay soil. The soil was analyzed before and after planting. The following plant parameters were recorded: Plant height, fresh weight, dry weight, leaves number/plant, fruit number/plant and fruit weight/plant.

Result: using treated wastewater significantly increased production parameters, the highest production was obtained with treated wastewater supplied with 10 ppm N-P-K fertilizer (81.5 cm/plant higher in vetch and 112.5 cm/plant in alfalfa for plant height). When treated wastewater was used alone compared to fresh water higher fresh weights (62.8 g/plant) (82.33 g/plant (132 and 87.17 g/plant) for vetch and alfalfa were obtained respectively. Regarding the dry weight, irrigation with TWW produced 33.83 g/plant and 44.67 g/plant compared to 22 g/ plant and 24.5 g/ plant for plants irrigated with fresh water for vetch and alfalfa respectively. The results of soil analysis show an increase in soil content of nitrogen, phosphorus and potassium, as well as an increase in soil salinity and SAR values.

Key words: Conventional water, *Medicago sativa*, Treated wastewater, *Vicia sativa*.

INTRODUCTION

The global demand on water is continuously increasing, where the world population has exceeded seven billions and is still growing. Not only the continuous population growth is requiring water for domestic purposes, but also the demand on food is increasing, which causes an increasing and a growing demand on water for irrigation (Ahmadi and Merkley, 2017; Kumar *et al*., 2017; Sarkar *et al*., 2017). The competition among different sectors of water users is increasing and agriculture is the most vulnerable sector since it is the main consumer of water. Moreover, the scarcity of fresh water resources in many areas of the world is pushing towards utilizing new unconventional water sources such as brackish and treated wastewater (Libutti *et al*., 2018).

In Palestine, the situation of water utilization and availability is more complicated, where Palestine as a part of the southern Mediterranean is located in the semiarid region. In many arid and semi-arid countries water is becoming an increasingly scarce resource and planners are forced to consider any sources of water which might be used economically and effectively to promote further development (MoA, 2014). Moreover the fresh water resources in Palestine are limited in both the availability and accessibility to the Palestinians due to the Israeli practices on ground (Rahil and Qanadillo, 2015). With the continuous high population growth, the demand on water is growing fast by all sectors, and the competition between the different water users is clearly apparent, where the per capita share is less than 70 liters per day (Shadeed and Alawna, 2021). The scarcity of water is combined with the absence of the free access to water resources, where the Palestinian are allowed to use only 15% of the available resources which complicates the dilemma for the water management in Palestine(Jayyousi and Srouji, 2009).

Agriculture in Palestine as in the rest of the world is the main consumer for water, where it is estimated that the total available water quantities are estimated to be 291 MCM per year (MoA, 2014). The total agricultural area in the West Bank is around 165,000 hectares (62% fruit trees, 11% vegetables and 27% field crops). Around 93 MCM/year of water is used for irrigation, or 70% of the total water

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How to cite this article: Qaoud, H.A., Shtaya, M., Mizyed, N., Fares, H.A. and Lebdi, A. (2022). Effect of Short-term Irrigation of Treated Wastewater on Vetch (*Vicia sativa* L.) and Alfalfa (*Medicago sativa* L.) Growth. Legume Research. 45(5): 626-630. DOI: 10.18805/LRF-654.

Submitted: 06-09-2021 **Accepted:** 25-01-2022 **Online:** 03-03-2022

resources. Irrigated agriculture represents 37% of total agricultural production compared to only 24% from rain fed agriculture (McNeilla *et al*., 2009). This means that there is a good opportunity to expand the irrigated area if more irrigation water becomes available for agriculture.

Under the current political climate, it is not expected for the Palestinians to have new fresh water quantities for irrigation and the only foreseen scenario is to utilize marginal water resources, as brackish ware and treated wastewater (Gatta *et al*., 2018; Salem *et al*., 2019; Shadeed and Alawna, 2021). The treated wastewater is a highly important potential source for irrigation (Reznik *et al*., 2019). If these quantities were treated to an accepted level and utilized in agriculture, the irrigated area could be expanded significantly. Taking into account that the area planted with fodders is very small in Palestine forming only 4% of the cultivated area, where most of the required fodders for animal agricultural sector are imported (MoA, 2014), which create a growing difficulties for the farmers and increase the production costs for them (Salem *et al*., 2019; Shadeed and Alawna, 2021).

This study is examining the differences of production in two fodder crops irrigated with fresh water and treated wastewater as a part of the efforts trying to figure out the possibility of utilizing this new source in agriculture. It is aiming to assess the possibility to produce high quality fodders of common vetch and alfalfa using treated wastewater.

