Effect of Irrigation with Treated Wastewater on Corn *(Zea mays.L)* Growth Parameters and Tissues Uptake of Pesticides.

By

Jihad Muhammad Mustafa

B.Sc: Hebron University- Palestine

Supervisor: Dr Claude EL-Ama
Co-Supervisor: Dr Jaber Masalha

A thesis Submitted in Partial Fulfillment of Requirements for the Degree of Master of Science in Applied Earth and Environmental Science /Graduate Studies

AL-Quds University

June-2006

Program of postgraduate Studies in Applied Earth and Environmental Sciences
Deanship of Graduate Studies

Effect of Irrigation with Treated Wastewater on Corn *(Zea mays.L)* Growth Parameters and Tissues Uptake of Pesticides.

By

Student Name: Jihad Mustafa
Registration No: 20111608

Supervisor: Dr Claude EL-Ama
Co-Supervisor: Dr Jaber Masalha

Master thesis submitted and accepted. Date: 22/6/2006.
The names and signatures of the examining committee members are as follows:

1- Dr.Claude EL-Ama/ Head of committee Signature El Ama claude.

2- Dr.Raed AL-kowni/ External Examiner Signature Raed AlKowni

3- Dr. Khalid Sawalha/ Internal Examiner Signature..........

AL-Quds University

2006

Declaration

I certify that this thesis submitted for the degree of Master is the result of my own research except where otherwise acknowledged, and that this thesis (or any part of the same) has not been submitted for a higher degree to any other university or institution.

Signed: ....

Jihad Muhammad Mustafa

Date: 22/6/2006

ACKNOWLEDGMENT

Before all and above, I would like to express my endless thanks to GOD for conciliation, and providing patience.

I sincerely thank AL-Quds University for giving me the opportunity to study the M.Sc., and its efforts and help during my work in this research.

I owe a great deal of thanks to my supervisor Dr. Claude EL-Ama for her fruitful discussion, invaluable guidance, and allowing me a lot of her time. I would like to extend my special thanks and appreciation to Dr. Jaber Massalha for his guidance, advice and invaluable assistance. Special thanks and appreciation to Dr. Amer Marei and Dr. Qasem Abdul-jaber for their excellent suggestions, helping, generous advice, and constructive criticism.

The wormiest feeling are extending to my family especially my parents for their supporting, and encouragement during this work. My great thanks to the staff of AL-Aroub Agricultural Secondary School for their help and support.

Last, and no means least, my great thanks to everyone contributed towards the progress of this work, provided help, moral support, love, or encouragement.

ABSTRACT

Shortage of available water in arid and semiarid areas such as Palestine, forces the planners to consider any sources of water for irrigation. Treated wastewater can be considered as a solution for saving fresh water and mineral fertilizers and obtaining the same or better economic results. The effect of irrigation with treated wastewater on the growth rate, fresh weight, yield, heavy metals concentration, and chemical composition of corn (*Zea mays L.*) parts evaluated at two different growth stages was studied under field conditions. In addition, the effect of irrigation with treated wastewater was also investigated on soil characteristics, and the uptake and partitioning of pesticides (atrazine and diazinon) in corn parts.

The results showed that irrigation with treated wastewater significantly increased corn growth, yield and fresh weight compared to the fresh water irrigation. The chemical composition of corn parts was not significantly different between both treatments. Protein content was higher in corn parts irrigated with treated wastewater compared to fresh water irrigation. The irrigation with treated wastewater affected soil characteristics such as Nitrogen, Potassium, and Phosphorus content compared with soil irrigated with fresh water.

The results show that, atrazine concentrations in corn parts irrigated with fresh water were higher than that irrigated with treated wastewater at ten days after emergence. Meanwhile, the concentrations of atrazine in corn root and leaves irrigated with treated wastewater were higher than that irrigated with fresh water at harvesting time. The concentrations of atrazine in corn parts at ten days after emergence were in the following order: root > leaves > stalk. Meanwhile, the concentrations of atrazine in corn parts at harvesting time were in the following order: root > leaves > stalk > fruit. In addition, the results show that diazinon concentration in corn parts were higher in corn irrigated with fresh water compared to that irrigated with treated wastewater. Diazinon concentration in corn parts were in the following order: leaves > stalk > root > fruits.

According to the results obtained from the present study, it is recommend that treated wastewater can be used successfully for irrigation of corn planted under arid to semi-arid conditions. Since irrigation with treated wastewater gave similar plant characteristics, better economic results, and lower pesticides concentration compared to that irrigated with fresh water. The growth parameters indicated that corn (*Zea mays L.*) is suitable for plantating with treated wastewater under conditions described in this study.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Treated wastewater effluents are a potentially important source of irrigation water in semi-arid and arid zone such as Palestine since the largest Palestinian water consumption sector is agriculture. In addition, in the last few years, it has been noticed that different types of pesticides were used in Palestine. Atrazine and Diazinon are examples of these pesticides. Atrazine is a herbicide used to control weeds on agricultural crops, especially corn, and it is one of the most commonly used agricultural herbicides in Palestine. Diazinon is an organophosphate insecticide used to control a wide range of insects and mites on different crops such as corn. It has been known that pesticides are toxic chemicals, and may cause health problems to human. An increase in cancer cases has been observed in Palestine, which may be attributed to the use of pesticides in uncontrolled manner.

Irrigation of crops with treated wastewater may affect the uptake of pesticides by plants. Treated wastewater, compared to fresh water, contains high concentration of suspended and dissolved organic (DOM) and inorganic matters (Hussain *et al.* 2002). The application of treated wastewater into the soils might affect the physical and chemical properties of the soil. Change in soil organic matters (SOM) and the introduction of relatively high concentrations of DOM into the soil have a major influence on the interaction between non- and weakly-polar (hydrophobic) pesticides and the soil matrix. Moreover, the concentration of some of these compounds is higher in soils irrigated with effluent than on sites irrigated only with fresh water (Kalbitz and Kaiser 2003). The complexation or association of hydrophobic components with DOM results in enhanced aqueous solubility, and therefore decreased sorption to the solid phase and enhanced mobility. The physico-chemical nature of the effluent DOM has a major influence on the fate of hydrophobic pesticides in the environment (Kearney and Kaufman, 1976). The uptake of pesticides by plants is influenced by the physico-chemical properties of the substances, the biogeochemical properties of the soil and plant̀s characteristics (Akkanen, 2002). It is proposed that, the association of atrazine and diazinon with DOM will result in enhanced aqueous solubility, and therefore may increase the uptake of atrazine and diazinon by corn tissues. The uptake and partitioning of herbicide atrazine and insecticide diazinon will be studied in corn tissues in function of water irrigation type. The response of corn to irrigation with treated wastewater in semi-arid area in Palestine will be studied under field conditions. The location of the field was Abu-Dies because of the type of the soil, which characterize large area of Palestine soil (clay-loam soil). The effect of irrigation with treated wastewater on the yield, growth rate, fresh weight, pesticides uptake, and chemical composition of corn (*Zee Mays*) will be studied compared to irrigation with fresh water. It is proposed that the response of corn to irrigation with treated wastewater will be positive, since it is a source of the essential nutrients for corn growth such as (NPK) and provides all moisture necessary for corn growth. The choice of corn in this study is to find edible crop that is suitable for plantation in such conditions described in this study.

`

1.2 Reuse of Wastewater Worldwide

With increasing global population, the gap between the supply and demand for water is widening and is reaching an alarming levels that in some parts of the world it is posing a threat to human existence. Scientists around the globe are working on new ways for conserving water (Hussain *et al.* 2002). Treated municipal wastewater is being received attention as a reliable source of water. So, in many countries of the world, treated wastewater is considered as an important supporting element in water resources planning (Tchobanoglous and Burton, 1991).

In both developed and developing countries, the most prevalent practice is the application of municipal wastewater (both treated and untreated) to land. In developed countries where environmental standards are applied, much of the wastewater is treated prior to use for irrigation of seed crops and fiber, and, to a limited extent, for the irrigation of orchards, and other crops. In developing countries, though standards are set, these are not always strictly adhered to. Wastewater, in its untreated form, is widely used for agriculture and aquaculture and has been the practice for centuries in countries such as China, India and Mexico (Hussain *et al*. 2002). Interest in the use of treated wastewater has accelerated significantly in developing countries due to the increase of the population resulting in more and more wastewater production (Pesccod, 1997).

In practice, most developing countries use untreated wastewater for agriculture for a variety of reasons, least of which are the cost of treatment and the loss of precious nutrients. It has been estimated that as much as 80% of wastewater generated in developing countries may be used for irrigation (Cooper, 1991). However, treatment of wastewater prior to agricultural use, is believed to be essential: first, from the point of view of public health protection, and second, to respect local social and religious beliefs (Mara, 2000). Municipal wastewater treatment is a well-developed engineering science and various processes and techniques are available to efficiently treat the wastewater. Worldwide, the wastewater for more than 4,000 million people does not receive any form of treatment (Asano *et al.* 1985; NRC report, 1996).

Increasing efficiencies in crop management and the continuing increase in crop yields has increased demands on water resources for irrigation purposes. Effluent is reused for irrigation purposes in many countries around the world on all the populated continents (USEPA, 1992). Wastewater and its nutrient content can be used extensively for irrigation and other ecosystem services. Its reuse can deliver positive benefits to the farming community, society, and municipalities. So clean water can be made available for use in other sectors that need fresh water and provide water to sectors that can utilize wastewater, for example, irrigation (Hussain *et al.* 2002). The treatment of wastewater decrease its effect on environment, thus reduce its hazard on human, plant and animals (Schevah and Waldman, 2001). From an economic point of view, wastewater irrigation of crops under proper agronomic and water management practices may provide the following benefits: higher yield, value of fertilizer saved, and additional water for irrigation (Hussain *et al.* 2002).

In addition, scarcity of conventional sources of waters in arid and semi-arid regions has promoted the search for additional sources, such as treated wastewater (Pasternak and

`

DeMalach, 1987). Urban wastewater in agriculture is receiving renewed attention with increasing scarcity of fresh water resources in many arid and semi-arid regions (Pasternah and Demalach, 1987; Scott *et al.* 2004). The reuse of treated wastewater is already well-established elsewhere in various water-scarce and arid regions of the world, in some cases for many decades (NRC, 1996). Use of wastewater in agriculture could be important when its disposal is being planned. Irrigating agricultural crops with treated wastewater has been practiced in arid and semi arid regions and is rapidly getting popular in the countries of the Middle East. In Palestine, irrigation with wastewater of different qualities has been practiced for along time (Tamimi, 2003). In 2002, it was reported by the Palestinian Water Authority that the total expected treated effluent that would be available for irrigating agricultural crops would reach 92 million cubic meters in 2020. In Jordan and according to the Water Authority of Jordan about 60 million cubic meters of treated effluent were reused in irrigating agricultural crops in 1995 that increased to about 72 million cubic meters in 1998. Water Authority of Jordan is predicting that amount to increase to about 140 million cubic meters in 2010 due to the rapid construction of wastewater treatment plants (Tamimi, 2003).

1.2.1: Characteristics of Wastewater

The liquid waste produced by the community is usually termed wastewater. Therefore wastewater can be a combination of liquid or water-carried wastes removed from residence, institutions, commercial, and industrial establishments, ground water, surface water and storm water (Tamimi, 2003). Municipal wastewater is mainly comprised of water (99.9%) together with relatively small concentrations of suspended and dissolved organic and inorganic solids. The actual composition of wastewater may differ from community to community (Hussain *et al.* 2002). Among the organic substances present in sewage are carbohydrates, lignin, fats, soaps, synthetic detergents, proteins and their decomposition products, as well as various natural and synthetic organic chemicals from the industrial process (UN, 1985). Table (1.1) shows the levels of the major constituents of strong, medium and weak domestic wastewater.

Table 1.1: Major constituents of typical domestic wastewater **(**mg/l).

Constituent	Strong	Medium	Weak
Total solids	1200	700	350
Total dissolved solids (TDS)	850	500	250
Suspended solids	350	200	100
Nitrogen (as N)	85	40	20
Phosphorus (as P)	20	10	6
Chloride	100	50	30
Alkalinity (as $CaCO_3$)	200	100	50
Grease	150	100	50
Biological oxygen demand	300	200	100

Source: UN Department of Technical Cooperation for Development (1985).

`

In arid and semi-arid countries, fresh water usage is often fairly low and sewage tends to be very strong. Municipal wastewater also contains a variety of inorganic substances from domestic and industrial sources, including a number of potentially toxic elements such as arsenic, cadmium, chromium, copper, lead, mercury, zinc.

1.2.2: Dissolved Organic Matter

Dissolved organic matter (DOM) is present in all natural aquatic environment (Benner, 2002). The total organic matter in terrestrial and aquatic environments consists of two operationally defined phases, particulate organic matter (POM) and (DOM). (DOM) is defined as the organic matter fraction in solution that passes a 0.45µm filter. Some workers have used finer filter paper (0.2µm) to separate true DOM from colloidal materials, which are not retained in 0.45µm filters (Dafner and Wangersky, 2002). Meanwhile, in the case of studies involving soils, the term, water soluble organic matter (WSOM) or water extractable organic matter (WEOM) is also used which represents the fraction of the soil organic matter extracted with water or dilute salt solution that passes a 0.45µm filter (Zsolany, 2003). Dissolved organic carbon (DOC) is the carbon component of the DOM (Elder, 1988). DOM is present in all natural waters; the concentration varies greatly between locations depending on the geochemistry, season, type of water (Thurman, 1985). Treated wastewater contains high concentration of suspended and dissolved organic matter compared to fresh water (Hussain *et al.* 2002). DOM in treated wastewater water consists mostly of humic substances (HS) that formed during the decays of biomatter. The rest of the DOM, which is not considered to be humic material, is mainly carbohydrate, amino acids, low molecular weight organic acids and fatty acids (Thurman, 1985; Kronberg, 1999). The introduction of treated wastewater into soils might affect the physical and chemical properties of the soil as well as the chemical properties and composition of the soil organic matter (SOM), (DOM), and (HS). DOM represents one of the most mobile and reactive organic matter fractions, thereby controlling a number of physical, chemical and biological processes in both terrestrial and aquatic environments (Kalbitz and Kaiser 2003).

1.2.3: Wastewater in Palestine

Water shortage in the Middle East has forced countries to reuse treated wastewater for agriculture, and to recharge aquifers (Asano and Mills, 1990). Palestine is located in a semi-arid to arid region with limited natural resources (Abu-Faris, 1998). The water resources in Palestine are surface and ground waters. The surface water resources contain only Jordan River (Abu-Faris, 1998). In the West Bank the annual renewable quantities of groundwater in the Western, Northeastern, and Eastern basins in addition to springs are estimated at 691-811 MCM/year. Out of that only 143 MCM/year are accessible for the Palestinians in the West Bank due to the political situation (IUGG, 2003). The Palestinian populations are 1.2 Million in Gaza and 2.1 Million in the West Bank (IUGG, 2003). The West Bank and Gaza suffer from a chronic water shortage, preventing sustained economic growth and damaging the environment and health of Palestinians communities. In many parts of the West Bank and Gaza, the existing water supply system can only provide an average daily consumption of less than 50 liters per capita. Meanwhile, the World Health Organization has established a minimum per capita standard of 100 liters per day for small rural households. Effective long-term resolution of the water shortage problem in the West

`

Bank and Gaza requires a combination of rapid development of new water sources and implementation of more effective and efficient water distribution and management systems, since many water losses are caused by deteriorated old infrastructure (USAID, 2003). Achieving even the minimum per capita standard for Palestinian populations in the West Bank and Gaza is a daunting development challenge with significant implications for prospects of long-term economic growth and stability in the region (USAID, 2003).

On the wastewater side, more than 80% of the West Bank is not served by wastewater collection systems, instead cesspits are used (IUGG, 2003). The discharge of raw wastewater without any treatment causes hazards as it carries disease agents in the form of pathogens and toxic elements. In the West Bank and Gaza, the untreated effluent are used for irrigation in uncontrolled manner. Reuses of treated wastewater in agriculture are key points in the Palestinian water sector policy especially since the agriculture sector consumes about 80% of the total abstraction (IUGG, 2003). Few wastewater treatment plants exist in the West Bank and Gaza strip, such plants produce partially treated effluent. The efficiency of many plants is very low due to design and maintenance failure (PECDAR, 1994). Different technologies are used in wastewater treatment plants in Palestine that give different performances and efficiencies (Gleick, 1993). Existing, but badly working treatment plants are: (1) Gaza treatment plant (2) Rafah treatment plant (3) Biet Lahya treatment plant (4) Jenin treatment plant (5) Tulkarm treatment plant (6) Hebron treatment plant (7) Ramallah treatment plantp (PNA, 1999).

1.2.4: Corn Irrigation with Treated Wastewater

Crop scientists have attempted to quantify the effects of treated wastewater on a number of qualities and yield parameters under various agronomic scenarios (Hussain *et al.* 2002). Irrigation with treated wastewater has been practiced successfully in a number of countries for a variety of crops. Besides facing the environmental problems and saving water for irrigation, wastewater reuse results in saving significant quantities of essential nutrients to plant growth, especially nitrogen (N) and phosphorus (P) (Tsadilas and Vakalis, 2003). Its reuse can deliver positive benefits to the farming community, society, and municipalities (Hussain *et al.* 2002). Tsadilas and Vakalis (2003) concluded that treated wastewater could be used for irrigation of corn and cotton, saving fresh water and mineral fertilizers and obtaining the same or better economic results. Several studies showed that treated wastewater significantly increased corn yield and may substitute considerable quantities of mineral fertilizers. The auther attributed this increase mainly to the increase of N uptake and secondly to the increase of P, K, B, Fe, Zn, Mn, and Cu uptake. The primary problem associated with using treated wastewater for agriculture is the inherent health risks from wastewater containing bacteria, viruses, and a wide range of parasitic organisms. Oron *et al*. (1999) demonstrated that sweet corn (*Zea mays*) could be irrigated using treated wastewater through drip irrigation systems without detection of fecal coliform in plant parts and with minimal bacteria concentrations in the soil surface. Maximum bacterial concentrations were detected at a soil depth of 30-50 cm.

