Agronomic and Technological Assessment of Oregano (*Origanum vulgare* ssp.) Biotypes

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Abstract

The market's interest in aromatic plants is growing dramatically, in particular for oregano, one of the most popular, which is traditionally used for many food preparations. Yet, great confusion about the correct taxonomic classification of oregano still remains due to the many species marketed under this name.

Most species, collected or cultivated to produce oregano, are characterised by a composition of essential oils rich in carvacrol, the component to which the characteristic taste and aroma of this spice is attributable. This work reports on studies focused on the morphological, chemical, and agronomic traits of some clones obtained from wild populations in different environments of southern Italy.

INTRODUCTION

The market's interest in aromatic plants is growing dramatically, not only for fresh consumption, but also for the new needs of agri-food sector. Oregano is among the most important of them, since it is largely used as a spice, condiment, and flavoring (Lawrence and Reynolds, 1984). The genus *Origanum* is characterised by a high variability of morphological and technological traits which has resulted in confusion in the correct taxonomic identification of oregano, due to the many species marketed under this name, and the opportunity to select, according to the final use of the product, the peculiarities characterizing different species and within each species, the different wild biotypes (Bernath, 1997).

The purpose of this work is to test the morphological, chemical and agronomic traits of the collected accessions with a view to contribute to their assessment and characterisation, targeted to the present and new prospective uses.

MATERIALS AND METHODS

Plant Material

Twenty-three biotypes belonging to the genus *Origanum*, selected from wild populations in different locations of southern Italy (Apulia, Basilicata and Calabria) (Table 1) have been collected since 1998.

Experimental Design

The germplasm is kept in a collection field at the Agricultural Faculty of Bari (Italy). The field was fertilized with 120 kg ha^{-1} N, 100 kg ha^{-1} P_2O_5, 100 K_2O kg ha^{-1}. The experimental design was a randomised complete-block design with three replications. The planting distance was 0.75 m between rows and 0.35 m within rows.

Harvest and Processing

The herb of the experimental material was harvested in the early flowering stage (20% of opened flowers). Shortly before harvest the date of flowering and the plant height were recorded. The material to be harvested was cut for each single plant at 10 cm above the ground to ensure the re-growth. Plant samples were tested for morphological traits, based on the indications provided by Ietswaart (1980). Measurements included the number of glandular hairs on the leaves, the indumentum of stems and leaves, and the color and shape of corolla that are considered as very influential for the characterisation

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of different botanical forms of oregano (Kokkini et al.1991, Tucker and Maciarella, 1994).

The measurement of the number of glandular hairs per cm^2 was made on the upper blade of six leaves taken from the fourth node starting from the first inflorescence; images were taken by a stereo-microscope equipped with a video camera and analysed, after an appropriate calibration using an image analysis program (Scion image).

At harvest samples of 20 leaves per plant were taken for the determination of the mean leaf area, whereas the fresh biomass for each single plant was weighed and oven-dried at 35 °C. Leaves and flowers were then separated from the stems, and single samples of leaves-flowers and stems (10 g for each) were oven-dried at 105 °C for the dry matter content determination.

Content of Essential Oil

A 5 g air-dried leaf-flower fraction of each single plant was submitted to water distillation in a Clevenger type-apparatus with a flask of 500 ml and 200 ml water for 60 minutes.

Composition of Essential Oil

The distilled essential oil was analysed using gas chromatography/mass spectrometry on a HP 6890 coupled with a HP 5972 MSD and fitted with a HP 30 m x 0.25 mm capillary column coated with HP-5MS (0.25 μm film thickness). Analytical conditions were: helium as carrier gas, injector temperature 250 °C, split ratio 50:1, temperature program 60-110 °C with 2 °C/min rise and 110-220 °C with 10 °C/min rise. The analysed components were then identified by the system HP Enhanced ChemStation G1701BA Version B.00.00 (Hewlett Packard) by comparing their mass spectra with the data in the literature (John Wiley & Sons) and confirmed by their gas chromatographic retention indices (Adams, 1995).

Statistical Analysis

The percentage concentrations of the components in the different oils were used as matrix elements to perform the hierarchical cluster analysis. All PC analyses were carried out using SAS software (SAS Institute Inc., Cary, NC) procedures.

