Effect of Reclaimed Wastewater on the Growth and Nutrient Content of Three Landscape Shrubs[1]

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Abstract

An experiment was set up to determine the effects of treated municipal wastewater irrigation and fertilization on growth, leaf morphological characteristics, chlorophyll content, and ion uptake of three container-grown landscape shrubs characterized by different growth habits (*Abutilon* 'Kentish Belle', *Viburnum tinus* 'French White', *Weigelia florida* 'Bouquet Rose'). The study was conducted in Tuscany (Central Italy) in a typical landscape plant production area. One-hundred plants per species were watered with treated sewage effluent from the nearby wastewater treatment facility (RW) and 100 with well water after ponding (WW) from the nursery where the research plots were located. Fifty plants per species and within each irrigation treatment received controlled-release fertilizer application at transplant and 50 received no fertilization. The experiment showed no major limitations to the use of sprinkle-irrigated wastewater for container-grown landscape plant production and a general, positive, influence on growth of the plants. However, the species under observation showed a different behavior in response to the effluent irrigation for all the parameters considered. Weigelia was the most responsive and Abutilon the least. The influence of fertilizer addition at transplanting was less evident and the combined effect of RW and fertilization was rarely found and seemed to be species-specific.

Index words: dry matter partitioning, chlorophyll content.

Species used in this study: Abutilon (*Abutilon* 'Kentish Belle'); Viburnum (*Viburnum tinus* 'French White'); Weigelia (*Weigelia florida* 'Bouquet Rose').

Significance to the Nursery Industry

In most nursery areas irrigation water supply has become a major concern due to more frequent drought periods and high evapotranspiration. We are now facing an increased impact of water use on available water resources so that, in this scenario, it is important to evaluate alternative irrigation sources. Treated municipal wastewater can be an alternative source of water and fertilizer nutrients for landscape plant production since nutrients are present in a usable form and, in general, do not require any additional energy input to make them available to plants. Moreover, the potential physical, chemical or biological (potential) problems that can be associated with effluent water applied to edible crops, are not as much of a concern for landscape plant production.

Introduction

Landscape plant production is the most economically important nursery activity in Tuscany (Central Italy) comprising more than 5,700 ha (14,084 acres; 30.2 % of the national nursery surface) and an annual gross product of 250 million dollars (31% of the nursery GNP). As known, landscape plants can require significant amounts of irrigation water to achieve optimum growth and give economic results. It has been estimated that annual water consumption for landscape plant production in this area is more than 6 million m^3 (1.6 billion gal) with a significant increase expected over the next 10 years (24). Therefore irrigation water supply has become a major concern due to increasing frequency of drought and high evapotranspiration in spring-summer. Water rationing has a very negative effect on plant growth (9), so that, in this scenario, it is important to evaluate alternative irrigation sources thus conserving high quality water for human uses.

Treated municipal wastewater can be an alternative source of water and nutrients for nursery crop production since nutrients are present in a usable form and, in general, do not require any additional energy input to make them available to plants (22, 26). Moreover the potential physical, chemical or biological problems that, though rarely, can be associated with effluent applied to vegetable or fruit crops (12) are not as applicable to landscape plant production.

Several studies have shown that nutrients in recycled irrigation runoff (after suspended solids removal and monitoring the pH, salinity, herbicides and other compounds) can positively affect plant growth (11, 15, 27). Conversely, only a limited number of research projects have examined the effects of wastewater on the growth of landscape species, with differing results probably due to the different cultivation techniques and environments and to the different characteristics of the species under observation. Fitzpatrick et al. (10) found that of the 20 landscape species tested, only four had significantly increased growth when irrigated with treated wastewater, while the remaining 16 species showed no influence of irrigation source. In a more recent study on nine widely grown landscape plants (30) it was found that plant growth after 3 months of irrigation with wastewater was strongly dependent on the species. Tolerance ratio (percentage of growth under wastewater irrigation to the growth under the control treatment) varied between 0.08% and 119% for Lace fern (*Athyrium filix-foemina* ROTH.) and Raphiolepis (*Raphiolepis indica* LINDL.) respectively. In the same study, tissue mineral content was also affected by wastewater treat-

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ment and by 4 of the 9 species for Cl and Mg concentration. Calcium and K concentration were different only among the species.

