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The Effect of the use of Sewage Water from the Treatment Plant in Makkah Al Mukarramah on the Dry Forage Yield and Microbiological Characteristics of Sudan Grass (Sorghum Sudanensis L.)

Abdullatif A. Neamatallah
Environment Department, Faculty of Meteorology, Environment and Arid Land Agriculture, King Abdulaziz University, Jeddah, Saudi Arabia.
Corresponding author email id: falghabari@gmail.com

Abstract – **The effect of irrigation with mixed sewage water from Makkah City treatment plant with normal water on the dry forage yield of Sudan grass and its components and its microbiological implications on the crop during 2016 season. Complete Design with three Replications was used. The water mixture treatments are (100% normal water + zero sewage water, 75% normal water + 25% sewage water, 50% ordinary water + 50% sewage, 25% normal water + 75% sewage, 0% normal water + 100% sewage). There were three replicates, irrigation treatments were represented by 5 plots (5 x 5 m). Irrigation with 75% treated sewage water + 25% normal water and 50% treated sewage water + 50% normal water significantly enhanced and increased the dry forage yield of Sudan grass crop compared to other treatments, with no significant difference between them followed by 100% treated sewage water. Irrigation with 100% normal water gave the least means of the dry forage yield of Sudan grass. It is recommended to irrigate crops with 75% treated sewage water + 25% normal water and 50% treated sewage water + 50% normal water.**

Keywords – **Makkah City, Treated Sewage Water, Sudan Grass.**

I. Introduction

The reuse of treated sewage water in irrigation is now a booming phenomena all over the world and that is due to lack of fresh water. So water availability for irrigation is needed badly in Saudi Arabia, and under use of wastewater in agriculture as an alternative to fresh water, this will liberalize fresh water to be used for drinking and other essential purposes. Benefits that can be gained from use of sewage water in irrigation is that it contains high level of organic matter and recycling of nutrients, thereby reducing the need to invest in chemical fertilizers (Al-Sha'lan, 2001). In Saudi Arabia, there are more than 30 desalination water treatment plants producing around 3 million m3/day. Part of it is reused for agricultural purposes. Economically the savings in irrigating field crops might rise up to 45% in fertilizers cost for wheat crop and 94% for alfalfa crop compared to irrigation with well water due to the fact that sewage water contains the essential elements needed by such crops (Al-Abdulqader and Al-Jaloud (2003). They also indicated that the usage of treated sewage water in irrigating of wheat and alfalfa crops increased their yield by 11 and 23%, respectively, and increased the profit by 14 and 28%, respectively as compared to irrigation with well water.

Sudan grass which is a fodder crop grows better under a--rid land conditions with scarcity in water and with high temperature. It has high nutritional value, containing 5% protein and 55% carbohydrate of wet weight, and water stress reduced Sudan grass plant length, leaf area and total yield (Benneit and Sullivan, 1981). Surface area of the leaves and plant height of Sudan grass increased with increase in irrigation water (Rosenthal et al 1987; Scarascia et al, 1983), and the plant content of protein significantly increased with increased rate of irrigation (Cabiel and Ashcroft, 1972). Studies on irrigation of field crops with treated sewage water showed significant increases in plant fresh and dry weight, yield, plant content of nitrogen and phosphorus as well as many other nutrient elements (Akponikpe et al., 2011). Soybean was irrigated with secondary treated municipal wastewater and gave a yield of 354 kg/ha and under well water irrigation yield was 205 kg/ha (Cordonnier and Johnston, 1980). Wheat yield increased by almost 11% and yield of alfalfa reached 24% increase under irrigation with sewage water compared to normal water (Al-Abdulqader and Al-Jaloud, 2003). Treated sewage water is used for production of vegetables, and corn, potato, lettuce, olive trees, and alfalfa produced significantly high yields compared to irrigation with fresh water (Munir and Mohammed, 2004; Kouraa et al., 2002; Lopez et al., 2006; Jasim and Abdul, 2010).

