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Forage yield of pearl millet (*Pennisetum glaucum*) under different water quality and accessions

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ABSTRACT

This study examined the effect of reused treated grey water on yield of 10 pearl millet accessions (*Pennisetum glaucum*) in An-Najah University, Tulkarm, Palestine. Ten pearl millet seeds were planted during May 2010 in each separate plastic containers (35 x 50 x 15 cm) filled with 45 kg sandy clay soil in four replication of a completely randomized design and irrigated with three types of water (Fresh water as control, raw grey water, treated grey water). Results clearly showed that there were no significant differences in the yield under different water treatments. Also no significant interaction was observed between water treatments and cultivars. However, accessions IP3616, IP22269, Sudan pop II, and Sudan pop I gave high total fresh weight fresh weight of straw while accessions IP3616 and IP22269 produced the highest fresh weight of straw. The accessions IP6104, IP6110, IP19612 and ICMV155 registered the highest plant height.

Key words: Brackish water, Pearl millet, *Pennisetum glaucum*, Raw grey water, Treated grey water.

INTRODUCTION

The growth and development of land plants is largely influenced by water shortage (El-Sawaf, 2005). Therefore reuse of wastewater 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 work on use of nontraditional water sources including saline water, municipal and industrial waste water. On account of increase in population, both water consumption and wastewater production are increasing (Galavi *et al.,* 2009). Because of the lack of water resources in semi-arid Mediterranean regions, wastewater may be used for irrigating agricultural crops (Meli *et al.,* 2002). 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). As a main consumer of water, agricultural sector is being more affected due to this growing crisis of irrigation water for producing forage in arid and semi-arid regions including the West Bank.

Pearl millet is one of the main forage crops in arid and semiarid regions due to its relatively low water requirement than other crops (Rostamza *et al.,* 2011). Landrace open-pollinated cultivars of pearl millet exhibit high levels of vegetative vigor and are best with a very high biomass production. These are necessary adaptive features in the crop to survive under stressful conditions (Andrews *et al.,* 1993). In light of fact that there is a high need to strengthen the forage production sector and increase the productivity of forage crops in Palestine to enhance the food security of people and at the same time to save fresh water for domestic purposes through utilization of non conventional water resources, including use of treated wastewater for irrigating forage crops under a situation where only 8.4% of the total agricultural area is irrigated (PCBS, 2007). Therefore, the effect of different quality water in different accessions of pearl millet was investigated in this study.

MATERIALS AND METHODS

Plant material: Seeds of 10 Pearl millet cultivars obtained from the Palestinian Ministry of Agriculture, Palestine (Table 1).

Field experiment: Ten seeds of pearl millet were planted in May 10th 2010 in separated plastic containers (35 x 50 x 15 cm) filled with 45 kg sandy clay soil in a complete randomized design having four replications. The plants were irrigated with three quality of water i.e, fresh water as control (FW), raw greywater and treated greywater.

Irrigation was started with planting of seeds and the quantities of irrigation water to be applied in unit area was calculated using the Modified FAO Penman-Montieth equation, using CROPWAT software but quantity of irrigation water was kept constant for all three qualities of irrigation water. The irrigation was applied at three days intervals.

Pearl millet plants were monitored for growth and production parameters *viz* total fresh and dry weight, fresh and dry weight of roots, fresh and dry weight of panicle, fresh and dry weight of vegetative parts and plant height.

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Table 1: Pearl millet accessions used in the experiment

Number	Accession Code
1	IP3616
2	IP6104
3	IP6110
4	IP19612
5	IP22269
6	Sudan pop I
7	Sudan pop II
8	ICMS7704
9	MC94C2
10	ICMV155

Data analysis: Data were analyzed statistically using one way analysis of variance to examine the treatment effects. Treatment means were separated by Duncan's multiple range test at P≤0.05

RESULTS AND DISCUSSION

Effect of water treatment on biomass : There were no significant differences among irrigation water of different quality (Table 2). This was in agreement with the findings of Maman *et al.*, (2004), who reported that crop and water treatment didn't interact for grain or aboveground biomass yields.