MATERIALS AND METHODS

Experiment site and design

The experiment was implemented during the period from July-November 2015, close to the treatment plant at Attell town north of Tulkarm city, Palestine. All the laboratory work was conducted at the Faculty of Agriculture and Veterinary Medicine, An-Najah National University, Palestine. The plant is composed of a settling tank followed by anaerobic upflow gravel filter and then a trickling filter and aerobic filter and finally the clarifier and the storing tank. The chemical analysis of the used fresh and treated waste water (TWW) is shown in Table 1.

Local varieties of vetch and alfalfa commonly used by local farmers were used. Seeds were planted directly in plastic pots filled with 5 kg soil (4:1 v/v sandy to clay soil). The experiment was carried out in a completely randomized design with four treatments each replicated six times. Each of the plant species was subjected to the following treatments:

T1: Control, (irrigation with fresh water).
T2: Control+10 ppm N-P-K fertilizer (irrigation with fresh water, partial mineral fertilization).
T3: TWW (irrigation with reused wastewater, no mineral fertilization).
T4: TWW+10 ppm N-P-K fertilizer (irrigation with TWW and partial mineral fertilization).

Irrigation with treated and fresh water started with the planting. The irrigation schedule was selected to be a four days irrigation interval schedule used by the local farmers. Drip irrigation system was applied in the field. The crops water requirements were calculated based on the calculation of the reference evapotranspiration (ET_0) from the climatic data using the modified Penman-Montieth formula (Allen *et al*., 1998). Then the reference evapotranspiration was used to calculate the crop water requirements during the different growth stages using CROPWAT software version 7.0 (Smith, 1992; Dang, 2018).

The following growth variables were monitored during the growing:

Plant height (cm)

The height of 10 plants per replicate was taken from the soil surface to the upper side of the stem using a graduated ruler and then the average of the 10 plants was used for statistical analysis.

Plant fresh weight (g)

The weight of 10 plants per replicate was measured using an electrical balance and then the average of the 10 plants was used for statistical analysis.

Plant dry weight (g)

The plants used to measure the fresh weight were oven dried in an electric oven for 72 h at 70°C (Shtaya *et al*., 2021). The average weight of the 10 plants was used for statistical analysis.

Leaves number/plant

The number of leaves of 10 plants per replicate was counted and then the average of the 10 plants was used for statistical analysis.

Seed number/plant

The number of seeds of 10 plants per replicate was counted and then the average of the 10 plants was used for statistical analysis.

Table 1: The results of water samples analysis.

Parameter	Fresh water	TWW
pH	7.21	7.45
EC (ds/m)	0.56	1.65
BOD5 (mg/l)	ND	156
COD (mg/l)	ND	237
TDS (mg/l)	560	1200
Cl (mg/l)	115	278
N (mg/l)	8	85
P (mg/l)	0.09	0.6
K (mg/l)	7	41
Ca (mg/l)	14	54.4
Mg (mg/l)	43	100
Na (mg/l)	57	117
SAR	1.69	2.17
TFC (CFU/100 ml)	ND	20

Seed weight/plant (g)

The seeds weight of 10 plants per replicate was measured using an electrical balance and then the average of the 10 plants was used for statistical analysis.

Statistical analysis

Analysis of variance (ANOVA) was conducted using the PROC GLM procedure of SAS/STAT software, version 9.0 for Windows (SAS institute 2002). Multiple comparisons among means were performed using Tukey-test at 0.05 probability value.

RESULTS AND DISCUSSION

The effect of treatments on plant height

The results of plant height showed that treated wastewater significantly increased the height of vetch and alfalfa plants compared to control (68.5 cm in vetch and 99.33 cm in alfalfa) (Table 2). In both crops, 10 ppm supplemental fertilization with TWW resulted in a significant difference in plant height when compared to control and TWW without supplementary fertilization (75.5 cm in vetch, 106.17 cm in alfalfa). These results agree with the results reported in foxtail millet (Aghtape *et al*., 2011), barley (Samarah *et al*., 2020), wheat (Le *et al*., 2020) and lucerne (Gholamali *et al*., 2011). TWW contain nutrient elements that satisfy the plants needs and enhance the growth parameters. In addition to this the plants irrigated with treated wastewater without any fertilizers (TWW) significantly have higher plant height than those plants irrigated with fresh water supplied with fertilizers in both crops, this means that production could be boosted without the use of extra mineral fertilizers. This is due to the nutritional content of the treated wastewater (Table 1), which may meet the needs of the plants at various phases of development, as demonstrated by (Gholamali *et al*., 2011; Babayan *et al*., 2012).

The results of leaves number show that there are significant differences (Table 2). Both crops showed higher leaf numbers under TWW (41.33 and 72.67 leaves per plant respectively) than control (26 and 33 leaves per plant respectively. Adding 10 ppm supplementary fertilizer to the TWW also showed a significantly higher leaf number per plant (48.67 and 79 leaves per plant respectively) than control and TWW without any supplementary chemical fertilization. Balkhair *et al.* (2013) attributed this to an increase in soil nutrients due to wastewater irrigation, which enhanced the physical and nutrient contents of the soil, resulting in a considerable rise in total chlorophyll and carotene, as well as good crop development, biomass and yield.

