Pak. J. Bot., 41(6): 3139-3147, 2009.

COMPOSTED POSIDONIA, CHICKEN MANURE AND OLIVE MILL RESIDUES, AN ALTERNATIVE TO PEAT AS SEED GERMINATION AND SEEDLING GROWING MEDIA IN TUNISIAN NURSERY

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Abstract

In order to reduce the peat use in Tunisian nurseries, new types of composts were tested for seed germination and seedling growth of tomato. These composts were made at three different combinations from Posidonia (*Posidonia oceanica*), chicken manure and solid fraction of olive mill residues. These wastes are abundant and therefore considered as a pollution source in Tunisia. Tomato seeds were sown in potting media containing mixtures of three composts (C_1, C_2 and C_3) and peat at increasing ratios (10%, 30% and 50% v/v). Control potting media consisted of using 100% peat. Percentage seed germination and the seedling length were studied weekly and during five weeks. At the end of the experiment, shoot and root dry matter weights were measured. Toxicity test of compost extracts was conducted on tomato and radish seeds. The results showed higher seed germination and seedling growth rates in the media containing the three composts compared to control. Toxicity test showed that compost extracts were not toxic. The tested composts might be used as an alternative to peat and the mixtures compost-peat as a growing media for tomato.

Introduction

Many authors try to establish the potential value of different compost types as horticultural substrates and nutrient sources (Hartz *et al.*, 1996*;* Spiers and Fietje, 2000). Compost act as an effective mulch, increase concentration of soil organic matter, improve tilth and water-holding capacity, suppress weeds and provide a long-term supply of nutrients with decomposition of its organic material (Evanylo & Daniels, 1999). Several composts from vegetal material were assessed by many authors: Seagrass and seaweed residues were tested with yard waste for horticultural purposes (Orquin *et al*., 2001), composted green waste was used as a growing medium component (Prasad and Maher, 2001), Roig *et al*., (2001) studied the composting of the solid fraction of olive mill waste water, woodwaste composts were performed as growing media for vegetables under protection by Pudelski (2001). More than one compost from animal material were also studied eg., pig manure (Atiyeh *et al.*, 2000), mink manure (Ferguson, 2001), racetrack manure (Warman & Termeer, 1996. Production and use of composts not only reduce the volume of wastes but also offer a high potential substrate and reduce usage of peat in the market of growth media (Zoes *et al*., 2001). In this study, we tested the efficiency of three composts, made from Posidonia, chicken manure and solid olive mill wastes, to enhance germination and growth of tomato seedlings in order to replace part of peat in growing media and reduce cost of substrates. Posidonia (*Posidonia oceanica,* Delile) is a Mediterranean marine phanerogam that covers more than two million hectares along the Mediterranean coasts. Leaves accumulated in litter are rejected in enormous quantities on the Tunisian beaches. The chicken manure accumulation is accompanied by serious environmental problems; for instance, the underground water is affected by nitrates and phosphates, air by ammonia emission and soil by accumulated heavy metals and phosphorus (Walker & Bernal, 2007). The solid fraction of olive mill wastewater is accumulated each year in the Tunisian oil mills and it is very rich in organic matter but its utilisation uses only a small fraction of the available quantities (Fourati *et al*., 2001). The objective of the present study was to reduce the use of peat as a potting medium by its substitution with composts at different concentrations (0%, 10%, 30% and 50% by volume). Potting media were tested on tomato seedlings and compost extract toxicity was evaluated on tomato and radish seeds.

