GROWTH AND METAL ACCUMULATION IN VARIOUS TREE SPECIES IN RESPONSE TO URBAN WASTE WATER IRRIGATION

By

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A study was designed to determine growth behaviour and uptake of Cd, Cr, and Cu metals by *Morus alba* and *Syzygium cuminii under* different sources of irrigation i.e. canal water (CW), domestic waste water (DW) and municipal waste water (MW). Both plant species showed higher growth rate when irrigated with DW followed by MW and CW. *Morus alba* attained maximum plant height (79.47%) under DW irrigation followed by MW (69.93% increase) and CW (65.83% increase). Similarly, Collar diameter increment in *Morus alba* was maximum (80%) under DW irrigation followed by (73.91%) under MW. Minimum collar diameter increment (65.87%) was noted under CW irrigation. *Syzygium cuminii* got maximum plant height (69.09% increase) under DW followed by (64.28% increase) MW and CW irrigation (57.02%). Collar diameter increment in *Syzygium cuminii* was maximum (73.03%) under DW irrigation followed by MW (67.54%) and CW (63.55%). Metal uptake by both species was higher under MW irrigation followed by DW and CW. Overall Cd contents were found similar in both species. Whereas, overall Cr contents were higher (189.64 mg kg^{-1}) in *Syzygium cuminii* as compared to *Morus alba* (154.45 mg kg^{-1}). As far as Cu contents are concerned, overall, Cu contents were 4 times higher (45.92 mg kg^{-1}) in *Syzygium cuminii* than *Morus alba*. Conclusively, *Syzygium cuminii* actively absorbed metals than *Morus alba*. This suggested that raising of *Morus alba* and *Syzygium cuminii* under waste water irrigation is hygienically safe.

Keywords : Fe : Ferous or Iron, Mn : Manganese, Co : Cobalt, Zn : Zinc, Pb : Lead, Ni : Nickle, LSD : Least Significant Difference

INTRODUCTION

Today, whole world is focusing on the problem of pollution (Misra and Dinesh, 1991). Urbanization and industrialization have resulted in huge quantity of waste water. Underground water is becoming contaminated with the seepage of municipal and industrial effluents. According to a recent study, 7000 cubic feet of municipal waste water is coming from Lahore, Faisalabad and Multan. This 7000 cusec per year is equivalent to 4.5 million acre feet of irrigation water. This is a huge volume which is being added to our total water resources (Saleem 2001). Although the sewage effluents are considered a source of organic matter and plant nutrients, yet municipal waste water effluents may contain a number of toxic elements, including heavy metal pollutants. These toxic elements are normally present in small amounts and hence they are called trace elements. Heavy metals (trace elements) as Fe, Cd, Cu, Cr, Mn, Co, Zn, Pb and Ni are normally present in municipal waste water but their concentrations are variable in time and space. Some of them may be removed during the treatment process but other will persist and could cause phytotoxic problems (Ghafoor *et al.,* 1994).

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A number of attempts have been made to increase the utilization of industrial and municipal waste water as irrigation source (Parveen *et al.,* 1996; Barnah and Das, 1997; Catrnus *et al.,* 1996 ; Asha and Katewa, 1999). However, very little work has been done to know the growth behaviour and heavy metals uptake by the trees in response to waste water irrigation. An attempt was made to determine growth and heavy metal uptake in *Morus alba* and *Syzygium cuminii.* These are common tree species growing in urban as well as rural areas. They are fast growing and valuable trees which are very popular social trees because of their multiple uses. These plants were grown by applying irrigation water originated from municipal and / or domestic source as well as canal water.

MATERIALS AND METHODS

The research work was designed to determine growth performance of various tree species and to asses, their potential to uptake various heavy metal pollutants under different irrigation regimes. Data regarding survival of tree species, their growth behaviour and uptake of heavy metals was recorded for one year from the date of planting. Present work mainly consisted of two parts; a) tree plantation in the field and irrigated by waste water. b) plant tissue analysis to determine different metals uptake.

The experiment was laid out in randomized complete block design (RCBD) comprising three treatments i.e. Municipal waste water (MW), Domestic waste water (DW) and Canal water (CW) with three replications. Total number of plants of each species used in whole of the experiment were=6 x 3 x 3 = 54. One year old seedlings of almost uniform size were planted in spring 2006 at an equal spacing of 2m x 2m from plant to plant and row to row (Hunter, 2001; Paramathma et al., 2003), with the stocking rate of 2500 trees per hectare. MW was obtained from WASA (Water and Sanitation Agency) drainage channel 1 passing besides the experimental area, Department of Agronomy, University of Agriculture Faisalabad. DW and MW were also available at the experimental site from the source located at University of Agriculture, Faisalabad. Plants were irrigated by flood irrigation through small channels made between the rows of trees. All plots were irrigated uniformly either with (MW), (DW) or (CW) at proper intervals.

