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A Comparison of Methods for the Analysis of Compost-Based Growing Media

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Abstract

The objective of this study was to evaluate 3 analytical methods used for the characterization of compost-based substrates and their ability to predict nutritional disorders during plant cultivation. Five composts (CO) from different origins (green waste and a mixture of green waste and organic fraction of household waste) were mixed with light peat (LP) and perlite (PE) in the following rates: 33% CO, 50% LP, 17% PE; 50% CO, 33% LP, 17% PE and 66% CO, 17% LP, 17% PE. The growing media obtained were analysed in two laboratories with the following water extraction methods: Sonneveld 1:1.5 (V/V); EN 13652 1:5 (V/V); Regione Piemonte 1:5 (W/V). Electrical conductivity (EC), pH and plant available nutrients (NO_3-N, NH_4-N, P and K) were determined. A field trial with the 15 substrates analysed was carried out in order to correlate results of the chemical analysis with plant growth responses. Tested species were *Impatiens hawkerii* 'New Guinea', *Prunus laurocerasus* 'Rotundifolia' and *Euphorbia pulcherrima*. Results showed good correlation between the methods; for EC, pH, NO_3-N and K it was possible to define conversion factors. Plant growth was adversely influenced by the amount of compost in the growing medium. High values of EC reduced plant development, especially in the stages following the transplanting of rooted cuttings into pots. Relations between analytical methods and plant growth show that both the methods according to EN 13652 and Sonneveld seem to be the most suitable to predict nutritional disorders in the cultivation of ornamental plants, while Regione Piemonte method is less accurate to characterize compost-based substrates.

INTRODUCTION

Peat is the predominant organic material for the production of growing media in horticulture. However, an increasing demand for recycling of organic matter has stimulated the research of alternative constituents. Production of composted materials from green waste and the organic fraction of household waste has improved in Italy and the evaluation of the amount of compost that can be added to a growing medium has been studied in several works on ornamental pot plants (Lamanna et al., 1991; D'Angelo and Castelnuovo, 1995; D'Angelo, 1996; Frangi et al., 2004).

In Italy, in lack of official methods, still several methodologies based on differing water extraction procedures are used to determine pH, electrical conductivity (EC) and available nutrients (NO_3-N, NH_4-N, P and K) in growing media and soil improvers. Up to now European standards and regional methods are performed in parallel in several laboratories. Therefore, a comparison of results from different methods is important to get a basis for a possible conversion of established guidelines for chemical and physical properties of substrates (Baumgarten, 2004; Wever and van Winkel, 2004).

The goal of this study was to evaluate three water extraction methods, one commonly adopted in Italy for compost characterization (Regione Piemonte) and two applied to growing media (Sonneveld and EN 13652), in order to identify the most suitable for the prediction of nutritional disorders of ornamental potted plants grown in compost-based substrates.

MATERIALS AND METHODS

Two sets of experiments were carried out, each one including an analytical comparison and a field test with ornamental potted plants.

In each experiment, 5 composts (CO) coming from different sources were chosen and mixed with light peat (LP) and perlite (PE) in the following rates: 33% CO, 50% LP, 17% PE; 50% CO, 33% LP, 17% PE and 66% CO, 17% LP, 17% PE. The 15 substrates obtained (5 composts x 3 mixtures) were then analysed for pH, EC, water soluble macronutrients (NO_3-N, NH_4-N, P and K) in two laboratories (Minoprio Analisi e Certificazioni and Department of Plant Production, University of Milan) applying the following water extraction methods:

- 1:1.5 (v/v, solid/water) Sonneveld and Ende, 1974;
- 1:5 (v/v solid/water) UNI EN 13652, 2001;
- 1:5 (w/v solid/water) Regione Piemonte (Italy), 1998.

Data were calculated as means of 3 replicates. FII linear regression was adopted in order to verify the possibility to predict results obtained with one method from values obtained with another one (Anderson, 1987).

