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Sesbania (*Sesbania aegyptiaca* [Poir]) Agroforestry Using Industrial Drainage Water Bioremediation with Effective Microorganisms (EM)

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TWO EXPERIMENTS were conducted during the 2008 and 2009 summer seasons to investigate the effect of different water quality (Nile water, untreated industrial derange and industrial drainage bio-remediated with Effective Microorganisms (EM)), and two plant spacing (45 and 60 cm between plants) and Effective Microorganisms foliar application (0, 20 and 40 ppm) in addition to their interactions on Sesbania (*Sesbania aegyptiaca* [Poir]) growth, productivity and water quality. Sesbania studied growth characters included plant height, number of second branches, second branches fresh and dry weights, main stem diameter, weight of main stem, branching level, crude protein and crude fiber . The studied water quality indicators included (ph., Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)). Results indicated that the industrial drainage water bioremediated with EM improved the industrial drainage properties significantly. The irrigation with Nile water gave the highest observations of Sesbania growth characters, followed by industrial drainage bio-remediated with EM and the untreated industrial derange, respectively. Concerning plant spacing the highest Sesbania growth characters obtained at 60 cm between plants except 2*nd* branches fresh and dry weights and crude protein which gave the highest observations at 45 cm distance. Similar, trend was obtained from applying EM as a foliar treatment as 20 ppm.

The second order and third order interactions were mostly significant. The superior interaction concerning Sesbania growth was obtained by (EM industrial water bioremediated with EM × 60 cm line spacing × 20 ppm EM foliar application).

Keywords: Biological drainage, Combating desertification, CO_2 emissions, Fresh water conservation, Odor control, Plant spacing, Water quality.

Nile water conservation is one of the Egyptian national priorities nowadays, not only because it is the main source of fresh water that Egypt has, but also it is finite for many reasons political, social or environmental; that may introduced the country to drought (Anonymous, 2005). As the Nile water is managed in Egypt as a closed basin, the pollutants are concentrating rapidly within time, therefore special care should be taken to stop this decay, which negatively affects the environment (Anonymous, 2005).

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Sugar factories and consequently MDF wood and Paper industries are located intensively in Upper Egypt where the sugar cane is the main cash crop. Unfortunately, these industries are consuming enormous quantity of Nile water, either during the industrial process or to translocate the bagasse with 10% concentration from sugar factories after the sugar extraction towards the MDF or Paper factories. Yet, the most dramatic part happens when this highly polluted industrial drainage is flushed back into the Nile basin because of the absence of the separated industrial drainage as an outcome of the poor planned industrial revolution in the middle of last century (1950s).

Sesbania aegyptiaca (formerly *Sesbania sesban*) grows widely as a wild legume plant under the Egyptian conditions. It is a multi-branched, soft-wooded tree that grows rapidly; It is useful for fodder, green manure, absorbs CO_2 emissions form the industrial sector and consumes large quantity of irrigation water as biological drainage (Singh, 1990). Cultivation of *Sesbania aegyptiaca* in marginal soils can be considered as one of the effective solutions of the feed crisis as it has a good quality feed for small ruminant (Reed *et al.,* 1990 and El-Morsy, 2009). This species has long been used for soil improvement in India and Africa. Recent interests in such multipurpose, nitrogen fixing trees made this species to be collected, studied , recommended for fodder "banks", alley cropping and as wind breaks, thus combating desertification (Dommergues, 1981 and El-Morsy, 2009).

The effective microorganisms (EM), is a formulas that contain a mixture of microorganisms groups that Includes: lactic acid bacteria, photosynthetic bacteria, yeasts, actinomycetes and fermenting fungi. The basis for using these EM species of microorganisms is that they contain various organic acids due to the presence of lactic acid bacteria, which secrete organic acids, enzymes, antioxidants, and metallic chelates (Higa & Chinen, 1998). The creation of an antioxidant environment by EM assists in the enhancement of the solid-liquid separation, which is the foundation for cleaning waste water (Higa & Chinen, 1998 and Zuraini *et al.,* 2010).

This study aimed to use the EM bioremediation industrial drainage of Naga Hammady MDF Co. in Sesbania agroforestry as a biological drainage model. Consequently, to use its main stem in MDF manufacture and 2^{nd} branches as a green fodder for the small ruminates in the Upper Egypt region, thus conserve the Nile water.