The objective of this research was to evaluate the effects of effluent irrigation compared with traditional well-water irrigation on three container-grown species, characterized by different growth habits.

Materials and Methods

One-year-old uniform cutting propagated plants of Laurustinus (*Viburnum tinus* 'French White'), an evergreen bushy habit shrub, Weigelia (*Weigelia florida* 'Bouquet Rose'), a medium sized deciduous shrub and Abutilon (*Abutilon* 'Kentish Belle', *A.* x *milleri* x *A.* 'Golden Fleece'), a semi-evergreen small to medium-sized shrub, were selected for the experiment in Pistoia (Central Italy), one of the largest nursery areas in Europe, specialized in landscape plant production.

On May 4, 1998, a total of 600 plants (200 per species) were planted in 3 liter (18 cm [7 in] dia) black plastic containers using a peatmoss-pumice medium (3:2 by vol) supplemented (F) or not (NF) with a 5 kg/m^3 [8.42 lb/yd^3] (15 g [0.53 oz]/pot) of a slow-release fertilizer (Osmocote Plus 5–6, 14N–14P_2O_5–14K_2O and 18–11–10 microelements, Scotts Co., Marysville, OH). At planting, shoots were pruned to 20 cm [8 in], and at the same time, root and canopy fresh and dry weight were determined (following the procedure described later).

Plants were placed outdoors in two plots in a nursery adjacent to a municipal wastewater treatment facility; irrigation water was provided from two sources: treated sewage effluent from the nearby wastewater treatment facility (RW) and well-water after ponding (WW) from the nursery where the research plots were located. Four treatments (F vs NF and RW vs WW) were arranged in a randomized complete block design with 5 replicates (10 plants each) per treatment. Standard commercial nursery production for irrigation and pest control were followed. Plants were spaced 0.15 m (0.5 ft) within blocks and 0.6 m (2 ft) between blocks, in full sun with sprinkler irrigation. A 30-minutes irrigation delivered 7 mm of water, which was applied twice a day from 900–1000 hr and from 1700–1800 hr.

The sewage effluent was treated by a biological plant. The treatment was composed of a primary treatment (screening and primary sedimentation), secondary treatment (activated sludge and secondary sedimentation) and biological denitrification. The portion of the effluent used in the irrigation test was then treated with UV irradiation in a pilot plant to achieve the national quality standard: Italian legislation requires 20 MPN (Most Probable Number) total coliforms per 100 ml for restricted irrigation and 2 MPN/100 ml for unrestricted irrigation.

Analyses of effluent were carried out on instantaneous (single sample analyzed immediately) and composite (mean of 4 samples in 12 hours) samples by two different Public Water Service Agencies.

On August 6, 1998, six plants of each species and water treatment (since no differences were observed in terms of shoot growth, the samples were formed randomly taking 3 plants for each fertilization treatment) were planted out, roots were washed free of media, and roots and shoots excised. Total leaf area and fresh weights were recorded immediately, and dry weights after the vegetative material was oven-dried at 110C (230F) until constant weight was achieved. Leaf area was measured with a CID CI-203 leaf area meter (CID Inc., Vancouver, WA). On a random sample of 60 fresh leaves per replication, chlorophyll *a*, *b*, Chl *a*/Chl *b* ratio and total chlorophyll content were determined. The determination was done measuring the absorbance at 664, 647 and 625 nm with a Hitachi U-2000 spectrophotometer after extraction with dimethylformamide (DMF) (21). Specific leaf weight (SLW g*cm^{-2}) was also calculated on these samples.

Relative growth rate (RGR) was calculated as $(\ln W_2 - \ln W_1) * (t_2 - t_1)^{-1}$ (where W_1 and W_2 are respectively the dry matter at the beginning and at the end of the observations, t_2 and t_1 are the number of days between the two sampling dates). Shoot:root ratio was also determined on this date. On October 6, the tops of all species were removed and biomass production was determined on 15 plants per treatment following the aforementioned procedure.

Ion uptake was determined by leaf mineral content analyses carried out by a specialized laboratory. The analyses were restricted to randomly taken samples from RW and WW irrigated plants (formed by 50% leaves of fertilized plants and 50% not fertilized).

Root systems were scanned producing a bitmap file to determine root length using the GS Root software provided by Agricultural Center Louisiana State University.

