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MORE SUSTAINABILITY IN AGRICULTURE: NEW FERTILIZERS AND FERTILIZATION MANAGEMENT

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N USE AND PARTITIONING IN CORIANDER (*CORIANDRUM SATIVUM* L.) AFTER ORGANIC AND CONVENTIONAL N FERTILIZATION

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Abstract

In coriander, a well known spice herb, many studies concerning the effect of N fertilization have been conducted in special areas where the cultivation of such plant has a major importance, such as India. Limited information is available as concerns the response of coriander to N fertilization under Mediterranean climatic conditions, above all when organic N fertilizers (mandatory when organic cropping management is chosen) are used. This work refers about some observations realised from 2004 to 2006 by an experiment on organic and mineral N fertilization techniques in coriander, carried on in the experimental farm “Sparacia” (Cammarata, AG, Sicily). Similarly to what suggested for other species, each year at harvest time, for each fertilizer treatment, seeds yield and plant biomass were weighed and the respective N content was determined in order to compare N plant uptake with total and mineral N measured in the soil before and after cropping cycle. From such data a few indices were calculated in order to get information about the efficiency of use by plants of the tested N forms. Some differences in N partitioning and use efficiency according to treatment were noticed, suggesting an overall higher efficiency of N chemical fertilizers.

Keywords: Coriander, N fertilizers, organic fertilization, Nitrogen use efficiency.

Introduction

The widespread utilization of N fertilization worldwide is probably a consequence of the generally evident and quick effect that the addition of this element exerts on the overall performance of vegetation in most crops. As a matter of fact, such an effect may in some cases push farmers to an excess in distribution, in the belief that a more luxury habit of vegetation also means a higher healthiness condition for the plant. In this way, supplying crops with excessive N doses, that plants are unable to adsorb and soil cannot retain, may generate losses due to volatilization or to solubilization and leaching, with many environmental risks. The growing concern related to N excesses and misuses, therefore, calls attention to the necessity of a fine tuning of N management in field, keeping into account the exact requirement from crops and the real advantage of N supply (Sangwan *et al.*, 2001). In coriander, a well known spice herb, many studies concerning the effect of N fertilization have been conducted in special areas where the cultivation of such plants has a major importance, e.g. India or Pakistan. A review of world data about N fertilization in coriander (Carrubba, 2009) has shown that, in most examined cases, N fertilization allowed a 10 to 70% increase in seed yields in comparison with untreated control; notwithstanding, a large variability according to the site fertility could be ascertained, with the maximum yield advantages under high fertility conditions, whereas in less favorable environments the advantages of additional N supply were significantly lower. Limited information is available as concerns the response of coriander to N fertilization under Mediterranean climatic conditions, above all when organic N fertilizers are taken into consideration, as it is mandatory under organic cropping management (Carrubba and Ascolillo, 2009). The high costs of organic fertilizers for each single N unit push towards the necessity to a deep insight of the efficiency of use of the element by crops. A few considerations about N partitioning among the different parts of some crops have been exposed by Sinclair (1998), who suggested some interesting algorithms in order to quantify the relationships between HI and N use by plants, since in cereals seeds and straw have not the same N content, and therefore a shift in the relative fractions of both components (i.e. a modification in harvest index) involves a great modification in N accumulation and allocation by plants. Coriander is, by far, a not improved crop, and its plant architecture and metabolism have not been improved to increase N use efficiency; its HI often takes values lower than 10%, a value that may possibly decrease after N fertilization.

With the aim to give some detailed information about the bio-agronomical behavior of Coriander after organic and conventional N fertilization, a field trial was performed from 2003-04 to 2005-06.