Materials and Methods

Characterization of the original composts: Composts used in this study were produced after 300 days of composting in the Technical Center of Organic Agriculture in Chott Meriem-Sousse. Tunisia. Three composts (C_1, C_2 and C_3) were tested, with the following combinations: i) C_1: 50% solid olive mill wastes (SOMW), 20% Posidonia (P), and 30% chicken manure (CM); ii) C_2: 35% (SOMW), 35% (P), and 30% (CM); iii) C_3: 20% (SOWM), 50% (P), and 30% (CM). These percentages are proportions in weight. Each compost pile weight was 20 tons. Posidonia was collected from Hergla beach (20 km North from Sousse) and was abundantly washed to eliminate salts from leaves surface as suggested by Saïdane *et al*., (1979). SOMW and CM were collected from an olive mill near Sousse and from a chicken breeding unit in Sousse, respectively. For compost analysis, sampling was made by mixing three subsamples taken from three different points in pile. Each subsample was a mixture of three samples taken from the top to the bottom of the pile at each sampling pile. Samples were placed in polyethylene bags and transferred in the same day to the laboratory (Benito *et al*., 2005). The samples were analyzed for total organic carbon (TOC) by dry combustion method at 540°C during 4h (Abad *et al*., 2002) and total N (TN) by Kjeldahl digestion (Bremmer & Mulvaney, 1982). Electrical conductivity (EC) and pH were analyzed in a 1:5 (v/v) water extract. After water extraction (1:5 v/v), K_2O, CaO and MgO were evaluated by atomic absorption and P_2O was determined colorimetrically following Murphy & Riley (1962) method. Mean values of three replications on a dry-weight basis (oven dried at 105°C for 24h) were reported. Chemical properties of the investigated composts are summarized in Table 1.

Compost extracts: Three extracts (E_1, E_2 and E_3) corresponding to C_1, C_2 and C_3 respectively, were prepared according to the steepage procedure of Weltzein (1992) modified by Znaïdi (2002). Each compost was suspended in tap water (1:5 vol/vol) in a loosely covered 10-liter plastic container. The suspension was incubated for 6 days at 15 to 20°C and stirred 5 to 10 min., daily. Extracts were filtered through a 2-mm screen to remove large particles and then preserved in closed flasks at +4°C to be used for the toxicity test.

Table 1. Physical and chemical characteristics of the three composts C_1, C_2 and C_3.

Parameters	C_1	C_2	C_3
E.C	1.64 a (±0.31)	2.07 b (±0.15)	1.70 c (±0.2)
pH	8.23 a (±0.03)	8.51 b (±0.15)	8.17 a (±0.17)
TOC	198.67 a (±33.3)	207 a (±32.97)	244.33 a (±53)
TN	17.56 b (±1.1)	15.7 ab (±1.5)	14.53 a (±1.33)
CaO	66.7 a (±11.7)	96.76 b (±1.36)	97.93 b (±12.25)
MgO	5.04 a (±0.87)	8.08 ab (±0.45)	10.05 a (±3.05)
K_2O	2.34 a (±0.33)	2.68 ab (±0.2)	4.97 b (±1.94)
P_2O_5	5.09 a (±0.54)	9.70 b (±0.51)	13.87 c (±3.01)
C/N	11.41 a (±2.66)	13.35 a (±3.14)	16.69 a (±2.35)

C_1: 20% *Posidonia oceanica* (Po), 30% Chicken Manure (CM), 50% Solid Olive Mill Wastes (SOMW); C_2: 35% (Po), 30% (CM), 35% (SOMW); C_3: 50% (Po), 30% (CM), 20% (SOMW).
EC: Electrical Conductivity (mS.cm^{-1}); TOC: Total Organic Matter (g.kg^{-1}DW); TN: Total Nitrogen (g.kg^{-1}DW); Macronutrient content: CaO: MgO; K_2O and P_2O_5 (g.Kg^{-1} of Dry Weight). Values between parentheses are the standard deviations.

Seedling growth substrates: The seedling growth media consisted of peat as a control substrate (C) and substitutions of peat with 10%, 30% and 50% by volume of composts (S_1, S_2 and S_3, for each compost concentration respectively). This test gave 9 treatments. Inductively Coupled Plasma Atomic Emission Spectroscopy (ICP-AES) was used to determine chemical properties of substrate samples using a Perkin-Elmer Optima 3300 DV ICP-AE Spectrometer. Chemical composition of the growing media is given in Table 2.