All the data were subjected to analysis of variance, or factorial analysis of variance (Irrigation water × fertilization), where appropriate, using SPSS (Release 8.0 for Windows 95). Treatment means were separated by LSD, with $p \leq 0.05$ level of significance.

Results and Discussion

Water characteristics. The effluent irrigation water was a source of nutrients compared to well water (Table 1). For

Table 1. Physical properties and mineral content of both the effluent and well water. Data are mean values, n = 25.

Parameter		Effluent	Well water
pH		7.81	7.26
Conductivity	[µS/cm]	655	441
Sediment after 120 min	[ml/l]	0.0	0.0
Total Suspended Solids	[mg/l]	6.35	4.5
Turbidity	[NTU]	5.1	4
Phosphate	[mg/l]	0.72	0.063
Ammonium	[mg/l]	0.906	—
N-NO_2	[mg/l]	0.095	0.008
N-NO_3	[mg/l]	5.67	—
Potassium	[mg/l]	15	1.2
Calcium	[mg/l]	62.6	35.5
Magnesium	[mg/l]	8.5	23.3
Hardness	[F]	18.5	18.3
Chloride	[mg/l]	70.7	31.9
Sodium	[mg/l]	91	39.3
SAR		2.7	1.3
Cadmium	[mg/l]	(not detectable)	—
Chromium	[mg/l]	—	—
Iron	[mg/l]	—	0.13
Manganese	[mg/l]	—	1.14
Nickel	[mg/l]	—	—
Lead	[mg/l]	—	—
Copper	[mg/l]	—	—
Zinc	[mg/l]	0.11	0.047

Table 2. **Effect of different irrigation water and fertilization on dry matter (g) partitioning in Abutilon after 23 weeks. Data are mean values, n = 6.**

Treatment	Leaves	Stems	Trunk	Roots	Total
Well water	1.55b[z]	5.48ns	1.16ns	6.38a	14.58ns
Recycled water	2.54a	5.82	1.17	4.74b	14.47
Fertilized	2.18ns	6.59a	1.25ns	6.04ns	16.14a
Not fertilized	1.91	4.71b	1.08	5.07	12.91b
Significance (p-value)					
Water	0.000	0.517	0.990	0.000	0.919
Fertilization	0.204	0.001	0.204	0.204	0.008
Interaction	0.090	0.169	0.565	0.090	0.103

[z]Means between treatments with different letters are significantly different at p ≤ 0.05.

Table 3. **Effect of different irrigation water and fertilization on dry matter (g) partitioning in *Laurustinus* after 23 weeks. Data are mean values, n = 6.**

Treatment	Leaves	Stems	Trunk	Roots	Total
Well water	5.91b[z]	2.83b	1.05ns	5.67ns	15.46b
Recycled water	9.07a	4.10a	1.18	5.09	19.45a
Fertilized	9.60a	4.37a	1.30a	6.83a	22.09a
Not fertilized	5.39b	2.56b	0.94b	3.94b	12.83b
Significance (p-value)					
Water	0.001	0.016	0.326	0.249	0.025
Fertilization	0.000	0.001	0.013	0.000	0.000
Interaction	0.993	0.235	0.507	0.700	0.845

[z]Means between treatments with different letters are significantly different at p ≤ 0.05.

example N, P and K additions in the effluent water (RW) yielded average values respectively of 6.68, 0.72 and 15 mg per liter of irrigation water applied. In contrast, the average well water (WW) concentration were 0.008 mg*l^{-1} for N (nitrite-N form), 0.063 mg*l^{-1} for total P and 1.2 mg*l^{-1} of K. According to the literature (2, 3, 8, 19, 28), the RW had medium salinity and low to medium sodium hazard. Only the total N value was slightly above the threshold (5 mg*l^{-1}) established for advanced wastewater treatment (AWT) and the water can be classified as usable for agriculture uses with no particular restrictions (3). RW was also low in heavy metals, reflecting the urban nature and the lack of heavy industry in this area as found by Davies et al. (5) in a similar environment. Many people are concerned about the heavy metal content of reclaimed water, considering them hazardous to human beings. In this experience heavy metal concentrations in the RW were always at low or undetectable levels and lower than that of well water which needed to be treated for Fe and Mn reduction.

