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MORE SUSTAINABILITY IN AGRICULTURE: NEW FERTILIZERS AND FERTILIZATION MANAGEMENT

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EFFECTS OF ORGANIC AND CONVENTIONAL N-FERTILIZATION ON QUALITY TRAITS IN CORIANDER (*CORIANDRUM SATIVUM* L.)

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Abstract

In organic cropping management of Medicinal and Aromatic Plants, the best quality expression is crucial to gain satisfactory incomes. Coriander (*Coriandrum sativum* L.) is an annual herbaceous plant with a commercial value due to the typical scent of its fruits (commonly termed "seeds"), rich in a pale yellow oil (1-2% in small-sized types, 0.2-0.5% in large-sized ones). Several studies have been done for determining the composition of volatile fraction of Coriander, which was found to vary also as a consequence of cropping techniques, including nitrogen fertilization. In order to gain useful information about the effects, if present at all, of organic N fertilization on Coriander quality in terms of volatiles composition pattern, a three-year trial (2004-2006) was carried out using different types and rates of organic and conventional N fertilizers. Volatile composition of fruits was obtained by means of GC-MS and data were evaluated by multivariate statistical analysis. The most representative compound are linalool, followed by camphor, geranyl acetate and geraniol. The group partition was mainly due to different quantitative ratio of compounds; the differences in volatile composition, however, followed a scheme more resembling the cropping year than the fertilization management.

Keywords: Coriander, N fertilizers, seed composition, volatile compounds.

Introduction

Coriander *(Coriandrum sativum* L.) is an annual herbaceous plant belonging to the *Apiaceae* family, with a good commercial value due to the typical scent of its fruits, rich in a pale yellow oil (1-2% in small-sized types, 0.2-0.5% in large-sized ones) (Catizone *et al.*, 1986).

The diffusion of Coriander into the Mediterranean cropping systems still needs the pointing out of many aspects; one of the most relevant is the fertilization, above all with nitrogen (Carrubba, 2009). N fertilization, as a matter of fact, is claimed to exert on most crop an evident and fast effect, generally promoting growth and increasing plants biomass. Coriander has been targeted by many studies concerning the effects of N fertilization on quantitative aspects of yield; limited information is available, however, as concerns the response of coriander to such practice from the point of view of seed composition (Carrubba and Ascolillo, 2009).

In order to gain useful information about the effects, if present at all, of N fertilization on Coriander quality, the volatiles composition pattern was studied over a three-year trial (2004-2006) by considering different types and rates of N fertilizers, both organic and conventional.

Materials and methods

The trial was carried out from 2004 to 2006 in the experimental farm "Sparacia" (Cammarata - AG 37° 38' N – 13° 46' E; 415 m a.s.l.), in a representative area of the Mediterranean semi-arid environments. The treatments considered were three organic and two organo-mineral NP fertilizers, compared with three rates and application time of a chemical N-fertilizer and one untreated control (table 1).

Treatments were laid out according to randomized complete block design with three replications. Sowing was performed by hand on January 17^{th} 2004, January 19^{th} 2005 and January 14^{th} 2006, distributing seeds of a small-sized Coriander biotype *(Coriandrum sativum* L. subsp. *microcarpum)* on continuous rows 50 cm apart, obtaining a plant population of 40 plants m^{-2}. Climatic parameters (temperatures and rainfall; fig.1) were measured during the period by means of a weather station (CR 10, Campbell Sc., Oregon, USA).

The growth and development of the crop and its phytosanitary state were monitored throughout the trial. Top-dressed N fertilizers were applied as the crop was starting the fast stem elongation phase, i.e. between the middle of March and the first days of April.

The harvest was manually performed as the majority of seeds had reached the full ripening stage, and this occurred in the last ten-days of June. Thereafter, on representative samples of seeds for each treatment and repetition, volatile composition was obtained by means of GC-MS; all data were then submitted to statistical analysis, including ANOVA and MANOVA, by means of the package SAS v. 9.0 (SAS Institute Inc., Cary, NC, USA).

Results and Discussion

The evaluation of volatile composition of fruits allowed the recognition of 27 different compounds, among which monoterpenes (both hydrocarbons and oxygenated) were the most abundant (98-99%).

Figure 1: Sparacia (Cammarata - AG) - 2004-2006. Coriander (*Coriandrum sativum* L.). 10-day values of climatic parameters measured during the trial.

