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Cover crops in vineyards for sustainable soil management

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SUMMARY – With the objective of evaluating and selecting cover crop pastures to improve soil management in vineyards cv. Cabernet Sauvignon, 5 cover crops were evaluated: (i) control without vegetation; (ii) control with spontaneous vegetation; (iii) legumes mixture of early maturing cvs. of *Trifolium subterraneum* and *Medicago polymorpha*; (iv) legumes mixture of late maturing cv. of *T. subterraneum* and *T. michelianum*; and (v) legumes mixtures of late maturing cvs. and *Lolium rigidum* cv. Wimmera. The three pasture mixtures realized large populations of plants; 600-800 and 900-1200 plant/m^2 in the first and second growing seasons, respectively. Biomass production was significantly higher ($P \leq 0.05$) in the mixtures with late maturing cultivars of *T. subterraneum* and *T. michelianum*. The contents of N, P and K in the biomass of the cover crop were higher ($P \leq 0.05$) than those cover with spontaneous species, which allowed the content of available N to be increased in the soil. Also, higher contents of K and P were detected in the soil; the later was mainly due to the fertilization with phosphate during the establishment of the cover crops.

Keywords: Vineyard ground cover, *Vitis vinifera, Trifolium michelianum, T. subterraneum, Medicago polymorpha.*

RESUME – *"Cultures de couverture dans les vignobles pour une gestion durable du sol". Dans l'objectif d'évaluer et de sélectionner des pâturages pour améliorer la gestion du sol dans des vignobles cv. Cabernet Sauvignon, 5 cultures de couverture ont été évaluées : (i) témoin sans végétation ; (ii) témoin avec la végétation spontanée ; (iii) mélange de légumineuses précoces cvs. de* Trifolium subterraneum *et* Medicago polymorpha *; (iv) mélange de légumineuses tardives cv. de* T. subterraneum *et* T. michelianum *; et (v) cvs. de légumineuse tardives en mélange avec* Lolium rigidum *cv. Wimmera. Les trois mélanges de pâturages ont donné de fortes populations de plantes; 600 - 800 et 900 - 1200 plantes* m^{-2} *dans la première et deuxième période de croissance, respectivement. La production de biomasse était significativement plus haute (P ≤ 0,05) dans les mélanges à variétés tardives de* T. subterraneum *et de* T. michelianum. *Les teneurs en N, P et K dans la biomasse des pâtures était plus haute (P ≤ 0,05) que celles du couvert à espèces spontanées, ce qui a permis d'augmenter la teneur en N disponible dans le sol. Egalement, des teneurs plus hautes en K et P ont été détectées dans le sol ; principalement en raison de la fertilisation avec du phosphate pendant l'établissement de la pâture.*

Mots-clés : *Enherbement du vignoble,* Vitis vinifera, Trifolium michelianum, T. subterraneum, Medicago polymorpha.

Introduction

In vines (*Vitis vinifera* L.), cover crop is a technology used in diverse regions of the world to produce fine wines, like in California, Australia, Italy, France and others, as an alternative for sustainable soil management (Nieddu *et al.,* 2000; Masson and Gintzburger, 2000; Miller *et al.,* 1989). In Chile, their use is recent and the effects of cover crops in soil-plant system have not been accurately studied, particularly when legume species are used. The objective of this study was to evaluate and select cover crops pastures to improve soil management in vineyards, and to determine their contribution with nitrogen and others nutrients to the system.

Cover crops in vineyards present multiple advantages like to increase soil organic matter content and nutrients in the soil, due to the mineralization of the aerial and underground biomass, improve soil physical properties as porosity, structure, and aggregates stability, increase water holding capacity, reduce soil erosion, and increase the biological activity in the soil (Frye and Blevins, 1989). Also, data have been reported on the effect of cover crops in reducing weeds and in the control of some nematodes species (Aballay and Insunza, 2002).

