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THE EFFECT OF FISH POND EFFLUENT REUSE ON THE PRODUCTION OF SUGAR BEET PLANTS (*Beta vulgaris* , L) .

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Abstract: The need for alternative water resources, coupled with increasingly stringent water quality discharge requirements, are the driving forces for developing wastewater reuse strategies in the world today, especially the arid and semiarid areas, i.e. Saudi Arabia. Reuse of fish pond effluent for crop production enables practitioners to manipulate the water cycle, thereby creating needed alternative water resources and reducing effluent discharge to the environment. The present study was designed to evaluate the effect of the reuse of fish pond effluent and its interaction with applied fertilizer on the production of sugar beet plants *Beta vulgaris*. It was clear that the irrigated sugar beet plants with fish pond effluent showed significant increases in root fresh weight yield, sucrose concentration and theoretical sugar yield (TSY) when compared with the irrigated plants with groundwater (control), especially at the lower and median N fertilizer levels (119 and 238 kg ha^{-1}).

Key words: Fish pond effluent, Sugar beet root yield, Root sucrose concentration, Theoretical Sugar Yield (TSY).

Introduction

Most of the semiarid and arid countries with limited water resources are in the Middle East with high population growth rates, and their water problems are increasing fast. Kingdom of Saudi Arabia is an example of a country with intensified impacts on natural water resources due to increasing demands on groundwater by the agricultural sector (Ministry of agriculture and Water, 1984; Al-Shaibani, 2003). Water is a scarce and extremely valuable resource in Saudi Arabia. The renewable water resources are only 111 m^3/capita/year (2.4 billion m^3/year or 634 billion gallons/year). As a result of agricultural, urban, and industrial growth, the demand country's water has been increasing steadily over the past two decades, reaching around 20 billion m^3/year (5,283 billion gallons/year) in 2000. Irrigation consumes the largest amount of water in the kingdom.

The majority of water requirements are supplied by depleting non-renewable groundwater and desalination. Saudi Arabia is now the world's largest producer of desalinated water, which covers 70 percent of the demand total water. In 1985, Saudi Arabia began focusing on ways to economize and regulate the use of water through a National Water Plan. The plan concentrates on conservation, greater coordination between agriculture and water policies, intensive use of reclaimed waste and surface water, and the best coordination of supply and distribution. As a result, Saudi Arabia is committed to a policy of complete water and wastewater reuse. In this respect, the integration of aquaculture with crop farming could offer greater efficiency in resource utilization, reduces risk by diversifying crops and provides additional food and income (Pullin and Shehadeh, 1980). When fish are recovered from ponds, the effluent is often drained presenting both an environmental challenge and an agricultural opportunity.

Fertilizers are usually applied to fish ponds to increase inorganic nutrient concentrations that favor phytoplankton growth, enhancing production of fish and crustaceans (Boyd, 1990). Effluents from fertilized fish ponds usually have relatively high nutrient concentrations and could be potential sources of pollution. Fish pond effluents have been applied to crops as irrigation water (Redding and Midlen, 1991; Al-Jaloud et al., 1993; Hussein and Al-Jaloud, 1995). In addition, greenhouse vegetable production integrated with intensive fish production systems (Aquaponics) may require little or no added nutrients other than those provided in fish discharge waters (Rakocy and Hargreaves, 1990; Al-Shallash and Shereif, 2006).

Little work has been conducted in the Middle East on the use of fish pond effluent as a source of irrigation water for high-value crops. The present study was designed to evaluate the reuse of the pond fish effluent in Al-Kharj area, Saudi Arabia, for the irrigation of sugar beet plants *Beta vulgaris*, L. Sugar beet plants were chosen due to its tolerance to salinity found in the effluent of Al-Kharj fish farm.

Material and Methods

1. The Experiment

The experiment was conducted using the effluent of one of Al-Kharj private fish farms, receiving groundwater, supplementary feeds and fertilizers through the growing season of the fish Nile tilapia (*Oreochromis niloticus* L.) (April-October, 2005). The analysis of Al-Kharj fish pond effluent for temperature, pH, dissolved oxygen (DO), biological oxygen demand (BOD5), total suspended solids (TSS), and electrical conductivity

(E.C.) are given in Table 1. The commercial feed analysis is shown in Table 2. The farm was also supplied with inorganic fertilizers (0.75 kg urea and 1.50 kg superphosphate ha-1) every ten days.

Sugar beet plants (*Beta vulgaris* ssp. vulgaris) were grown under greenhouse conditions in plastic pots filled with 12 kg sandy soil. Ten seeds were sown and then seedlings were thinned after four weeks to one plant per pot. Due to the saline nature of pond effluent (table 1), plants (10 replicates) were irrigated with only groundwater (E.C: 0.7 deci-siemens/m) for two weeks after planting, then irrigated with the fish pond effluent. Another set of plants were irrigated with only groundwater as a control. Three levels of nitrogenous fertilization were applied (as ammonium nitrate 33.5%), i.e. 119, 238, and 357 kg N ha^{-1}. At harvesting, roots were weighed per plant, and root sucrose concentration (%) was determined according to Le-Docte, (1927). Theoretical sugar yield (TSY) was calculated using the following equation (Winner, 1981):

TSY (gm sugar/100 gm root yield) = root yield x sucrose concentration.

2. Statistical Analysis

Statistical comparisons between averages of data for fish growth and sugar beet plants were made using one way analysis of variance using "Stat Graphics Plus" program, version 7. Means are compared using the least significant difference at the 5% level of probability (Steel and Torrie, 1980).