Sewage water when used in irrigation should be well treated, or diluted with fresh water or use of subsurface drip irrigation, and contamination of crops irrigated with wastewater will not occur if the wastewater had been treated well (Vaz da Costa et al. 1996; Najafi et al. 2003; Panoras et al. 2003; Al-Lahham et al. 2003; Aiello et al. 2007). Excessive contents of heavy metals in crops irrigated with wastewater have not been reported (Zavadil 2009). Whenever used for irrigation treated sewage water imposes its significant effects on growing plants, vegetables or crops due to its high nutritive quality (Khaled S. Balkhair et al. 2013; 2014). Treated sewage water used for irrigation also contains coliform and fecal bacteria, but the level of these bacteria (fecal coliforms) should not exceed (1000/100 ml) as suggested by international bodies, like the Environmen--tal Protection Agency in America (EPA 1973; WHO, 1989). The objective of this study was to investigate the effect of irrigating Sudan grass fodder crop with treated sewage water from Makkah sewage treatment plant diluted with fresh water up to five levels. The study was to test the effects of these five levels of dilutions on the growth parameters of the crop, its dry forage yield and components.

II. Materials and Methods

Design

Complete randamized plot design with three replications was used. The experimental area was divided into 3 replicates each is represented by 5 plots (5x5 m) to represent irrigation treatments,

Irrigation Treatments

Sprinkle irrigation was used in this experiment, where two types of irrigation water were used (irrigation water from Huda Al-Sham station and treated wastewater from Makkah City mixed with different rates of normal water at five irrigation rates as follows:

Normal Water Treated Water
First Treatment 100% 0%
Second treatment 75% 25%
Third treatment 50% 50%
Fourth treatment 25% 75%
Fifth Treatment 0% 100%

The amount of water added to each irrigation treatment was fixed based on the water consumption of the crop. Where water consumption is calculated using the following formula:

$$ETc = Kc \, X \, ETr$$

Where as:
ETc: Water Consumption of Crop (mm / day)
ETR: Water Consumption of Reference Crop (mm / day)
Kc: Crop coefficient

The water consumption values of the reference crop for the study area were used from Mashat et al (2000). The values of the cropping coefficient for alfalfa and Sudan plow are used in the paper published by FAO in paper No. 56 (Allen et al., 1998).

Planting method

The soil was ploughed, levelled, and seeds were dispersed at rate of 50/ ha. Phosphorus was added in the form of Super Phosphate (P_2O_5 46%) at a rate of 150 kg/ ha. Potassium was added in the form of Potassium Sulphate (K_2SO_4 50%) at rate 100 kg/ha. Nitrogen fertilizers were added in the form of urea (N 46%) in batches at a rate of 109 kg urea / ha where the first batch was added after 15 days of planting. The other batch will be added at the same rate after each share. The trial was carried out on 1/4/2016 corresponding to 22/2 / 1437H.

Plant Samples Collection

3 Cuttings from Sudan's grass were taken. Five full plants were randomly selected from each treatment before each cutting. The dry weight of the total vegetative growth and its components of leaves and stems were estimated using a frame area of one square meter so that it was tossed three times in each plot randomly and then the plants within the frame were cut at a height of 5 cm from soil. The dry yield per hectare was calculated from the total weight of the plants from the whole area of the experimental unit (25 m2).

Plant Samples for Microbiological Analysis:

100 gm from each plant was put in glass tube with 900 cm 2 distilled water. This was used for determination of coliform and fecal bacteria using probability counts.

III. Results

First: Effect of cuttings on dry yield components and total forage yield of Sudan grass

Statistical analysis data in Table (1) show the significant differences between cuttings on dry forage yield and its component.

Table 1. Statistical analysis of variance of plant characteristics of Sudan grass under cuttings and irrigation water type.

	DF	Dry weight (gm/ cm2)			Total dry wt.
		Leaves	Stem	Vegetative growth	
Rep.	2	25069	63288	117281	0.85
cuttings	2	446111**	2255213**	464611**	406**
Water type	4	199349**	368844*	1069916*	94**
Irrig.xcut	8	4135	15912	328569	25*
LSD	28	2181	177795	285571	10.3

* The averages followed by the same letter (letters) do not differ significantly from each other at a significant level 0.0

Dry Weight of Sudan Grass Shoot System:

Leaves dry Weight (gm / m2):

Results of the dry weight of the leaves (gm / m2) showed the domination of the first cutting with a dry weight of 565.28 gm / m 2 followed by the third cutting with 312.77 gm / m 2, and then the second with 235.55 gm / m 2 (table 2).

Stem dry Weight (Gm / M 2):

The results of means (Table 2) showed that the mean dry weight of the stem / m 2 was significantly higher in the first cutting (1211.3 gm / m 2) than the second (548.2 gm / m 2) and the third (531.6 gm / m 2).

