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Effect of Sewage Irrigation on Yield and Active Ingredients of the Herbal Plant, *Psyllium* (*Plantago ovata* L.)

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ABSTRACT: To evaluate the effect of irrigation with wastewater on the performance and the active ingredient in the herb *Psyllium* (*Plantago ovata*), a test was implemented in the agricultural year 2012-2013 in a farm located in the city of Zabol. The experiment was performed in completely randomized block design with three replications. Irrigation treatments were at three levels: 1) irrigation with tap water, 2) irrigation with 50% tap water + 50% urban sewage, 3) full irrigation with wastewater from the city of Zabol. The results showed that the effect of irrigation with wastewater on grain yield and other traits such as plant height, number of grains per spike has been significant.

Key words: wastewater, *Psyllium*, grain yield, mucilage

INTRODUCTION

During the 21st century, numerous studies have been conducted on medicinal plants. In fact, medicines with natural origins have opened new horizons to physicians, pharmacologists, and other researchers. One of the most important issues which has been considered in agriculture, medicine and even the international trade is producing, processing, and using medicinal plants (Pirzad *et al.,* 2006). Nowadays, nearly a third of drugs used by humans are originally extracted from herbal plants and this rate is speeding remarkably (Omidbeigi, 1997).

Due to limitation of drinking water resources in Iran and gradual increase of urban wastes, replacing water required for agriculture with residues of urban wastes can in part solve the problems related to providing tap water and reduce health problems made by improper discharge of these sewages. Moreover, returning water through waste currents to farms has several advantages such as saving expenses of using chemical fertilizers, improving the quality of cities, expanding green space and beautiful sightseeing, monitoring deforestation, protecting soil and enhancing its quality through raising plants, and finally, preventing soil erosion (Binam, 1998). In fact, as a complementary method for sewage, irrigation with purified wastewater and recycling these sources for agricultural purposes can be regarded as a nutrient source, which contributes in maintaining mineral fertilizers and increasing plants' yield (Fonseca *et al.,* 2007).

Even in some countries, some parts of the urban sewage is purified to provide drinking water for residents, for example in Windhoek, South Africa, drinking water is directly attained through purified sewage (Rlamis *et al.,* 1985). On the other hand, it is quite evident that using unpurified urban sewage without evaluating its possible risks and its improper management for irrigation can create serious threats for water, soil, and ultimately, all human beings (Muntaza *et al.,* 2008). *Psyllium* (*Plantago ovate*) is one of the most valuable herbal plants which belongs to Plantain (Plantaginaceae). It is an annual grass, 5-10 cm high with soft hair. It is a native plant of India, Iran, and other ME countries. Nowadays, India is regarded as the largest exporter of its seed in the international market (Gupta, 1982), whereas in terms of economical aspects, in Iran which is one of the natural habitats of this plant, its cultivation has a very short history. Its seed mucilage is not only used to stabilize ice cream, chocolate, and foods but it is also used in salads (Cho *et al.,* 2004). PP seeds are effective in reducing blood cholesterol, inflammation, dysentery and abnormalities of the biliary and tract problems (Carrubba *et al.,* 2002; Goldsmith, 1997 .these seeds are useful for treating dysentery and pneumonia-induced gout and rheumatism (Carrubba *et al.,* 2002; Gupta, 1982). In countries like Iran, where the climate is arid and semi-arid, it is recommended to use soil and water resources better and better. Hence, in order to reduce the country's dependence to imported food (including human food or animal feed), there remains no remedy but efforts to increase agricultural production.

It is just possible by making important changes in the country's agricultural base through effective and sustainable usage of soil and water resources and provision of facilities to take advantage of potential soil and water resources (Bahremand *et al.*, 2002; Jafari Malekabadi, 1379). Using sewage with fewer minerals and enough nutrients could be effective in increasing crop yields (Tavakoli and Tabatabai, 1378; Vaseghi *et al.*, 2001). Materials existing sewage can influence plants' biomass and yield.