Material and Methods

Two field experiments were conducted during the 2008 and 2009 summer seasons at Naga Hamady MDF Co. – Deshna – Upper Egypt to investigate the effect of bioremediation with EM on water quality indicators (pH, BOD and COD) of industrial drainage, compared with Nile water and untreated industrial water. The water quality indicators were estimated following the methods of A.P.H.A. (1995). Effective microorganisms (EM) used in this study was kindly obtained from Egyptian Environmental Affairs Agency (EEAA). EM $_{2nd}$ ^{TM}

solution is a brownish liquid with a pleasant odor and sweet sour taste with a pH of 2.8 and stored in area with minimal temperature fluctuations so not to affect the survival of microorganisms. EM culture contained a mixture of lactic acid bacteria, phototrophic bacteria, yeast, actinomycetes and fermenting fungi.

The EM $_{2nd}$ ^{TM} was injected in the main water reservoir of the waste water treatment station as biological remediation, with 10 liters of EM for each 10 cubic meters of drainage water during the aeration process (normally takes 8 -12 hr), which helped in odor control, prevent the decay of bagasse and drainage bioremediation.

Moreover, the effect of three irrigation water quality treatments (untreated industrial drainage, industrial drainage bioremediated with EM and Nile water as control), line spacing (45 and 60 cm apart) and foliar application with EM_1 (20, 40 ppm and water as control) once at 30 days after transplanting date was studied, in addition to their interaction on Sesbania some growth characters and chemical composition were also studied.

Treatments were arranged in the split split plot design in three replicates, where the water quality treatments occupied the main plots, line spacing the sub main plots and EM foliar application in the sub-sub ones, respectively, where the plot area was 5×6 m ($30m^2$).

Sesbania (*Sesbania aegyptiaca* [Poir]) seeds were obtained from Ministry of Agriculture and Land Reclamation, then directly sown in the soil, as two seeds per hill at 15^{th} of March in both seasons at distance of 45 cm. Plants were thinned 25 days after sowing date to one plant/hill. When the plants reached 75 cm height they were pruned continuously by removing the 2^{nd} branches, while the 2^{nd} branches in the upper third of the main stem were left to grow for photosynthesis and plant growth (later were used as green fodder for small ruminates).

The physical analysis of the experimental soil (Black, 1965) indicated that it was sandy clay loam soil as (sand 53.00, clay 28.26 and silt 18.74) with pH 8.4. During soil preparation calcium super phosphate 16% P_2O at the rate15 kg P_2O/ fed was added, while ammonium nitrate 33.5% N at the rate 120 kg/fed was added in five equal dosage; the first when the plants reached 25 cm , then once every 45 days. When the plants reached 1.5 – 2 m, potassium sulfate 40% K_2O was added at the rate 20 kg K_2O/fed. The other common agricultural practices were followed.

Samples were taken six months after sowing date over two seasons to study growth characters, *i.e.* plant height (cm), number of 2^{nd} branches /plant, 2^{nd} branches fresh weight (ton/ fed), 2^{nd} branches dry weight (ton/ fed), height of branching (cm), main stem perimeter (cm), main stem weight (kg), main stem diameter (cm), crude protein was measured by Kjeldahl procedure (CP%= N%×6.25) following the method described by Paech & Tracey (1956) and crude fiber (%) was determined by acid detergent (AOAC, 1990).

The obtained data from the two seasons were prepared and subjected to the statistical analysis according to procedure outlined by Snedecor & Cochran (1980), while Duncan's multiple range test was used to verify the significant differences between treatments means as described by Duncan (1955).

Results and Discussion

Effect of EM bioremediation on water quality

Results presented in Table 1 showed the effect of EM bioremediation on some water quality indicators, *i.e.* BOD, COD and pH of industrial drainage water compared with the Nile water and untreated industrial drainage water. It is clear that EM bioremediation improved the industrial drainage water quality to be near to the river Nile water quality, consequently it will be ready to be used as irrigation water. As EM consists of various species of microorganisms is that they contain various organic acids due to the presence of lactic acid bacteria, which secrete organic acids, enzymes, antioxidants and metallic chelates. The creation of an antioxidant environment by EM assists in the enhancement of the solid-liquid separation, which is the foundation for cleaning water thus; decrease the BOD, COD and pH values of industrial drainage water. This is agreeing with what had reported by Elewa *et al*. (2009), Higa (2000) and El Karamany *et al*. (2013).

