

NUTRIENTS AND HEAVY METALS IN A VINEYARD SOIL UNDER ORGANIC, BIODYNAMIC AND CONVENTIONAL MANAGEMENT

Authors: Raffaella MORELLI*, Roberto ZANZOTTI, Daniela BERTOLDI, Enzo MESCALCHIN

Fondazione E. Mach-Technology Transfer Center, via E. Mach 1, San Michele all'Adige (TN)-38010 Italy

*Corresponding author: raffaella.morelli@fmach.it

Abstract:

Context and purpose of the study – Promoting sustainable agricultural practices is one of the challenges of the last decades. Organic and biodynamic viticulture can be an alternative to intensive viticulture, furthermore contributing to reduction of impact on environment and human health and guaranteeing soil preservation and quality products¹.

The aim of this experimentation was to evaluate the medium and long-term effects of different agronomic practices in viticulture on nutrient availability and heavy metal accumulation in soil.

Material and methods – In 2011 an intensive vineyard in north-eastern Italy (Trentino) was subjected to three different managements: integrated pest management (IPM), organic management (OM) and biodynamic management (BM). The experimental vineyard (1.5 ha) was divided in twelve plots, four per management with a randomized scheme. BM plots were subjected to green manure between alternate rows (BM+GM). Every autumn, from 2012 to 2018, soil was sampled in four repetitions per management. Air dried soils were analyzed. Exchangeable K and Mg (extraction in 1 M ammonium acetate pH 7 for 1 hour – 1:20 p/v) and bioavailable heavy metals (extraction in DTPA/CaCl₂/TEA pH 7.3 for 2 hours – 1:2 w/v) were determined with ICP-OES. TOC and total N were analyzed with elemental analyzer and assimilable P with Olsen method². Statistical analysis were performed using the RStudio software.

Results – Exchangeable K is the nutrient that exhibited mainly significant differences ($P < 0.001$) among the managements. In detail, OM and IPM showed on average the highest values, proving that manure is a good supplier of K, which is a promoter of photosynthesis³, is involved in sugar translocation from leaf to fruit^{3,4} and plays an important role in determining the size of the berries, influencing the final yield of crop⁴. The lower values in biodynamic managements (BM and BM+GM) were due to lack of K supply. Total N did not show significant differences among the three managements. This result highlights how organic manure and leguminous plants of green manure provide enough nitrogen for the crop needs, as well as conventional practices. Bioavailable heavy metal content was similar among the managements. Although Cu was used (<5 kg/ha) during the whole experimentation on all the plots, it was not found an increase of the bioavailable concentrations in the years, as expected for the accumulation of this metal in soil. The high Cu content in the soil, due to the abuse of this fungicide in the past decades, means that its use at the doses allowed by current regulations does not cause a significant increase in soil concentrations. These results valorize organic and biodynamic practices, being more compatible alternatives to protection of environment and human health than conventional viticulture.

Keywords: Vineyard, organic and biodynamic viticulture, soil, nutrients, heavy metals.

1. Introduction



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R. MORELLI*, R. ZANZOTTI, D. BERTOLDI, E. MESCALCHIN

Technology Transfer Centre, Fondazione Edmund Mach, via E. Mach 1, 38010 San Michele all'Adige, Italia

* corresponding author: raffaella.morelli@fmach.it

Context and purpose

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Results and conclusion

Exchangeable K is the nutrient that exhibited mainly significant differences (P<0.001) among the managements. In detail, OM and IPM showed on average the highest values, proving that manure is a good supplier of K, which is a promoter of photosynthesis³, is involved in sugar translocation from leaf to fruit⁴ and plays an important role in determining the size of the berries, influencing the final yield of crop⁵. The lower values in biodynamic managements (BM and BM+GM) were due to lack of K supply. Total N did not show significant differences among the three managements. This result highlights how organic manure and leguminous plants of green manure provide enough nitrogen for the crop needs, as well as conventional practices. Bioavailable heavy metal content was similar among the managements. Although Cu was used (<5 kg/ha) during the whole experimentation on all the plots, it was not found an increase of the bioavailable concentrations in the years, as expected for the accumulation of this metal in soil. The high Cu content in the soil, due to the abuse of this fungicide in the past decades, means that its use at the doses allowed by current regulations does not cause a significant increase in soil concentrations.