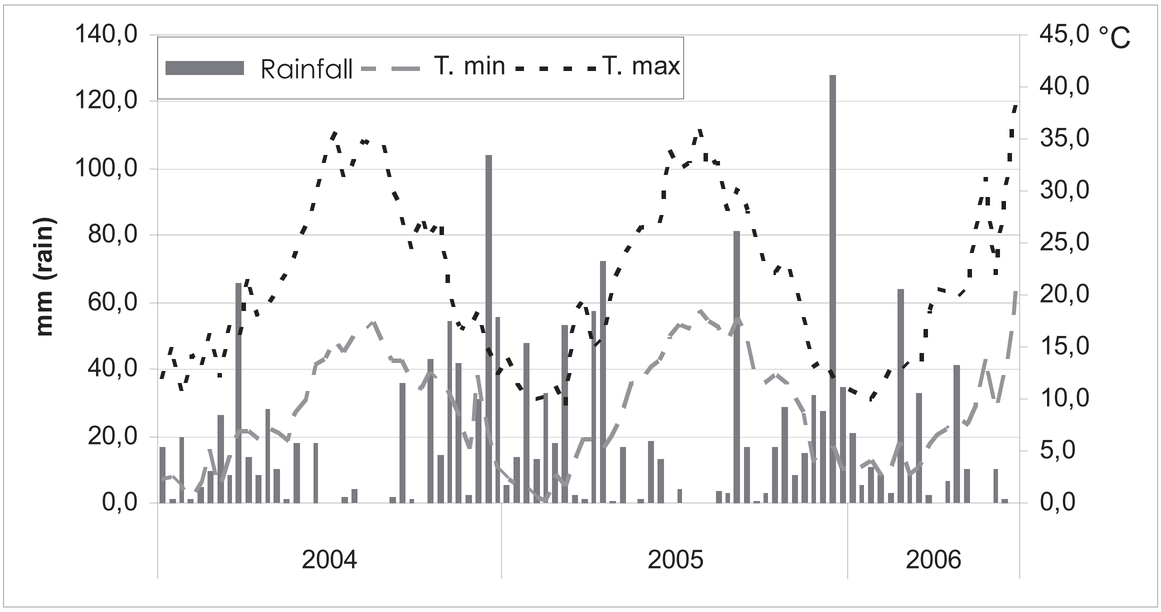

Table 1: Sparacia (Cammarata - AG) 2004-2006. Organic and chemical N-fertilization in Coriander. Treatments tested during the trial.

Treatment /Year	Total N (kg ha $^{-1}$)	N-fertilizer type	Distribution method	Name	Formulation	N content
C1 - 2004 to 2006	80	Inorganic	At sowing	Urea		46%
C2 - 2004 to 2006	80		½ at sowing, ½ top-dressed			
C3 - 2004 to 2006	120		2/3 at sowing, 1/3 top-dressed			
O1 - 2004-2005	80	Organic	At sowing	Natural N8	Pellets	Total N 8.0% (organic 8%)
O2 – 2004- 2005	80			Biagrin	Liquid (solution-sospension)	Total N 5.0% (organic 1%)
O4 - 2006	80			Xena N12	Pellets	Total N 12.0% (organic 12%)
O3 - 2004 to 2006	80	Organo mineral NP		Xena Starter	Pellets	Total N 7.0% (organic 7%)
O5 - 2006	80			Geco Natura	Compost	Total N 5.0% (organic 5%)
T – 2004 to 2006	Non fertilized control					

Oxygenated compounds were the primary group, showing an average content of about 77%, and two of the major compounds, linalool (66.7%) and geranyl acetate (3.4%) belong to this group. The other two dominant compounds, namely γ-terpinene (7.4%) and α-pinene (7.1%), belong to monoterpene hydrocarbons. Other substances, belonging anyway to the monoterpenes, were found in lower quantities: camphor (4%), limonene (2%) and geraniol (2%). A preliminary ANOVA performed on data reported in table 2 allowed us to state that the factor "year", and therefore climatic variability, was the major determinant in assessing the differences of the volatile composition.

Table 2: Sparacia (Cammarata - AG) – 2004-06. Results of ANOVA for some volatiles detected in seeds (SV: source of variability; DF: degrees of freedom; Y: year; T: treatment).

SV	DF	Thujone	α-pinene	Camphor	Limonene	β-pinene	Myrcene	p-cymene	γ-terpinene	Terpinolene	Linalool	Geranyl acetate
Y	2	***	*	**	**	***	*	***	*	***	**	*
T	6	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
total	20											

Significance of difference: *: P≤ 0.05; **: P≤ 0.01; ***: P≤ 0.001; n.s.: not significant

Table 3: Sparacia (Cammarata - AG) - 2004-2006 – Mean values (%) of major volatiles detected in Coriander (*Coriandrum sativum* L.) seeds under different N fertilization managements (n=21). Each value is the average of 3 replicates. Data arranged into the clusters obtained through CA. Variables with dark heading were the most significant for clustering.