Water samples from different irrigational sources were collected at the start of the experiment and after final harvesting. All samples were collected in polystyrene bottles of one litre capacity. Before collecting the samples, the bottles were washed properly and rinsed thoroughly several times with the same water. EC and pH of the samples were determined immediately after sample collection. Nitric acid (HNO_3) was added (2 ml L^{-1}) as a preservative in the sampling bottles for further analysis (Jones, 2001). Soil samples were also taken randomly from each plot prior to start of experiment and were taken to the laboratory for analysis. All experimental plots were irrigated with equal amount of water (Standard irrigation i.e. 1 irrigation = 3 acre inches). Initially, irrigation was applied at an interval of 4-7 days for the first growing season i.e. six months. After complete establishment, the same was repeated quarterly from the month of November to February. Irrigation intervals of 7-10 days were fixed for remaining months of the years. Field watering was done by flood irrigation system.

Data collection, Sampling, Chemical analysis and statistical analysis:
The parameters used in data collection were survival (%), Plant Height (m), Collar Diameter (cm) and uptake Cd, Cr and Cu by tree species (mg kg^{-1}). Growth measurements were taken: immediately after complete establishment of the plants; and, at termination of the experiment.

Plants samples were carried out for metal detection at the end of the experiment and were washed with 1% HCl and with distilled water to remove unwanted material and contaminants and were put on clean plastic sheet for drying. Plant samples were then oven-dried at 65-70 ^{0}C till constant weight. The dried plant material was ground to powder form Wiley Mill (1mm size) and was stored in separately in clean plastic bags for chemical analysis.

Plant samples were digested using the procedure adopted by US Salinity Lab. Staff (1954) for digestion 0.5 g ground plant material was taken in a conical flask using 15 ml di-acid mixture (HNO_3: $HClO_4$:: 2:1). The material was digested on hot plate until it was colorless. After digestion, the flask was left to cool and the flask volume was made 100 ml by adding deionized water and for further analysis was carried out with the help of atomic absorption spectrophotometer (Perkin Elmer Aanalyst 300). Plant samples were subjected to metal determination using the prescribed method AOAC, 1980). Various metals were detected in different samples.

Data were analyzed using software statistics ver. 8.1. The significance of the differences was recorded for three types of sources for growth assessment and metal detection by applying analysis of variance technique. Fisher's LSD test was applied with probability level ($P \geq 0.05$) to compare the mean differences.

RESULTS
The study was conducted to know the effect of different types of irrigational water i.e. Canal water, Domestic waste water and Municipal waste water on growth behavior and uptake of different metals by *Morus alba* and *Syzygium cuminii* from polluted water. The data recorded for different growth parameters and uptake of Cd, Cr and Cu was noted. Statistical interpretation of the analyzed data is given as under.

PLANT HEIGHT (%)
Data revealed that two tree species responded positively to waste water irrigation. Plant height of *Morus alba* was (71.74%) significantly higher than *Syzygium cuminii* (63.46%). Domestic waste water treatment resulted maximum plant height in both species (74.28%) followed by municipal waste water (67.10%) and canal water (61.42%). All individual treatments means (Table No. 1) were also statistically different. In *Morus alba* plants, maximum mean plant height was recorded (79.47%) when treated with domestic waste water followed by municipal waste water (69.93%) minimum plant height was recorded (65.83%) under canal water. Height increment in *Syzygium cuminii* (69.09 %) was maximum in domestic waste water followed by municipal waste water (64.28%) Minimum increase in height was (57.02%) recorded under canal water treatment.

Consequently, *Morus alba* attained relatively higher height and collar diameter under all irrigational resources as compared to the *Syzygium cuminii.*

Table No.1: Comparative means of Height and Collar Diameter

		CW	**DW**	**MW**	**Mean**	**LSD Values**
Height (%)	**M. alba**	65.83	79.47	69.93	71.74	4.2830
	S. cuminii	57.02	69.02	64.38	63.46	
	Mean	61.42	74.08	69010		
Diameter (%)	**M. alba**	65.87	80.44	73.91	73.41	
	S. cuminii	63.55	73.03	67.54	68.04	7.5585
	Mean	64.71	76.73	70.73		

COLLAR DIAMETER (%)