1.3 Pesticides

Pesticides are chemical substances or mixture of chemical substances intended for preventing, destroying, repelling, or mitigating any pest. Pests can be insects, mice, other

`

animals, unwanted plants (weeds), fungi, or microorganisms like bacteria and viruses. The term pesticide also applies to herbicides, fungicides and various other substances used to control pests (Hoff and Zoonen, 1999). Pesticides generally are man-made organic compounds. Some are selective, against a given pest (target organism), while others are relatively non-selective, toward a large group of organism (Doxtader and Croissant, 1992). Chemical classification of pesticides can be based on functional groups in their molecular structure or their specific biological activity on pests (Hoff and Zoonen, 1999).

1.3.1: Biopesticides

The environmental hazards resulting from half a century's intensive use of synthetic organic crop protection agents makes it imperative to consider alternative or complementary approaches to sustainable agricultural development and integrated pest management. Biopesticides could be the key to the future (Roger *et al.*2005). Biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals. At the end of 2001, there were approximately 195 registered biopesticide active ingredients and 780 products. Biopesticides are inherently less harmful than conventional pesticides (Szuhay and Chief, 2006). The two types of biopesticides are biochemical and microbial. Biochemical pesticides may have a similar structure to, and function like, naturally occurring chemicals, and have nontoxic modes of action. Several significant classes of pesticides are derived from plants. Examples are nicotine from tobacco, rotenone extracted from certain legume roots, and pyrethrins that are extracted from pyrethrums flowers (Stanley, 1994).

1.3.2: Pesticides Usage in the West Bank

Agriculture is the backbone of the Palestinian economy, contributing 33% and 24% of the gross national products in the West Bank and Gaza Strip respectively (Arij, 1994). West Bank agriculture has, in the last few years, increased in sophistication, and has had many negative side effects, of which the overuse of pesticide could prove to be the most serious (Igbedioh, 1991. WRI, 1994).

A total of 123 pesticides currently are being used in the West Bank. Among these, fourteen are internationally suspended, cancelled or banned (WHO, 1993. Safi *et al.* 1991. Hassoun, 1991). Seven of these pesticides are members of the "dirty dozen" namely Aldicarb, Chlordan, DDT, Lindane, Paraquate, Parathion and Pentachlorophenol (PAN, 1993). The total quantity of pesticide (including Methyl Bromide) used in the West Bank is estimated to be around 493.82 tons per year, of which about 200 tons are methyl bromide, 72 tons are sulfur (50 tons of which are consumed in Hebron). The districts show variations in the quantity of the pesticide used. Of total pesticide used, insecticides contribute 49.4%, fungicides 33.7% and herbicides 12.78%. Triazine herbicides like Atranix, Atrazine, Primatol, Sematol, Saminyl, Simazine, Simazole, Cyanazine, Prometryn, Desmetryn, comprises about 30% of the herbicides used in West Bank (Saleh *et al.*1995).

`

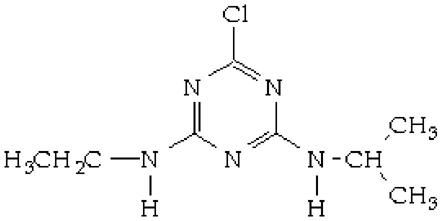
1.4 ATRAZINE

1.4.1: Overview

Atrazine (2-chloro-4-ethylamino-6-isopropylamino-1, 3,5-triazine) is a herbicide registered in the United States for the control of broadleaf weeds and some grassy weeds. Atrazine is classified as a selective pre- and post-emergence herbicide. Atrazine is most widely used on corn followed by use on sorghum (US-EPA, 2002). Despite being banned in most European countries, it is the most widely used herbicide in the United States and is registered in more than 70 countries worldwide (Kauffmann *et al.* 2000). Atrazine was first released for experiment station evaluations in 1957 and became commercially available in 1958 (Eisler, 1989). While atrazine is only moderately persistent in the environment, with a half-life of one to twelve months, appearance in surface waters raises concern due to its possible health hazards. For this reason, atrazine is considered to be an important environmental contaminate, with potential carcinogenic effect of s-triazine being of growing concern in water quality management (Donnelly *et al*. 1993. Tugulea *et al*. 1998). Atrazine is produced by a continuous process where isopropylamine is reacted with cyanuric acid under basic conditions, forming 2,4-dichloro-6- isopropylamino-s-triazine, which is then reacted with monoethylamine and dilute caustic to form atrazine (Akkanen *et al.* 2001).

1.4.2: Identification (WHO, 1990. Alexander, 1990)

1. Common name: atrazine.
2. Trade names: Aatrex, Atratol, Atranex.
3. Active ingredient: triazine.
4. Chemical formula: $C_8H_{14}ClN_5$.
5. CAS chemical name: 2-chloro –4- ethylamine-6- isopropylamino 1,3,5- triazine.
6. Molecular weight: 215.72g.
7. Pesticide classification: herbicide.
8. Structural Formula



Atrazine

1.4.3: Physical and Chemical Properties (WHO, 1990; Seol *et al.* 2000)

1. Atrazine is a colourless crystalline powder with low vapor pressure (40 nPa at 20 ºC).

2. The melting point of atrazine range between 175-177ºC.
3. The density of atrazine is 1.187g/cm.
4. Physical state: white, odorless, crystalline solid.
5. Field half-life is 60 days.
6. Solubility: it is soluble in dimethylsulfoxide (183g/litre), chloroform (52g/litre), and ethyl acetate (28g/litre) and very slightly soluble in water (30mg/litre).
7. Stability: it is stable in the dry state, but is hydrolyzed to the herbicidally inactive 2-hydroxy analogue in acid or in alkaline solution and more slowly in neutral solutions, even at elevated temperature.
8. Technical atrazine is not flammable, but on heating it decomposes to form toxic fumes containing oxides of nitrogen (Nox) and hydrogen chloride (HCl).

1.4.4: Mode of Action of Atrazine

Herbicides are chemicals that inhibit or interrupt normal plant growth and development**.** The term mode of action refers to the sequence of events from absorption into plants to plant death. The herbicide mode of action involves absorption into the plant, translocation in the plant, metabolism or biochemical reaction, and mechanism of action (Mosier *et al*. 1990). To be effective, herbicides must 1) adequately contact plants; 2) be absorbed by plants; 3) move within the plants to the site of action, without being deactivated, and 4) reach toxic levels at the site of action (Mosier *et al.* 1990. Gunsolus and Curran, 2002). Widely used herbicide families are grouped by their mode of action. These seven major modes of action are as follows: growth regulation, amino acid synthesis inhibition, lipid synthesis inhibition, seedling growth inhibition, photosynthesis inhibition, cell membrane disruption, and pigment inhibition (Gunsolus and Curran, 2002).

Atrazine's primary mode of action in plants is through inhibition of photosynthesis by disruption of photosystem II pathway (DePardo *et al.* 2000). Photosynthesis inhibitors shut down the photosynthetic process in susceptible plants by binding to specific sites within the plant's chloroplasts (Gunsolus and Curran, 2002). Triazine herbicide associate with a glutathione protein complex of photosystem II in chloroplast photosynthetic membranes (Fairchild *et al.* 1998). Atrazine interferes with photosynthesis in many annual broadleaf plants and grasses (Solomon *et al*. 1996). After application atrazine continues to control sprouting weeds for 5-6 weeks, allowing the desired crop to become well established without competition for moisture, nutrients and sunlight (Ballantine *et al*. 1998).

1.4.5: Fate of Atrazine in Plants

Atrazine is mainly absorbed through roots but some absorption also occurs through foliage, depending upon the foliage species (Fan, and Alexeeff, 1999). Plants, which are sensitive to atrazine, do not metabolize (or break down) atrazine. Tolerant plants metabolize atrazine to hydroxyatrazine and amino acid conjugates, for example, corn and sorghum (Hull, 1967; Reed, 1982; Beste, 1983). Three basic reactions have been identified in plants metabolism of atrazine: hydrolysis of the 2-chloro groups, N-dealkylation of the side chain, and conjugation of the 2-chloro group with glutathione. The dechlorination reaction is nonenzymatic and is mediated in corn by a natural constituent (2,4-dihydroxy-7-methoxy-1, 4[2H]-one) (DHS, 1989). Hydroxyatrazine, de-ethylatrazine, deisopropylatrazine, de-ethylhydroxyatrazine, and didealkylatrazine metabolites are identified in plants by using

`

UV detector (Burken and Schnoor, 1997). The transformation and distribution of ^{14}C-atrazine was studied in corn plants. The transformation products varied in leaf, stalk, and root parts. Roots contained 25% of the total extractable root ^{14}C residues as hydroxyatrazine, whereas leaves and stalks had 41% and 42% of their extractable residue as hydroxyatrazine (Mathew *et al.* 1996).

Tests using poplar trees shows that part of the atrazine residue becomes a part of the plant leaves, stems and roots (Burken and Schnoor, 1996). In sensitive plants such as oats, cucumber, and alfalfa, which are unable to detoxify atrazine, the compound accumulates causing chlorosis and death.

1.4.6 DOM and Atrazine Uptake by Plants

Plant uptake is the process whereby pesticides are transported into and within the plant structure. This process can be separated into two distinct pathways, sorption by the roots of the plant and adsorption with subsequent movement to the plant's supersurface structure (Burner *et al*. 1997). The most important factor governing sorption and movement within the plant is the solubility of the pesticide in the water. The content of the surrounding soil is also important to the plant uptake. Studies have shown that, association with DOM affects the environmental fate of various contaminates processes, such as transport, and solubility (Burner *et al*. 1997). The complexation or association of atrazine with DOM results in enhanced aqueous solubility, and therefore decreased sorption to the solid phase and may enhance uptake by plants. The uptake of pesticides by plants is influenced by the physico-chemical of the substances, the biogeochemical properties of the soil and the plant's characteristics. Water management is an important factor since the use of water with high DOM content could increase (1) the potential of leaching. (2) It may increase plants uptake of atrazine adsorbed to the DOM (Hassan, 2005).

On the other hand, dissolved organic matter (DOM) has been shown to be one of the most important factors controlling the bioavailability of hydrophobic organic contaminates in water (Akkanen, 2002). Only, the herbicide dissolved in the available water may be taken up by the plant. The availability of herbicides in the soil to plants depends on many factors including the physico-chemical properties of the compound, climatic and soils condition (Kearney and Kaufman, 1976). Bioavailability of hydrophobic organic compounds can be largely controlled by the presence of DOM. In water, several studies have shown that in most cases DOM either decrease or does not affect the bioavailability of organic materials. But in a few cases, DOM has increased the bioavailability of certain compound (Akkanen, 2002).

1.5 Diazinon

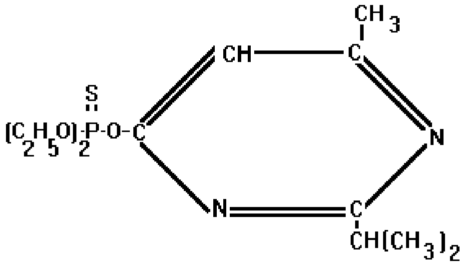
1.5.1: Overview

Diazinon is an organophosphate pesticide (OP) originally developed by JR Geigy company (now Novartis) in the early 1950s. Diazinon is used throughout the world to control a wide range of sucking and chewing insects and mites on a range of crops, including deciduous fruit trees, citrus fruit, bananas, sugarcane, cotton, corn, and rice (Tomlin, 1997). It is also used to control household pests such as flies, fleas and cockroaches. The World Health

Organization (WHO) classifies diazinon as a class II ‘moderately hazardous’ pesticide (WHO, 1998). The Food and Agriculture Organization advises against using WHO class II pesticides like diazinon in developing countries. Diazinon is not considered carcinogenic by agencies such as the International Agency for the Research on cancer, and the US EPA. Public interest groups around the world have raised concerns about the use of Ops in general, and diazinon in particular (BCERF, 1999).

1.5.2: Identification (WHO, 1998).

1. Common name: Diazinon.
2. Primary use: Insecticides.
3. Molecular formula: $C_{12}H_{21}N_{2}O_{3}P_{5}$.
4. Relative molecular mass: 304.35.
5. Chemical Formula.



1.5.3: Physical and Chemical Properties (WHO, 1998)

1. Diazinon is a clear colourless liquid with a faint ester-like odor.
2. Boiling point of Diazinon is 83-84 ºC at 26.6 mPa.
3. The vapor pressure of diazinon is 9.7 mPa at 20ºC.
4. The density of diazinon is 1.11g/cm at 20ºC.
5. The refractive index of diazinon is 1.4978-1.4981.
6. The specific gravity of diazinon is 1.116-1.118 at 20ºC.
7. Stability: susceptible to oxidation above 120ºC, stable in neutral media, but slowly hydrolyzed in alkaline media, and more rapidly in acidic media.
8. Solubility: 60mg/L in water at 20ºC, completely miscible with common organic solvents.

1.5.4: Toxicological Effects

Diazinon is an OP insecticide and acaricide, which acts as a control stomach and respiratory poison (Tomlin, 1997). Diazinon, as with other Ops, poisons humans and insects through its effects on nerve enzymes. Diazinon combines chemically with the acetyl cholinesterase enzyme and inactivate it. This enzyme is essential for the control of nerve impulse transmission. Loss of acetyl cholinesterase allows the accumulation of acetylcholine, the substance secreted by nerves that activates muscles, glands, and other nerves. Accumulation of sufficient levels of acetylcholine at junctions between nerves muscles will cause muscle contractions or twitching. Accumulation of acetylcholine at junctions between nerves and glands results in gland secretion and accumulation between nerves in the brain causing sensory and behavioral disturbances (EPA, 2003).

1.5.5: Environmental Fate

The movement of diazinon through soil is highly influenced by a number of factors, particularly by organic matter content. Diazinon is not expected to bind strongly to soil, owing to its K_{OC} value of 500, and is expected to show moderate mobility in the soil (WHO, 1998). Diazinon has a low persistence in soil. The half-life is 2 to 4 weeks. Biological processes appear to be the main factor in the degradation of diazinon in soil. In natural water diazinon has a half-life of the order of 5-15 days (WHO, 1998). The breakdown rate is dependent on the acidity of water. At highly acidic levels, one half of the compound disappears within 12 hours while in a neutral solution; the pesticide took 6 months to degrade to one half of the original concentration (EPA, 2003). Diazinon has not been detected in drinking-water samples and its concentrations in surface water are at the level of ng/litre. Environmental levels of diazinon are generally low. Diazinon uses fall into two major categories: as a pesticide in agriculture and as a drug in veterinary medicine. Diazinon residues in vegetables, fruits and animal products are very low. Volatilization of diazinon from soil is of minor importance (WHO, 1998).

1.5.6: Residues in Plants

Diazinon is absorbed by plant roots when applied to the soil and translocated to other parts of the plant (FAO and WHO, 1979). Generally the half-life is rapid in leafy vegetables, forage crops and grass. The range is from 2 to 14 days. Levels of diazinon permitted by (WHO) in the USA on human food range from 0.1 mg/kg in potatoes to 0.7 mg/kg in most leafy vegetable. The different studies on food indicated that diazinon residues are generally low and suggested that diazinon rapidly breaks down in both plant and animal products (WHO, 1998).

There are no available studies about the effect of treated wastewater on diazinon uptake and residues in plants. It is proposed that the association of diazinon with DOM found in treated wastewater may increase the leaching of diazinon to depths far from the root zone, or may increase the solubility of diazinon in treated wastewater which enhance the uptake of it by corn parts.

`

1.6 Study Objectives

Irrigating agricultural crops with treated wastewater save fresh water and reduce the hazard effects on the environment especially in arid and semiarid regions such as Palestine. The composition and characterization of treated wastewater could affect the growth parameters and pesticides uptake of corn. The aims of this study are: -

1- To investigate the effect of irrigation with treated wastewater on the yield, growth rate, fresh weight, and chemical composition of corn parts compared to fresh water irrigation in a clay loam soil.

2- To study the impact of irrigation with treated wastewater on soil characteristics.

3- To compare the characteristics of fresh water and treated wastewater.

4- To study the feasibility of irrigation with treated wastewater in reducing fertilizer use in agriculture.

5- To study how irrigation water of various qualities (fresh water, treated wastewater) influences the uptake and partitioning of herbicide atrazine by corn.

6- To measure the residues of insecticide diazinon in different corn parts.

`

CHAPTER 2

MATERIALS AND METHODS

2.1 Materials

Sweet Corn seeds (*Zea mays* cultivar) obtained from local commercial market, pipes, ice container, plastic sacks, meter sticks, manual pump, water pump, water meter, thermometer, test tubes, screw capped auger, column, filter papers (Whatman No 54),

2.2 Chemicals

Atrazine (2 – chloro-4-ethylamino-6-isopropylamino-1, 3,5-triazne) 99%, Lot No. 63200, assay HPLC grade), was obtained from RHD-Laborchemikalien GmbH. ATRANIX 50 SC with active ingredient concentration (45% w/w) was obtained from AGAN Chemical Manufacturers LTD (table 3). Hexane 95% HPLC grade, methanol, chloroform, and petroleum ether (all of spectrophotometeric grade). Acetone 99% HPLC grade, ethanol, potassium sulfate, boric acid, hydrochloric acid, selenious acid, sodium hydroxide, copper sulfate, and sulfuric acid (all of analytical grade), antifoam, methyl red, bromocresol green (Sigma Co), dichloromethane, activated florisil, deactivated florosil, toluene.