RESULTS

Morphological Traits

Within the tested biotypes the colour of the corollas was mostly white with some light pink shades (accessions 2, 7, 11, 15 and 20); the unique exception was accession 12 with pink flower (Table1). The shape of corolla varied from the campanulate in accessions 2, 3, 5, 10, 12, 14, 15, 17, 18, 20 and 21, to tubular in the rest. Biotype 16 revealed a pilose indumentum; the latter was hirsute in accessions 1 and 2, and glabrous in the majority of cases. The number of sessile glands per cm^2 was over 1000 for most accessions; only in three of them (1, 4 and 9) it was over 2000 per cm^2 ; the rest had a density below 1000 (Fig. 1).

Composition of Essential Oils

The gas-chromatography of the essential oils of oregano accessions allowed the detection of 44 components with the predominance of carvacrol, thymol, γ-terpinene, linalyl acetate, germacrene D and cis-ocymene (Table 2). The phenolic compounds, carvacrol and thymol, detected in different accessions, revealed a high variability in concentration. Carvacrol ranged between 0.18 and 66.74 %, thymol from 0.20 to 43.68 %. Linalyl acetate was detected only in accessions 13, 14 and 15 with values ranging between 51.27 and 60.93 %, thus outlining a new oregano chemotype.

Through the cluster analysis four major groups were identified (Fig.2). The first group indicated the chemotype rich in linalyl acetate (accessions 13, 14 and 15) coming

from different sites in the Pollino area in Lucania; the subsequent group, including accessions 12 and 22, does not allow a clear detection of a specific chemotype, since there is a predominance of the precursors of the two monoterpenic phenols (thymol/carvacrol), notably γ-terpinene. The third group that is the most numerous, represents totally the chemotype with thymol/γ- terpinene with so high variations in the percent content of thymol (11.03 – 43.68%) as to identify high thymol and low thymol types. The last group, instead, includes accessions 1, 4 and 9, and defines distinctly the carvacrol chemotype (with 66.68, 66.74 and 66.15 %, respectively).

Agronomic Assessment

Among the tested parameters the flowering time is an agronomically-relevant element. In particular, the tested biotypes exhibited a prevailing uniformity in flowering time (end-May) (Table3). Unique exceptions were the early accessions 7 and 15 with flowering occurring two weeks before and the late accession 4 with a flowering delay of 7-13 days. Most tested accessions are characterised by a plant height exceeding 60 cm, with a peak of 96.4 cm in accession 2. A low size characterises accession 14 (37.7 cm), whereas a medium size, around 50 cm, is typical of accessions 5 and 7. The dry biomass produced per plant ranged between 50.0 and 329.4 g. An interesting yield potential was expressed by accessions 3, 8 and 9 where the average weights of the dry biomass were 329.4, 314.0 and 294.0 g, respectively. The assessment of biotypes in terms of leaf-flower fraction yield shows some variability with values ranging from 45 to about 73 %.

It is noteworthy that in the biotypes with a higher biomass potential, the leaf-flower fraction yield exceeded 60 % in a single case, whereas in most of them it was below this value. On the other hand, values over 70 % were observed in biotypes with lower yields. As to the leaf area, accessions 5, 6, 8, 9, 16, 17 and 18 could be defined as "large-leaved" types, with an average leaf area over 3.00 cm^2. Accession 23, instead, could be defined as "small-leaved" type with an average leaf area of about 1.00 cm^2, whereas in most cases the leaf size was in the 1.00-3.00 cm^2 range. The essential oil content ranged from 0.50 to 5.10 %. Accessions 4, 9 and 11 showed the highest values; 5.10, 4.30 and 3.75 %, respectively.

CONCLUSION

The results obtained showed the essential need for an approach able to integrate the traditional agronomic and technological parameters aiming at a better use and enhancement of the oregano biotypes collected in some southern Italy environments.

The predominance of a single component of essential oils should be considered a major parameter to orient the choices on the growing of oregano types, which have aroma characteristics induced by different volatile components, specifically demanded by the market. In this connection it seems that the material under study currently includes different samples of aroma types, those rich in carvacrol, basically the most largely demanded on the market, the types with thymol/γ-terpinene, a new type with linalyl acetate, which is appreciated in the typical spreading area, but for which a sensory analysis should be conducted on diverse populations and eventually for other uses than as condiment. The predominance of this component, indeed, characterises to a large extent the Pollino oregano giving it an intensive and particularly sweetish aroma, so as to make it hardly comparable to the classical oregano aroma.

