Table 2. The influence of vermiculite size on seedling counts along 6 m rows planted with the baffle planter.

Planters	Vermiculite size	Row section: First 2 m	Middle 2 m	Last 2 m
		Cabbage		
Baffle	1	53 a[z]	35 b	34 b
Baffle	2	81 a	29 b	10 c
Baffle	3	104 a	8 b	2 b
Standard	none	53 a	50 a	57 a
		Cucumber		
Baffle	1	9 a	14 a	20 a
Baffle	2	18 a	20 a	26 a
Baffle	3	20 a	27 a	24 a
Standard	none	11 a	26 a	23 a

[z]Values in these tables are means of 4 replications. Means in rows separated by Duncans' multiple range test at 5%.

lations in this position would result in an inferior stand, and thus it has not been tried.

Four belt planter units have been used for all our plot planting this year and we plan to use them again next year without modification. The materials consisting of 2 sprockets, a chain, 4 collar locks, 2 short pieces of rod, a section of inner tube, and a funnel cost less than $30 per unit and can be assembled in less than 4 hr by someone with access to a shop. To convert from plot planting to field planting requires less than 15 min per unit.

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Earthworm Casting in Plant Propagation

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Abstract. **Rooting experiments on layers of *Ficus elastica* Roxb. ex Hornem., *Dieffenbachia amoena* Bull., *Cordyline terminalis* (L.) Kunth, *Dracaena deremensis* Engl., and on shoots of *Ficus elastica*, *Begonia masoniana* Irmsch, *Aglaonema costatum* N.E. Br., *Saintpaulia ionatha* H. Wendl. were performed to ascertain the possibility of employing earthworm casting in plant propagation. Rooting of layers was favored when casting alone was supplied whereas, rooting of shoots generally was enhanced when casting mixtures were used.**

Earthworm casting utilization in horticulture has been proposed for several years (1): growth improvement for specific plants, compatibility with technology in use, and low cost of production were among the reasons which supported their employment as a growth medium.

There is considerable literature showing that earthworms and their castings favor rooting, root growth, and plant development (4, 6, 15). Beneficial effects have been mainly related to the soil improvement and to the increased content of available mineral nutrients (8, 10), but it seems likely that the stimulation could be related to the microflora and to some metabolites produced by microorganisms as a consequence of their secondary metabolism (13, 17).

In our previous papers we pointed out the importance of these biological factors, particularly gibberellins, cytokinins, and auxins, present in earthworm castings as consequence of microbial metabolism (17, 18). These substances play an important role in rooting and in root and plant development (19).

This study was designed to evaluate stem and layer rooting response to casting application. Casting can be obtained easily and economically from the biodegradation of many organic materials such as municipal, agricultural, and farmyard wastes. In our experiments, earthworm casting from a mixture of organic urban wastes and urban sewage sludge was used. Chemical and biological analysis of the casting were performed as follows:

Total nitrogen and carbon: were assayed by a C/H/N Analyzer Perkin Elmer mod. 240/B.

Total phosphorus: was assayed after mineralization according to Taussky and Shorr (16).

Phosphate (PO_4^{-3}): was assayed according to Taussky and Shorr (16).

Nitrate (NO_3^-): was assayed by means of a NO_3^- electrode Orion Research.

Elements: were determined, after mineralization, by atomic absorption spectroscopy with a Perkin Elmer mod. 380 Spectrophotometer.

Microbiological analysis: the weighed samples of the casting were placed into known volumes of sterile water in sterile bottles. The bottles were shaken in a rotary shaker for 5 min and serial dilutions were made. Total bacteria grown on the medium described by Brown (2) were counted after incubating the plates for 3 days at 30°C. Fungi were grown on the same medium supplemented with rose bengal and streptomycin (10) and were incubated for 7 days at 30°. Actinomycetes were grown on the medium of Pridham et al. (14) and incubated for 8 days at 30°.

Extraction of hormones from the casting: 1000 g of air-dried casting were collected and shaken in 1 liter of acidified water at pH = 2.5–3.0, according to Brown and Burlingham (3). The suspension was filtered, activated charcoal added to the supernatant to a final concentration of 1% (w/v), and shaken for 5 hr in a rotary shaker. After centrifugation, the charcoal was shaken with 95% acetone 1/1 (v/v) for 5 hr and acetone evaporated. The dried residue was dissolved in water and used for the phytohormone determinations.

Phytohormone bioassay: the cytokinin activity was tested by means of the radish ('Cherry Belle') cotyledon assay, according to the procedure described by Letham (9). The gibberellin activity was tested by the elongation of lettuce seedling ('Great Lakes') hypocotyls (7). The auxin activity was tested by the elongation of a section of coleoptile of *Triticum vulgare* 'Marzotto' according to the procedure described by Nitsch and Nitsch (12). Phytohormone activity was related to μg equivalent of N^6-Δ^2-isopentenyladenine (Sigma), indol-3-acetic acid (Merck), and gibberellic acid (Fluka).

