VARIABILITA’ SPAZIALE E TEMPORALE DELLA RESPIRAZIONE DEL SUOLO IN RELAZIONE ALLE VARIABILI AMBIENTALI IN UN VIGNETO DEL NORD ITALIA

SPATIAL AND TEMPORAL VARIATION OF SOIL RESPIRATION IN RELATION TO ENVIRONMENTAL CONDITIONS IN A VINEYARD OF NORTHERN ITALY

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Abstract

In the current climate change perspective, a thorough knowledge of carbon budgets of vineyards and orchards may play an important role in improving sequestration capacity of these crops. Some research efforts have focused on vineyard soil respiration (R_S), but there is a lack of information about the magnitude of actual carbon fluxes in relation to soil management. The purpose of the investigation was to study the spatial and temporal variability of R_S and the partitioning between main components – autotrophic (R_A) and heterotrophic (R_H) respiration. In a commercial vineyard in Northern Italy, an automated soil CO_2 flux measurement system has been deployed on inter-row (grass covered soil), vine row (bare soil) and on trenched areas, intended to eliminate root contribution on total R_S and quantify actual R_H. Average R_S fluxes measured in vine rows were about 57% of inter-row. The contribution of R_A was about 67% of total R_S. The remarkable relevance of these findings for the improvement of vineyard C budget may result in the development of more sustainable cultivation practices.

Keywords:
Soil temperature, grass cover, carbon fluxes, grapevine, heterotrophic respiration;
Parole chiave:
Temperatura del suolo, inerbimento, flussi di carbonio, vite, respirazione eterotrofa;

Introduction

The effects of climate change on agricultural ecosystems and productivity of crops are already taking place, and will likely increase in future decades. A need exists to understand which land management has the greatest potential to mitigate greenhouse gas (GHG) emissions. A common belief is that agricultural fields cannot be net carbon sinks due to many technical interventions and repeated disturbances. However, perennial tree crops (vineyards and orchards) can behave differently: they grow a permanent woody structure, stand undisturbed in the same field for decades, originate woody pruning debris, and are often grass-covered. In this context, detailed informations on carbon fluxes exchanged by the canopy and soil respiration (R_S) are required (Gianelle *et al.*, 2015). The partitioning of R_S between its main components – autotrophic (R_A) and heterotrophic (R_H) respiration – can enable a better understanding of complex below-ground carbon dynamics. Especially for vineyards these data are scant and relatively sparse, and more information is needed on management practices in order to generate an accurate vineyard GHG footprint. The purpose of this investigation was to study the partitioning of vineyard R_S between autotrophic and heterotrophic components.

Materials and methods

Trials were carried out in North-Eastern Italy on a commercial vineyard located in Lison di Portogruaro (45°44'25.80"N 12°45'1.40"E). The vineyard mainly composed by *Vitis vinifera L.* cv. 'Sauvignon blanc' was planted in 2001 with vines spaced 2.2 m by 0.9 m. Vineyard alleys were grass covered (1.6 m wide) whereas 0.6 m wide strip along row was chemically treated (bare soil). In late summer 2014, an automated dynamic soil CO_2 flux system (Li-Cor LI-8100) was installed, with 5 long-term chambers mounted on PVC soil collars and connected by a dedicated multiplexer. Dedicated soil temperature (T_{soil}) and volumetric soil water content (*SWC*) probes were installed close to each chamber. Each of the five soil CO_2 flux sampling points was monitored with a 30' temporal resolution. To partition the two components of R_S – microbial respiration and root respiration – two trenched plots ($60\times60\times60$ cm^3) were established in the vine alleys to exclude roots using two different nylon meshes (5 µm internal; 50 µm external) on soil plot walls (Fisher and Gosz, 1986). Measurements were carried out from August 26th to November 20th 2014, on two adjacent alleys. One chamber was installed on grass-covered inter-row, two on the trenched plots and one along the row. One additional chamber was placed within the row from August 26th to October 7th; thereafter it was relocated in the alley and remained until the end of the experiment. The dataset was filtered for rainy days and for *SWC* >0.35, to avoid erroneous measurements caused by transient flooding of the sample soil.

