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Biosolids Improve Rooting of Bougainvillea (*Bougainvillea glabra*) Cuttings[1]

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Abstract

Cuttings of *Bougainvillea glabra* were placed in 80-ml (4.9 in^3) containers containing rooting medium mixed with various concentrations of biosolids (1, 2.5, 5 and 7.5%) from two sources (Herzliyya and Haifa). Two biosolids-free control media were used (with or without addition of mini-Osmocote fertilizer). Half of the cuttings were treated with IBA. The rooting percentage was improved by adding biosolids to rooting media. Treating cuttings with IBA without biosolids was inferior to some of the biosolid treatments. Root development was significantly stimulated by the biosolids compared with a slow-release fertilizer treatment. However, the effect of biosolids on shoot development was slightly improved. Generally, high concentrations of Herzliyya biosolids showed the best results in rooting and growth, whereas Haifa biosolids were best at lowest concentrations.

Index words: rooting media, root growth, shoot growth, IBA, *Bougainvillea glabra*.

Significance to the Nursery Industry

These results clearly indicate that municipal activated biosolids can form an important component in rooting medium. Adding biosolids to rooting medium at concentrations of 1%–7.5% can compensate for the application of fertilizer and for treating the cuttings of *Bougainvillea glabra* with IBA rooting hormone. Using biosolid in the rooting medium improved the rooting percentage as well as the shoot and root development of the rooted cuttings. The biosolids used were typical to primarily-domestic municipal sewage systems (2). Hence, one can expect similar plant response using biosolids from similar processes. Domestic biosolids are characterized by near neutral pH values, low salinity, high concentrations of organic carbon, nitrogen and phosphorus and low concentrations of heavy metals. However, as precaution it is suggested to make a small-scale rooting test to assure the adequacy of biosolids concerned and the appropriate amendment rate in rooting medium.

Introduction

Successful propagation of landscape plants by rooting leafy stem cuttings depends on several factors, including the physiological state of the stock plant (12), the propagating environment (9), and the treatment applied to the cuttings prior to rooting. The use of auxins to improve rooting is a common practice (4). However, auxins alone do not fully support vegetative propagation and, therefore, other hormones such as cytokinins have been suggested as possible complements to enhance adventitious root formation (9). The influ-

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ence of cytokinins on root initiation may thus depend upon the particular stage of initiation and the cytokinin concentration (3).

Biosolids can serve as a valuable soil-amendment additive (7, 8), but vary in chemical composition and organic matter concentration. Biosolids quality can vary based on sewage water, purification process and additives (15), although secondary activated sludges without chemical amendments tend to be quite similar and uniform (2).

Biosolids are widely used as an agricultural soil additive, but are not commonly used as a component of artificial growing medium. Their organic matrix contains nutrients, microbial metabolites and plant hormones (19). The combination of nutrients and plant hormones is known as stimulating combination for rooting and early development of seedlings (18). These characteristics of biosolids are the basis for testing them as a rooting and growing medium. In the present study, we investigated the effects of two sewage biosolids as a component of a rooting medium on the rooting of *Bougainvillea glabra* cuttings.

Materials and Methods

Semi-woody shoots of bougainvillea (*Bougainvillea glabra* 'Cypheri'), subapical sections of 10 cm (4 in) long with 3–4 nodes were used. Bougainvillea was chosen as representative semi-woody species with a normal rooting success of approximately 50–60%. Cuttings were each placed in an 80-ml (4.9 in^3) plastic rooting container on a rooting table maintained at 25C (77F).

Waste biosolids from two urban sources, Herzliyya and Haifa were tested. The more industrialized Haifa region contributed larger amounts of heavy metals to the sludge (Table 1). Both sludges were from secondary-stage mechanical-biological treatments. The lower organic matter concentration of the Herzliyya biosolids was due to the larger amount of drying-bed sand that was collected with the sludge. The Herzliyya biosolid material was aerobically digested and the Haifa sludge underwent anaerobic digestion. The biosolids were collected from drying beds at approximately 10% water content and were crushed to pass 2-mm screen openings.