TABLE 1. Effect of EM bioremediation on industrial drainage water quality compared with Nile water and untreated drainage (average of 2008-2009 spring growing seasons).

Water quality indicators	Irrigation water quality		
	Untreated industrial drainage water	**EM-bioremediation industrial drainage water**	**Nile water**
BOD (mg/l)	105 a	3.7 b	2.17 c
COD (mg/l)	208 a	12 b	5.7 c
pH. (units)	9.4 a	7.3 b	7.0 c

*Means having similar letters in the same row are not statistically differed at P ≥ 0.05.

Effect of water quality on Sesbania studied characters

Data illustrated in Table 2 indicted that all the Sesbania studied characters increased significantly by using the Nile water for irrigation as a control treatment followed by the industrial drainage water bioremediated with EM and the untreated industrial water, respectively. Nile water increased plant height (cm), number of 2*nd* branches /plant, fresh and dry weights of 2*nd* branches (ton/fed), height of branching (cm), main stem perimeter (cm), main stem weight (kg), main stem diameter (cm), crude fiber (%), this may be due to the Nile water quality (as a fresh water) has the features that enhance the absorbance of water and nutrients by the plants. It provided perfect environmental conditions for the soil microflora and roots to be established (Sandra, 2000 and Chauhan *et al.*, 2007). In regard to crude protein (%) the highest values were obtained from the irrigation with the untreated industrial water, as the plant need to readjust its osmotic potential to absorb water form high osmotic potential water (*i.e.* waste water), therefore some osmoregulators such as soluble sugars and amino acids like proline hence total protein should be released into the cell sap in order to compensate the plant osmotic potential (Devieln, 1969; Abdel-Ati, 2006 and Swaefy & Basuny, 2011).

TABLE 2. Effect of irrigation water quality on the studied characters of Sesbania grown under Deshna conditions (average of 2008-2009 summer growing seasons).

Studied characters	Irrigation water quality		
	Untreated industrial drainage water	EM-Bioremediation industrial drainage water	Nile water
Plant height (cm)	121.5 c	133.8 b	172.3 a
No. of 2nd branches /plant	8.59 c	10.45 b	11.82 a
2nd branches fresh weight (ton/ fed)	5.80 c	6.31 b	6.77 a
2nd branches dry weight (ton/ fed)	1.18 c	1.33 b	1.57 a
Height of branching (cm)	21.27 c	30.95 b	41.48 a
Main stem perimeter (cm)	10.14 c	17.44 b	22.96 a
Main stem weight (kg)	17.72 c	19.39 b	23.91 a
Main stem diameter (cm)	3.23 c	5.55 b	7.31 a
Crude protein (%)	23.94 a	23.38 b	23.28 b
Crude fiber (%)	21.78 c	23.41 b	23.89 a

*Means having similar letters in the same row are not statistically differed at $P \geq 0.05$.

When taking into account that the industrial drainage water is full of molecules of sugars and fibers of bagasse; coming from the sugar factory that elevates both biological oxygen demand "BOD" and chemical oxygen demand "COD" of the drainage water consequently degrade its quality to be hazardous to the environment. Once EM is applied into such waste water, it readjusts the BOD, COD and prevents the decay of the bagasse fibers by the rotten microflora, hence prevent the elevation of the C/N ratio in the soil as the water applied into it. Compared with the untreated waste water, this turned the EM bioremediation waste water to be like a liquid biofertilizer that can use the present pollutants as production inputs, and this is the fascination of EM technology as Higa (2000) had reported.

Despite the Nile water which is the control treatment in this study, surpassed the other two water quality in enhancing Sesbania growth and productivity. Yet, the usage of the industrial water bioremediation with EM for Sesbania irrigation and growth, is adding an economic value to the biological drainage to provide a successful model that conserve the fresh water basin from discharge millions of cubic meters of untreated industrial drainage that will magnify the problem if the fresh water is finite despite it is renewable. In another word, the less fresh water we have the more pollution we get by flushing the same cubic meters of drainage into water basins. This is agree with what reported by Sandra (2000).

