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Effect of Irrigating Pearl Millet with Treated Grey Water

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Dedication

This Project is dedicated to my mother, father,wife, sisters, brother and friends.

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الإقرار

إنا الموقع أدناه مقدم الرسالة التي تحمل عنوان

Effect of Irrigating Pearl Millet with Treated Grey Water

تأثير ري محصول الدخن بالمياه الرمادية المعالجة

اقر بان ما اشتملت عليه هذه الرسالة إنما هو نتاج جهدي الخاص ، باستثناء مـــا تمـــت الإشارة إليه حيثما ورد، وان هذه الرسالة ككل من أو جزء منها لم يقدم من قبل لنيل أية درجة أو بحث علمي أو بحثي لدى أية مؤسسة تعليمية أو بحثية أخرى .

Declaration

The work provided in this thesis, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's name: **اسم الطالب:**

Signature: **التوقيع:**

Date: **التاريخ:**

List of Contents

List of Tables

List of Figures

Effect of Irrigating Pearl Millet with Treated Grey Water
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Abstract

This study was implemented in order to examine the effect of reused treated grey water on yield of 10 Pearl millet accessions (*Pennisetum glaucum* [L] Leeke). The experiment was conducted in the research station of Faculty of Agriculture, An – Najah University,Tulkarm,Palestine. The seeds were planted in the summer season 2010, in separated plastic containers filled with 45 kg sandy clay soil, ten plants were planted in each container, the distribution of the plots was completely randomized plot design. The plants were irrigated with three types of water (Fresh water as control, raw grey water, treated grey water), with four replicates for each treatment. The collected data were analyzed statistically using two way analysis of variance to examine treatment effects, means were separated by Duncan's multiple range test at $P \leq 0.05$.

The results show clearly that there are no significant differences of the yield under different water treatments. No significant interaction was observed between water treatments and accessions. At the same time, accessions 1,5,6, and 7 gave high total fresh weight (1152.5 g/plant , accession 1), however , accessions 6,7,8,10 gave significantly the highest root fresh weight (244.67 g/plant , accession 7), for the straw fresh weight , accessions 1 and 5 have the highest straw fresh weight (940.5 g/plant

accessions 5). Regarding the plant length, accessions 2,3,4 and 10 gave the highest plant length(70 cm line 2). These results are showing a totally different pattern of production among the accessions, where accessions 1 and 5 significantly have the highest total dry weight, while for the fresh weight in addition accessions 1,5,6 and 7 significantly have the highest fresh weight . The results of seed production indicate that accessions 6,7,8, 9, and 10 gave significantly the highest seed dry weight. It is concluded that lines 1and 5 are the highest productive lines regarding both fresh and dry weight, while accessions 6,7,8,9,10 have the highest seed production.

Chapter One

Introduction

Chapter One
Introduction

The growth and development of land plants is largely influence by water shortage (El-Sawaf. 2005). Reuse of waste-water for irrigating agricultural lands is on the rise particularly in peri-urban areas of developing countries. (Rattan et. ,al 2005).. The lack of water resources have encouraged the researchers to use of non ordinary water including salinity waters, municipal and industrial waste water. By increasing population, water consumption increases wastewater production as well.(Galavi 2009). The reduced availability of water resources in semi-arid Mediterranean regions requires an efficient use of supply sources. Wastewater, after treatment to minimize health hazards, may constitute an important resource for irrigation in areas characterized by intensive agriculture (Meli et al., 2002)

Under the current status in Palestine, the water shortage become more distinguished, and the water scarcity due to the limited resources is increasing more and more each day. This is mainly due to the limited resources of water in and the continuous population growth (Alhaj hussein, 2001), the total available water resources in Palestine is estimated to be around 159 MCM, while the ratio between agricultural and domestic use of Palestinian well abstractions is 67% versus 33%.(Al Yaqoubi, 2007).

This water status is leading to utilize more resources than that available for the Palestinian, shifting toward the utilization of marginal water resources and more salinity tolerant crops. This is becoming a very crucial step in water management. Together the water shortage and the absence of free access and full control to their fresh water resources made the Palestinian passing through continuous crises management of water in the past two decades. In addition, the existing resources in the eastern aquifer basin have a high potential salinity due to the geological formation of the basin. These facts are forcing the Palestinians for reforming the allocation of fresh water through all sectors. As a main consumer of water, agricultural sector is the main affected by this growing crisis. At the same time, the demand on food is growing day by day, where the population growth increase not only the demand on water, but in addition the demand on food.

The increasing scarcity of water for irrigation is becoming the most important problem for producing forage in all arid and semi-arid regions including the West Bank. Currently the animal raising in Palestinian agriculture is facing a severe dilemma, where the farmers are using the available land resources for vegetables, field crops and trees plantations, and they buy forages for their animal feeding. The forage production sector in Palestinian agriculture is very weak, where it is only forming 4% of the total planted areas in Palestine(PCBS, 2007; Alhaj Hussein et al, 2010), the forages planted don't satisfy the need of the animal feeding, most farmers are planting forages to feed their animals and reduce the cost of forages (Mansour, 2009). Pearl millet is a key crop in arid and semiarid regions which needs relatively less water than other crops. (Rostamza et al., 2011)

Pearl millet is a cereal crop that had been domesticated in Africa long time ago (Manning et al., 2011). Landrace open-pollinated cultivars of pearl millet exhibit high levels of vegetative vigor and a very high biomass production. These are necessary adaptive features for the crop to survive stressful conditions (Andrews et al., 1993). Millet is mainly used for it's feeding value.

Forages planted in Palestine don't satisfy the need of the animal feeding, most farmers are planting forages to feed their animals and reduce the cost of forages (Mansour, 2009).

This leads to the fact that there is a high need to develop the forage production sector and increase the productivity of forages in Palestine, which will enhance the food security status as a result. At the same time the high need to save fresh water through utilization of non conventional water resources, make it more reliable to seek the opportunities to use the treated wastewater including treated grey water in irrigating forage crops. This is a high potential source for irrigation, and could be implemented since the irrigated areas forming only 8.4% out of the total agricultural area (PCBS, 2007).

In Palestine, research in the field of utilization of marginal water in forage production is limited, therefore, therefore, the objective of this study is to examine the effect of using treated grey water on the growth and yield of 10 accessions of pearl millet.

Chapter Two

Literature Review

Chapter Two
Literature Review

2.1 Pearl Millet

The term “millet” is applied to various grass crops whose seeds are harvested for human food or animal feed. Sorghum is called millet in many parts of Asia and Africa, and broomcorn is called broom millet in Australia. Compared to other cereal, grains, millets are generally suited to less fertile soils and poorer growing conditions, such as intense heat and low rainfall. In addition, it require shorter growing seasons. (Baker, 2003). Millets include five genera, *Panicum, Setaria, Echinochloa, Pennisetum,* and *Paspalum*, all of the tribe *Paniceae*; one genus, *Eleusine*, in the tribe *Chlorideae*; and one genus, *Eragrostis*, in the tribe *Festuceae*. The most important cultivated species of millet are foxtail (*Setaria italica*), pearl or cattail millet (*Pennisetum glaucum*), proso (*Panicum miliaceum*), Japanese barnyard millet (*Echinochola crusgalli*), finger millet (*Eleusine coracana*), browntop millet (*Panicum ramosum*), koda or ditch millet (*Paspalum scrobiculatum*), and teff millet (*Eragrostis tef*). (Baker, 2003).

Pearl millet (Pennisetum glaucum [L] Leeke) is one of the most important drought-tolerant crops in semi-arid tropic regions of the world. Pearl Millet originated in Africa (Burton *et al.*1972). Pearl millet is grown on about 26 million hectar in the warm tropics divided equally between Africa, particularly in the West African Sahel region, and the Indian subcontinent. earliest archaeobotanical evidence for domesticated pearl millet (*Pennisetum glaucum*), predating other finds from Africa or India by several centuries. (Manning et al., 2011).

As a cereal for human food pearl millet contributes a great part of dietary nutrients for 90 million people in Africa and Asia who live in agroclimatic zones where there are severe stress limitations to crop production due mainly to heat, low and erratic rainfall, and soil type and is often considered highly palatable and a good source of protein, minerals and energy (Andrews et al., 1993.,Abdalla et al.,1998a,b).

Pearl millet is a highly tillering, cross-pollinating diploid tropical C4 cereal with grain on the surface of erect candle shaped terminal spikes. It takes a flower about 30 more days to develop into a mature seed. Grain heads will mature a few weeks prior to leaf dry down". Grain size varies from 0.5 to over 2.0 g/100, and, depending on head size, grain number per head ranges from 500 to 3,000. Pearl millet tillers freely, compensating well for stand irregularities, and produces 2 or 3 times more heads per plant than sorghum at similar plant populations. (Myers, 2002).