The rooting medium contained peat:perlite (3:2 by vol). The biosolids were added to the rooting medium in four concentrations: 1, 2.5, 5 and 7.5% (by vol). In addition, a biosolids- and additive-free control medium was used as was a standard amended medium in which 5 g/l of Osmocote-Mini (Sierra Osmocote) (18N: $6P_2O_5$:$12K_2O$) was added. The amounts of N, P, and K in the Osmocote were considered adequate for plant development (1). The experiment was design as followed: 6 (medium treatments) × 2 (sludge sources) × 2 (with or without IBA) × 60 (cuttings per treatment) = 24 treatments with total of 1440 cuttings. Cuttings treated with IBA were dipped in talc powder that contained 0.8% indole-3-butyric acid (IBA). The treatments were placed randomly on the rooting table.

The cuttings were maintained under mist conditions for 5 weeks in a greenhouse where the rooting table was covered with shade net (30% shade). At the end of the rooting period, cuttings were removed from the containers and each cutting with at least one root was considered rooted. The number of rooted cuttings, root and shoot number and length were recorded. Rooting percent was analyzed by generalized logit analysis SAS.

Table 1. Concentrations of sludge constituents in Haifa and Herzliyya sludges.

Constituent	Conc. unit	Haifa	Herzliyya
Organic carbon	%	55.00	40.1
EC[z]	dS/m	12.30	13.1
pH[z]		6.70	6.78
N	%	3.09	2.93
P	%	2.24	0.74
Ca	%	7.87	2.56
Mg	%	0.78	0.24
Fe	%	0.98	0.35
Na	%	0.26	0.14
K	%	0.25	0.13
Zn	mg/kg	2671	1010
Cu	mg/kg	251	49
Ni	mg/kg	47	11
Cd	mg/kg	13.2	1.6

[z]Determined in 1:1 biosolid:water extract.

Results and Discussion

Rooting of cuttings is generally based on two phases. The first phase includes induction and initiation of the adventitious roots, in which plant hormones play a major role, while nutrients play insignificant role. The second phase includes the elongation of the formed root initials, in which nutrients play an important role (9).

Effect of biosolids on rooting. Without IBA: The optimal biosolids concentration for rooting differ between the two biosolids sources. Haifa Biosolids significantly enhanced rooting of *B. glabra* cuttings at low concentrations (1 and 2.5%) compared to control, while Herzliyya biosolids showed the same effect at high concentrations (5 and 7.5%) (Fig. 1). Haifa bioslids showed inhibiting effect at high concentrations (5 and 7.5%). Maximum rooting enhancement of the two biosolids was about 82%, compared 36% with the unamended control. As mentioned earlier, nutrients play secondary role in the first stage of rooting. Therefore, adding fertilizer to rooting medium improved insignificantly rooting by 13% to about 48%.

With IBA: Treating cuttings with IBA improved the rooting of cuttings in biosolids-free medium to about 68%. Adding biosolids combined with IBA treatment improved rooting in certain concentrations (Fig. 1). In case of Haifa biosolids the lower concentrations (1 and 2.5%) showed over 80% rooting, while the highest concentrations inhibited root-

Table 2. Interaction between sludge source and application of IBA on rooting and root and shoot development.

Sludge source	Parameter	Interaction with IBA
Haifa	rooting	**
	root number	*
	root length	NS
	shoot number	NS
	shoot length	NS
Herzliyya	rooting	**
	root number	**
	root length	**
	shoot number	NS
	shoot length	NS

ing (similar pattern to the case without IBA). In case of Herzliyya biosolids, except of treatment with 2.5% biosolids, all the other biosolids treatments did not differ statistically and showed between 75–85% rooting. Significant interaction was found between the two factors tested (adding biosolids and treating with IBA) (Table 2). This was more prominent in the case of Herzliyya biosolids. In this case when IBA and biosolids were added, 1% of biosolids was enough to give maximum rooting compared to at least 5% biosolids needed when biosolids were added without IBA (Fig 1). Treating cuttings with IBA mimic the effect of adding fertilizer. Adding fertilizer improved rooting only by 7% to about 75%.

