EFFECT OF TREATED INDUSTRIAL WASTEWATER REUSE ON THE GERMINATION AND SEEDLING GROWTH OF *LEUCAENA LEUCOCEPHALA*

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ABSTRACT

Denim laundry wastewater (Blue water) and olive mill wastewater are the top water polluting industries in Jordan in terms of discharge volume, chemical composition, and/or strength. Blue water if disposed untreated to municipal sewers or into surface waters, not only causes damage to aquatic life, but also to human beings, and the environment. The polluting properties of the olive mill wastewater are essentially due to their high organic content and their toxicities, especially those caused by their phenolic molecules. In this study, volcanic tuff as an adsorbent is used to treat blue water and olive mill wastewater. The effect of using volcanic tuff on a number of parameters, such as pH, COD, alkalinity, turbidity, phosphate, nitrate, electric conductivity, oil and grease, and suspended and total solid were evaluated. The treated effluents were reused, either separately or after mixing at different proportions, for the irrigation of *leucaena leucocephala (LL)*. The effect of using these treated wastewaters on the germination and seedling growth of this plant was evaluated. The results indicated that mixing treated blue water and treated olive mill wastewater at different ratios produced higher morphological parameters than the use of treated blue water or treated olive mill wastewater without mixing. The highest germination percentage was scored for the mixture of blue water and olive mill wastewater at 25% and 75%, respectively. This study is an attempt to utilize a low-cost and readily available adsorbent for the treatment of two industrial wastewaters and their reuse in irrigation.

Keywords: Blue water, OMW, Volcanic Tuff, Wastewater reuse, Germination.

1. Introduction

Industrial effluents could be reused if concentrations of all trace elements were found to be low and within guidelines for irrigation of agricultural crops (Shatanawi and Fayyad, 1996). Zeolite columns have been used to remove contaminants from olive mill wastewater (OMW) owing to the high sorption affinity of clinoptilolite on its active sites (Aly *et al*., 2014). Plant responses to irrigation with recycled water from different sources are different because of the different chemical constituents (Lopez *et al*., 2006). Irrigating plants with wastewater of salinity higher than the crop can tolerate will result in reduction in vegetative growth, yield loss and may decrease crop quality. Wastewater damage to plants is produced by a combination of several causes, including mainly osmotic injury and specific ion toxicity. Recently, Komilis *et al*. (2005) reported the phytotoxicity of polyphenols from untreated OMW on seed germination and plant growth. The present investigation was carried out to study the effect of treated wastewater from Denim laundry (Blue water) (BW) and olive mill wastewater (OMW) on seed germination and early growth of *Leucaena leucocephala (LL).*

2. Materials and methods

BW was collected from a denim laundry plant after receiving sedimentation and coagulation treatments. OMW samples were collected in plastic containers (20 L) from a three-phase olive mill and maintained at 4 °C. Wastewater analyses were conducted according to APHA (1995). OMW and BW were filtered through volcanic tuff sand (red tuff, Jabal Artin, Jordan). Volcanic tuff sand was sieved, washed with distilled water, and oven-dried. Effective size of this media was 0.45-0.55 mm, with uniformity coefficients of 1.7. A batch treatment process was considered using a 10-cm diameter column with 30-cm bed depth. A minimum flow rate of 120 ml/min was applied to achieve a hydraulic loading of 1.5 ml/cm^2.min with a contact period of 25–50 min.

Twenty five *(LL)* seeds were treated with 0.1% $HgCl_2$ to prevent surface fungal/bacterial contamination. The germination test (21 days) was carried out following a standard procedure in autoclaved petri-dishes (ISTA, 2003; Al-Tabbal and Ammary, 2014). Germination was defined by radical emergence (Crowe *et al.*, 2002), and the time for such emergence was recorded. Seedling length was calculated by adding the root length and shoot length. Seedling Vigour Index (VI) (Abul-Baki and Anderson, 1973) and phytotoxicity index (PI) (Mekki *et al*. 2007) were calculated using equations (1) and (2).

$$VI = \text{seedling length (cm)} \times \text{germination percentage} \quad (1)$$

$$PI = 1 - \frac{RLT}{RLC} \quad (2)$$

In equation (2), RLT is the root length in the treated seeds and RLC is the root length in the control treatment. PI value ranges between (0) and (1), in which a higher value means a negative (i.e., toxic) effect and a lower value means a positive (i.e., stimulatory) effect. The experiment was replicated four times and data were subjected to ANOVA using SAS software package (SAS, 2002). The differences between results were evaluated using Fisher's Least Square Difference tests (LSD) at 0.05 probability level.