Plant growth experiment: Twenty tomato seeds (var. Rio Grande) were sown in alveolus plates containing peat substituted with 0% (control), 10%, 30% or 50% by volume of composts (substrates S_1, S_2, S_3 respectively). Plates were put in a glasshouse at 23°C and watered daily. The number of seedlings successfully emerging in each alveolus plate was weekly recorded during 5 weeks. At the end of the fifth week, five plants from each alveolus plate were randomly chosen, separated into shoot and root portions and dried at 60°C for 3 days to determine their dry weight. Mean values of three replicates were recorded.

Toxicity test: Before suggesting the use of such composts for field cultivation, their toxicity was tested on tomato (L*ycopersicum esculentum*, L. var. Rio Grande) and radish (*Raphanus sativus* L. var. National) seeds. These two spices seeds were disinfected in absolute ethanol for 5 min. They are then rinsed with sterile distilled water to eliminate traces of pesticides that might be used in seed treatments (Benhamou *et al.*, 1997) and placed in Petri dishes (Ø 8 cm) lined with filter paper containing 6 ml of the three obtained aqueous extracts (E_1, E_2 and E_3). Petri dishes were incubated in a growing chamber at 26°C. Seeds were maintained soaked with the corresponding composts extracts and distilled water was used as control. During 7 days, germinated seeds were counted and at the seventh day, root and shoot lengths were measured and mean values were recorded. Three Petri dishes were replicated for each treatment and in each Petri dish, 5 seeds were used.

Statistical analysis: Mean values of all the studied parameters were compared by variance analysis (ANOVA), using the SPSS 16.0 (SPSS Inc., 2007) and differences between the means were determined using the Duncan test. Means were separated on the basis of least significant difference at 5% probability level.

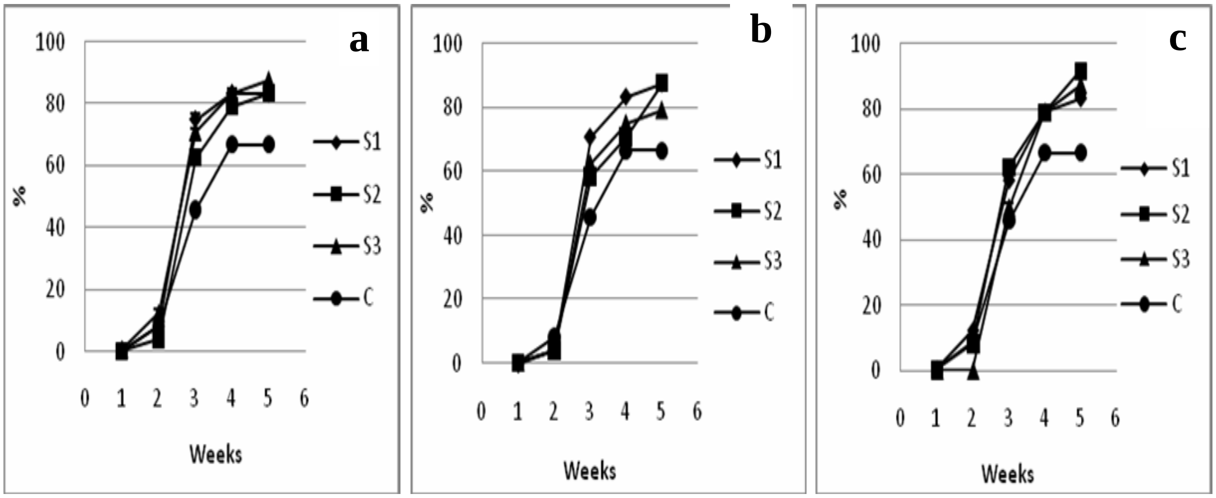

Fig. 1. Seedling emergence percentages in the four substrates (S_1, S_2, S_3 and control C) at the three composts concentrations (a: 10%; b: 30% and c: 50%). S_1: mixture peat and C_1, S_2: mixture peat and C_2 and S_3: mixture peat and C_3.Vertical bars show the average standard deviations.