Effect of line spacing on Sesbania studied characters

Data presented in Table 3 showed the effect of line spacing on studied characters of Sesbania. Results indicated that the fresh and dry weights of 2^{nd} branches (ton/fed) in addition to crude protein (%) were increased significantly at 45 cm line spacing. While at 60 cm line spacing each of plant height (cm), No. of 2^{nd} branches /plant, height of branching (cm), main stem perimeter (cm), main stem weight (kg), main stem diameter (cm), crude fiber (%) were increased significantly. Superiority of low density plants per area unit (60 cm apart) the high density ones (45 cm apart) may be due to minimizing the competition between the plants to get the environmental factors that important for grow and production, as reported by El-Morsy (2009).

TABLE 3. Effect of line spacing on the studied characters of Sesbania grown under Deshna conditions (average of 2008-2009 summer growing seasons).

Studied characters	Line spacing	
	45 cm apart	60 cm apart
Plant height (cm)	133.7 b	151.4 a
No. of 2^{nd} branches /plant	9.83 b	10.78 a
2^{nd} branches fresh weight (ton/ fed)	6.39 a	6.20 b
2^{nd} branches dry weight (ton/ fed)	1.40 a	1.32 b
Height of branching (cm)	29.27 b	33.19 a
Main stem perimeter (cm)	15.40 b	18.33 a
Main stem weight (kg)	19.04 b	21.65 a
Main stem diameter (cm)	4.89 b	5.84 a
Crude protein (%)	23.72 a	23.28 b
Crude fiber (%)	22.85 b	23.20 a

*Means having similar letters in the same row are not statistically differed at P≥0.05.

Effect of foliar application with EM on Sesbania studied characters

As presented in Table 4 the foliar of application with EM enhanced significantly all the studied characters of Sesbania compared with the control treatment (water). Foliar application of EM with 20 ppm exceeded significantly the foliar application with 40 ppm in 2^{nd} branches dry weight (ton/fed), height of branching (cm), main stem perimeter and diameter (cm) and crude protein (%).

TABLE 4. Effect of foliar application with EM on the studied characters of Sesbania grown under Deshna conditions (average of 2008-2009 summer growing seasons).

Studied characters	Foliar Application with EM		
	Water (control)	EM 20ppm	EM 40ppm
Plant height (cm)	131.9 b	147.9 a	147.8 a
No. of 2*nd* branches /plant	9.87 b	10.55 a	10.50 a
2*nd* branches fresh weight (ton/ fed)	6.19 c	6.34 b	6.35 a
2*nd* branches dry weight (ton/ fed)	1.30 c	1.40 a	1.38 b
Height of branching (cm)	29.04 c	32.68 a	31.98 b
Main stem perimeter (cm)	15.48 c	17.65 a	17.41 b
Main stem weight (kg)	19 c	20.62 b	21.40 a
Main stem diameter (cm)	4.93 c	5.62 a	5.54 b
Crude protein (%)	23.30 b	24.47 a	22.73 c
Crude fiber (%)	23.35 a	22.51 b	23.23 a

*Means having similar letters in the same row are not statistically differed at P≥0.05.

However, the 40 ppm concentration surpassed in 2*nd* branches fresh weight (ton/fed), main stem weight (g) and crude fiber (%). This may be due to the high concentration of the plant growth promoters like IAA and GA_3 that existed in EM as reported by Higa (1993). Consequently, when the EM concentration elevated up to 40 ppm the main stem growth was enhanced more than the 2*nd* branches as clear specifically in the main steam weight (kg) and the crude fiber (%), the vice versa at 20 ppm.