Figure (1): Pearl millet spikes

The expected height for the crop is 3 – 6 ft (1 – 2 m) which is highly dependent on the soil and the climatic conditions. Plett et al., (1991) indicated that pearl millet did not perform well compared with grain sorghum and corn when grown in western Nebraska. However, those hybrids were experimental, and cool night temperatures resulted in problems with seed set. Progress has been made in pearl millet breeding, and hybrids less sensitive to cold night temperatures have been developed. Pearl millet is usually grown as a rainfed crop on sandy soil in the semiarid tropics of the world, and it can produce yield in water stressed environments where grain sorghum fails (Bostid, 1996).

The pearl millet is consumed as food, where The FAO reported that In Burkina Faso *Pennisetum glaucum* is grown as a multipurpose crop providing food (grains) in the lower rainfall area (Northern and eastern regions). The diet is characterized by a strong prevalence of cereals, mainly the sorghum and the millet .Several food preparations are made from *Pennisetum glaucum*. Burkina Faso is the third producer of pearl millet in Africa with 1147890 tons (FAOSTAT Database results, 2010). It represents the second cereal cultivated in Burkina after the Sorghum with 36% of the annual cereal production. It is cultivated on surroundings 40% of the cultivable grounds. Moreover, it occupies a place of choice in the eating habits in the sense that it is consumed by 90% of the rural population and 50 to 60 % of townsmen (Diawara et al., 1993). Landrace open-pollinated cultivars of pearl millet exhibit high levels of vegetative vigor and a very high biomass production. These are necessary adaptive features for the crop to survive stressful low fertility conditions, pests, diseases, weed competition, yet take advantage of brief periods favorable for growth and still yield consistently. As a result, the harvest index of these traditional cultivars which are tall, is only 15 to 20%. A crop of a local variety of pearl millet, cv. ex Bornu, grown under high fertility conditions without irrigation, in northern Nigeria produced 22 t/ha of above ground dry matter 90 days after sowing, but only 3.2 tons of this (14.5%) was grain (Kassam and Kowal 1975). In contrast, grain yields on a field basis of over 5 t/ha were produced by semi-dwarf hybrids maturing in 85 days in India (Rachie and Majmudar 1980) where experimental yields of up to 8 t/ha have been reported (Burton et al. 1972).

2.2 Feeding Value

According to Mayers (2002), the protein content of pearl millet is 45% higher than feed corn and is also 40% higher in lysine. This higher protein and other feed characteristics have helped drive the interest in the grain by poultry producers and other livestock producers. Pearl millet is much lower in tannin than sorghum and its seed is about half the weight of a sorghum seed. Seeds are pointed at one end, rounded at the other and primarily light colored with a blue or gray tinge to them. Studies on the comparative value of pearl millet with sorghum or corn for cattle are few. When millet and sorghum grain were compared in high-silage growing rations for steers adjusted to equal protein intake, the results suggested millet protein had a high biological value as the addition of Rumensin to the rations gave millet grain a 10% advantage over sorghum grain (Brethour 1982). With finishing steers, Brethour and Stegmeier (1984) comparing rations where 25% of the sorghum component was replaced with pearl millet, reported that average daily gains were 1.40 and 1.20 kg, and feed/gain ratios were 7.53 and 8.03, respectively. Therefore, It was concluded that pearl millet grain can replace corn in dairy cow diets up to 30% of the diet DM with no adverse effects on milk yield or milk composition (Mustafa, 2010). Pear millet have good nutritional value, where if it was harvested prior to advanced maturity stages, the range of total digestible nutrients (TDN) can be expected to be 52-58%, while crude protein (CP) will range from 8-11%. There is evidence to suggest that seeding rates at the high end of the recommended ranges will promote a higher leaf :stem ratio. This may improve forage quality, but these gains may not compensate for the expense of the higher seeding rate. (Hancock, 2009).While Cheik et al. (2006) examined the nutritional value of 14 pearl millet cultivars, they found that:"The contents of proteins ranged from 8.66 % to 17.11 % for all the cultivars. Water-soluble proteins ranged from 1.81 % to 3.18 % . Fat content in the grains values ranged from 6.76 % to 10.24 %. The carbohydrates are the major components of these cultivars, values ranged between 71.82 % to 81.02 %. The energy values of cultivars flours ranged from 426.21 Kcal/100g to 446.53Kcal/100g.

Results of Technological properties showed capacities of swelling in water (VI/VF) ranged from 2.33 and 8.28. Masses of 1000 grains ranged from 5.53 g to 13.13 g; cutivars IKMV8201, IKMP5, B1 had the highest masses of 1000 grains and consequently present better outputs potential millers. Starch is present in relatively significant quantity of 51.49 % at 79.07 % and cultivars IKMP1, B1, and SG have the most raised contents. The crude fibres also are present in high quantity 8.06 % to12.40% and cultivars IKMP3, SOSAT C88 are provided greater quantity. The cultivars contents of phytates from 5.45 to 14.26 mg / g and in polyphenols from 2.27 to 3.20 mg / g. The energy values of cultivars flours lies between 426.51 kcal / 100 g and 446.53 kcal / 100 g. Samples IKMP3, IKMP5, SOSAT C88 and KM are equipped best with it. In addition, cultivars IKMP3, IKMP5, S0SAT C88, IKMV8201, KM and L Zatiib have better nutritional profiles". (Cheik et al., 2006).

Pearl millet is a summer crop, and it is drought tolerant It has been widely grown in arid and semi-arid regions in Africa and Asia since prehistoric times, (Raj et al , 2003) (Diawara et al., 1993; Mayers, 2002). It is particularly well adapted to nutrient-poor, sandy soils in low rainfall areas (Baker, 2003). However, drought is the primary constraint in pearl millet (*Pennisetum glaucum*) production in the drier semi-arid and arid regions of south Asia and Africa. The traditional landraces from drier regions are good sources of drought adaptation but often lack high yield under near-optimum growing environments (Yadav 2010).

Eastin and Sullivan,(1974) developed simple developmental stage terminology useful for yield and yield component analyses for grain sorghum on the basis of growth stage as follows: (i) the vegetative period from planting to panicle initiation (GS1); (ii) the reproductive period (GS2) from panicle initiation to flowering; and (iii) grain filling period (GS3) from flowering to physiological maturity. Maman et al., (2004), reported that both temperature and water stress during late GS1 and GS2, will affect the yield production of pearl millet. Reduction in yield may occur when irrigation and rainfall combined are insufficient to meet ET demand. Smaller plants transpire less water than larger ones because ET increases with increases in leaf surface area (Cothren et al., 2000). Timing of water supply generally has a larger effect on grain yield than total water for many crops (Shaw, 1988). Both pearl millet and grain sorghum productivity are most sensitive to water stress during flowering and grain filling (Garrity et al., 1983; Hattendorf et al., 1988).

2.3 Grey water

Due to irrigation water shortage, especially in arid and semiarid regions using alternative water resources is considered very important to produce crops (Al-Karaki, 2011). Wastewater reuse in agriculture presents a potentially important alternative for fresh water and save it for drinking and industry water supplies. (Al-Karaki, 2011).

Treated wastewater as a source of water and fertilizing elements required for the plants has been used for irrigating and growing agricultural produce at many places of the world since ancient times (FAO,1992; Fiegin, 1991; Tavakoli and Tabatabaee1997). At the same time the use of TWW in agriculture should be done with precautions to prevent any consumer health risks (Al-Karaki, 2011), to minimize adverse environmental impacts and to prevent soil degradation . This is confirmed by Alberta Environment (2000) where it was confirmed that:" Not all treated municipal wastewater meets a quality that would enable unrestricted use for irrigation. Treated municipal wastewater has been found to contain salt or sodium levels that would completely exclude consideration of its use for irrigation due to the harmful effects it would cause to the land and the crops to be grown". According to Qadir et al (2007) Wastewater often contains a variety of pollutants: salts, metals, metalloids, pathogens, residual drugs, organic compounds, endocrine disruptor compounds, and active residues of personal care products. Any of these components can harm human health and the environment. Farmers can suffer harmful health effects from contact with wastewater, while consumers are at risk from eating vegetables and cereals irrigated with wastewater. Application of treated wastewater has to be carefully managed for effective use.

On the other hand, the benefits, potential health risks, and environmental impacts resulting from treated wastewater reuse for irrigation and management measures aimed at using treated wastewater within acceptable levels of risk to public health and the environment are well documented (WHO, 1973, WHO, 1989; FAO, 1992), where properly use of this treated wastewater can reduce the environment and health related hazards.

