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Cultivation Substrate Composition Influences Morphology, Volatilome and Essential Oil of *Lavandula Angustifolia* Mill.

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Abstract: Aromatic plants are commonly produced for ornamental, cosmetic and medicinal purposes. Their morphological traits and the amounts and compositions of the volatile substances and essential oils (EOs) produced can be influenced by several factors, including the cultivation technique. In the present study, the influence of substrate composition on *Lavandula angustifolia* Mill. production was evaluated. In particular, substrates containing mixes of peat (P), green compost (C) and/or demolition aggregates (A) were tested in the following ratios: 70%:30% *v*/*v*, P:C; 70%:30% *v*/*v*, P:A; and 40%:30%:30% *v*/*v*, P:C:A. The P:C mixture allowed to obtain the best results in terms of survival rate, compactness of the plant and flower production. The P:C:A led to higher yields and better quality of EOs, with higher amounts of linalool, an important compound for medicinal uses. The volatiles and the blooming trend were not affected by the different cultivation substrates. Therefore, substrate composition in pot lavender cultivation can be regulated depending on the final use of the plant, successfully using locally sourced material in addition to peat.

Keywords: lavender; pot aromatic plants; potting media; secondary metabolites; soilless cultivation

1. Introduction

Lavender, *Lavandula angustifolia* Mill. (Lamiaceae family), is a small evergreen shrub, with aromatic foliage and flowers, mostly cultivated in open fields on well-drained and lime-rich soils in full sun [1,2]. The great economic importance of lavender is due to the high quality of its essential oil (EO), of which 200 tons are produced worldwide every year [3]. The lavender EO is considered one of the most medically useful EOs. It has antibacterial and antifungal activities [4] and is being used to treat infections [5] and neurological disorders [1]. The delightful perfume of this oil has also been widely used in different industries such as perfumery and cosmetics [6] as well as flavoring in food manufacturing [7]. The first phase of lavender cultivation generally occurs in pots, with peat as the main constituent of growing media used throughout Europe (European Peat and Growing Media Association, EPAGMA). However, numerous issues are related to the use of peat as a cultivation substrate [8,9] and its demand and costs are rising [10]. Currently, composts are widely used as component for potting mixtures in many peat-based cultivations [9], and composted green waste is the most widely utilized compost in Europe [8,10,11]. However, composted materials often lack the large particles necessary for adequate aeration, which is improved by the addition of coarse components that can be made of several materials [12]. The use of locally sourced materials as potting media is an object of intensive investigation in floriculture and horticulture. Indeed, several studies have investigated the potential

of waste derived from agriculture, specifically nutshells, rice husks, coconut fiber, cattle manure and peanut shells [13–18]. Municipal wastes are also of interest; these include green compost, vermicompost and sewage sludge [16,19,20]. Finally, industrial by-products (e.g., biochar, pine bark and bamboo residues) have been studied [16,21,22]. The suitability of a growing medium for pot cultivation depends on several physical, chemical and biological characteristics [23], and establishing the best proportion of materials to obtain good plant growth and productivity results is a very complex process [24].

The scientific research to improve the quality of cultivated medicinal and aromatic plants commonly focuses on fertilization [25–30] or irrigation regimes [31–34]. Nonetheless, previous experimental studies revealed that many other factors interfere with the volatile and essential oil composition: genotype [35], latitude [36], developmental conditions [37,38], harvesting time [39], development stage and environmental conditions [38,40], such as temperature [41]. The effects of different mixtures used as substrates for potting plants have been reported in few studies on lavender [42] and other Lamiaceae plants, such as *Thymus vulgaris* L. [43], *Ocimum basilicum* L. [39] and *Rosmarinus officinalis* L. [44]. Whilst the impact of a growing medium on plant performance is important, it does need to be evaluated in the context of a commercial plant production system while using an adaptive approach [8]. This work deals with the effects of different peat-based potting substrates composed of a mixture of peat and organic and/or mineral material from local markets (green compost and demolition aggregates) on the growth, appearance and composition of aroma and EOs of *L. angustifolia* in pots in a nursery production system.

2. Materials and Methods

2.1. Soilless Cultivation

Three populations of *Lavandula angustifolia* of North West Italian Alps and referred to as Susa Valley (Sus), Stura Valley (Stu) and Tanaro Valley (Tan) according to their geographical origin, were selected based on their different phytochemical profile [36]. Cutting propagation occurred in September 2014 under plastic tunnels in the nursery Fratelli Gramaglia (Collegno, Italy; 45°05′22.4′′ N, 7°34′26.4′′ E, 302 m.a.s.l.). The soilless cultivation trial started in March 2015, when rooted plants were transplanted in 1.2 L pots (one rooted plant each). Peat (P), green compost (C) and demolition aggregates (A) were used to prepare three different mixtures to be tested as substrates (Table 1): P:C, 70%:30% *v*/*v*; P:A, 70%:30% *v*/*v*; and P:C:A, 40%:30%:30% *v*/*v*, with 180 plants grown in each substrate (60 Sus, 60 Stu, 60 Tan). Peat and green compost were provided by the local fertilizer producer ItalConcimi S.r.l., while the demolition aggregates were supplied by Perino Piero & C. S.n.c.; both companies were located within 20 km from the nursery. Demolition aggregates were composed of 70% bricks and 30% concrete, with particle size of 0.01–2 cm (40% < 0.02 cm). The chemical and physical characteristics are shown in (Table 1). The P:C substrate generally had a higher cation exchange capacity, as well as carbon, nitrogen and phosphorous content, which was conversely very low in P:A. The presence of the demolition aggregates in the substrates P:A and P:C:A markedly increased the content of the heavy metals Cr and Ni.

Table 1. Physical properties, chemical properties and heavy metal content of raw materials (P = peat; C = compost; A = demolition aggregates) and mixtures tested as cultivation substrates (P:C = peat and green compost, 70%:30% *v*/*v*; P:A = peat and demolition aggregates, 70%:30% *v*/*v*; P:C:A = peat, green compost and demolition aggregates, 40%:30%:30% *v*/*v*) with standard deviation.

Parameter	Units	P	C	A	P:C	P:A	P:C:A
pH [1]		4.1 ± 0.70	8.0 ± 0.10	9.8 ± 0.20	5.1 ± 0.51	7.0 ± 0.11	8.2 ± 0.49
C tot [2]	%	25.4 ± 1.40	27.0 ± 0.60	2.0 ± 2.20	41.5 ± 0.70	28.1 ± 0.70	16.1 ± 1.30
N tot [2]	%	1.8 ± 0.04	1.9 ± 0.08	0.02 ± 0.00	1.6 ± 0.08	0.8 ± 0.05	0.6 ± 0.00
C/N		14.4 ± 0.03	14.6 ± 0.01	109.7 ± 0.07	26.1 ± 0.09	33.8 ± 0.51	25.5 ± 1.00
Available P [3]	mg/kg	18.1 ± 0.57	291.0 ± 0.40	11.6 ± 0.51	190.7 ± 0.52	14.7 ± 0.45	130.9 ± 0.49
Carbonates [4]	%	0.4 ± 0.10	2.2 ± 0.05	13.1 ± 0.30	0.8 ± 0.71	6.6 ± 0.62	9.8 ± 0.10
CEC [5]	meq/100g	108.4 ± 7.10	82.4 ± 12.00	7.4 ± 0.03	55.5 ± 0.05	25.9 ± 0.02	24.8 ± 0.40
Exchangeable Ca	meq/100g	31.6 ± 2.50	39.1 ± 2.80	16.5 ± 0.06	32.7 ± 0.05	27.3 ± 0.03	27.5 ± 0.03

Table 1. *Cont.*

Parameter	Units	P	C	A	P:C	P:A	P:C:A
Exchangeable K	meq/100g	0.2 ± 0.20	18.7 ± 0.03	0.9 ± 0.06	4.8 ± 0.06	0.5 ± 0.05	3.9 ± 0.03
Exchangeable Mg	meq/100g	5.7 ± 0.01	19.2 ± 0.20	0.2 ± 0.01	7.6 ± 0.00	2.4 ± 0.00	4.2 ± 0.00
Cr [6]	mg/kg	137.7 ± 8.70	135.8 ± 1.40	320.0 ± 0.04	137.2 ± 0.02	128.6 ± 0.11	232.6 ± 0.02
Cu [6]	mg/kg	68.0 ± 4.70	69.2 ± 1.20	26.5 ± 0.01	23.3 ± 0.01	14.5 ± 0.00	29.6 ± 0.02
Ni [6]	mg/kg	100.8 ± 5.50	99.6 ± 9.50	155.8 ± 0.06	29.5 ± 0.06	79.4 ± 0.05	119.7 ± 0.02
Gravel	%	-	-	40	-	50	40

[1] ISO 10390; [2] ISO 10694; [3] Olsen; [4] ISO 10693; [5] CEC: cation exchange capacity, ISO 11260; [6] EPA 3051A.

Cultivation was performed in open air. Water was provided when needed (pH 7.4, conductivity 505 µS cm^{-1} at 20 °C), while fertilizer (Peters© Professional Allrounder 20-20-20, Scotts Professional, Geldermalsen, The Netherlands) was applied three times during spring and once during autumn. Cultivation lasted until the summer of 2016, when survival percentage, flowering and morphology were evaluated and volatile organic compound (VOC) and EO profiles were analyzed. The weather parameters were monitored using the closest weather station (Latitude N 450447, Longitude E 073639; WGS84). During the blooming period (June–August 2016), the average maximum temperature was 29.6 °C (34.9 °C was the highest), the average minimum temperature was 18 °C (12.5 °C was the lowest) and the average solar radiation was 23.29 MJ m^{-2} per day.