Sanitary aspects are of priority interest because RW contains high concentrations of microorganisms (for example from 10^5 to 10^6 total coliforms per 100 ml). In the field of wastewater treatment, the three categories of human enteric organisms of the greatest consequence in producing disease are bacteria, viruses and amoebic cysts. With UV rays equipment we achieved strong reduction (from 99.96% to 100%) of the indicators used to evaluate disinfection efficacy (total coliforms, fecal coliforms and fecal streptococcis). To achieve the Italian standard, the optimal radiation dose was about 500 mW.s^{-1}.cm^{-2} (exposure time 19 sec.), consistent with values used by others (14, 16). In light of an industrial use, the UV efficiency could be increased (at least doubled) implementing a filtering pre-treatment unit to reduce suspended solids (6, 29).

Table 4. **Effect of different irrigation water and fertilization on dry matter (g) partitioning in *Weigelia* after 23 weeks. Data are mean values, n = 6.**

Treatment	Leaves	Stems	Trunk	Roots	Total
Well water	8.05b[z]	4.40b	1.13b	6.78ns	20.36b
Recycled water	14.97a	7.80a	1.54a	6.60	30.91a
Fertilized	11.56ns	6.46ns	1.34ns	6.75ns	26.12ns
Not fertilized	11.46	5.74	1.33	6.63	25.16
Significance (p-value)					
Water	0.000	0.000	0.004	0.714	0.000
Fertilization	0.915	0.227	0.906	0.800	0.620
Interaction	0.598	0.912	0.120	0.217	0.479

[z]Means between treatments with different letters are significantly different at p ≤ 0.05.

Plant growth. After 14 weeks of irrigation the three species did not show any remarkable effects caused by RW. Abutilon showed a slight reduction in total dry weight (canopy + root dry weight) and a significantly lower RGR in the individuals irrigated with RW (data not shown). After 23 weeks a different response of the species tested to irrigation water was detected. Abutilon showed no difference in Total Dry Mass (TDM) with regard to the kind of water used (Table 2); on the other hand, Laurustinus and Weigelia plants irrigated with RW had a strong increase in top-growth and, consequently, showed a growth (TDM) significantly higher than those irrigated with well water (Tables 3–4), as previously shown on other woody species (5, 31).

More specifically, Abutilon seemed to be more sensitive to fertilization than to RW irrigation; Laurustinus had a linear response in relation to both fertilization and RW irrigation, while Weigelia showed a higher dry weight enhancement in response to RW regardless of the fertilization. Water source and fertilization showed no interactions for all the growth parameters. No differences were detected among the species between RWNF and WWF in terms of canopy growth (results not shown) leading us to hypothesize that this kind of RW (treated urban sewage) has the potential to increase growth while saving on fertilizers accordingly with what observed by other Authors (5, 10, 18).

The Relative Growth Rate (RGR) was calculated for the irrigation water, and all the species showed a better RGR with RW at the end of the growing season, but only Weigelia irrigated with RW showed a significantly higher RGR compared to the WW treatments (Fig. 1). The results for these three species suggest a species/specific response of plants to RW as found in other research conducted on landscape plants (10, 30).

Root growth. As shown for plant growth, no differences were found among the treatments at the first sampling date (results not shown). At the end of the season, RW showed a negative effect on root growth in Abutilon (Table 2) and no effect with the other species (Tables 3–4). Fertilization was,