The term grey refers to wastewater from households, business complexes, hotels, schools as well as some types of industries, where no contributions from toilets, bidets or heavily polluted process water are included. This agrees with the term used by (Al-Hamaiedeh and Bino, 2010) where he defines the grey water as: " wastewater generated from domestic activities such as dish washing, laundry and bathing, whereas black water consists of toilet water". He estimated the grey water to be accounting for as much as 50–80% of the total water use, while it is estimated to be approximately 75 volume-percentage of the combined residential sewage (Hansen and Kjellerup, 1994 from Eriksson et al, 2003). Erikson et al (2002) reported that despite contributing 75% of the total wastewater flow to domestic sewers, little is currently known concerning the detailed production patterns and characteristics of grey wastewater, where he indicated that:" The information available regarding characteristics of grey wastewater is mainly on the content of organic matter (BOD/COD), nutrients (N, P, K) and micro-organisms". (Eriksson et al, 2003). He confirmed that nine hundred different substances or groups of substances were found to be potentially present in grey wastewater from the product information available in the list of contents of common Danish household and personal care products (Eriksson et al., 2002 from Erikson et al , 2003)). The major groups of compounds were fragrances & flavours, preservatives, solvents and some surfactants, i.e. nonionic and anionic surfactants. Other groups were the amphoteric and cationic surfactants as well as the softeners and emulsifiers. The groups with only a few compounds in each were the bleaches, dyes, sunscreen agents and enzymes. These groups are, however, of a special interest since they all contain bioactive compounds. This shows that the content of Grey wastewater is different from that of wastewater, Compared to municipal wastewater grey water contains less nutrients. The BOD 5 : N : P ratio is about 100 : 20 : 5 for typical municipal wastewater and about 100 : 4 : 1 for grey water (Laber & Haberl, 1999, found in Müllegger et al, 2003) , The optimal ratio for heterotrophic growth is 100 : 5 : 1. Therefore a biological treatment of grey water without addition of nutrients is possible. The microbiological contamination of grey water is typically about a factor 10 lower compared to municipal wastewater. However the concentrations for phosphorus, heavy metals, and xenobiotic organic pollutants are around the same level(Müllegger *et al*, 2003). Al-Hamaiedeh, (2010) analyzed raw and treated grey water samples where he found that the pH didn't differ between raw and treated grey water while BOD had dropped down from 942 as an average in the raw grey water to 108 in the treated grey water, and the nitrate was 0.68 ppm in the raw grey water to become less than 0.2 (the average is negligible) in the treated grey water. (Al-Hamaiedeh, 2010). The results of the samples are presented in table 1.

As seen the treated grey water is considered of good quality water that could be used for irrigation, and currently the use of GW for irrigation is one of the methods which is currently widely used. According to DHWA (2002) this is particularly important in arid zones, where water is scarce and reuse of GW for irrigation could reduce potable water use by up to 50% according to DHWA (2002).

Table (1): Quality of raw and treated GW compared with allowable Palestinian standard limit for restricted irrigation. (From MOA. 2011)

Parameter	Unit	Raw GW		Treated GW		Palestinian Allowable limit (crop: trees)
		Range	Average	Range	Average	
pH		6.9 - 7.8	7.2	6.8-7.9	7.2	6-9
TSS	mg/L	23-358	275	12-312	128	30-90
BOD	mg/L	110-1240	942	10-412	108	20-60
COD	mg/L	92-2263	1712	36-763	489	50-150
EC	dS/m	1.57-2.0	1.83	1.46-1.91	1.76	
Nitrate	mg/L	0.44-0.93	0.68	0.2<	0	20-40
Total Nitrogen	mg/L	38-61	52	8-14	11	30-60
Cadmium	mg/L		0.008		0.008	0.01
Lead	ppb	1.0-1.31	1.19	0.8-1.15	0.113	0.02
SAR	(Mmole/l) 0.5	2.23-4.76	3.3	1.8-3.6	2.8	5.83

Although irrigation with treated GW and treated wastewater effluents can mitigate the utilization of natural water resources, it may also result in environmental problems. One particular concern is the long-term sustainability issue. A study was conducted by Travis et al.,(2008) suggested that oil and grease from GW can accumulate in soils and affect the ability of the soils to absorb water essentially making it water repellent. Another study conducted by Gross et al.(2005) found evidence that, long-term irrigation of arid loess soil with GW may result in accumulation of salts and surfactants in the soil, causing changes in soil properties and toxicity to plants. Roesner et al (2006) conducted a literature review on the long term effects of the reuse of grey water in landscape irrigation in USA, one of the important results is the identification of the information gaps in the use of grey water and at the same time the determined the required information needed, where :" Knowledge gaps were found in the following areas: 1) documentation on whether or not constituents in grey water will accumulate in the soil in sufficient quantities to harm plants or perhaps be transported below the root zone to the groundwater during the rainy season; 2) information on the effects of grey water irrigation on landscape plants, which are typically inferred from experiments with recycled treated wastewater used for irrigation; 3) information on both short-term and long-term effects of grey water irrigation on indigenous soil microorganism communities and their important ecosystem functions; 4) information on whether the indicator organism counts are an accurate predictor of an actual health threat posed to individuals coming into direct contact with grey water; and 5) guidance to help the homeowner design a proper grey water capture, storage and distribution system". In many cases, the potential long-term agronomic impacts of using grey water for irrigation depends on the chemical constituents of the local grey water sources. For instance, if local grey water is somewhat saline, salts can slowly accumulate and reduce crop productivity. Allen et al (2010)reviewed the long term effects of using grey water in irrigation, he reported that:" Yet, it remains to be documented whether or not these constituents will accumulate in the soil in sufficient quantities to harm plants or people, or perhaps be transported into groundwater (Roesner et al. 2006). Though literature on the subject is scant, there have been several recent studies of grey water use for irrigation that have not documented soil or health problems associated with grey water irrigation, like that of (Al-Hamaiedeh, 2010), where :" study of grey water use for irrigation in the Middle East took place in southern Jordan between February 2004 and October 2007. According to the study, "Two simple and low-cost GW [grey water] treatment units – the four barrels and the confined trench type – were installed for 110 low-income households not served by a sewerage network. The resulting GW was used to irrigate crops that are not eaten raw. The quality of treated GW obtained by these units was shown to be in accordance with both Jordanian and WHO [World Health Organization] guidelines for the use of treated wastewater" (Al-Hamaiedeh, 2010). A study of grey water use for irrigation in Canada used a paired study design to record water quality and plant productivity in three plots, two of which were irrigated with grey water (untreated and sand filtered), and one that was irrigated with tap water. “The key result in this study was the similarity in the distributions of bacteria on plant surfaces following irrigation with tap and domestic grey water. Both showed very high variations. This suggests that bacterial contamination may not be a significant risk factor for edible crop irrigation” (Finley et al. 2009). In addition, plant productivity was unaffected by the use of tap water or grey water for irrigation in the study" (Allen et al, 2010).

In Palestine the reuse of treated wastewater and grey water is limited to the research and pilot projects (Abdo, 2008). This is mainly due to the lack of treatment plants and grey water treatment units. Al – Sa'ed (2001) reported that the only centralized wastewater treatment plant(WWTP) that is operating at high efficiency rate exists in Al-Bireh in the Ramallah District and is serving Al-Bireh city, two refugee camps, and a small part of Ramallah city. The other existing WWTPs that were constructed during the occupation period are not functioning at all, except for Tulkarm ponds that were rehabilitated in 2004. Moreover, the wastewater that is collected by vacuum tankers is discharged directly into open areas without any treatment. The major wastewater streams flow in Wadi Zeimar, Wadi Al-Sajour, Wadi Betunia, Wadi Al- Samen, and Wadi Al-Nar. Al-Bireh WWTP was planned and implemented with the objective to apply its treated effluent for agricultural irrigation at Deir Debwan town. Abu Madi et al (2009), found that there is a good consensus in the Palestinian community toward the reuse of the treated wastewater (this includes the grey water) where they confirmed that :" The major research findings show a national consensus on the importance of wastewater reclamation and reuse in irrigated agriculture. The results show positive knowledge and perceptions of all stakeholders towards reuse of reclaimed wastewater. It also shows that there is a big gap between various institutions related to the subject. It also shows poor collaboration between the academic/research institutions and policy making".

However the treated wastewater is considered excellent potential source for the Palestinian agriculture, where it was estimated to be 100 MCM per year, and that agriculture consumes 173 MCM (Yaqoub, 2004) while Amnesty (2009), estimated that the untreated sewage generation in the West Bank by 56MCM , this figure agrees with the estimations of ARIJ (2011) where it was estimated at 47 MCM in the West Bank, among this quantity is that generated by grey water treatment plants. There are 558 on – site small scale treatment unites implemented by NGO's agencies. This quantity (50 MCM) is estimated to be 38% of the agricultural consumption if we consider that agriculture is consuming 173 MCM.