2.2. Analysis of Biometric Parameters and Performance

During the first flowering season (Summer 2015), only 8.9% of plants bloomed; thus, the biometric parameters were recorded in the second flowering season (Summer 2016) among the surviving plants (110 plants in P:C, 92 in P:A, and 71 in P:C:A), from the beginning of June until mid-August. The percentages of flowering plants in each substrate per week were recorded. Concurrently, morphological characteristics of each flowering plant were evaluated according to selected guidelines of the International Union for the Protection of New Varieties of Plants (UPOV) proposed for lavenders. The parameters were number of spikes per plant (n), spike length (cm), plant height (cm) and plant diameter (cm). Afterwards, the flowered spikes of each plant were cut, air-dried and weighed and used for the analyses of emissions profiles and essential oils.

2.3. Analysis of Secondary Metabolites

Spontaneous emission profiles and essential oil compositions of the lavender plants were analyzed using methods described in a previous study [36]. Emitted volatiles were sampled from the headspace of each plant with a Supelco (Bellefonte, USA) solid phase microextraction (SPME) device (Supelcor, Bellafonte, PA, USA) coated with polydimethylsiloxane (PDMS, 100 µm coating thickness, St. Louis, MO, USA). They were then injected into a Varian CP-3800 apparatus (Varian Inc., Palo Alto, Santa Clara CA, USA) coupled to a Varian Saturn 2000 (Palo Alto, Santa Clara, CA, USA) for the gas chromatography–flame ionization detection (GC-FID) and gas chromatography-mass spectrometry (GC-MS) analyses. Essential oils were obtained by the hydro-distillation of dried lavender inflorescences using a Clevenger-type apparatus (Tecnovetro, Milan, Italy), and those oils were then injected into the GC-FID and GC-MS devices for the identification of oil constituents.

2.4. Statistical Analyses

All of the data were first tested for the homogeneity of variances (Levene test). A one-way ANOVA (Analysis of Variance) was performed on biometric parameters of the three local lavender selections to test the effect of cultivation substrate and means were separated according to Tukey post-hoc tests; a two-way ANOVA was performed to analyze the interaction between the substrate and lavender selection effects. Statistically significant differences induced by substrate and lavender selection on VOC, EO compounds and EO yields were assessed with one- or two-way PERMANOVAs (Permutational Multivariate Analysis of Variance) with Euclidean distances, which were based on a

distribution-free analysis of variance. The percentage contribution of each compound to the observed dissimilarity was assessed through similarity percentage analysis (SIMPER, Euclidean distance). For each compound, the differences between substrates and lavender selections were tested with the Mann-Whitney pairwise test. The value for statistical significance was $p < 0.05$. All statistical analyses were performed by Past 3 software, version 3.15.

3. Results and Discussion

3.1. Influence of Cultivation Substrate on Morphology and Performance

Lavandula angustifolia plants performed differently after a year and a half under cultivation in the various substrates, which influenced all the measured parameters except for the spike length (Table 2). The best results were obtained in the P:C substrate, where more plants survived (61.1%), had a higher spike number (9.0) and higher flower yield (3.7 g of dried flowers per plant). In the P:A substrate, plants flowered less (6.3 spikes and 1.4 g of dried flowers per plant) and P:C:A showed lower plant survival (39.4%) and compactness (height = 45.3 cm and diameter = 15 cm). The lavender selection factor interacted with the substrate factor only for the survival rate, which ranged from 45.4% for Susa, 50.2% for Stura, and 57.6% for Tanaro lavender selections

Table 2. Differences in *Lavandula angustifolia* survival rate, height, diameter, spike number, spike length and flower yield (grams of dry flowers per plant) after two cultivation cycles in different substrates (P:C = peat and green compost, 70%:30% *v*/*v*; P:A = peat and demolition aggregates, 70%:30% *v*/*v*; P:C:A = peat, green compost and demolition aggregates, 40%:30%:30% *v*/*v*) with standard deviation.

Substrate	Survival (%)	Height (cm)	Diameter (cm)	Spike (number)	Spike Length (cm)	Flower Yield (g Dry Flowers per Plant)
P:C	61.1 ± 5.54 a [1]	41.1 ± 0.77 b	13.7 ± 0.42 b	9.0 ± 0.52 a	6.2 ± 0.20	3.7 ± 0.48 a
P:A	51.1 ± 3.49 a	43.9 ± 0.77 a	12.3 ± 0.32 c	6.3 ± 0.33 c	6.6 ± 0.43	1.4 ± 2.10 b
P:C:A	39.4 ± 0.44 b	45.3 ± 0.75 a	15.0 ± 0.41 a	7.6 ± 0.44 b	6.1 ± 0.19	1.6 ± 10.18 ab
P	***	**	***	***	ns	*
Substrate × Lavender selection *p*	**	ns	ns	ns	ns	ns

[1] Means followed by the same letter in the same column denote no significant differences according to Tukey test ($p < 0.05$). Statistical significance: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$, ns, not significant.

The addition of demolition aggregates to peat and compost raised the substrate pH in P:A and P:C:A when compared to P:C, similarly to what was observed by [45] after mixing crushed bricks to compost-based pot media for the cultivation of parsley (*Petroselinum crispum* (Mill.) Fuss) and coriander (*Coriandrum sativum* L.). Lavender usually thrives best in neutral to alkaline soils [2]; however, plants grown in P:A (pH 7) and P:C:A (pH 8.2) showed low performances, especially concerning flower production and survival rate in P:C:A, thus adapting better to acidic media. Adaptation of plants to pH ranges different from species optima has been previously observed in other ornamental plants [46,47]. P:C had generally higher nutrient levels compared to P:A and P:C:A; nonetheless, conflicting results on how mineral nutrients affect Lamiaceae morphology and performance are reported in the literature [29,43,45,48–50]. Lavenders were generally scarce after cultivation in P:C:A, with the lowest survival rate and spread plants, even if peat, compost and mineral material mixtures have been reported to support an adequate establishment of lavender [42] and other Lamiaceae species, namely *L. dentata* L., *Satureja montana* L., *Thymus pseudolanuginosus* Ronniger and *T. caespititius* Brot. [51,52]. Both substrates with demolition aggregates had very high heavy metal concentrations (Cr and Ni), which are known to reduce plant growth and biomass, as reviewed by [53]. References [54,55] have not recorded any negative influence of heavy metals on peppermint (*Mentha* × *piperita* L.), basil and lavender, but two of the studied heavy metals, Cr and Ni, exceeded in P:C:A the accepted limits in soils according to Italian legislation (Cr: 150 mg kg^{-1} and Ni: 120 mg kg^{-1}; D. Lgs. 152/2006–Norme in materia ambientale–G.U.88), possibly contributing to the limited lavender survival.

The flowering period (Figure 1) lasted 10 weeks (from 6 June 2016 to 19 August 2016). Every potted plant bloomed, and almost 90% of lavenders bloomed within the first four weeks. Plants cultivated on P:C and P:C:A had peak blooming during the second week, with 37% and 30% of plants flowering, respectively, whereas in P:A, the blooming was more gradual and delayed by one or two weeks. However, no significant differences were recorded between the different substrates.

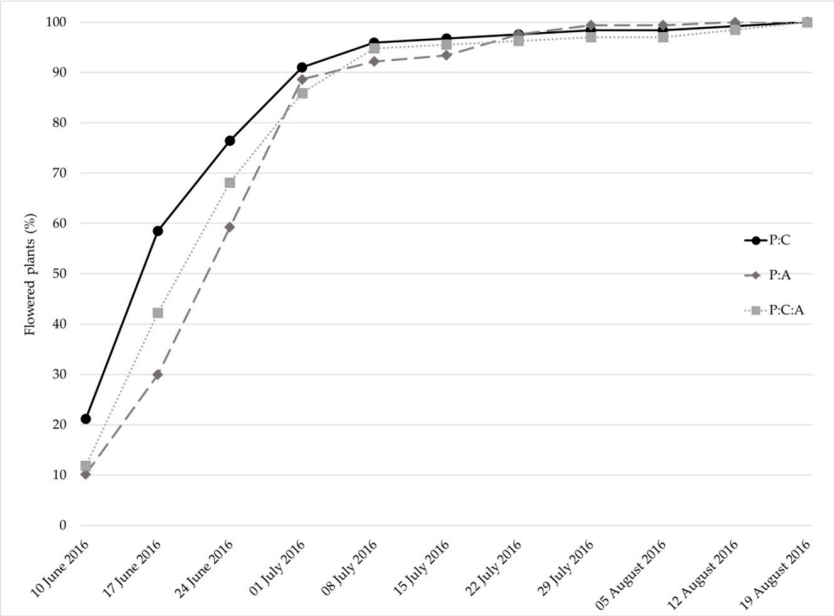

Figure 1. Blooming trend per week of *Lavandula angustifolia* plants after two cultivation cycles in different substrates (P:C = peat and green compost, 70%:30% *v*/*v*; P:A = peat and demolition aggregates, 70%:30% *v*/*v*; P:C:A = peat, green compost and demolition aggregates, 40%:30%:30% *v*/*v*).

3.2. Influence of Cultivation Substrate on Vocs

Volatile compounds analyzed by the SPME technique are reported in Table 3. The most prevalent class of compounds was oxygenated monoterpenes (OMs), with percentages ranging from 68.8% (in P:A-Sus) to 84.9% (in P:A-Tan), followed by monoterpene hydrocarbons (MHs, 5.7% in P:A-Stu, 15.5% in P:C-Sus). This study is in agreement with previous papers on the same species [36,56]. It is important to emphasize the highest percentage of non-terpene derivatives (NTs) was found in Sus samples grown in P:A substrate (13.4%). The percentage of sesquiterpenoids (SHs) in the aroma profile was very low (from 1.7 in P:C-Stu to 3.5% in P:C:A-Stu). Interestingly, all samples were oxygenated sesquiterpene (OS) free, except for P:C-Stu and P:A-Sus where caryophyllene oxide was the unique compound. Da Prorto and Decorti (2008) [57] noted the absence of OS when analyzing the volatile compounds of lavender flowers cultivated in the north east regions of Italy, while a considerable amount of SH was measured (7% of the whole composition).