2.3 Instrumentation

pH meter (Meter lab pH meter 201 Radiometer Co), Conductivity meter (Meter lab EC meter M 201 Radiometer Co). Milli-Q water purifier (Millipore Co). Microprocessor Oximeter (oxi 196, WTW) was used for measuring the dissolved oxygen. UV/VIS spectrophotometer, lambda 10 (Perkin Ellmer). Flamephotometer (Jenway, Clinical PFP7). Ion Chromatography (Dionex IC model DX-500 pumping system (GP 50)) with Dionex electrochemical detector (ED 40) coupled with self-regenerating suppressor was used for major ions determination. The system is coupled with auto sampler (Dionex AS 3500). IonPac CS12A, analytical column (30x250mm), IonPac CS12A guard column (3x50mm), self-regenerating suppressor (CSRS P/N 53949) from Dionex, for cation analysis. IonPac AS11-HC analytical column (2x250mm), IonPac AS11-HC guard column (2x50mm), self-regenerating suppressor (Dionex, ASRS Ultra 2mm, P/N 53947), an ATC-1 carbonate trap column for anions analysis. Analytical balance, porcelain crucibles, muffle furnace, desicator, Kjeldahl digestion apparatus, Kjeldahl distillation apparatus, conical flasks, Buchner flask, dispenser (200ml), condenser (cold finger type), extraction thimble, Soxhlet extractor, Soxhlet flask, oven. Accelerated solvent extraction (ASE) on an automated Dionex-200 ASE system. Stainless steel ASE vessels (22ml), Dionex vials for extract collection (60 ml, P/N 49466). Gas chromatography-mass spectrometry (GC-MS) equipped with a 30-m x 0.53mm wide-pore capillary column, 1.0-µm film thickness, chemically bonded with 5% phenylpolysiloxane, 95% methyl polysiloxane (DB-5, SPB-5, RTx-5).

2.4 Treatment Plant System Description

The treated wastewater was supplied from the wastewater treatment plant at AL-Quds University. A pilot plant (produced by DOTAN ecology-Israel) for the treatment of wastewater was installed at AL-Quds University, main campus at Abu-Dies. The number of students is about 6000 with kitchen, cafeterias, and science laboratories. It is based on the activated sludge-extended aeration treatment process. The capacity of the plant is $50m^3$/day. The plant utilizes activated sludge-extended aeration technology. The

`

wastewater collected in hole from different places from AL-Quds University campus is pumped to the plant. An aeration pump using six diffusers continuously aerates the reactor. By laminar flow, the water passes to the clarifier compartment where sludge is separated from the effluent. The sludge is circulated back to the reactor automatically, the effluent then treated by flocculation, chlorination and sand filtration before collecting it in a special pond. Suitable pond for storing the treated wastewater was established at the site. The pond design is characterized with a dimension of 25m x 25m x 2m, was diged in the ground with hole for water pumping. Two holes were made inside the pond, one for the inlet water and the other for the connection of the pond to the pumping main hole. The water leakage was prevented by spread marl layer on the pond and supported by 0.2mm polyethylene and another layer of marl was spread over the polyethylene layer. A small stone layers spread on the top of the second marl layer. The pipes from the wastewater treatment plant to the pond were connected in a way that the flow of the effluent was run by gravity. A protection fence was installed around the pond.

2.5 Field Experiment

2.5.1: Site Description

The experiment was conducted at AL-Quds University, Abu-Dies campus, during April 2003 to July 2003. Abu-Dies is located in the central part of the West Bank, 5km southeast of Jerusalem. It lies 600m above sea level, and the climate of Abu-Dies is of arid to semi-arid type.

The annual temperature in summer is 25-36°C and in winter 5-15°C. The rainwater precipitation for the 1999, 2000, 2001, 2002, 2003 seasons was 200, 273, 315, 400 and 600mm respectively. The soil on the site was classified as clay loam. The main soil type is “terra rossa” and major mineral in the clay fraction is montmorillonite (AL2 [(OH)2Si4O10] nH2O). Its soil reaction is generally neutral to moderately alkaline and it has a high content of soluble salts. Both the high iron content and the low organic matter content are responsible for the red color.

2.5.2: Experimental Design

The field of 1/10 ha was chosen and prepared for the field experiment at April 2003. Experimental design of the field trial was completely randomized design with two treatments (a) irrigation with fresh water and (b) irrigation with treated wastewater. The experiment was developed according to the following variables; (1) water types were fresh water and treated wastewater. (2) Corn parts. (3) Time duration.

2.5.3: Planting and Irrigation

Sweet corn seeds (*Zea mays* cultivar) were sown on April, 19th, 2003, the grains were planted on both sides of the row, three to four grains in a hill, each grain about 2 to 3 cm deep in the ground, 50 cm between each hill and the other, the distance between the rows was 60 cm.

`

Table 2.1: Sweet corn seeds (*Zea Mays* cultivar) characteristics.

Cultivar	Variety	VOT NO	Type	Purity
Zea Mays	Bandit	145003014	Yellow SH2	99%

In the same day planting took place, the herbicide atrazine (Atranix) was applied (table 2.1). Following the instructions, 90 ml of technical atrazine was dissolved in 64 L of water, the mixture was sprayed at the two treatments equally. To activate the herbicide, 15 m^3 of fresh water and treated wastewater was sprayed using sprinklers for treatment a and treatment b respectively. Drip irrigation system was used to irrigate both fields during the season, this system consists of distributing network pipes on the surface, and each field was irrigated with 2 m^3/3days. Drip irrigation is highly efficient, accurate, energy efficient easily automated, environmentally friendly and reducing the amount of water, herbicides and nutrient leaching below the root zone. The quantity of irrigation water was varied during the season depending on the weather and growth stage. The total amount was 119 m^3 for fresh water, and 121 m^3 for treated wastewater.

Table 2.2: ATRANIX 50 SC characteristics.

Active Ingredient Concentration (45% w/w)		**Status:**	
ATRAZINE		Restricted	
Registration Number	**Registrant**	**Country of Origin**	**Package Size**
MHPH/001/98-R	Agricultural Chemical Plants	Israel	5 L Plastic, 20 L Plastic
Manufacturer	**Formulation**	**Mode of Action**	**Toxicity**
AGAN CHEMICAL MANUFACTURES LTD.	Suspension concentrate	Systemic	Class III
Where to Use:			
Corn, Pineapple, Sorghum, Sugarcane.			

Both treatments were fertilized with 150 g of N, P, K (20% nitrogen, 20% phosphorus, and 20% potassium) at three growing stages during the experiment. Diazinon was applied three times among the season 7, 30, and 60 days after emergence.

2.6 Sampling and Analysis

2.6.1: Water Sampling and Characterization

Water samples were taken once during the experiment. Fresh water and treated wastewater samples were collected before the experiment, the samples were collected in plastic bottles, labeled and sent to the laboratory for analysis. EC, pH, and BOD analysis of the water were carried immediately as soon as it reaches the laboratory. Standard methods were used for all analysis (Andrew *et al*. 1998). Dissolved oxygen (DO) was measured by oximeter before and after incubation for 5 days at 20°C. The chemical oxygen demand (COD) was measured by the transfer of 2.5ml of samples, and different standards of KHP, to test tubes, then 1.5ml digestion solution ($K_2Cr_2O_7$ (10.216g)) was added. H_2SO_4 (167 ml conc), $HgSO_4$ ((33.3g) in 1000ml distilled water) and 3.5 ml sulfuric reagent (5.5g of Ag_2SO_4 per one kilogram of conc H_2SO_4) were added and refluxed for 2 hours in the oven at 150°C. Samples and different standards are centrifuged and their absorbance was measured on UV/VIS spectrophotometer at 600nm. Total solids was measured by the transfer of certain quantity of samples to evaporating dishes and heated at 103°C in the oven. The same procedures were applied for total dissolved and suspended solids using filtration before evaporation.

2.6.2: Soil Sampling and Characterization

At harvesting time, soil samples were collected by using screw type auger, from both treatments at different depth (0-5, 5-30, 30-60cm), the samples were collected from three sites in the field. Standard procedures were used for soil analysis (Ryan *et al*. 1996). The soil samples were extracted with the ratio of (1:10) using 5g soil (< 2-mm) to 50 ml distilled water. The extract was then filtrated and used for further analysis of pH, EC, major cations and major anions using IC instrument. The available cations in soil extract were analyzed using an IonPac CS12A guard column coupled with self regenerating suppressor; CSRS. The mobile phase (9Mm H2SO4) was prepared using 18.2 MΩ.cm water. The flow rate was 0.75ml/ min and the injection volume was 10µl. Three replicates were performed on each sample for statistical analysis. Dionex standard was used for calibration. The data were analyzed on Peak Net 5.1 software. Available major anions were analyzed using IonPac As11-HC analytical column and IonPac As11-HC guard column coupled with self regenerating suppressor; ASRS. The mobile phase was eluted using low carbonate sodium hydroxide solution from 0.5Mm to 45Mm in 35 min. The flow rate was 0.5ml/min and the injection volume was 10µl. Three replicates were performed on each sample for statistical analysis. Dionex standard was used for calibration, and the data were analyzed on Peak Net 5.1 software. Sand%, Silt%, Clay%, content was analyzed according to Ketter *et al* (2001).

2.6.3: Plant Sampling and Characterization

Plant samples were collected twice during the experiment; twelve plants were collected randomly from each treatment, at ten days after emergence and at harvesting time. Each plant was separated into different parts (root, stalk, leaves, and fruit). The parts were kept cool during transport to the laboratory. The water content in the parts was determined as a loss in weight, which results from drying a known weight of each part of the plant to constant weight at 100°C over night in the oven, then the same parts were homogenized by a blender to obtain a homogeneous mixture. Analysis of ash, fat, crude fiber, crude protein was performed to samples in accordance with the official methods of analysis of the Association of Official Analytical Chemist (AOAC, 1990). The results represent the average of three replicates of each part as a percent of dry weight.

2.6.3.1: Ash

Ash represent the inorganic constituents of the plant, it may contains organic origin such as sulfur and phosphorus from protein. To determine ash, a well dried crucible was weighed to the nearest mg, 1-2g of well ground minced homogeneous samples were transferred to the weighed crucible, and the total weight was recorded, the crucible was ignited gradually in the muffle furnace to 550°C for four hours, cooled while warm in the desicator to room temperature, and constant weight, the following equation was used to calculate ash percent**:**

$$\%Ash = \frac{(A - B) \times 100}{\text{Sample wt (g)}}$$

Where:

A: weight of crucible after ignition (g).

B: weight of empty crucible (g).

2.6.3.2: Crude Fat

The term crude fat embraces all substances extracted by ether. In addition to fat, it includes phosphlipids, lectithins, sterols, waxes, fatty acids, carotenoids, chlorophyll and other pigments. To determine crude fat, the flask of the soxhlet extractor was weighed (W1) and recorded, 5g of dried sample was transferred to an extraction thimble with porosity permitting a rapid flow of ether, extracted in a soxhlet extractor at a rate of 5 to 6 drops per second, consideration of about four hours, the ether was removed by cautious evaporation of the content of the soxhlet, the flask was dried in oven at 100°C for 30 minutes, cooled and reweighed (W2), the following equation was used to calculate the percent of the crude fat:

$$\% \text{ Crude fat} = \frac{(W2 - W1) \times 100}{\text{Wt of sample (g)}}$$

2.6.3.3: Crude Fiber

The term crude fiber is a measure of the material in a food of vegetable origin that has no appreciable food value other than roughage. It consists largely of cellulose, lignin, and pentosans. To determine crude fiber, 1g of dried sample was weighed into a conical flask using dispenser, 200ml of 1.25% H_2SO_4 (sulfuric acid) which has been brought to boiling point was added, the first 30-40 ml was used to disperse the sample, few drops of anti-foam was added, and the flask was heated to boiling for two minutes, then the flask was boiled gently under cold finger condenser for 30 minutes, the flask was rotated occasionally to mix the content, the contents of the flask was filtered through Buchner funnel equipped with a wet 12.5 filter paper, then the sample was washed back into the original flask with 200 ml of 1.25% of sodium hydroxide which measured at room temperature and brought to boiling point by using the dispenser, the contents of the flask was boiled for 30 minutes, all the insoluble matter was transferred to the crucible by means of boiling water, the insoluble matter was washed with boiling water, 1% HCl, and again with boiling water until acid free, washed twice with alcohol, three times with acetone, dried at 110°C to constant weight (w1), ashed in muffle furnace at 550°C for one hour, cooled in a dessicator and reweighed (w2). The percent crude fiber was measured by using the following equation:

%Crude fiber = W1- W2 X 100/ Wt of sample (g).

`

2.6.3.4: Crude Protein

The crude protein content was calculated from the nitrogen content of the plant by multiplying the nitrogen by 6.25. The term crude protein is a measure of proteins, amino acid, amines, nitrates, nitrogenous glycosides, glycolipids, B-vitamins, and nucleic acid. To determine nitrogen, 1g of homogenized dried sample was weighed on a paper free of nitrogen and was put in the digestion tube, 5g of catalyst (potassium sulphate and copper sulphate) and 15g of sulfuric acid was added, the digestion temperature was 420°C for two hours, at the end the liquid has a transparent green color, the sample was left to cool at room temperature, 50 ml of distilled water was added into digestion tube and was left to cool at room temperature, 50ml of boric acid and some drops of mixed indicator was introduced at an Erlenmeyer flask, then 50ml of NaOH was introduced to the digestion tube, the distillation must be prolonged to the necessary time to collect a minimum of 150 ml of distilled solution, the distilled solution was titrated with 0.25N hydrochloric acid until it changes from green to purple, the following equation was used to calculate the crude protein:

$$\%\text{Nitrogen} = \frac{1.4 \times N \times (V1 - V)}{P}$$

Where:
P: sample weight in g.
V1: hydrochloric acid volume used in the titration.
N: hydrochloric acid normality.
V: hydrochloric acid volume used in the white test (ml).
The nitrogen content of the plant parts was multiplied by factor 6.25, to get the crude protein content.

2.7 Growth Parameters

2.7.1: Plant's Height

Using a meter stick ± 0.5-mm accuracy, the length of the plant was measured from the surface of the soil to the top of the growing tip of the plant. Three plants from each treatment was labeled, the plant length was measured at different growth stages 10, 20, 30, 40, 60, and 90 days after emergence. By using a meter stick ± 0.5-mm accuracy, the length of the root was measured at two growth stages, 10 days and harvesting time.

2.7.2: Plant's Weight

Six plants were collected randomly from each treatment at different growth stages 10, 20, 30, 40, 60, and 90 day after emergence. Using analytical balance, the weight of each plant was measured, the mean and standard deviation was recorded.

2.7.3: Corn and Silage Yield

By using corn ear weight method (Lauer, 2002). The corn yield was calculated for the two treatments. The product of leaves, stalks, roots, and dry matter were calculated.

`

2.8 Nutrients Analysis in Corn Tissues

Total nitrogen and phosphorus in corn parts were determined by using spectrophotometer UV-VIS in accordance with the official methods of analysis of the Association of Official Analytical Chemist (AOAC, 1990). Potassium content of corn tissues was determined using flame photometer. The micronutrient concentrations in corn tissues were determined by using ICP in accordance with the official methods of analysis of the Association of Official Analytical Chemist (AOAC, 1990).

2.9 Atrazine and Diazinon Extraction and Analysis

Accelerated solvent extraction (ASE) was used for the simultaneous extraction of atrazine from different parts of corn (roots, stalk, leaves, fruits). Extractions were carried out using steel vessels of a Dionex ASE 200 (Dionex GmbH, Idstein, Germany). Mixed samples of each part of corn from different sampling site were used for the investigations. Before applying ASE, 10g fresh weight of corn parts were dried at room temperature for nearly 24 hours until a constant final weight had been reached, samples were accurately weighed, and depending on the water content, 10g dw per 11ml vessel was applied. The extractions were performed at 40 and 120°C, the pressure was 15 Mpa. The extraction solvents was a mixture of n-hexane/dichloromethane 80:20. The extraction of the sample consists of a heating phase of 5 min and three static cycles of 10 min each (total extraction time 35 min), the volume of the solvent was 80 ml for one sample.

After applying extraction procedure (ASE), the extracted phases were concentrated to 2 ml. This concentrated solution was transferred to column 1 (diameter 1 cm, length 20 cm) containing 15g of deactivated Florisil (4% water) to separate out the hydrophilic plant compounds. It was eluted with 160 ml of n-hexane/dichloromethane 1:1. The first 60 ml of the eluate, containing the principle quantity of the pollutants, was transferred to column 2 (diameter 0.5 cm, length 20 cm) containing 3.5g of activated Florisil to separate out lipophilic plant compounds. Column 2 was eluted with 60 ml of n-hexane/dichloromethane 1:1. The eluates were concentrated to dryness, the residue being extracted three times with 2 ml diethyl ether, transferred to a vial, evaporated to dryness under nitrogen and dissolved in 200 µl of toluene, then the sample was ready to GC/MS analysis (Wenzel, *et al.* 1998).

2.10 Statistical Analysis

All treatments were replicated four times. One Way Analysis of variance (ANOVA) was used for generation of means and for determination of standard error terms, all tests were performed with significance level set to 0.05.

`

CHAPTER

RESULTS

`

3.1 Fresh and Treated Wastewater Characterization

Fresh water was supplied from Abu-Dies municipal water net. The treated wastewater was supplied from the wastewater treatment plant at AL-Quds University. The characteristics of fresh and treated wastewater used in field irrigation compared to the international acceptable characteristics for irrigation are displayed in table (3.1).

Table 3.1: The characteristics of fresh water and treated wastewater used in Abu-Dies experimental field, compared to international acceptable characteristics for irrigation. Values represent the mean ± SE (n =3).

Parameters	FW	International Standards*	TWW	International Standards*
pH	7.30±0.2	6.5-8.5	7.50± 0.2	4.5-9
EC (mS/cm)	0.910±0.1	---------------	1.840± 0.1	0.7-3
TS (mg/l)	770 ± 30	---------------	823±120	---------------
TDS (mg/l)	460 ± 20	1000	900± 22	450-2000
TSS (mg/l)	310 ± 20	0	30± 21	45
DOC (mg/l)	9.10±0.17	80	59.72± 0.34	---------------
BOD (mg/l)	0.0±0.0	0	150± 20	30
COD (mg/l)	0.0±0.0	0	210± 20	130-160
SAR	2.62	3-6	2.66	6-9
TN (mg/l)	2.01± 0.02	10	165.9± 0.91	5-30

*** International standards according to (WHO, 1989., Pratt, 1972., Ayers *et al.* 1985).**

Treated wastewater contains a variety of inorganic substances from domestic and industrial sources, including a number of potentially toxic elements such as arsenic, cadmium, chromium, copper, lead, mercury, zinc. The concentration of toxic elements in treated wastewater depends on the source of the wastewater. Table (3.2) shows the concentration of minerals in fresh and treated wastewater compared to the international standards. International standards according to (WHO, 1989., Pratt, 1972., Ayers *et al.* 1985).

