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Original article

Litter quality and decomposition of *Vitis vinifera* L. residues under organic and conventional farming systems

Anna E. Nikolaidou [a,*], Athina K. Pavlatou-Ve [b], Sofia K. Kostopoulou [b], Andreas P. Mamolos [a], Kiriaki L. Kalburtji [a]

[a] Faculty of Agriculture, Laboratory of Ecology and Environmental Protection, Aristotle University of Thessaloniki, 541 24 Thessaloniki, Greece
[b] Faculty of Agriculture, Laboratory of Soil Science, Aristotle University of Thessaloniki, 541 24 Thessaloniki, Greece

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ABSTRACT

In viticulture, residue decomposition may be important in terms of fertilization, due to the low grapevine nutritional demands. Grapevine residue quality, mass loss and nutrient release rates were studied in an organic (Vorg) and a conventional vineyard (Vconv) for 19-months. Leaf and cane residues of the Vorg (Lorg, Corg) and of Vconv (Lconv, Cconv) were buried in litterbags in both vineyards. Lorg contained in mg g^{-1} 526 C, 14.7 N, 1.2 P and 5.4 K; Lconv 509 C, 17.9 N, 1 P and 7.3 K; Corg 556 C, 5.7 N, 1.4 P and 6.9 K; Cconv 554 C, 7.6 N, 0.9 P and 7.7 K. Mean mass loss and N, P and K release rates ($k' = k \times 10^5$) were higher in leaf ($k' = 543, 541, 448, 725$) than in cane residues ($k' = 146, 90, 136, 494$). In Vorg, mass loss and N, P and K release rates were higher in Lconv ($k' = 904, 748, 630, 1287$) than in Lorg ($k' = 293, 357, 336, 502$). For Lorg, mass loss and N release rates and for Corg mass loss rate were lower in Vorg ($k' = 293, 357, 102$) than in Vconv ($k' = 537, 541, 218$). For Lconv, mass loss and N and K release rates were lower in Vconv ($k' = 440, 518, 557$) than in Vorg ($k' = 904, 748, 1287$). Incorporation of plant residues in Vconv allowed reductions of nutrient applications of 25, 2 and 21 kg ha^{-1} y^{-1} of N, P and K, respectively; in Vorg nutrient applications reduced by 7, 1, 5.5 kg ha^{-1} y^{-1}.

1. Introduction

Crop residue addition in agroecosystems supplies plants with nutrients and replenishes soil organic matter pool, which is the major source of N, P and other nutrients in soils and is critical to efficient crop production because of its high cation exchange and water holding capacities. In Greece, agricultural soils are characterized by low organic matter contents, due to the climatic conditions and the applied soil management practices [15]. It is therefore essential to sustain soil organic matter through addition of organic inputs, i.e. crop residues.

Residues from different plant parts differ in litter quality and this influences decomposition rates. Kalburtji and Mamolos [13] found that the productive parts of soybean, sunflower and maize (pods, heads and cobs) had different decomposition rates from their supporting parts (stems and stalks) related to their litter quality. Also, leaves from grassland plant species had higher decomposition rate compared to the stems due to high N and low C content [16].

The amount of nutrients released during crop residue decomposition is highly important in both organic and conventional farming systems; in the former, it has a decisive influence on crop yield and in the latter, it could lead to a reduction in mineral fertilizer application [18,19,33]. At the agroecosystem level, residue mass loss and nutrient release rates are regulated by initial residue chemical composition [40]. Residue mass loss is positively affected by the initial N, P [50] and K [25] contents, and negatively affected by the C/N [31], C/P [25] and N/P ratios [20]. Nitrogen mineralization proceeds more rapidly in residues rich in N [4,45] and P [28] or in residues with a low C/N ratio [9]. Nitrogen release dynamics are also regulated by a combination of N, lignin and/or soluble polyphenol content [14,16,32]. Generally residues high in P [28], or with a low C/P ratio [2] or N/P ratio [19] release more P within a shorter period. High quality residues release nutrients rapidly, while nutrients from low quality residues are initially immobilized, and later are eventually mineralized and become available to crops [12,24]. Farming systems may affect residue mass loss and nutrient release since organic farming practices increase microbial biomass C [36] and cattle manure application increases the proportion of potentially mineralizable N and P in soils [49].

Abbreviations: Vorg, organic vineyard; Vconv, conventional vineyard; Pp, plant parts; Lorg, leaves collected from Vorg; Lconv, leaves collected from Vconv; Corg, canes collected from Vorg; Cconv, canes collected from Vconv.

* Corresponding author. Tel.: +30 2310 998621; fax: +30 2310 998652.
E-mail address: annikola@agro.auth.gr (A.E. Nikolaidou).

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In viticulture, which is the second most important crop in Greece [7] and especially in organic viticulture, which constitutes the third major organic crop in Greece [11], residue decomposition may be important in terms of fertilization, due to the comparably low nutritional demands of grapevine [27]. In Greece, however, burning grapevine residues has been a common practice, even under organic farming systems.