Effect of the interaction between water quality, line spacing and foliar application with EM on Sesbania studied characters

The interaction between water quality and line spacing

As presented in Table 5 the interaction between water quality and line spacing increased significantly all the studied characters of Sesbania. The highest observations were obtained from the group of interaction between (Nile water × line spacing), followed by (EM bioremediation industrial drainage water × line spacing) and (Untreated bioremediation industrial drainage water× line spacing), respectively. Highest values of all studied characters were recorded from the interaction (Nile water × 60 cm apart), (Nile water × 45 cm apart), (EM bioremediation industrial drainage water × 60 cm apart), (EM bioremediation industrial drainage water × 45 cm apart), (Untreated bioremediation industrial drainage water × 45 cm apart) and (Untreated bioremediation industrial drainage water × 60 cm apart), respectively. This was true for all the studied characters except for the crude fiber (%). Despite the group of interaction (Nile water × line spacing) surpassed the other groups of interactions yet, the improvement that happened in the quality of the industrial water as a result of the bioremediation with EM, provides a significant capability to the group of interaction between

(EM bioremediation industrial drainage water × line spacing) to be used for Sesbania agriculture, in addition to the viability for biological drainage that conserve Nile water basin from various pollutants that seriously affect its aquatic ecosystem. Moreover, it conserves the Nile fresh water for the municipal use particularly it is finite for the overpopulation and decline of the river water resources either for political or environmental purposes. This is highly appreciated if take into consideration that the Nile is the main source of fresh water that Egypt has. For the all abovementioned and under this condition the group (EM bioremediation industrial drainage water × 60 cm line spacing) would be the promised treatment, and this would agree with what Sandra (2000) was reported.

TABLE 5. Effect of the interaction between water quality and line spacing on the studied characters of Sesbania grown under Deshna conditions (average of 2008-2009 summer growing seasons).

Studied characters	**Untreated Industrial drainage water**		**EM-bioremediation industrial drainage water**		**Nile water**	
	45 cm apart	**60 cm apart**	**45 cm apart**	**60 cm apart**	**45 cm apart**	**60 cm apart**
Plant height (cm)	116.7d	126.2cd	131.1c	136.5c	153.2b	191.4a
No. of 2nd branches /plant	7.8 f	9.4 e	10.2 d	10.7 c	11.5 b	12.2 a
2nd branches fresh weight (ton/ fed)	5.7 f	5.9 e	6.3 d	6.4 c	6.7 b	6.9 a
2nd branches dry weight (ton/ fed)	1.1f	1.2 e	1.3 d	1.4 c	1.5 b	1.6 a
Height of branching (cm)	19 f	23.5 e	28.7 d	33.2 c	40.1 b	42.9 a
Main stem perimeter (cm)	8.68 f	11.62 e	15.96d	18.90 c	21.49b	24.43a
Main stem weight (kg)	17.4 c	18 c	19.2bc	19.6bc	20.4b	27.4a
Main stem diameter (cm)	2.73f	3.71e	5.11d	6.02c	6.86b	7.77a
Crude protein (%)	24.5a	23.4ab	24.2a	22.3b	22.4b	24.2a
Crude fiber (%)	21.6c	21.9c	22.8b	24.1a	24.1a	23.6a

*Means having similar letters in the same row are not statistically differed at P≥0.05.

The interaction between water quality and foliar application with EM

As cleared in Table 6 the group of interaction (Nile water × foliar application with EM) surpassed all the other groups of interactions in all Sesbania studied characters significantly. This was true except for crude fiber; the highest record was obtained from the interaction (Nile water × foliar application with water) while the crude protein (%); showed insignificant response. This may be caused by the accumulative effects of Nile water positive features for Sesbania growth as reported by Chauhan *et al*. (2007) and EM promoting effects as indicated by Higa (2000).

TABLE 6. Effect of the interaction between water quality and foliar application with EM on the studied characters of Sesbania grown under Deshna conditions (average of 2008-2009 summer growing seasons).