As mentioned, maximum rooting enhancement occurred at different loading rates with the two biosolids. It seems to us that the difference reflected the effect of the dilution of Herzliyya biosolids with the drying-bed sand as can be seen in Table 1. Wiesman et al. (19) showed that Herzliyya biosolids contained considerable amounts of auxins and cytokinins, that enhanced rooting of mungbeans. Hartman et al. (9) showed that auxins and cytokinins promote adventitious rooting. The best effect on rooting occurs when auxin is present at high concentrations, together with cytokinins at very low concentrations (5, 17). The results in Fig. 1 suggest that the sewage biosolids contained auxins and cytokinins in concentrations and proportions that when applied at the correct amounts they promote rooting of *B. glabra*. On the other hand, as often happends with plant hormones, too high concentrations might acts as inhibitors (5 and 7.5% of Haifa biosolids). Nevertheless, other constituents of the biosolids could also have promoted rooting. These results support the suggestion that biosolids might contain important factors other than minerals (15).

Effect of biosolids on cutting development. Cutting development was studied in more detail on 10 rooted cuttings in

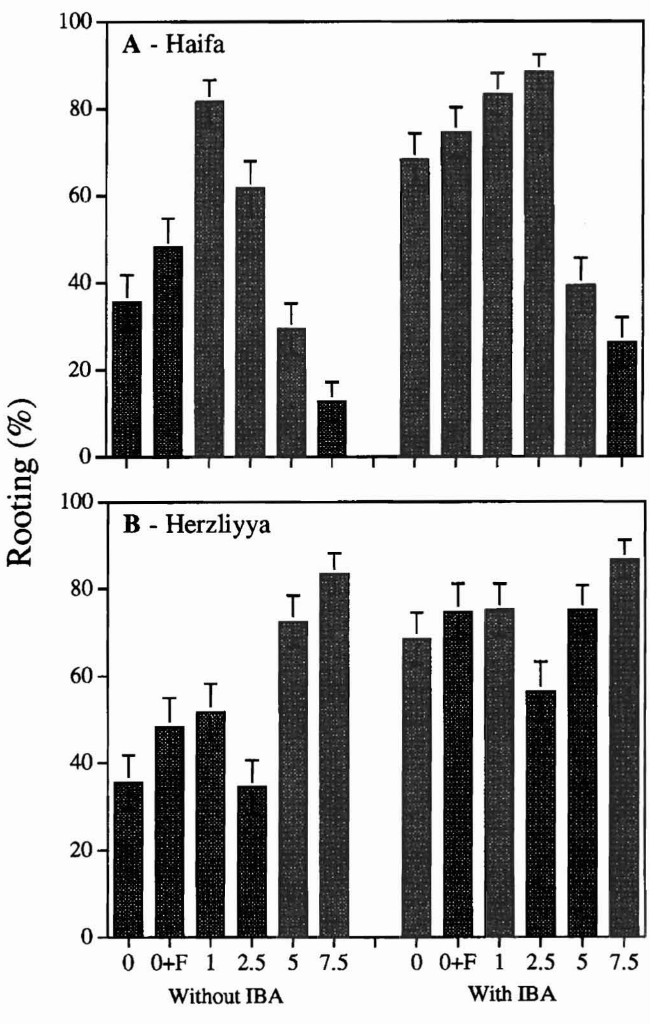

Fig. 1. Effect of biosolids or fertilizer in the rooting medium, and IBA treatment on rooting percentage of *Bougainvillea glabra* cuttings. (A) Haifa biosolids, (B) Herzliyya biosolids. Treatments: biosolids-free control medium without fertilizer (0), biosolids-free control medium amended with slow-release fertilizer (0 + F), addition of 1% (1), + 2.5% (2.5), + 5% (5), and + 7.5% (7.5) biosolids. Vertical bars indicate SE.