Experiment 1

In this trial, two green waste composts (GWC) and three composts derived from a mixture of the organic fraction of household waste (25–50%) and green waste (HGWC) were used. pH and EC ($mS.m^{-1}$ at 25°C) were determined in the extracts as described above.

A pot trial with the 15 substrates (5 composts in 3 mixtures) was carried out both in greenhouse, using New Guinea *Impatiens* (*Impatiens hawkerii* Bull.) cv. Riviera Red, and outdoors, using *Prunus laurocerasus* 'Rotundifolia' cultivated under an anti-hail net. Final measurements of plant height, plant diameter and number of branches were done on 16 plants per treatment (4 replications with 4 plants) and then submitted to analysis of variance.

Experiment 2

In this experiment, three composts were produced from green wastes (GWC), two were derived both from green waste and from the organic fraction of household waste (HGWC). The 15 substrates (5 composts in 3 mixtures) obtained were extracted according to the methods described above and analyzed for NH_4-N, NO_3-N, P and K. Ammonium was determined by steam distillation on boric acid and titration with 0.01N H_2SO_4; nitrate, previously reduced to ammonium by Devarda alloy, by steam distillation on boric acid and titration with 0.01N H_2SO_4 (University of Milan) or by a colorimetric test kit (Minoprio); phosphorus by colorimetric analysis using the molybdate-blue/ascorbic acid method; potassium by flame atomic emission spectroscopy. All the results are expressed as mg/L of water extract.

The substrates were compared in a cultivation trial with poinsettia. At the end of the trial data on plant height, plant diameter and number of bracts were collected on 16 plants per treatment and then submitted to analysis of variance.

In both experiments, a correlation analysis between growth characteristics and analytical results (pH, EC, NO_3-N and K) was performed to identify the method that best predicts plant nutritional disorders.

RESULTS AND DISCUSS

Analytical Methods

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RESULTS AND DISCUSSION

Analytical Methods

According to Alt et al. (1988), water is an unsuitable extractant for available NH_4-N and P in compost-based substrates. As these nutrients are mainly contained in compost, their concentrations in water extracts should follow linear trends linked to the compost rate. Regardless of the method, we observed that the concentration of NH_4-N in the water extracts was independent of the compost rates in the mixture, while P concentration even showed a negative relationship with the amounts of compost. The values of P increased at the decrease of compost in the mixtures, probably due to the pH of substrates that was lowered by light peat. Nevertheless, for the others parameters (pH, EC, NO_3-N and K), we found good relationships between the compost percentage and analytical results.

The possibility to predict values for one method from values obtained with a second method was investigated by means of FII linear regression indicated by Anderson (1987), that takes into account the error in the measurements of both variables rather then just in the independent one. FII regression was applied to the values of pH, EC, NO_3-N and K obtained with the three extraction methods, considering Sonneveld method as the independent variable X. The conversion coefficients were developed as reported in Table 1. Moreover, to allow the evaluation of guideline schedules based on a specific method, the error associated to the use of these numerical conversion factors was determined calculating the standard deviation of the mean difference between X values (analytical data) and the values obtained by numerical conversion factors (transformed Y). For each parameter analyzed, the minimum and maximum values obtained with the three methods are reported in Table 2.

Cultivation Trials in Compost-Based Substrates

As regards New Guinea *Impatiens*, both the type and the amount of compost significantly affected plant development (Table 3). Stunted growth was recorded with substrates containing GWC1 and HGWC2, and the last compost caused 100% plant mortality when its amount in the mixture reached 66%. Regardless of the compost type, plant height and diameter decreased when the rate of compost in the media increased. Also for the ornamental shrub *Prunus laurocerasus,* plant height and diameter were influenced by the type and the amount of compost in the substrate. For GW composts, the lowest values of these parameters were detected on plants cultivated with 50% of compost in the medium. For both species, the best results in terms of overall plant growth were obtained with substrates containing 33% of GWC1, HGWC1 and HGWC3. For poinsettia an EC higher than 350 mS/m (Sonneveld method) in the first month of cultivation caused more than 50% of plant mortality (data not shown). No poinsettia plants survived when cultivated with 66% of GWC4, or with 50% and 66% of HGWC4 and HGWC5 (Table 4). An acceptable level of quality in poinsettia cultivation was reached only with 33% or 50% of GWC3 in the substrate.