Seventy-five VOCs were identified in all the analyzed samples, with a percentage of identification ranging from 96.5–99.9%. The number of compounds in each sample varied from 37 (P:A-Sus) to 49 (P:C-Tan). Among them, only 25 were common in all of the lavender profiles. Linalyl acetate (accounting at least 20.6% of the total composition) and linalool (ranging from 18.7% in P:A-Sus to 42.7% in P:C-Tan) were identified as the main compounds of the aroma emission, with values higher than the amounts recorded the previous year in the same lavender selections [36]. The amount of linalyl acetate is in accordance with the content in the aroma of several Bulgarian lavender varieties [58], while linalool reached higher values in this study. Both isomers trans- and cis-linalool oxide (furanoids) were present in good amounts and the highest percentages were measured in P:C-Stu (8.3 and 7.1%, respectively). All these latter compounds accounted for at least 50% of the total identified and detected, up to 75.3% in P:A-Tan.

Table 3. Solid phase microextraction (SPME) volatile profiles (%) of lavender selections from Susa (Sus), Stura (Stu) and Tanaro (Tan) valleys, grown in different substrates (P:C = peat and green compost, 70%:30% *v*/*v*; P:A = peat and demolition aggregates, 70%:30% *v*/*v*; P:C:A = peat, green compost and demolition aggregates, 40%:30%:30% *v*/*v*) with standard deviation.

	Compounds	Class *	LRI [1]	P:C			P:A			P:C:A		
				Sus	Stu	Tan	Sus	Stu	Tan	Sus	Stu	Tan
1	1-octene	NT	810	-	-	0.1 [2] ± 0.05	-	-	-	-	-	-
2	1-butyl acetate	NT	811	-	0.1 ± 0.08	-	0.1 ± 0.15	-	-	-	-	-
3	Hexyl methyl ether	NT	832	-	-	-	0.2 ± 0.23	-	0.1 ± 0.10	-	-	-
4	α-thujene	MH	932	-	-	0.2 ± 0.06	-	-	0.1 ± 0.05	0.1 ± 0.05	0.1 ± 0.05	0.4 ± 0.27
5	tricyclene	MH	938	0.1 ± 0.02	0.2 ± 0.03	0.7 ± 0.51	0.1 ± 0.10	0.2 ± 0.18	0.4 ± 0.34	0.2 ± 0.18	0.4 ± 0.17	0.8 ± 0.20
6	β-citronellene	MH	946	-	0.1 ± 0.09	-	-	-	-	0.1 ± 0.09	-	-
7	4-methyl pent-2-enolide	NT	951	0.1 ± 0.07	0.2 ± 0.20	0.1 ± 0.06	-	0.4 ± 0.04	0.1 ± 0.08	0.1 ± 0.04	0.1 ± 0.16	-
8	camphene	MH	955	0.4 ± 0.05	0.2 ± 0.03	0.3 ± 0.09	0.2 ± 0.09	0.2 ± 0.04	0.2 ± 0.06	1.0 ± 0.32	0.4 ± 0.03	0.3 ± 0.05
9	sabinene	MH	978	-	-	0.2 ± 0.05	-	0.2 ± 0.07	-	-	0.1 ± 0.04	0.1 ± 0.08
10	1-octen-3-one	NT	980	-	-	0.1 ± 0.13	-	-	-	-	-	-
11	β-pinene	MH	981	0.1 ± 0.04	-	0.1 ± 0.08	0.1 ± 0.13	-	-	0.2 ± 0.09	0.1 ± 0.08	0.1 ± 0.08
12	1-octen-3-ol	NT	982	0.1 ± 0.09	0.3 ± 0.26	0.2 ± 0.05	-	0.2 ± 0.05	0.3 ± 0.27	0.4 ± 0.39	0.4 ± 0.09	0.4 ± 0.04
13	3-octanone	NT	987	2.3 ± 0.53	1.9 ± 0.18	2.7 ± 1.02	2.7 ± 1.25	1.1 ± 0.39	2.1 ± 1.07	3.3 ± 1.52	1.9 ± 0.36	1.9 ± 0.30
14	butanoic acid, butyl ester	NT	993	0.1 ± 0.06	0.3 ± 0.09	0.4 ± 0.02	0.4 ± 0.07		0.5 ± 0.46	0.2 ± 0.09	0.2 ± 0.03	0.2 ± 0.09
15	myrcene	MH	993	6.5 ± 1.25	3.9 ± 0.27	0.8 ± 0.41	6.4 ± 0.55	0.9 ± 0.14	0.8 ± 0.03	3.7 ± 0.22	2.4 ± 0.50	1.3 ± 0.48
16	3-octanol	NT	998	0.1 ± 0.08	0.1 ± 0.07	0.1 ± 0.03	-	-	-	0.1 ± 0.7	0.1 ± 0.08	0.1 ± 0.04
17	α-phellandrene	MH	1006	-	-	0.1 ± 0.01	-	-	0.1 ± 0.01	-	0.1 ± 0.10	0.1 ± 0.03
18	δ-3-carene	MH	1012	-	-	0.1 ± 0.06	-	-	0.1 ± 0.09	-	0.1 ± 0.06	0.2 ± 0.23
19	*n*-hexyl acetate	NT	1013	0.9 ± 0.10	0.8 ± 0.03	0.2 ± 0.09	2.1 ± 0.63	0.3 ± 0.01	0.2 ± 0.01	0.9 ± 0.86	0.6 ± 0.01	0.1 ± 0.08
20	α-terpinene	MH	1019	-	-	-	-	0.1 ± 0.01	-	-	-	-
21	*o*-cymene	MH	1026	-	-	-	-	0.2 ± 0.03	-	0.1 ± 0.10	-	-
22	*p*-cymene	MH	1028	0.2 ± 0.14	0.5 ± 0.04	0.8 ± 0.54	0.3 ± 0.21	0.7 ± 0.05	0.7 ± 0.60	0.3 ± 0.27	0.4 ± 0.31	0.9 ± 0.57
23	limonene	MH	1032	1.2 ± 0.97	0.5 ± 0.30	0.3 ± 0.08	-	1.0 ± 0.06	0.3 ± 0.12	-	1.7 ± 0.81	0.6 ± 0.41
24	1,8-cineole	OM	1036	4.3 ± 2.76	1.3 ± 1.00	0.9 ± 0.41	7.3 ± 3.25	3.0 ± 0.56	0.7 ± 0.70	6.1 ± 3.58	0.4 ± 0.06	0.9 ± 1.12
25	(*Z*)-β-ocimene	MH	1042	2.9 ± 0.83	1.8 ± 1.01	1.6 ± 1.02	3.3 ± 1.34	1.0 ± 0.16	2.6 ± 0.12	2.9 ± 0.89	4.4 ± 1.34	3.3 ± 0.51
26	lavender lactone	NT	1046	0.5 ± 0.38	1.2 ± 0.76	0.9 ± 0.72	0.3 ± 0.41	0.6 ± 0.58	0.5 ± 0.46	0.4 ± 0.19	0.3 ± 0.09	0.5 ± 0.79
27	(*E*)-β-ocimene	MH	1053	4.1 ± 0.65	2.5 ± 1.69	1.8 ± 1.6	4.5 ± 1.23	1.2 ± 1.08	1.6 ± 0.92	2.5 ± 1.86	2.9 ± 0.05	3.6 ± 2.38
28	γ-terpinene	MH	1062	-	-	0.2 ± 0.25	-	-	0.1 ± 0.18	-	0.2 ± 0.11	0.4 ± 0.37
29	*trans*-linalool oxide (furanoid)	OM	1069	2.3 ± 1.14	8.3 ± 2.26	6.8 ± 4.5	1.7 ± 1.00	5.5 ± 3.82	5.8 ± 2.20	2.7 ± 1.22	2.7 ± 0.12	5.4 ± 0.11