3. Results and discussion

Table 1 shows BW and OMW characteristics before and after double pass treatment using volcanic tuff. The reduction in suspended solids as a result of filtration with volcanic tuff was 58 % for OMW which is important for germination and preventing of soil particle clogging. Volcanic tuff was inefficient in pH neutralization of both wastewaters. Three mixture proportions were proposed, mainly to achieve neutralization. By doing this other characteristics like salinity, COD, and phenols have also been alleviated. Five treatments T1 (Tap water), T2 (100% OMW), T3 (25% BW: 75% OMW), T4 (50% BW: 50% OMW), T5 (75% BW: 25% OMW), and T6 (100% BW) were compared.

Statistical analysis of the results showed that the overall germination percentage was significantly different between the different mixtures of BW and OMW. The highest germination percentage was scored by T1 (Tap water). Mixing gave higher germination percentage compared to using each wastewater without mixing (Fig. 1a).

Table 1: BM and OMW characteristics before and after treatment using volcanic tuff.

Parameter	BW		OMW	
	Initial conc.	Final Conc.	Initial Conc.	Final Conc.
pH	11.7	11.4	4.8	4.5
COD (mg/L)	401	147	81000	53000
Alkalinity (mg/l)	807	340	1200	830
PO4 (mg/L)	20	16	107	65
NO3 (mg/L)	66	39	17	11
EC (µS/cm)	3900	3100	22000	21200
TSS (mg/l)	540	370	7400	3100
Phenol (mg/l)	-	-	2300	1700
Turbidity	270	130	1100	342
Oil &Grease (mg/l)	7	5	4600	1900
Total Solids (mg/l)	3500	3300	24400	17400

Different mixtures of OMW and BW showed significant effects in *leucaena leucocephala (LL)* morphological parameters in the early growth stages except shoot dry weight/root dry weight (Fig.1 b - l). Irrigation of *(LL)* with various mixtures of BW and OMW caused a reduction in all morphological parameters in the early growth stages compared to tap water. The significant differences indicated that mixing gave higher shoot length (Fig. 1 b). Root and seedling length were higher in T3 and T4 compared to T5 or compared to irrigation with these types of wastewater alone (Fig 1 c, d). The significant effect of the different mixtures of effluent water on shoot and root length was reflected on the shoot fresh weight and dry weight and root dry weights (Fig 1 e-h). The highest dry weight of the root was obtained from T3 which was not significantly different than T1 (Tap water) while significantly greater than other mixtures or any effluent alone (Fig. 1 h). Shoot to root length was significantly higher for seedling under T5 and T6 compared to seedlings under other mixtures or wastewater alone (Fig. 1 i). Results depicted in (Fig. 1 k) showed that seedling vigor index was the highest for the control treatment T1. The lowest seedling vigor index value was observed for the treatment with OMW alone. Phytotoxicity index (PI) was significantly higher for seedling under T2 and T6 (Fig 1 l). This indicates that OMW and BW were very phytotoxic to *(LL)* seeds. However, phytotoxicity decreased significantly following mixing (T3 and T4).

It seems that OMW and BW had extreme values of some detrimental wastewater characteristics. These have been alleviated by mixing. The most obvious of these were the reduction of COD, salinity, phenols, oil and grease, and suspended solids of OMW, and the reduction of pH of BW. Other characteristics may have contributed to that also.

4. Conclusion

Results showed that mixing blue water (BW) and olive oil mill wastewater (OMW), especially, at ratio 25 %: 75% for *(LL)* produced higher germination percentage and seedling growth than OMW and BW without mixing. Mixing lowered COD, TDS, TSS, oil and grease, and phenol concentration of OMW, as well as reducing pH of BW. OMW or BW should not be applied pre-sowing due to lowering germination percentage.