Fresh and dry weight

The results of fresh and dry weight showed that irrigation with TWW has a positive effect on the fresh and dry weight of vetch and alfalfa (Table 3). It was found that there are

Table 2: The effect of TWW on plant height of vetch and alfalfa.

Treatment	Plant height (cm)		Leaf number	
	Vetch	Alfalfa	Vetch	Alfalfa
Control (fresh water only)	42.83^{d}	59.33^{d}	26.00d	33.00d
Fresh water+10 ppm fertilizer	51.17^{c}	66.17^{c}	30.17c	54.17c
TWW	68.50^{b}	99.33^{b}	41.33b	72.67b
TWW+10 ppm fertilizer	75.50^{a}	106.17^{a}	48.67a	79.00a

Number in each column followed by the same letter(s) are not significantly differ at 0.05 level according to Tukey test ($p<0.05$).

Table 3: The effect of TWW on plant fresh and dry weight of vetch and alfalfa.

Treatment	Vetch		Alfalfa	
	Plant FW (g)	Plant DW (g)	Plant FW (g)	Plant DW (g)
Control (fresh water only)	53.83^{d}	22.03^{d}	62.83^{d}	24.50^{d}
Fresh water+10 ppm fertilizer	60.83^{c}	24.83^{c}	72.00^{c}	30.50^{c}
TWW	71.50^{b}	33.83^{b}	87.17^{b}	44.67^{b}
TWW+10 ppm fertilizer	77.17^{a}	40.50^{a}	105.00^{a}	50.00^{a}

Number in each column followed by the same letter(s) are not significantly differ at 0.05 level according to Tukey test ($p<0.05$).

Table 4: The effect of TWW on seed number and seed weight (g) per plant of vetch and alfalfa.

Treatment	Seed number per plant		Seed weight per plant (g)	
	Vetch	Alfalfa	Vetch	Alfalfa
Control (fresh water only)	86.50^{d}	645^{d}	8.27^{d}	2.15^{d}
Fresh water+10 ppm fertilizer	98.33^{c}	890^{c}	10.52^{c}	2.60^{c}
TWW	117.00^{b}	1570^{b}	14.02^{b}	3.78^{b}
TWW+10 ppm fertilizer	122.83^{a}	1710^{a}	16.43^{a}	4.43^{a}

Number in each column followed by the same letter(s) are not significantly differ at 0.05 level according to Tukey test ($p<0.05$).

significant differences in the fresh and dry weight production among the different treatments. TWW showed higher fresh (71.5 and 87.17 g per plant of vetch and alfalfa respectively) and dry weight (33.83 and 44.67 g per plant respectively) of both crops compared to plants irrigated with fresh water and fresh water with fertilizer, however, plants irrigated with TWW and 10 ppm chemical fertilizer significantly exhibited the highest fresh (77.17 and 105 g per plant of vetch and alfalfa respectively) and dry weight (40.5 and 50 g per plant respectively) of both crops. These results are in agreement with the results reported in foxtail millet (Aghtape *et al*., 2011), barley (Samarah *et al*., 2020), wheat (Le *et al*., 2020) and lucerne (Gholamali *et al*., 2011).

Seed number and weight

The results of seed number and seed weight per plant showed that irrigation with TWW has a positive effect on both variables in vetch and alfalfa (Table 4). TWW showed higher seed number per plant (117 and 1570 seeds per plant of vetch and alfalfa respectively) and seed weight per plant (16.02 and 3.78 seeds per plant respectively). This increase in seed number per plant and seed weight per plant was higher than adding supplementary fertilization to the control treatment. Adding 10 ppm of supplementary chemical fertilizer showed significantly higher seed number per plant (122.83 and 1710 seeds per plant of vetch and alfalfa respectively) and seed weight per plant (16.43 and 4.43 g per plant respectively). These results are in agreement with the results reported in foxtail millet (Aghtape *et al*., 2011), barley (Samarah *et al*., 2020) and wheat (Le *et al*., 2020).

CONCLUSION

The reuse of treated wastewater is highly possible in the Palestinian area, where there is high acceptance for the reuse of treated wastewater in irrigation due to water shortages. Irrigation with treated wastewater has the potential to boost productivity by at least 40%. Alfalfa has greater production parameters and is a perennial crop, whereas vetch is an annual crop, so alfalfa is a better choice for the farmer. More research into the socioeconomic aspects of recycling treated wastewater is needed, as well as more research into the impact of treated wastewater on the soil.

Conflict of interest: None.

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