Studi Trent. Sci. Nat., *Acta Biol*., 83 (2007): 227-231 ISSN 0392-0542

Microbial activity of soil with different plant cover in Mediterranean area

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SUMMARY - *Microbial activity of soil with different plant cover in Mediterranean area* - Soil is an extremely heterogeneous substratum, site of numerous and important processes of the terrestrial ecosystems, but still now little known, in particular for the microbial communities biodiversity. Different studies have been performed on the climate effect on the microorganisms activity, while very little is known around the effects of the different plant cover on the soil microbial activity and/or on its biodiversity, especially in Mediterranean maquis of the South Italy. The aim of this work was to verify if the different plant cover is able to modify the soil microbial activity. It has been measured the respiration and some enzymes activity on the soil collected under *Cistus* and *Myrtus* shrubs, two kinds typical of the maquis, and the litter decomposition dynamics of *Cistus* and *Myrtus*. In addition to a remarkable spatial variability, the data showed for the two different shrubs, during the year, a different enzymes expression as well as a respiration much more variable in the *Cistus* soil. Besides the different decomposition dynamics of the *Cistus* litter incubated under the two types of shrubs suggests the presence of a different microbial community.

RIASSUNTO - *Attività microbiologica del suolo con diversa copertura vegetale in area mediterranea* - Il suolo è un substrato estremamente eterogeneo, sede di numerosi e importanti processi di funzionamento degli ecosistemi terrestri, ma ancora oggi poco conosciuto soprattutto per quanto concerne la biodiversità delle comunità microbiche. Diversi studi sono stati condotti sugli effetti dei fattori climatici sull'attività dei microrganismi, mentre poco si conosce circa gli effetti delle diverse coperture vegetali sull'attività della comunità microbica del suolo e/o sulla sua biodiversità, soprattutto negli ambienti a macchia mediterranea del Sud Italia. Obiettivo di questo lavoro, quindi, è stato quello di verificare se una diversa copertura vegetale potesse in qualche modo modificare l'attività microbica del suolo. Sono state misurate la respirazione e l'attività di alcuni enzimi sul suolo prelevato sotto cisto e mirto, due specie tipiche della macchia, e la dinamica di decomposizione della lettiera delle stesse foglie. Oltre a una notevole variabilità spaziale, i dati hanno evidenziato per i due tipi di cespugli una diversa espressione degli enzimi saggiati nel corso dell'anno nonché una respirazione molto più variabile in suolo di cisto. Anche il diverso andamento di perdita di peso della lettiera di cisto incubata sotto i due tipi di cespugli suggerisce la presenza di una differente comunità microbica.

Key words: soil biological activity, *Cistus incanus*, *Myrtus communis*, Castel Volturno Natural Reserve, Campania
Parole chiave: attività biologica del suolo, *Cistus incanus*, *Myrtus communis*, Riserva Naturale di Castel Volturno, Campania (Italy)

1. INTRODUCTION

Soil bacteria and fungi play a central role in carrying out the element biogeochemical cycles, the formation of soil structure, the functionality of soil system and in driving above-ground ecosystems (Wall & Virginia 1999). On the other hand, plant species affect microbial community composition of the rhizosphere (Pinzari *et al*. 1999; Rutigliano *et al*. 2004) probably by differences in the composition of root cell components and root exudates (Merbach *et al*. 1999). In addition, soil aeration and physical-chemical characteristics result in different microbial communities and spatial variability (Gelsomino *et al*. 1999; Carelli *et al*. 2000). It follows that microbial community composition is affected by a complex interaction between soil type, plant species and root zone location (Marschner *et al*. 2001). Nevertheless, our knowledge of soil microbial diversity is limited by our inability to study soil microorganisms (Kirk *et al*. 2004). So very little is known about spatial and temporal variability of microorganisms in soil.

Aim of this work was to compare soil biological activity under cover of two typical shrubs of Mediterranean maquis, *Cistus incanus* L. and *Myrtus communis* L. In particular, we measured microbial respiration, enzyme activities and litter decomposition rate as indexes of microbial diversity (Parkinson & Coleman 1991).

2. STUDY AREA

The study was carried out within the Natural Reserve of Castel Volturno, a flat coastal area of about 268 ha at South of the Volturno estuary (Campania, Southern Italy, 40°57′N; 13°55′E).