Table 3. *Cont.*

	Compounds	Class *	LRI [1]	P:C			P:A			P:C:A		
				Sus	Stu	Tan	Sus	Stu	Tan	Sus	Stu	Tan
30	*cis*-sabinene hydrate	OM	1072	0.1 ± 0.11	0.4 ± 0.35	0.9 ± 0.65	0.1 ± 0.11	0.4 ± 0.31	0.8 ± 0.78	-	0.3 ± 0.06	1.1 ± 0.44
31	*cis*-linalool oxide (furanoid)	OM	1075	2.1 ± 0.93	7.1 ± 3.54	5.5 ± 3.70	1.3 ± 1.02	4.5 ± 2.02	4.5 ± 3.08	2.2 ± 1.02	1.8 ± 0.72	4.5 ± 0.03
32	6,7-eoxymyrcene	OM	1095	-	-	-	-	-	-	-	0.4 ± 0.15	-
33	linalool	OM	1102	19.1 ± 3.04	23.5 ± 1.90	33.4 ± 11.65	18.7 ± 1.05	26.1 ± 5.94	42.7 ± 2.44	28.5 ± 4.11	40.3 ± 7.86	35.4 ± 6.56
34	*n*-nonanal	NT	1104	0.1 ± 0.27	-	-	-	-	-	-	-	-
35	(*E*)-2-heptyl acetate	NT	1114	-	0.1 ± 0.18	-	-	-	-	-	-	-
36	1-octen-3-yl acetate	NT	1117	4.9 ± 3.26	3.6 ± 2.82	1.0 ± 0.30	5.3 ± 4.27	6.5 ± 0.64	0.5 ± 0.51	3.9 ± 3.94	1.0 ± 0.26	0.3 ± 0.26
37	3-octanol acetate	NT	1129	0.5 ± 0.08	0.3 ± 0.05	0.1 ± 0.02	0.7 ± 0.57	0.1 ± 0.03	-	0.8 ± 0.78	0.1 ± 0.06	-
38	*allo*-ocimene	OM	1133	0.1 ± 0.09	0.1 ± 0.03	-	0.1 ± 0.02	-	-	0.1 ± 0.08	0.1 ± 0.02	0.1 ± 0.07
39	nopinone	OM	1142	-	-	-	-	0.1 ± 0.07	-	-	-	-
40	*trans*-pinocarveol	OM	1144	-	-	-	-	0.1 ± 0.09	-	-	-	-
41	eucarvone	OM	1146	-	-	-	-	0.1 ± 0.07	-	-	-	-
42	camphor	OM	1148	0.6 ± 0.07	0.6 ± 0.01	0.2 ± 0.14	0.4 ± 0.10	0.9 ± 0.78	0.2 ± 0.20	0.7 ± 0.27	0.3 ± 0.08	0.4 ± 0.17
43	hexyl isobutyrate	NT	1153	0.1 ± 0.06	0.2 ± 0.12	-	0.2 ± 0.18	0.2 ± 0.02	0.1 ± 0.08	0.1 ± 0.03	0.1 ± 0.01	-
44	pinocarvone	OM	1166	-	-	-	-	0.1 ± 0.10	-	-	-	-
45	borneol	OM	1169	0.5 ± 0.05	0.5 ± 0.07	0.6 ± 0.43	0.3 ± 0.03	1.0 ± 0.80	0.6 ± 0.33	0.9 ± 0.74	0.2 ± 0.08	1.0 ± 0.43
46	pinocampheol	OM	1170	-	-	-	-	-	-	-	0.1 ± 0.02	-
47	lavandulol	OM	1172	0.1 ± 0.03	-	0.2 ± 0.07	-	-	-	0.1 ± 0.09	0.2 ± 0.03	0.1 ± 0.04
48	*trans*-linalool oxide (pyranoid)	OM	1177	-	0.4 ± 0.04	-	-	-	-	-	-	-
49	4-terpineol	OM	1180	1.8 ± 0.96	2.5 ± 1.92	5.1 ± 1.36	1.1 ± 0.22	2.6 ± 1.09	5.3 ± 3.69	0.9 ± 0.50	3.3 ± 1.96	7.4 ± 1.98
50	cryptone	NT	1187	0.1 ± 0.08	0.3 ± 0.31	-	-	0.4 ± 0.58	-	0.3 ± 0.29	-	-
51	octanoic acid	NT	1191	0.1 ± 0.08	-	-	-	-	-	0.1 ± 0.04	-	-
52	α-terpineol	OM	1192	-	-	0.1 ± 0.08	-	-	-	-	-	-
53	dihydro carveol	OM	1194	-	0.1 ± 0.10	-	-	-	-	-	-	-
54	hexyl butyrate	NT	1195	0.7 ± 0.51	1.2 ± 0.68	0.5 ± 0.07	1.2 ± 0.53	0.8 ± 0.73	0.7 ± 0.63	0.2 ± 0.03	0.3 ± 0.08	0.3 ± 0.04
55	myrtinal	OM	1196	-	-	-	-	0.1 ± 0.18	-	-	-	-
56	*n*-decanal	NT	1206	0.1 ± 0.02	-	-	0.1 ± 0.07	0.2 ± 0.19	-	-	-	-
57	verbenone	OM	1214	-	-	-	-	0.1 ± 0.18	-	-	-	-
58	isobornyl formate	OM	1230	-	0.1 ± 0.10	1.4 ± 0.36	-	0.2 ± 0.13	-	0.1 ± 0.7	-	-
59	hexyl 3-methyl butanoate	NT	1242	0.1 ± 0.03	0.1 ± 0.04	-	0.1 ± 0.10	0.1 ± 0.09	-	-	-	-

Table 3. *Cont.*

	Compounds	Class *	LRI [1]	P:C			P:A			P:C:A		
				Sus	**Stu**	**Tan**	**Sus**	**Stu**	**Tan**	**Sus**	**Stu**	**Tan**
60	cuminaldehyde	OM	1244	-	-	0.1 ± 0.04	-	-	-	-	-	-
61	linalyl acetate	OM	1260	27.0 ± 6.35	24.6 ± 6.72	23.0 ± 5.21	26.6 ± 5.95	32.0 ± 7.27	22.3 ± 3.75	24.4 ± 3.32	22.6 ± 4.66	20.6 ± 1.20
62	isobornyl acetate	OM	1287	0.9 ± 0.38	0.1 ± 0.10	-	0.2 ± 0.19	-	-	0.4 ± 0.28	0.1 ± 0.03	-
63	lavandulyl acetate	OM	1289	4.1 ± 1.98	3.4 ± 2.41	3.7 ± 1.90	5.3 ± 3.27	3.8 ± 0.74	1.4 ± 0.58	4.5 ± 3.03	2.7 ± 0.75	3.5 ± 1.84
64	(*Z*)-8-hydroxylinalol	OM	1360	0.6 ± 0.46	1.1 ± 0.85	0.4 ± 0.01	0.4 ± 0.45	0.4 ± 0.41	0.1 ± 0.20	0.6 ± 0.56	0.2 ± 0.15	0.2 ± 0.06
65	neryl acetate	OM	1368	1.8 ± 0.64	1.1 ± 0.91	0.2 ± 0.06	1.8 ± 0.04	0.2 ± 0.13	0.2 ± 0.03	1.1 ± 1.02	0.6 ± 0.03	0.2 ± 0.02
66	α-copaene	SH	1376	-	-	0.1 ± 0.08	-	-	-	-	0.1 ± 0.04	0.1 ± 0.09
67	β-bourborene	SH	1383	-	-	0.1 ± 0.04	-	-	-	-	-	-
68	geranyl acetate	OM	1386	3.9 ± 0.94	2.3 ± 1.74	0.4 ± 0.12	3.3 ± 0.11	0.5 ± 0.08	0.4 ± 0.04	2.2 ± 1.90	1.3 ± 0.67	0.5 ± 0.09
69	(*E*)-caryophyllene	SH	1418	2.7 ± 1.74	1.3 ± 1.00	1.7 ± 1.27	1.6 ± 1.03	1.3 ± 0.80	2.0 ± 0.58	2.0 ± 1.16	3.0 ± 1.22	1.8 ± 1.15
70	α-santhalene	SH	1419	-	-	-	0.2 ± 0.27	-	-	-	-	-
71	*trans*-α-bergamotene	SH	1437	-	0.1 ± 0.10	0.1 ± 0.02	-	-	0.1 ± 0.01	-	-	0.1 ± 0.02
72	(*E*)-β-farnesene	SH	1460	0.5 ± 0.04	0.3 ± 0.07	0.3 ± 0.27	1.0 ± 0.07	0.1 ± 0.09	0.4 ± 0.36	0.2 ± 0.19	0.3 ± 0.15	0.2 ± 0.21
73	germacrene D	SH	1481	0.1 ± 0.08	-	0.2 ± 0.19	-	-	0.2 ± 0.01	-	0.2 ± 0.16	0.2 ± 0.17
74	*trans*-γ-cadinene	SH	1513	0.1 ± 0.09	-	-	-	-	-	0.2 ± 0.07	-	-
75	caryophyllene oxide	OS	1582	-	0.1 ± 0.02	-	0.1 ± 0.02	-	-	-	-	-
	Class of Compounds			P:C			P:A			P:C:A		
				Sus	Stu	Tan	Sus	Stu	Tan	Sus	Stu	Tan
	Monoterpene hydrocarbons (MH)			15.5 ± 2.3	9.7 ± 2.36	7.2 ± 4.81	14.9 ± 3.34	5.7 ± 1.42	7.0 ± 2.85	11.1 ± 3.3	13.3 ± 5.8	12.1 ± 4.46
	Oxygenated monoterpenes (OM)			69.4 ± 3.88	77.3 ± 4.18	83.0 ± 6.06	68.8 ± 4.90	81.8 ± 3.89	84.9 ± 5.73	75.5 ± 6.73	77.6 ± 4.00	81.4 ± 1.33
	Sesquiterpene hydrocarbons (SH)			3.4 ± 0.64	1.7 ± 0.80	2.4 ± 1.76	2.8 ± 1.96	2.5 ± 0.21	2.7 ± 0.83	2.4 ± 1.13	3.5 ± 1.41	2.3 ± 0.90
	Oxygenated sesquiterpenes (OS)			-	0.1 ± 0.12	-	0.1 ± 0.12	-	-	-	-	-
	Non-terpene derivatives (NT)			10.8 ± 2.80	10.7 ± 2.33	6.4 ± 3.53	13.4 ± 5.47	10.9 ± 1.03	4.4 ± 1.24	10.8 ± 4.11	4.7 ± 2.51	3.7 ± 1.50
	Total identified			99.1 ± 0.91	97.5 ± 2.57	98.5 ± 1.23	96.5 ± 3.31	99.9 ± 0.10	99.8 ± 0.22	99.9 ± 0.12	99.7 ± 0.11	99.7 ± 0.18

[1] LRI: Linear retention indices on DB-5 column; [2] The percentages are averages of at least three independent samples for each lavender selection and for each substrate. Compounds with abundance < 0.1% are not present in the table.