Based on the data obtained in terms of oil content, half of the accessions being tested are attributable to biotypes "poor" in essential oils, the other half, to the "rich" ones that are more suitable for the production of essential oils. Another relevant trait not only agronomically speaking is the leaf area, considering both the incidence on the leaf-flower fraction yield and the different assessment of the leaf size for products intended for fresh or frozen consumption. Another equally interesting trait in the marketing of the most traditional product, harvested in bunches at flowering, besides aroma, is the colour of the corolla where the occurrence of some pinkly flowers seems more appreciated by consumers, as it would reflect a greater naturalness of the product.

Based on the collected information, it would be possible to define a kind of explanatory note of the different effective characteristics for the assessment of the most appropriate combinations according to the final intended use of the product.
The extension of the investigation to a higher number of individuals, based on the large genetic basis of the genus *Origanum* and an integration with sensory assessments will enable selection and standardization of specific traits for different types of use of oregano.

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Tables

Table 1. Morphological characters of oregano biotypes.

Accessions	Origin	Corollas		Indumentum stem and leaves	Glands (cm^{-2})
		color	shape		
1	Bitonto (Ba)	white	tubular	irsute	741
2	Carovigno (Br)	light pink	campanulate	irsute	509
3	Castellaneta (Ta)	white	campanulate	glabrous	394
4	Policoro (Mt)	white	tubular	glabrous	580
5	Murgia A (Ba)	white	campanulate	glabrous	368
6	Casarano (Le)	white	tubular	glabrous	379
7	Locorotondo (Ba)	light pink	tubular	glabrous	327
8	Valenzano (Ba)	white	tubular	glabrous	214
9	Varano (Fg)	white	tubular	glabrous	734
10	Modugno A (Ba)	white	campanulate	glabrous	351
11	Modugno B (Ba)	light pink	tubular	glabrous	370
12	Modugno C (Ba)	pink	campanulate	pilose	385
13	Pollino A (Pz)	white	tubular	glabrous	405
14	Pollino D (Pz)	white	campanulate	glabrous	287
15	Pollino G (Pz)	light pink	campanulate	glabrous	207
16	Spinazzola (Ba)	white	tubular	glabrous	297
17	Murgia B (Ba)	white	campanulate	glabrous	277
18	Murgia C (Ba)	white	campanulate	glabrous	275
19	Putignano (Ba)	white	tubular	glabrous	470
20	Ostuni (Br)	light pink	campanulate	glabrous	306
21	Ceglie Messapica (Br)	white	campanulate	glabrous	425
22	Montemoro (Vv)	white	campanulate	glabrous	368
23	Catanzaro (Cz)	white	campanulate	glabrous	497

Table 2. Agronomical characters related to major volatile oil constituents of oregano biotypes, Italy.