The present work was conducted to investigate the decomposition of organic and conventional grapevine residues (leaves and canes) as a means of fertilization in vineyards. The tested hypotheses were if a) organic and conventional farming systems affect grapevine residue (leaves and canes) quality and decomposition and b) there are differences between the studied plant part residues (leaves and canes) related to their litter quality and origin. One practical implication of the results obtained would be the partial replacement of fertilizers with grapevine residues.

2. Materials and methods

2.1. Study sites

The experiment was conducted in two vineyards, one organic (Vorg) and one conventional (Vconv), located at Northern Greece (40°44′N, 22°45′E) and lasted 19 months (January 2002–July 2003). There was a main road of 12 m width between the two vineyards and the area was flat. Soil samples were collected in October 2001. The soil texture of both vineyards is sandy clay loam (SCL) and their soil physicochemical characteristics are presented in Table 1. Temperatures and rainfall data of the study area, according to the records of the Greek National Meteorological Service, are presented in Fig. 1.

Both vineyards were planted with the variety “Roditis” grafted on a Berlandieri × Rupestris Richter No 110 rootstock, Vorg in 1992 and Vconv in 1995. Previous crops were grapevine for Vorg and wheat (*Triticum aestivum* L.) for Vconv. Organic vineyard was managed organically since 1997. Farming practices for both vineyards are presented in Table 2.

The soil of the experiment sites in both vineyards had not been cultivated during the 19 months. Thus in Vorg, weeds, such as *Amaranthus retroflexus* L., *Amaranthus blitoides* S. Watson, *Portulaca oleracea* L. and *Paspalum distichum* L. and in Vconv, *Convolvulus arvensis* L. and *P. oleracea* L., grew profusely over the experiment sites.

2.2. Experimental design

Plant parts (Pp) of grapevine were collected in October 2001 and stored at 25 °C. The Pp included all mature leaves before abscission had commenced and all fully developed vine shoots of the current vegetative period, called “canes” henceforth. The canes were cut at the point where normal pruning is done by the farmers in January. In each vineyard, all leaves and canes of 10 grapevines were also collected in order to obtain the mean weight of leaves and canes per grapevine. The mean dry weight of leaves per grapevine was 71.6 ± 5.7 g and 313.1 ± 37.8 g in Vorg and in Vconv, respectively, while the mean dry weight of canes per grapevine was 186.3 ± 21 g and 532.2 ± 62 g in Vorg and in Vconv, respectively. Twenty grams of Pp were placed in bags (30 × 18 cm) made of plastic net with 4.0-mm diameter holes. The canes only were cut into 10 cm pieces before placing them into the bags. Four litter treatments were used: leaves (Lorg) and canes (Corg) collected from the Vorg and leaves (Lconv) and canes (Cconv) from the Vconv. On 6 January 2002 and in each vineyard, litterbags with Pp (Lorg, Corg, Lconv and Cconv) were buried under the grapevines, surface-flat, into the soil at a depth of 5 cm. One hundred and twenty eight litterbags were used for each vineyard. Litterbags of each treatment from each vineyard were carefully retrieved in February, March, April, May, August and

Table 1
Physicochemical characteristics of the surface soil layer (0–30 cm) of the two vineyards (means ± 1 standard error in parentheses, $n = 2$).

Vineyard	Sand[a] (%)	Clay[a] (%)	Silt[a] (%)	$CaCO_3$[b] (%)	pH[c]	Organic matter[d] ($g\ kg^{-1}$)	Total N[e] ($g\ kg^{-1}$)	Olsen P[f] ($mg\ kg^{-1}$)	Exchangeable[g] Ca^{2+} ($cmol^{(+)}\ kg^{-1}$)	Mg^{2+} ($cmol^{(+)}\ kg^{-1}$)	K^+ ($cmol^{(+)}\ kg^{-1}$)	Na^+ ($cmol^{(+)}\ kg^{-1}$)	Zn[h] ($mg\ kg^{-1}$)	Mn[h] ($mg\ kg^{-1}$)	Fe[h] ($mg\ kg^{-1}$)
Organic	58.9	21.3	19.8	1.1	7.7	7.6	0.6	20.0	20.8	3.6	0.7	0.2	2.0	16.3	4.5
	(0.3)	(1.1)	(1.1)	(0.0)	(0.0)	(0.1)	(0.0)	(1.2)	(0.5)	(0.1)	(0.0)	(0.2)	(0.0)	(0.5)	(0.1)
Conventional	62.4	22.4	15.2	0.2	7.4	6.3	0.5	19.3	14.8	4.2	0.5	0.3	3.8	21.7	6.7
	(1.1)	(0.7)	(1.4)	(0.0)	(0.1)	(0.2)	(0.5)	(0.0)	(0.2)	(0.1)	(0.0)	(0.0)	(0.1)	(1.3)	(0.2)

[a] Pipette method.
[b] Volumetrically with a calcimeter after reaction with 3 M HCl.
[c] In 0.01 M $CaCl_2$ 1:1 (w/v).
[d] Wet oxidation.
[e] Kjeldahl method.
[f] Extraction with 0.5 M $NaHCO_3$, pH 8.5 (1:20 w/v).
[g] Extraction with 1 M CH_3COONH_4 pH 7.
[h] Extraction with D.T.P.A. (1:2 w/v).