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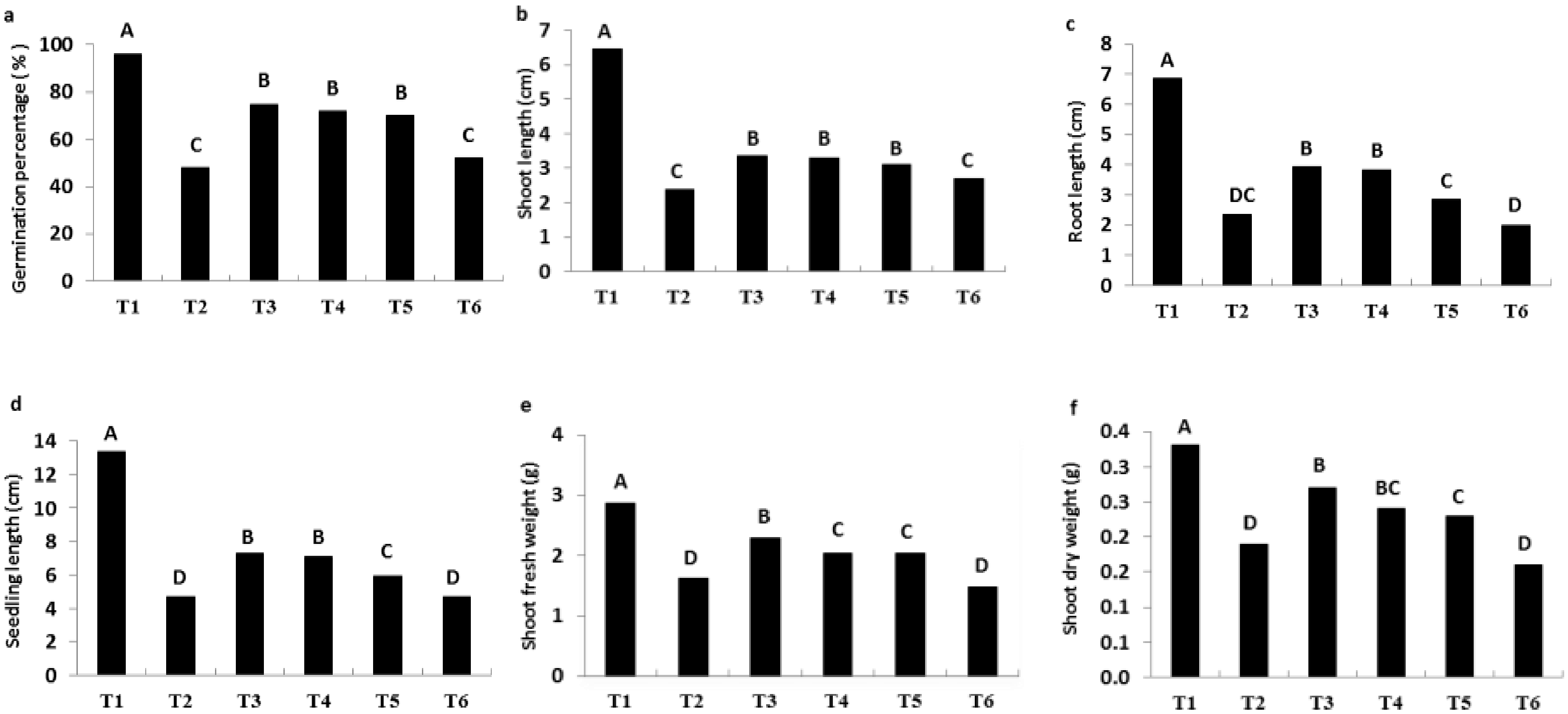
a
Germination percentage (%)
100
80
60
40
20
0
A
C
B
B
B
C
T1
T2
T3
T4
T5
T6
b
Shoot length (cm)
7
6
5
4
3
2
1
0
A
C
B
B
B
C
T1
T2
T3
T4
T5
T6
c
Root length (cm)
8
7
6
5
4
3
2
1
0
A
DC
B
B
C
D
T1
T2
T3
T4
T5
T6
d
Seedling length (cm)
14
12
10
8
6
4
2
0
A
D
B
B
C
D
T1
T2
T3
T4
T5
T6
e
Shoot fresh weight (g)
4
3
2
1
0
A
D
B
C
C
D
T1
T2
T3
T4
T5
T6
f
Shoot dry weight (g)
0.4
0.3
0.3
0.2
0.2
0.1
0.1
0.0
A
D
B
BC
C
D
T1
T2
T3
T4
T5
T6