Materials and methods

The work was carried on in the experimental farm “Sparacia” (Cammarata, AG, Sicily), comparing the types and rates of N fertilizers that are listed in table 1. Each year, prior to sowing, on representative soil samples (0-30 cm depth), total N content (both in organic and mineral form) was determined; at harvest time, both biomass and grain yields were weighed and converted to kg ha^{-1} of dry matter. Thereafter, the following soil and plant data inputs (all expressed in kg ha^{-1}) were determined for further analyses:

Nt: N total, i.e. N amount stored in aerial plant biomass at harvest time;

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})	Distribution method	N-fertilizer type, name, formulation	Producer, provenience	N content	Technical details
C1 - 2004 to 2006	80	At sowing	Inorganic (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	At sowing	Organic (Natural N8) Pellets	SCAM (Modena, Italy)	Total N 8,0 %, of which organic 8 %	C of biological origin (TOC) 37,0 % Organic matter of biological origin 63,0 % C/N ratio 4,6
O2 – 2004-2005	80	At sowing	Organic (Biagrin) Liquid (solution-sospension)	PFB (S. Giuseppe Jato, PA, Italy)	Total N 5,0 %, of which organic 1%	Humic extract obtained from residual olive waters. C of biological origin (TOC) 30,0 % Humic acids 15% C/N ratio 6,0
O3 – 2004 to 2006	80	At sowing	Organo mineral NP (Geco Natura) Compost	Gecos Fertilizzanti (Scordia, CT, Italy)	Total N 5,0 %, of which organic 5 %.	C of biological origin (TOC) 12 % C/N ratio 2,4 Total P_2O_5 7 % Water soluble K_2O 1 %
O4 – 2006	80	At sowing	Organic (Xena N12) Pellets	Nuova Geovis spa (Ozzano dell'Emilia, BO, Italy)	Total N 12,0 %, of which organic 12 %	C of biological origin (TOC) 40,0 % C/N ratio 3,3
O5 – 2006	80	At sowing	Organo mineral NP (Xena Starter) Pellets	Nuova Geovis spa (Ozzano dell'Emilia, BO, Italy)	Total N 7,0 %, of which organic 7%.	C of biological origin (TOC) 38 % C/N ratio 5,4 P 10 %, of which soluble in 2% formic acid 6 % (upon 10)
T: non fertilized control - 2004 to 2006						

Nf: N supplied by means of fertilization;

Nh: N in inorganic form measured in soil at harvest time;

Ns: N supply, i.e. all N potentially available in the soil, given by Nt0 + Nh0 + Nf, where Nt0 was total N amount stored in plant biomass; Nh0 was inorganic N originally in soil (both directly measured in the unfertilized plots), and Nf was, as written above, N supplied by means of fertilization;

Nav: N available, i.e. soil N effectively available for plants, given by Nt + Nh, determined for each fertilization treatment.

Similarly to what suggested for other species such as corn (Moll *et al.*, 1982), in order to get information about the efficiency of use of different N forms by plants, from such measured data a few indices were calculated, among which:

NUE = Gw/Ns, Nitrogen use efficiency, i.e. the ratio between grain yield and N supply;

NAE = Nt/Ns, Nitrogen absorption efficiency, i.e. the ratio between N uptaken by plants and N supply.

Results and discussion

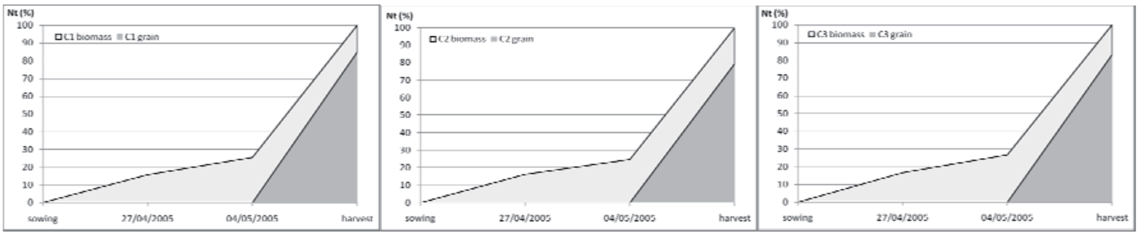

Figure 1: Trend of N storage (% of Nt at harvest) in coriander aerial biomass and grain in conventional N fertilization treatments.