Results

Compost effect on physical and chemical properties of potting media: Upon the substitution of 10%, 30% and 50% composts into peat, electrical conductivities of potting media increased with the increasing concentrations of the three assessed composts (Table 2) while pH values of the potting mixtures remained almost unchanged with increasing substitutions of the tested composts and recorded values of Mg, K, Na and P were not correlated with the compost concentrations (Table 2).

Seedling emergence: Fig. 1 shows an evolution of seedling emergence percentage during 5 weeks which was obvious from the third week in all substrates. At the third week, in control treatment (C), we registered significantly lower percentage emergence (66.7%). Whereas, the mean percentage of seedling emergence obtained in the three assessed treatments was 69% and 57% at 10% and 50% respectively and at 30% compost concentration, the highest rate of seedling emergence was in S_1 (71%). By the end of the experiment (fifth week), emergence was far more complete in all treatments with more than 80% of emerged seedlings. However, significant differences between all treatments and control were noted.

Seedling growth: Growth rates were comparable for all treatments and assessed concentrations of composts (Fig. 2). At the three assessed concentrations, there were significant differences between the three composts applied and the control. Statistical analysis showed that the difference of seedling length was significant between mixed substrates and peat. This difference appeared after two weeks of growth. Seedlings growth was also estimated by root and shoot dry weights (Table 3). Root and shoot dry weights measured at the assessed concentrations of the three composts were significantly higher than control and the highest values were recorded at 50% of composts for root dry weight and at 10% for shoot dry weight.

Table 2. Physical and chemical characteristics of the assessed substrates (peat substituted with different concentrations of three composts C_1, C_2 and C_3).

Parameters A	Control B	S1			S2			S3		
		10%	30%	50%	10%	30%	50%	10%	30%	50%
pH	6 a (±0.09)	6.91 d (±0.04)	6.86 c (±0.07)	6.74 cd (±0.06)	6.88 cd (±0.06)	6.84 cd (±0.04)	6.77 cd (±0.07)	6.83 cd (±0.09)	6.78 cd (±0.01)	6.53 b (±0.01)
EC (mS/m)	30 a (±0.21)	132.0 b (±0.7)	158.3 d (±0.52)	170.0 g (±0.82)	163.5 e (±0.36)	187.0 h (±0.43)	201.2 i (±0.7)	132.8 b (±0.78)	148.0 c (±0.79)	165.6 f (±0.7)
Na (mg/g)	0.38 a (±0.004)	0.21 e (±0.004)	0.18 b (±0.02)	0.48 g (±0.009)	0.19 d (±0.002)	0.18 c (±0.001)	0.6 i (±0.006)	0.6 i (±0.006)	0.25 f (±0.004)	0.57 h (±0.004)
Mg (mg/g)	0.16 a (±0.002)	1.26 c (±0.019)	1.25 c (±0.004)	1.13 b (±0.002)	1.41 f (±0.018)	1.45 g (±0.009)	1.62 h (±0.012)	1.31 d (±0.011)	1.65 i (±0.018)	1.38 e (±0.008)
K (mg/g)	0.43 a (±0.005)	1.75 ef (±0.028)	1.60 d (±0.011)	1.18 b (±0.021)	1.60 de (±0.017)	1.40 c (±0.002)	1.68 de (±0.016)	1.44 c (±0.012)	1.77 f (±0.024)	1.54 de (±0.011)
P (mg/g)	0.12 e (±0)	0.16 a (±0.001)	0.17 b (±0)	0.24 c (±0.004)	0.43 g (±0.008)	0.64 h (±0.001)	0.36 f (±0.005)	0.25 d (±0.002)	0.65 h (±0.006)	0.34 e (±0.001)

S_1: mixture peat and C_1, S_2: mixture peat and C_2 and S_3: mixture peat and C_3;
A: Means within the same line followed by the same letter are not significantly different at $p \leq 0.05$.
B: Control represent 100% of peat. Values between parentheses are the standard deviations.

