Effect of vineyard management strategy on the nutritional status of irrigated « Tempranillo » vineyards grown in semi-arid areas

Influence des pratiques sur l'alimentation minérale des vignobles irrigués de « Tempranillo » cultivés dans des zones semi-arides

Luis Gonzaga SANTESTEBAN*, Carlos MIRANDA and J. Bernardo ROYO

Dpt Producción Agraria, Universidad Pública de Navarra, Campus de Arrosadía, 31006 Pamplona, Spain
*Corresponding author: gonzaga.santesteban@unavarra.es, Fax +34 948169732

Abstract: The combination of cover crops with regulated deficit irrigation has been lately shown to be a good method to improve harvest quality in irrigated vineyards of Southern Europe with semiarid climate, as an alternative to the conventional management, that consists on mechanical tillage and irrigation from fruitset to veraison and from then on reduced, or even ended. In this work, we present the implications of this alternative management method on vineyard nutrition through blade, petiole and berry analysis, showing that the presence of the cover crop does not imply further nutrient needs but, rather on the contrary, results in a progressive improvement of vine nutritional status as a result of the decrease of its nutrient needs due to lower growth and yield, and probably of an improvement of soil characteristics enhancing nutrient availability.

Key words : *Vitis vinifera* L., cover crop, nutrient dynamics, plant nutritional analysis

Introduction

Vineyards at semiarid regions in Europe are increasingly grown under irrigation. Many of those regions receive in winter and spring enough rainfall to maintain soil water at non-limiting levels till the beginning of summer, when rainfall is scarce. As a consequence, those vineyards experience a very intense vegetative growth in spring, since there is neither water nor temperature limitation in that period, and when summer deficit appears. Vineyards are usually irrigated till veraison, when irrigation is highly reduced or frequently finished (in some Appellations d'Origine irrigation after veraison is banned). This often results in vineyards with shoot vigour, berry size and yield higher than desired to obtain high quality grapes. In earlier works we have shown that the introduction of a new management strategy consisting on combining Regulated Deficit Irrigation with a cover crop that limits spring growth results in an considerable increase in quality (Santesteban *et al*., 2005; Santesteban and Royo, 2004)

This new management strategy improves water availability control, since irrigation allows promoting plant activity at certain moments whereas the competence of the cover crop allows decreasing it at other moments. Nevertheless, this strategy also implies a modification of other important aspects in the vineyard, since the cover crop affects soil physical, chemical and biological characteristics (Caspari *et al.*, 1993; Maigre, 1996; Pieri *et al*., 1999; Reinecke *et al.*, 2002), reduces growth and yield (Caspari *et al.*, 1993; Maigre 1996; Pieri *et al*., 1999) and increases the competence for nutrients (Maigre, 1996; Rodriguez-Lovelle *et al*., 2000). The combination of these effects makes it necessary to reconsider fertilising practices, which requires analysing the plant nutrient dynamics under this new strategy. The aim of this work is to compare the nutritional status of conventionally managed vines with others managed combining cover crops and regulated deficit irrigation.

Material and methods

The experimental work was performed in a commercial vineyard located in Traibuenas, Southern Navarre, Spain (42º22'N; 1º37'W; 340m asl), a region of semiarid climate (*Bs type* in Koppen's classification; P <350 mm; ETP_{Penman}> 1150 mm). The vineyard is planted with 'Tempranillo'/110Richter scion/rootstock combination; the training system is double-cordon, with inter-row spacing of 3 m and in-row of 1 m. Bud load was fixed to 3 spurs of 2 buds/plant. Soil characteristics prior to the beginning of the experiment are summarized in table 1.

