COVER CROPS AND COMPOST AMENDMENTS FOR ORGANIC GRAPE PRODUCTION

Ron Walser[1], Milagra Weiss[2], Steve Guldan[3], April Ulery[4], and Robert Flynn[5]
New Mexico State University
[1]Extension Urban Small Farm Specialist, Los Lunas Science Center; [2]Student, Dept of Plant & Env'l Sci.; [3]Professor and Superintendent, Alcalde Ag Science Center; [4]Associate Professor, Dept of Plant & Env'l Sci.; [5]Associate Professor and Extension Soil Scientist, Artesia Ag Science Center.

ABSTRACT

Increased costs of fertilizers that rely on petroleum products coupled with increased pest control and transportation costs has prompted more management practices that can make use of local waste products and utilize cover crops to reduce purchased inputs. A burgeoning wine industry could benefit from organic production techniques; however, their effects on vine growth and grape quality have not been explored in New Mexico. Alternative vineyard floor management systems were evaluated for organic grape production at the Alcalde Sustainable Agriculture Science Center in Alcalde, NM, from 2003 to 2006. Grape yield and vegetative biomass were compared between plants grown with and without compost and cover crop. Soil and leaf tissue analyses were performed yearly to monitor changes in soil fertility and chemistry. Addition of compost to vineyard soils provided adequate mineral nutrition, with the exception of plant available potassium; though vegetative growth may have been excessive. A combination of cover cropping and compost addition supported adequate grape yield; however, soil and plant mineral nutrition were varied. The use of cover crops in vineyards must be carefully managed to avoid mineral nutrition competition and to obtain consistent effects.

INTRODUCTION

As wine grape production increases in acreage throughout the western United States, it is important to pursue good soil management practices to protect soil and water natural resources. Grapes have relatively low nutritional needs and therefore are well suited to marginal soils, including those with calcareous characteristics (Winkler, et al., 1974; Pongracz, 1978). Though wine of better quality is produced in soils with low fertility, additions of nitrogen, potassium, zinc, magnesium and boron are often necessary for acceptable yields (Winkler, et al., 1974; Mullins, 1992; Christensen, 2005). Recent investigations in areas of intensive viticulture in Germany have found high nitrate contents in well water, exposing excessive fertilization regimes (Schaller, 2000). Organic soil nutrient management practices, including the use of slow release fertilizer sources such as compost and perennial leguminous cover crops provide a possible alternative to conventional fertilizer regimes for ecologically based vineyard management.

Beyond nutritional needs, vineyard soils should have good physical and biological properties for consistent yield and longevity of the vines (White, 2003). Increased organic matter content of soils is probably the most well documented benefit of the use of both compost and cover crops, making these amendments highly desirable for vineyard management (Hirschfelt, 1998; Pinamonti, 1998; Ingels, et al., 2005). Additional benefits of compost and cover crops for marginal soils include: cleaner fruit due to vegetative ground cover, erosion control, increased water penetration and retention, and decreased soil evaporative losses (Winkler, et al., 1974; Hirschfelt, 1998; Pinamonti, 1998; Ingels, et al., 2005).

The use of cover crops in vineyards has shown varying levels of practicality in other studies, as cover crops may cause yield reductions due to competition for mineral nutrition and water (Hirschfelt, 1998; Ingels, et al., 2005; Krohn, et al., 2005; Smart, et al., 2006). Cover crops have sometimes been shown to improve wine quality, though quality decreased in instances where high nitrogen green manure mixes caused excessive vegetative growth (Ingels, et al., 2005). A perennial leguminous ground cover as used in this study provides nitrogen over time while avoiding competition with the vine for nutrients (Hirschfelt, 1998).

MATERIALS AND METHODS

Plant Material and Cultural Conditions

In April of 2002, own-rooted Leon Millot hybrid grapes were obtained from Double A Vineyards, Inc., of Fredonia, NY, and planted at the New Mexico State University Sustainable Agriculture Science Center in Alcalde, New Mexico. The grapes were planted bare-root into a Fruitland sandy loam soil (coarse-loamy, mixed, superactive, calcareous, mesic Typic Torriorthents). Initial soil test results are given in Table 1. Plants were subsequently trained into bilateral cordons on one-wire trellising. Plants were arranged in three rows of sixteen plants each on ten foot centers with six foot spacing between plants. Irrigation was provided as needed by under canopy, solid-set micro-sprinklers with average irrigations of one-half inch of water. Shoots were bottom-trimmed by hand when more than 2 feet below the cordon.