In his study, Abu Shaban et al (2006) evaluated public acceptance for the reuse of the treated wastewater. Abu Shaban et al (2006) reported that:" A classification of the existing farming systems according to their agricultural activities and family income revealed three relatively homogeneous classes: mixed cropping farmers (A), low-income perennial crop farmers (B) and high-income perennial crop farmers (C). Acceptance of treated wastewater was significantly lowest in class A, but showed no difference between farmers from the classes B and C, whereby the fear of diseases and pollution through treated wastewater use was the most frequently stated concern". (Abu Shaban et al, 2006). This was confirmed by Abu-Rahma and Rabi, (2006), where they found that, there is a good acceptance for the use of grey water by the farmers mainly in the rural areas in Palestine. Grey water treatment and reuse in the irrigation of gardens and farms is acceptable by the Palestinian families which helps ensure a good and durable source of water for agricultural use ensuring their basic needs from vegetables which are planted in the house garden with an area of 150 to 200 square meters, in addition to the reduction in pollution and sanitary problems caused by untreated grey wastewater (UNEP 2003). This is confirmed by the study of Mahmoud, and Mimi, (2008), which indicated that the biggest incentive for applying this system is the reuse of treated grey water for irrigation purposes, which is socially accepted. The application of those systems is currently limited and tied to the availability of external funds. The main concerns people have over the constructing of those house onsite systems are health risks, flooding, and odor emission.

Abu-Rahma and Rabi, (2006) in their study analyzed water samples from grey water treatment units to examine the efficiency of the treatment units for the removal of the water pollution load. They found that It is clear that most values fall within the acceptable guidelines set by WHO and PWA (COD= 150-200mg/l). However where they do exceed the permitted limits reasons are due to inadequate operation and lack of maintenance (Abu-Rahma and Rabi. 2006). The results are illustrated in table 2.

Table (2): Characteristics of raw and treated grey water from different sites Ramallah, Bethlehem and Gaza Strip. (Abu-Rahma and Rabi., 2006)

Sample	Location	In effluent C O D (m g / l)	Effluent C O D (m g / l)	Efficiency (%)
1	West Bank	462.1	176.1	62
2	West Bank	692.7	475.0	31
3	West Bank	933.1	166.4	82
4	West Bank	702.5	192.4	73
5	West Bank	50.0	30.0	40
6	Gaza	1500.0	270.0	82
7	Gaza	820.0	80.0	90
8	Gaza	1500.0	230.0	85
9	Gaza	590.0	170.0	71

Moreover, they reported that around 500 house treatment unites is what implemented serving about 650 families and 30 schools, treating an average of about 0.5 cubic meter per day per unit. These technologies were initially acceptable to the public but unfortunately later faced technical problems that led to insufficient treatment efficiency and bad odors. But with good management this could be pass over, however they estimate the annual water saving by 150 m^3 yearly per household.

However even though farmers may use raw wastewater as reported by (Abu-Rahma and Rabi. 2006), still from the legal side it is forbidden to use neither the raw nor the treated wastewater in irrigating vegetables in Palestine according to the Palestinian law of agriculture (Palestinian Law of agriculture, 2003). This will leave the opportunity only for the reuse in irrigating fodders and tree crops only.

Pearl millet is not widely spread in Palestinian agriculture, this is due to many reasons, among them is the limited land areas, thus the dominating is vegetables crops. But even though, the Palestinians are importing large quantities of fodders for animal feeding, which raise the relative importance for the researches aiming to develop both the utilization of marginal water sources, and in the same time increasing the productivity of fodder crops.

2.4 Use of waste water in irrigation

As urban populations in developing countries increase, and residents seek better living standards, larger amounts of freshwater are diverted to domestic, commercial, and industrial sectors, which generate greater volumes of wastewater (Lazarova and Bahri, 2005; Qadir et al., 2007, Asano et al., 2004). Farmers in urban and peri-urban areas of nearly all developing countries who are in need of water for irrigation have often no other choice than using T waste water. They even deliberately use undiluted wastewater as it provides nutrients or is more reliable or cheaper than other water sources (Keraita and Drechsel, 2004; Scott et al., 2004). Moreover, this practice could ensure the transfer of nutrients, such as nitrogen, phosphorous, potassium, meso- and micro-nutrients into agricultural soil. Irrigation with wastewater raises, however, sanitary problems (risk of viral and bacterial infection both for farmers and crops) and problems of agronomic nature, due to the presence of toxic substances for health and environment. Besides crop farming, wastewater is used also for aquaculture in Africa, and in Central, South, and Southeast Asia (Bangladesh, Cambodia, China, India, Indonesia, and Vietnam).(Qadir, et al., 2008).

In many areas, treated wastewater is used for fodder production, groundwater recharge or other environmental purposes, such as enhancing water supply for wetlands, wildlife refuges, riparian habitats, and urban lakes and ponds.

In other areas, large wetland areas are misused as natural treatment facility, like at Vientiane, Laos (Asano, 1998; Asano and Cotruvo, 2004). The risks of using untreated or only partially treated wastewater in agriculture can be reduced through wastewater treatment and non-treatment options or a combination of both (WHO, 2006). These include: (1) water quality improvements, (2) human exposure control, (3) farm-level wastewater management, and (4) harvest and post-harvest interventions. Improved wastewater irrigation depends on the implementation of suitable farm-level practices and post-harvest interventions, which are classified as non-treatment options and can be divided into the following major categories: (1) crop selection and diversification in terms of market value, irrigation requirements, and tolerance of ambient stresses; (2) irrigation management based on water quality, and irrigation methods, rates, and scheduling; and (3) soil-based considerations such as soil characteristics, soil preparation practices, application of fertilizers and amendments if needed, and soil health aspects. Waste water irrigation did not increase mineral concentrations of either macro- and micro-elements or heavy trace metals in corn and sorghum plants to hazardous limits according to the established standards and could be used safely for crop irrigation.(Al-Jaloud et al., 1995). A field experiment was conducted to study the performance of fodder sorghum irrigated by different waste treatments, The plant height, number of tillers per plant, leaf-stem ratio and fodder quality parameters like crude protein, ether extractives, crude fiber, minerals (Ca, P, Fe, Mn, Zn and Cu), heavy metals (Pb and Ni) and sugar content increased and plant silica decreased upon irrigation with wastewater (Gladis et al., 1996). An experiment was conducted to evaluate the effect of irrigating sorghum with waste water in Iran, results showed irrigation with wastewater lead to significant increase ($p \leq 0.01$) on total yield, leaf fresh and dry weight, stem fresh and dry weight, stem diameter and leaf number (Galavi et al., 2009). In another study that investigated the effect of irrigation with different treatments of sewage waste-water on the growth and bioavailability of some macro-and micro-elements in two plant species, Sorghum durra and Sorghum dochna. Results showed significant increase in shoot length, number of leaves/ plant, total leaf area/ plant and dry weight of shoot and root of Sorghum durra plants irrigated with sewage waste-water, more so in plants irrigated with raw sewage waste-water (EL-Sawaf 2005). In another study in India agricultural land where various cereals, millets, vegetable and fodder crops have successfully been grown. Sewage effluents, ground water, soil and plant samples were collected and analyzed mainly for metal contents. Results indicated that sewage effluents contained much higher amount of P, K, S, Zn, Cu, Fe, Mn and Ni compared to groundwater. There was an increase in organic carbon content ranging from 38 to 79% in sewage-irrigated soils as compared to tube well water-irrigated ones. (Rattan et al., 2005). It was found with seven crops, including celery, wheat, maize, millets, apples, rapeseed and yellow beans, that the quality of the crops that made use of treated sewage was not distinctively different from those that did not use treated sewage. However, yields for the former were much higher than they were for the latter (Wang et al., 2007). In most cases, the quality of the crops that made use of treated sewage was not distinctively different from those that did not use treated sewage. However, yields for the former were much higher than they were for the latter.(Wang et al., 2007) Studying the Long-term impact of irrigation with sewage effluents on heavy metal content in soils, crops and groundwater there was an increase in organic carbon content ranging from 38 to 79% in sewage-irrigated soils as compared to tubewell water irrigated ones. On an average, the soil pH dropped by 0.4 unit as a result of sewage irrigation. Sewage irrigation for 20 years resulted into significant build-up of DTPA-extractable Zn (208%), Cu (170%), Fe (170%), Ni (63%) and Pb (29%) in sewage-irrigated soils over adjacent tubewell water-irrigated soils, whereas Mn was depleted by 31%. Soils receiving sewage irrigation for 10 years exhibited significant increase in Zn, Fe, Ni and Pb, while only Fe in soils was positively affected by sewage irrigation for 5 years. Among these metals, only Zn in some samples exceeded the phytotoxicity limit (Rattan et al., 2005)

Chapter Three

Materials and Methods

Chapter Three
Materials and Methods

The experiment was implemented in the research station of Faculty of Agriculture ,An – Najah University, located in Tulkarm city,Palestine.