Bio-types	Early flowering (dd)*	Plant height (cm)	Biomass (g plant^{-1})	Leaf-flower yield (%)	Leaf area (cm^2 leaf^{-1})	Essential oil content (% v/w)	Major volatile oil constituents
1	149	78.5 ± 4.3	255.0 ± 18.2	66.7	2.24 ± 0.66	2.65 ± 0.21	carvacrol
4	156	72.1 ± 4.4	162.0 ± 15.1	60.3	2.46 ± 0.65	5.10 ± 0.09	carvacrol
9	149	79.5 ± 6.0	329.4 ± 31.5	59.5	3.53 ± 0.84	4.30 ± 0.18	carvacrol
22	149	51.3 ± 3.1	80.5 ± 2.9	73.1	1.02 ± 0.29	1.00 ± 0.19	g-terpinene
12	143	65.3 ± 4.4	232.0 ± 16.2	45.1	1.60 ± 0.58	1.00 ± 0.06	g-terpinene
15	133	63,2 ± 5,9	85.0 ± 3.7	68.0	2.65 ± 0.52	1.95 ± 0.21	linalyl acetate
14	143	37.7 ± 5.4	77.0 ± 3.5	62.9	2.16 ± 0.49	2.15 ± 0.14	linalyl acetate
13	143	78.0 ± 4.1	178.0 ± 11.8	57.2	2.01 ± 0.44	1.95 ± 0.11	linalyl acetate
23	149	64.2 ± 7.8	130.2 ± 3.6	72.0	1.01 ± 0.17	2.30 ± 0.24	thymol/γ-terpinene
5	149	50.8 ± 5.0	79.0 ± 10.3	62.8	3.18 ± 0.72	1.50 ± 0.11	thymol/γ-terpinene
10	143	70.8 ± 1.8	233.0 ± 35.0	62.2	1.82 ± 0.27	1.90 ± 0.21	thymol/γ-terpinene
17	143	62.2 ± 2.4	77.6 ± 1.1	59.9	3.71 ± 0.49	1.15 ± 0.12	thymol/γ-terpinene
18	149	69.4 ± 4.1	203.0 ± 8.7	59.7	3.27 ± 0.61	1.90 ± 0.15	thymol/γ-terpinene
21	149	73.4 ± 3.9	209.0 ± 13.0	58.8	2.65 ± 0.62	2.05 ± 0.07	thymol/γ-terpinene
7	133	57.1 ± 4.2	80.0 ± 5.4	58.5	1.88 ± 0.38	0.50 ± 0.07	thymol/γ-terpinene
11	143	70.6 ± 3.5	219.0 ± 19.1	57.2	2.22 ± 0.62	3.75 ± 0.04	thymol/γ-terpinene
16	143	61.9 ± 4.0	50.0 ± 2.1	55.9	3.35 ± 0.51	0.50 ± 0.08	thymol/γ-terpinene
3	143	71.4 ± 3.1	294.0 ± 35.0	54.8	2.12 ± 0.25	2.30 ± 0.24	thymol/γ-terpinene
6	149	88.3 ± 2.5	259.3 ± 23.4	54.6	3.01 ± 0.74	2.58 ± 0.13	thymol/γ-terpinene
8	149	76.3 ± 3.7	314.0 ± 14.3	52.7	3.63 ± 0.90	1.05 ± 0.10	thymol/γ-terpinene
19	149	76.5 ± 6.4	141.0 ± 9.7	51.8	1.66 ± 0.32	2.23 ± 0.08	thymol/γ-terpinene
2	149	96.4 ± 2.3	204.0 ± 30.7	48.7	2.11 ± 0.36	1.75 ± 0.12	thymol/γ-terpinene
20	149	67.7 ± 3.3	269.0 ± 19.6	47.8	2.97 ± 0.32	1.28 ± 0.13	thymol/γ-terpinene
* days from 1 january 2002							

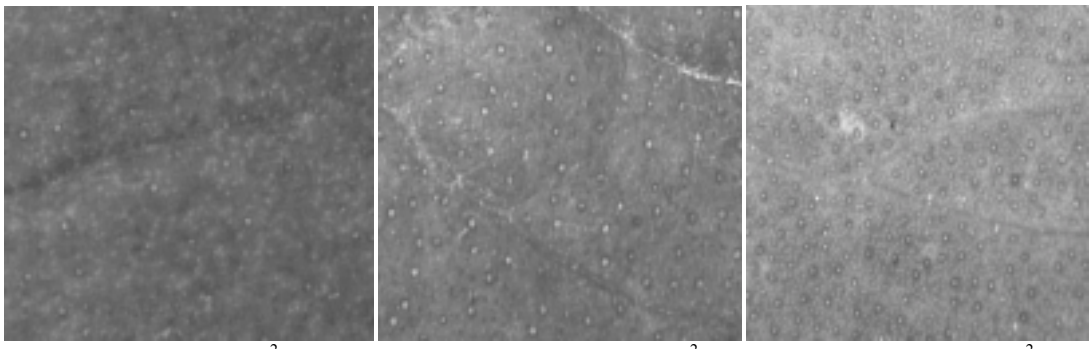
Table 3. Essential oil quali-quantitative component (% v/v) in the 23 oregano biotypes.