The rows were divided into four plots each, with four plants in each treatment plot. The two treatment variables were compost application to the rooting zone and cover cropping of the vineyard floor. The four experimental treatments were: with compost/with cover crop, without compost/without cover crop, with compost/without cover crop and without compost/with cover crop. New Zealand white clover (*Trifolium repens L.*) was seeded in May 2002 at fifteen pounds per acre in the treatment plots with cover crop. The cover crop was mowed four times throughout the growing season. Compost was produced in 2001 from mixing 30% horse manure and 70% chopped alfalfa (Table 2). Compost was initially applied in May 2002, at a rate equivalent to 4.345 tons per acre (dry weight basis) to the area extending one foot on each side of the plant base. The compost was reapplied in November of each subsequent year at the same rate. Treatment plots without cover crop were kept vegetation-free by machine tilling between rows and hand hoeing between plants.

There were no insect pests or pathogens that affected grape yield; however, birds caused some damage in the 2004 season. Bird nets were used in the 2005 and 2006 seasons to protect yield.

Measurements

Yield, plant growth and leaf nutrient analysis data were recorded from the second and third plants of each plot. Fruit yield was measured as the total weight of grapes harvested from the two plants. Plant growth was measured as the weight of all biomass removed during winter spur pruning. Soil subsamples were collected in the fall of each growing season using a soil auger to a depth of twelve-inches in a one-foot radius surrounding the second and third plants of each treatment plot and pooled for analysis. Twenty representative leaves from each plot were collected mid-summer, during the initiation of fruit set and oven-dried for tissue analysis.

Soil and tissue analyses were performed by A&L Plains Agricultural Laboratories of Lubbock, TX. Methods are described in detail in Gavlok et al., 2003. Soil Nitrate was measured using an ISE meter on an aluminum sulfate extraction, phosphorus by the Bray method and potassium, magnesium, calcium and sodium by ammonium acetate extraction. Soil trace elements, iron, manganese, copper, and zinc, were measured by DTPA extraction. Boron was extracted with hot water. Soil pH was measured on a 1:1 soil:water (w/w) extract. Soil organic matter was found colorimetrically. Soil electrical conductivity was measured on a 1:2 soil:water extract. Compost total nitrogen was measured by combustion. Compost phosphorus and sulfur were measured colorimetrically after perchloric acid digestion. Compost potassium, magnesium, calcium, sodium, iron, copper and zinc were measured by atomic absorption spectroscopy after perchloric acid digestion. Organic matter content of the compost was measured by combustion. Plant available nitrogen was measured in plant tissue using automated combustion on a LECO 528 auto-analyzer. Phosphorus, potassium, magnesium, calcium, sodium, sulfur, zinc, manganese, iron, copper, aluminum and boron in plant tissue were measured by atomic absorption spectroscopy after perchloric acid digestion.

Testing for calcium carbonate content by manometric determination of CO_2 released after acid addition and decomposition of carbonate, was performed on soils in 2006, at New Mexico State University.

Table 1. Initial soil test values for study site.

Parameter		2002
Nitrogen (Nitrate ppm)		1
Phosphorus	Weak Bray (ppm)	30
	Strong Bray (ppm)	152
Potassium (ppm)		290
Magnesium (ppm)		197
Calcium (ppm)		3191
Sodium (ppm)		112
Sulfur (ppm)		5
Zinc (ppm)		0.4
Iron (ppm)		4
Manganese (ppm)		6
Boron (ppm)		0.8
Soil pH		8.4
Organic Matter (%)		0.5
Electrical Conductivity (mmohs/cm)		0.3

Table 2. Characteristics of compost (dry weight basis).

