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Alternative substrates based on green compost in *Agave victoria-reginae* and *Agave striata minima*

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Abstract

The aim of this work was to study the use of two composts, obtained from olive mills (OM) and green waste (SV), at the CREA Research Centre for Vegetable and Ornamental Crops in Pescia (PT), as components of the growing substrate on plants of *Agave victoria-reginae* and *Agave striata minima*. Substrates containing 30% inert matter in each case and increasing doses of compost (0, 30, 50, 70%) were compared; satisfaction at 100% volume, if necessary, was achieved by adding quantities of peat to the mixture. The cultivation density was 6 p m^{-2} for a total of 98 plants. The cultivation lasted 350 days; the plants never showed any symptoms of water stress. The results were statistically analysed. The chemical and physical properties of the growing media were analysed; the vegetative growth of the plants was determined at 350 days. The results showed that plant growth depends on the percentage of compost. The composts used in the preparation of the substrates were not phytotoxic and allowed the plants to grow disease- and weed-free. Due to their physical and chemical characteristics, composts prepared from municipal park and garden waste and solid fractions of mill waste can be considered as partial substitutes for peat.

Keywords: Growing media; Alternative substrates; Renewable sources; Waste management; Agave

1. Introduction

In ornamental plant nurseries, *Agave* is grown in containers and in a protected environment to make it easier to maintain. It is often used in Mediterranean gardens because of its ease of maintenance. For potted ornamental plants, sphagnum peat is the most commonly used substrate, as it offers the best overall characteristics than any other component [1,2]. Consequently, non-renewable resources like peat are depleted as a result of the high demand for this material [3,4]. Composted organic residues have been found to be effective growing media [5-11]. The use of compost and recycled materials is being increased in Italy to reduce the use of peat in growing media. Various types of organic waste can be treated by composting, both ecologically and economically [12,13]. Waste from the wood and food processing industries, as well as animal excrement, are the most prevalent raw materials for composting. It is important to understand that the quality of pot plants depends on the physico-chemical properties of the substrates used. In fact, growth and root physiology are closely related to the amount of water and air in the substrate. The use of municipal green waste from parks and gardens as plant substrates [14,15] has been successful, but solid waste from crushers has been considered undesirable or of little value. After appropriate composting of organic residues, such as sewage sludge, spent mushroom substrate, many studies have shown that organic residues can be used as growing substrates with excellent results, rather than peat [16,17]. Compost waste, such as olive mill and green compost, has been used as a growing medium only a few times in the literature [18,19].

In the present study, olive mill and green compost were used to evaluate the amount of peat that could be replaced by crusher compost in the common culture medium for *Agave* plants.

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Figure 1 Detail of trials with compost on *Agave striata minima* (A) and *Agave victoria-reginae* (B).

2. Materials and methods

The research was conducted in the CREA-OF greenhouses in Pescia (Pt), Tuscany, Italy (43°54′N 10°41′E), in an east-west heated greenhouse (30 x 10) with a galvanised structure and plastic cover. Two 150-day-old composts were used, olive mill (OM) and green waste (SV). On 11 April 2023, the rooted cuttings of *Agave victoria-reginae* and *Agave striata minima* were individually potted into 16 cm diameter brown plastic containers filled with seven substrates:

Control= 70% sphagnum peat (P) + 30% inert substances (is) as drainage materials (composed of 50% pumice + 50% pozzolan, river sand, chosen because they are conventional draining materials in Tuscany).

Treated substrates:

- OM-30 = 40% P + 30% OM + 30% is;
- OM-50 = 20% P + 50% OM + 30% is;
- OM-70 = 0% P + 70% OM + 30% is;
- SV-30 = 40% P + 30% SV + 30% is;
- SV-50 = 20% P + 50% SV + 30% is;
- SV-70 = 0% P + 70% SV + 30% is.

The planting density was 6 plants m^{-2} for a total of 98 plants. One week after potting, the plants were fed daily, twice, with 300 mL pot^{-1} of a water-soluble N:P:K fertiliser (5:1:7.5) and trace elements. The EC level of the fertigation was set at 1.6 dS m^{-1}. The cultivation lasted 350 days; the plants never showed any symptoms of water stress. The climatic parameters of external and confined temperature and relative air humidity in the greenhouse were determined. The treatments were arranged in a randomised complete block design with three replications. The significance of the result was tested with analysis of variance (F-test) at $P \leq 0.05$ and the averages of the treatments were compared with Student Newman Keuls (S.N.K.) test at $P \leq 0.05$.

The chemical and physical properties of the culture media were analysed; vegetative growth of the plants was determined 180 days after transplanting and at 350 days. For the substrates, the pH and electrical conductance (EC) were determined according to EN 13038, the volume of water at pF1 according to EN 13041.The bulk density and total porosity were determined according to Bibbiani and Pardossi (2004). Organic matter and ash were determined according to UNI EN 13039. Total nitrogen was determined according to the Kijeldhal method. The macro- and micro-nutrients and heavy metal content in the substrates were determined using a simultaneous plasma emission spectrophotometer (ICP) on dry tissue incinerated at 400°C for 24 hours.