The seeds of 10 Pearl millet accessions obtained from Ministry of Agriculture through Fresh Water Saving Through Production of Forages Using Saline Water (ICBA). (Table 3)

Table (3): Pearl millet accessions used in the experiment

Accessions	Accessions Code
1	IP 3616
2	IP 6104
3	IP 6110
4	IP 19612
5	IP 22269
6	Sudan pop I
7	Sudan pop III
8	ICMS 7704
9	MC 94 C2
10	ICMV 155

The seeds were planted in May 10th 2010, in separate plastic containers filled with 45 kg soil with 10 plants each plot with sandy clay soil,(Fig 2). The plants of each accession (factor 1) were irrigated with three types of water (factor 2) (Fresh water, raw grey water and treated grey water). The factorial treatments were arranged in a completely randomized design with four replicates for each treatment.

Figure (2): Experiment layout

The grey water was obtained from the grey water treatment unit existing in the station. This unit is composed of four chambers, the first one is for settling, the second and the third are filled with gravel media, and the second chamber is anaerobic, while the third is aerobic, the fourth is for treated water storage and pumping to a tank used for the distribution of water. The inflow effluent is coming from the sinks of the Faculty of agriculture cafeteria, and the washing sinks in the faculty.

The raw grey water was obtained from the separating a pipe from the coming inflow pipe, and used for irrigation, while the treated grey water was used from the tank. The freshwater was coming from the ground water well which is used in irrigating the station.,

Irrigation started with the planting, and the quantities of irrigation requirements was calculated following the Modified FAO Penman – Montieth equation, using CROPWAT software, depending on the average climatic parameters of Tulkarm area, and the plants received the same quantities of water for each treatment. The irrigation schedule was selected to be three days irrigation interval schedule.

The soil was analyzed before and after the end of the season to examine the effect of treated grey water on the soil. The irrigation water was analyzed two times, in the middle of the season and at the end of the season to examine wither there is any change in the quality or not, and its content is registered

The following parameters were recorded during and after the experiment termination:

- The total weight (fresh and dry)
- The root weight (fresh and dry)
- The panicle weight (fresh and dry)
- The vegetation part weight (fresh and dry)
- The plant length in three dates through the growth season.

All collected data were analyzed statistically using two way analysis of variance to examine treatment effects, means were separated by Duncan's multiple range test at $P \leq 0.05$

Chapter Four

Results and discussion

Chapter Four
Results and discussion

The experiment was implemented in Agricultural station Tulkarm area. This area is a semi coastal area with the climatic parameters presented in table4. Where the cropping season was in the period from May up to September.

Table (4): The climatic Parameters of Tulkarm area

Month	MaxTemp	MiniTemp	Humidity	Wind	SunShine	ETo
	(C^0)	(C^0)	(%)	(Km/d)	(Hours)	(mm/d)
January	13.3	8.6	72.0	103.2	5.2	1.3
February	13.8	8.7	76.0	98.4	5.5	1.6
March	16.7	10.8	75.0	76.8	6.5	2.3
April	21.5	13.8	65.0	81.6	7.7	3.5
May	24.6	15.9	62.0	79.2	9.0	4.3
June	27.2	19.4	69.0	69.6	10.3	4.9
July	29.0	22.1	68.0	69.6	9.7	4.9
August	29.6	22.7	74.0	64.8	8.9	4.5
September	28.2	21.2	70.0	62.4	8.3	3.7
October	26.8	19.2	67.0	69.6	7.6	2.8
November	20.8	14.3	64.0	103.2	6.7	2.0
December	15.9	10.6	71.0	96.0	5.3	1.3

(Ministry of Agriculture, 2010)

The crop water requirements was calculated according to the FAO modified Penman – Montieth equation utilizing CROPWAT software, the results of the water requirements are presented in table 5 as monthly results but it worth to mention that the irrigation was set to 3 days irrigation interval.

Table (5): The monthly water requirements of pearl millet.

Date	ETo	Kc	Crop (ETm) mm
9/5	128.08	0.31	39.96
31/5	144.03	0.76	110.20
30/6	146.92	1.19	175.20
30/7	136.12	1.11	151.18
29/8	60.38	0.66	40.23
Total	615.54		516.77

(Ministry of Agriculture, 2010)

The soil analysis results are presented in table 6 In these results it was clear that the water treatment affect the soil properties, where the EC for the raw grey water irrigated soil has been increased to be 2.6 compared to 1.1 and 1 for fresh water and treated grey water.

Table (6): Soil extract analysis results before the planting and after the end of the season.

sample no	Ca	(ca+mg)	K	Na	CL	HCO 3	CO 3	E.C	pH
	meq/L	meq/L	Ppm	ppm	ppm	ppm	ppm	ds/m	
Before planting	6.80	10.80	5.00	30	142	274.5	NIL	0.40	7.55
Soil irrigated with fresh water	4.70	9.50	11.00	120	461	192.2	NIL	1.10	7.39
Soil irrigated with raw wastewater	9.00	15.00	19.00	180	1240	201.3	NIL	2.60	7.42
Soil irrigated with treated grey water	3.50	8.50	21.00	115	461	213.5	NIL	1.00	7.30

Regarding the irrigation water, samples of irrigation water were taken for analysis at the beginning, and the middle, and at the end of the irrigation season, the results for fresh water raw and treated grey water at the middle of season are summarized in table 7 .

Table (7): Analysis results for irrigation water samples at the middle of season.

Water	E.C	PH	TDS	CO3	HCO3	CL	Hardness (ca+mg)	Ca	Mg	K	Na	SAR	BOD5
	mmhos/cm		ppm	ppm	ppm	ppm	Meg/L	meq/L	meq/L	ppm	ppm		meq/L
Raw	1.00	7.57	640	240	427	106.4	20	5.00	15.00	140	250	3.43	100
Treated	0.70	7.74	448	72	292.8	425.4	15	2.80	12.20	40	100	1.59	10
Fresh	0.40	7.20	256	60	170.8	141.8	8	4.00	4.00	10	60	1.30	0

As the results show the raw grey water have BOD ranged from 100 for the raw grey water to 0 for fresh water. While the SAR and the EC was in accepted levels for irrigation with no expected reducing effect on plant growth or production, and the water quality was almost stable during the season as table 8 show the results of water sample analysis at the end of irrigation season.

Table (8): Analysis results of water sample at the end of irrigation season.

Water	E.C	PH	TDS	CO3	HCO3	CL	Hardness (ca+mg)	Ca	Mg	K	Na	SAR	BOD5
	mmhos/cm		ppm	ppm	ppm	ppm	Meg/L	meq/L	meq/L	ppm	ppm		meq/L
Raw	0.8	7.59	512	216	542.9	70.9	17.5	9.1	8.4	40	115	1.69	110
Treated	0.6	7.32	384	72	262.3	70.9	10.5	2.8	7.7	55	135	2.56	20
Fresh	0.6	7.33	384	60	213.5	141.8	8.5	2.8	5.7	10	65	1.37	0

As the table show the concentration has changed, and both raw and grey water become more diluted, this is because of the expected water consumption at the end of the season, where it is in September where the students are existing in the college thus more water is discharged into the grey water treatment unit, while in the middle of the season was during the summer vacation which resulted in less water consumption, and that lead to increase the concentration.

4.1 Effect of water treatment on biomass of 10 millet accessions

The analysis of data indicated a non significant interactive between the accessions and water treatment (Fresh water as control, Raw grey water, Treated grey water) as presented in table 9(a and b),

Table (9a): The statistical analysis of the water treatment effect on the accessions (at α=0.05)

Trt	Total fresh wt g/plant	Root fresh wt g/plant	Straw fresh wt g/plant
Fresh water	845.85	162.13	578.25
Raw grey water	922.35	180.80	626.68
Treated grey water	855.73	162.40	579.25
	Ns	ns	Ns

Table (9b): Yield component of 10 pear millet accessions under different water treatment (data per plant).

Treatment	Total dry wt g/plant	Root dry wt g/plant	Straw dry wt g/plant	Seed g/plant
Fresh water	428.45	59.425	272.88	37.538
Raw grey water	479.85	67.250	316.65	40.146
Treated grey water	468.68	67.250	307.40	37.975
	ns	ns	Ns	Ns

Table 9 a and b, show clearly that there are no significant differences under 95% level ,This agree with the finding of Maman et al., (2004), who found that crop and water treatment didn't interact for grain or aboveground biomass yields. But at the same time it is in the contrary to the findings of (Aghtape et all, 2011) who found that millet response to the irrigation with treated wastewater, therefore the results were represented separately for each factor.

4.2 Fresh biomass production

The biomass production for the different accessions is shown in table 10, where the results show that there is a significant difference between the accessions.