`

Table 3.2: Minerals in fresh water and treated wastewater used for the irrigation compared to the international standard characteristics for irrigation. Values represent the mean ± SE (n =3).

Minerals	FW	International Standards	TWW	International Standards
Na^{+} (mg/l)	75± 5	200	90± 5	69-207
Ca^{+2}(mg/l)	56± 7	100	57± 7	100-130
K^{+} (mg/l)	3.5± 5	10	22± 5	30
Mg^{+2} (mg/l)	29± 7	50	30± 7	142-355
Cl^{-} (mg/l)	142± 10	250	232± 10	350
NO3^{-} (mg/l)	6± 2	50	16± 2	30
Al^{+3}(mg/l)	<0.01	0.2	0.07	5
Cd (µg/l)	<0.01	0.005	<0.01	0.01
Cr (µg/l)	<0.01	0.05	5.65	0.1
Co (mg/l)	<0.01	0.05	<0.01	0.05
Cu (mg/l)	<0.01	1	<0.01	0.2
Fe (mg/l)	<0.58	0.3	0.07	5.0
Li (µg/l)	<0.01	0.05	4.71	2.5
Mn (mg/l)	<0.02	0.1	0.04	0.2
Ni (mg/l)	<0.01	1.0	<0.01	0.2
Zn (mg/l)	<0.01	5	0.09	2.0

3.2 Soil Characterization

3.2.1: Soil Texture

The physical and chemical properties of soil can vary with geographical location, climate, and weathering processes (Dudeen, 2000). Soil is classified according to the size of the mineral particles (clay, silt, sand, and gravel) that reflects the parent rocks (Ryan *et al.* 1996). The soil texture of the field experiment is listed in Table (3.3).

Table 3.3: Soil texture in Abu-Dies experimental field in function of depth. Values represent the mean ± SE (n=3).

Soil depth (cm)	0-5	5-30	30-60
Sand %	33.20± 0.06	27.96± 0.07	37.00± 0.02
Silt %	42.43± 0.12	45.40± 0.05	23.16± 0.03
Clay %	24.37± 0.01	26.64± 0.02	39.84± 0.01

3.2.2: Effects of Effluent Chemistry on Soil Properties

Effluent is the resulting liquid flow from a wastewater treatment system; hence its quality depends on both the source of the wastewater and the level of treatment. The effects of effluent quality upon the receiving soil may range from behaving as clean water input to that causing serious sodicity/salinity levels in the receiving soil, or clogging the soil microspores with solids (Patterson, 1999).

`

Table 3.4: Soil properties in Abu-Dies experiment field as function of depth and water type. Values represent the mean ± SE (n=3).

Name	Soil irrigated with FW			Soil irrigated with TWW		
depth(cm)	0-5	5-30	30-60	0-5	5-30	30-60
pH (soil: water) (1:5)	8.20± 0.1	7.90± 0.1	7.90± 0.1	7.80± 0.1	7.80± 0.1	7.90± 0.1
EC(ms/cm)	0.190± 0.01	0.160± 0.01	0.130± 0.01	0.150± 0.01	0.160 ± 0.01	0.100 ±0.01
SAR	0.67	0.48	0.562	0.975	0.996	0.93
N (mg/g)	0.01± 0.00	0.02± 0.01	0.02± 0.00	0.55± 0.01	0.03± 0.01	0.03± 0.01
P (mg/g)	0.3± 0.01	0.43± 0.02	0.38± 0.05	0.68± 0.01	0.85± 0.01	0.53± 0.01
Na$^+$ (mg/g)	0.146 0.002	0.11± 0.002	0.122± 0.002	0.203± 0.002	0.198± 0.002	0.182± 0.002
K$^+$ (mg/g)	0.06± 0.001	0.0392± 0.001	0.0254± 0.001	0.0371± 0.001	0.0419± 0.001	0.0103± 0.001
Ca^{+2} (mg/g)	0.293± 0.011	0.250± 0.011	0.233± 0.011	0.193± 0.011	0.226± 0.011	0.206± 0.011
Mg^{+2} (mg/g)	0.080 ± 0.011	0.089 ± 0.011	0.075 ± 0.011	0.082 ± 0.011	0.044 ± 0.011	0.051 ± 0.011
Cl$^-$ (mg/g)	0.09 ± 0.001	0.069 ± 0.001	0.049 ± 0.001	0.115 ± 0.001	0.132 ± 0.001	0.031 ± 0.001
F$^-$ (mg/g)	0.0012 ± 0.0	0.001 ± 0.0	0.0017 ± 0.0	0.002 ± 0.0	0.002 ± 0.0	0.0037 ± 0.0
SO4^{2-} (mg/g)	0.195 ± 0.001	0.09 ± 0.001	0.1290 ± 0.001	0.08 ± 0.001	0.067 ± 0.001	0.028 ± 0.001
NO3$^-$ (mg/g)	0.057 ± 0.01	0.052 ±0.001	0.023 ±0.001	0.067 ± 0.001	0.097 ± 0.001	0.011 ± 0.001
HCO3$^-$ (mg/g)	0.76 ± 0.03	0.95 ± 0.03	0.92 ± 0.03	1.01 ± 0.03	0.89 ± 0.03	0.95 ± 0.03

3.3 Corn Growth Parameters

3.3.1: Plant's Weight

As shown in Fig (3.1), average plant weight was significantly different for the two treatments at the growth stage 40, 60, and 90 DAE respectively. The weight of plants irrigated with fresh water and treated wastewater increased with an average of 9.98 g/day, and 15.69 g/day respectively. It was found that, the reuse of treated wastewater for irrigation causes an increase in the weight of vegetative parts of plants.

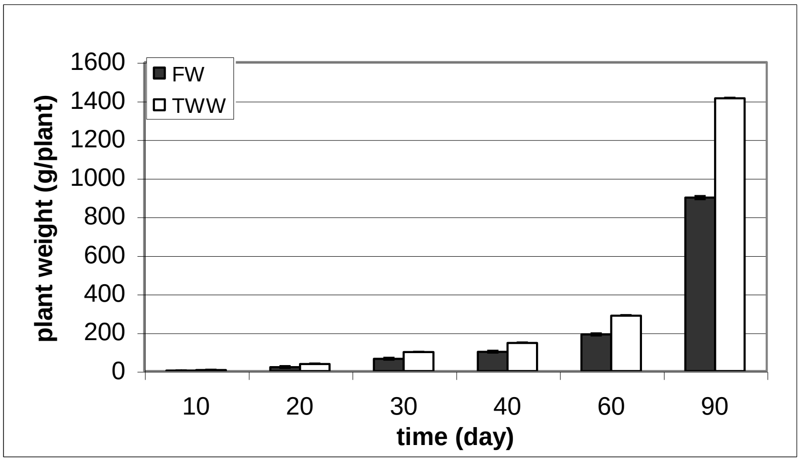


Fig 3.1: Effect of irrigation with fresh water and treated wastewater on plant fresh weights (g/plant) of corn. Values represent the mean ± SE (n=3).

3.3.2: Corn and Silage Yield

As shown in Table (3.5), the highest yield of ears, leaves, stalks, and roots per hectare were obtained from corn irrigated with treated wastewater.

Table 3.5: Yield of corn ears, leaves, stalks, and roots and dry matter percentage in function of water type at harvesting time.

Fresh Water					Treated Wastewater			
Corn Parts	Root	Stalk	Leaves	Ears	Root	Stalk	Leaves	Ears
F.wt Kg/ha	505	4714	2357	9,260	750	7005	3,502	13,760
DM Kg/ha	146	942	636	2407	225	1471	1,015	3713
DM%	29	20	27	26	30	21	29	27
F.Wt/DM	3.45	5.00	3.70	3.84	3.33	4.76	3.45	3.70

3.3.3: Plant’s Height

Plant’s height varied in both treatments and reached their maximum height at 12th week.

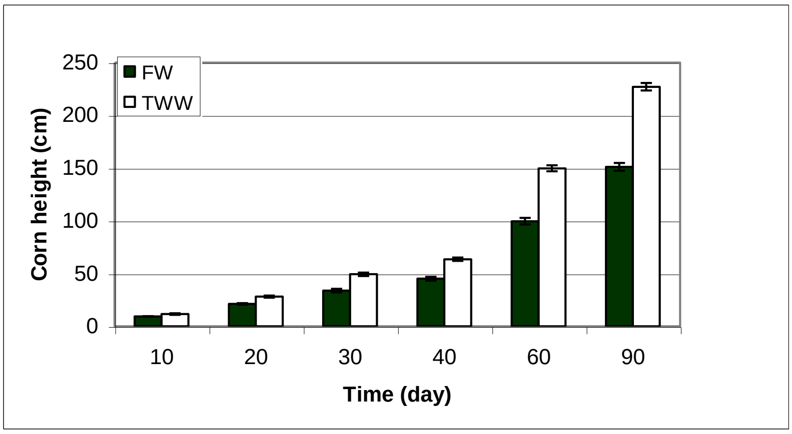


Fig 3.2: Effect of irrigation with fresh water and treated wastewater on corn height (cm) in function of time. Values represent the mean ± SE (n=3).

Fig (3.2) shows that, plant height at different growth stages shows a significant difference between two treatments. Growth rate for plant irrigated with fresh water was 1.77 cm/day and 2.66 cm/day for plant irrigated with treated wastewater.

In addition, the length of the roots at 10 DAE was in the range of 5 to 8cm, and at harvesting time was in the range of 20-30cm.

3.4 Corn Parts Characterization

3.4.1: Water Content in Corn Parts

The water content of different parts of corn is listed in Table (3.6). The result shows that, there was no significant difference in water content between the two treatments. The results also show that, there was significant difference in water content between corn parts at 10 DAE and harvesting time. Water content in different corn parts varied from 69.27% to 84.33% in the following order: fruits > stalks > leaves > roots.

Table 3.6: The percentage of water in different parts of corn in function of time and water type. Values represent the mean ± SE (n = 3).

Water type	Time	Root	Stalk	Leaves	Fruit
F.W	Harvesting time	71.71± 1.55 a	79.93± 0.696 a	72.43± 1.584 a	84.33± 0.318 a
T.W.W	Harvesting time	69.27± 0.953 a	79.87± 0.524 a	70.73± 1.081 a	83.80± 1.582 a
F.W	10 DAE	73.87± 1.75 b	82.80± 0.173 b	76.5± 1.528 a	N.F
T.W.W	10 DAE	72.53± 0.882 b	81.87± 1.396 b	76.40± 0.907 b	N.F

Means within column followed by the same letter are not significantly different at $P = 0.05$ according to Fisher’s protected LSD test.

3.4.2: Ash

The ash content of corn parts of both treatments at two growth stages is presented in Table (3.7). The results reveal that there was no significant difference in both treatments for the same growth stage. There was a significant difference in ash content between corn parts at 10 DAE and harvesting time. Ash content in different corn parts varied from 2.26% to 13.04% in the following order: leaves > roots > stalks > fruits.

Table 3.7: The percentage of ash in different parts of corn in function of water type and time. Values represent the mean ± SE (n = 3).

Water type	Time	Root	Stalk	Leaves	Fruit
F.W	Harvesting time	5.16± 0.093 a	3.21± 0.350 a	13.04± 0.239 a	2.31± 0.179 a
T.W.W	Harvesting time	5.87± 0.139 a	3.83± 0.471 a	12.48± 0.463 a	2.26± 0.155 a
F.W	10 DAE	4.23± 0.072 b	2.26± 0.054 b	10.00± 0.069 b	N.F
T.W.W	10 DAE	4.14± 0.075 b	2.39± 0.179 b	9.20± 0.123 b	N.F

Means within column followed by the same letter are not significantly different at *P* = 0.05 according to Fisher's protected LSD test.

3.4.3: Crude Fat

The crude fat of corn parts of both treatments at two growth stages is presented in table (3. 8). The difference in fat content for the same corn parts was not significantly difference in both treatments for the same growth stage. In addition results showed no significant difference in fat content in corn parts at the two stages. Fat content in different corn parts varied from 0.52% to 8.39% in the following order: fruits > leaves > roots > stalks.

Table 3.8: The percentage of crude fat in different parts of corn in function of water type and time. Values represent the mean ± SE (n = 3).

Water type	Time	Root	Stalk	Leaves	Fruit
F.W	Harvesting time	0.82± 0.029 a	0.52± 0.015 a	0.8± 0.049 a	8.39± 0.257 a
T.W.W	Harvesting time	0.78± 0.020 a	0.56± 0.011 a	0.84± 0.017 a	8.33± 0.247 a
F.W	10 DAE	0.64± 0.026 a	0.64± 0.032 a	0.72± 0.012 a	N.F
T.W.W	10 DAE	0.68± 0.054 a	0.68± 0.020 a	0.89± 0.048 a	N.F

Means within column followed by the same letter are not significantly different at *P* = 0.05 according to Fisher's protected LSD test.

3.4.4: Crude Fiber

The crude fiber results of corn parts for both treatments at two growth stages are shown in Table (3.9). The results show that, there was no significant difference in fiber content of corn parts between both treatments for the same growth stage. However, there was a significant difference in fiber content between corn parts at 10 DAE and harvesting time. At harvesting time, fiber content varied from 1.81% to 44.10% in the following order: roots > stalks > leaves > fruit, and at ten days after emergence roots > leaves > stalks.

Table 3.9: The percentage of crude fiber of different parts of corn in function of water type and time. Values represent the mean ± SE (n = 3).

Water type	Time	Root	Stalk	Leaves	Fruit
F.W	Harvesting time	44.10± 0.898 a	30.22± 2.03 a	28.68± 1.37 a	1.85± 0.040 a
T.W.W	Harvesting time	42.46± 2.89 a	31.84± 0.658 a	28.92± 1.37 a	1.81± 0.061 a
F.W	10 DAE	33.36± 0.617 b	17.52± 0.520 ac	20.24± 0.416 b	N.F
T.W.W	10 DAE	33.34± 0.469 b	16.7± 0.361 ac	23.44± 1.10 bc	N.F

Means within column followed by the same letter are not significantly different at *P* = 0.05 according to Fisher’s protected LSD test

3.4.5: Crude Protein

The crude proteins content of corn parts for both treatments at two growth stages are presented in Table (3.10). The data reveals that, protein contents in corn root, stalk, leaves, and fruit irrigated with treated wastewater are higher than that irrigated with fresh water. The highest concentration of protein was found in leaves irrigated with treated wastewater. There was a significant difference in protein content between corn leaves at 10 DAE and harvesting time. Protein content in different corn parts varied from 2.52% to 16.18%.

Table 3.10: The percentage of crude protein in different parts of corn in function of water type and time. Values represent the mean ± SE (n = 3).

Water type	Time	Root	Stalk	Leaves	Fruit
F.W	Harvesting time	3.27 ± 0.708 a	2.52 ± 0.666 ac	9.41 ± 0.604 b	10.68 ± 0.317 a
T.W.W	Harvesting time	4.23 ± 0.313 a	3.76 ± 0.210 b	16.18 ± 0.872 a	12.32 ± 1.35 b
F.W	10 DAE	3.80 ± 0.185 b	3.6 ± 0.385 b	10.48 ± 2.46 b	N.F
T.W.W	10 DAE	4.23 ± 0.146 a	4.78 ± 0.326 a	10.96 ±0.175 b	N.F

Means within column followed by the same letter are not significantly different at *P* = 0.05 according to Fisher’s protected LSD test.

3.5 Nutrient Concentrations in Corn Tissue

3.5.1: Macronutrient Concentration at 10 DAE

The macronutrient concentrations in corn parts at ten days after emergence are shown in Table (3.11). The results show that the concentrations of N, P, and K in corn parts irrigated with treated wastewater were higher than that irrigated with fresh water. The concentration of Mg in root and stalk was slightly different between two treatments; meanwhile the leaf content of Mg was higher in plants irrigated with fresh water than that irrigated with treated wastewater.

Table 3.11: Macronutrient concentration in corn parts in function of water type at ten days after emergence. Values represent the mean ± SE (n = 3).

Parts	Root		Stalk		Leaves	
Nutrients	FW	TWW	FW	TWW	FW	TWW
N(mg/kg)	8.05 ± 0.60	13.73 ± 0.43	13.42 ± 0.80	14.81 ± 0.81	23.64 ± 0.99	30.33 ± 1.2
P (mg/kg)	1.24 ± 0.09	1.46 ± 0.08	0.80 ± 0.003	1.05 ± 0.02	0.25 ± 0.01	1.30 ± 0.08
K (ppm)	171.5 ± 6.2	277 ± 7.1	49 ± 1.2	440 ± 11.2	443 ± 10.3	461 ± 12.3
Mg(ppm)	16 ± 0.67	15.80 ± 0.98	11.4 ± 0.4	12.8 ± 0.88	17.1 ± 0.92	15 ± 1.2

3.5.2: Macronutrient Concentration at Harvesting Time

The macronutrient concentrations in corn parts at harvesting time are shown in table (3.12). The results show that the concentrations of N, P, and K, in corn parts irrigated with treated wastewater were higher than that irrigated with fresh water. In addition, the concentration of Mg in corn roots and stalks was nearly the same in both treatments. Meanwhile, the concentration of Mg in corn leaves irrigated with fresh water was higher than that irrigated with treated wastewater

.

Table 3.12: Macronutrient concentration in corn parts in function of water type at harvesting time. Values represent the mean ± SE (n = 3).