The selected experimental area was a stand of low Mediterranean maquis (average height of 6-8 m a.s.l., about 600 m from the sea). The shrub cover was about 70% and included *Cistus incanus*, *Cistus salvifolius*, *Myrtus communis*, *Rhamnus alaternus*, *Asparagus acutifolius*, *Phyllirea angustifolia* and *Pistacia lentiscus*, the canopies of which overlapped and intermingled. *Myrtus* and *Cistus* species were the main components of the shrub canopy (40% and 30%, respectively).

The main characteristics of the soil are reported in table 1, while further information on biological characteristics of this area can be found in Fioretto *et al*. (2003).

3. METHODS

Microbial respiration was measured *in situ*, under 10 *Cistus* or *Myrtus* shrubs, by an EGM Gas Monitor (PP system) on undisturbed profile after standing litter removal. At the same time, water potential was measured by a Theta Probe, ML1-UM1 (ΔT Devices). In laboratory, collected samples were sieved through a 2 mm mesh before further processing. Soil respiration was also measured as CO_2 evolution from sieved soil (2 mm mesh) at field moisture level on samples collected in the upper layer (0-5cm) under both shrub types according to Froment (1972) and as described in Fioretto *et al*. (2001).

Tab. 1 - Physical and chemical properties of the top soil (0-5 cm) under *Cistus* and *Myrtus* shrubs.
Tab. 1 - Caratteristiche chimico-fisiche del suolo (0-5cm) al di sotto dei cespugli di Cistus *e* Myrtus.

	C. incanus	*M. communis*
Sand (%)	98.8	99.9
Water holding capacity (H_2O g/100 g d.wt)	57	57
pH	8.5	8.2
Potential pH	7.9	7.4
C org (%)	1.32	2.40
N (%)	0.19	0.21
C/N	6.9	11.43
CO_2 evolution rate (CO_2 g^{-1} d.w. $24h^{-1}$)	1.95	1.84

Xylanase, carbossimethyl-cellulase and invertase activities were determined according to Schinner & Von Mersi (1990), protease activity according to Ladd & Butler (1972) and trehalase activity according to Kiem & Kandeler (1997). Enzyme activities were expressed on a soil mass basis.

Decomposition dynamics of *Cistus* and *Myrtus* leaves was followed by litter bag method as described in Fioretto *et al*. (2001), where further informations on dynamics of respiration, fungal biomass and enzyme activities during litter decomposition are also reported.

4. RESULTS

Microclimatic conditions under the two shrub types were different. Soil temperature measured at 5 cm depth was similar in the winter months, but in summer was 3-4 °C higher under *Cistus* than under *Myrtus*, being the first a summer semi-deciduous species. On the contrary, the soil water potential often appeared higher under *Myrtus* (Fig. 1a).

Similarly, soil respiration measured *in situ* (Figg. 1a, 1b), that evidenced a seasonal variation, was on average higher under *Myrtus* (Fig. 1a), although the differences often were not significant because of a high spatial variability.

Soil respiration under *Myrtus* measured in laboratory showed small changes during the study period, although with the expected seasonal variations (Fig. 1c). On the contrary, the CO_2 evolution rate under *Cistus* shrubs was very variable (Fig. 1d).

Cellulase, xylanase and protease activities were significantly higher under *Cistus* than under *Myrtus* shrubs (Fig. 2) during autumn and spring while trehalase activity during the summer. Invertase activity, on the contrary, at each sampling period was significantly higher under *Cistus* (Fig. 2).

As expected by considering the different litter quality (*Cistus* litter was richer in N, P, K, Ca and Mn respect to *Myrtus*, but had similar content of lignin and cellulose, Fioretto *et al*. 2000, 2005a), decomposition dynamics appeared different (Fig. 3). The average decomposition rates were similar for both litter types during the first 8 months, but, subsequently, the decomposition of *Myrtus* litter generally proceeded more quickly (Fig. 3). Nevertheless, also the decomposition dynamics of *Cistus* litter incubated under *Myrtus* shrubs proceeded at the same way of *Myrtus* litter throughout about 550 days. Thereafter, the degradation slowed down and after 800 days the residual mass was about 45%, similar to the same litter but incubated under *Cistus* shrubs (Fig. 3).