Materials and methods

The study was carried out from May 2005 to May 2007 in a 5 years old vineyard, cv. Cabernet Sauvignon. The experiment was set up on a hilly granitic soil (fine, kaolinitic, mesic Typic Palexeralfs), deep, but with low fertility. At the beginning of the study the soil chemical characteristics were: pH (water) 6.7; organic matter (OM) 1.55%; N 1.93 ppm; P_2O_5 5.47 ppm and K_2O 207 ppm.

The cover crop treatments sowed in May 2005 were: (i) control without vegetation; (ii) control with spontaneous vegetation; (iii) legumes mixture of early maturing cvs. of *Trifolium subterraneum* and *Medicago polymorpha*; (iv) legumes mixture of late maturing cvs. of *T. subterraneum* and *T. michelianum*; and (v) legumes mixture of late maturing cvs. and *Lolium rigidum*. Plot size was 25 x 4 m (100 m^2). The experimental design was randomized blocks with four replications. Plantation distance of the vineyard was 2.5 m between rows 0.5 m over row. The sowing rate of legume mixtures is indicated in Table 1. Pasture fertilization consisted of 150 kg P_2O_5 ha^{-1}, 110 kg K_2O ha^{-1}, 2.2 kg B ha^{-1} (boron calcite), 66 kg ha^{-1} CaO, and 36 kg ha^{-1} S (calcium sulphate). Additionally, 110 kg K_2O, 90 kg MgO, and 110 kg S (potassium and magnesium sulphate) were applied on June 2006. Vineyard was drip irrigated from September to March in each season.

The above-ground biomass production and floristic composition of cover crops were determined using four quadrants of 1 x 0.5 m per plot; the samples were dried in an oven with forced ventilation at 70ºC for 48 hours. The evolution of soil nutrient content was followed using tubes of PVC 20 cm long and 10 cm diameter, in which the biomass coming from each cut of the cover crop was placed inside the tubes (Eghball, 2000). Pasture biomass availability was calculated, and in each tube the proportional quantity of biomass to the area of the tube (74.6 cm^2) was placed. Later on one tube per treatment and replication was collected every 30 days after its installation (Eghball, 2000). Time variation of pH, organic matter, total available nitrogen ($N\text{-}NO3^-$ + $N\text{-}NH4^+$), extractable phosphorus and potassium were evaluated.

Table 1. Cover crop characteristics, species and cultivars composition, and seed rates

Cover crop	Species	Cultivar	Seed rate (kg ha^{-1})
Early flowering legumes	*Trifolium subterraneum*	Seaton Park	12
	Medicago polymorpha	Santiago	8
Late flowering legumes	*Trifolium subterraneum*	Antas	12
	Trifolium michelianum	Paradana	5
Late flowering legumes plus annual grass	*Trifolium subterraneum*	Antas	12
	Trifolium michelianum	Paradana	5
	Lolium rigidum	Wimmera	10

Results and discussion

The three pastures mixtures achieved high populations of plants; 600 - 800 and 900 - 1200 plant m^{-2} in the first and second growing seasons, respectively. Biomass production of late flowering legumes with or without the annual grass, was significantly higher ($P<0.05$) than the early flowering cultivars or the spontaneous vegetation. In both years the production of the sowed covers was higher, but in particular in the second season the productions overcame the 5300 kg DM ha^{-1} $year^{-1}$ (Table 2).

In the two growing seasons, *T. subterraneum* showed the highest relative abundance, in all annual legume mixtures (Table 3). In the second growing season the relative abundance of *T. subterraneum* was similar in all legume mixtures. The relative abundance of the other components of the cover crop mixtures (*T. michelianum*, *M. polymorpha* and *L. rigidum*) were much lower (< 15%) (Table 3). The main spontaneous species in the control were *Rumex acetocella* L., *Hypochoeris glabra* L., *Plantago lanceolata* L., *Hypochoeris radicata* L., *Leontodon leysseri* (Wallr.), *Avena barbata* Link, and *Lolium multiflorum*. However, the relative abundance of spontaneous species in cover crops of legume mixtures was very low (<6%) indicating that these cover crops had an appropriate control of the weed in the vineyard.