Parts	Root		Stalk		Leaves		Fruit	
Water type	FW	TWW	FW	TWW	FW	TWW	FW	TWW
N(mg/g)	3.31 ± 0.09	15.45 ±0.9	3.05 ±0.08	12.90 ±10.9	13.84 ±1.2	19.20 ±1.4	20.04 ±0.08	20.46 ±1.2
P(mg/g)	2.23 ± 0.07	10.05 ± 0.6	1.88 ±0.02	2.65 ±0.5	1.74 ±0.08	1.59 ± 0.09	2.00 ± 0.05	2.37 ±0.08
K (ppm)	174 ± 7.8	407 ±14.4	230 ±11.3	619 ±23	269 ±14.5	363 ±13.7	102.4 ±8.7	112.6 ±4.6
Mg(ppm)	10.9 ± 0.4	11.4 ±0.9	14.5 ±1.1	11.6 ±0.9	17.2 ±1.3	11 ±0.9	9.7 ±0.9	11.4 ±0.9

3.5.3: Micronutrient Concentration in Corn Parts

3.5.3.1: Micronutrient Concentration at 10 DAE

The results of the micronutrients at ten days after emergence are shown in table (3.13). The results show that, the concentrations of Ag, AL, Ba, Bi, Co, Ga, In, pb, and Cd in the corn parts were not different between two treatments, meanwhile the concentration of B, Cu, Fe, Ni, Zn, and Mn were higher in most corn parts irrigated with treated wastewater than that irrigated with fresh water.

The concentration of Cr and Sr in the root irrigated with treated wastewater was higher than that irrigated with fresh water, meanwhile the concentration of Sr in the stalk and leaves were not different. In addition the concentrations of Cr in stalk and leaves of plants irrigated with treated wastewater were higher than that irrigated with fresh water.

Table 3.13: Micronutrients concentration (ppm) in corn parts in function of water type at 10 days after emergence.

Parts	Root		Stalk		Leaves	
Water type	FW	TWW	FW	TWW	FW	TWW
Ag	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
AL	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
B	0.12	0.28	0.06	0.41	0.065	0.13
Ba	< 0.07	< 0.07	< 0.07	0.07	< 0.07	0.07
Bi	< 0.012	< 0.012	< 0.012	< 0.012	< 0.012	< 0.012
Co	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cd	< 0.015	< 0.15	< 0.015	< 0.015	< 0.015	< 0.015
Cr	0.11	0.25	0.04	0.46	0.04	0.28
Cu	0.06	0.15	0.03	0.03	0.07	0.09
Fe	33.6	76	3.65	7.74	5.20	11.0
Ga	< 0.065	< 0.065	< 0.065	< 0.065	< 0.065	< 0.065
In	< 0.02	< 0.2	< 0.02	< 0.02	< 0.02	< 0.02
Ni	< 0.06	0.27	< 0.06	0.06	0.06	0.10
Pb	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Sr	0.08	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
Ti	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15
Zn	0.69	0.60	0.38	2.10	0.34	0.44
Mn	0.72	2.4	0.31	0.49	0.84	0.84

<: Under the instrument limitation.

3.5.3.2: Micronutrient Concentration at Harvesting Time

The results of the micronutrients at harvesting time are shown in table (3.14). The results show that, the concentration of Ag, AL, Ba, Bi, Co, Ti, Cd, Ga, and pb in the corn parts were not different between two treatments, meanwhile the concentration of B, Cr, Ni and Fe were higher in corn parts irrigated with treated wastewater than that irrigated with fresh water.

The concentration of Zn in root, stalk, leaves of corn irrigated with fresh water were higher compared to that irrigated with treated wastewater, meanwhile fruit content of Zn was higher in plants irrigated with treated wastewater compared to that irrigated with fresh water. The concentration of Mn in root, stalk, leaves of corn irrigated with fresh water were higher than that irrigated with treated wastewater, meanwhile fruit content of Mn was higher in plants irrigated with treated wastewater compared to that irrigated with fresh water. The concentration of Sr in root, stalk, leaves of corn irrigated with fresh water was higher than that irrigated with treated wastewater, meanwhile, there was no difference in fruit content of Sr between two treatments.

Table 3.14: Micronutrients concentration (ppm) in corn parts in function of water type at harvesting time.

Parts	Root		Stalk		Leaves		Fruit	
Water type	FW	TWW	FW	TWW	FW	TWW	FW	TWW
Ag	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
AL	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03	< 0.03
B	0.015	0.33	0.21	0.24	0.03	0.21	0.03	0.21
Ba	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07	< 0.07
Bi	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012	<0.012
Co	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Cd	<0.015	<0.015	< 0.05	<0.018	< 0.05	< 0.05	<0.015	< 0.05
Cr	< 0.04	0.21	< 0.04	0.1	0.30	0.12	< 0.04	< 0.04
Cu	0.07	0.03	< 0.02	0.03	0.04	0.06	< 0.02	0.05
Fe	3.33	5.48	2.81	3.77	4.63	5.84	0.80	6.18
Ga	<0.065	<0.065	<0.065	<0.065	<0.065	<0.065	<0.065	<0.065
In	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Ni	< 0.06	0.10	< 0.06	0.08	0.22	0.3	< 0.06	< 0.06
Pb	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25	< 0.25
Sr	0.04	<0.002	0.04	0.02	0.12	<0.002	<0.002	<0.002
Ti	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15
Zn	0.44	0.36	0.44	0.23	0.41	0.21	0.41	0.52
Mn	0.85	0.37	0.34	0.32	0.56	0.55	0.04	0.20

<: Under the instrument limitation.

3.6 Atrazine Concentration

3.6.1: Atrazine Concentration in Corn Parts

Fig (3.3) shows the concentrations of atrazine in corn parts in both treatments at ten days after emergence. The results show that the concentration of atrazine in corn parts are in the following order: roots > stalks > leaves. Atrazine was found with maximum concentration in the root, meanwhile the minimal concentration was found in the leaves.

Fig (3.4) shows the concentrations of atrazine in corn parts in both treatments at the harvesting time. The results show that the concentration of atrazine in corn parts are in the following order: roots > leaves > stalks > fruit.

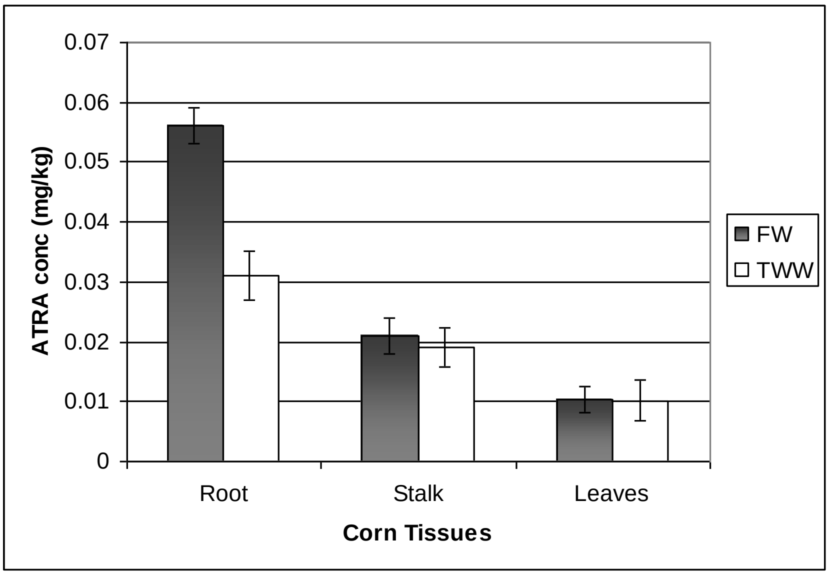


Fig 3.3: Atrazine concentration in corn parts at 10 days after emergence in function of water type. All concentrations in mg/kg dry weight.

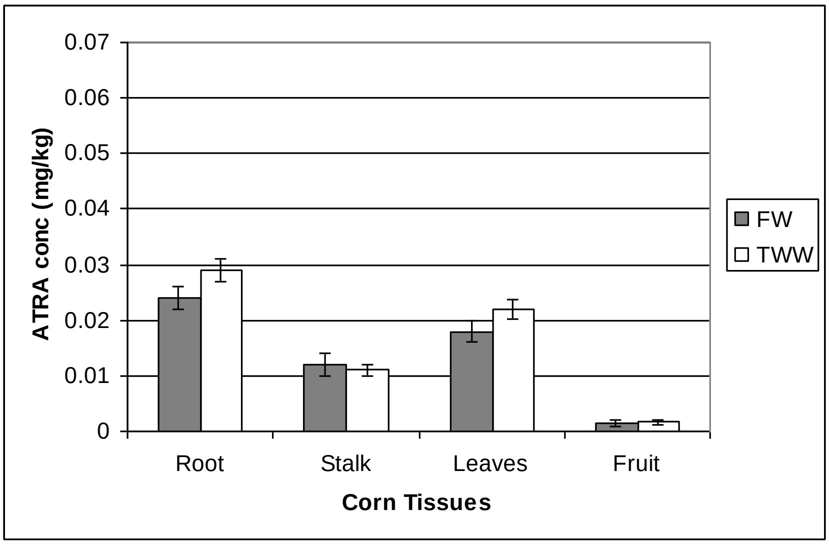


Fig 3.4: Atrazine concentration in corn parts at harvesting time in function of water type. All concentration in mg/kg dry weight.

3.6.2: Atrazine Concentration and Water Irrigation

Table 3.15: The relationship between atrazine concentration in corn parts and soil in function of depth and water type.

Time	10 DAE		H.T	
Water type	FW	TWW	FW	TWW
Soil depth (cm)	0-5	0-5	5-30	5-30
[ATR] µg/kg soil*	115.2	60.3	30.7	53.0
[ATR] mg/kg root	0.056	0.031	0.024	0.029
[ATR] mg/kg Stalk	0.021	0.019	0.012	0.011
[ATR] mg/kg leaves	0.01	0.01	0.018	0.022
Root length (cm)	5-8		20-30	

*** source: Hassan (2005).**

Table [3.15] indicates the relationship between the concentration of Atrazine in corn parts and its concentration in soil in function of depth and water type at two growth stages. The results show that the concentration of atrazine in corn root and stalk irrigated with fresh water was higher than that irrigated with treated wastewater at 10 days after emergence. Meanwhile, there was no difference in concentration of atrazine in the leaves.

In addition, the concentration of atrazine in corn root and leaves irrigated with treated wastewater was higher than that irrigated with fresh water at harvesting time. Meanwhile, the concentration of atrazine in stalks was slightly differing.

3.6.3: Atrazine Concentration and Time

Fig (3.5) shows the concentration of atrazine in corn parts irrigated with fresh water at two growth stages. The results show that, atrazine concentration decreased from ten days after emergence to harvesting time in root and stalk, meanwhile increase in leaves.

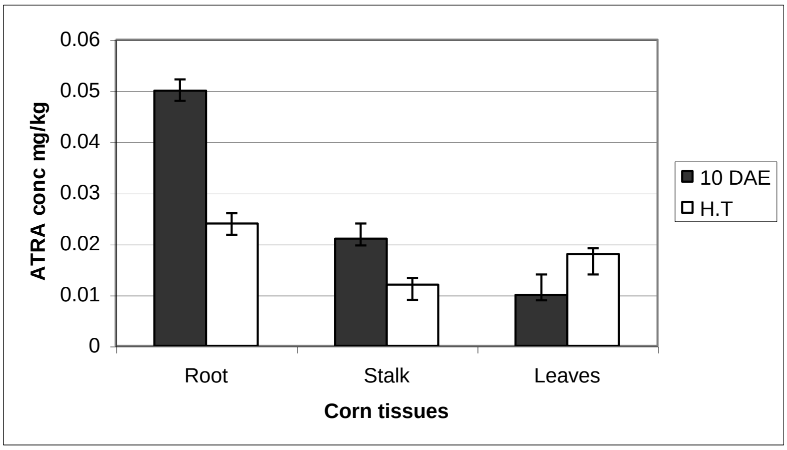


Fig 3.5: Atrazine concentration in corn parts irrigated with fresh water at two growth stages. All concentrations in mg/kg dry weight.

Fig (3.6) shows the concentration of atrazine in corn parts irrigated with treated wastewater at two growth stages. The results show that, atrazine concentration has decreased from ten days after emergence to harvesting time in root and stalk, meanwhile increase in leaves.

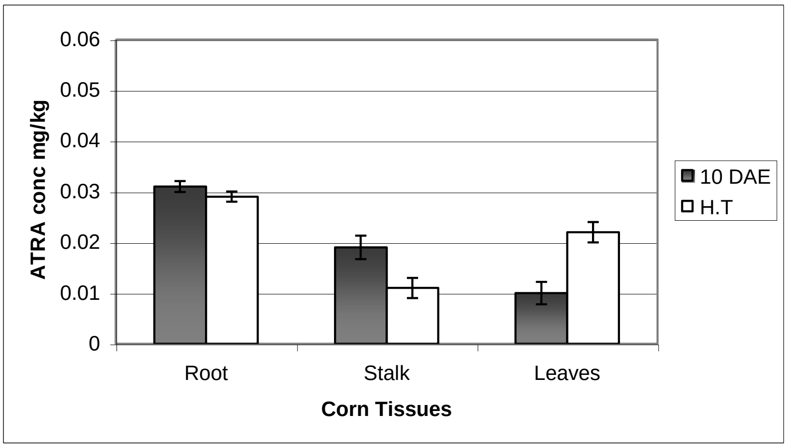


Fig 3.6: Atrazine concentration in corn parts irrigated with treated wastewater at two growth stages. All concentrations in mg/kg dry weight.

3.7 Diazinon Concentration in Corn Parts

Fig (3.7) shows the concentration of diazinon in corn parts in both treatments at ten days after emergence. The results show that the concentration of diazinon are in the following order: leaves > stalks > roots. Low concentration of diazinon was obtained in the root.

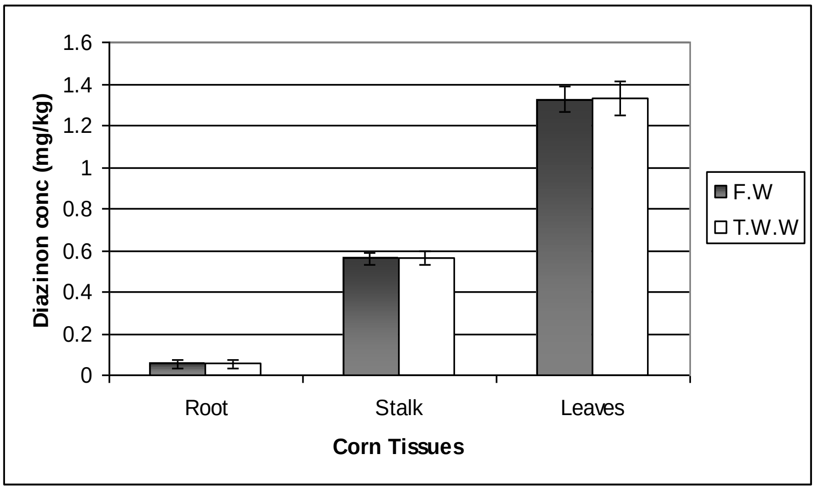


Fig 3.7: Diazinon concentration in corn parts at 10 days after emergence in function of water type. All concentrations in mg/kg dry weight.

Fig (3.8) shows the concentration of diazinon in corn parts in both treatments at harvesting time. The results show that the concentration of diazinon are in the following order: leaves > stalks > roots. Low concentration of diazinon was obtained in the fruit.

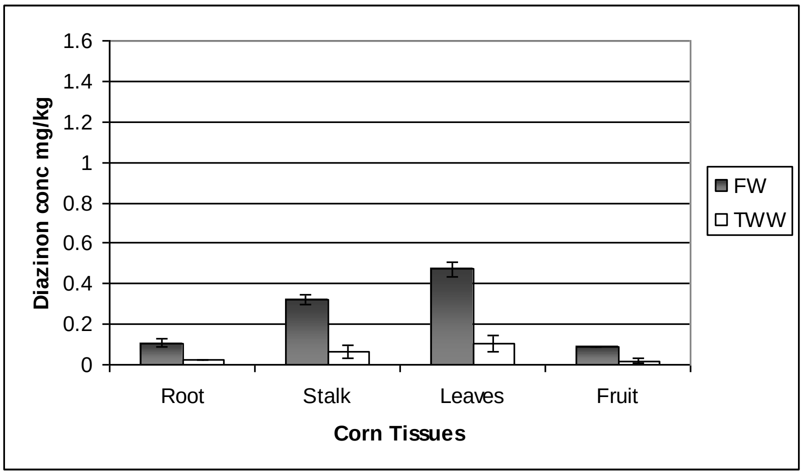


Fig 3.8: Diazinon concentration in corn parts at harvesting time in function of water type. All concentrations in mg/kg dry weight.

CHAPTER 4

DISCUSSION

4.1 Fresh and Treated Wastewater Characteristics

The results obtained from the analysis of FW and TWW used in field irrigation showed that there was no significant difference in pH value between FW and TWW. The pH of fresh water used in field irrigation was 7.3, and of treated wastewater was 7.5. The pH values of used water were in the range of 7.3 to 7.5, which is acceptable for irrigation purposes without negative effects on growth or yield of corn. According to Ayers and Westcot (1985), the pH of irrigation waters should be in the range of 4.5 to 9 to avoid restrictions on nutrient solubility or increasing solubility of toxic metals.

Results showed that SAR values were found to be 2.62 with an electrical conductivity of 0.910 mS/cm for fresh water and 2.66 with an electrical conductivity of 1.840 mS/cm for treated wastewater. Irrigation with waters having an SAR above 9 will cause permeability problem to soil. The permeability affects the aeration and permeability of fertilizers and irrigation water (Ryan *et al*. 1996). Also, Salinity (EC) greater than 3.0 mS/cm reduce the water uptake of plants because of lowering the osmotic potential of the soil, and reduces the growth rate along with some effects identical to those caused by water stress (Munns, 1993). The results showed that fresh water and treated wastewater have SAR less than 9 and EC less than 3.0 mS/cm, therefore it is suitable for irrigation without negative effects on growth or yield of corn.

The results showed that, the total solids which represent the total dissolved solids and total suspended solids concentration was significantly different between fresh water and treated wastewater. The total solids of fresh water and treated wastewater were in accordance with the international standards for water irrigation (WHO, 1989).

Organic matters are usually measured by biochemical oxygen demand (BOD), and chemical oxygen demand (COD) (Pettygrove and Asano, 1985). The concentration of BOD in fresh water was zero, meanwhile it was 150 ppm in treated wastewater. The BOD concentration in treated wastewater was higher than the international standards for water irrigation (WHO, 1989). The high concentration of COD in treated wastewater is most probably due to the high concentration of chemicals that are dumped from the laboratories in the university.