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Table 1. Chemical analysis, microbial population, and growth regulators content of earthworm casting.

Constituent	Amount
Chemical analysis	
Water content	51.60 %
pH	6.50
C (total)	16.78 % d.w.
C (inorganic)	1.37 % "
N (total)	1.63 % "
$N\text{-}NO^{-3}$	0.40 % "
P (total)	0.92 % "
$P\text{-}PO_4^{-3}$	0.14% "
K_2O	1.61 % "
Ca (total)	8.60 % "
Ca (available)	0.14 % "
Mg (total)	2.51 % "
Mg (available)	0.45 % "
Na	3.03 % "
Fe	910.10 ppm d.w.
Mn	218.40 ppm "
Cu	7.20 ppm "
B	0.35 ppm "
Zn	68.30 ppm "
Microbial Population (Number of cells/g d.w.)	
Bacteria	1.8×10^8
Actinomycetes	2.8×10^6
Fungi	2.0×10^5
Growth Regulators (µg equiv./g d.w.)	
Gibberellins (GA_3)	2.75
Cytokinins (IPA)	1.05
Auxins (IAA)	3.80

Table 2. Effect of casting treatments on rooting initiation of layers (days from the beginning of the experiment).

Species	Days to root initiation: Control	Casting-control medium mixture 1:1 (f.w.)	Casting alone
Ficus elastica	22	20	17*[z]
Dracaena deremensis	36	35	30*
Dieffenbachia amoena	32	30	30
Cordyline terminalis	30	28	23*

[z]*Significant at $P = 0.05$ (horizontal comparison by t test).

Table 3. Effect of casting treatments on rooting of layers after 6 weeks.

Species and measurement	Control	Casting-control medium mixture 1:1 (f.w.)	Casting alone
Ficus elastica			
fresh weight (g)	6	8	12**[z]
root elongation (cm)	5	6	10**
Dracaena deremensis			
fresh weight (g)	5	6	9*
root elongation (cm)	9	10	13*
Dieffenbachia amoena			
fresh weight (g)	10	10	15**
root elongation (cm)	9	9	12*
Cordyline terminalis			
fresh weight (g)	7	7	8
root elongation (cm)	7	7	7

[z]*,**Significant at 5% or 1% level, respectively.

The chemical analysis, microbial population, and growth regulator content of casting medium is presented in Table 1. Rooting experiments replicated 3 times were carried out at the Municipal Greenhouses of Rome.

Rooting experiments on layers were performed on *Ficus elastica* ('Decora'), *Dieffenbachia amoena* ('Bauxi'), *Cordyline terminalis* ('Bicolor') and *Dracaena deremensis* Roehrsii. Twenty plants of each species were grown indoors in 20 liter plastic containers. Stems were layered by wrapping them with: a) sphagnum moss; b) casting mixed with sphagnum (1:1 v/v fw); and c) casting alone. The layers were wrapped with clear plastic film and were harvested after 6 weeks.

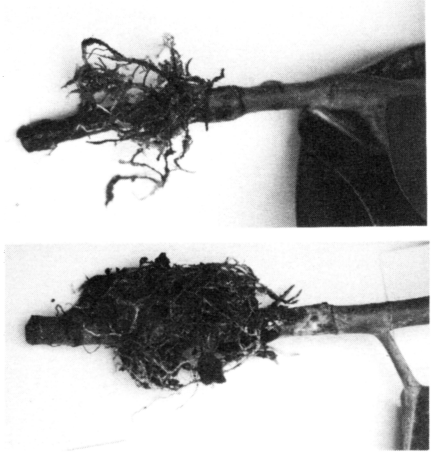

Fig. 1. Effect of earthworm casting on Ficus layer rooting. Control on the top; layer treated with casting alone on the bottom.

Casting generally stimulated root initiation, root elongation, and root biomass with the best results obtained when casting alone was used (Tables 2, 3 and Fig. 1). Casting acts in different ways when applied to different plants; it was most effective on *Ficus* and *Dracaena* whereas less effect was noted on *Dieffenbachia* and *Cordyline*.

Rooting experiments on stem cuttings were performed on *Begonia masoniana* ('Iron-cross'), *Ficus elastica* ('Decora'), *Aglaonema costatum* ('Virens') and on stalked leaves of *Saintpaulia ionantha* ('Pink Puff'). A hundred shoots of each species were planted indoors in plastic trays (30 × 25 × 6 cm) with: a) peat:sand 1:1 (v/v) as control medium; b) the same control medium in which Rizophon (from Aifar Agricola containing 0.5% IAA)-treated shoots were planted; c) casting mixed with the control medium (a) in the ratio 1:3 (v/v fw) and d) in the ratio 1:1 (v/v fw); e) casting alone. Twenty shoots of each species were harvested after 2 weeks in order to ascertain casting effect on the rooting initiation. If compared to the control (a), results showed that casting mixtures greatly favored rooting percentage, showing a behaviour similar to that of auxin-treated plants (Fig. 2).