Components	RT	1	2	3	4	5	6	7	8	9	10	11	12
α-thujene	12.93	0.91	1.09	0.44	0.89	0.90	0.83	0.66	0.90	0.92	0.86	0.84	0.57
α-pinene	13.24	0.46	0.53	-	0.46	0.49	-	-	-	0.45	0.51	0.47	-
camphene	14.00	0.09	-	-	0.16	-	-	-	-	0.09	-	0.33	-
sabinene	15.42	0.1	6.4	2.42	0.1	-	-	-	-	0.11	-	-	-
octen - 3 - ol	16.08	-	-	-	0.4	-	-	-	-	0.68	-	0.4	0.96
myrcene	16.41	1.3	1.58	0.86	1.53	1.49	1.6	1.36	1.17	1.45	1.46	1.35	1.58
α – phellandrene	17.03	0.22	-	-	0.22	-	-	-	-	0.16	-	0.2	-
d – 3 – carene	17.31	-	-	-	-	-	-	-	-	0.06	-	-	-
α – terpinene	17.67	0.98	1.77	0.7	1.07	1.63	1.4	1.07	1.97	1.08	1.18	1.47	1.26
o – cimene	18.14	3.2	6.17	2.15	4.68	5.57	3.58	3.01	3.31	2.3	6.79	4.94	2.37
β – phellandrene	18.32	0.32	0.97	0.27	0.3	0.64	-	-	-	0.24	0.5	0.46	-
1,8 cineolo	18.45	-	1.18	-	-	-	-	-	-	-	-	-	-
cis – ocimene	18.90	1.48	3.48	1.56	-	3.19	4.78	3.87	2.1	0.15	5.58	3.91	13.04
trans - β - ocimene	19.44	0.16	3.31	1.12	-	-	0.6	0.55	-	-	0.56	0.41	3.09
γ - terpinene	19.91	8.93	24.69	11.61	11.31	21.69	21.57	18.53	25.69	9.78	11.9	13.48	24.25
cis - sabinene hydrate	20.46	0.29	-	-	-	0.67	-	-	-	0.31	0.81	0.33	-
trans linalool oxide	21.55	-	-	-	-	-	-	-	-	-	-	-	-
linalool	22.17	0.06	2	0.86	0.05	0.75	2.57	2.41	0.77	0.53	-	0.2	2.92
octen - 3 - yl - acetate	22.75	0.24	0.66	-	0.38	-	-	-	-	-	-	-	-
neo allo ocimene	23.56	-	-	-	-	-	-	-	-	-	0.38	0.18	0.75
borneol	25.49	-	-	-	-	-	-	-	-	0.28	-	0.92	-
terpinene - 4 - ol	26.00	0.2	-	-	0.21	-	-	-	-	0.21	-	0.16	-
α - terpineol	26.71	-	-	-	-	-	-	-	-	-	-	-	2.28
thymol methyl ether	28.69	-	1.31	2.43	-	9.39	4.97	3.88	2.84	-	1.5	0.47	-
carvacrol methyl ether	29.12	0.24	1.29	1.06	-	2.33	2.06	1.75	1.92	0.75	-	2.09	-
trans sabinene hydrate	29.51	0.33	-	-	0.97	-	-	-	-	-	-	-	-
linalyl acetate	29.59	-	6.97	-	-	-	-	-	-	0.06	-	-	-
thymol	31.79	0.27	11.03	13.19	0.2	18.36	18.63	15.89	22.47	0.2	38.16	43.68	3.88
carvacrol	32.26	66.15	-	2.69	66.74	0.2	1.38	0.39	0.18	66.68	4.01	1.1	-
δ – elemene	33.20	0.24	-	-	0.26	-	-	-	-	0.65	-	-	0.62
3,4 dihydro coumarin	34.92	-	-	-	0.16	-	-	-	-	0.86	-	-	-
β – buorbonene	35.30	-	-	-	-	0.29	0.38	0.36	-	0.05	-	0.14	0.81
β – caryophyllene	36.78	2.81	2.8	1.34	3.08	3.41	7.27	6.37	2.52	2.78	2.9	0.77	9.77
aromadendrene	37.61	0.21	-	-	-	-	-	-	-	0.11	-	-	-
α – humulene	38.21	0.37	-	0.27	0.33	0.57	-	-	-	0.45	0.59	0.18	1.1
allo aromadendrene	38.51	-	-	0.28	-	-	0.62	0.53	-	-	0.48	-	-
germacrene D	39.34	0.23	2.58	0.94	0.48	5.86	5.75	4.77	3.86	0.95	2.11	3.36	12.85
germacrene A	39.99	0.94	1.79	0.78	0.21	0.47	1.42	1.26	1	0.56	1.37	0.78	5.03
β – bisabolene	40.41	0.25	0.2	0.69	0.85	1.6	-	-	1.15	3.49	0.6	0.71	0.55
γ – cadinene	40.70	-	-	-	-	-	-	-	-	-	-	0.24	-
δ – cadinene	41.05	-	-	-	0.15	-	-	-	-	0.28	0.25	0.39	-
germacrene D – 4 – ol	43.16	-	-	1.9	-	1.18	4.58	-	-	-	2.25	0.22	2.38
sphathulenol	43.27		-	-	-	-	-	-	-	-	-	-	-
caryophyllene oxide	43.44	0.11	-	-	0.21	-	-	4.73	1.64	-	-	-	-