Heavy metal concentration of (Al, Cd, Cr, Co, Cu, Fe, Li, Mn, Ni, Zn) of fresh water and treated wastewater were found to be within the safe limit that is acceptable for irrigation according to the international standards. With the exception of Cr and Li which was found in high concentration. The high concentration of Cr and Li is most probably due to the activities that take place in the university laboratories. Micronutrients toxicities are more probable when the pH of the substrate solution is low, rendering the micronutrients more available for plant uptake (Bailey, *et al*. 2002).

4.2 Soil Characteristics

4.2.1: Soil Texture

Abu-dies soil texture represented in Table (3.3). It shows that, soil is sand clay loam. It is terra–rossa", calcareous soil with a major clay minerals fraction montmorillonite. This type of soil usually associated with excellent filtration and percolation of water. The soil characteristic is dependent on the history of the field, irrigation with treated wastewater for long time may increase salinity of soil by increasing sodium and potassium concentrations. The experimental field has no agricultural history with treated wastewater, so the growth of plant was not affected by the salinity.

4.2.2: Effects of Effluent Chemistry on Soil Properties

Impact from treated wastewater on agriculture soil, is mainly due to the presence of high nutrients contents (nitrogen and phosphorus), high total dissolved solids and other constituents such as heavy metals, which are added to the soil over time. Wastewater can also contain salts that may accumulate in the root zone with possible harmful impacts on soil health and crop yields. The leaching of these salts below the root zone may cause soil and groundwater pollution (Bond, 1999).

4.2.2.1: Soil pH

The pH results show that, there was no significant difference in pH value between soils irrigated with fresh water compared to that irrigated with treated wastewater for each depth. The pH of the soil samples was found to be within the range of 7.80-8.20, which is the most desired range of agricultural soil (Ryan, 1996). Soil with pH greater than 8.5 can affect plant growth and nutrient availability.

4.2.2.2: Soil SAR and EC

The EC results show that, there was no significant difference in EC value between soil irrigated with fresh water and that irrigated with treated wastewater. The EC of the soil was found to be within the range of 0.100 to 0.190 mS/cm, which is the most suitable range for agricultural soil. The soil classification is nonsaline soil since it has EC less than 4 mS/cm (Patterson, 1999). There was a significant increasing in SAR value for soil irrigated with treated wastewater compared to that irrigated with fresh water. This difference was attributed to the concentration of (Mg^{+2}, Ca^{+2}, and Na^{+}) in treated wastewater. The SAR value of soil was within the range of 0.48 to 0.996, which is acceptable for agriculture.

4.2.2.3: Soil Chloride and Sodium

Effluent irrigation generally adds significant quantities of salts to the soil environment, such as sulphates, phosphates, bicarbonates, chlorides, sodium, potassium, and magnesium. The total impact of these salts may increase soil salinity to extreme levels. The results show that, there was a significant increase of chloride and sodium concentration in the field irrigated with treated wastewater compared to that irrigated with fresh water. This is due to the high concentration of chloride and sodium that found in treated wastewater. Soils high in sodium are a problem because they restrict plant growth (Pesccod, 1997). Sodium salts effect the exchangeable cation composition of the soil causing lowered permeability. Sodium does not impair the plant uptake of water but reduces the infiltration of water into the soil (Tanji, 1990). Patterson (1998) showed that significant loss of soil hydraulic conductivity was associated with small increases in sodium in the percolating solution.

4.2.2.4: Soil Bicarbonate

The bicarbonate contents showed no significant difference between soil irrigated with treated wastewater and that irrigated with fresh water. The bicarbonate ion can be toxic to plants, but more importantly, it interferes with other nutrients and makes them less available to plants (Gaskell, 2002). High soil bicarbonate levels are also important factors in decreasing iron availability to plants.

4.2.2.5: Soil Nitrogen and Phosphorous

The three main nutrients that have been identified as necessary for plants are nitrogen, phosphorous, and potassium. The results show that, nitrogen and phosphorous concentrations in soil irrigated with treated wastewater were higher than that irrigated with fresh water. This is due to that treated wastewater is a rich source of nutrients such as nitrogen and phosphorous. Nitrogen encourages leaf growth, and phosphorous encourages roots. If one of these nutrients is not available, then plant growth will be slower or stunted, and leaves will be discolored (Smith, 2003).

4.2.2.6: Soil Potassium

The results of potassium concentration show that, there was no significant difference between soil irrigated with treated wastewater and that irrigated with fresh water. The potassium concentration decreases through soil depth in field irrigated with fresh water. Meanwhile, in field irrigated with treated wastewater, potassium concentration was nearly stable through the depth 0-30 cm. At depth 30-60 cm potassium concentrations significantly decreased. The increasing in the potassium concentration in soil will cause better nutrition source for plants.

4.3 Corn Growth Parameters

4.3.1: Plant’s Weight

Fig (3.1) shows values relative to the fresh weight of corn. Average plant weight was significantly different for the two treatments at the growth stage 40, 60, 90 DAE respectively. The fresh weight of plant irrigated with fresh water increased with an average of 9.98 g/day, while that irrigated with treated wastewater was at 15.69 g /day. This difference in fresh weight between the two treatments was attributed to the composition of treated wastewater, which is a rich source of essential nutrients that is necessary for corn growth. These results agree with those of Afifi and Tubail (1998), which found that, the reuse of treated wastewater in irrigation causes an increase in the weight of vegetative parts in plants. The sharp increase in weight after 40 DAE was attributed to the beginning of ears formation. During this time, grain is developing rapidly and increasing in weight (Eisenhaur, *et al.* 1997). The contribution of ears in the fresh weight of corn was nearly 55%, leaves 14%, stalks 28%, and root were 3% only.

4.3.2: Corn and Silage Yield

As shown in Table (3.5), highest yield of ears, leaves, stalks, and roots per hectare were obtained from corn irrigated with treated wastewater. The yield of corn ears in treated wastewater treatment was 13,760 kg/ha, while in fresh water treatment 9,260 kg/ha. The difference was 4500 kg. This result can be explained due to the chemical properties of treated wastewater. It is a rich source of plant nutrients (NPK). The positive effect of irrigation with treated wastewater on corn yield has been also reported by several studies. Tsadilas (1999) had shown that treated wastewater significantly increased corn yield and may substitute considerable quantities of mineral fertilizers. Also Tsadilas and Vakalis (2003) concluded that irrigation of corn with treated wastewater resulted in economic benefit compared with conventional practices of irrigation with fresh water.

4.3.3: Plant's Height

Fig (3.2) shows plant's heights at different growth stages. There is a significant difference between the two treatments. Growth rate for plant irrigated with fresh water was 1.77cm/day and 2.66cm/day for plant irrigated with treated wastewater. The results obtained in this study confirm the positive effect of using treated wastewater on the height of corn since; it is a rich source of essential nutrients (NPK), which positively affect the plant height. These results are similar to those previously obtained by Lima *et al.* (2004), and Afifi and Tubail (1998). These studies concluded that the treated wastewater application contributes to increase in the height of corn plant.

4.4 Corn Parts Characterization

4.4.1: Water Content in Corn Parts

Table (3.6) shows that, water content in corn parts was not significantly different between two treatments. The results also show that, there was significant difference in water content between corn parts at 10 DAE and harvesting time. The water content of plants varied with age (Cheeke, 1991). The water content of growing plant is related to the stage growth, younger plants contain more water than older plant (Cheeke, 1991). Also there was a significant difference in water content between different corn parts for the same growth stage in both treatments. Water content in different corn parts are varied from 69.27% to 84.33% in the following order: fruits > stalks > leaves > roots.

4.4.2: Ash

The ashes content of corn parts of both treatments at two growth stages are presented in Table (3.7). The results reveal that there is no significant difference in both treatments for the same growth stage. This is due to that ash content in corn parts depends rather on hybrid features than on nutrition level. Fertilization (NPK) tended to increase slightly the ash content in corn parts (AL-Bakeir, 2000).

There was a significant difference in ash content between corn parts at 10 DAE and harvesting time. This can be explained that ash represent the inorganic constituents (Al, Cd, Cr, Co, Cu, Fe, Li, Mn, Ni, Zn) of the corn parts and the concentration of these nutrients increased with time. Also there was a significant difference in ash content between different corn parts for the same growth stage in both treatments. Ash content in different corn parts are varied from 2.26% to 13.04% in the following order: leaves > roots > stalks > fruits. The ash results are similar to that obtained by AL-Bakeir (2000) which concluded that, the content of ash in corn fruit is 1.6-2.5 %, leaves 8.6-10.6%, and in the stalks 3.5-5.4%.

4.4.3: Crude Fat

The crude fat of corn parts of both treatments at two growth stages is presented in Table (3. 8). The difference in fat content for the same corn parts was not significantly different in both treatments for the same growth stage. Result showed no significant difference in fat content in corn parts at the two stages. The fat content was very low in root, stalk, and leaves in both treatments at the different growth stages. Cheeke, (1991) reported that the crude fat content in the corn root and leaves was up to 1%. Fat content in different corn parts were varied from 0.52% to 8.39% in the following order: fruits > leaves > roots > stalks. The fat content of corn fruit is high comparing to other parts. A factor contributing to the high-energy value of corn is its high oil content (Cheeke, 1991).

4.4.4: Crude Fiber

The crude fiber results of corn parts of the both treatments at two growth stages are shown in Table (3.9). The results show that, there is no significant difference in fiber content of corn parts between both treatments for the same growth stage. Day *et al.* (1975) concluded that, there was no change in total fiber content of plant irrigated with treated wastewater compared to that irrigated fresh water. However, there was a significant difference in fiber content between corn parts at 10 DAE and harvesting time. Crude fiber fraction contains cellulose, lignin and hemicellulose, a variable proportion of them depending upon the species and stage of growth of the plant material (Cheeke, 1991).

The fiber content in corn parts is significantly different. Fiber content in different corn parts are varied from 1.81% to 44.10% in the following order: roots > stalks > leaves > fruit at harvesting time, and roots > leaves > stalks at 10 DAE. The fiber content of root, stalk, and leaves was relatively high. Fruit had low amount of fiber.

4.4.5: Crude Protein

The crude protein content of corn parts of both treatments at two growth stages is presented in Table (3.10). The data reveals that, protein content in corn roots, stalks, leaves, and fruits irrigated with treated wastewater is higher than that irrigated with fresh water. The protein content in corn leaves irrigated with treated wastewater was significantly differente compared to that irrigated with fresh water. This is due to the increase of nitrogen uptake by corn since treated wastewater is considered as an important source of essential nutrients to corn growth especially nitrogen. Tsadilas (1999) showed that nitrogen concentration in corn tissue was increased gradually in the case of treated wastewater. Also, Marten *et al.* (1980) concluded that the irrigation of corn with treated wastewater resulted in higher crude protein yield per hectare.

The results show that, there was a significant difference in protein content between corn parts at 10 DAE and harvesting time. In general, the protein contents of all parts were decreased with time; the concentration of protein is high in growing plant and falls as plant matures (Cheeke, 1991). Protein content in different corn parts is significantly differente and varied from 2.52% to 16.18%.

4.5 Nutrient Concentration in Corn Tissue

4.5.1: Macronutrient Concentration at 10 DAE

The results show that corn parts accumulated different concentration of nutrient. At 10 days after emergence, the concentrations of macronutrients N, P and K were higher in corn parts irrigated with treated wastewater than that irrigated with fresh water. Berry *et al.* (1980) reported that wastewater has been recognized as a possible important source of the major plant nutrients, such as N, P, and K. If one of these three nutrients in not available, then plant growth will be slower or stunted, and leaves will be discolored (Smith, 2003). The concentration of Mg in corn parts was slightly higher in corn parts irrigated with fresh water than treated wastewater.

4.5.2: Macronutrient Concentration at Harvesting Time

The nutrients content of corn parts at harvesting time are presented in table (3.12). The results show that the concentration of the macronutrients in corn parts irrigated with treated wastewater was higher compared to that irrigated with fresh water. Nitrogen mainly affects vegetative growth and general health. Chlorophyll is largely composed of nitrogen. Potassium is important for general health of plants, it is key in the formation of chlorophyll and other plant compound (Black, 2004). Phosphorus is important for healthy roots and is used more heavily during blooming and seed set (Smith, 2003). Soxten *et al*. 1996 have investigated the positive effect of irrigation and N interaction on corn production. Tsadilas (1999) concluded that the increase in corn yield was attributed mainly to the increase of N uptake.

As shown in table (3.11) and table (3.12). Increase in corn yield, height, and weight of plant irrigated with treated wastewater compared to plant irrigated with fresh water may be attributed to the increase of nutrient uptake.

4.5.3: Micronutrients Concentration in Corn Parts

4.5.3.1: Micronutrients Concentration at 10 DAE

The concentrations of heavy metals in corn parts at ten days after emergence are presented in table (3.13). The results show that the accumulation of micronutrients in corn parts was differing from part to other. This may be attributed to the ability of each part to accumulate the metals. The micronutrients uptake of plants depends on the species of plants and on the heavy metals element (Sabua, *et al*. 2002).

The results show that the concentrations of B, Cr, Cu, Fe, Ni, Zn, and Mn were higher in corn parts irrigated with treated wastewater than that irrigated with fresh water. These elements are essential to plant growth and are required in small quantities (Baily, 2002). These results indicate that wastewater could be an efficient source of micronutrients to corn plant.

Tsadilas (1999) reported that the increase in corn yield was attributed mainly to the increase of N uptake and secondary to the increase of P, K, B, Fe, Zn, Mn, and Cu uptake. No differences in corn parts content of Ag, Al, Ba, Bi, Co, Cd, Ga, In, pb, Sr, and Ti were found between plants irrigated with either fresh water or treated wastewater.

4.5.3.2: Micronutrients Concentration at Harvesting Time

The concentrations of micronutrients in corn parts at harvesting time are presented in table (3.14). The results indicated that, the corn parts contents of B, Cr, Cu, Fe, and Ni were higher in plants irrigated with treated wastewater than that irrigated with fresh water. Wastewater significantly affected B concentration in corn leaves. Corn is a tolerant to B crops (FAO, 1985) and may be used for cultivation of lands irrigated with wastewater (Tasdilas, 1997). Similar influence was also recorded for the metals such as Fe, and Cu.

The irrigation with treated wastewater did not affected the concentration of Ag, Al, Ba, Bi, Co, Cd, Ga, In, pb, Sr, and Ti. Tasdilas (1997) reported that the leaf concentration of Pb was not affected by the irrigation with treated wastewater.

The concentration of Zn and Mn were higher in corn parts irrigated with fresh water than that irrigated with treated wastewater. The higher accumulation of Zn in plant tissue was due to its very mobile and bio-available characteristics. Zn concentration in the matured tissue exceed 400 mg/kg dry matter is considered toxic (Kiekens, 1996). Smith (1996) indicated that Ni concentration up to 50 mg/kg dry matter is toterable in agricultural crops. The uptake of Mn and Zn could be detected in maize because these elements are essential for the plants metabolism (smith, 1996).

The micronutrients concentration found in the corn parts during the experiment were not apparently limiting for growing corn plants since no toxicity symptoms were observed. The results indicated that the use of treated wastewater to irrigate corn plants is not harmful for this crop.

4.6 Atrazine Concentration

4.6.1: Atrazine Concentration in Corn Parts

At ten days after emergence, the concentrations of atrazine in corn parts in both treatments are in the following order: roots > stalks > leaves (Fig 3.3). Atrazine is taken up into the plant via the roots and move in the stem to plant leaves (Brooks, 1973). Atrazine was found with maximum concentration in the root, but the minimal concentration was found in the leaves. The direct contact between root and soil enhance the absorption of atrazine by root, thus atrazine was bioavailable for root uptake more than stalks and leaves. Diminution in atrazine concentration in corn parts was due to chemical transformation of atrazine into its hydroxy derivatives (hydroxyatrazine) especially in the leaves (Raveton et al. 1996). This hydrolysis of atrazine in corn is due to the presence of high levels of benzoxazinone derivatives in corn plant cells (Raveton *et al*. 1996). A second hypothesis is that the internal distribution of free atrazine from cell to cell inside the corn plant could only be very limited (Schmitt *et al*. 1996).

At the harvesting time Fig (3.4), the concentrations of atrazine in corn parts in both treatments are in the following order: roots > leaves > stalks > fruit. Low concentration of atrazine was obtained in the fruit. This might be attributed to the capacity of grain to degrade atrazine, and the distribution of free atrazine from other corn parts to fruit is very low. Ye CM *et al*. (2001) observed that the concentration of atrazine in plant compartments are in the following order: roots > stalk > kernal > leaf. And the concentration of atrazine in the kernel of corn overrides the limitation of 0.05 mg/kg. Monitoring of domestic and imported foods in the human diet by the U.S Food and Drug Administration between 1978 and 1982 showed that only 3 of 4500 samples analyzed had detectable atrazine residues. Two samples in 1980 contained 0.01 and 0.08 mg atrazine/kg and one in 1978 contained 47 mg/kg (Reed, 1982).

The results indicated that the various corn parts accumulate atrazine differently from soil. These differences could be due to specific morphological and physiological characteristics of the cell, such as lipid content, and the structure and composition of cell wall.

4.6.2: Atrazine Concentration and Water Irrigation

Table (3.15) indicates the relationship between the concentration of Atrazine in corn root and soil. The effect of water type on atrazine uptake by corn was obvious in the root zone at 10 DAE. At this growth stage, the roots are concentrated at depth of (0-5cm), and the maximum concentration of atrazine was found at this depth. The results show that Atrazine concentration was higher in the root irrigated with fresh water compared to that irrigated with treated wastewater. Atrazine was available in soil irrigated with fresh water (115.2 μg/kg) more than that irrigated with treated wastewater (60.3 μg/kg) as shown in table (3.15). This variation of atrazine concentration in the field irrigated with treated wastewater compared with the field irrigated with fresh water, within the depth of 0-5 cm are attributed to the desorption of atrazine from the surface and leaching to the depths due to higher content of DOM found in the treated wastewater. Water management is an important factor since the use of water with high DOM content could increase the potential of leaching, and it may increase plants uptake of minerals and herbicides adsorped to the DOM (Hassan, 2005).