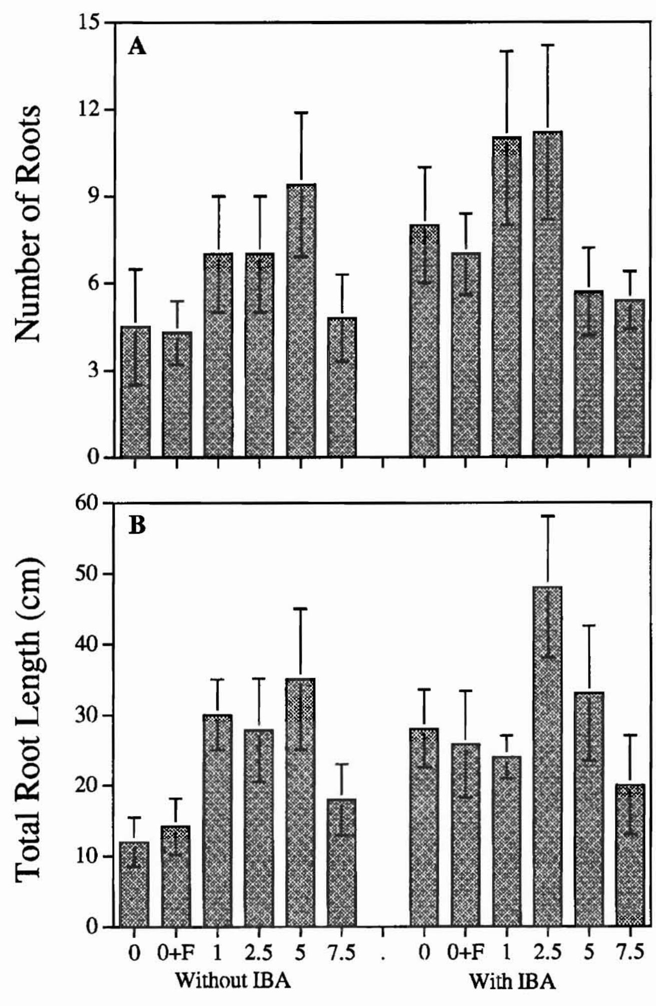

Fig. 2. Effect of Haifa biosolids on the number (A) and the total length (B) of roots of rooted *Bougainvillea glabra* cuttings. For description of treatments see Fig. 1. Vertical bars indicate SE.

each treatment. The parameters used to assess development were number and cumulative length of roots and emerging shoots.

Effects on roots. For cuttings without IBA, all Haifa biosolids treatments except the highest biosolids concentration, increased the number of roots while treating with 5% doubled the number of formed roots. Similar pattern was found also for root length, where 5% of Haifa biosolids increased the total length of Bougainvillea roots by 3 times compared with the non-sludge-amended control medium (Fig. 2). Root initiation and elongation at highest biosolids concentration were similar to those of the control. The two high concentrations of Herzliyya biosolids (5 and 7.5%) increased root initiation and elongation, while 1% had no effect and 2.5% was in between but did not differ significantly from control (Fig. 3).

Adding IBA to biosolids treatments showed interaction effects (Table 2). For Haifa biosolids the addition of IBA decreased the biosolids concentration needed for the highest results (1 and 2.5% for root initiation, and 2.5% for root elongation) (Fig. 2). For Herzliyya biosolids adding IBA with 1 and 5% of biosolids showed the best results (Fig. 3). The combination of IBA with any of biosolids sources showed significant differences only for root elongation.

Effect on shoots. When IBA was not added, Haifa biosolids in the rooting medium did not affect emergence of new Bougainvillea shoots (Fig. 4) but low concentrations of these biosolids increased their total length by up to ≈3 times compared with the unamended control (Fig. 4b). Shoot emergence and elongation at high biosolids concentration were similar to those with the control. The Herzliyya biosolids improved emergence and elongation at the highest concentration used (Fig. 5). Treating with IBA alone had no effect on shoot development. IBA treatment combined with biosolids treatments had no interaction effects (Figs. 4 and 5).