MATERIALS AND METHODS

The experiment was conducted in the winter of 2012 in a field located in east of Zabol, Sistan and Baluchistan. The site was located in 61° 41' East and latitude of 30° 54' North, 481 m above sea level. In this research, the field soil had a clay texture, pH = 7.9. Table 1 shows its physical and chemical properties.

Table 1: Physical and chemical properties of the soil at a depth of 0-30 cm.

Soil texture	Sand %	Clay %	Mud %	(ppm) manganese	(ppm) zinc	(ppm) Fe	(ppm) potassium	(ppm) phosphorous	(%) nitrogen	(%) Organic matter	Apparent weight g/cm^3	pH	Electric conductivity (ds/m)
clay	31.6	48	20.4	2.80	3.2	1.97	119	9.45	0.09	0.87	1.49	8.2	1.5

The experiment was conducted in a completely randomized complete block design with three replications. The irrigation treatments included 1) irrigation with tap water 2) 50% tap water + 50% urban sewage 3) complete irrigation with Zabol sewage. Plantation was performed manually on 3 February. Seeds were planted at a depth of up to 0.5 cm. In order to prevent the crust effect on seedling and emergence of Psyllium, continuous irrigation was done for the topsoil until seedling's emergence. Irrigation treatment with wastewater started 45 days after planting and continued until physiological maturity. Hand weeding of weeds was done during the growing season in two steps. To measure height, spike length, number of grains per spike, number of spikes per plant, 10 plants were randomly selected and measured from each plot. While investigating, samples were taken from each plot, removing the effects of marginal area, 1.5 m^2, to determine the seed yield. For assessing qualitative indicators, the amount of mucilage was measured (Kalayasundram *et al.*, 1982). The obtained data were analyzed using SAS software and statistical comparison was performed using Duncan test.

RESULTS

A. Effect of sewage irrigation on yield and yield components

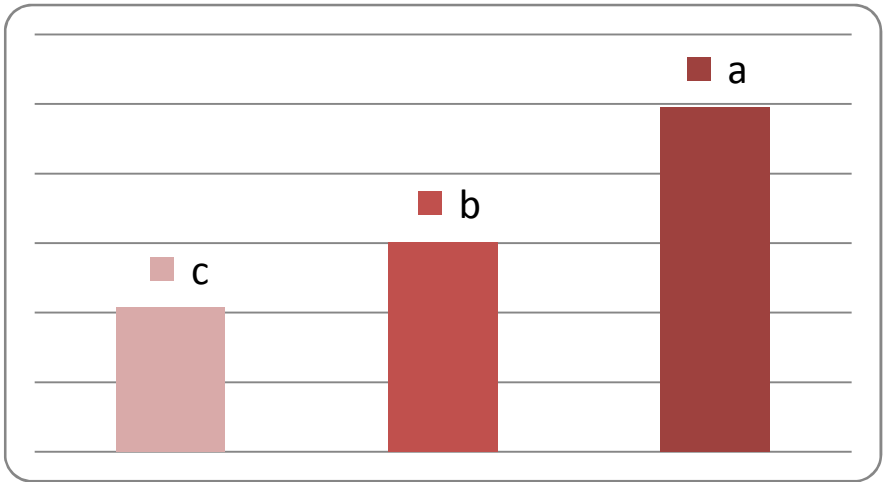
The results showed that plant height, number of tillers, spike length, number of tillers, number of ears per plant, number of grains per spike, 1000- grain weight and grain yield were influenced by different irrigation treatments. Therefore, height, spike length, number of grains per spike and 1000- seed weight per plant showed a significant difference at the 5% level, whereas number of tillers and grain yield had a significant difference of 1% (Table 2). Maximum height, spike length, number of grains per spike, grain weight, number of tillers, number of spikes per plant were obtained in irrigation treatment (50% tap water + 50% sewage), and their lowest rates were obtained in the control (tap water) (Table 2). The maximum seed yield was obtained in irrigation treatment (50% tap water + 50% sewage) which was statistically difference from other irrigated treatments. Meanwhile, the least seed yield was observed in the control treatment (tap water), 213.82 kg/ha. 50% tap water + 50% sewage treatment increased grain yield rather than the control (tap water) and treated sewage, respectively by 57.85% and 11.99%.