Table 3. Final dry weight of tomato roots and shoots five weeks after germination in the four substrates (S_1, S_2, S_3 and control C) at the three concentrations of composts (10%, 30% and 50%).

Substrates		S1			S2			S3		
Concentrations	Control B	10%	30%	50%	10%	30%	50%	10%	30%	50%
Root DW (g)	0.41a (±0.08)	0.63 bc (±0.04)	0.63 bc (±0.07)	0.73 cd (±0.1)	0.59 b (±0.04)	0.57 b (±0.06)	0.86 e (±0.03)	0.61 bc (±0.04)	0.55 b (±0.04)	0.77 de (±0.09)
Shoot DW (g)	3.1 a (±0.06)	6.65 g (±0.12)	4.55 c (±0.1)	5.65 e (±0.17)	5.55 e (±0.16)	4.65 c (±0.09)	5.15 d (±0.11)	6.05 f (±0.18)	3.65 b (±0.11)	5.45 e (±0.08)

A: Means within the same line followed by the same letter are not significantly different at $p \leq 0.05$.
B: Control represent 100% of peat.

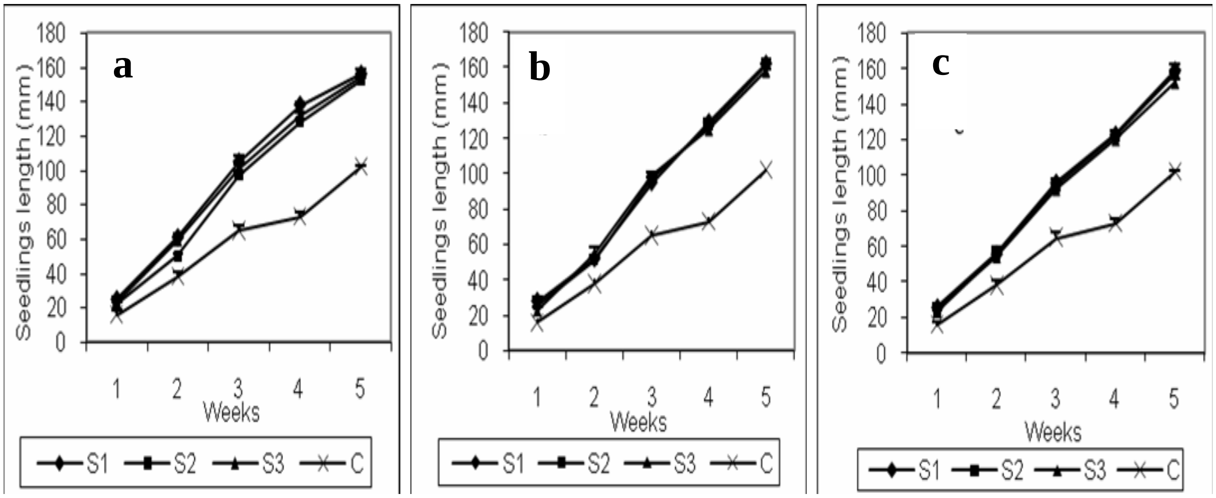

Fig. 2. Growth of tomato seedlings in the four substrates (S_1, S_2, S_3 and control C) at the three composts concentrations (a: 10%; b: 30% and c: 50%). S_1: mixture peat and C_1, S_2: mixture peat and C_2 and S_3: mixture peat and C_3.Vertical bars show the average standard deviations.