At the harvesting time, atrazine concentration was higher in corn's root irrigated with treated wastewater than that irrigated with fresh water. This means that atrazine was available for plant uptake in the root zone irrigated with treated wastewater (53.0μg/kg) compared to that irrigated with fresh water (30.7μg/kg). As shown in table (3.15) at this growth stage, the roots reach to the depth of 30cm, where atrazine is more available in treated wastewater irrigation than fresh water irrigation. This was due to the adsorption of atrazine to DOM that found in treated wastewater and leaching deep of the root zone (5-30cm), which make this root more exposed to atrazine than root in soil irrigated with fresh water. Green and Obien (1969) reported that only, plants might take up the herbicide dissolved in the available water.

4.6.3: Atrazine Concentration and Time

The results show that Fig (3.5) and Fig (3.6) in corn parts irrigated with fresh water and treated wastewater, atrazine concentration was decreased from ten days after emergence to harvesting time. Such decrease was attributed to the decrease of atrazine concentration available in the soil for plant uptake. Many factors are responsible for the decrease of atrazine concentration in soil such as leaching, photochemical degradation, and microbial degradation, desorption to soil and all these processes are time dependent. Under field conditions, the half-life of atrazine is 60 day.

Another important factor is attributed to decrease of atrazine concentration in corn parts with time. It is the chemical transformation of atrazine in corn parts to hydroxy derivatives, especially hydroxyatrazine (Raventon *et al*. 1996).

4.7 Diazinon Concentration in Corn Tissue

At ten days after emergence Fig (3.7) and after three days of diazinon application, the concentrations of diazinon in corn parts in both treatments are in the following order: leaves > stalks > roots. Low concentration of diazinon was obtained in root. This was due to the method of diazinon application, which is sprayed directly to the leaves and stalks, and only small amount reach to the soil, and may be available to the root uptake. Diazinon residues in corn parts range from 0.055 to 1.32 mg/kg in plant irrigated with fresh water, and from 0.055 to 1.33 mg/kg in plant irrigated with treated wastewater. There was no significant difference between both treatments at ten days after emergence. This is may be attributed to short time between the first application of diazinon at seven days after emergence and the analysis of diazinon at ten days after emergence, so the effect of irrigation with treated wastewater on diazinon uptake was not clear at this growing stage.

At the harvesting time Fig (3.8), the concentrations of diazinon in corn parts in both treatments are in the following order: leaves > stalk > roots > fruit. Low concentration of diazinon was obtained in the fruit. This is due to that fruit begin to appear at 50 days after emergence, and were not exposed directly to diazinon during application. Diazinon found in fruit was distributed from leaves and stalks to the fruit. Diazinon residues in corn parts range from 0.087 to 0.472 mg/kg in plant irrigated with fresh water, and from 0.018 to 0.0105 mg/kg in plant irrigated with treated wastewater. There was a significant difference between both treatments. This may be attributed to high solubility of diazinon in treated wastewater compared to fresh water due to high content of DOM. This increasing in solubility increases the potential of leaching of diazinon to depth far from the root zone.

The concentration of diazinon in corn parts irrigated with fresh water and treated wastewater decrease from 10 DAE to harvesting time. These results indicated that the concentration of diazinon decrease with time. Such decrease of diazinon concentration was attributed to many factors such as leaching, photochemical degradation, and microbial degradation. Also, the time from the application of diazinon to the sampling time was different at two growth stages.

Results of supervised trials and monitoring of diazinon residues in or on food and feed commodities have been comprehensively reviewed and summarized by FAO and WHO (FAO and WHO, 1994). These results indicate that diazinon residues are generally low. Harvest samples showed that less than 0.05 mg/kg remained in either the foliage or grain. Ward *et al.* (1972) showed that the amount of diazinon remaining on foliage samples were range from 0.16 to 0.31 mg/kg. Levels of diazinon permitted in the USA on human food range from 0.1 mg/kg in potatoes to 0.7 mg/kg in most leafy vegetables (WHO, 1998).

As shown in Fig (3.8), diazinon residues of corn parts irrigated with fresh water at harvesting time were ranging from 0.087 to 0.472 mg/kg, and from 0.018 to 0.0105 in corn parts irrigated with treated wastewater, which was in the permitted level that acceptable on human food according to WHO (1998).

CONCLUSIONS AND RECOMMENDATIONS

It can be concluded from the results of the present study that treated wastewater can be used successfully safely and for irrigation of corn planted under arid to semi-arid conditions, and substituting considerable quantities of inorganic fertilizers. The irrigation with treated wastewater significantly increase the corn height, weight and agricultural income compared to that irrigated with fresh water. The growth parameters indicated that corn (*Zea mays L.*) is suitable to plantation with treated wastewater in such conditions that is described in this study.

The uptake of pesticides by corn parts was lower in plants irrigated with treated wastewater compared to that irrigated with fresh water at ten days after emergence. In addition, the concentration of atrazine in corn root and leaves irrigated with treated wastewater was higher than that irrigated with fresh water at harvesting time. Meanwhile, the concentration of atrazine in stalks was slightly differing. In fruit no significant difference in atrazine concentration between both treatments.

It is expected that the irrigation of crops with treated wastewater will be widening in the future especially in arid and semiarid regions such as Palestine. It is recommended to do more detailed studies on the effect of irrigation with treated wastewater on soil characteristics, plant growth parameters, heavy metals concentration, pesticides uptake, and chemical composition of different crops compared to irrigation with fresh water in many regions of Palestine. In addition, to carry out green house experiments for the same objectives.

It is important to do more studies on the reuse of treated wastewater in irrigation of several crops with more than one season to investigate the effect of time on plant characteristics. And, also to apply separation between blackwater and greywater to reduce the health risks on human.

It is recommended to carry out training courses to qualified personals on the usage of pesticides and irrigation systems. In addition, to modify a model for atrazine uptake by plants and optimization of the method of extraction of pesticide by ASE.

APPENDIX A

Table [A.1]: Effect of irrigation with treated wastewater on plant fresh weights (g/plant) of corn. Values represent the mean ± SE (n=3).

DAE	10	20	30	40	60	90
FW	3.14± 0.03	20.82± 5.18	63.45± 4.63	99.8± 4.84	189.4± 5.30	898.3± 8.66
TWW	5.53± 0.80	36.81± 1.93	98.61± 1.46	145.4± 2.62	286.5± 2.79	1412.4±43.7

Table [A.2]: Effect of irrigation with treated wastewater on corn height (cm) in function of time. Values represent the mean ± SE (n=3).

DAE	10	20	30	40	60	85
FW	9.45± 0.22	21.31± 0.72	33.88± 1.67	45.16± 1.84	99.66± 3.06	151.11± 3.69
TWW	11.65± 0.69	28.22± 1.03	49.33± 1.65	63.61± 1.49	149.81± 2.89	227.13± 3.61

Table [A.3]: Atrazine concentration in corn parts at 10 days after germination. All concentrations in mg/kg dry weight.

Water type	Root	Stalk	Leaves
FW	0.05 ± 0.001	0.021 ± 0.001	0.01 ± 0.001
TWW	0.031 ± 0.003	0.019 ± 0.002	0.01 ± 0.001

Table [A.4]: Atrazine concentration in corn parts at harvesting time. All concentration in mg/kg dry weight.

Water type	Root	Stalk	Leaves	Fruit
FW	0.024 ± 0.003	0.012 ± 0.002	0.018 ± 0.003	0.0015± 0.0001
TWW	0.029 ± 0.002	0.011 ± 0.001	0.022 ± 0.002	0.0017± 0.0001

Table [A.5]: Atrazine concentration in corn parts irrigated with fresh water at two growth stages. All concentrations in mg/kg dry weight.

Parts	Root	Stalk	Leaves
10 DAE	0.05± 0.001	0.021±± 0.001	0.01±0.001
H.T	0.024± 0.003	0.012± 0.002	0.018± 0.003

Table [A.6]: Atrazine concentration in corn parts irrigated with treated wastewater at two growth stages. All concentrations in mg/kg dry weight.

Parts	Root	Stalk	Leaves
10 DAE	0.031± 0.003	0.019± 0.002	0.01± 0.001
H.T	0.029± 0.002	0.011± 0.001	0.022± 0.002

Table [A.7]: Diazinon concentration in corn parts at 10 days after germination. All concentrations in mg/kg dry weight

Water type	Root	Stalk	Leaves
FW	0.055 ± 0.005	0.56± 0.05	1.32± 0.11
TWW	0.055 ± 0.006	0.56± 0.04	1.33± 0.10

Table [A.8]: Diazinon concentration in corn parts at harvesting time. All concentrations in mg/kg dry weight

Water type	Root	Stalk	Leaves	Fruit
FW	0.10 ± 0.05	0.32 ± 0.08	0.47 ± 0.08	0.087 ± 0.004
TWW	0.02 ± 0.003	0.06 ± 0.005	0.10 ± 0.01	0.018 ± 0.003

References

1. Abu-Faris, H., 1998. Potential Hydropower Production of the Dead Sea, M.Sc thesis, University of Jordan, Amman.
2. Afifi, S and Tubail, K., 1998. Treated Wastewater Re-use in Agriculture and its Impact on Soil and Plants. A Case Study in Northern Gaza Area. Bethlehem University Journal, Vol.**17**: pp 30-46.
3. Akkanen, J., 2002. Does Dissolved Organic Matter Matter? - Implication for bioavailability of organic chemicals. University of Joensuu, PhD Dissertations, no 16. ISSN 1457-2486.
4. Akkanen J., Penttinen, S., Haitzer, M., 2001. Bioavailability of atrazine, pyrene and benzo[a]pyrenein in European River Water. Chemospher.Vol.**45**: pp 453-462.
5. AL-Bakeir, H.M., 2000. Yield, Growth Rate, and Nutrients Content of Corn (*Zea mays L.*) Hybrids. Hebron University. Hebron. Palestine. Bethlehem University Journal, pp 25-40.
6. Alexander, M., 1990. Biodegradation and Our Microbial Allies in Soils and Waters. P.18-19 in New York's Food and Life Sciences Quarterly, Vol.**18**: no 1 and 2.
7. Andrew, D., Lenore, S., and Amold, E., 1998. Standard methods for the examination of water and wastewater, 19th edition, American public health association.
8. Anon, 1963. Atrazine –Geigy Agric.Chem.Tech. Bull. Avail, from Geigy Chem. Crop., P.O.Box 430, Yonkers, New York, p14.
9. AOAC, 1990. Official Methods of Analysis, Association of Official Analytical Chemists (AOAC). Vol **1**: 15th ed, Arlington, VA. USA.
10. ARIJ, Applied Research Institute-Jerusalem, 1994. Dryland Farming in Palestine. Bethlehem, West Bank.
11. Asano, T., and Mills, R.A., 1990. Planning and analysis for water reuse projects. Journal American Water Works Association. pp 38-47. 6.
12. Asano, T., Smit, R.G., and Tchobanoglous, G., 1985. Municipal wastewater: Treatment and reclaimed water characteristics. Water Science and Technology, Vol. **33**, no.10-11, pp 1-14.
13. Ayers, R.S., and Westcot, D.W., 1985. Water quality for agriculture. Irrigation and irrigation paper 29. Rev .1.FAO, Rome, p-174.
14. Ballantine, L.G., McFarland, J.E. and Hackett, D.S., 1998. Triazine Herbicides, Risk Assessment. American Chemical Society. Washington D.C.
15. Baily, D., Bilderback, T., and Bir, D., 2002. Water Considerations for Container Production of Plants. Cyber Conference Water Quality. North Carolina State University.
16. BCERF, 1999. Pesticides and Breast Cancer Risk, An Evaluation of Diazinon. Fact Sheet no 28. Cornell University Program on Breast Cancer and Environmental Risk Factors in New York State.
17. Benner, R., 2002. Chemical Composition and Reactivity, Biogeochemistry of Dissolved Organic Matter. Acadimic Press, pp 59-90.
18. Beste, C.E. (ed.) 1983. Herbicide handbook of the Weed Science Society of America. Weed Science Society of America, 309, West Clark Street. Champaign. Illinois, pp 515.
19. Black, J., 2004. What's this about N-P-K. Planet Natural. Website. www.planetnatural.com

20. Bolan, N.S., Domy, C., A., and de-la-Luz, M., 2004. Dynamic and Environmental Significance of Dissolved Organic Matter in Soil. 3rd Australian New Zealand Soils Conference, 5-9 December 2004, University of Sydney, Australia. Published on CDROM. Website www.regional.org.au/au/asssi/.
21. Bond, W.J., 1999. Effluent irrigation- an environmental challenge for soil science. Australian Journal of Soil Research, Vol **13**: no 4, p 543.
22. Brooks, H.L., 1973. Cooperative Extension, Kansas State University, Manhattean, Kansas.
23. Burken, J.G and Schnoor, J.L., 1997. Uptake and metabolism of atrazine by poplar trees. Env Sci & Technol .Vol **31**: no 5, pp 399-406.
24. Burken, J.G and Schnoor, J.L., 1996. Phytoremediation: Plant Uptake of Atrazine and Role of Root Exudates. J. of Environ. Eng. (ASCE) 122: 958-963.
25. Burner, H. S., Crosswell., Kaufman, K., Orouke, S., and Shelton, L., 1997. Movement of Pesticides and Best Management Practices.
26. Cheeke, P.R., 1991. Applied Animal Nutrition. 3rd edition. Department of Animal Science. Oregon State University. USA.
27. Cooper, R.C., 1991. Public health concerns in wastewater reuse. Water Science and Technology, Vol **24**: no9: pp55-65.
28. Dafner, E.V., and Wangersky P.J., 2002. A brief Overview of Modern Directions in Marine DOC Studies- part I. Methodological Aspects. Journal of Environmental Monitoring, no 4, pp 48-54.
29. Day, A.D., Taber, F.A., and Katterman, F.R.H., 1975. Influence of treated municipal wastewater on growth, fiber acid soluble nucleotide, protein and amino acid content in wheat grain. Journal of Environmental Quality. Vol **4**: no 2. pp.167-169.
30. DePardo, R., Lopez-Martinez, N., and Gonzalez, J., 2000. Identification of Two Mechanisms of Atrazine Resistance in Setaria faberi and Setaria viridius Biotypes. Pesticides Biochemistry and Physiology, no 67, pp114-24.
31. DHS, 1989.Proposed Maximum Contaminant Level-Atrazine. California Department of Health Services, Berkeley, 1-49. Currently Office of Environmental Health Hazard Assessment, California Environmental Protection Agency.
32. Donnelly, P.K., Entry, J.A., and Crawford, D.L., 1993. Degradation of Atrazine and 2,4-Dichlorophenoxyacetic Acid by Mycorrhizal Fungi at Three Nitrogen Concentrations in Vitro, Appl. And Environment. Microbial. Vol **59**: pp2642-2647.
33. Doxtader, K.G., and Croissant, R.L., 1992. Fate of pesticides in soil. U.S Department of Agriculture.
34. Dudeen, B., 2000. Land System Classification of the West Bank and Gaza Governorates, Land Research Center.
35. Eisenhaur, D.E., Martine, D.L., and Hoffman, G.J. 1997. Irrigation System Management MSM 452/852: University of Nebraska, Lincoln.
36. Eisler, R., 1989. Atrazine Hazards to Fish, Wildlife, and Invertebrates: A synoptic Review. Biological report No 18. U.S Fish and Wildlife Research Center Laurel, MD 20708.
37. Elder, J.F., 1988. Metal Biogeochemistry in Surface-Water Systems- A Review of Principals and Concepts. U.S. Geological Survey Circular 1013.
38. EPA, 2003. Diazinon, Notice of Receipt of Requests to Voluntarily Cancel Certain Pesticide Products. Federal Register Online via GPO Access, Vol **68**, no 237.
39. Fairchild, J.F., Ruessler, D.S., and Carlson, A.R., 1998. Comparative Sensitivity of Five Species of Macrophytes and Six Species of Algae to Atrazine, Metribuzin,

Alachlor and Metolchlor. Environmental Toxicology Chemistry. Vol **17**: pp1830-1834.

40. Fan, A.M. and Alexeeff, G.V., 1999. Public Health Goal for Atrazine in Drinking Water. Ph.D, Chief. Office of Environmental Health Hazard Assessment California Environmental protection Agency.
41. FAO and WHO, 1979. Pesticide Residues in Food. WHO Expert Group on Pesticide Residues. Geneva.
42. FAO. 1985. Water Quality for Agriculture. Irrigation and Drainage Paper 33. FAO, Rome.
43. FAO/WHO, 1994. Diazinon. In: Pesticide residues in food. Evaluations, Part I – Residues. Rome, Food in Agriculture Organization of United Nations, pp 157-294 (FAO Plant Production and Protection Paper 124).
44. Gaskell, M., 2002. Acid injection in irrigation water- Improving pH adjustment for blueberries. Central Coast Agriculture Highlights Newsletter.
45. Gleick, P., 1993. Water in crisis. Oxford. Oxford University Press.
46. Green, R.8E. and Obien, S.R., 1969. Herbicide equilibrium in soils in relation to soil water content. Weed Sci. Vol **17**: pp 514-519.
47. Gunsolus, J.L., Curran, W., 2002. Herbicide Mode of Action and Injury Symptoms. North Central Regional Publication. University of Minnesota Extension Service Distribution Center at (800) 876-8636.
48. Hassan, J., 2005. The Presence of Pesticides in West Bank Soil Irrigated with Wastewater, M.Sc thesis. AL-Quds University. Palestine.
49. Hussain I., Raschid, L., Hanjra, M., Marikar, F., and Hoek. W, 2002. Wastewater Use in Agriculture, working paper 37. International Water Management Institute.
50. Hassoun, R., 1991. Hazardous Pesticide Use in Occupied Palestine. SPES Journal. USA.
51. Heldrich, H., 1990.Official Methods of Analysis, Association of Official Analytical Chemists (AOAC). Vol **1**, 15th ed., Arlington, VA.USA.
52. Hoff, G.R., and Zoonen, P., 1999. Trace analysis of pesticides by gas chromatography. National Institute of Public Health and the Environment. Bilthoven, the Netherlands. Journal of Chromatography A. Vol **843**: pp301-322.
53. Hull, H.M., 1967. Herbicide handbook of the Weed Society of America. W.F. Humphery Press. Geneva, New York, p 293.
54. Igbedioh, S.O., 1991. Effect of Agricultural Pesticides on Humans, animals, and Higher plants in Developing Countries. Vol **46**: no 4. College of Food and Technology, University of Agriculture. Makurdi, Nigeria.
55. IUGG, 2003. Aspects of ground water enrichment by wastewater reuse in the Palestinian territories, engineering unit, UNDP.
56. Kalbitz, K., and Kaisar, K., 2003. Ecological aspects of dissolved organic matter in soils: Preface. Geoderma. Vol **113**: pp177-178.
57. Kauffmann, C., Shoseyov, O., Shpigel, E., Bayer, E.A., Lamed, R., Shoham, Y., and Mandelbaum, R.T., 2000. Novel Methodology for Enzymatic Removal of Atrazine from Water by CBD-Fusion Protein.
58. Kearny, P.C., and Kaufman, D.D., 1976. Herbicides, Chemistry, Degradation and Mode of Action, 2nd Edition, Vols **1**and **2**: p1036, Marcel Dekker, New York.
59. Ketter, T.A., Doran, J.W., and Gilbert, T.L., 2001. Simplified Method for Soil Particle Size Determination to Accompany Soil Quality Analysis. J. of American soil science.Vol **65**: pp 849-852.
60. Kiekens, L., 1996. Heavy Metals in Soil. Blakie Academic & Professional, Glasgow. pp 284-305 in B.J. Alloway (ed).