3. Results and Discussion

3.1. Substrates for cultivation: physical and chemical characteristics

As shown in Table 1, the substrates had higher bulk density and air capacity than the control mixture; however, the total porosity and water volume of the mixture were similar to the control mixture, except for SV-30. Based on the OM-70 and SV-70 substrates, the pH values obtained experimentally increased slightly. The pH values in SV-30 were within the range suitable for plant growth. When using more OM and SV, the EC values increased proportionally; however, if peat was substituted up to 50%, they remained below the acceptable limit. Based on the OM-70 and SV-70 mixtures, N was

1.7 times and 1.8 times higher, respectively, compared to the control mixture. With increasing compost percentages, control linearly. When using SV substrate, organic matter increased with increasing OM percentage, whereas an opposite trend was observed. When composting organic matter in a crusher, it is difficult to achieve complete mineralisation, while when composting green waste, with an excellent C/N ratio, mineralisation is possible. Conversely, the control substrates were less rich in K, P, Ca, and Mg than compost-based substrates. It was found that the total heavy metal content (Table 2) was below the Italian legal limit (L.D. 2177). These results are in agreement with those obtained by Smith [18] according to which the concentration of heavy metals depends on the quality of the raw materials and the composting technique used.

3.2. Agave victoria-reginae and Agave striata minima growth

In *Agave victoria-reginae* (Table 3), plant height and diameter were reduced only in OM at the highest doses (Figure 2B); the number of leaves was similar and higher in the compost-grown plants (regardless of dose) than in the peat-grown control plants; the plants grown in the SV substrate showed the best productive performance, expressed in fresh weight (over 3300 g), then the percentage dry matter content was similar and statistically higher with peat substitution up to the maximum dose.

The plants produced lateral shoots from the collar buds (unpublished data). Growth was not concurrent: the earliest were those in the substrates with SV compost. According to the values of the biometric characteristics, the number of shoots was high in all substrates (more than 5) but in OM-70 (only 3); fresh weight was statistically higher in the SV substrates as was also the dry weight.

In *Agave striata minima* (Table 4), growth was also continuous in all plants, although differences between substrates were still evident. The height and diameter of the plants, as absolute values, had the same trend as in Agave victoria-reginae (Table 3) (Figure 2A). The most efficient soil for plant growth appeared to be SV, regardless of the replacement dose of peat. The dry matter content was statically different: substrates OM-30 and OM-50 showed higher values. The biometrics recorded on the plants, the number and fresh weight increased in all substrates; SV-70 was statistically different from the others due to its better performance. Dry matter weight was statistically higher in peat-grown plants.

These results are in contrast to those obtained by Papafotiou et al. [13], who reported a negative effect of crushed compost in Poinsettia. Our results support the hypothesis that plant responses to the increasing replacement of peat with compost are highly species-dependent.

Grigatti et al. [10] reported that considerable variation occurred within the same species when green compost was used. 25-50% compost gave better or comparable biomass production than the control.

Table 1 Main physical – chemical properties of growing media at transplant

Parameters	Control	OM-30	OM-50	OM-70	SV-30	SV-50	SV-70
Bulk density (g cm^{-3})	0.642 b	0.701 b	0.890 a	1.226 a	0.931 a	1.188 a	1.446 a
PD (g cm^{-3})	5.24 b	4.27 b	3.73 b	8.75 c	10.22 a	11.80 a	14.36 a
AC (% v/v)	20 b	43 a	41 a	36 a	38 a	42 a	37 a
TP (% v/v)	74.40 a	74.27 a	71.1 a	61.7 a	70.5 a	65.1 a	67.3 a
WV pF_1 (%)	36 a	32 a	39 a	40 a	42 a	49 a	76 a
Ash (%)	64.56 b	70.49 b	63.82 b	58.64 b	82.30 a	84.84 a	86.86 a
TOC (%)	35.40 b	29.47 c	36.14 b	41.32 b	17.66 a	15.12 a	13.09 a
pH	6.6	6.1	6.1	7	5.7	6.5	6.9
Ec (µS/cm)	66 d	183 c	236 c	434 b	360 b	534 b	841 a
Total N (%)	0.53 b	0.66 b	0.82 a	0.90 a	0.55 b	0.60 b	0.98 b
C/N	64.38 a	43.35 b	43.03 b	44.91 b	31 b	24.40 b	13.09 c

P (mg Kg^{-1} D.M.)	2923 b	5298 a	5029 a	3684 a	2352 a	4284 a	4950 a
K (mg Kg^{-1} D.M.)	3122 b	6115 a	7397 a	5989 a	1754 a	3615 b	1914 b

PD : particle density; AC: air capacity; TP: total porosity; WV: water volume at pF1; TOC: total organic matter. Means with the same letter within a line are not significantly different at P <0.05