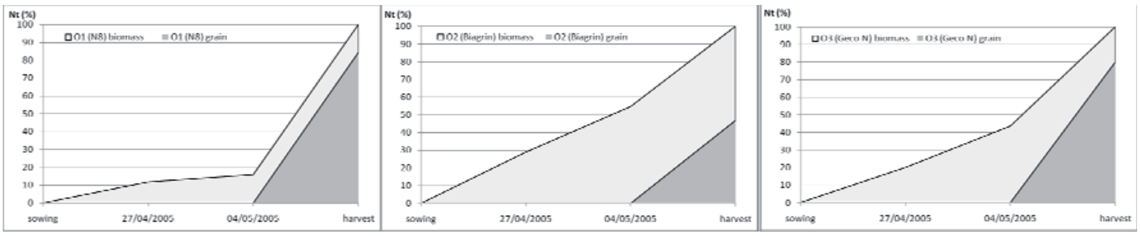

Figure 2: Trend of N storage (% of Nt at harvest) in coriander aerial biomass and grain in organic N fertilization treatments.

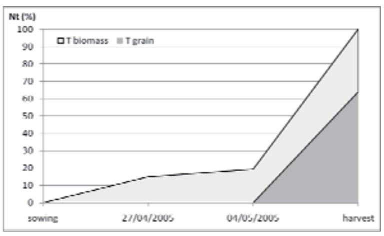

Figure 3: Trend of N storage (% of Nt at harvest) in coriander aerial biomass and grain in unfertilized plots (T).

Figs 1 to 3 show the trend of N accumulation in plants biomass recorded in 2004-05 in all groups of treatments, expressed in percentage of total N measured at harvest time. In the conventional treatments (C1 to C3) a substantially homologous trend is shown, apparently independent upon tested distribution rates and timing. Total N measured in seeds represented more than 80% of total N detected in plant biomass at harvest time (70-90 kg ha^{-1}). Among organic N fertilizers a higher variability was observed: Nt values ranged from 46 (O2) to 108 (O1) kg ha^{-1}, with a proportionally higher N storage in plants biomass than in seeds.

Additional remarks are reported in fig. 4, that summarizes the values calculated for some index related to N uptake and use in coriander plants. First, it is worth to notice the high variability among the three trial years, as a consequence of the effect exerted on N uptake and storage by the variations in rainfall and temperature. The high instability of the climatic pattern caused a strong variability in some data, such as grain yield, in relation to the cropping year. This variability explains, probably, a large part of the differences in some of the calculated indexes, such as Gw/Ns. The trend of the Gw/Ns ratio may be interpreted as an evaluation of plant's ability to convert all potentially available N into marketable biomass. In our experiment, it took rather low values, ranging from less than 5 to a maximum of 30, in this assessing the scarce ability of coriander to use efficiently N supply in soil. Generally speaking, the conventional treatments showed values higher than the organic ones, and among them no advantage was found for N fertilization at the highest rate (C3, 120 kg ha^{-1}). However, although the effect exerted by variability among years is still evident, the overall efficiency of organic treatments rises to levels closer to the conventional treatments when the Gw/Nav values are taken into consideration. As a matter of fact, since Gw/Nav= Gw/Nt x Nt/Nav, it comes out that such efficiency value must be attributed to the concurrence of the efficiency of use of stored N (Gw/Nt, kg of grain for each kg of N uptaken by plants), generally unmodified across years for the conventional treatments, and the ability of plants to uptake N from soil and to convert it into plant biomass (Nt/Nav), which appeared to be greatly dependent upon climatic constraints. Similarly, being Gw/Ns = Gw/Nav x Nav/Ns, the variations detected in nitrogen use efficiency of coriander plants may be due to the highly variable reactivity of crop to N uptake from soil and in its allocation into plant's tissues.