Total Dry Weight of Shoot Growth (gm / m2):

Based on the dry weight data of leaves and stems, first cutting was significantly higher than the second and third cuttings whereas the second and third cuttings did not differ significantly. The dry weight of the shoot system was as follows: 1776.6 gm / m 2, 783.7 gm / m², 844.4 gm / m2 for the three cuttings respectively (table 2).

Total dry Fodder Yield (tons / ha):

Based on the results of the averages of the three cuttings shown in Table (2), it is clear that the first cutting gave the highest dry yield (17.07 tons / ha) superior to the second cutting (8.76 ton / ha) and the third was 7.65 ton / ha.

Second: Effect of Irrigation Water Quality on Sudan Grass:

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Leaves dry Weight (gm / m2):

Table (2) shows that irrigation with 75% sewage water + 25% normal water or 50% wastewater + 50% normal water gave the highest leaves dry weight with significant difference from the rest of the treatments while irrigation with normal water only and 25% sewage water + 75% normal water gave the least leaf dry weight in / m 2.

Stem dry weight (gm / m2):

Irrigating Sudan grass with 75% sewage water + 25% normal water or 50% wastewater + 50% normal water or 100% sewage water with no significant differences between them gave significantly higher dry stem weight than Irrigating with 100% normal water and 25% sewage water + 75% normal water (Table 2).

Total dry Forage Yield (tons / ha):

Results of means in table (2) show that the total dry yield per hectare of Sudan grass was obtained by irrigation with 75% drainage water + 25% normal water or 50% wastewater + 50% normal water which are significant from the other treatments with a yield of 14.30 tons / ha and 14.28 tons / ha respectively, followed by irrigation with 100% sewage water with 10.87 tons / ha, then 25% drainage water + 75% normal water with an average of 9.93 tons / ha, and the least dry forage yield of 6.6 tons / ha was given by irrigation with 100% normal water.

Table 2. Means of dry forage yield of Sudan grass and its components under different irrigation water types.

Treatments	Dry weight (gm/ cm2)			Total dry wt.
	Leaves	Stem	Vegetative growth	
100% normal water	184.8c	466.7b	651.5c	6.6c
75% sewage+25% normal water	268.3b	640.3ab	908.5c	9.93b
50% sewage+50% normal	513.17a	898.4a	1420.9ab	14.28a
75% sewage + 25% normal	522.59a	930.5a	1444.2a	14.30a
100% sewage water	366.56	882.8a	1249.3ab	10.87b
LSD	142.61	407.16	516.02	3.1

* The averages followed by the same letter (letters) do not differ significantly from each other at a significant level 0.05.

Microbiological Characteristics of Sudan Grass:

Results in table (3) show that cutting treatments had a significant effect on the total number of bacteria estimated on forage of Sudan grass at a level of 1%. The number of fecal coliforms was not affected by the cuttings. The irrigation water quality also had a significant effect on total coliform (TCB) and total fecal bacteria (TFB) in Sudan grass. Irrigation with 100% sewage water, 75% drainage water + 25% normal water, or 50% wastewater + 50% normal water gave averages of 2880, 2588, 2401 (TCB) and 2620, 1202, 451 (TFB) respectively with no significant differences between them , and the least bacteria is in the plants irrigated by 100% normal water (588 TCB and 26.4 TFB) (table 4).

Table 3. Analysis of variance of effect of cuttings and irrigation water type on (TCB and TFB) in Sudan grass.

	DF	TCB /100ml	TFB/100ml	Total logarithmic number
Replicates	2	1086427.4	4229365.1	1.09
cuttings	1	269611.2	2129814.8	1.45 **
treatments	4	5403546.8 **	6378545.3 **	31.92 **
treatXcutting	8	101109.5	166036.5	0.21
LSD	18	17148.8	610814.3	0.11

Table 4. Means of effect of cuttings and irrigation water type on (TCB and TFB) in Sudan grass.

Cuttings	TCB /100ml	TFB/100ml	Total logarithmic number
First	2048.5a	1207.1a	8.69b
Second	2238.1a	674.2a	9.13a
LSD	317.64	599.56	0.25
100% normal water	588c	26.4c	5.38e
75% sewage+25% normal water	1966.7b	403.8bc	8.06d
50% sewage+50% normal	2401.7ab	451bc	9.34c
25% normal+75% sewage	25880a	1202b	10.65b
100% sewage water	2880.a	2620a	11.12a
LSD	502.23	947.99	0.41

IV. Discussion

From the results obtained from this study different cuttings of Sudan grass fodder crop under these treatments showed significant variations in dry leaves weight, dry stems weight, dry vegetative shoot growth. The first cutting was superior and dominated all other cuttings giving the highest dry leaves weight, dry stem weight, dry shoot growth and the highest dry forage yield of Sudan grass. This is because most of the plant nutrients in the soil might have been taken by the growing plants during the first cut, and might have been caused by the favorable soil structural and textural soil characters.