Fresh biomass production: Fresh biomass production under different accessions (Table 3) results showed that there was a significant variation among various accessions of pearl millet. The accessions IP3616, IP22269, Sudan pop II, and Sudan pop I registered significantly higher total fresh weight while, accessions Sudan pop I, Sudan pop II, ICMS7704 and ICMV155 gave significantly higher fresh weight of roots and for the straw fresh weight accession IP3616 and IP22269 recorded the highest values. The accessions IP6104, IP6110, IP19612 and ICMV155 recorded the highest plant height. Results indicated that higher biomass production was mainly limited with fresh weight of straw and this is in agreement with the findings of Rai *et al.* (1999). Dakheel *et al.* (2009) have also reported that the fresh weight production of millet were responds to good environmental conditions. Accession IP3616 which gave the highest total fresh weight (1152.5 g/ plant) was also superior in fresh weight of straw but moreover root fresh weight and plant height were also higher than other accessions. These results were in agreement with the findings of Plett *et al.* (1991) and Cheik *et al.* (2006).

Dry biomass production: The results on biomass production under different millet accessions (Table 4) show a totally different pattern of dry biomass production and accessions IP3616 and IP22269 recorded significantly higher total dry weight.

On the other hand, accession Sudan pop II recorded significantly higher root dry weight. This might be due to genetic differences which were also in agreement with the findings of Rai *et al.* (1999). Regarding the straw dry weight, accession IP3616 recorded significantly higher values. These results indicated that the differences in dry biomass productions were due to the variations in straw production. These results were in agreement with the findings of Maman *et al.* (2004).

Table 2: The statistical analysis of the water treatment effect on the lines

Treatment	Total		Root		Straw		Seed
	FW (g)	DW (g)	FW (g)	DW (g)	FW (g)	DW (g)	
Fresh water	845.85^{a}	428.45^{a}	162.13^{a}	59.43^{a}	578.25^{a}	272.88^{a}	37.54^{a}
Raw greywater	922.35^{a}	479.85^{a}	180.80^{a}	67.25^{a}	626.68^{a}	316.65^{a}	40.15^{a}
Treated greywater	855.73^{a}	468.68^{a}	162.40^{a}	67.25^{a}	579.25^{a}	307.40^{a}	37.98^{a}

Data with the same letter per column are not statistically different (Duncan-test, P ≤ 0.05).
FW: fresh weight, DW: dry weight

Table 3: Total fresh weight, root fresh weight straw fresh weight, plant height and root: shoot ratio of 10 pearl millet accessions under different water treatments.

Accessions	Total fresh weight (g)	Root fresh weight (g)	Straw fresh weight (g)	Plant height (cm)	Root:Shoot ratio
IP3616	1152.5^{a}	165.3^{bcde}	915.7^{a}	49.6^{de}	14.3^{d}
IP6104	710.3^{c}	127.9^{de}	480.7^{bc}	70.0^{a}	19.6^{bcd}
IP6110	644.6^{c}	114.8^{e}	426.7^{c}	62.5^{abc}	23.5^{bcd}
IP19612	725.9^{c}	132.0^{cde}	482.1^{bc}	65.5^{ab}	20.6^{bcd}
IP22269	1114.0^{a}	147.4^{bcde}	940.5^{a}	47.9^{e}	17.3^{cd}
Sudan pop I	946.0^{ab}	204.1^{ab}	618.2^{b}	57.5^{bcd}	25.8^{bc}
Sudan pop II	964.5^{ab}	244.7^{a}	572.5^{bc}	56.2^{bcd}	42.1^{a}
ICMS7704	841.6^{bc}	184.3^{abcd}	530.9^{bc}	51.1^{de}	24.8^{bc}
MC94C2	841.7^{bc}	168.3^{bcde}	506.8^{bc}	53.8^{cde}	29.9^{b}
ICMV155	805.4^{bc}	195.7^{abc}	473.3^{bc}	67.3^{a}	26.7^{bc}

Data with the same letter per column are not statistically different (Duncan-test, P ≤ 0.05).