Table (10): Biomass production of 10 pear millet accessions under different water treatments (per plant)

Accessions no	Accessions code	Total fresh wt g/plant	Root fresh wt g/plant	Straw fresh wt g/plant	Plant length cm/plant
1	IP 3616	1152.5^{a}	165.25 bcde	915.67^{a}	49.583^{de}
2	IP 6104	710.30 ^{c}	127.92^{de}	480.67^{bc}	70^{a}
3	IP 6110	644.6 ^{c}	114.83^{e}	426.67^{c}	62.5^{abc}
4	IP 19612	725.9^{c}	132^{cde}	482.08^{bc}	65.5^{ab}
5	IP 22269	1114^{a}	147.42 bcde	940.5^{a}	47.917^{e}
6	Sudan pop I	946^{ab}	204.08^{ab}	618.17^{b}	57.5^{bcd}
7	Sudan pop III	964.5^{ab}	244.67^{a}	572.50^{bc}	56.167^{bcd}
8	ICMS 7704	841.6^{bc}	184.33 abcd	530.92^{bc}	51.083^{de}
9	MC 94 C2	841.7^{bc}	168.25 bcde	506.83^{bc}	53.750 cde
10	ICMV 155	805.4^{bc}	195.67 abc	473.25^{bc}	67.333^{a}

As shown in table 10, it is obviously clear that accessions 1,5,6, and 7 gave high total fresh weight (accession 1 is the highest production), however accessions 6,7,8,10 gave significantly the highest root fresh weight, for the straw fresh weight accession 1 and 5 have the highest straw fresh weight. Regarding the plant length accessions 2,3,4,10 gave the highest plant length.

The results indicated that the high biomass production was mainly due to the straw fresh weight. This agree with the findings of Rai et al (1999) who found that pearl millet have a high dry matter productivity, and that the productivity of this crop could be enhanced through genetic improvement. It is also agree with findings of (Dakheel et al, 2009) where they reported that the production of millet (mainly the fresh weight) will respond to good environmental conditions For instance accession 1 which gave the highest total fresh weight (1152.5 g/plant) was also superior in straw fresh weight, moreover root fresh weight and plant length were higher than other accessions, but at the same time.

These results agree with the findings of Plett et al. (1991) who found variations in the production of the hybrids of millet. He referred the variations to the differences of hybrids (experimental hybrids) that affected the production. Moreover he confirmed that millet response to the irrigation.

Table 10 shows the vegetation fresh weight for the different accessions under both fresh water and treated grey water. It is worth to mention that except accessions 5,7,and 10 the vegetation fresh weight under treated grey water irrigation was higher than that for fresh water even though the differences were not significant.

These results of biomass production is also similar to the findings of Cheik et al (2006) who found significant differences among millet cultivars where the weight of 1000 grain was ranging between 5.53 g to 13.23 g.

4.3 Dry biomass production

The results of biomass production and statistical analysis for the dry mass production for the different millet accessions is presented in table 11. These results are showing a totally different pattern of production among the accessions, where accessions 1 and 5 have significantly the highest total dry weight while for the fresh weight in addition accessions 6 and 7 have significantly high total fresh weight in addition to these accessions.

Table (11): Dry weight parameters for 10 millet lines under different water treatments

Accessions no	Accessions code	Total dry wt g/plant	Root dry wt g/palnt plant	Straw dry wt g/plant
1	IP 3616	650.17^{a}	70.58^{bc}	512.83^{a}
2	IP 6104	380.58^{cd}	42.58^{e}	255.17^{bc}
3	IP 6110	348.33^{d}	47.42^{de}	206.92^{c}
4	IP 19612	398.08^{cd}	50.33^{cde}	248.67^{bc}
5	IP 22269	563.17^{ab}	75.5^{b}	468^{a}
6	Sudan pop I	471.33^{bc}	73.25^{b}	293^{b}
7	Sudan pop III	475.33^{bc}	98.33^{a}	265.25^{bc}
8	ICMS 7704	434.75^{cd}	60.75^{bcde}	263.58^{bc}
9	MC 94 C2	451.08^{cd}	64.75^{bcd}	241.42^{bc}
10	ICMV 155	417.08^{cd}	62.92^{bcde}	234.92^{bc}

On the other hand, accession 7 significantly gave the highest root dry weight, where in the fresh weight accessions 6, 7,8, and 10 gave the highest significant weight. This indicates that the gentic differences is reflected in these results which agree with the findings of Rai et all (1999), who indicated that the genetic improvement of millet cultivars could increase the harvesting index by 20%. Regarding the straw dry weight only accession 1 gave significantly the highest weight while accessions 1 and 5 gave the higher fresh weight. These results indicate clearly that the differences are not in the water storage capacity among the accessions rather than it was due to the straw production as shown in table 12.

Table (12): The total dry weight as a percentage of the total fresh weight

Accessions No	Accessions code	Total fresh weight	Total dry weight	Dry weight percentage
1	IP 3616	1152.50	650.17	56.4%
2	IP 6104	710.30	380.58	53.6%
3	IP 6110	644.60	348.33	54.0%
4	IP 19612	725.90	398.08	54.8%
5	IP 22269	1114.00	563.17	50.6%
6	Sudan pop I	946.00	471.33	49.8%
7	Sudan pop III	964.50	475.33	49.2%
8	ICMS 7704	841.60	434.75	51.7%
9	MC 94 C2	841.70	451.08	53.6%
10	ICMV 155	805.40	417.08	51.8%

As shown in table 12, the percentage was ranging from 49.2% up to 56.4% in all accession, which indicate that the water percentage is almost similar in the accessions and as the plants were not subjected to water stress during the experiment, then the differences are coming as a result to the accession genetic characteristics. These results were explained by the findings of Maman et all (2004) where he reported that the biomass production is not affected by the irrigation, where the irrigation is affecting the grain production not the above ground biomass. This is noticed clearly when taking the root dry weight as a percentage to the total dry weight (table 13) where the dry weight of the roots as a percentage of the total dry weight is ranging from 10.9% - 20.7% . accessions 1 and 5 have the highest significant production when comparing both the total fresh and dry weights

Table (13): The dry weight of the root as a percentage of the total dry weight

Accessions No	Accessions code	Total dry wt	Root dry wt	Root weight as percentage of total dry weight
1	IP 3616	650.17	70.58	10.9%
2	IP 6104	380.58	42.58	11.2%
3	IP 6110	348.33	47.42	13.6%
4	IP 19612	398.08	50.33	12.6%
5	IP 22269	563.17	75.5	13.4%
6	Sudan pop I	471.17	73.25	15.5%
7	Sudan pop III	475.33	98.33	20.7%
8	ICMS 7704	434.75	60.75	14.0%
9	MC 94 C2	451.08	64.75	14.4%
10	ICMV 155	417.08	62.92	15.1%

As the table indicates, the root weight is relatively low, where in the best case it is 20.7%. This could be explained by the volume available for the root growth is limited to the pots, and at the same time the plants were irrigated, thus the plants developed low root system and tended to develop higher vegetation and tillering. This tillering is reflected in the high straw production both in the fresh or dry weight.

4.4 Seed Production

The results of seed production is presented in table 14, where these results indicate that accessions 6,7,8, and 10 gave significantly the highest seed dry weight among the 10 accessions. In the same time taking the spikes accession 9 have the highest significant spike weight

Table (14): spikes and seed weight for 10 millet accessions under different water treatments.

Accessions no	Accessions code	Spike fresh wt g/plant	Spike dry wt g/plant	Seed dry wt g/plant
1	IP 3616	86.08^{d}	63.08^{e}	25.23^{d}
2	IP 6104	95.75^{cd}	78.00^{de}	35.33^{cd}
3	IP 6110	102.00^{bcd}	87.25^{bcd}	$38.^{42bcd}$
4	IP 19612	106.83^{bcd}	92.25^{bcd}	40.77^{bc}
5	IP 22269	21.83^{e}	15.17^{f}	6.00^{e}
6	Sudan pop I	117.67^{bc}	100.23^{bcd}	42.58^{abc}
7	Sudan pop III	129.08^{b}	106.25^{bc}	45.67^{abc}
8	ICMS 7704	124.08^{bc}	106.08^{bc}	44.75^{abc}
9	MC 94 C2	160.83^{a}	140.67^{a}	56.33^{a}
10	ICMV 155	129.08^{b}	114.25^{b}	49.82^{ab}

Taking into account that the normal planting dinsity is 16,000 plants per dunum (Dakheel et al, 2009) then the production parameters could be calculated per dunum, the results are presented in table 15.

Table (15): The seed production of millet per dunum.

Accessions code	Total fresh w.t	Total dry w.t	Seed dry w.t		Accessions code	Total fresh w.t	Total dry w.t	Seed dry w.t
	kg/dunum					kg/dunum		
IP 3616	18440	10402.72	403.696		**Sudan pop I**	15136	7541.28	681.28
IP 6104	11364.8	6089.28	565.28		**Sudan pop III**	15432	7605.28	730.72
IP 6110	10313.6	5573.28	614.72		**ICMS 7704**	13465.6	6956	716
IP 19612	11614.4	6369.28	652.32		**MC 94 C2**	13467.2	7217.28	901.28
IP 22269	17824	9010.72	96		**ICMV 155**	12886.4	6673.28	797.12

These results are conifermed by the findings of Dakheel et al (2009), where they found that the good environment enhance the production, they reported a production of 24,600 kg / ha dry matter production under salinity levels, while the results are showing 73440 kg/ha dry weight. The results of this study is much similar to that of (Agtape et al, 2011), where they obtained a dry biomass production ranging from (12462 kg/ha) as a maximum and the lowest amount (6962.5 kg/ha). Moreover (Maman et al, 2004) found a grain production of 2 – 3 ton per hactar for non irrigated and 5 ton per hactar for the multiple irrigated millet, while this study have 6.15 ton per hactar of grain as average for the 10 accessions with a range 0.96 – 9.01 ton per hactar. This variations among the accessions production is mainly a result of the genotype differences as indicated by (Dakheel et al, 2009; Maman et al; 2004; Evenson *and* Gollin, 2003).