It is clear from (Table No.1) that the *Morus alba* had 73.41% addition in collar diameter. Whereas, collar diameter increment in *Syzygium cuminii* (68.04%) was significantly lower than *M. alba*. Treatment effects for producing collar diameter in both species were significantly different resulting maximum collar diameter increment of 76.73% under domestic waste water irrigation followed by municipal waste water 70.73% and canal water (61.42%) in *Morus alba*. Both species individually showed almost similar trend as collar diameter increment under domestic irrigation and municipal waste water irrigation was (80.44%) and (73.91%) respectively. The lowest collar diameter increment (65.87%) was noted in canal water irrigation. Similarly, *Syzygium cuminii* gained maximum collar diameter increment (73.03%) under domestic waste water irrigation. Collar diameter increment under canal water (63.55%) was significantly low. Municipal waste water revealed in almost similar value of collar diameter increment (67.54%) in *Syzygium cuminii*. Consequently, *Morus alba* was found to be potential species to grow better under all irrigational treatments than that of *Syzygium cuminii.*

Metal uptake by *Morus alba* and *Syzygium cuminii*

Both species (*M. alba* and *S. cuminii*) were found partially similar with regard to Cd uptake (Table 2). However, metal contents in plant matter of two species were statistically different under different sources irrigation suggesting significant role of various types of irrigation water in metal uptake. M.W. contributed more Cd to be observed by the plants (8.50 mg kg^{-1}) followed by DW (5.77 mg kg^{-1}) and CW (2.83 mg kg^{-1}) respectively. The data clearly depicted *M. alba* had maximum Cd concentration (8.00 mg kg^{-1}) when irrigated M.W followed by D.W (6.11 mg kg^{-1}). The plant had lowest cadmium concentration under C.W irrigation (3.22 mg kg^{-1}).

The individual treatment means of Cd concentration in plant matter (9.00 mg kg $^{-1}$ a) was gained by *S. cuminii* under municipal waste water treatment and followed by (5.44 mg kg $^{-1}$ c) under domestic waste water. The lowest Cd concentration in plant matter was noted (2.44 mg kg $^{-1}$ e) under canal water treatment. It is interesting to note that in response to municipal waste water treatment was the carrier of high content of Cd, *S. cuminii* exhibited more Cd intake (9.0 mgkg^{-1}) as compared with *M. alba* (8.00 mg kg-1 b) in the same treatment. While sharing for cadmium intake was same in domestic waste water treatment conversely. The share for Cd intake was higher in *M. alba* when treated with canal water. Perhaps, *S. cuminii* contributed more activity in cadmium intake when it was irrigated with Municipal waste water.

Table 2: Comparative means of species x treatments (Cd)

TREATMENT	SPECIES		Mean(mg/kg)
	***Morus alba*(mg/kg)**	***Syzygium cuminii* (mg/kg)**	
Canal water	3.22 d	2.44 e	**2.83 C**
Domestic waste water	6.11 c	5.44 c	**5.77 B**
Municipal waste water	8.00 b	9.00 a	**8.50 A**
Mean	**5.7778 A**	**5.6296 A**	

LSD value at 0.05 for treatment = 0.5472
LSD values at 0.05 for species = 0.4468
LSD values at 0.05 for interaction = 0.7739

CHROMIUM (Cr) CONCENTRATION IN THE PLANT MATTER (MG / KG DRY WEIGHT)

The mean chromium content (Table 3) in plant matter of *S. cuminii* (189.64 mg kg $^{-1}$ A) and *M. alba* (154.45 mg kg $^{-1}$ B) were statistically different. The comparison of individual treatment means revealed that maximum mean Cr concentration in plant matter of both species (239.13 mg kg $^{-1}$ A) was obtained under municipal waste water treatment, followed by domestic waste water (160.73 B mg kg^{-1} B) and lowest in canal water (116.27 mg kg $^{-1}$ C). The comparison of individual treatment means was statistically different. The data showed statistically maximum value of chromium concentration in plant matter in *M. alba* plants (240.80 mg kg $^{-1}$ a) treated with municipal waste water followed by (139.69 mg kg $^{-1}$ e) Cr in plant matter under domestic waste water treatment. . Lowest value of mean Cr concentration in plant matter was resulted in canal water treatment (82.84 mg kg $^{-1}$ f). The individual treatment means of Cr concentration in plant matter (237.46 mg kg $^{-1}$ b) was gained by *S. cuminii* under municipal waste water treatment followed by (237.46 mg kg $^{-1}$ b) under domestic waste water. The lowest Cr concentration in plant matter was noted (149.69 mg kg $^{-1}$ d) under canal water treatment.