Table 4. Total dry weight, root dry weight and straw dry weight for 10 pearl millet accessions under different water treatments

Accessions	Total dry weight (g/plant)	Root dry weight (g/plant)	Straw dry weight (g/plant)
IP3616	650.17^{a}	70.58^{bc}	512.83^{a}
IP6104	380.58^{cd}	42.58^{e}	255.17^{bc}
IP6110	348.33^{d}	47.42^{de}	206.92^{c}
IP19612	398.08^{cd}	50.33^{cde}	248.67^{bc}
IP22269	563.17^{ab}	75.50^{b}	468.00^{a}
Sudan pop I	471.33^{bc}	73.25^{b}	293.00^{b}
Sudan pop II	475.33^{bc}	98.33^{a}	265.25^{bc}
ICMS7704	434.75^{cd}	60.75^{bcde}	263.58^{bc}
MC94C2	451.08^{cd}	64.75^{bcd}	241.42^{bc}
ICMV155	417.08^{cd}	62.92^{bcde}	234.92^{bc}

Data with the same letter per column are not statistically different (Duncan-test, P ≤ 0.05).

Table 5. Spike fresh weight, spike dry weight and seed dry weight for 10 pearl millet accessions under different water treatments.

Accessions	Spike fresh weight (g/plant)	Spike dry weight (g/plant)	Seed dry weight (g/plant)
IP3616	86.08^{d}	63.08^{e}	25.23^{d}
IP6104	95.75^{cd}	78.00^{de}	35.33^{cd}
IP6110	102.00^{bcd}	87.25^{bcd}	38.42^{bcd}
IP19612	106.83^{bcd}	92.25^{bcd}	40.77^{bc}
IP22269	21.83^{e}	15.17^{f}	6 .00^{e}
Sudan pop I	117.67^{bc}	100.23^{bcd}	42.58^{abc}
Sudan pop III	129.08^{b}	106.25^{bc}	45.67^{abc}
ICMS7704	124.08^{bc}	106.08^{bc}	44.75^{abc}
MC94C2	160.83^{a}	140.67^{a}	56.33^{a}
ICMV155	129.08^{b}	114.25^{b}	49.82^{ab}

Data with the same letter per column are not statistically different (Duncan-test, P ≤ 0.05).

Seed production: Seed production (Table 5) indicated that accession MC94C2 recorded the highest spike fresh weight, spike dry weight and seed dry weight, whereas accessions Sudan pop I, Sudan pop III, ICMS7704, and ICMV155 produced significantly higher seed dry weight among all the 10 accessions.

These results were in confirmity with findings of Dakheel *et al.* (2009) and Agtape *et al.* (2011). Moreover, Maman *et al.* (2004) found a grain production of 2–3 tons per hectare for non irrigated and 5 tons per hectare for multiple irrigated millet, while this study have a grain production of 6.15 ton per hectare on average for the 10 accessions with a range 0.96 – 9.01 tons per hectare. This variations among the lines production was mainly a result of the genotype differences as also indicated by Dakheel *et al.* 2009; Maman *et al.* 2004.

For the ten accessions of pearl millet were grouped in three main clusters (Figure 1), the first cluster consisted two accessions, IP3616 and IP22269 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 (IP6104) with coefficient of