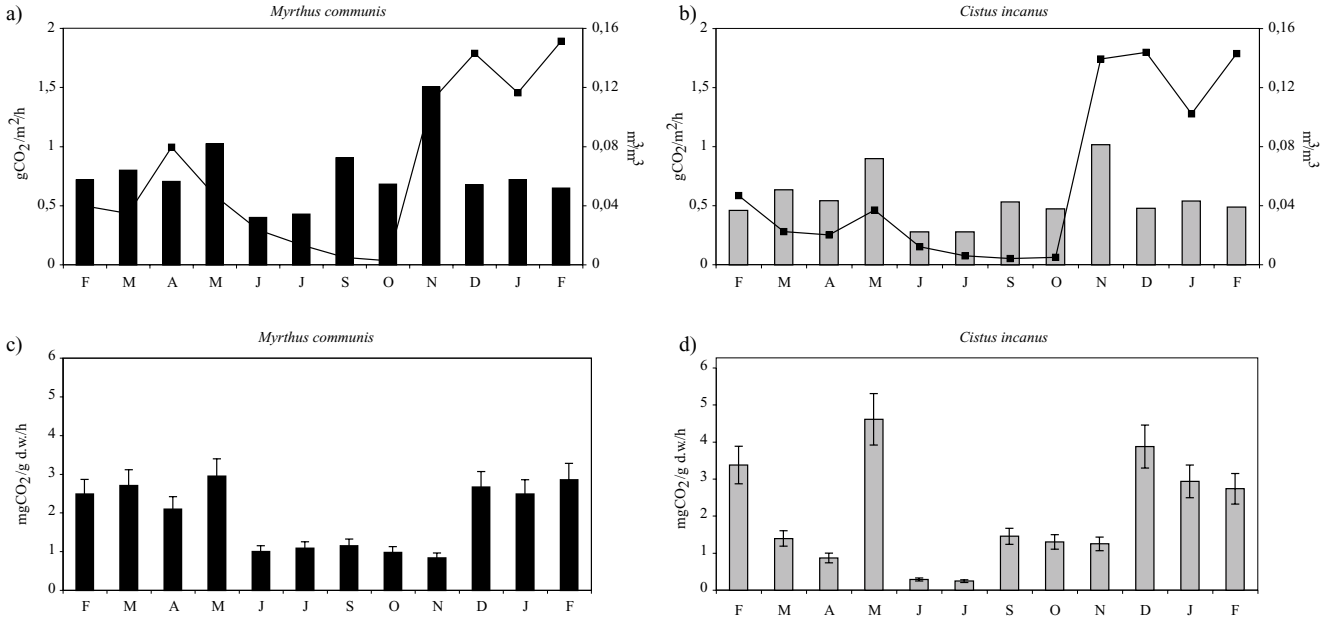

Fig. 1 - Soil respiration (□) and water potential (—) measured *in situ* under *Cistus* and *Myrtus* shrubs (a, b). The soil microbial respiration (□) rates at the field moisture evaluated through laboratory measurement is also reported (c, d). The values are mean ± S.D. of 30 field replicates (3 for every shrubs) and ± S.D. of 10 field replicates and 3 laboratory replicates, respectively.
Fig. 1 - Respirazione del suolo (□) *e potenziale idrico (—) misurati* in situ *al di sotto dei cespugli di* Cistus *e* Myrtus *(a, b). È riportato anche il tasso di respirazione microbica* (□) *al tenore idrico di campo valutato in laboratorio (c, d). I valori sono medie ± D.S. di 30 prove di campo (3 per ogni cespuglio) e ± D.S. di 10 prove di campo e 3 di laboratorio, rispettivamente.*