The most common strategy for vineyard management in Spanish irrigated vineyards (**Ctrl**, mechanical tillage + moderate irrigation ended at veraison) was compared to an alternative system **(CovC)** that includes the introduction of spontaneous flora as a cover crop and water management according to RDI (as described in Santesteban *et al.*, 2005). In both treatments, the area under the vines (0.7 m approx) was maintained free of vegetation using chemical tillage. Cover crop was established in 2003, when vines were 5 years-old. In order to accelerate the development of spontaneous vegetation, the first year, 30 units of mineral N were applied on soil surface in CovC area Afterwards, in both treatments the same fertilization program was followed (30 N, 60 P and 100 K units/ha)

The evaluation of the effect of vineyard management strategy on nutritional status started in 2004, when the cover crop was already well established. Samples of blades, petioles and berries were analysed from fruitset to harvest every 7-14 days and the concentration of macronutrients (N, P, K, Ca and Mg) was measured. Vegetative growth was monitored weekly from early June, measuring basal diameter of all the shoots of each vine. At harvest, yield, berry size, and berry number per plant were measured. Nutrient analyses were made on 3 replicate samples from 10 vines per treatment, whereas for the remaining experimental controls, 6 replicates of 10 vines were used.

Results and discussion

The evolution of mineral contents in blades, petioles and berries from each management strategy is represented in figure 1. Table 2 includes vegetative and reproductive growth values measured at the most representative moments in the growing season.

Nutrient levels and evolution (figure 1) agree with that reported as normal in literature for blades and petioles (Fregoni, 1998; González Andrés and Berberana, 2002; Loué, 1990), although K levels are usually on the lower side of the reported range. Nutrient levels and evolution in berries also are similar with those reported by Esteban *et al.* (1999) in Tempranillo.

CovC vineyard management strategy has modified clearly vine nutrient dynamics (figure 1). In 2004 fruitset, control vines showed higher N, P and Ca values either in blades and petioles, but this differences decreased as the season progressed, and only lasted till harvest for Ca. Next year, control vines only showed higher levels for Ca, whereas for P they were similar to CovC vines, and for N both treatments showed no differences at fruitset, and CovC vines had higher values at harvest. This trend of CovC vines to progressively reduce initial differences in nutrient status and reach, or even outcome, those values shown in Control vines can also be seen for Mg, for which both years values at fruitset were similar in both treatments and at harvest higher in CovC vines and, particularly for K, that was higher in blades and petioles from fruitset of 2004, just after the year of cover crop establishment.

The presented results show clearly that CovC strategy has not implied a reduction in nutrient levels but, on the contrary, it has improved plant nutritional status. This behaviour is a result of the higher impact that the lower growth and yield obtained with CovC (table 2) has had on nutrient needs than that of the competence of cover crop for nutrient uptake. This effect has been particularly clear and precocious for K, that as it has been mentioned above was the nutrient for which levels in leaves were more limited in this vineyard especially when Tempranillo is grown, since this variety is known to be very demanding for K that accumulates in berries (figure 1) and that normally produces musts with K contents over 2 g/L.

The observed improvement in fertility will probably be higher at mid-term as a consequence of the effect of the cover crop increasing soil organic matter content, improving soil structure and enhancing biological activity as reported in literature (Ingels and Klonsky, 1998).

Conclusion

The presented results show that introducing an strategy combining RDI and cover crop at semiarid climated does not imply an increase on nutrient needs of the vineyard, but on the contrary results in a better nutritional status due to the lower growth and yield of the plants that results in lower needs and overcompensates the cover crop competence for nutrients.

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Figure 1 - Effect of vineyard management technique on the evolution of mineral content of blades, petioles and berries in years 2004 and 2005