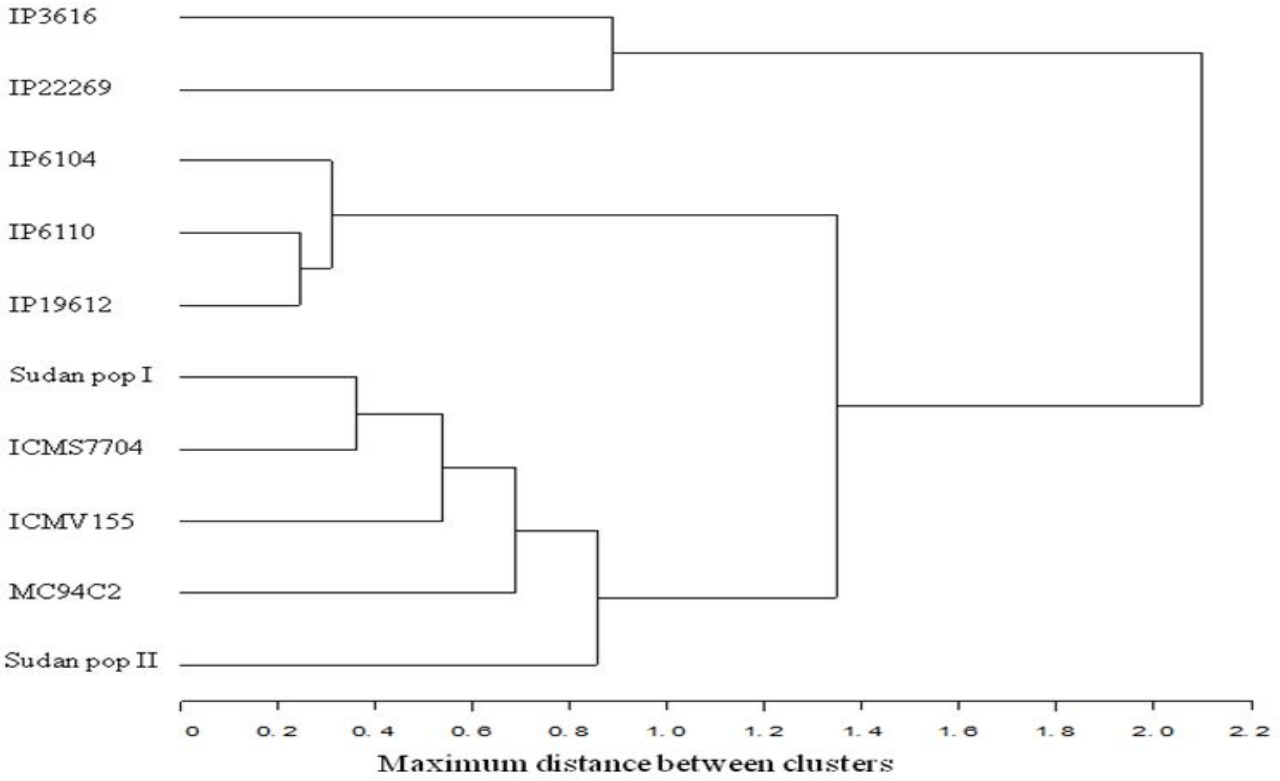

Fig 1: Dendrogram of ten pearl millet lines.

Table 6. Total fresh weight and total dry weight in kg/dunum of 10 pearl millet accessions under different water treatments.

Accessions	Total fresh weight	Total dry weight
IP3616	18807[a]	10641.5[a]
IP6104	10850[c]	5915.1[bc]
IP6110	10313[c]	5573.3[c]
IP19612	11739[bc]	6316.0[bc]
IP22269	19299[a]	9833.6[a]
Sudan pop I	15136[b]	7541.3[b]
Sudan pop II	14860[b]	7394.7[bc]
ICMS7704	13962[bc]	7152.0[bc]
MC94C2	13467[bc]	7217.3[bc]
ICMV155	13424[bc]	6986.7[bc]

Data with the same letter per column are not statistically different (Duncan-test, $P \leq 0.05$).

similarity equal to 0.3. The second sub cluster consisted from two accessions (IP6110 and IP19612), the coefficient of similarity was 0.20. The third cluster consisted of two sub clusters, the first sub cluster consisted of one accession (Sudan pop II), and the other sub cluster consisted of four accessions (Sudan pop I, ICMS7704, MC94C2 and ICMV155) and a coefficient of similarity ranging from 0.35- 0.85.

CONCLUSIONS

Based on the results of this study it can be concluded that the production of the pearl millet is affected by the cultivars. Under the local conditions, where pearl millet has potential as a forage crop for both of straw and grain production. It can be useful to reuse both grey water and reclaimed wastewater.

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