To conclude, inclusion of each of the two biosolids in rooting medium, at the optimal concentration for each of the biosolids, significantly enhanced root and shoot development. We attribute the effect mainly to the presence of biosolids-

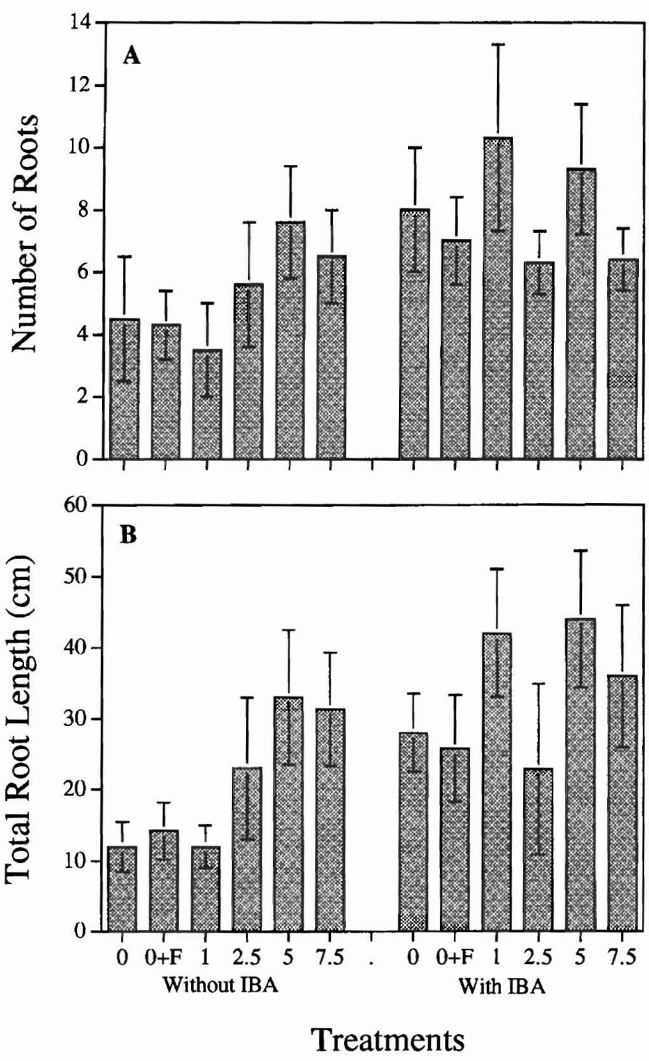

Fig. 3. **Effect of Herzliyya biosolids on the number (A) and the total length (B) of roots of rooted *Bougainvillea glabra* cuttings. For description of treatments see Fig. 1. Vertical bars indicate SE.**

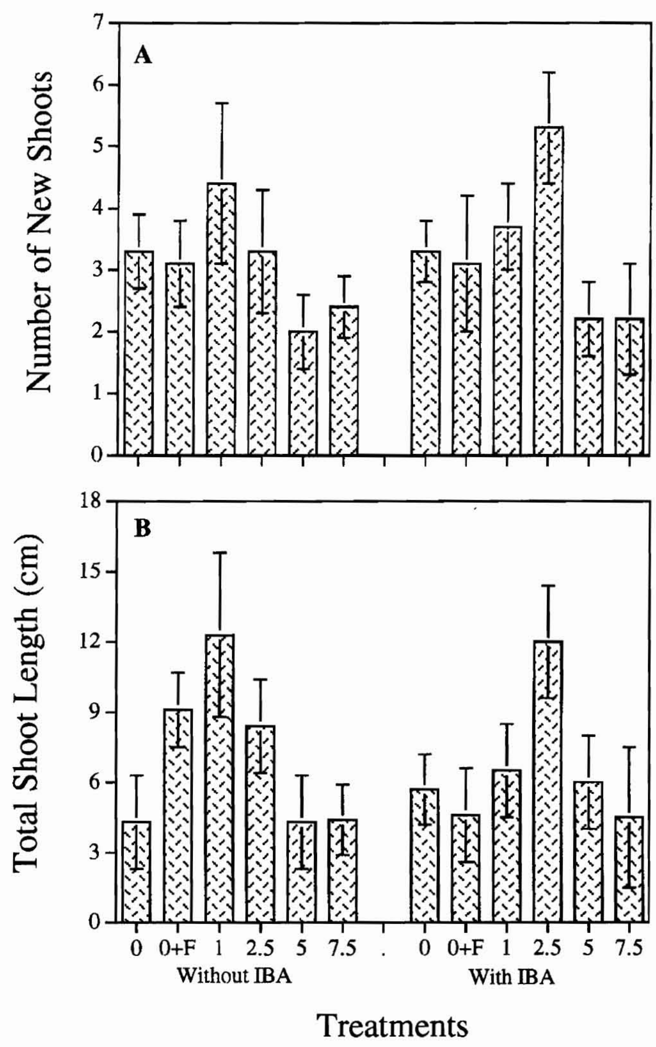

Fig. 4. **Effect of Haifa biosolids on the number (A) and the total length (B) of new shoots of rooted *Bougainvillea glabra* cuttings. For description of treatments see Fig. 1. Vertical bars indicate SE.**