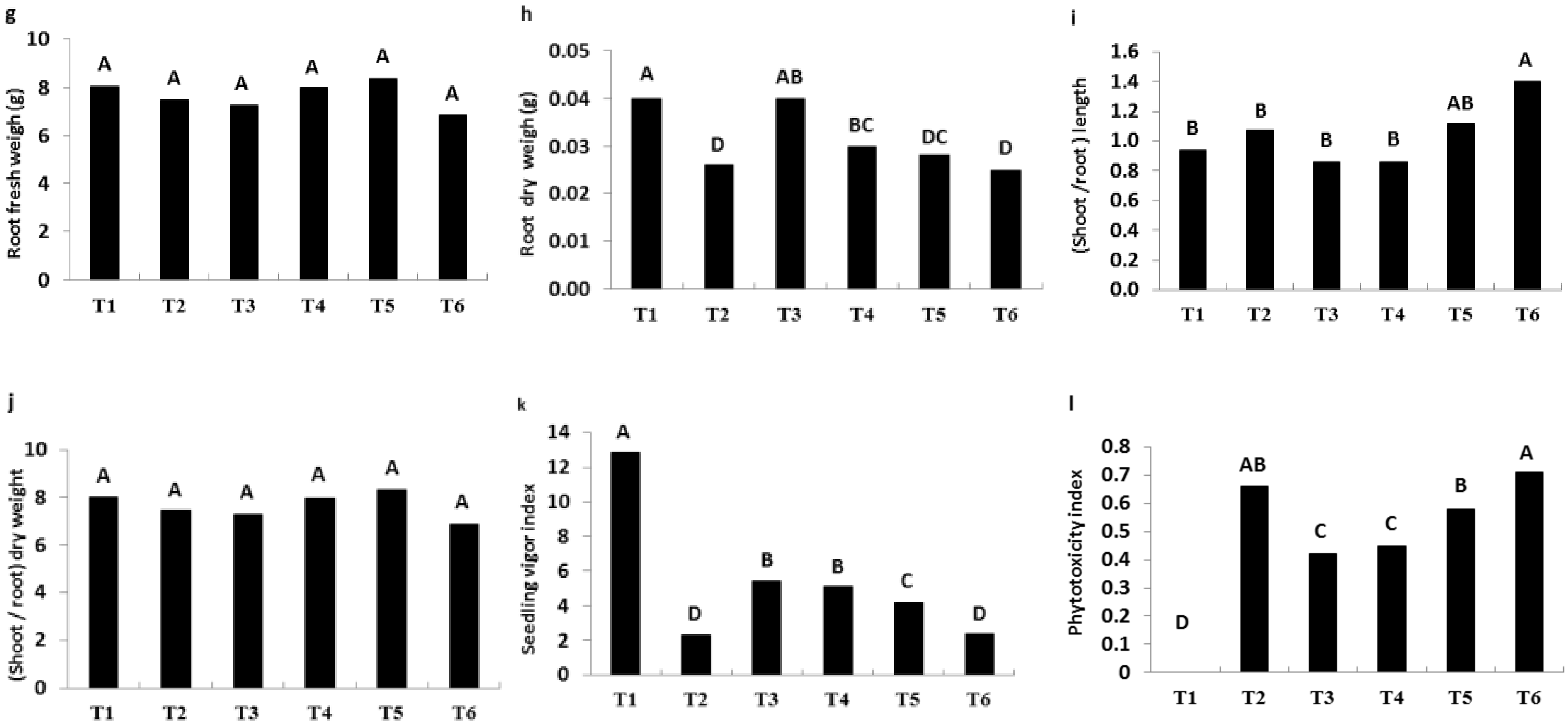

Figure 1: Effect of different mixtures of denim laundry wastewater (Blue water) and olive mill wastewater on *Leucaena leucocephala* germination percentage and seedling growth.