Cluster	Treatment	Year	α-pinene	Camphor	Limonene	Geraniol	β-pinene	Myrcene	γ-terpinene	Linalool	Geranyl-acetate
Result of F Test			41,71 **	8,11 n.s.	35,34 **	1,67 n.s.	81,15 ***	46,98 **	10,26 *	99,20 ***	6,39 *
1	C1	200304	7,14	4,04	2,29	2,28	0,63	1,08	7,37	65,73	3,67
	C2	200304	7,60	4,06	2,32	2,24	0,63	1,11	7,47	65,74	3,78
	C3	200304	7,03	4,07	2,29	2,39	0,60	1,08	7,32	66,22	3,63
	O1	200304	7,11	4,25	2,29	2,29	0,58	1,08	6,36	66,14	3,61
	T	200304	7,84	4,11	2,33	2,27	0,64	1,11	7,66	64,73	3,56
	O2	200304	7,66	4,15	2,38	2,22	0,61	1,11	8,09	64,76	3,52
	O3	200304	7,27	4,26	2,38	2,36	0,59	1,10	7,70	65,33	3,48
	C1	200405	7,51	4,14	2,37	2,36	0,58	1,09	7,73	66,00	3,34
	C2	200405	7,71	4,14	2,42	2,38	0,59	1,12	8,08	65,59	3,21
	C3	200405	8,26	4,09	2,53	2,20	0,63	1,18	7,91	64,63	3,53
	O1	200405	7,07	4,19	2,38	2,44	0,55	1,09	7,71	66,23	3,29
	O2	200405	7,26	4,11	2,33	2,37	0,57	1,08	7,81	66,43	3,22
	O3	200405	8,09	4,1	2,47	2,30	0,60	1,14	8,04	64,99	3,38
	Average		**7,50**	**4,13**	**2,37**	**2,32**	**0,60**	**1,11**	**7,63**	**65,58**	**3,48**
2	T	200405	6,67	4,19	2,28	2,41	0,53	1,03	7,54	67,29	3,15
	C1	200506	7,00	3,96	2,18	2,27	0,52	1,07	7,55	67,57	3,42
	C2	200506	6,68	3,87	2,09	2,31	0,50	1,01	7,24	67,99	3,39
	C3	200506	7,09	4,02	2,23	2,35	0,53	1,07	7,43	67,04	3,35
	T	200506	6,58	3,54	1,93	1,93	0,52	0,95	7,19	68,10	3,74
	O2	200506	7,03	4,04	2,20	2,31	0,51	1,05	7,33	67,35	3,40
	Average		**6,84**	**3,94**	**2,15**	**2,26**	**0,52**	**1,03**	**7,38**	**67,56**	**3,41**
3	O1	200506	5,25	3,9	1,19	2,48	0,41	0,89	6,34	71,09	3,09
	O3	200506	5,04	3,7	1,74	2,37	0,39	0,83	6,31	71,59	2,89
	Average		**5,15**	**3,80**	**1,47**	**2,43**	**0,40**	**0,86**	**6,33**	**71,34**	**2,99**
			Signif. Cluster analysis								

In order to have a deeper insight on the effects of tested factors on the volatile composition of seeds, a multivariate statistical analysis was performed, including Cluster Analysis (CA) and

Principal Components Analysis (PCA). The tree diagram reported in fig. 2 shows the composition of the groups obtained through CA. Such analysis originated three clusters, whose main characteristics are reported in table 3, where partitioning is mainly linked to a difference in the relative amounts of linalool, γ- terpinene, geranyl acetate and α- pinene. The ANOVA performed on clustered data confirmed such observation.

The scatter diagram plotted against the two main PCAs (fig. 3) confirms that the differences of volatile composition follow a scheme more resembling the cropping year than the fertilization management. In detail, the analysis of volatiles has shown in the first two years similar mean values of the monoterpene content, both for those belonging to the chemical class of hydrocarbons (22% approx.) and for the oxygenated ones (about 76.5 %). The seed samples obtained in the third trial year (2005-06) showed, oppositely, a reduction in monoterpene hydrocarbons (about 20%) and an higher amount of oxygenated ones (about 79%). No definite effect was identified on seeds volatile composition, that in our experiment showed to be rather unaffected by the type and rate of N fertilizer.