Results and discussion

Throughout the experimental period, the total average R_S was 10.7 g CO_2 m^{-2} d^{-1} with a standard deviation (*SD*) of 4.9 g CO_2 m^{-2} d^{-1}, with consistent differences between positions and times. In the same period, average inter-row (R_{SI}), trenching (R_{SH}) and row (R_{SR}) soil respiration were 12.4, 3.4 and 6.7 g CO_2 m^{-2} d^{-1}, respectively. Spatial variability was higher in the inter-row, with average *SD* between measurement points of 1.65, 0.47 and 1.19 g CO_2 m^{-2} d^{-1} for R_{SI}, R_{SH} and R_{SR} respectively. Table 1 reports average R_S values for selected time intervals based on similar daily air temperature trend. In this case, *SD* showed temporal variability between R_{SI}, R_{SH} and R_{SR} and between different seasons. Inter-row fluxes presented higher time variability, i.e. greater R_S fluctuations during days and seasons. Such as for seasonal variability, there were daily fluctuation patterns, for both R_{SI} and R_{SR}, but with higher values and scattering for R_{SI}. Roots represent major sources of carbon dioxide within the soil therefore stimulating soil efflux. The areas of highest soil respiration activity are generally concentrated around the plant roots and their associated microbes, the rhizosphere zone (Bardgett, 2011). Moreover, higher root respiration is associated with fine root density (Ceccon *et al*., 2010). As shown in Figure 1, R_{SI} resulted more closely related to R_A than R_H, and R_{SR} better related to R_H than R_A. R_S fluxes measured in the vine rows were about 57% of the inter-row on average. Therefore, in the inter-rows there was much more autotrophic activity (due to the presence of grass and vine fine roots) than along the rows, i.e. higher fine root density compared to the vine row, where a higher number of older medium-large roots are expected (Franck *et al*., 2011). Autotrophic component was about 67% of the total CO_2 fluxes on average, reaching a minimum of about 30%. A robust exponential relationship (R^2 = 0.7) was found between R_S and soil temperature (for all datasets). R_A values were more temperature-related (R^2 = 0.65) than R_H (R^2 = 0.4), probably as a consequence of a greater dependence of heterotrophic microflora on soil O_2 levels as compared to autotrophic component. With values of *SWC* higher than 0.34, the heterotrophic component of R_S tended to zero, suggesting transient anoxia conditions due to rainfall events leading to a break in basal microbial metabolism.

Tab. 1- R_S Mean ±SD, average T_{soil} and SWC for time intervals with homogeneous temperature trend.

Tab. 1- R_S Media ±SD, T_{soil} e SWC medie per intervalli temporali con simili andamenti di temperatura.

	R_{SI}	R_H	R_{SR}	R_A	T_{soil}	*SWC*
	(g m^{-2} d^{-1})				(°C)	
26/08 - 13/09	15.6 ± 3.5	4.9 ± 1.7	9.9 ± 2.6	9.5 ± 2.6	20.76	0.32
14/09 - 22/10	14.7 ± 5.2	3.5 ± 0.9	7.8 ± 1.7	8.6 ± 4.3	18.11	0.3
23/10 - 4/11	7.8 ± 3.5	2.6 ± 0.9	3.5 ± 1.7	3.5 ± 1.7	10.58	0.29
5/11 - 20/11	6 ± 3.5	1.3 ± 0.3	2.8 ± 1.7	*3.9 ± 2.6*	12.55	0.33

Conclusions

Vineyard soil respiration presents high spatial variability, with higher respiration fluxes in the vine alleys. Within optimal *SWC* range, temporal soil respiration variation resulted strongly related to temperature, whereas *SWC* represent the limiting factor at high values (~0.35). Attention to *SWC* levels and collar conditions is recommended. Autotrophic respiration is responsible for most CO_2 emissions, about 67% on average. A deeper understanding of carbon balance in vineyards is of great importance to promote sustainability and to improve cultivation practices.

Acknowledgments

Research funded by the Italian Ministry of Education, University and Research (Contract PRIN 2010-11 CARBOTREES).

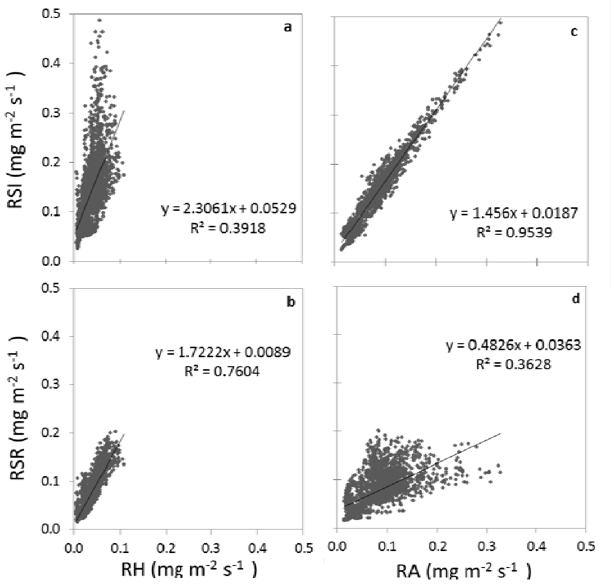

Fig. 1- R_S components relationship: a) heterotrophic (R_H) vs. inter-row (R_{SI}); b) heterotrophic (R_H) vs. row (R_{SR}); c) autotrophic (R_A) vs. inter-row (R_{SI}); d) autotrophic (R_A) vs. row (R_{SR});

Fig. 1- Relazione tra componenti di R_S: a) Eterotrofa (R_H) vs. Interfila (R_{SI}); b) Eterotrofa (R_H) vs. Fila (R_{SR}); c) Autotrofa (RA) vs. Interfila (R_{SI}); d) Autotrofa (R_A) vs. Fila (R_{SR});

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