Studied characters	Untreated industrial drainage water			EM-bioremediation industrial drainage water			Nile water		
	Water (control)	EM 20ppm	EM 40ppm	Water (control)	EM 20ppm	EM 40ppm	Water (control)	EM 20ppm	EM 40ppm
Plant height (cm)	113.8d	125.8cd	124.9cd	132.4c	134.6c	134.4c	149.6b	183.4a	184a
No. of 2nd branches /plant	7.8e	9.2d	8.8d	10.4c	10.4c	10.5c	11.4b	12.1a	12a
2nd branches fresh weight (ton/ fed)	5.7e	5.9d	5.9d	6.3c	6.3c	6.3c	6.6b	6.9a	6.8a
2nd branches dry weight (ton/ fed)	1.1f	1.3d	1.2e	1.3c	1.3c	1.3c	1.5b	1.6a	1.6a
Height of branching (cm)	18.2e	23.4d	22.3d	30.1c	31.1c	31.7c	38.9b	43.6a	42a
Main stem perimeter (cm)	8.19e	10.92d	11.72d	16.94c	17.78c	17.64c	21.28b	24.22a	23.31a
Main stem weight (kg)	17.4b	17.9b	17.8b	19.4b	19.3b	19.5b	20.3b	24.6a	26.9a
Main stem diameter (cm)	2.59e	3.5d	3.57d	5.39c	5.67c	5.6 c	6.79 b	7.7a	7.42a
Crude protein (%)	24.7a	24.7a	22.4bc	23.8ab	24.6a	21.5c	21.4c	24.1ab	24.3ab
Crude fiber (%)	21.5d	21.7d	22.1d	23.7b	22.8c	23.7b	24.8a	23 c	23.9 b

*Means having similar letters in the same row are not statistically differed at $P \geq 0.05$.

The interaction between line spacing and foliar application with EM

Results illustrated in Table 7 indicated that the group of interaction (60 cm line spacing apart × foliar application with EM) surpassed the other group (45 cm line spacing apart × foliar application with EM). The superior observation was obtained from (60 cm line spacing × 40 ppm foliar application with EM) in all the studied characters except crude protein (%) where the highest value was obtained from (45 cm line spacing apart × 20 ppm foliar application with EM). This may be due to the integrated effects between reducing the competition among the plants apropos the environmental factors that is important for growth and production in case of exceeding the line spacing into 60 cm apart, as reported by El-Morsy (2009) and the promoting effects of EM as indicated by Higa (2000).

The interaction between water quality , line spacing and foliar application with EM

Data in Table 8 indicated the effect of the interaction between water quality, line spacing and the foliar application with EM on studied characters of Sesbania. Results illustrated that the interaction (Nile water × 60 cm line spacing × 40 ppm EM foliar application) was the surpassed treatment between the others. This was true for all the studied characters except for crude fiber where the highest observation was obtained from the interaction (Nile water × 45 cm line spacing × 0 ppm EM foliar application). Despite of this, the interaction (EM bioremediation industrial drainage water × 60 cm line spacing × 40 ppm EM foliar application) seemed to be the promised under the experiment condition because it provides a relatively appropriate Sesbania growth for the two use purpose, *i.e* the main stem for MDF wood production and the 2nd branches as a fodder crop for the small ruminants. In addition, it provides a perfect chance for the biological drainage for the industrial discharge water, hence conserve the Nile basin from extremely dangerous pollutants, consequently safe the limited fresh water for the municipal use. In another word, it accomplishes the study targets perfectly.

TABLE 7. Effect of the interaction between line spacing and foliar application with EM on the studied characters of Sesbania grown under Deshna conditions (average of 2008-2009 summer growing seasons).

Studied characters	Line spacing 45 cm apart			Line spacing 60 cm apart		
	Water (control)	EM 20ppm	EM 40ppm	Water (control)	EM 20ppm	EM 40ppm
Plant height (cm)	123.1 d	144.5bc	133.4cd	140.7bc	151.3ab	162.1a
No. of 2nd branches /plant	9.4c	10.3b	9.8c	10.3b	10.8a	11.1a
2nd branches fresh weight (ton/ fed)	6.1d	6.3b	6.2c	6.3b	6.3b	6.5a
2nd branches dry weight (ton/ fed)	1.3c	1.4b	1.3c	1.3c	1.4b	1.5a
Height of branching (cm)	26.6d	33.2b	28d	31.5c	32.2bc	36a
Main stem perimeter (cm)	13.9e	17.4bc	14.8d	17.1c	17.9b	20.0a
Main stem weight (kg)	18.7c	19.4bc	19c	19.3bc	21.8ab	23.8a
Main stem diameter (cm)	4.4e	5.5bc	4.7d	5.5bc	5.7b	6.4a
Crude protein (%)	22.6bc	24.4a	24.1ab	24ab	24.5a	21.4c
Crude fiber (%)	23.1ab	22.5b	23ab	23.6a	22.5b	23.5a

*Means having similar letters in the same row are not statistically differed at $P \geq 0.05$.