As for treatments with different mixtures of treated sewage water and normal water, the treatments significantly affected the plant dry forage yield and its components, dry leaves weight, dry weight of stem, dry shoot vegetative growth and dry fodder yield. It is clear that irrigation with 75% sewage water + 25% normal water and 50% wastewater + 50% normal water gave significantly the highest means of Sudan grass dry forage yield and yield components compared to all other irrigation water treatments, and mostly there is no significant differences between them. They are followed by the treatment 100% sewage water. Irrigation with 100% normal water attained the lowest means of all these parameters. This is mostly due to the high plant nutrient contents and high organic and inorganic substances in sewage water compared to normal water. These contents enhanced Sudan grass growth thus increasing its dry forage yield compared to irrigation with normal water. Lazarova and Bahri, (2005) mentioned that treated sewage water contains elements and metals which are useful to plants thus increasing crop yield. Mandi and Abissy (2000) working on Sorghum, Kouraa, et al. (2002) on potato, Munir and Mohammad (2004) on lettuce, Lopez et al. (2006) on alfalfa, irrigated these crops with treated sewage water and found significant increases in yield compared to normal water. Al-Lahham et al. (2003) studied the effect of irrigation with a mixture of wastewater and potable water at different rates (100% normal water with zero% wastewater, 50% normal water with 50% wastewater, 25 normal water with 75% wastewater and 0% normal water with 100% sewage) on the productivity of the tomato crop, and found an increase in the productivity of the tomato crop with an increase in the percentage of wastewater in irrigation water particularly 75% of the wastewater and 100% wastewater with no significant differences between them. Bashey et al. (2007) conducted a study on the effect of the use of wastewater from the treatment plant in Makkah Al Mukarramah after mixing it with different percentages (0%, 25%, 50%, 75%, 100%) of the irrigation water for alfalfa, and obtained the highest fodder yield from the first cutting and irrigation with 100% treated sewage water dominated all other water mixtures giving the highest alfalfa fodder yield. On the other hand the irrigation water quality also had a significant effect on total coliform (TCB) and total fecal bacteria (TFB) in Sudan grass. Number of bacteria increased successively with increase in percentage of sewage water in the mixture with 100% sewage water with the highest bacterial number, then 75% drainage water + 25% normal water, 50% wastewater + 50% normal water, then 25% wastewater + 7% normal water and 100% normal water with the least bacteria.

V. Conclusion

The use of Sudan grass irrigation with treated sewage water mixed with normal water at different rates significantly increased Sudan grass dry forage yield and its components. Application of the mixed sewage effluent 75% treated sewage water + 25% normal water and 50% treated sewage water + 50% normal water (with no significant difference between them) gave significant increase in Sudan grass dry forage yield and its components and caused some implications in the biological characteristics of the crop, and also 100% treated sewage water proved to be best compared to other mixtures and to irrigation with 100% normal water. They gave the maximum dry leaves weight, maximum dry stem weight, maximum dry shoot vegetative growth and the highest dry forage yield of Sudan grass compared to other sewage effluents and 100% normal water irrigation. Sudan grass yield components and dry forage yield were significantly the highest in the crop first cutting compared to the second and third cut. It is recommended to irrigate crops with 75% treated sewage water + 25% normal water and 50% treated sewage water + 50% normal water.

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AUTHOR'S PROFILE

Abdullatif A Neamatallah
Associate Professor Department of Environmental Sciences Faculty of Meteorology, Environment and Arid Land Agriculture King Abdulaziz University
Phone: 6952368 Ext. 62386
Email : anemalallah@kau.edu.sa

Education:
1981 : Bachelor degree from Biology, Science, KAU,
1994 : Master degree from Environmental Sciences, Meteorology and Environment, kau,
2005 : Doctorate degree from Environmental Health, Environmental Health, HWU, UK.

Courses:

- Office Phone: 6952368 Ext. 62386
- Email : anemalallah@kau.edu.sa
- Email2 : Alatif75@hotmail.com
- Email3 : Bioalan2000@yahoo.co.uk
- P.O. Box : 80208
- URL : http://anematallah.kau.edu.sa
- Fax : 026952364
- Mobile : 0506622322

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