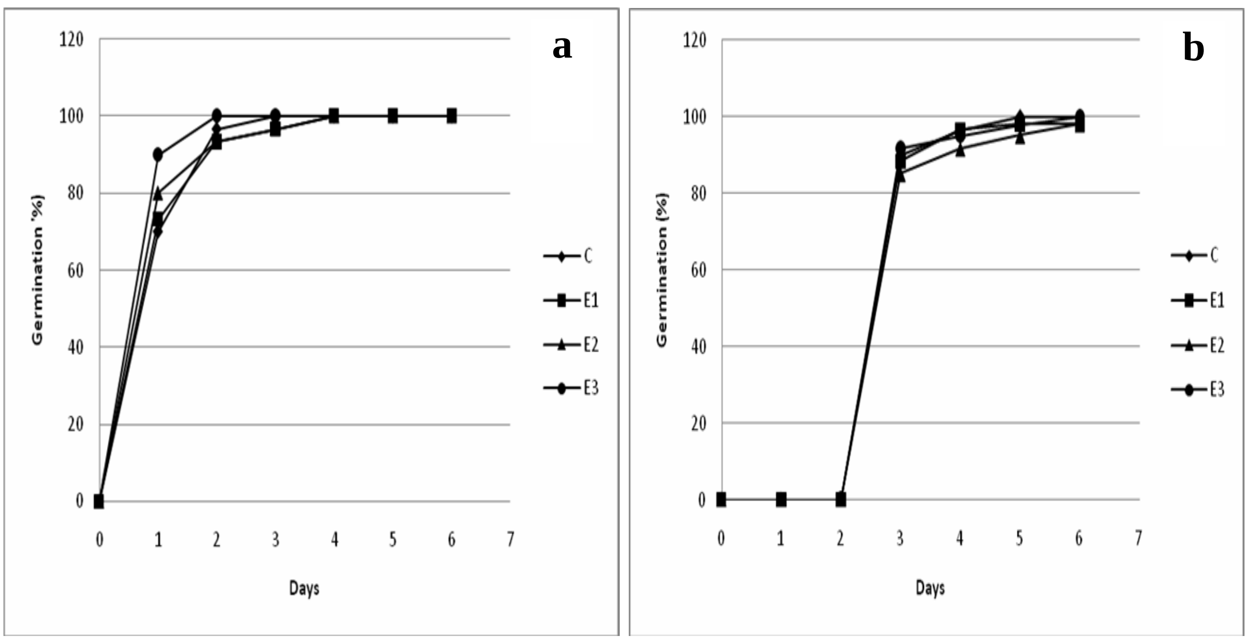

Fig. 3. Germination kinetic of Radish (a) and Tomato (b) seeds in four compost extracts (E_1, E_2, E_3) and control (C). E_1: C_1 extract, E_2: C_2 extract and E_3: C_3 extract.

Toxicity test: The high rates of tomato and radish seed germination in all treatments suggests that compost extracts are not phytotoxic. Mean values of seed germination percentages in all treatments were at least 98% for radish seeds and 100% for tomato seeds and were not significantly different from germination in control (100%) at the seventh day (Fig. 3a and 3b). Seed germination was not delayed by compost extracts for tomato and radish. Since the first day, tomato seed germination was accelerated in C_2 and C_3 extracts with respective germination rates of 80% and 90% (Fig. 3b). Concerning radish seeds, there was no significant difference between the germination speed in all treatments (Fig. 3a). Compost extracts did not affect shoot length of radish (Fig. 4a) but they increased tomato shoot length in all treatments (which ranged between 32.7 mm and 36.9 mm). Notice that the shoot length of control did not exceed 19.3 mm, and root length was not affected by compost extracts in almost all treatments for the two tested species (Fig. 4b).