Conclusion

In order to conserve the Nile water which is inadequate main source of fresh water in Egypt; prevention of discharge of waste water into the Nile basin is a must. Biological drainage one of these eco-technologies that provide an economic value added to the drainage to produce a valuable commodity with environmental conservation. Sesbania is one of the fast growing shrubs that can consume large quantities of drainage water. Its main stem can be used for MDF wood manufacture when the factory runs out of bagasse which is the main industrial raw material. The second branches can be used as green fodder for the small ruminates during the middle of summer to fit the green fodders gap particularly in the extremely hot summer of Upper Egypt. EM technology can provide an economic and environmental treatment for the industrial drainage to make it ready for use as bio fertile irrigation water. In order to gather all the above mentioned ideas, a forest of Sesbania should be agriculture in 60 cm line spacing apart, and be irrigated with EM bioremediation industrial drainage water and foliar application of EM with 20 ppm concentration should be applied.

TABLE 8. Effect of the interaction between water quality, line spacing and foliar application with EM on the studied characters of Sesbania grown under Deshna conditions (average of 2008-2009 summer growing seasons).

Studied characters	Untreated industrial drainage water		EM-bioremediation industrial drainage water		Nile water		Foliar appli-cation with EM
	45 cm apart	60 cm apart	45 cm apart	60 cm apart	45 cm apart	60 cm apart	
Plant height (cm)	102.3Cf	125.3Be	127.7Ad	137Bc	139.4Cb	159.7Ca	Control
	125.5Ae	126ABe	135.9Bc	133.4Cd	172.2Ab	194.6Ba	20ppm
	122.5 Bf	127.4Ae	129.7Ad	139.2Ac	148Bb	219.9Aa	40ppm
No. of 2nd branches /plant	7.1 Cf	8.4 Be	10 Bd	10.8 Ac	11.2 Cb	11.6 Ca	Control
	8.6 Af	9.8 Ae	10.5 Ac	10.3 Bd	11.8 Ab	12.4 Ba	20ppm
	7.9 Bf	9.8 Ae	10.1 Bd	11 Ac	11.4 Bb	12.6 Aa	40ppm
2nd branches fresh weight (ton/ fed)	5.5 Cf	5.8 Ce	6.2 Bd	6.4 Bc	6.5 Cb	6.7 Ca	Control
	5.8 Af	5.9 Be	6.3 Ac	6.2 Cd	6.8 Ab	6.9 Ba	20ppm
	5.7 Bf	6.1 Ae	6.2 Bd	6.5 Ac	6.6 Bb	7.1 Aa	40ppm
2nd branches dry weight (ton/ fed)	1.0 Ce	1.2 Bd	1.3 Ac	1.4 Ab	1.5 Ba	1.5 Ca	Control
	1.2 Ac	1.3 Ab	1.3 Ab	1.3 Bb	1.6 Aa	1.6 Ba	20ppm
	1.1 Be	1.3 Ad	1.3 Ad	1.4 Ac	1.5 Bb	1.7 Aa	40ppm
Height of branching (cm)	15.6 Cf	20.7 Ce	25.9 Cd	34.2 Bc	38.4 Bb	39.4 Ca	Control
	22.8 Ae	23.7 Bd	33.2 Ab	29 Cc	43.6 Aa	43.6 Ba	20ppm
	16.7 Bf	25.9 Ae	27 Bd	36.3 Ac	38.4 Bb	45.6 Aa	40ppm
Main stem perimeter (cm)	7.21 Ce	9.24 Cd	14.4 Cc	19.5 Ab	20.2 Bb	22.4 Ca	Control
	10.3 Af	11.6 Be	18.1 Ac	17.4 Bd	23.7 Ab	24.5 Ba	20ppm
	8.5 Bf	14 Ae	15.4 Bd	19.8 Ac	20.3 Bb	25.4 Aa	40ppm
Main stem weight (kg)	16.9 Cf	17.9 Be	19.1 Bd	19.6 Bc	20 Cb	20.5 Ca	Control
	17.9 Ae	17.9 Be	19.5 Ac	19.2 Cd	20.9 Ab	28.3 Ba	20ppm
	17.5 Bf	18.2 Ae	19.1 Bd	19.9 Ac	20.4 Bb	33.4 Aa	40ppm
Main stem diameter (cm)	2.3 Cf	2.9 Ce	4.6 Cd	6.2 Ac	6.4 Bb	7.1 Ca	Control
	3.3 Af	3.7 Be	5.7 Ac	5.5 Bd	7.6 Ab	7.9 Ba	20ppm
	2.7 Bf	4.5 Ae	4.9 Bd	6.3 Ac	6.5 Bb	8.3 Aa	40ppm
Crude protein (%)	24.5 Bb	25 Aa	24.2 Bc	23.3 Be	19.3 Cf	23.6Cd	Control
	24.7 Aa	24.6 Bb	24.4 Ac	24.4 Ac	24.1 Ad	24.1 Bd	20ppm
	24.4 Cb	20.4Ce	24.1 Bc	18.9 Cf	23.8 Bd	24.7 Aa	40ppm
Crude fiber (%)	21.5 Ae	21.5 Ce	22.8 Ad	24.6 Ac	24.9 Aa	24.7 Ab	Control
	21.8 Cd	21.6 Bel	22.8 Ac	22.9 Cb	22.9 Cb	23.1 Ca	20ppm
	21.6 Be	22.6 Ad	22.8 Ac	24.6 Ba	24.6 Ba	23.2 Bb	40ppm