Table 2. Total and sown species biomass of cover crops during two growing seasons

Cover crop	2005-2006		2006-2007	
	Sown species (kg ha^{-1})	Total (kg ha^{-1})	Sown species (kg ha^{-1})	Total (kg ha^{-1})
Spontaneous vegetation		410 c		320 c
Early flowering legumes	2330 b	3460 b	5391 b	5445 b
Late flowering legumes	4070 a	4160 a	6148 a	6148 a
Late flowering legumes plus annual grass	3900 a	4010 a	6623 a	6623 a

Means followed by different letters in a column are significantly different ($P \leq 0.05$) according to Duncan test.

Table 3. Floristic composition (%) of cover crops in vineyard, in two growing seasons

Cover crop	*Trifolium subterraneum*		*Trifolium michelianum*		*Medicago polymorpha*	*Lolium rigidum*	Others species	
2005								
Spontaneous vegetation	--		--		--	--	100	a
Early maturing legumes	92	a	--		2	--	6	b
Late maturing legumes	88	ab	10	a	--	--	2	b
Late maturing legumes plus annual grass	77	b	15	a	--	5	3	b
2006								
Spontaneous vegetation	--		--		--	--	100	a
Early maturing legumes	96	a	--		3	--	1	b
Late maturing legumes	95	a	5	a	--	--	0	b
Late maturing legumes plus annual grass	93	a	4	a	--	3	0	b

Means followed by different letters in a column are significantly different ($P \leq 0.05$) according to Duncan test.

The contents of N, P and K in the biomass of legume mixtures were higher ($P \leq 0.05$) than in the control with spontaneous vegetation (data not shown). Soil pH was not affected by the cover crop (Table 4). Soil mineral N content was significant higher ($P < 0.05$) with legume mixtures from July to November (Table 4). This pattern is explained by the active mineralization of organic matter that took place in this period when the environmental conditions in the soil are adequate.

Similar situation was observed with cover crops in organic orchards of raspberry in Chile (Ovalle *et al*., 2007). P soil content was significantly higher in cover crops of legume mixtures due to the fertilization that received the legumes (equivalent to 150 and 50 kg P_2O_5 ha^{-1} in year one and two, respectively). Soil K content also increased as a result of the mineralization of the organic matter.

Conclusions

In summary, the incorporation of cover crop in the inter-row of a Cabernet Sauvignon vineyard in granitic soils of the sub-humid Mediterranean region of Chile, presented advantages in terms of soil management, when being compared with a soil managed free of vegetation or with the spontaneous vegetation.

Table 4. Time variation of pH, organic matter, N, P, and K under different cover crops in vineyard established in granitic soils, during the 2006 growing season

Cover crop	Sampling date							
	11-08-06		09-09-06		23-09-06		09-11-06	
pH								
Control without vegetation	6.65	a	6.70	a	6.43	a	6.42	a
Early maturing legumes	6.48	a	6.28	a	6.73	a	6.66	a
Late maturing legumes	6.77	a	6.81	a	6.53	a	6.50	a
OM (%)								
Control without vegetation	1.55	a	1.61	b	1.68	a	1.55	a
Early maturing legumes	1.86	a	1.90	ab	2.17	a	2.07	a
Late maturing legumes	1.71	a	2.44	a	2.22	a	2.12	a
N (ppm)								
Control without vegetation	1.9	b	6.8	c	9.5	b	5.1	c
Early maturing legumes	21.9	a	62.6	b	26.9	a	17.0	b
Late maturing legumes	14.1	a	193.7	a	39.8	a	44.7	a
P_2O_5 (ppm)								
Control without vegetation	5.5	b	7.5	b	6.4	b	5.2	b
Early maturing legumes	12.9	a	19.4	a	16.1	a	18.2	a
Late maturing legumes	15.5	a	23.1	a	18.6	a	18.7	a
K_2O (ppm)								
Control without vegetation	208	b	252	b	226	b	214	b
Early maturing legumes	279	a	438	a	474	a	442	a
Late maturing legumes	287	a	557	a	521	a	505	a

Means followed by different letters in a column are significantly different ($P \leq 0.05$) according to Duncan test.

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