B. Effect of sewage irrigation on the qualitative characteristics of PP

The results showed that different types of irrigation had a significant effect on PP seed mucilage content at the 5% level (Table 2). The highest content of mucilage (18.54 %) belonged to 50% tap water + 50% wastewater (Fig. 2). There was no statistically significant difference between wastewater irrigation and irrigation with tap water.

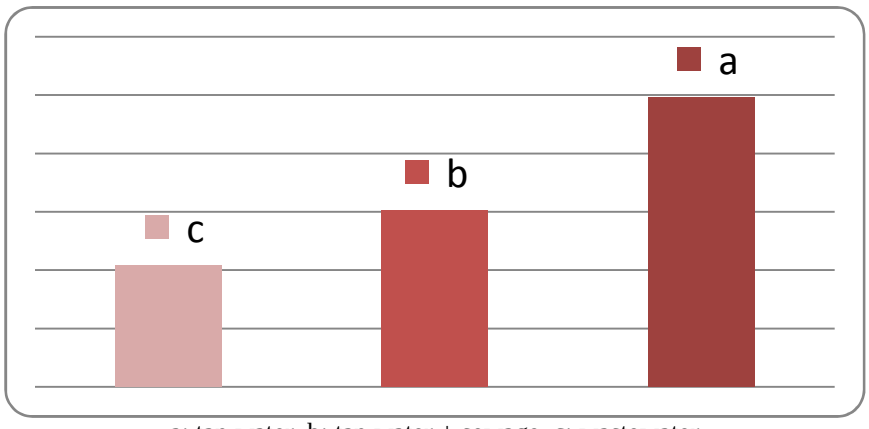
Table 2: Analysis of variance of some morphological properties of PP under different levels of irrigation.

Square mean										
Mucilage yield	Mucilage %	grain yield kg/ha	1000- seed weight (gr)	number of grains per spike	number of ears per plant	number of tillers	spike length (cm)	Plant height (cm)	Df	Variation sources
159.99	0.002	4501.49	0.005	5.21	2.94	0.006	0.04	4.19	2	repetition
1390.57**	1.10*	36415.08**	0.04*	191.14^{ns}	22.01**	0.29**	0.22*	8.55*	2	Type of irrigation
171.35	1.15	3293.03	0.006	47.29	8.70	0.03	0.12	1.01	4	error
18.78	2.77	18.34	5.82	10.19	15.80	6.41	8.79	6.86		CV (%)



a: tap water, b: tap water + sewage, c: wastewater

Fig. 1. Effect of irrigation on PP yield.



a: tap water, b: tap water + sewage, c: wastewater

Fig. 2. Effect of irrigation on psyllium mucilage content (%).

DISCUSSION

Although in plants with limited height, at the onset of flowering, height is affected by latitude and temperature, lack of adequate access to water or nutrients plays an important role in determining plant height. Regarding the fact that sewage is rich in nutrients, especially nitrogen, so this nitrogen can increase plant growth, and ultimately, increased stem height is inevitable. Other investigators (Rezvani Moghaddam and Mirzai Najmabadi, 2009; Alizadeh *et al.*, 2001) have reported similar results.

Wastewater increased spike length, number of tillers, number of grains per spike, 1000-grain weight, and seed number in PP. This increase was mainly due to proper amounts of nutrients such as nitrogen, phosphorus and potassium in wastewater which improved the general condition of the soil, promoted root growth, increased nutrient uptake, increased photosynthesis, and ultimately, resulted in better growth of plants in sewage treatment + tap water treatment (Taei Semiromi *et al.*, 2005). Sewage could increase PP grain yield, so the highest yield was obtained in sewage treatment + conventional water treatment. This yield increase was due to high amounts of nitrated nitrogen available in purified urban sewage (Alizadeh *et al.*, 2001).

The performance can be increased to high levels of nitrogen in the effluent of the city (Alizadeh *et al.*, 2001). Ghanbari *et al* (2006) in their research on wheat and Esmailian *et al.*, 2008 for his research on maize single cross found similar results.

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