Table 4. Essential oil quali-quantitative component (% v/v) in the 23 oregano biotypes.

Components	RT	13	14	15	16	17	18	19	20	21	22	23
α-thujene	12.93	-	-	-	0.70	0.84	0.64	0.82	1.07	0.95	-	0.68
α-pinene	13.24	-	-	-	0.61	-	0.28	0.40	0.43	0.42	-	0.58
camphene	14.00	-	-	-	0.93	-	-	-	-	-	-	-
sabinene	15.42	5.02	-	-	-	-	-	-	-	-	33.28	-
octen - 3 - ol	16.08	-	-	-	-	0.8	-	0.85	-	-	1.34	-
myrcene	16.41	0.47	0.96	0.53	1	2.11	1.92	1.58	1.88	1.49	1.19	1.06
α – phellandrene	17.03	-	-	-	-	-	-	-	-	-	-	-
d – 3 – carene	17.31	-	-	-	-	-	-	-	-	-	-	-
α – terpinene	17.67	-	-	-	0.74	1.37	1.72	1.57	1.79	1.82	-	0.62
o – cimene	18.14	-	-	-	3.1	3.52	2.83	6.44	3.92	2.43	-	13.41
β – phellandrene	18.32	-	-	-	-	-	0.4	0.59	0.51	-	0.98	-
1,8 cineolo	18.45	0.46	-	-	-	-	-	-	-	-	-	-
cis – ocimene	18.90	1.98	13.68	7.7	5.88	3.83	5.96	2.33	5.07	4.51	6.3	2.29
trans - β - ocimene	19.44	2.76	2.69	1.48	0.65	-	0.57	0.52	0.52	0.54	1.34	-
γ - terpinene	19.91	-	-	1.6	6.96	16.1	25.7	19.71	25.9	22.49	-	12.99
cis - sabinene hydrate	20.46	-	-	-	-	-	-	-	-	-	-	-
trans linalool oxide	21.55	-	-	-	-	-	0.33	-	-	-	-	-
linalool	22.17	1.51	1.15	1.92	-	11.81	7.55	0.84	-	6.96	-	1.21
octen - 3 - yl - acetate	22.75	0.86	2.75	1.1	-	-	-	-	-	-	-	-
neo allo ocimene	23.56	-	0.87	0.55	-	-	0.36	-	0.36	-	-	-
borneol	25.49	-	-	-	1.81	-	-	-	-	-	-	-
terpinene - 4 - ol	26.00	-	-	-	-	-	-	-	-	-	-	-
α - terpineol	26.71	0.41	-	-	-	-	-	-	-	-	-	-
thymol methyl ether	28.69	-	-	-	5.3	1.81	1.07	5.39	2.86	7.64	-	8.27
carvacrol methyl ether	29.12	-	-	-	2.9	2.54	1.31	2.9	2.58	2.35	-	2.13
trans sabinene hydrate	29.51	-	-	-	-	-	-	-	-	-	-	-
linalyl acetate	29.59	0.93	51.27	5.3	-	-	-	-	-	-	-	-
thymol	31.79	-	-	-	28.56	33.64	15.7	30.24	29.15	24.17	-	15.67
carvacrol	32.26	-	-	-	1.28	2.22	1.18	1.62	-	-	-	1.65
δ – elemene	33.20	-	-	0.43	-	-	0.64	-	-	-	-	-
3,4 dihydro coumarin	34.92	-	-	-	-	-	-	-	-	-	-	-
β – buorbonene	35.30	0.45	0.45	0.5	0.36	-	0.26	0.28	-	-	2.67	0.5
β – caryophyllene	36.78	3.73	3.16	4.65	4.65	1.57	2.41	4.97	3.59	3.02	21.59	3.54
aromadendrene	37.61	-	-	-	-	-	-	-	-	-	-	-
α – humulene	38.21	0.56	-	0.78	0.81	-	0.24	0.81	0.59	0.55	1.58	0.6
allo aromadendrene	38.51	0.47	-	-	-	-	0.34	0.42	0.28	-	-	0.26
germacrene D	39.34	5.39	5.88	4.37	4.58	5.92	10.13	5.6	4.15	5.33	12.52	2.57
germacrene A	39.99	0.62	1.59	2.84	1.57	1.19	4.84	0.79	1.41	0.74	2.39	0.88
β – bisabolene	40.41	-	-	2.44	1.25	0.95	0.33	0.8	1.87	1.28	-	2.22
γ – cadinene	40.70	-	-	-	-	-	-	-	-	-	-	-
δ – cadinene	41.05	-	-	-	-	-	-	0.23	0.37	-	-	-
germacrene D – 4 – ol	43.16	6.28	1.92	4.7	-	2.26	1.2	2.49	2.75	0.62	4.53	-
sphathulenol	43.27	-	-	-	-	-	0.27	-	-	-	-	-
caryophyllene oxide	43.44	-	-	0.37	1.42	-	-	-	-	-	0.99	0.