Table 2 Total nutrient and heavy metal in growing media (mg kg^{-1} D.M.) at transplant

Parameters	Control	OM-30	OM-50	OM-70	SV-30	SV-50	SV-70
Ca	9873 c	16510 b	15974 b	13850 b	17576 b	22549 a	24966 a
Mg	510 c	2650 a	2034 a	1681 b	1572 b	4772 a	5710 a
Mn	131 c	141 a	169 a	138 b	112 b	241 a	293 a
Fe	671 c	1570 a	1751 a	1591 a	781 b	1890 a	2238 a
Na	1689 a	2101 a	2591 a	1953 a	771 b	1843 a	1591 a
Cd	0.07 c	0.35 a	0.28 b	0.23 b	0.16 c	0.36 a	0.38 a
Pb	28 b	33 b	32 b	28 b	28 b	53 a	70 a
Cr	1 c	5 b	4 b	3 b	2 b	7 a	11 a
Cu	7 b	38 a	30 a	23 a	11 b	26 a	35 a
Zn	8 d	54 b	77 b	121 a	32 c	73 b	121a
Ni	1 c	2 b	1 b	1 b	1 b	2 b	3 a

Means with the same letter within a line are not significantly different at P <0.05.

Table 3 Effect growing media containing olive mill wastes compost (OM) and green wastes compost (SV) on some morphological traits. *Agave victoria-reginae* (Means with the same letter within a column are not significantly different at P)

Groups	Plant height (cm)	Plant diameter (cm)	Plant leaves (n°)	Plant fresh weight (g)	Plant dry matter (%)
CTRL	51 a	54 a	15 b	2821 b	3.91 b
OM-30	50 a	54 a	19 a	2944 b	4.45 a
OM-50	47 b	50 b	18 a	2911 b	4.69 a
OM-70	47 b	47 b	17 ab	2531 c	4.36 a
SV-30	51 a	53 a	18 a	3431 c	3.67 b
SV-50	51 a	58 a	18 a	3368 a	3.85 b
SV-70	51 a	54 a	19 a	3563 a	2.81 c

Table 4 Effect growing media containing olive mill wastes compost (OM) and green wastes compost (SV) on some morphological traits. *Agave striata minima* (Means with the same letter within a column are not significantly different at P <0.05).

Groups	Plant height (cm)	Plant diameter (cm)	Plant leaves (n°)	Plant fresh weight (g)	Plant dry matter (%)
CTRL	59 a	67 a	19 b	3933 a	3.28 b
OM-30	56 a	64 b	21 a	4046 a	3.91 a
OM-50	52 b	65 b	18 c	3556 b	3.93 a
OM-70	51 b	65 b	19 b	3662 b	2.55 c
SV-30	56 a	67 a	20 a	3926 a	3.36 b
SV-50	55 a	69 a	20 a	3941 a	3.10 b
SV-70	56 a	67 a	19 b	3936 a	3.05 b

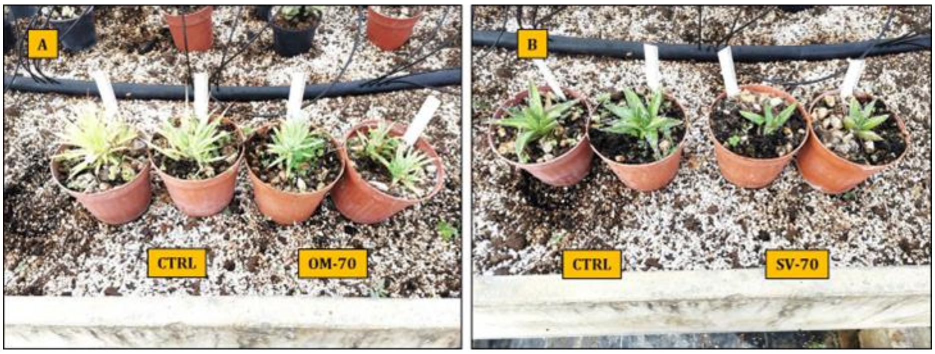

Figure 2 Comparison of the control thesis (CTRL) and the theses treated with olive mill 70% (OM-70) on *Agave striata minima* (A) and theses treated with control (CTRL) and green waste 70% (SV-70) on *Agave victoria-reginae* (B)

4. Conclusion

From the results obtained, it can be concluded that both composts tested, i.e. crusher (OM) and green waste (SV), can be considered as partial substitutes for peat. The plants do not show any phytotoxicity, appear disease- and weed-free, as already demonstrated for strawberry, strawberry and photinia plants [19]. These substrates have shown adequate adequate physical and physico-chemical properties and, although the pH and EC values were higher than peat, they produced plants comparable to control plants.

Compliance with ethical standards

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Disclosure of conflict of interest

The author declares no conflict of interest.

Statement of ethical approval

The present research work does not contain any studies performed on animal/human subjects.

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