Volatile organic compounds can vary drastically depending on several other factors [59]. Among these, abiotic and biotic stresses have affected the emission rate of the hydrophilic oxygenated monoterpene 1,8-cineole in *Eucalyptus globulus* Labill., through the regulation of terpene synthase and stomatal conductance [60]. The emission rates of the same compound were found to be also light- and temperature-dependent in *Pinus sylvestris* L. [61], *Hesperis matronalis* L. [62] and *Pinus pinea* L. [63]. In medicinal and aromatic plants under moderately water-stressed conditions, volatile oxygenated and monoterpene hydrocarbons increased in *Salvia sinaloensis* Fern. and *Helichrysum petiolare* Hilliard & B.L. Burtt plants [31,32]. While, under similar conditions, an increase in sesquiterpene hydrocarbons was revealed in *Salvia dolomitica* Codd. Plants [33]. In lavenders, factors such as latitude [36], stage of flower development [64] and genotype [6,57,58,65,66] may affect the volatile composition. However, in this study, the two-way PERMANOVA (using 9999 permutations) performed on VOCs revealed that the cultivation substrate did not significantly affect the volatilome of lavender ($F = 0.69$, $p = 0.2156$, Table 4).

Table 4. Effects of lavender selection (Susa (Sus), Stura (Stu) and Tanaro (Tan)) and cultivation substrate (P:C = peat and green compost, 70%:30% *v*/*v*; P:A = peat and demolition aggregates, 70%:30% *v*/*v*; P:C:A = peat, green compost and demolition aggregates, 40%:30%:30% *v*/*v*) on volatile organic compounds (VOCs) and essential oils (Eos), according to the two-way PERMANOVA analysis.

VOCs	*F*	*p*	Significant Pair-Wise Comparisons at $p < 0.05$
Lavender selection	3.27	0.0001	Sus versus Tan
Substrate	0.69	0.2156	-
EOs			
Lavender selection	2.94	0.0013	Sus versus Tan
Substrate	2.48	0.0065	P:A versus P:C:A

3.3. Influence of Cultivation Substrate on EO Yield and Composition

Essential oil yields varied from very low in P:C:A-Sus to a maximum of 1% in P:A-Sus (Table 5). Reference [67] showed that the average yield of lavender EO was 0.14% (*w*/*w*), although sometimes it can reach 5% [68]. The cultivation substrate influenced the EO yields according to the one-way PERMANOVA analysis ($F = 3.225$, $p = 0.047$), with yields obtained from plants in the P:C substrates significantly lower than yields obtained from plants in P:C:A substrates. The production of secondary metabolites, including EOs, is regulated by genetics and edaphic factors [69], water stress [31–33] and light, as well [70]. Differences in EO yield caused by substrates have been observed in other Lamiaceae species, such as *Thymus caespititius* Brot. [69] and *Ocimum basilicum* [39]. Particularly in the latter species, the yields of EOs increased up to 40% with the addition of 20–60% mineral material to peat. Likewise, a higher EO yield was obtained in this study from lavenders grown in both substrates containing mineral material (P:A). Contrasting results have been achieved concerning the effect of mineral nutrients on EO production in Lamiaceae species. Elevated levels of potassium can decrease the EO content in many plants [40], as highlighted in *Origanum dictamnus* [49] and lavender [30] with >300 mg L^{-1} in hydroponics; however, no evident relations between potassium and yields were found in *Rosmarinus officinalis* [48]. Lavender EO production was not influenced by 30 to 70 mg L^{-1} of available phosphorus, according to [29], in contrast with another study on lavender, where higher amounts of oil were produced with increased P applications in field trial [50]. Essential oil synthesis can be also fostered by stress conditions [70]. Plants in P:C:A substrate indeed had a poor performance; however, they produced higher amounts of EOs.

Table 5. Percentage of major constituents in lavender essential oils obtained from lavender selections collected in Susa (Sus), Stura (Stu), and Tanaro (Tan) valleys and grown in pot with different substrates (P:C = peat and green compost, 70%:30% *v*/*v*; P:A = peat and demolition aggregates, 70%:30% *v*/*v*; P:C:A = peat, green compost and demolition aggregates, 40%:30%:30% *v*/*v*) with standard deviation.

	Compounds	Class	LRI [1]	P:C			P:A			P:C:A		
				Sus	Stu	Tan	Sus	Stu	Tan	Sus	Stu	Tan
1	α-thujene	MH	932	-	-	-	-	-	0.1 [2] ± 0.07	-	-	0.1 ± 0.04
2	tricyclene	MH	938	0.1 ± 0.10	0.1 ± 0.07	0.1 ± 0.07	0.1 ± 0.01	-	0.3 ± 0.06	0.1 ± 0.08	0.1 ± 0.09	0.3 ± 0.01
3	camphene	MH	955	0.6 ± 0.29	0.2 ± 0.03	0.2 ± 0.02	0.6 ± 0.2	0.1 ± 0.03	0.5 ± 0.11	0.4 ± 0.09	0.4 ± 0.19	0.6 ± 0.16
4	1-octen-3-one	NT	980	0.2 ± 0.03	0.2 ± 0.10	-	0.1 ± 0.02	-	-	0.8 ± 0.47	0.1 ± 0.06	-
5	β-pinene	MH	981	0.3 ± 0.06	-	-	0.4 ± 0.04	0.1 ± 0.01	0.2 ± 0.06	-	0.1 ± 0.03	0.2 ± 0.05
6	1-octen-3-ol	NT	982	0.2 ± 0.16	0.4 ± 0.26	0.3 ± 0.11	0.3 ± 0.12	0.3 ± 0.16	0.3 ± 0.12	-	0.7 ± 0.18	0.3 ± 0.09
7	3-octanone	NT	987	0.7 ± 0.34	0.5 ± 0.17	0.4 ± 0.26	0.9 ± 0.38	0.5 ± 0.35	0.7 ± 0.26	1.3 ± 0.16	0.5 ± 0.07	0.6 ± 0.14
8	myrcene	MH	993	1.0 ± 0.24	0.7 ± 0.07	0.5 ± 0.10	1.0 ± 0.11	0.7 ± 0.16	0.9 ± 0.20	1.2 ± 0.59	0.6 ± 0.22	1.0 ± 0.39
9	butanoic acid butyl ester	NT	994	-	0.1 ± 0.08	-	0.2 ± 0.1	0.1 ± 0.08	-	-	-	-
10	3-octanol	NT	998	0.1 ± 0.08	0.1 ± 0.10	0.1 ± 0.05	0.1 ± 0.06	0.1 ± 0.09	0.2 ± 0.08	0.2 ± 0.04	0.2 ± 0.05	0.2 ± 0.01
11	*cis*-dehydroxylinalool oxide	OM	1009	0.1 ± 0.06	0.1 ± 0.09	-	0.1 ± 0.08	0.1 ± 0.06	-	0.1 ± 0.08	0.1 ± 0.09	-
12	N-hexyl acetate	NT	1013	0.3 ± 0.04	0.2 ± 0.10	-	0.2 ± 0.52	0.2 ± 0.07	0.1 ± 0.09	0.7 ± 0.17	-	-
13	α-terpinene	MH	1019	0.1 ± 0.02	0.1 ± 0.08	0.1 ± 0.09	0.1 ± 0.09	0.1 ± 0.09	0.2 ± 0.03	-	0.1 ± 0.10	0.2 ± 0.05
14	*o*-cymene	MH	1026	0.1 ± 0.01	0.1 ± 0.10	0.1 ± 0.09	0.1 ± 0.06	0.1 ± 0.09	0.1 ± 0.01	-	0.1 ± 0.09	0.1 ± 0.04
15	*p*-cymene	MH	1028	0.3 ± 0.04	0.5 ± 0.24	0.4 ± 0.21	0.3 ± 0.06	0.5 ± 0.14	0.5 ± 0.07	0.2 ± 0.03	0.4 ± 0.24	0.5 ± 0.24
16	limonene	MH	1032	-	0.2 ± 0.06	0.3 ± 0.07	-	0.1 ± 0.03	0.2 ± 0.03	-	0.3 ± 030	0.3 ± 0.03
17	1,8-cineole	OM	1036	6.3 ± 0.47	1.5 ± 0.45	1.0 ± 0.15	5.2 ± 1.84	1.6 ± 0.76	2.3 ± 0.29	3.6 ± 0.91	4.3 ± 0.88	2.0 ± 0.46
18	(*Z*)-β-ocimene	MH	1042	0.8 ± 0.33	0.4 ± 0.27	0.5 ± 0.20	0.9 ± 0.25	0.5 ± 0.33	0.9 ± 0.46	1.0 ± 0.16	0.8 ± 0.25	0.9 ± 0.47
19	(*E*)-β-ocimene	MH	1053	0.9 ± 0.24	0.6 ± 0.12	0.7 ± 0.18	1.0 ± 0.02	0.7 ± 0.38	1.1 ± 0.21	1.2 ± 0.42	0.5 ± 0.42	1.1 ± 0.42
20	γ-terpinene	MH	1062	-	-	0.1 ± 0.06	-	-	0.2 ± 0.02	-	-	0.2 ± 0.01
21	*trans*-linalool oxide (furanoid)	OM	1069	1.2 ± 0.28	2.0 ± 0.67	1.3 ± 0.43	1.7 ± 0.70	1.7 ± 0.18	2.2 ± 0.16	1.0 ± 0.13	1.7 ± 0.70	2.5 ± 0.57
22	*cis*-sabinene hydrate	OM	1072	0.2 ± 0.10	0.4 ± 0.16	0.4 ± 0.27	0.3 ± 0.04	0.4 ± 0.05	0.5 ± 0.35	0.2 ± 0.01	0.4 ± 0.18	0.4 ± 0.14
23	*cis*-linalool oxide (furanoid)	OM	1075	1.2 ± 0.20	1.8 ± 0.63	1.2 ± 0.33	1.6 ± 0.57	1.6 ± 0.92	2.2 ± 0.18	1.1 ± 0.25	1.5 ± 0.86	2.5 ± 0.17
24	camphenilone	OM	1086	-	0.1 ± 0.09	-	-	-	-	-	-	-
25	6,7-epoxymyrcene	OM	1095	0.5 ± 0.13	0.5 ± 0.10	0.3 ± 0.15	0.5 ± 0.21	0.5 ± 0.02	0.2 ± 0.16	0.4 ± 0.06	0.3 ± 0.02	0.2 ± 0.05
26	linalool	OM	1102	21.0 ± 3.24	23.9 ± 3.36	29.5 ± 3.51	23.7 ± 3.77	20.4 ± 3.40	36.9 ± 5.38	33.8 ± 3.72	36.7 ± 4.03	38.5 ± 0.69
27	1-octen-3-yl acetate	NT	1117	3.0 ± 0.73	2.4 ± 1.30	0.6 ± 0.08	3.1 ± 1.32	3.0 ± 0.56	0.5 ± 0.76	1.6 ± 0.17	0.8 ± 0.73	0.5 ± 0.06
28	*cis*-*p*-menth-2-en-1-ol	OM	1125	-	0.2 ± 0.11	0.1 ± 0.09	-	0.2 ± 0.14	0.1 ± 0.08	0.1 ± 0.08	0.2 ± 0.07	0.1 ± 0.02