These results were confirmed 3 weeks after the beginning of the experiment when all shoots were harvested. Particularly, improvement in the rooting percentage of *Ficus* and *Begonia* was recorded when 1:3 casting mixture was supplied, whereas the best results were evident at higher concentrations for *Aglaonema* and *Saintpaulia*. A relationship between the percentage of rooting and root biomass always was evident. Casting effects on different plants were not always the same, and differences also were evident when the same amounts of casting were used for promoting roots from layer and from shoot by the same plant. These differences could depend on the physiology of the different plants and on the kind of tissue from which rooting must be stimulated.

Increases in rooting rate, rooting percentage, and root development could be explained partially by growth regulators present in the casting.

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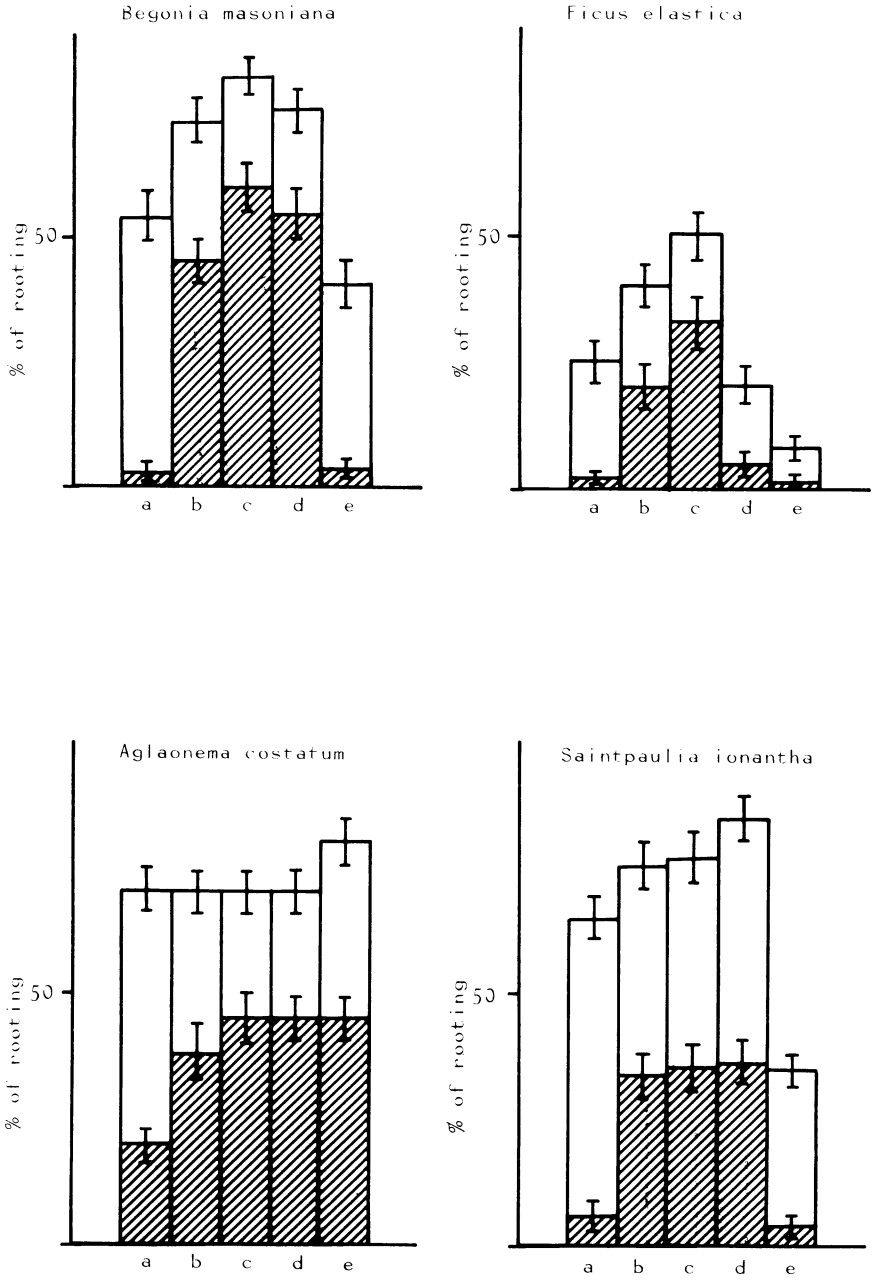

Fig. 2 Percentage of rooting of shoots after 2 weeks ▨ and after 3 weeks □, from the beginning of the experiment. **a)** Control medium (peat:sand 1:1). **b)** Control medium in which Rizophon-treated shoots were planted. **c)** Casting-control medium mixture in the ratio 1:3 (f.w.). **d)** Casting-control medium mixture in the ratio 1:1 (f.w.). **e)** Casting alone. Bars indicate the SD of the mean.