*For each studied character means having similar capital letters in the same column and similar small letters in the same row are not statistically differed at P≥0.05.

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زراعة غابة من السيسبان بإستخدام مياة الصرف الصناعي المعالج بالكائنات الحية الفعالة (EM)

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أقيمت تجربتان خلال الموسمين الصيفيين ٢٠٠٨ ، ٢٠٠٩ لدراسة تأثير نوعية مياة الري (مياه نهر النيل ، مياه صرف صناعي غير معالج ، و مياه صرف صناعي معالج بالكائنات الدقيقة النافعة) ، و مسافات الزراعة (٤٥ سم ، ٦٠ سم)، و الرش بتركيزات مختلفة من الكائنات الدقيقة النافعة (صفر ، ٢٠ ، ٤٠ جزء في المليون) ، إضافة إلى تفاعل تلك العوامل مع بعضها البعض ، وذلك على بعض صفات النمو للسيسبان وهي طول النبات ، عدد الأفرع الثانوية ، الوزن الغض والجاف للأفرع الثانوية ، قطر و محيط الساق الرئيسي، وزن الساق الرئيسي ، إرتفاع التفريع و النسبة المئوية للبروتين الخام والألياف. إضافة إلى تقدير بعض مؤشرات نوعية المياة مثل (رقم الحموضة ، الأحتياج الكيميائي للأكسجين ، الأحتياج الحيوى للأكسجين).

أظهرت النتائج أن المعاملة الحيوية لمياة الصرف بالكائنات الحية الدقيقة النافعة قد حسنت من نوعية مياة الصرف الصناعى معنويا مقارنة بمياة الصرف الصناعي الغير معامل . تم الحصول على أفضل نتائج لنمو السيسبان من الري بمياه النيل ثم مياة الصرف الصناعي المعالج بالكائنات الحية الدقيقة النافعة ، ثم مياه الصرف الصناعى الغير معالج على الترتيب.

بالنسبة لمسافات الزراعة تم التوصل إلي افضل النتائج بالنسبة لنموالسيسبان عند الزراعة علي مسافات ٦٠ سم بين الخطوط ، عدا الوزن الغض و الجاف و النسبة المئوية للبروتين التى أعطت أعلى النتائج مع ٤٥ سم بين الخطوط.

بالنسبة لمعاملة الرش بالكائنات الحية الدقيقة النافعة فقد تم التوصل إلى أفضل النتائج مع الرش بتركيز ٢٠ جزء في المليون .

كانت أفضل التفاعلات الثنائية والثلاثية بين العوامل معنوية ، في حين تفوق التفاعل بين (الرى بمياه صرف صناعي معالج بالكائنات الدقيقة النافعة × الزراعة على مسافات خطوط ٦٠ سم × الرش بالكائنات الحية الدقيقة النافعة بتركيز ٢٠ جزء في المليون) على باقى التفاعلات بالنسبة لنتائج نمو السيسبان.