As the accessions have different genotype charactersitics, they will give different behavior in the production where the results of this study indicate that the differences in the production among the accessions vary according to the production paramter, where accessions 1 and 5 were the highest significant productive for the straw and aboveground biomass, however, they were not the highest for grain production. This could be explained by the tendancy of these accessions for tillering and vegetational growth which reduced the grain production as explained by (Hay andWalker,1989;Mamanetall2004).

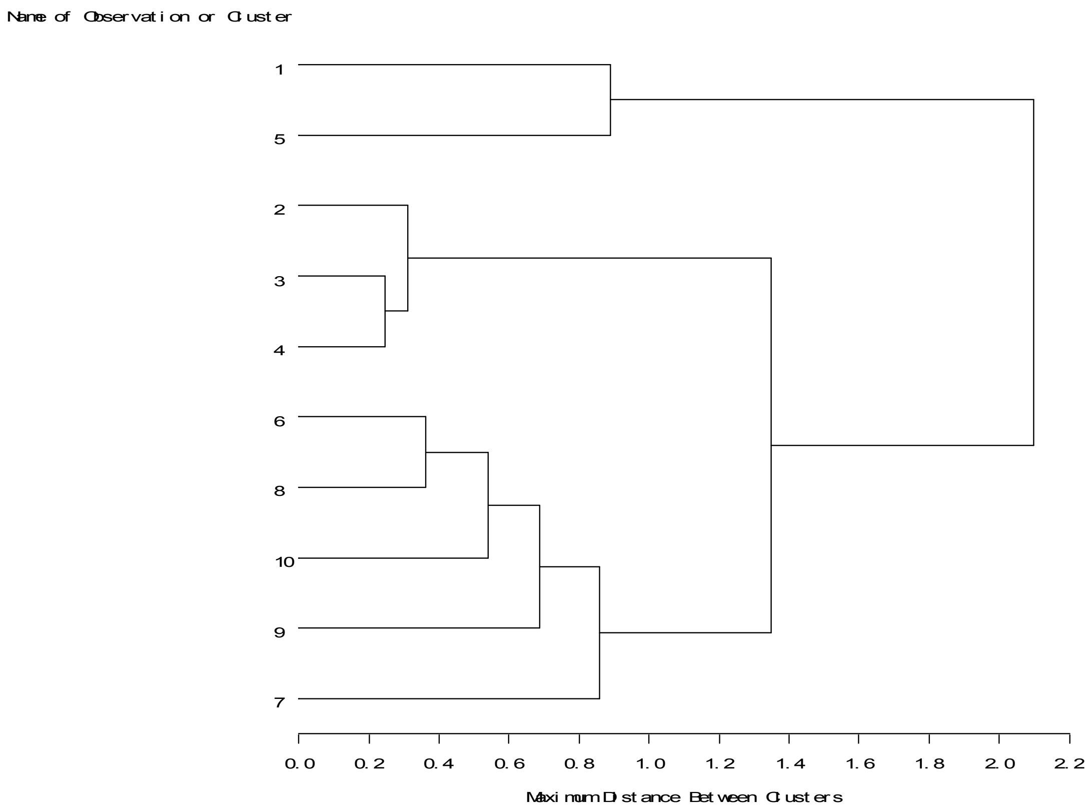

Figure (3): Dendrogram of ten pear millet.

The ten lines grouped in three main clusters, the first cluster consisted two accessions, one and five the coefficient of similarity between these accessions was 0.90 . The second main cluster consisted of two sub clusters, one sub cluster consisted of one accession (number 2) with coefficient of similarity equal to 0.3 . The second and sub cluster consisted from two accessions (3 and 4), the coefficient of similarity was 0.20. The third cluster consisted of four sub clusters with one sub cluster consisted of two accessions (6 and 8) and o.25 coefficient of similarity, the other three sub clusters consisted of four accessions (8,10,9 and 7) and a coefficient of similarity ranging from 0.35- 0.85.

Chapter Five

Conclusions and recommendations

Chapter Five
Conclusions and recommendations

5.1Conclusions

Based on the results of this study it is concluded that:

- The production of the pearl millet is affected by the cultivar where the study found significant differences in the production parameters of the accessions.

- This study was implemented in one planting season, thus it gives an idea on the behavior of the accessions, and there is a need to be repeated to better understand the lines behavior on the long term

- Neither raw nor treated grey water has a significant effect on the production of the planted 10 accessions of pearl millet

- For animal feeding either fresh or dry, accessions 1 and 5 have the highest significant production (as total weight and straw weight).

- For grain production accessions 6,7,8,9,10 have the highest significant production, with accession 9 is the highest.

- Under the local conditions pearl millet has a promising potentiality to be planted as a forage crop for both straw and grain production.

- The grey water could be reused in the irrigation of forage crops where the results didn't show any negative impact on the plants, or production.

5.2 Recommendations:

- It is important to continue this research and repeat it for more years to understand the differences between the different lines and cultivars of millet on the long term
- It is recommended to continue the research on the behavior of the pearl millet cultivars under the local conditions and to extend this study on larger scale.
- The production of millet could be improved by irrigation, but in the same time the millet is drought tolerant crop, Therefore it is recommended to implement researches on the millet production under drought conditions, and under salinity conditions.
- It is highly important to examine the nutritional value of the different lines and the variability in the nutritional content of the accessions in order to give better understanding on the differences of these accessions.
- It is important to implement researches about the digestibility of these accessions and the acceptability of animals for these accessions.
- It is important to examine the effect of grey water on the nutritional value of the millet.
- Forage production sector is weak in Palestine and the researches on that sector are limited, thus it is highly recommended to expand the researches about different forage crops.

- Grey water and treated wastewater is a good potential source for irrigation water, therefore it is highly important to continue such researches on reusing that source in irrigation.

- It is important to implement researches on the impact of reuse of grey water and reclaimed wastewater on both soil and crops on the long term.

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Annexes

Class Level Information

Class	Levels	Values
cv	10	1 2 3 4 5 6 7 8 9 10
trt	3	1 2 3

Number of observations 120

raslan data

11:50 Tuesday, December 28, 1999 2

The GLM Procedure

Dependent Variable: totalfr

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	4495701.84	155024.20	2.35	0.0011
Error	90	5931587.75	65906.53		
Corrected Total	119	10427289.59			

R-Square	Coeff Var	Root MSE	totalfr Mean
0.431148	29.35175	256.7227	874.6417

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cv	9	3080485.008	342276.112	5.19	<.0001
trt	2	138515.417	69257.708	1.05	0.3539
cv*trt	18	1276701.417	70927.856	1.08	0.3886

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cv	9	3080485.008	342276.112	5.19	<.0001
trt	2	138515.417	69257.708	1.05	0.3539
cv*trt	18	1276701.417	70927.856	1.08	0.3886

raslan data
11:50 Tuesday, December 28, 1999 3

The GLM Procedure

Dependent Variable: rootfrh

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	283795.3417	9786.0463	1.41	0.1106
Error	90	623304.2500	6925.6028		
Corrected Total	119	907099.5917			

R-Square	Coeff Var	Root MSE	rootfrh Mean
0.312860	49.40595	83.22021	168.4417

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cv	9	172448.6750	19160.9639	2.77	0.0066
trt	2	9165.2167	4582.6083	0.66	0.5185
cv*trt	18	102181.4500	5676.7472	0.82	0.6729

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cv	9	172448.6750	19160.9639	2.77	0.0066
trt	2	9165.2167	4582.6083	0.66	0.5185
cv*trt	18	102181.4500	5676.7472	0.82	0.6729

raslan data
11:50 Tuesday, December 28, 1999 4

The GLM Procedure

Dependent Variable: spikefr

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	179138.5750	6177.1922	4.69	<.0001
Error	90	118533.7500	1317.0417		
Corrected Total	119	297672.3250			

R-Square	Coeff Var	Root MSE	spikefr Mean
0.601798	33.81418	36.29107	107.3250

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cv	9	145444.7417	16160.5269	12.27	<.0001
trt	2	214.8500	107.4250	0.08	0.9217
cv*trt	18	33478.9833	1859.9435	1.41	0.1453