61. Kronberg, L., 1999. Content of humic substances in freshwater. In: Keskitalo, J., Eloranta, P. (Eds), Limnology of Humic Waters. Backhuys Publishers, Leiden, the Netherlands, pp.9-10.
62. Lauer, J., 2002. Methods for Calculating Corn Yield. University of Wisconsin, Agronomy Department.
63. Lima, J.S., De Queiroz, J.E.G., and Freitas, H.B.,2004. Effect of selected and non-selected urban waste compost on initial growth of corn. Resources, Conservation, and recycling. Vol **42**: no 4, pp 309-315.
64. Marten, G.C., Larson, W.E., and Clapp, C.E., 1980. Effect of municipal wastewater effluent on performance and feed quality of maize vs reed canary grass. Journal of Environmental Quality. Vol. **9**: no. 1, pp.137-141.
65. Mara, D.D., 2000. The production of microbiologically safe effluents for wastewater reuse in the Middle East and North Africa. Water, Air, and soil pollution. 123 (1-4): pp 595-603.
66. Mathew, R., Nelson, S., and Khan, S.U., 1996. Transformation products distribution of atrazine in corn plants treated with radiolabeled herbicide. Chemosphere. Vol **33**: no12, pp 2395-402.
67. Moiser D., Peterson, D.E., and Regehr, D.L., 1990. Herbicide Mode of Action. Cooperative Extension Service. Kansan State University, Manhattan.
68. Munns, R., 1993. Plant Cell Environmental. Journal of Environmental Quality. Vol **19**: pp 75-84.
69. NRC (US National Research Council), 1996. Use of Reclaimed Water and Sludge in Food Production. National Academy Press, Washington.
70. Oron, G., Campos, C., Gillerman, L., and Salgotm, M., 1999. Wastewater treatment, renovation and reuse for agricultural irrigation in small communities. Ag. Water Management. Vol **38**: pp223-224.
71. Pasternak, D., and DeMalach, Y., 1987. Saline water irrigating in the Negev Desert. Paper presented at the Regional Conference on Agriculture and Food Production in the Middle East, 21-26 Jan, Athens, Greece. p 24.
72. Patterson, R.A., 1998. Soil Capabilities for On-site Wastewater Treatment and Disposal, Lanfax Laboratories. Armidale.
73. Patterson, R.A., 1999. Soil and Effects of Effluent- What Do We Measure? Proceedings of 1999 Production and Environmental Monitoring Workshop. University of New England Armidal. March 1999. Paper PEM009.
74. PECDAR, 1994.Wastewater treatment and reuse strategy for the West Bank and Gaza strip. Palestinian economic council for development and reconstruction, Rammallah.
75. Pesticide Action Network International (PAN), 1993. Dirty Dozen Fact Sheet Guide.
76. Pettygrove, G.S., and Asano, T., 1985. Irrigation with Reclaimed Municipal Wastewater-A guidance Manual, 3rd edition, Lewis Publishers, Michigan, USA.
77. Pesccod, M.B., 1997. Wastewater treatment and use in agriculture, Rome, FAO. Irrigation and drainage paper no 47, pp 22-26.
78. PNA, 1999. Palestinian National Authority. Palestinian Environmental Strategy. Ministry of environmental affairs. P 77.
79. Pratt, P.E., 1972. Quality criteria for trace element in irrigation waters. California. Agriculture experiment station. P-48.
80. Raveton, M., Ravanal, P., Serre, A.M., Nurit, F., and Tissut, M., 1996. Kinetics of Uptake and Metabolism of Atrazine in Model Plant System. Pestic. Sci. Vol **49** :pp 157-163.

Comment [R1]:

81. Reed, D., 1982. Atrazine (unpublished data) Available U.S Food and Administration, Bureau of Food. Washington, DC. p 6.
82. Roger, R., Bernard, J.R., and Charles, V., 2005. Biopesticides of plant origin. Bureau of food, Washington DC. p 6.
83. Ryan, J., Harmsen, K., and Rashid, A.A., 1996. Soil and plant analysis, manual adapted for the west Asia and North Africa region, ICARDA Aleppo. Syria.
84. Sabua, V., Tammarates, S., Pumklom, M., Chaiwanakupt, P., and Srithongtim, S., 2002. The effect of irradiated wastewater sludge cake on maize and environment. Department of Agriculture, Bangkok, Thailand, symposium no.59, p 735.
85. Safi, J.M., ElNahhal, Y., Soliman, S.A., and Elsebae, A.H. 1991. Mutagenic and Carcinogenic Pesticides Used in the Gaza Strip Agricultural Environment. Third Workshop of Chemistry and Metabolism of Modern Pesticides. Bilthorn, Netherlands.
86. Saleh, A., Neiroukh, F., Ayyash, O., and Gasteyer, S., 1995. Pesticides Usage in the West Bank and Dryland Farming in Palestine. Applied Research Institute – Jerusalem (ARIJ).
87. Schevah, Y., and Waldman, M., 2001. Treatment and reuse of wastewater- the Israeli experience, 4th international Austrian-Israeli Technion symposium cum industrial forum “Technology for space-science for mankind” Vienna, Austrian. pp 273-280.
88. Seol,Y., and Lee, L.S., 2000. Effect of Dissolved Organic Matter in Treated Effluents on Sorption of Atrazine and Prometryn by Soils. Soil Sci. Soc.AM.J.
89. Sexton, B.T., Moncrief, J.F., Rosen, C.J., Gupta, S.C., and Cheng, H.H., 1996. Optimizing nitrogen and irrigation inputs for corn based on nitrate leaching and yield on a coarse-textured soil. J. Environ. Qual. Vol **25**: pp 982-992.
90. Smith, R., 2003. Improving Soil. Journal of Environmental Quality. Vol **4**: no 2. pp167-169.
91. Solomon, K.R., Baker, D.B., Richards, R.P., Dixon, K. R., Kaline, S.J., LaPoint, T.W., Kendall, R.J., Weisskopf, C.P., Giddings, J.M., Giesey, J.P., Hall, L.W., and Williams., W.M. 1996. Ecological Assessment of Atrazine in North American Surface Waters. Environmental Toxicology and Chemistry. Vol **15**: no1, pp 31-76.
92. Solly, W.B., Pierce. R.R, and Perlman, H.A., 1998. Estimated Use of Water in the United States. Department of Interior, USGS, Denever,CO.
93. Stanley, E.M., 1994. Environmental chemistry. Library of Congress Card Number 1-56670-088-4, USA.
94. Schmitt, P.H., Garrison, A.W., Freitage, D., and Kettrup, A., 1996. Separation of s-triazine herbicides and their metabolites by capillary zone electrophoresis as a function of pH. J. Chromatogr. A. Vol **723**: pp169-177.
95. Scott, C., Faruqi, N., and Raschid, L., 2004. Wastewater use in Irrigated Agriculture. Confronting the Livelihood and Environmental Realities. ISBN 1-55250-112-4 206 pp 210-213. USA.
96. Szuhay, D., and Chief, R., 2006. Biopesticides and Pollution Prevention Division, Microbial Pesticides Branch, prevention division, (703) 305-6098.
97. Tamimi, H., 2003. Wastewater Characterization and the Reuse of Recycled Effluent in Irrigation Agriculture Crops- Ph.D Dissertation. Hebron Center for Water and Environmental Studies, Ghadeer-Hebron, West Bank, Palestine.
98. Tanji, K.K., 1990. Agriculture Salinity Assessment and Management. American Society of Civil Engineers, New York, USA.
99. Tchobanoglous, G., and Burton, L.F., 1991. Wastewater Engineering Treatment Disposal and Reuse. 3rd edition, McGraw-Hill Inc. New York. USA.

100. Thurman, E.M., 1985. Organic geochemistry of natural waters. Martinus Nijhoff/Dr W.Junk Publishers, Dordrecht, the Netherlands.
101. Tomlin, C.D., 1997. The pesticide Manual. British Crop Protection Council. pp 354-356.
102. Tsadilas, C. D., 1999. Irrigation of Corn with Treated Municipal Wastewater, Paper presented at the R´99 Congress (Recovery, Recycling, Re-integration), February 1999.
103. Tsadilas, C.D. and Vakalis, P.S., 2003. Economic benefit from irrigation of cotton and corn with treated wastewater. Water Supply. Vol **3**: no 4, pp 223-229.
104. Tsadilas, C.D. 1997. Soil Contamination with Boron due to Irrigation with Treated Wastewater. In Boron in Soil and Plants R.W. Bell and B. Rerkason (eds). Kluwer Academic Publishers, the Netherlands, pp.265-270.
105. Tugulea, A.M., Sarna, L.P., and Webster, G.R., 1998. Solid Phase Micro extraction (SPME) of the Herbicide Atrazine in Aqueous Soil Suspensions, Internet. J. Environ. Anal. Chem. Vol **68**: pp137-153.
106. USEPA, Environmental Protection Agency, 2002. Overview of Atrazine Risk Assessment, Reregistration Branch 3, Health Effect division. Office of Pesticides Progras A.
107. UN, 1985. Wastewater Characteristics and Effluent Quality Parameters. Department of Technical Cooperation for Development.
108. US-EPA, 1992. Offices of Water and Wastewater and Compliance (Ed). Guidelines for water reuse. US-EPA, Washington.
109. USAID, 2003. Greater access to and more effective use of scarce water resources, activity data sheet, pp 294-200.
110. U.S. Department of Agriculture, 1995. Atrazine Pesticide Fact Sheet.
111. Ward, C.R., Owens J.C., and Turner, W.E., 1972. Residues of Diazinon remaining after application to wheat. J Econ Entomol. Vol **65**: p 899.
112. Wenzel, D.K., Hubert, A., Manz, M., Weissflog, L., Engewald, W., and Schuurmann, G., 1998. Accelerated Solvent Extraction of Semivolatile Organic Compounds from Biomonitoring Samples of Pine Needles and Mosses. Department of Chemical Ecotoxicology, UFZ Centre of Environmental Research, Permoserstrasse 15, D-04318 Leipzig, Germany, and Faculty for Chemistry and Mineralogy, Institute for Analytical Chemistry, University of Leipzig, Linnestrasse 3, D-04103 Leipzig, Germany.
113. WHO, 1989. Health guideline for the use of wastewater in agriculture and aquaculture. Technical report No.778.Geneve. P-74.
114. WHO, 1990. Atrazine, Health and Safety Guide. International Programme on Chemical Safety. Health and Safety Guide No.47. www.inchem.org/
115. WHO, 1993. The WHO Recommended Classification of Pesticides by Hazard and Guidelines to Classification. International Program on Chemical Safety (IPCS).
116. WHO, 1998. Diazinon, Environmental Health Criteria 198. International Programme on Chemical Safety. Geneva, p12.
117. WRI, World Resources Institute, 1994. World Resources 199495. Oxford Press. Baltimore, USA.
118. Ye CM., Wang, XJ., Gong, AJ., Zheng, HH., and Lei, ZF., 2001. Distribution of atrazine in a crop-soil ground water systems of Baiyangdian lake area in China. Research Center for Eco-Environmental Science, Chinese. Academy of Science, Beijing , China.

119. Zsolnay, A., 2003. Dissolved Organic Matter: artefacts, definitions and functions. Geoderma. Vol **113**: pp178-210.

ARABIC ABSTRACT

ملخص

قلة المياه المتوفرة في المناطق الجافة وشبه الجافة مثل فلسطين دفعت العلماء والمخططون للبحث عن أي مصدر بديل لمياه الري. أن أستخدام المياه المعالجة في الري يمكن أن تعتبر حلا لتوفير المياه العذبة والأسمدة المعدنية وتحقيق نتائج أقتصادية أفضل. تهدف هذه الدراسة الى فحص تأثير استخدام المياه المعالجة على معدل النمو, الكتله الطرية, الانتاج, تراكيز المعادن الثقيلة, والتركيب الكيميائي لأجزاء نبات الذرة في مرحلتين مختلفتين من مراحل النمو تحت الظروف الحقلية. كما تهدف الدراسة الى تحديد تراكيز المبيدات في أجزاء الذرة المختلفة وعلاقة ذلك بنوعية مياه الري. كذلك دراسة تأثيراعادة استخدام المياه المعالجة على صفات التربة.

أظهرت النتائج أن استخدام المياه المعالجة في ري الذرة قد زاد معدل النمو, الكتلة الطرية,الطول, والأنتاج بشكل ملحوظ مقارنة باستخدام المياه العذبة في الري. وأظهرت النتائج أيضا ان التركيب الكيميائي لأجزاء الذرة المختلفة لم يتأثر باستخدام المياه المعالجة. كما وجد أن كمية البروتينات الموجودة في أجزاء الذرة المروية بالمياه المعالجة اكثر من تلك المروية بالمياه العذبة. كما أظهرت النتائج أن بعض خصائص التربة قد تأثرت بأستخدام المياه المعالجة مثل كمية النيتروجين- البوتاسيوم- الفسفور مقارنة باستخدام المياه العذبة في الري.

فيما يتعلق بتراكيز المبيدات في أجزاء الذرة المختلفة,أظهرت النتائج أن أجزاء الذرة المروية بالمياه العذبة تحتوي على تراكيز أكثر من الاترازين مقارنة بتلك المروية بالمياه المعالجة بعد عشرة أيام من النمو, في حين أن تركيز الاترازين في جذور واوراق الذرة المروية بالمياه المعالجة أكثر من تلك المروية بالمياه العذبة في فترة الحصار. ويعزى ذلك الى أن ارتباط المبيدات بالمواد العضوية الذائبة الموجودة في المياه العادمه يزيد من ذائبيتها ونفاذها خلال التربة مع الماء الى أعماق أبعد من منطقة الجذوروبالتالي يقل أمتصاصها من قبل هذه الجذور مما يؤدي الى تقليل تركيزها في أجزاء الذرة المختلفة. كما وجد أن تركيز الاترازين في أجزاء الذرة كان حسب الترتيب التالي: الجذور > الساق > الأوراق وذلك بعد عشرة أيام من النمو. أما في مرحلة الحصادفكان الترتيب كالتالي: الجذور > الأوراق > الساق >الثمار. أما تركيز الديازينون في أجزاء الذرة المروية بالمياه العذبة أكثر من تلك المروية بالمياه المعالجة. وكان تركيز الديازينون في مرحلة عشرة أيام على النحو التالي: الأوراق > الساق > الجذور, أما في مرحلة الحصاد فكانت التراكيز كالتالي: الأوراق > الساق > الجذور > الثمار. اعتمادا على نتائج هذه الدراسة, فأنه من الممكن أستخدام المياه المعالجة بشكل ناجح لري الذرة في المناطق الجافة وشبه الجافة. لأن الري بأستخدام المياه المعالجة أعطى نفس الخصائص لأجزاء النبات, كما انه أعطى نتائج أقتصادية أفضل, وتراكيز منخفضة من المبيدات في أجزاء النباتات مقارنة بأستخدام المياه العذبة في الري.

بيان

أقر أنا مقدم الرسالة أنها قدمت لجامعة القدس لنيل درجة الماجستير و أنها نتيجة أبحاثي الخاصة باستثناء ما تم الاشارة له حيثما ورد, وأن هذه الرسالة أو أي جزء منها لم يقدم لنيل أية درجة عليا لأي جامعة أو معهد.

التوقيع:

جهاد محمد مصطفى

التاريخ: 22-6-2006

برنامج الدراسات العليا في الدراسات البيئية

عمادة الدراسات العليا

تأثيرالري بالمياه المعالجة على عوامل نمو الذرة وامتصاص المبيدات في أجزائها

اسم الطالب: جهاد محمد مصطفى

الرقم الجامعي: 20111608

المشرف : د. كلود الاعمى

المشرف المشارك : د. جبر مصالحة

نوقشت هذه الرسالة واجيزت بتاريخ 22-6-2006.

من لجنة المناقشة المدرجة أسماءهم وتواقعيهم:

1) د. كلود الاعمى/ رئيسا للجنة المناقشة. التوقيع ....

2) د. رائد الكوني/ ممتحنا خارجيا. التوقيع ....

3) د.خالد صوالحة/ ممتحنا داخليا. التوقيع ....

جامعة القدس

2006

تأثيرالري بالمياه المعالجة على عوامل نمو الذرة

وامتصاص المبيدات في أجزائها

جهاد محمد مصطفى

بكالوريوس : جامعة الخليل, فلسطين

رسالة مقدمة استكمالا لمتطلبات درجة ماجستيرالعلوم في

الدراسات البيئية / الدراسات العليا

جامعة القدس
2006