Relation between Analytical Methods and Plant Growth

In order to identify the analytical method best related to plant development, the correlation between EC values obtained with the three methods and some growth parameters of New Guinea *Impatiens* and *Prunus laurocerasus* was calculated (Table 5). For *Impatiens* the EN method showed significant correlations between EC values and plant characteristics for all the composts tested, while the Sonneveld method and, even more, Regione Piemonte method were not so accurate in predicting the plant growth delays. *P. laurocerasus,* a hardy species, showed correlations only for three HGWC composts, no differences were observed between the analytical methods. The different responses of the methods compared are probably due to the fact that two (Sonneveld, EN) are volume/volume extraction methods while Regione Piemonte method uses a weight/volume extraction, designed for compost analysis.

CONCLUSIONS

Results obtained in these experiments allowed to find conversion factors for pH, EC, NO_3-N and K between three water extraction methods utilized to characterize compost based substrates. A comparison of results from different methods is essential to explain established guidelines for chemical and physical properties of substrates. For the tested species, plant growth was adversely influenced by the amount of compost in the growing medium, and an acceptable level of growth was observed with an amount of 33% of compost in the substrate. Relations between analytical methods and plant growth show that both EN 13652 and the Sonneveld method seem to be able to predict nutritional disorders in the cultivation of ornamental plants, while Regione Piemonte method is less accurate to characterize compost-based substrates.

ACKNOWLEDGEMENTS

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Tables

Table 1. Numerical coeffi… by the application of co…

Parameter	y=
pH	$Y_{RP} = X_S$ 0
	$Y_{EN} = X_S$ 1
EC	$Y_{RP} = X_S$ 0
	$Y_{EN} = X_S$ 0
NO_3-N	$Y_{RP} = X_S$ 0
	$Y_{EN} = X_S$ 0
K	$Y_{RP} = X_S$
	$Y_{EN} = X_S$

RP=Regione Piemonte; S=Sonn…

Table 2. Range of values o…

	Reg…
pH	6.
EC (mS/m)	
NO_3-N (mg/L)	
K (mg/L)	2

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Direzione Generale Agricoltura Elio Desimoni for his contribution

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Tables

Table 1. Numerical coefficients from linear association relationship and the error caused by the application of conversion factors.

Parameter	y=bx+a	Transformed Y	$X-Y_{transf}$ (mean and st. dev.)
pH	$Y_{RP} = X_S\ 0.88522 + 1.10$	Y=(y/0.88522)-1.10	$2.21*10^{-5} \pm 0.09$
	$Y_{EN} = X_S\ 1.16356 - 0.98$	Y=(y/1.16356)+0.98	$7.46*10^{-6} \pm 0.08$
EC	$Y_{RP} = X_S\ 0.77365 + 27.4$	Y=(y/0.77365)-27.4	$8.68*10^{-6} \pm 19.4$
	$Y_{EN} = X_S\ 0.29942 + 13.0$	Y=(y/0.29942)-13.0	$8.43*10^{-2} \pm 7.3$
NO_3-N	$Y_{RP} = X_S\ 0.67724 + 19.8$	Y=(y/0.67724)-19.8	$6.20*10^{-4} \pm 8.80$
	$Y_{EN} = X_S\ 0.34314 + 12.5$	Y=(y/0.34314)-12.5	$8.80*10^{-4} \pm 10.5$
K	$Y_{RP} = X_S\ 0.55203 + 119$	Y=(y/0.55203)-119	$1.02*10^{-2} \pm 35.6$
	$Y_{EN} = X_S\ 0.33759 + 24.6$	Y=(y/0.33759)-24.6	$7.10*10^{-4} \pm 20.4$

RP=Regione Piemonte; S=Sonneveld; EN=EN 13652.