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cv	9	145444.7417	16160.5269	12.27	<.0001
trt	2	214.8500	107.4250	0.08	0.9217
cv*trt	18	33478.9833	1859.9435	1.41	0.1453

raslan data
11:50 Tuesday, December 28, 1999 5

The GLM Procedure

Dependent Variable: strawfrh

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	4737263.675	163353.920	3.58	<.0001
Error	90	4103502.250	45594.469		
Corrected Total	119	8840765.925			

R-Square	Coeff Var	Root MSE	strawfrh Mean
0.535843	35.90376	213.5286	594.7250

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cv	9	3649212.508	405468.056	8.89	<.0001
trt	2	61268.150	30634.075	0.67	0.5133
cv*trt	18	1026783.017	57043.501	1.25	0.2400

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cv	9	3649212.508	405468.056	8.89	<.0001
trt	2	61268.150	30634.075	0.67	0.5133
cv*trt	18	1026783.017	57043.501	1.25	0.2400

raslan data
11:50 Tuesday, December 28, 1999 6

The GLM Procedure

Dependent Variable: totaldry

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	1242980.242	42861.388	2.57	0.0004
Error	90	1500540.750	16672.675		
Corrected Total	119	2743520.992			

R-Square	Coeff Var	Root MSE	totaldry Mean
0.453060	28.13182	129.1227	458.9917

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cv	9	867949.7417	96438.8602	5.78	<.0001
trt	2	58465.2167	29232.6083	1.75	0.1791
cv*trt	18	316565.2833	17586.9602	1.05	0.4100

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cv	9	867949.7417	96438.8602	5.78	<.0001
trt	2	58465.2167	29232.6083	1.75	0.1791
cv*trt	18	316565.2833	17586.9602	1.05	0.4100

raslan data
11:50 Tuesday, December 28, 1999 7

The GLM Procedure

Dependent Variable: spikedry

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	149950.1667	5170.6954	5.01	<.0001
Error	90	92832.5000	1031.4722		
Corrected Total	119	242782.6667			

R-Square	Coeff Var	Root MSE	spikedry Mean
0.617631	35.55337	32.11654	90.33333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cv	9	123176.8333	13686.3148	13.27	<.0001
trt	2	46.8167	23.4083	0.02	0.9776
cv*trt	18	26726.5167	1484.8065	1.44	0.1329

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cv	9	123176.8333	13686.3148	13.27	<.0001
trt	2	46.8167	23.4083	0.02	0.9776
cv*trt	18	26726.5167	1484.8065	1.44	0.1329

raslan data

11:50 Tuesday, December 28, 1999 8

The GLM Procedure

Dependent Variable: rootdry

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	46818.3417	1614.4256	2.39	0.0010
Error	90	60907.2500	676.7472		
Corrected Total	119	107725.5917			

R-Square	Coeff Var	Root MSE	rootdry Mean
0.434607	40.24396	26.01437	64.64167

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cv	9	28422.84167	3158.09352	4.67	<.0001
trt	2	1632.81667	816.40833	1.21	0.3041
cv*trt	18	16762.68333	931.26019	1.38	0.1633

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cv	9	28422.84167	3158.09352	4.67	<.0001
trt	2	1632.81667	816.40833	1.21	0.3041
cv*trt	18	16762.68333	931.26019	1.38	0.1633

raslan data

11:50 Tuesday, December 28, 1999 9

The GLM Procedure

Dependent Variable: strawdry

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	1481839.675	51097.920	4.54	<.0001
Error	90	1013639.250	11262.658		
Corrected Total	119	2495478.925			

R-Square	Coeff Var	Root MSE	strawdry Mean
0.593810	35.49650	106.1257	298.9750

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cv	9	1164861.008	129429.001	11.49	<.0001
trt	2	42583.850	21291.925	1.89	0.1569
cv*trt	18	274394.817	15244.156	1.35	0.1754

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cv	9	1164861.008	129429.001	11.49	<.0001
trt	2	42583.850	21291.925	1.89	0.1569
cv*trt	18	274394.817	15244.156	1.35	0.1754

raslan data 11:50 Tuesday, December 28, 1999 10

The GLM Procedure

raslan data 11:50 Tuesday, December 28, 1999 12

The GLM Procedure

Dependent Variable: len3

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	8559.36667	295.15057	2.35	0.0011
Error	90	11302.50000	125.58333		
Corrected Total	119	19861.86667			

R-Square	Coeff Var	Root MSE	len3 Mean
0.430945	19.27706	11.20640	58.13333

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cv	9	6593.533333	732.614815	5.83	<.0001
trt	2	358.316667	179.158333	1.43	0.2455
cv*trt	18	1607.516667	89.306481	0.71	0.7914

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cv	9	6593.533333	732.614815	5.83	<.0001
trt	2	358.316667	179.158333	1.43	0.2455
cv*trt	18	1607.516667	89.306481	0.71	0.7914

Dependent Variable: seedwt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	29	25995.64167	896.40144	3.01	<.0001
Error	90	26843.68333	298.26315		
Corrected Total	119	52839.32500			

R-Square	Coeff Var	Root MSE	seedwt Mean
0.491975	44.77070	17.27030	38.57500

Source	DF	Type I SS	Mean Square	F Value	Pr > F
cv	9	20604.98992	2289.44332	7.68	<.0001
trt	2	37.88468	18.94234	0.06	0.9385
cv*trt	18	5352.76707	297.37595	1.00	0.4708

Source	DF	Type III SS	Mean Square	F Value	Pr > F
cv	9	20069.02606	2229.89178	7.48	<.0001
trt	2	42.88438	21.44219	0.07	0.9307
cv*trt	18	5352.76707	297.37595	1.00	0.4708

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جامعة النجاح الوطنية
كلية الدراسات العليا

تأثير ري محصول الدخن بالمياه الرمادية المعالجة

إعداد
رسلان حسن عزيز شنابله

إشراف
د. حسان أبو قاعود
د. نعمان مزيد

قدمت هذه الأطروحة استكمالاً لمتطلبات الحصول على درجة الماجستير في تخصص الإنتاج النباتي في كلية الدراسات العليا في جامعة النجاح الوطنية في نابلس، فلسطين.

2012م

تأثير ري محصول الدخن بالمياه الرمادية المعالجة

إعداد

رسلان حسن عزيز شنابله

إشراف

د. حسان أبو قاعود

د. نعمان مزيد

الملخص

تم تنفيذ هذه الدراسة بهدف فحص تأثير استخدام المياه الرمادية المعالجة على إنتاجية 10 سلالات من الذرة اللؤلؤية و مقارنة إنتاج هذه الأصناف تحت تأثير الظروف المحلية في فلسطين. تمت تنفيذ التجربة في محطة الأبحاث في كلية الزراعة في طولكرم، و تمت الزراعة في الموسم الصيفي عام 2010 في حاويات بلاستيكية تتسع ل 45 كغم بتربة رملية طينية، وبمعدل 10 نباتات في الحاوية، و تم الري بثلاثة أنواع من المياه (مياه عذبة، و مياه رمادية، و مياه رمادية معالجة) كمعاملات، و أربع مكررات للمعاملة، و تم تحليل النتائج إحصائيا من خلال تحليل المتغيرات و فصل المتوسطات عن طريق فحص دونكان.

تشير النتائج بوضوح إلى عدم وجود تأثير لنوعية مياه الري على الإنتاج حيث لم يتأثر الإنتاج بمعاملة مياه الري.بينما كان هناك اختلافات ناتجة عن اختلاف السلاله، فالسلالات 7،6،5،1 أعطت اعلي إنتاج كلي طازج (1152.5 غم/ نبات من السلاله 1)، بينما أعطت السلالات 10،8،7،6 اعلي وزن جذور (244.67 غم/نبات من السلاله 7) بالنسبة لوزن القش أعطت السلالات 5،1 أعلى إنتاج)940.5 غم/نبات من السلاله 5)، بينما كان للسلالات 2، 3، 4، 10 أعلى طول للنبات (70 سم من السلاله 2). تشير النتائج إلى وجود اختلاف في نمط الإنتاج فبينما كان للسلالات 5،1 اعلي وزن جاف بينما للوزن الطازج كانت السلالات 7،6،5،1 هي الأعلى إنتاجا و دون فروق إحصائية. بالنسبة لوزن البذور تشير النتائج أن سلالات 6، 7، 8، 9، 10 هي الأعلى إنتاجا (56.33 غم/نبات من السلاله 9). و قد تم الحصول على 73440 كغ/دونم كمتوسط وزن جاف من مختلف السلالات مما يشير إلى نتائج

مبشرة لزراعة المحصول العلفي. فعند التوجه لإنتاج العلــق الأخضــر (طــازج أو جــاف) فالسلالات 5،1 تعطي اعلي إنتاج، بينما لإنتاج البذور فالسلالات 6،7،8،9،10 هــي الأعلــى إنتاجا دون فروق معنوية إحصائيا.