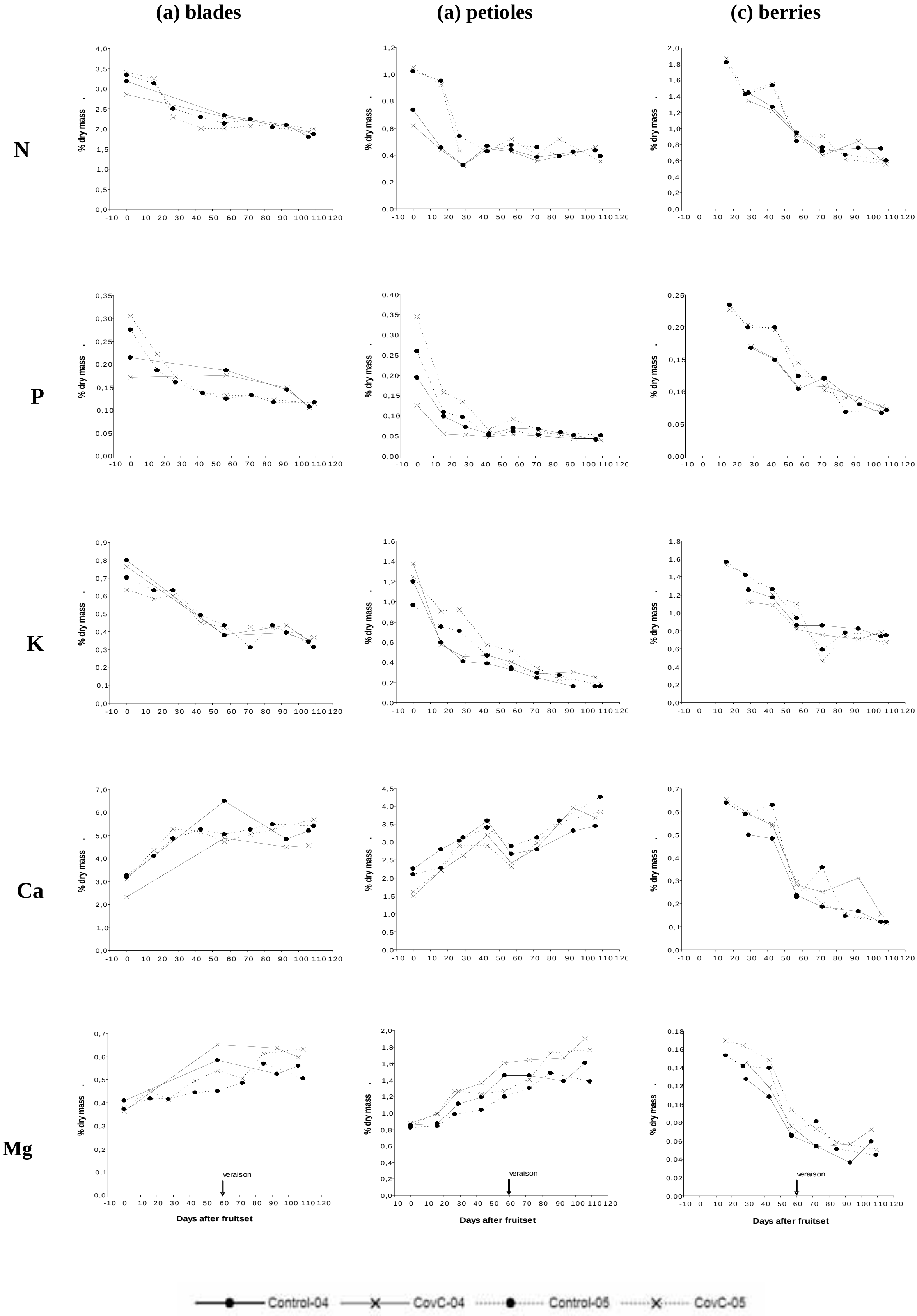

Table 1 - Soil characteristics at the vineyard at the beginning of the experiment

	topsoil (0-30 cm)	subsoil (30-70 cm)
Sand (%)	58,7	56,4
Silt (%)	21,4	30,4
Clay (%)	20,0	13,2
N (g/100g)	0,65	0,27
P (mg/kg)	6,6	4,9
K (mg/kg)	113	74,9
Mg (mg/kg)	42	36,4
Org. matter (g/100 g)	1,19	0,61
pH (water)	8,3	8,4
EC (dS/m)	0,19	0,18
Carbonates (g/100g)	22,3	31,3

Table 2 - Vegetative and reproductive growth of vines at each vineyard management strategy

		Sum of shoot basal area (mm^2/plant)			Berry total fresh mass (g/plant)		
year	treat.	fruit set	veraison	harvest	f.set+15	veraison	harvest
2004	Control	1161	1351	1073	736	4446	5442
	CovC	946	1117	927	386	2545	3316
2005	Control	898	884	871	564	2625	3984
	CovC	805	760	813	400	1831	2804