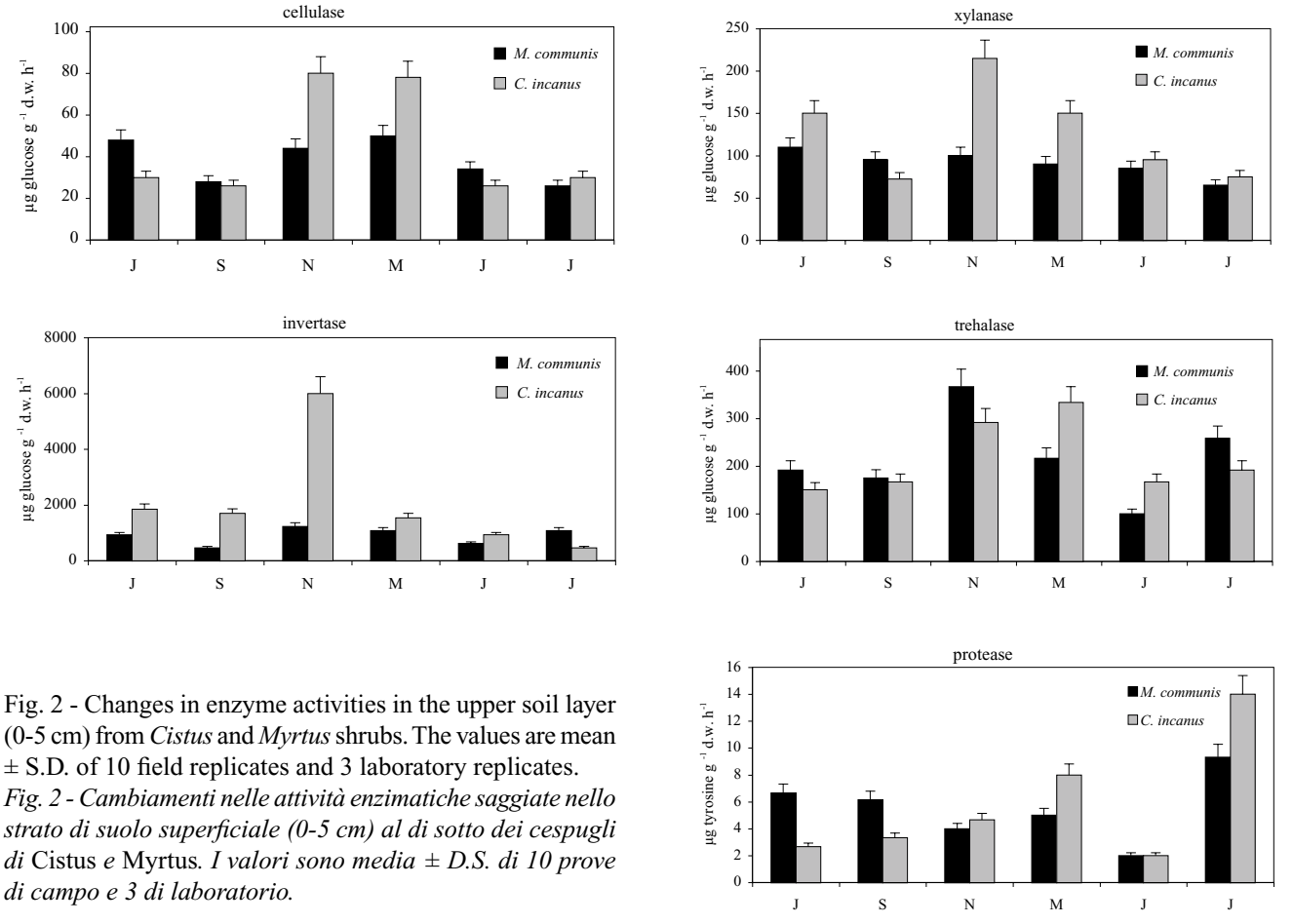

Fig. 2 - Changes in enzyme activities in the upper soil layer (0-5 cm) from *Cistus* and *Myrtus* shrubs. The values are mean ± S.D. of 10 field replicates and 3 laboratory replicates.
Fig. 2 - Cambiamenti nelle attività enzimatiche saggiate nello strato di suolo superficiale (0-5 cm) al di sotto dei cespugli di Cistus *e* Myrtus*. I valori sono media ± D.S. di 10 prove di campo e 3 di laboratorio.*