borne plant growth regulators such as auxins and cytokinins (10, 18). Auxins have been shown to be a by-product of anaerobic microbial metabolism (11). Addition of IBA stimulated root development in sludge-free medium but this stimulation faded in the presence of biosolids. Biosolids dosing could become inhibitory, as was apparent with the Haifa biosolids. Since plant nutrition (added in the form of mini-osmocote) did not affect root development, it seems that the biosolids contained other plant growth factors in addition to hormones. Tomati et al. (16) suggested that the biosolids affect the biological activities in the medium and therefore affect the production of various active biocatalysts, including enzymes, vitamins, growth regulator substances, antibiotics and many other compounds which play particular roles in plant growth and development. This stimulation of root development by the biosolids is important in producing quality seedlings in the nursery (14). At any rate, the enhancement of root and shoot development with Haifa biosolids occurred at lower concentrations than with Herzliyya biosolids. This was probably associated with higher concentrations of plant growth factors in the Haifa biosolids (e.g., plant growth regulators, nutrients). Our results confirm the assertion that the source of biosolids and the type of treatment can influence the effectiveness of the biosolids on rooting and development of cuttings (13).

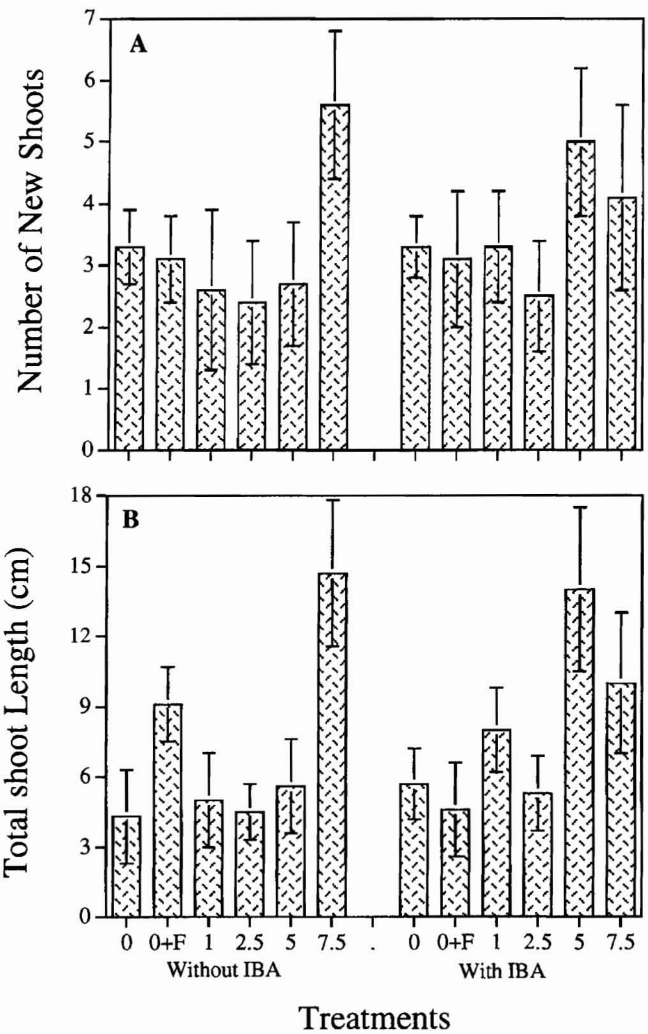

Fig. 5. Effect of Herzliyya biosolids on the number (A) and the total length (B) of new shoots of rooted *Bougainvillea glabra* cuttings. For description of treatments see Fig. 1. Vertical bars indicate SE.

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