Table 5. *Cont.*

	Compounds	Class	LRI [1]	P:C			P:A			P:C:A		
				Sus	Stu	Tan	Sus	Stu	Tan	Sus	Stu	Tan
29	3-octanol acetate	NT	1129	0.5 ± 0.34	0.1 ± 0.07	0.1 ± 0.01	0.5 ± 0.23	0.1 ± 0.05	0.1 ± 0.06	0.5 ± 0.06	-	0.1 ± 0.02
30	α-campholenal	OM	1130	-	0.1 ± 0.07	-	-	-	-	-	0.1 ± 0.08	-
31	(Z)-myroxide	OM	1137	0.2 ± 0.09	0.2 ± 0.05	0.1 ± 0.09	0.2 ± 0.07	0.2 ± 0.05	0.1 ± 0.10	0.1 ± 0.09	0.1 ± 0.04	-
32	*trans*-pinocarveol	OM	1142	0.1 ± 0.10	-	-	0.1 ± 0.1	0.1 ± 0.08	-	0.1 ± 0.08	0.1 ± 0.08	-
33	eucarvone	OM	1146	-	-	-	0.1 ± 0.08	-	-	-	0.1 ± 0.05	-
34	camphor	OM	1148	1.6 ± 0.22	1.8 ± 0.16	1.2 ± 0.52	1.3 ± 0.27	1.4 ± 0.34	1.4 ± 0.6	1.3 ± 0.35	1.6 ± 0.38	1.3 ± 0.71
35	*trans*-verbenol	OM	1150	0.1 ± 0.01	-	0.1 ± 0.04	0.1 ± 0.09	0.1 ± 0.08	0.1 ± 0.01	0.1 ± 0.02	-	0.1 ± 0.07
36	hexyl isobutyrate	NT	1153	0.2 ± 0.08	0.2 ± 0.12	-	0.2 ± 0.02	0.2 ± 0.06	0.1 ± 0.08	0.1 ± 0.07	0.1 ± 0.08	0.1 ± 0.03
37	nerol oxide	OM	1158	-	0.1 ± 0.05	-	0.1 ± 0.08	0.1 ± 0.09	-	-	0.1 ± 0.03	0.1 ± 0.03
38	pinocarvone	OM	1166	0.3 ± 0.10	0.1 ± 0.10	0.1 ± 0.08	0.2 ± 0.11	0.2 ± 0.16	0.1 ± 0.08	0.1 ± 0.07	0.1 ± 0.08	-
39	borneol	OM	1169	4.4 ± 0.58	5.3 ± 1.09	4.6 ± 1.66	3.6 ± 0.45	4.6 ± 1.48	5.3 ± 2.08	4.0 ± 0.67	5.1 ± 0.59	5.3 ± 0.39
40	4-terpinenol	OM	1180	0.9 ± 0.56	1.4 ± 0.55	3.0 ± 0.62	1.2 ± 0.67	2.3 ± 0.76	4.9 ± 0.80	1.7 ± 0.11	1.6 ± 0.11	4.1 ± 0.30
41	cryptone	NT	1187	0.7 ± 0.47	1.1 ± 0.56	0.8 ± 0.54	0.3 ± 0.06	1.1 ± 0.57	0.8 ± 0.30	0.3 ± 0.06	1.3 ± 0.28	0.8 ± 0.24
42	*p*-cymen-8-ol	OM	1189	0.2 ± 0.13	0.2 ± 0.10	0.1 ± 0.10	0.2 ± 0.05	0.2 ± 0.09	0.1 ± 0.01	0.1 ± 0.08	-	0.1 ± 0.04
43	α-terpineol	OM	1192	4.1 ± 0.98	3.1 ± 0.36	2.9 ± 0.51	4.5 ± 0.56	3.6 ± 1.10	4.1 ± 1.13	4.3 ± 0.20	2.9 ± 0.22	4.4 ± 0.13
44	verbenone	OM	1214	0.3 ± 0.12	0.4 ± 0.17	0.3 ± 0.11	0.2 ± 0.08	0.4 ± 0.19	0.3 ± 0.14	0.1 ± 0.03	0.3 ± 0.14	0.2 ± 0.10
45	*trans*-carveol	OM	1221	0.5 ± 0.38	0.6 ± 0.15	0.3 ± 0.20	0.5 ± 0.23	0.6 ± 0.08	0.2 ± 0.07	0.4 ± 0.26	0.3 ± 0.08	0.1 ± 0.06
46	*cis*-*p*-mentha-1(7),8-dien-2-ol	OM	1229	0.2 ± 0.17	0.3 ± 0.09	0.2 ± 0.11	0.1 ± 0.07	0.3 ± 0.16	0.1 ± 0.12	-	0.2 ± 0.10	0.1 ± 0.05
47	isobornyl formate	OM	1230	0.3 ± 0.05	0.3 ± 0.21	0.3 ± 0.14	0.2 ± 0.02	0.3 ± 0.13	0.2 ± 0.10	0.2 ± 0.01	0.3 ± 0.02	0.2 ± 0.13
48	nerol	OM	1232	1.0 ± 0.36	0.6 ± 0.08	0.7 ± 0.16	0.9 ± 0.07	0.7 ± 0.26	0.8 ± 0.23	1.1 ± 0.34	0.5 ± 0.17	0.9 ± 0.50
49	3-methyl-3hexen-1-yl butanoate	NT	1236	0.1 ± 0.07	0.1 ± 0.09	-	0.1 ± 0.03	0.1 ± 0.07	-	0.1 ± 0.03	-	-
50	cumin aldehyde	OM	1244	0.4 ± 0.26	0.7 ± 0.41	0.4 ± 0.07	0.2 ± 0.17	0.7 ± 0.39	0.3 ± 0.18	0.2 ± 0.02	0.8 ± 0.26	0.2 ± 0.05
51	carvone	OM	1248	0.2 ± 0.13	0.3 ± 0.20	0.2 ± 0.17	0.1 ± 0.02	0.3 ± 0.20	0.1 ± 0.03	0.1 ± 0.01	0.4 ± 0.11	0.1 ± 0.06
52	linalyl acetate	OM	1260	17.7 ± 1.55	15.3 ± 2.33	14.9 ± 1.32	16.7 ± 3.95	16.2 ± 2.02	7.5 ± 2.89	16.5 ± 1.24	10.3 ± 0.79	8.8 ± 1.81
53	isopulegol acetate	OS	1273	0.1 ± 0.08	-	-	0.1 ± 0.08	-	1.8 ± 0.17	0.1 ± 0.07	-	-
54	isobornyl acetate	OM	1287	1.6 ± 0.31	0.6 ± 0.05	0.3 ± 0.06	1.1 ± 0.28	0.5 ± 0.4	0.2 ± 0.1	0.9 ± 0.29	0.3 ± 0.11	0.3 ± 0.09
55	lavandulyl acetate	OM	1289	3.3 ± 1.65	3.9 ± 1.08	3.8 ± 1.21	4.8 ± 1.03	5.0 ± 0.48	4.4 ± 1.19	2.7 ± 1.32	2.1 ± 0.88	5.1 ± 0.79
56	carvacrol	OM	1301	-	0.3 ± 0.14	0.4 ± 0.06	-	0.4 ± 0.23	0.1 ± 0.02	-	0.1 ± 0.08	0.1 ± 0.03
57	hexyl tiglate	NT	1333	-	-	-	-	0.1 ± 0.01	-	0.1 ± 0.02	-	-
58	δ-elemene	SH	1340	0.1 ± 0.01	0.5 ± 0.25	0.5 ± 0.23	0.1 ± 0.08	0.6 ± 0.4	0.2 ± 0.08	-	0.3 ± 0.14	0.3 ± 0.13
59	(Z)-8-hydroxylinalol	OM	1360	0.6 ± 0.28	0.5 ± 0.13	0.2 ± 0.05	0.6 ± 0.23	0.7 ± 0.26	0.2 ± 0.09	0.3 ± 0.08	0.4 ± 0.14	-