Table 3: Comparative means of species x treatments (Cr)

Treatment	Species		Mean mg/kg)
	***Morus alba* (mg/kg)**	***Syzygium cuminii* (mg/kg)**	
Canal water	82.84 f	149.69 d	116.27 C
Domestic waste water	139.69 e	181.77 c	160.73 B
Municipal waste water	240.80 a	237.46 b	239.13 A

Mean	**154.45 B**	**189.64 A**	

LSD value at 0.05 for treatment = 0.7012
LSD values at 0.05 for species = 0.5725
LSD values at 0.05 for interaction = 0.9917

COPPER (Cu) CONTENTS IN THE PLANT MATTER (mg kg^{-1} DRY WEIGHT)

The mean copper contents (Table 4) in plant matter of *S. cuminii* (45.92 mg kg^{-1}A) and *M. alba* (11.69 mg kg^{-1} B) were statistically different. The comparison of treatment means (Table 4) revealed that statistically maximum mean Cu contents in plant matter of both species (38.50 mg kg^{-1} A) were under municipal waste water treatment followed by domestic waste water (28.18 mg kg $^{-1}$ B). Minimum Cu contents (19.73 mg kg^{-1} C) were under canal water treatment.

Table No. 4: Comparative means of species x treatments (Cu)

Treatment	Species		Mean (mg kg^{-1})
	***Morus alba* (mg kg^{-1})**	***Syzygium cuminii* (mg kg^{-1})**	
Canal water	6.28 f	33.17 c	**19.73 C**
Domestic waste water	11.69 e	44.67 b	**28.18 B**
Municipal waste water	17.11 d	59.90 a	**38.50 A**
Mean	**11.69 B**	**45.92 A**	

LSD value at 0.05 for treatment = 0.5284
LSD values at 0.05 for species = 0.4315
LSD values at 0.05 for interaction = 0.7473

Individual treatment means (Table 4) showed that *M. alba* was accumulated statistically maximum Cu contents in plant matter (17.11 mg kg^{-1} d) under municipal waste water treatment followed by (11.69 mg kg $^{-1}$ e) copper contents in plant matter under domestic waste water treatment. Minimum copper contents in plant matter (6.28 mg kg^{-1} f) were under canal water treatment. The individual treatment means showed that *S. cuminii* was accumulated maximum Cu contents in plant matter (59.90 mg kg^{-1} a) under municipal waste water treatment followed by (44.67 mg kg^{-1} b) under domestic waste water. Minimum Cu contents were noted (33.17 mg kg^{-1} c) under canal water treatment.

DISCUSSION

It is evident from data that both of the plant species resulted in good growth under domestic waste water because mean values of different growth parameters (plant height, collar diameter, shoot length,) were highest under domestic waste water followed by municipal waste water and then canal water. But in some cases canal water gave more growth than municipal waste water. Overall, both of the plants species gave different dry weight (leaf dry weight, stem wood dry weight and root dry weight) under different irrigational treatments.

The response of *M. alba and S. cuminii* against different irrigation treatments was clearly different. The lowest value of all growth parameters was noted under canal water treatment except root dry weight. The high growth of *M. alba* and *S. cuminii* under domestic waste water treatment was perhaps due to presence of more organic matter and nutrients in available form. Municipal waste water showed second best growth of the plant. The poor growth of *M. alba* and *S. cuminii* when irrigated with canal water might be due to low concentration of nutrients. The maximum (%) plant height was under domestic waste water followed by municipal waste water and then minimum (%) plant height was under canal water treatment. Both the species gave similar performances against all treatments in (%) plant height.

M. alba gained maximum (%) collar diameter under domestic waste water followed by municipal waste water statistically similar to domestic waste water and minimum (%) collar diameter was under canal water treatment*. S. cuminii* gave statistically similar results against all treatments. Stewart *et al*. (1984) conducted research on 11 tree species on contrasting soils. One site was irrigated by tannery waste water, other were irrigated by municipal waste water. Trees irrigated by tannery water suffered foliar scorch. More growth of trees was observed by domestic waste water than tannery water. Stress caused by waste water is almost similar when observed in case of municipal waste water treatment as *M. alba* and *S. cuminii* in our study. Chaturvedi (1985 and 1986) reported that the use of waste water irrigation for trees in arid environments can achieve rapid establishment and growth of trees. His results were in agreement with our study as in *M. alba*. Both when irrigated with municipal waste water actively absorbed the cadmium metal from soil and irrigational water followed by domestic waste water and canal water treatment. This showed that municipal waste water contained more cadmium than that of domestic waste water and canal water.

Regarding chromium metal uptake, *S. cuminii was* found physiologically more as compared to *M. alba*. In both plant species chromium metal uptake was higher when irrigated with municipal waste water followed by domestic waste water and minimum chromium uptake was under canal water treatment.

Lepp and Eardey (1978) studied on heavy metals accumulation within trees and noted active mobilization of the heavy metal throughout the plant. In sycamore seedlings grown in sludge-amended soil, concentrations of metals in the stems were found less as compared to leaves. Same results found in our experiment. Morin (1981) found that root tissues of several tree species grown on sludge-amended soil had the highest concentrations of Cd, Cu, Ni and Zn. *M. alba* showed similar behaviour by absorbing higher concentration of Cd and Cu and their accumulation in within the plant.

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