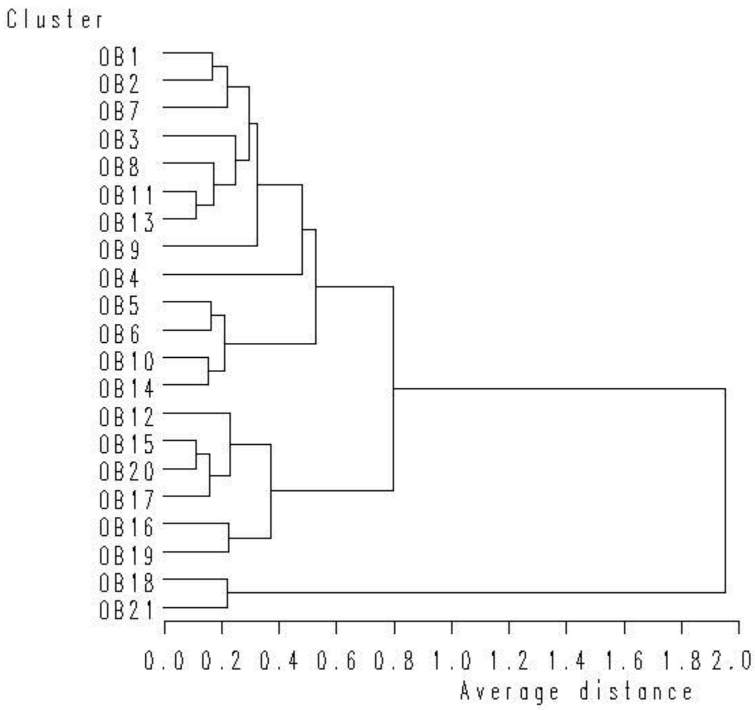

Figure 2: Sparacia (Cammarata-AG) - 2004-2006 - Tree diagram for analytical data of Coriander (*Coriandrum sativum* L.) seeds under different N fertilization managements (n=21).

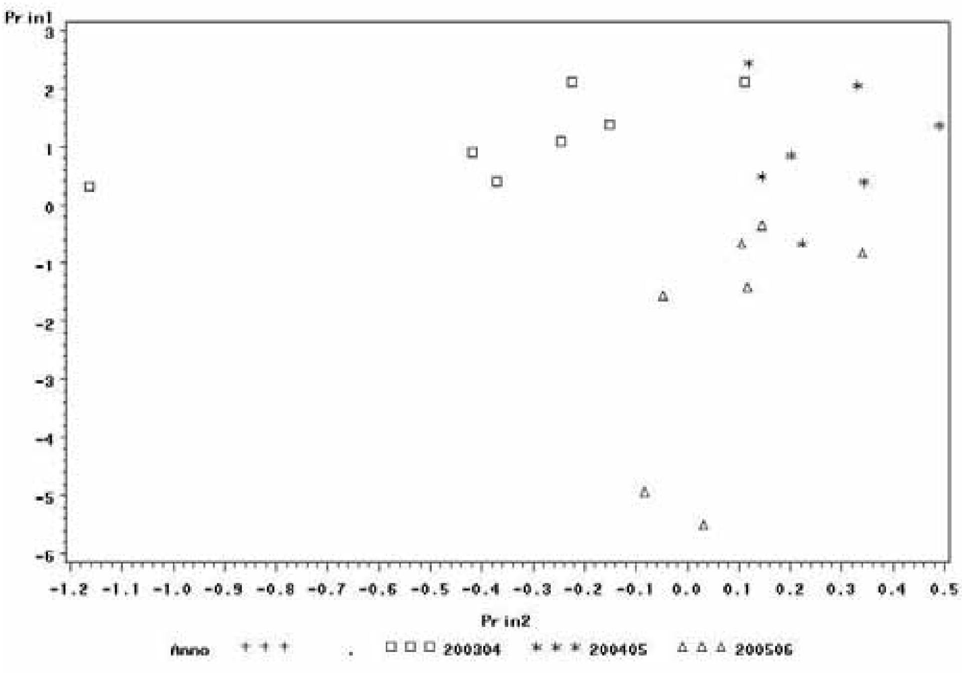

Figure 3: Sparacia (Cammarata - AG) - 2004-2006 - Scatter diagram for analytical data of Coriander *(Coriandrum sativum* L.) seeds under different N fertilization managements (n=21). Each value is the mean of 3 replicates.

<u>**References**</u>

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