Table 5. *Cont.*

	Compounds	Class	LRI [1]	P:C			P:A			P:C:A		
				Sus	Stu	Tan	Sus	Stu	Tan	Sus	Stu	Tan
60	neryl acetate	OM	1368	1.5 ± 0.36	1.3 ± 0.33	1.3 ± 0.27	1.5 ± 0.09	1.4 ± 0.41	1.3 ± 0.33	1.9 ± 0.40	0.9 ± 0.20	1.2 ± 0.60
61	α-copaene	SH	1376	-	-	0.1 ± 0.10	-	-	-	-	-	-
62	geranyl acetate	OM	1386	3.1 ± 0.79	2.8 ± 0.57	2.8 ± 0.64	3.1 ± 0.23	2.9 ± 0.85	2.6 ± 0.73	3.6 ± 0.57	1.9 ± 0.20	2.5 ± 0,23
63	(*E*)-caryophyllene	SH	1418	1.3 ± 0.48	1.8 ± 0.68	3.2 ± 1.00	1.4 ± 0.49	2.4 ± 0.89	1.6 ± 0.28	2.0 ± 0.91	1.9 ± 0.38	1.4 ± 0.12
64	*trans*-γ-bergamotene	SH	1437	-	0.2 ± 0.10	0.3 ± 0.11	-	0.2 ± 0.12	0.1 ± 0.01	-	0.1 ± 0.07	0.1 ± 0.07
65	aromadendrene	SH	1445	-	0.1 ± 0.08	0.2 ± 0.07	-	0.1 ± 0.12	0.1 ± 0.08	-	0.1 ± 0.09	-
66	*epi*-β-santalene	SH	1447	-	0.1 ± 0.09	0.1 ± 0.08	-	0.1 ± 0.01	-	-	-	-
67	α-humulene	SH	1456	-	-	-	-	0.1 ± 0.07	-	-	-	-
68	(*E*)-β-farnesene	SH	1460	0.3 ± 0.06	0.4 ± 0.09	0.7 ± 0.06	0.4 ± 0.20	0.4 ± 0.23	0.5 ± 0.14	0.4 ± 0.08	0.3 ± 0.08	0.3 ± 0.16
69	germacrene D	SH	1481	0.1 ± 0.07	0.1 ± 0.07	0.5 ± 0.04	0.1 ± 0.07	0.1 ± 0.03	0.3 ± 0.11	0.2 ± 0.02	0.1 ± 0.16	0.3 ± 0.08
70	γ-curcumene	SH	1484	-	-	0.2 ± 0.09	-	-	0.1 ± 0.06	-	0.1 ± 0.06	-
71	β-bisabolene	SH	1509	-	-	0.6 ± 0.09	-	-	-	-	-	-
72	*trans*-γ-cadinene	SH	1513	0.5 ± 0.16	0.1 ± 0.06	-	0.3 ± 0.23	0.2 ± 0.11	-	0.2 ± 0.06	0.2 ± 0.25	-
73	(*Z*)-γ-bisabolene	SH	1515	0.5 ± 0.10	1.9 ± 0.80	1.3 ± 0.19	0.5 ± 0.18	2.0 ± 0.47	1.1 ± 0.38	0.3 ± 0.04	1.0 ± 0.54	0.9 ± 0.31
74	(*E*)-γ-bisabolene	SH	1535	0.2 ± 0.05	0.8 ± 0.41	0.9 ± 0.37	0.2 ± 0.07	1.1 ± 0.71	0.5 ± 0.16	-	0.3 ± 0.07	0.3 ± 0.13
75	*cis*-sesquisabinene hydrate	OS	1545	-	0.3 ± 0.16	0.3 ± 0.12	0.1 ± 0.04	0.3 ± 0.25	0.1 ± 0.03	-	0.1 ± 0.02	0.1 ± 0.07
76	elemol	OS	1553	0.5 ± 0.22	0.7 ± 0.06	0.6 ± 0.26	0.4 ± 0.06	0.6 ± 0.20	0.3 ± 0.11	0.3 ± 0.01	0.5 ± 0.21	0.3 ± 0.10
77	germacrene B	SH	1556	-	0.2 ± 0.08	0.3 ± 0.09	-	0.2 ± 0.08	0.1 ± 0.02	-	0.1 ± 0.08	0.1 ± 0.02
78	spathulenol	OS	1581	0.1 ± 0.01	0.3 ± 0.13	0.2 ± 0.08	-	0.3 ± 0.22	0.2 ± 0.04	-	0.2 ± 0.05	0.1 ± 0.02
79	caryophyllene oxide	OS	1582	6.1 ± 1.21	7.4 ± 1.40	6.6 ± 1.41	6.0 ± 2.52	6.2 ± 1.08	3.6 ± 1.05	4.8 ± 0.20	5.8 ± 0.67	3.4 ± 0.49
80	thujapsan-2-α-ol	OS	1589	-	1.4 ± 0.81	1.5 ± 0.77	0.1 ± 0.09	1.4 ± 0,42	0.9 ± 0.32	-	0.6 ± 0.26	0.7 ± 0.19
81	β-oplopenone	OS	1606	-	-	-	-	0.1 ± 0.09	-	-	-	-
82	humulene epoxide II	OS	1607	0.2 ± 0.06	0.2 ± 0.04	0.2 ± 0.07	0.1 ± 0.05	0.2 ± 0.05	0.1 ± 0.09	-	0.2 ± 0.07	0.1 ± 0.10
83	1,10-di-*epi*-cubenol	OS	1614	0.3 ± 0.03	0.2 ± 0.07	0.2 ± 0.05	0.1 ± 0.07	0.2 ± 0.06	-	0.1 ± 0.02	0.2 ± 0.07	-
84	α-acorenol	OS	1633	-	0.1 ± 0.01	-	-	0.1 ± 0.02	-	0.1 ± 0.08	-	-
85	β-acorenol	OS	1636	-	0.1 ± 0.09	0.1 ± 0.12	-	0.1 ± 0.02	-	-	-	-
86	β-caryophylla-4(14),8(15)-dien-5-ol	OS	1639	-	0.2 ± 0.04	0.2 ± 0.09	-	0.1 ± 0.04	0.1 ± 0.03	-	0.1 ± 0.08	0.1 ± 0.04
87	τ-cadinol	OS	1642	3.0 ± 0.31	0.6 ± 0.37	0.2 ± 0.10	1.9 ± 0.15	1.1 ± 0.59	0.1 ± 0.03	0.8 ± 0.15	2.0 ± 0.97	0.1 ± 0.08
88	α-cadinol	OS	1655	-	0.1 ± 0.10	0.4 ± 0.11	-	0.2 ± 0.02	0.2 ± 0.06	0.2 ± 0.12	0.1 ± 0.06	0.1 ± 0.02
89	*neo*-intermediol	OS	1660	-	0.3 ± 0.02	0.2 ± 0.12	-	0.3 ± 0.08	-	-	0.2 ± 0.08	-
90	(*Z*)-α-santalol	OS	1665	0.7 ± 0.25	0.9 ± 0.34	1.0 ± 0.30	0.7 ± 0.34	0.4 ± 0.06	0.5 ± 0.08	0.3 ± 0.04	0.5 ± 0.21	0.4 ± 0.11
91	(*Z*)-nerolidol acetate	OS	1668	-	-	0.2 ± 0.15	0.1 ± 0.08	-	0.2 ± 0.08	-	-	0.1 ± 0.02

Table 5. *Cont.*

	Compounds	Class	LRI [1]	P:C			P:A			P:C:A		
				Sus	Stu	Tan	Sus	Stu	Tan	Sus	Stu	Tan
92	14-hydroxy-9-*epi*-(E)-caryophyllene	OS	1672	0.1 ± 0.05	0.2 ± 0.10	0.1 ± 0.02	0.4 ± 0.05	0.3 ± 0.02	-	-	0.1 ± 0.09	-
93	elemol acetate	OS	1675	-	0.4 ± 0.33	0.4 ± 0.26	-	0.6 ± 0.06	0.3 ± 0.04	-	0.3 ± 0.09	0.1 ± 0.03
94	*cis*-14-muurol-5-en-4-one	OS	1684	0.7 ± 0.13	0.2 ± 0.16	0.3 ± 0.12	0.2 ± 0.02	0.4 ± 0.17	0.1 ± 0.01	0.2 ± 0.05	0.5 ± 0.07	0.1 ± 0.10
95	14-hydroxy-α-humulene	OS	1714	-	-	0.1 ± 0.02	-	0.1 ± 0.10	-	-	-	-
96	curcuphenol	OS	1720	-	-	-	-	-	-	-	0.1 ± 0.01	-
97	cedr-8(15)-en-9-α-ol acetate	OS	1743	0.1 ± 0.02	-	-	0.1 ± 0.04	-	-	-	-	-
98	cyclocolorenone	OS	1758	0.5 ± 0.06	0.1 ± 0.10	-	0.4 ± 0.23	0.1 ± 0.02	-	0.2 ± 0.02	0.2 ± 0.06	-
99	benzyl benzoate	NT	1760	0.1 ± 0.09	0.2 ± 0.10	-	0.1 ± 0.08	-	-	0.1 ± 0.08	0.1 ± 0.08	-
100	(Z)-α-santalol acetate	OS	1763	0.1 ± 0.07	0.1 ± 0.09	-	-	0.2 ± 0.14	-	-	0.1 ± 0.08	-
101	hexahydrofarnesylacetone	AC	1845	0.2 ± 0.06	0.4 ± 0.12	0.2 ± 0.20	0.1 ± 0.03	0.2 ± 0.02	0.1 ± 0.07	0.1 ± 0.04	0.3 ± 0.14	-
	Yield of EO (% *w*/*w*)			0.4 ± 0.08	0.1 ± 0.05	0.2 ± 0.02	1.0 ± 0.53	0.4 ± 0.10	0.6 ± 0.25	vl [3]	0.2 ± 0.10	0.8 ± 0.37
	Class of Compounds			Sus	P:C Stu	Tan	Sus	P:A Stu	Tan	Sus	P:C:A Stu	Tan
	Monoterpene Hydrocarbons (MH)			4.4 ± 0.97	2.9 ± 0.57	2.8 ± 0.67	4.4 ± 1.08	2.9 ± 0.76	5.1 ± 0.51	4.1 ± 1.06	3.5 ± 1.35	5.6 ± 1.37
	Oxygenated Monoterpenes (OM)			73.2 ± 3.99	70.6 ± 2.36	72.2 ± 3.65	74.6 ± 3.37	69.6 ± 4.28	78.8 ± 1.45	79.6 ± 1.46	75.8 ± 2.97	81.8 ± 1.12
	Sesquiterpene Hydrocarbons (SH)			3.1 ± 0.47	6.2 ± 0.32	8.8 ± 1.97	3.1 ± 0.23	7.5 ± 1.97	4.6 ± 0.23	3.1 ± 1.04	4.5 ± 0.70	3.8 ± 0.33
	Oxygenated Sesquiterpenes (OS)			12.7 ± 2.20	13.7 ± 1.35	13.2 ± 2.88	10.9 ± 1.68	13.1 ± 2.54	8.7 ± 1.82	7.0 ± 1,81	11.6 ± 1.68	5.9 ± 0.73
	Non-terpene derivatives (NT)			6.0 ± 0.23	5.5 ± 0.22	2.4 ± 0.77	6.1 ± 1.70	6.0 ± 0.60	2.8 ± 0.85	5.7 ± 0.31	3.8 ± 1.12	2.8 ± 0.84
	Apocarotenoids (AC)			0.2 ± 0.06	0.4 ± 0.12	0.2 ± 0.20	0.1 ± 0.03	0.2 ± 0.02	0.1 ± 0.07	0.1 ± 0.04	0.3 ± 0.14	-
	Total Identified			99.5 ± 0.40	99.3 ± 0.36	99.5 ± 0.26	99.2 ± 0.14	99.3 ± 0.43	100.0 ± 0.01	99.7 ± 0.18	99.4 ± 0.55	99.9 ± 0.10