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Agricultural practices	IPM	OM	BM/BM+GM
Chemical weed control (row)	x		
Mechanical weed control (row)		x	x
Mechanical weed control (between rows)	x	x	x
Mineral fertilization (NPK 12:12:17)	x		
Organic manure (biannual)		x	
Green manure (between alternate rows)			x
Biodynamic preparations (500 and 501)			x
Fungicides	x		
Fungicides allowed in organic farming (Cu < 5 kg/ha per year)	x	x	x



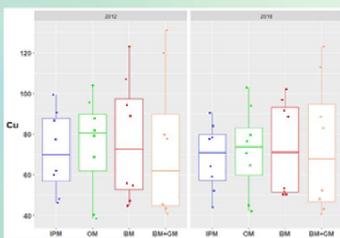
SOIL CHARACTERIZATION	Mean ± σ
Texture (USDA)	LOAM
pH	7,9 ± 0,1
Total carbonates (g/kg CaCO ₃)	11 ± 86
Active carbonates (g/kg CaCO ₃)	475 ± 1
CSC (meq/100 g)	14 ± 2



Principale Component Analysis on nutrients. Factor "Management".

Variables	Factor "Management"
K	***
Mg	*
P	**
N	NS
OM	NS
Cu	NS
Fe	NS
Mn	NS
Zn	NS

Kruskal-Wallis Rank Sum Test (α=0.05).
NS no-significant; * P<0.05; ** P<0.01; *** P<0.001



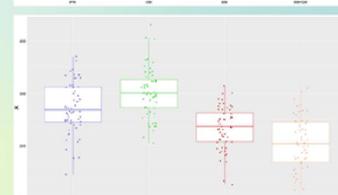
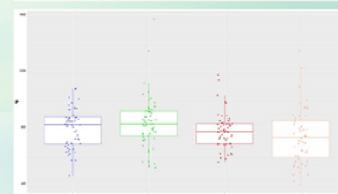
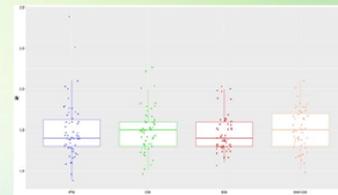
Box plots and jitter plots per management, start-end experimentation.

	IPM	OM	BM
OM	NS		
BM	***	***	
BM+GM	***	***	NS

	IPM	OM	BM
OM	NS		
BM	**	NS	
BM+GM	NS	NS	NS

	IPM	OM	BM
OM	NS		
BM	NS	NS	
BM+GM	NS	**	NS

Dunn's Test, Bonferroni adjustment (α=0.05).
Factor "Management". Reject H₀ if P ≤ α/2.



NPK box plots and jitter plots per management.

References

- Villanova-Rey P., L'Vázquez-Rowe L., Morela M.T., Feliso G. (2014) Comparative life cycle assessment in the wine sector: biodynamic vs. conventional viticulture activities in NW Spain. *Journal of Cleaner Production*, 65: 330-341.
- Decreto del Ministero per le Politiche Agricole of 13/9/96 in the file of "Ambiente - inquinamento e tutela del suolo e del sottosuolo - Difesa" published on Gazzetta Ufficiale n° 248 Dada, Suppl. n° 185 of 21/10/1996.
- Larsson R., Le Corre C., Ammassari R., D'Addato-Chessa F., Albaria T., Piarou N., Bonnemain J.L., Lohi M., Cautin-Thivest P., Mouroulet L., Fischer M., Grousseau C., Lemoine P., Parrilla J., Durand M. (2013). Source-to-sink transport of sugar and regulation by environmental factors. *Frontiers in Plant Science*, 4: 272.
- Rogers S.T., Cortez Z.A., Walker R.R., Deloire A., Tyrerman S.D. (2017). Potassium in the Grape (*Vitis vinifera* L.) Berry: Transport and Function. *Frontiers in Plant Science*, 8: 1829.