Figures



20 –Ostuni (825 glands cm^{-2}) 13 – Pollino A (1216 glands cm^{-2}) 9 – Varano (2202 glands cm^{-2})

Fig. 1. Oregano leaves with different number of glands per cm^2.

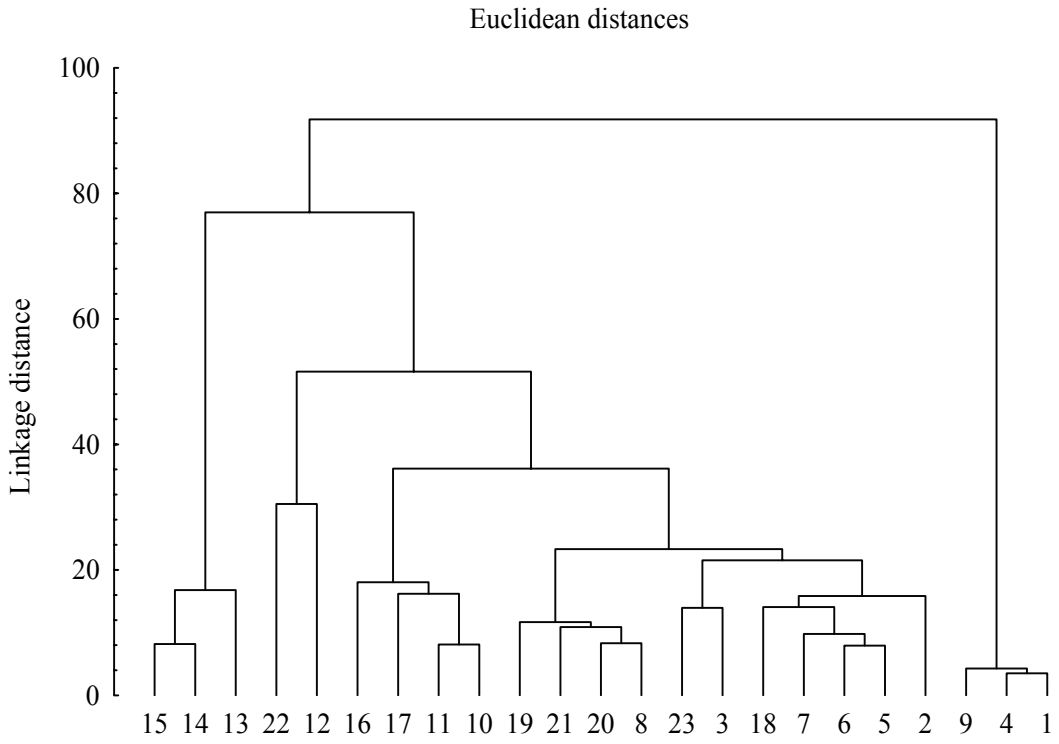


Fig. 2. Cluster analysis of GC essential oils data.