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Valorization of secondary treated wastewater in *Trigonella foenum-graecum* L. irrigation

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Abstract

Facing the water scarcity, several countries had recourse to increase the water supply for agricultural irrigation by reusing treated wastewater. This study aimed to assess the impact of secondary treated wastewater irrigation on agronomic characteristics, nutrient and metal trace elements rates and also on the health quality of *Trigonella foenum-graecum* (fenugreek) cultivated in open field and in plastic greenhouse, with and without addition of cattle manure as fertilizer. Irrigation control water was the groundwater of the region of Oued Souhil in Nabeul, northeast of Tunisia. Results showed that field cultivation was more productive. Irrigation water quality and fertilizer use did not significantly affect the vegetative and reproductive development of cultivated crops. A nutrient accumulation in the fenugreek aerial parts was observed. Plants cultivated in the greenhouse were richer in Na, K and P than those of the field. No significant bacterial contamination was recorded on fenugreek crops.

Keywords: Agronomic characteristics, Bacterial contamination, Fertilization with treated wastewater irrigation, Nutrients, Metal trace elements.

1. Introduction

Fresh water is a fundamental resource for human life and the natural environment. This resource is becoming increasingly scarce facing the growing population demands. In recent decades, climate change and human socioeconomic development changed the universal hydrological cycles, threatening human water security, health and biodiversity of aquatic environments [1, 2, 3]. The United Nations estimated that 1.8 billion people will live in countries or regions with water scarcity by 2025, and population growth added to climate change will continue to exert additional stress on fresh water resources with great intensity, even in developed countries [4].

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Table 1. Comparative table of physicochemical and bacterial characteristics of irrigation water with the Tunisian standard for treated wastewater reuse in agriculture NT 106.03 [22].

Parameters	***GW***	***TWW***	***NT 106.03***
pH	7.20	7.54	6.5 - 8.5
Electrical Conductivity (mS/cm)	4.34	3.01	7
Sodium (mg/l)	547.56	636.18	NS
Total Suspended Solid (mg/l)	NS	24.44	30
Dry Residue (mg/l)	NS	1742.22	NS
BOD5 (mg/l)	NS	53.44	30
COD (mg/l)	NS	121.34	90
Magnesium (mg/l)	2.82	36.29	NS
Calcium (mg/l)	12.25	26.05	NS
Potassium (mg/l)	29.8	26.1	NS
Ammonium ion (mg/l)	3.26	37.0	NS
Chloride (mg/l)	1050	500	2000
Bicarbonate ion (mg/l)	504.9	1285.2	NS
Cadmium (mg/l)	0.02	0.01	0.01
Cobalt (mg/l)	0.03	0.02	0.1
Chromium (mg/l)	0.10	0.03	0.1
Copper (mg/l)	0.02	0.01	0.5
Iron (mg/l)	0.05	0.27	5
Manganese (mg/l)	0.01	0.01	0.5
Nickel (mg/l)	0.03	0.02	0.2
Lead (mg/l)	0.12	0.04	1
Zinc (mg/l)	0.04	3.6	5
Total coliforms (MPN/100 ml)	4.1 103	2.24 104	NS
Escherichia coli (MPN/100 ml)	3.3 103	7.74 103	NS
Fecal streptococci (MPN/100 ml)	4.8 103	1.07 104	NS

Note. NS: not stated.

2.2.2 Chemical parameters

The fenugreek aerial parts (leaves and stems) were dried at • & ,5 8 DQG Ground to weights determined. A quantity of 1g of plant powder was wet-digested with HNO_3/$HClO_4$ (1/1, V/V) and the concentration of P in aerial parts was determined on the digests with colorimetric standard method (Model AE-11, Erma Optical Works Ltd., Japan) [23]. The concentrations of Na and K were determined with flame spectrophotometry (Jenway PFP7, U.K.) [23] and the concentrations of Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn in aerial parts were dosed using flame atomic absorption spectrophotometry (PerkinElmer A Analyst 400, U.S.A.) according to Jedrzejczak and Szteke (1990) method [24]. All samples were analyzed in triplicate with reagent blanks.

2.2.3 Bacterial parameters

The aerial parts of *T. foenum-graecum* were prepared for bacteriological analysis using the method described in ISO 6887-1 standard. Bacterial counts were made by the MPN technique in liquid media [25].

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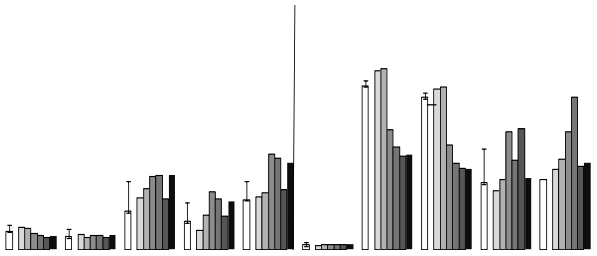
2.2.4 Statistical analyses

The considered statistical model included three qualitative variables namely the type of irrigation water (GW or TWW), location of fenugreek culture (field or greenhouse) and use of fertilizer (without or with fertilizer) which were considered as factors explaining the variations of quantitative variables (agronomic, chemical and bacterial parameters). All tests were performed using version 3.3.2 of R software [26]. Normality of the quantitative data was assessed by the Shapiro-Wilks test and variability of quantitative parameters was evaluated through a three factors ANOVA. Variations of fenugreek harvest index were explained and predicted by a multiple linear regression analysis involving the rest of the studied parameters.

3. Results and discussion

3.1 Agronomic study

Variations in the studied vegetative parameters based on the location of fenugreek crop, irrigation water type and use or not of fertilizer were shown in Figure 3. The three-factor variance analysis revealed no significant variations in all studied vegetative parameters according to the irrigation water type and the use or not of fertilizer (ANOVA, $p > 0.05$) and significant variations depending on the location of the crop ($p < 0.05$) for the majority of considered parameters (except for branches number). The highest values for the parameters number of leaves, number of plants in 1 m^2, number of branches, fresh weights of root and aerial part and dry weight of aerial part were recorded in the field crop (Figure 3).



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