Table 2. Range of values obtained for each parameter and method.

	Reg. Piemonte (min-max)	Sonneveld (min-max)	EN 13652 (min-max)
pH	6.70–8.69	6.85–8.38	6.80–8.60
EC (mS/m)	58–493	50–438	19–140
NO_3-N (mg/L)	52–251	45–373	17–120
K (mg/L)	270–673	303–1062	104–390

Table 3. Growth of New Guinea *Impatiens* and *Prunus laurocerasus* as affected by type and amount of compost in the substrate.

Type of compost	Amount of compost (%)	Plant height (cm)	Plant diameter (cm)	Number of branches
New Guinea *Impatiens*				
GWC 1	66	14.2 f	18.3 f	2.8 bd
	50	14.7 f	21.7 e	3.0 ac
	33	16.4 e	26.1 c	2.6 cd
GWC 2	66	16.1 e	22.7 de	2.7 bd
	50	17.5 bc	26.5 c	3.1 ac
	33	18.9 a	28.7 ab	3.1 ac
HGWC 1	66	16.5 e	23.7 d	3.5 a
	50	18.3 ab	26.9 bc	3.2 ac
	33	18.5 a	30.0 a	3.3 ab
HGWC 2	66	-	-	-
	50	14.8 f	17.1 f	2.3 d
	33	16.1 e	24.3 d	2.6 cd
HGWC 3	66	16.7 cd	24.0 d	2.6 cd
	50	18.3 ab	27.9 bc	2.9 ad
	33	18.1 ab	28.7 ab	3.0 ac
Significance				
Type of compost		**	**	**
Amount of compost		**	**	n.s.
Prunus laurocerasus				
GWC 1	66	35.4 cf	29.2 bc	2.4 bc
	50	31.2 eg	24.2 c	2.3 c
	33	39.0 bd	32.5 ab	2.9 ac
GWC 2	66	42.1 ab	32.7 ab	2.5 bc
	50	32.9 dg	28.2 bc	2.6 bc
	33	43.3 ab	35.2 a	3.3 a
HGWC 1	66	33.6 dg	27.9 bc	3.3 a
	50	40.0 bc	31.8 ab	2.8 ac
	33	47.8 a	35.0 a	3.0 ab
HGWC 2	66	29.0 g	24.0 c	2.4 bc
	50	30.8 fg	25.7 c	2.7 ac
	33	40.1 bc	31.8 ab	3.1 ab
HGWC 3	66	21.4 h	18.5 d	2.3 c
	50	37.2 be	29.1 bc	2.6 ac
	33	42.2 ab	37.0 a	3.3 a
Significance				
Type of compost		**	**	n.s.
Amount of compost		**	**	**
Interaction type x amount		**	**	n.s.

For each species values followed by the same letter in columns are not significantly different according to Duncan's multiple range test. n.s.: not significant; **: significant at p=0.01.

Table 4. Growth of poinset

Type of compost	Amo comp
GWC 3	
GWC 4	
GWC 5	
HGWC 4	
HGWC 5	
Significance	
Type of compost	
Amount of compost	

Values followed by the sa multiple range test. n.s.:

Table 5. Correlation b *Impatiens* and *Pru*

Compost	Meth
GWC1	Reg. Pier
	Sonnevel
	EN 1365
GWC 2	Reg. Pier
	Sonneve
	EN 1365
HGWC 1	Reg. Pie
	Sonneve
	EN 136
HGWC 2	Reg. Pi
	Sonnev
	EN 136
HGWC 3	Reg. Pi
	Sonnev
	EN 136