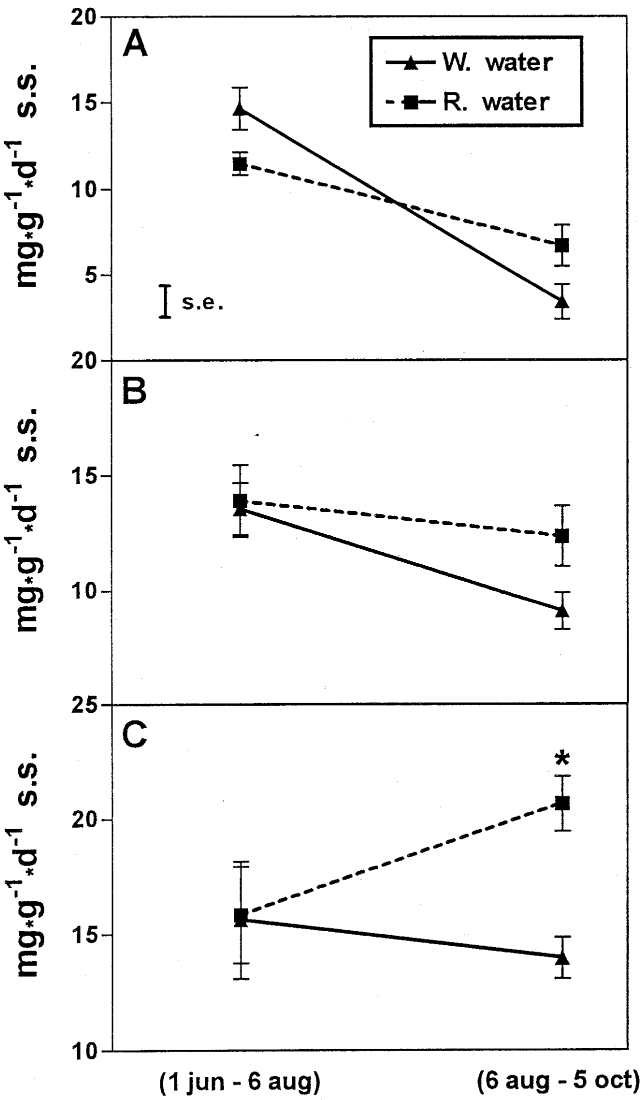

Fig. 1. Influence of well water and recycled water on relative growth rate of *Abutilon* (A), *Laurustinus* (B) and *Weigelia* (C) before and after August the 6th. Data are mean values, n = 6. Means between treatments with (*) are significantly different at $p \leq 0.05$.

on the other hand, effective only for Laurustinus, as there were no effects on Abutilon and Weigelia. On the other hand RW irrigation is similar to fertigation with a continuous nutrient supply which renders soil exploration by roots not as necessary as in WW plants (17).

It is known that increasing nitrogen supply, as happened in the RW irrigated plants enhances shoot growth more than root growth (17) leading to a typical increase in the shoot/root dry weight ratio. This was, in fact, higher in the RW irrigated plants while fertilization seems to be less effective (Table 5). The root length measured at the end of the growing season showed a pattern strongly dependant on the species (Table 6). There was a significant effect, for RW, in Abutilon (negative) and in Weigelia (positive), while Laurustinus confirmed to be more sensitive to fertilization, with a significant increase in total root length in fertilized plants.

Leaf parameters. Leaf area was positively influenced by RW in all the species, whereas the effect of fertilization was less pronounced except for Laurustinus which showed a strong response to both treatments (Table 7). SLW, on the other hand, was not influenced by the irrigation water and inversely related to fertilization in Abutilon and Laurustinus. In Weigelia, a significant interaction water × fertilization was observed for both leaf area and SLW. RW strongly increased chlorophyll *a*, *b* and total chlorophyll content regardless of the species tested (Table 8); since differences in leaf area and SLW could affect the chlorophyll results, usually expressed per unit area ($\mu g/cm^2$), we also referred the total chlorophyll content on a per-plant basis (mg/plant), obtaining the same result. Fertilization was less effective on chlorophyll content per unit area (only Weigelia was significantly influenced), whereas on a per plant basis the total chlorophyll content turned out to be positively affected by fertilization in Abutilon and Laurustinus, but not in Weigelia.

Leaf mineral content. Leaf mineral analyses indicated that RW increased N and K, and decreased Fe content in all three species, while the uptake patterns of the other ions in response to RW treatment were different among them (Table 9). Improved N, P, K nutrition of wastewater irrigated plants has been frequently observed (13, 22, 23, 31, 32) and in some cases the results depended on the species.

In our case, for example, application of RW had a positive effect on Laurustinus, which showed, in general, an increase

Table 5. Effect of different irrigation water and fertilization on shoot:root ratio in *Abutilon*, *Laurustinus* and *Weigelia*. Data are mean values, n = 6.

Treatment	Abutilon	Laurustinus	Weigelia
Well water	0.92b[z]	1.28b	1.57b
Recycled water	1.47a	2.07a	2.85a
Fertilized	1.26ns	1.75ns	2.27ns
Not fertilized	1.13	1.61	2.15
Significance (p-value)			
Water	0.000	0.000	0.000
Fertilization	0.109	0.181	0.417
Interaction	0.526	0.830	0.298

[z]Means between treatments with different letters are significantly different at $p \leq 0.05$.

Table 6. Effect of different irrigation water and fertilization on root length (m) in *Abutilon*, *Laurustinus* and *Weigelia*. Data are mean values, n = 6.