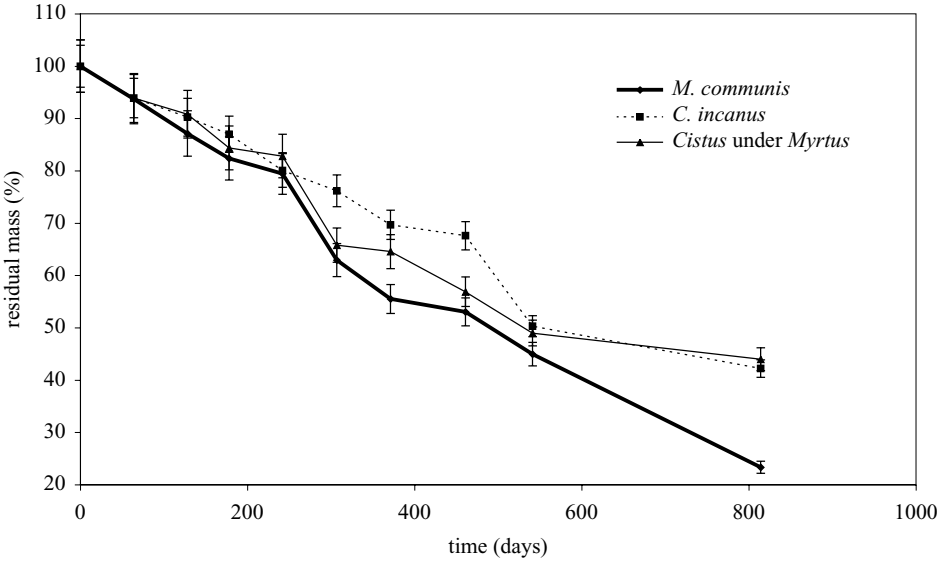

Fig. 3 - Residual mass (% of the initial) of decomposing leaf litter of *Cistus* and *Mirtus* incubated under the relative shrubs. The residual mass of *Cistus* litter incubated under *Mirtus* is also reported. The values are means ± S.E. of 20 measurements.
Fig. 3 - Peso residuo (% dell'iniziale) delle lettiere in decomposizione di Cistus *e* Mirtus *incubate al di sotto dei relativi cespugli. È riportato anche il peso residuo della lettiera di* Cistus *incubata sotto* Mirtus*. I valori sono media ± D.S. di 20 prove.*

5. DISCUSSION

Microbial respiration measured *in situ* showed a high variability among the shrubs of each species no always directly related to temperature and/or water content. This variability makes no possible to validate statistically the differences registered on CO_2 evolution between *Cistus* and *Myrtus* soils. The highest values of respiration showed by *Myrtus* soil *in situ* could be due principally to root respiration or to microbial biomass of rizosphere, because on the sieved soil it was not observed the same pattern (Fioretto *et al*. 2000, 2001).

The presence of a different microbial community has been suggested by the enzyme activity measurements, rather than respiration. The values of enzyme activities, in particular xylanase, cellulase and invertase, almost twice higher in the soil under *Cistus* during the wet periods, indicated a different functionality of community. This finding was also confirmed by a different answer and renewal of enzyme activities after fire (Fioretto *et al*. 2002, 2005b). In fact, in the fired plots, soil under *Cistus* showed, compared to controls, a more pronounced reduction of almost all tested enzyme activities. The lower enzyme activity respect to controls was still evident one year after fire, in particular for what concerns invertase activity. On the contrary, in the *Myrtus* soil, the activities were reduced respect to controls at least the first days after fire.

The peculiar pattern of decomposition rate of *Cistus* litter incubated under *Mirtus* shrubs, which followed the dynamics of *Myrtus* litter during about 550 days and that of *Cistus* incubated under the same shrub type thereafter, suggests that environmental conditions (abiotic and biotic) drove degradation in the first phases. Fungal biomass pattern matched that of litter mass loss both of *Myrtus* and *Cistus*, incubated under *Myrtus*, even if higher than that on the same litter under *Cistus*. This suggests the presence of a local microflora more abundant and able, during these phases, to colonize the material independently from the quality. Subsequently, litter quality prevailed in influencing decomposition rate. Although both undecomposed litters had similar contents of lignin and cellulose, after about 2.5 years of decomposition, *Cistus* litter showed a twice residual content of these components respect to *Myrtus* litter (Fioretto *et al*. 2005a).

In conclusion, the obtained results suggest the presence under the two shrub types of microorganisms with different functionality and resilience.

ACKNOWLEDGEMENTS

The researches were supported by MURST, by ModMed2 project contract n° ENV45T950130, by ModMed3 project contract n° ENV4CT979680 of European Community and by the Seconda Università di Napoli. Thanks to Dr N. Costantino as well as to the warrant officer N. Ricciardi and the staff of the Ispettorato della Forestale di Castel Volturno.

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Accettato per la stampa: 11 giugno 2007

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