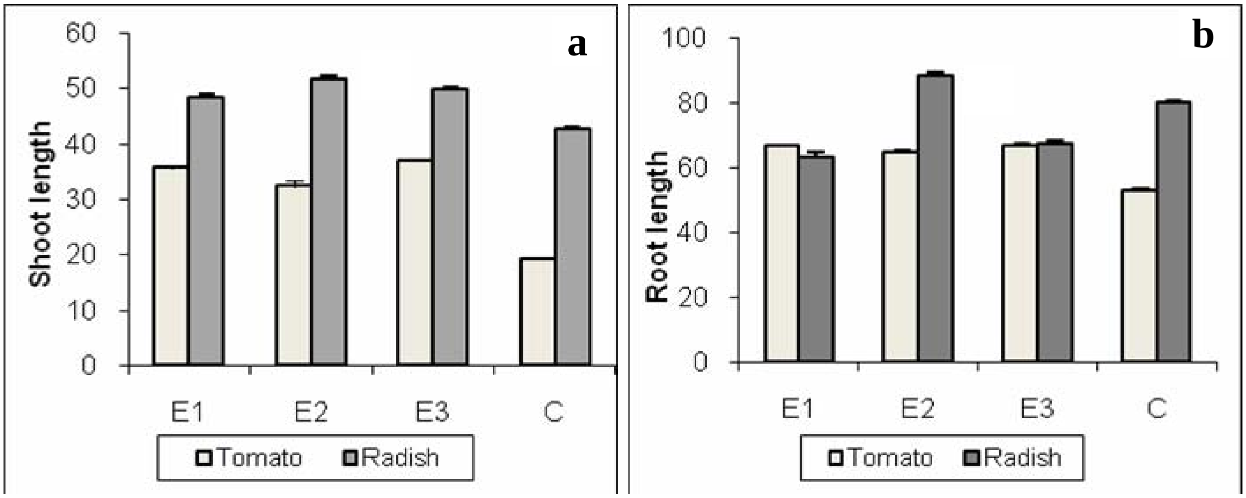

Fig. 4. Radish and Tomato shoot (a) and root (b) lengths (mm) in presence of compost extracts E_1, E_2, E_3 and control C. E_1: C_1 extract, E_2: C_2 extract and E_3: C_3 extract.

Discussion

There is a positive correlation between substrates electrical conductivity (EC) values and the compost concentrations, which corresponded with results reported by Klock (1997). EC values ranged between 132 and 201 mS/m, nevertheless substrates tested on tomato seedlings were not phytotoxic. This differs from the results of Gejdos (1997) who reported that salinity could be an adverse factor when it exceeded 100-300 mS/m. The relatively high pH values of the original composts were far from the optimum pH for growing media (5.2-6.3) given by Bunt (1988). However, close values (8.15) were registered by Mumtaz Khan *et al.*, (2006) in a potting media made from sand and compost. Values registered in this study do not seem to be hazardous for tomato plants even though their growing rate is better in acid media (Brady & Weil, 1999).

The pH values of the potting mixtures remain almost unchanged with increasing substitution of composts. This result does not confirm the findings of Tyler *et al.*, (1993) who reported increases in the substrate pH with increasing concentrations of composted turkey litter added to the potting medium. According to Levy & Taylor (2003), C/N ratios recorded in this study, which were between 11.3 and 16.8, might be considered suitable for vegetable crops. Abad *et al.*, (2001) mentioned that above 80% of organic matter should be adequate for potting media. Thus, the growing media used in this essay might be considered suitable. The three composts used in this work produced conspicuous differences in growth of young tomatoes from 10% by volume, compared with peat. This improvement of growth might be attributed to richness of the composts in nitrogen and other nutriments. The increasing of tomato seedling biomass was studied by Subler *et al.*, (1998) who reported that the incorporation of 10% by volume of pig manure vermicompost increased significantly the total biomass of tomato after three weeks of growth. Bugbee & Frink (1989) also mentioned that when a container medium was replaced with 10%, 20%, 30%, 40% or 50% (by volume) of sewage sludge compost, shoot dry weights and plant growth of marigold plants improved significantly, especially in 30% compost containing mixture. The phytotoxicity tests show that all compost extracts are suitable for germination and growth of tomato and radish, in spite of the well known sensitivity of radish to plant extracts (Tsuzuki *et al.*, 1995). We conclude that composting of Posidonia mixed with chicken manure and olive mill residues shows some interesting outcomes and the final product may be a substitute for peat as the organic component of potting media. Our results confirm those of Sarwar *et al*., (2007) who found that composts not only supplement the chemical fertilizers but also reduce the environmental pollution.

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(Received for publication 22 September 2008)