Treatment	Abutilon	Laurustinus	Weigelia
Well water	136.87a[z]	41.02ns	104.68b
Recycled water	96.99b	48.27	135.21a
Fertilized	126.96ns	59.45a	122.43ns
Not fertilized	106.90	29.84b	117.46
Significance (p-value)			
Water	0.008	0.311	0.039
Fertilization	0.151	0.000	0.723
Interaction	0.626	0.346	0.224

[z]Means between treatments with different letters are significantly different at $p \leq 0.05$.

Table 7. **Effect of different irrigation water and fertilization on leaf area (cm^2) and specific leaf weight (mg/cm^2) (SLW) in *Abutilon*, *Laurustinus* and *Weigelia*. Data are mean values, n = 6.**

Treatment	Abutilon		Laurustinus		Weigelia	
	Leaf area	SLW	Leaf area	SLW	Leaf area	SLW
Well water	4.97b[z]	10.52ns	3.88b	23.97ns	14.20b	12.26ns
Recycled water	10.14a	12.58	5.73a	25.46	21.59a	13.99
Fertilized	7.21ns	9.20b	5.28a	17.43b	18.37ns	12.06ns
Not fertilized	7.89	13.90a	4.33b	31.99a	18.09	14.19
Significance (p-value)						
Water	0.000	0.123	0.001	0.470	0.000	0.125
Fertilization	0.168	0.002	0.032	0.000	0.900	0.065
Interaction	0.311	0.348	0.251	0.706	0.002	0.003

[z]Means between treatments with different letters are significantly different at $p \leq 0.05$.

of N, P and K in leaf mineral concentration, while Weigelia appeared to be less sensitive and Abutilon had conflicting results, with a higher Ca and lower P and Mg in the RW plants. Generally, Abutilon mineral content was however by far higher than that of the other two species though this species was the least affected in terms of dry matter production. This is particularly important for some ions such as chloride and sodium, that are the two major constraints for plant growth in medium-high salinity conditions. Wu et al. (31) found that the species accumulating greater amounts of Cl were the ones that had a greater reduction of growth, but they also found that Hydrangea, though having a high tissue Cl concentration, did not show any growth reduction. According to Marschner (17) we can attribute this chloride and sodium tolerance to high tissue Ca content.

Salinity of irrigation water have also shown to affect pigment composition resulting in higher Chlor *a*/Chlor *b* ratio (1) and this was not found in this research. Other research pointed out that sodium accumulation can be another subject of major concern using effluent water. Our data show a general enhancement of Na leaf concentration in Weigelia and, particularly, in Abutilon (Na concentration almost doubled); this can be another reason for the minor response of Abutilon to the RW. Research conducted in *Citrus* also showed a negative relation between Na and Cl concentration on RGR, which was lower in Abutilon in comparison to the other two species (25). However the potential problem of leaf burn that can be associated with the use of such a water, richer in sodium and chloride (12) did not emerge in this study.

The lower Fe content in leaf tissue can be ascribed to the high pH (7.81) of the effluent. Berry et al. (4), working on container grown plants, found that iron deficiency would be a problem in unamended water. However, our results showed that RW has positive or no detrimental effects on plant growth despite lower leaf tissue iron. Apparently, increased production of dry matter tend to dilute leaf Fe concentration without any effect on growth and total chlorophyll content (20). Consistently with previous studies we can affirm that while the fertilizer value can vary with its nutrient content, our results suggest that this kind of effluent used for irrigation might be an important and effective source of mineral elements and that ion deficiency can be corrected, if necessary, with amendments, by foliar spray application or by light acidification of the water as proposed by Berry et al. (4).

Though general recommendations cannot be issued (i.e., variability of nutrient concentration must be considered), treated municipal wastewater has a great potential to be distributed in a larger scale to irrigate container-grown plants, with positive economic aspects. The choice not to do a supplemental fertilization in July has highlighted the fertilizing potential of the effluent which, in Weigelia, gave better results even when the plants were not fertilized at transplant in comparison to those fertilized and irrigated with WW.