Table (1): Average values of Al-Kharj fish pond effluent

Parameter	Value
Temp. (°C)	25.50
pH	7.35
DO (mg/l)	7.20
BOD_5 (mg/l)	4.00
E.C. (deci-siemens/m)	2.01
TSS (mg/l)	5.67

Table(2): Constituents of artificial feed supplied to Al-Kharj fish farm.

Ingredient	%
Soybean meal	25
Corn glutine	5
Yellow corn	28
Fish meal	10
Wheat bran	10
Rice bran	10
Mollas	5
Fish oil	2
Di. Ca. Phosphate	2
Vitamin & Mineral premix	3
Nutrient composition: determined on dry weight matter	
Crude protein (%): 25 Crude fiber (%): 5% Crude fat: 5% Metabolic energy (k cal/kg diet): 2600	

Results and Discussion

It was clear that the irrigated sugar beet plants by fish pond effluent showed significant increases in root fresh weight yield, sucrose concentration and theoretical sugar yield when compared with irrigated plants with groundwater (control) (table 3). This could indicate the value of nutrients present in the fish pond effluent are probably responsible for improving plant growth and sugar yield (Thys and Schrevens, 1995). The use of fish pond effluent resulted in significant increases of the sugar beet root yield, sucrose concentration and TSY at the lowest and medium rates of N fertilizer (119 and 238 kg ha^{-1}) (Table 3). These were adversely affected using fish pond effluent combined with higher N fertilization (357 kg ha^{-1}).

Table(3): Means of root yield, sucrose and theoretical sugar yield of irrigated sugar beet plants *B. vulgaris* by groundwater (A) and fish pond effluent (B) at different nitrogenous fertilization rates.

N fertilizer rates (kg Nha^{-1})	Root Yield (g/plant)		Sucrose Concentration Percentage		Theoretical Sugar Yield (g sugar/100g root)	
	A	B	A	B	A	B
119	23	32	5.0	16.4	18	49
238	64	80	9.0	19.8	58	158
357	105	90	14.0	14.6	146	117

LSD for root yield at 5% = 6.1

LSD for sucrose concentration at 5% = 3.5

LSD for theoretical sugar yield at 5% = 2.5

These findings are in agreement with those obtained by Eisa et al (2001) who reported that sugar beet yield decreased using excessive N fertilization rates under salt stress. Baskar *et al*. (2003) reported a significant increase of sugar beet yield by irrigating with distillery effluent after diluted by 1:10 with fresh water irrigation.

In a similar experiment by Hussein and Al-Jaloud (1995), improved water use efficiency (WUE) was reported with aquaculture-effluent-irrigated wheat crop having a WUE of 11 to 30 kg ha^{-1} mm^{-1}, whereas well-water treatments had a WUE of 7 to 22 kg ha^{-1} mm^{-1}. Wheat grain yield and (WUE) obtained with well water combined with 75 to 100% of the nitrogen requirement as fertilizer were comparable to irrigated treatments with fish pond effluents combined with 25 to 50% of the nitrogen requirement. Similar results were obtained by Al-Jaloud *et al.* (1993). In an integrated crop/ aquaculture system in Kenya, Meso *et al*. (2004) reported a highest French bean (*Phaseoulus vulgaris*) yield, 9.1 Mg ha^{-1} when fish pond effluent was used for irrigation in combination with fertilizer application. The highest (4.4 Mg ha^{-1}) fresh bean pod yield was observed in pond effluent irrigated and fertilized plots, while the lowest (1.3 Mg ha^{-1}) was observed in non irrigated/unfertilized plots.

CONCLUSION

According to the obtained data in this investigation, the reuse of fish pond effluent improved the cost benefits ratio and environmental impacts of both plant and fish production. This would reduce chemical fertilizers applied to plants, enhance soil health by increasing organic matter content and microbial activity, and provide a profitable and environmentally acceptable effluent discharge method for fish farmers. The growing trend is to consider wastewater reuse as an essential component of integrated water resources management and sustainable agricultural development ,especially in dry and water deficient areas. The reuse of fish pond effluent could offer other attractive benefits for the management of water resources, including (1) the increase in supply of water for productive agricultural use; (2) the difference in costs of irrigation by recycling water from fish ponds and effluent rather than desalinized sea water or groundwater; and finally (3) the reduction of surface water pollution (Edwards and Pullin, 1990).

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تأثير اعادة استخدام مياه صرف برك تربية الأسماك على انتاج نباتات بنجر السكر.

خالد سليمان الشلاش

قسم تقنية البيئة– الكلية التقنية بالرياض– الرياض/ المملكة العربية السعودية

تتزايد أهمية نظم الزراعة التكاملة و بخاصة في المناطق الجافة و شبه الجافة بسبب ندرة المياه. يتم عادة صرف مياه أحواض تربية الأسماك مما يؤدي الى الهدر و آثار بيئية سلبية. أجريت هذه الدراسة لتقييم كفاءة الري باستخدام مياه صرف إحدى برك تربية الأسماك في انتاج نباتات بنجر السكر تحت ظروف الصوبة الزجاجية (البيوت المحمية) بمنطقة الخرج، المملكة العربية السعودية. أظهرت نباتات بنجر السكر المروية بمياه صرف أحواض تربية الأسماك زيادة معنوية في قيم وزن الجذور وتركيز السكروز و محصول السكر النظري عن تلك التي تم ريها بالمياه الجوفية، و بخاصة عند مستويات التسميد النيتروجيني الدنيا و المتوسطة (١١٨ و ٢٣٨ كجم/ هكتار).