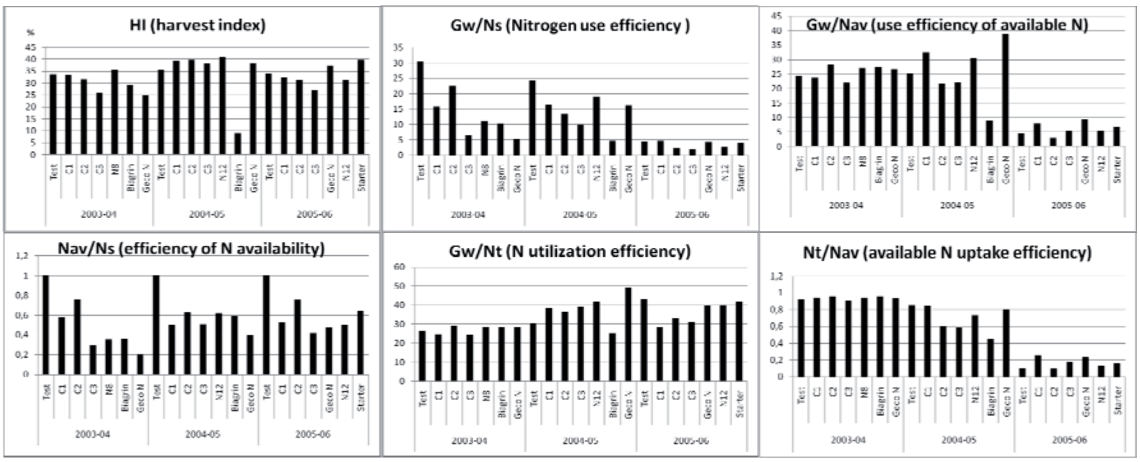

Figure 4: Sparacia (Cammarata – AG) 2003-04 to 2005-06. Indexes related to some aspects of N use efficiency in coriander under different N fertilization managements.

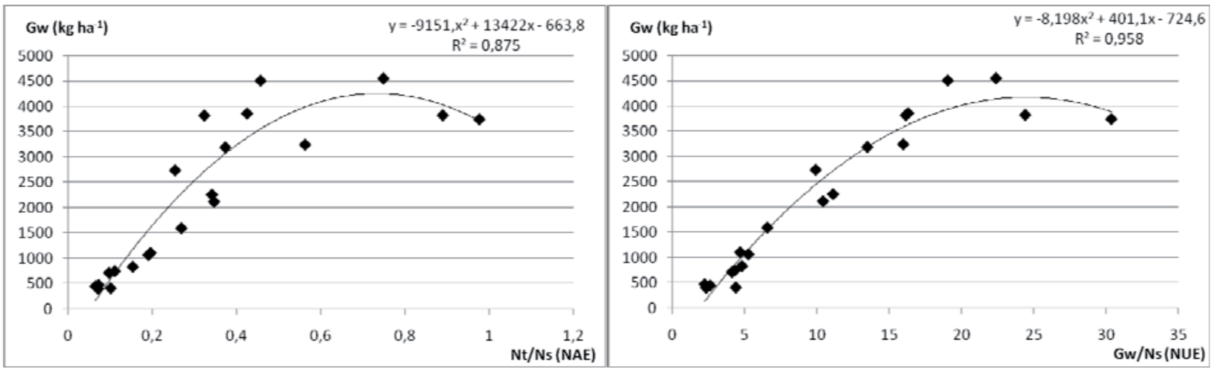

Figure 5: Sparacia (Cammarata - AG) 2003-04 to 2005-06. Relationship between coriander grain yield, nitrogen adsorption efficiency (NAE, on the left) and nitrogen use efficiency (NUE, on the right).

The importance to deepen the mechanisms that underlay N adsorption and use in coriander may be driven by the observation of the graphs in fig. 5, that stresses the tight relationship between grain yields and both examined aspects of efficiency, namely NAE (adsorption efficiency) and NUE (use efficiency).

As a matter of fact, organic fertilization is often considered as one of the recommended choices for growing medicinal and aromatic plants (Biffi, 2005). In our trial, however, organic fertilization did not allow advantages on yields, and its utilization gave erratic results. Expecially under Mediterranean climatic conditions, in which climatic patterns are often responsible of aleatory yield results, the lack of knowledge about behaviour of organic fertilizers could add a negative effect on the expected yields, with serious economical risks for farmers.

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