As to the nitrogen content in RW, there might be some concerns for the amount distributed along the growing season. Actually the potential N excess can be reduced if necessary: a) if low nitrogen content water is available and can be used in the second part of the growing season when the need

Table 8. **Effect of different irrigation water and fertilization on chlorophyll *a*, *b*, total ($\mu g/cm^2$) and per plant (mg/plant) in *Abutilon*, *Laurustinus* and *Weigelia*. Data are mean values, n = 60 (6 replicates of 10 leaves each).**

Treatment	Abutilon				Laurustinus				Weigelia			
	a	*b*	Total	$\bar{x}$ plant	*a*	*b*	Total	$\bar{x}$ plant	*a*	*b*	Total	$\bar{x}$ plant
Well water	20.44b[z]	6.29b	26.73b	4.83b	32.16b	10.18b	42.34b	11.86b	12.35b	3.52b	15.87b	9.68b
Recycled water	32.45a	10.31a	42.76a	9.41a	41.82a	16.39a	58.21a	23.07a	22.69a	6.42a	29.11a	36.93a
Fertilized	27.09ns	8.49ns	35.58ns	8.88a	36.47ns	12.50b	48.97ns	23.33a	19.71ns	5.53a	25.24a	24.69ns
Not fertilized	26.29	8.29	34.58	5.35b	37.51	14.06a	51.57	11.61b	15.33	4.41b	19.74b	21.91
Significance (p-value)												
Water	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
Fertilization	0.098	0.251	0.128	0.005	0.307	0.014	0.104	0.001	0.000	0.000	0.000	0.444
Interaction	0.571	0.702	0.766	0.421	0.021	0.002	0.008	0.377	0.823	0.621	0.975	0.234

[z]Means between treatments with different letters are significantly different at $p \leq 0.05$.

Table 9. Effect of different irrigation water and fertilization on leaf mineral content (% dry mass) in *Abutilon*, *Laurustinus* and *Weigelia*. Data are mean values, n = 3.

	Mineral element							
Treatments	**N (%)**	**P (%)**	**K (%)**	**Ca (%)**	**Mg (%)**	**Fe (ppm)**	**Na (ppm)**	**Cl (ppm)**
Abutilon								
Well water	2.960b	0.883a	2.657b	2.757b	1.150a	194.33a	3774.7b	7862.0
Recycled water	3.480a	0.680b	3.110a	3.110a	0.663b	173.67b	7250.0a	7538.7
Signif. Level (p)	0.002	0.011	0.015	0.018	0.000	0.023	0.000	0.212
Laurustinus								
Well water	0.960b	0.137b	1.467b	0.733	0.217	158.00a	1147.3	4561.3b
Recycled water	1.943a	0.247a	1.993a	0.683	0.200	118.30b	1203.0	5033.7a
Signif. Level (p)	0.000	0.000	0.000	0.295	0.067	0.007	0.302	0.026
Weigelia								
Well water	0.623b	0.430	1.257b	1.753	0.326	186.70a	925.0b	5761.0
Recycled water	1.943a	0.473	1.423a	1.833	0.423	152.00b	1379.0a	5695.0
Signif. Level (p)	0.000	0.051	0.015	0.289	0.524	0.012	0.002	0.312
Cumulative								
Well water	1.510b	0.483	1.793	1.745	0.564	179.70a	1949	6061
Recycled water	2.450a	0.467	2.176	1.876	0.429	148.00b	3277	6089
Signif. Level (p)	0.041	0.896	0.266	0.784	0.429	0.008	0.242	0.965

[z]Means between treatments with different letters are significantly different at $p \leq 0.05$.

of nutrient supply is lower thus avoiding early frost damages due to the reduced tissue lignification; b) limiting supplemental nitrogen fertilization; c) by mixing WW and RW in the right proportion; d) when it is necessary, a denitrification system can be used for the effluent before the utilization. Such a system might be set up by using plants, like water hyacinth (*Eichhornia crassipes*) or duckweed (*Lemna minor*) which remove a wide variety of organic and inorganic compounds.

Although there are a few instances in which the use of recycled water was associated with negative effects in some species (30), the species under experimentation showed a different behavior in response to the effluent irrigation. The results for Abutilon can be ascribed, as pointed out by other research projects (10), to a relatively narrow tolerance for optimum growth typical of some species. In conclusion, the reuse of treated municipal wastewater, especially when is low in heavy metals, has several beneficial impacts other than nutrient supply. Among them, the availability of more water for irrigation in an area where scarce summer rainfall and high evapotranspiration can be a real problem in the near future, is one of the most important.

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