* significant at p=0.05;

us laurocerasus as affected by type

Plant diameter (cm)	Number of branches
18.3 f	2.8 bd
21.7 e	3.0 ac
26.1 c	2.6 cd
22.7 de	2.7 bd
26.5 c	3.1 ac
28.7 ab	3.1 ac
23.7 d	3.5 a
26.9 bc	3.2 ac
30.0 a	3.3 ab
-	-
17.1 f	2.3 d
24.3 d	2.6 cd
24.0 d	2.6 cd
27.9 bc	2.9 ad
28.7 ab	3.0 ac
**	**
**	n.s.
29.2 bc	2.4 bc
24.2 c	2.3 c
32.5 ab	2.9 ac
32.7 ab	2.5 bc
28.2 bc	2.6 bc
35.2 a	3.3 a
27.9 bc	3.3 a
31.8 ab	2.8 ac
35.0 a	3.0 ab
24.0 c	2.4 bc
25.7 c	2.7 ac
31.8 ab	3.1 ab
18.5 d	2.3 c
29.1 bc	2.6 ac
37.0 a	3.3 a
**	n.s.
**	**
**	n.s.

not significantly different according to
t p=0.01.

Table 4. Growth of poinsettia as affected by type and amount of compost in the substrate.

Type of compost	Amount of compost (%)	Plant height (cm)	Plant diameter (cm)	Number of bracts
GWC 3	66	17.1 bc	24.0 cd	3.1 c
	50	23.9 a	33.8 a	4.1 ab
	33	22.9 a	31.3 ab	4.0 ac
GWC 4	66	-	-	-
	50	11.0 e	15.9 f	3.1 c
	33	17.6 bc	24.9 cd	3.9 ac
GWC 5	66	15.9 c	20.6 de	3.6 ac
	50	19.4 b	27.8 bc	3.9 ac
	33	19.6 b	27.0 bc	4.4 a
HGWC 4	66	-	-	-
	50	-	-	-
	33	13.4 d	19.3 ef	3.2 c
HGWC 5	66	-	-	-
	50	-	-	-
	33	16.8 c	21.6 de	3.4 bc
Significance				
Type of compost		**	**	**
Amount of compost		**	**	**

Values followed by the same letter in columns are not significantly different according to Duncan's multiple range test. n.s.: not significant; **: significant at p=0.01.

Table 5. Correlation between EC of tested composts and plant growth of New Guinea *Impatiens* and *Prunus laurocerasus*.

Compost	Method	New Guinea *Impatiens*		*Prunus laurocerasus*	
		Plant height	Plant diameter	Plant height	Plant diameter
GWC1	Reg. Piemonte	-0,847*	-0,915*	-0.343	-0.279
	Sonneveld	-0,834*	-0,910*	-0.310	-0.245
	EN 13652	-0,934**	-0,984**	-0.450	-0.385
GWC 2	Reg. Piemonte	-0,606	-0,549	-0.386	-0.521
	Sonneveld	-0,835*	-0,827*	-0.073	-0.286
	EN 13652	-0,918**	-0,909*	-0.074	-0.309
HGWC 1	Reg. Piemonte	-0,757	-0,878*	-0.884*	-0.872*
	Sonneveld	-0,796	-0,875*	-0.875*	-0.873*
	EN 13652	-0,897*	-0,984**	-0.984*	-0.982*
HGWC 2	Reg. Piemonte	-0,789	-0,837**	-0.720	-0.825*
	Sonneveld	-0,898*	-0,965**	-0.864*	-0.971*
	EN 13652	-0,818*	-0,920*	-0.942**	-0.994**
HGWC 3	Reg. Piemonte	-0,850*	-0,959**	-0.975**	-0.994**
	Sonneveld	-0,811	-0,907*	-0.920**	-0.933**
	EN 13652	-0,849*	-0,956**	-0.971**	-0.989**

* significant at p=0.05; ** significant at p=0.01