[1] LRI: Linear retention indices on DB-5 column; [2] The percentages are averages of at least three independent samples for each lavender selection and for each substrate. Compounds with abundance < 0.1% are not present in the table; [3] vl: very low amount.

The main class of compounds in EOs was OM (Table 5), which varied from 69.6% in P:A-Stu to 81.8% in P:C:A-Tan. OS followed, with 5.9% in P:C:A-Tan and 13.7% in P:C-Stu. The EOs included apocarotenoids (AC), represented only by hexahydro farnesyl acetone in all samples, except for P:C:A-Tan. MHs, a very important class in the aroma profile, were present in all EOs with varying percentages (2.8% in P:C-Tan and 5.6% in P:C:A-Tan). It is important to highlight that the number of NT compounds decreased by 38.1% (from 21 to 13 constituents in VOCs and EOs, respectively) in comparison with those reported in VOCs, and NT percentages were also drastically decreased (from 2.3% in P:C-Tan to 6.5% in P:A-Sus). On the other hand, the OSs, which were almost absent in VOCs, were present as a considerable amount (5.9% in P:C:A-Tan-13.7% in P:C-Stu) in EOs.

A total of 101 compounds were identified in lavender EOs (Table 5), representing more than 99.2% of the total EO compositions. [71] found only 21 different compounds in *L. angustifolia* EO, while in this study higher numbers of components were found, ranging from 62 in P:C:A-Sus to 86 in P:A-Stu. Only 39 compounds were the same in all of the studied samples. Linalool was the major compound, and its percentage represented at least 21.0% in P:C-Sus, followed by linalyl acetate (from 7.5% in P:A-Tan to 17.7% in P:C-Sus). The percentages of the major compounds were inverted in comparison to VOC composition. The obtained value in this work showed that the amount of linalool in Tan valley and in all substrates agreed with those reported in the European Pharmacopeia (E.Ph.), which mentioned that the percentage in linalool had to be ranged between 25 and 45% of the total composition. On the contrary, linalyl acetate was very low in comparison with the value reported by E.Ph. Taking into account the substrate, both P:C:A (36.3%, average of three values) and P:A (27.0%) pointed out a value of linalool which was accepted by both E.Ph. and AFNOR. Linalool and linalyl acetate are important compounds in the cosmetic and pharmaceutical industry for their numerous biological and therapeutic activities [72]. Usually, they are the most abundant compounds in lavender oil [4], but their proportion can vary widely within the species [2,36,37,73]. Reference [74], for instance, found that the sum of these compounds reached more than 70% of the total EO composition.

The two-way PERMANOVA performed on the EO composition showed that both factors (substrates and lavender selection) had a significant influence on the EO composition (Table 4). Sus and Tan selections differently produced EOs, as seen in a previous study [36]. In the case of cultivation substrates, the pair-wise test showed significant differences between samples grown in P:A and those grown in P:C:A (Table 4). The profile of an essential oil is complex to evaluate due to its numerous constituents, particularly in *L. angustifolia*, since it is the most variable in the genus [75]. Nonetheless, a few studies on Lamiaceae species have shown that oil composition varied in *Thymus caespititius* Brot. [69], *Thymus vulgaris* [43] and *Origanum vulgare* L. [76] according to substrate, ratio and type of compost. Moreoever, there is the evidence that heavy metal content (Cd, Cu, Pb) can alter the EO composition of basil and peppermint in a peat-based medium experiment, though without affecting the marketability of the product [55]. Similarity percentage (SIMPER) analysis was performed to determine the compounds that contribute to the differences among the substrates. The results (Table 6) indicate that linalool and linalyl acetate together were responsible for 76.86%. This dissimilarity reached 95.06% when adding the effect of 1,8-cineol, caryophyllene oxide, lavandulyl acetate, 4-terpineol, borneol, 1-octan-3-yl acetate, τ-cadinol, α-terpineol, isopulegol acetate and (E)-caryophyllene to the previous compounds. Linalool, caryophyllene oxide, (E)-γ-bisabolene and (Z)-α-santalol showed a significant difference for substrate factors at 0.05 criterions. Caryophyllene oxide, (E)-γ-bisabolene and (Z)-α-santalol were higher in plants grown on P:C substrates, while plants grown on P:C:A substrates had higher recorded amounts of linalool. This latter compound has positive effects on the central nervous system, thus important for medicinal purposes.

Table 6. List of compounds responsible for dissimilarity in lavender EOs induced by substrate (P:C = peat and green compost, 70%:30% *v*/*v*; P:A = peat and demolition aggregates, 70%:30% *v*/*v*; P:C:A = peat, green compost and demolition aggregates, 40%:30%:30% *v*/*v*), according to the similarity percentage (SIMPER) analysis.

	Contribution %	Cumulative %	Substrate P:C	Substrate P:A	Substrate P:C:A	Stat. Sign.	Significant Pair-Wise Comparisons at $p < 0.05$
linalool	58.11	58.11	26.60	27.00	36.60	*	P:C versus P:C:A
linalyl acetate	18.75	76.86	15.50	13.50	11.40	ns	-
1,8-cineole	4.16	81.02	2.13	3.07	3.13	ns	-
caryophyllene oxide	3.10	84.12	6.69	5.30	4.50	*	P:C versus P:C:A
lavandulyl acetate	2.78	86.90	3.75	4.71	3.56	ns	-
4-terpineol	1.80	88.70	2.23	2.82	2.84	ns	-
borneol	1.76	90.46	4.74	4.51	4.90	ns	-
1-octen-3-yl acetate	1.26	91.72	1.49	2.22	0.91	ns	-
τ-cadinol	1.23	92.95	0.82	1.03	0.86	ns	-
α-terpineol	0.74	93.69	3.17	4.06	3.94	ns	-
isopulegol acetate	0.71	94.40	0.03	0.66	0.01	ns	-
(*E*)-caryophyllene	0.66	95.06	2.50	1.81	1.70	ns	-
(*Z*)-*γ*-bisabolene	0.57	95.63	1.29	1.21	0.79	ns	-
thujapsan-2-*α*-ol	0.51	96.14	1.19	0.80	0.50	ns	-
geranyl acetate	0.32	96.46	2.87	2.86	2.66	ns	-
trans-linalool oxide	0.32	96.78	1.44	1.87	1.83	ns	-
cis-linalool oxide	0.27	97.05	1.34	1.78	1.80	ns	-
β-bisabolene	0.19	97.24	0.36	0.00	0.00	ns	-
camphor	0.17	97.41	1.42	1.40	1.34	ns	-
cryptone	0.17	97.58	0.83	0.74	0.79	ns	-
isobornyl acetate	0.16	97.74	0.63	0.61	0.43	ns	-
(*E*)-*γ*-bisabolene	0.16	97.90	0.74	0.56	0.24	*	P:C versus P:C:A
(*Z*)-*α*-santalol	0.11	98.01	0.90	0.52	0.40	*	P:C versus P:A; P:C versus P:C:A

Stat. Sign.: Statistical significance: * $p < 0.05$; ns, not significant.

4. Conclusions

An overview on the influence of different cultivation substrates on *L. angustifolia* morphology as well as VOC and EO profiles was provided in this study. All morphological parameters evaluated were affected by substrate composition, except for spike length. Generally, plants performed better in terms of survival rate, compactness, number of spikes and flower yield when cultivated in the substrate with peat and compost, being the best out of the three substrates tested from an ornamental horticulture perspective. The VOC profile after cultivation in different substrates did not change, and it had never been studied before in lavender. Interestingly, the highest EO yield and amounts of linalool were obtained by cultivating plants in the mixture of peat, compost and demolition aggregates, even though plants had a lower survival rate. Thus, locally sourced materials, such as green compost or demolition aggregates, can be effectively used in the preparation of pot mixtures. In the cultivation of lavender, substrate composition can be regulated depending on the final use of the plant, whether as an ornamental or for cosmetic, industrial and medicinal purposes. This will help the environmental protection by reducing waste material and supporting recycling, together with reducing the use of peat in horticulture.

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