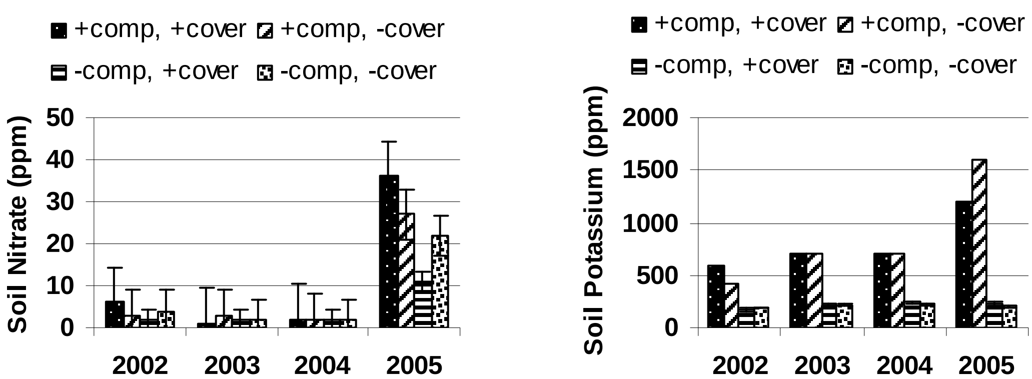
Parameter	2003	2006
Nitrogen (%)	0.040	
TKN (%)		0.360
Org-N (%)		0.360
Phosphorus (%)	0.130	0.089
Phosphate (%)	0.300	0.236
Potassium (%)	0.940	0.670
Potash (%)	1.130	0.922
Sulfur (%)	0.060	0.079
Magnesium (%)	0.460	0.270
Calcium (%)	2.000	1.699
Sodium (%)	0.080	0.030
Iron (ppm)	11588.0	9483.0
Manganese (ppm)	173.0	166.0
Copper (ppm)	11.0	7.9
Zinc (ppm)	43.0	29.6

RESULTS AND DISCUSSION

Nutrient sufficiency levels were compared against those established by Christensen (2005) for plant tissue testing. There was variability throughout time for nitrate levels measured in the vineyard soils; however, plant available nitrogen remained at acceptable levels for all years and treatments (Figs. 1A, 2A). Soil phosphorus was strongly influenced by the addition of compost to treatment plots and was not deficient in plant tissue analysis. Though enhanced by compost treatments, plant available potassium was insufficient in all treatments (Figs. 1B, 2B). Soil zinc increased significantly in the treatment with compost and cover crop, and was plant available for all treatment levels. Though soil boron increased significantly for both treatments with compost, it was only available in sufficient quantities in the treatment with both compost and cover crop (Figs. 3, 4).

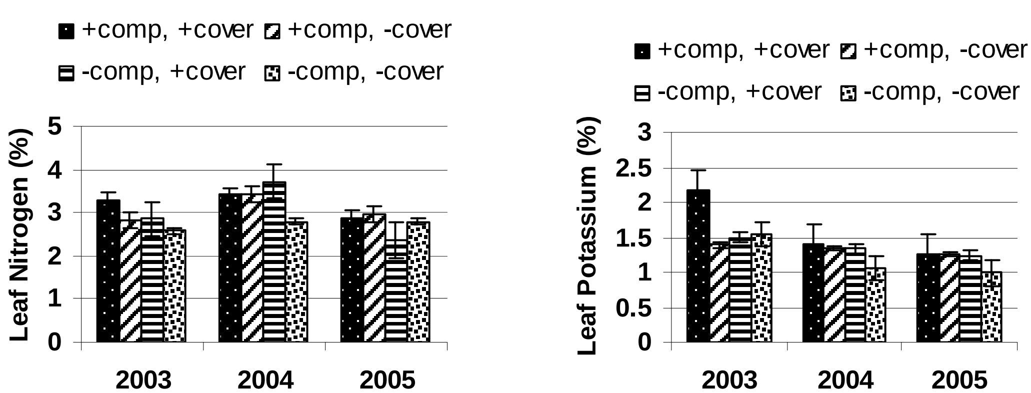
Organic matter significantly increased in soils where compost was applied (Fig. 5). Salinity, as measured by the electrical conductivity of vineyard soils increased with the addition of compost, however, all soils remained below 1 dS/m. Thus, annual additions of the compost used in this study did not pose a salinity hazard to this vineyard soil. Calcium carbonate content was between 3.5 and 4.5 % for all plots and variability in carbonate content or iron chlorosis was not correlated with different soil treatments.

In any given year, there was no significant difference in yield among treatments (Fig. 6). However, the treatment with compost only exhibited the greatest annual vegetative growth, lowering the yield-to-biomass ratio, indicating excessive growth (Fig. 7). The vegetative growth of the compost and cover crop treatment varied over time; cover crops require nutrition in addition to the grape plants which would reduce the proportion of nutrients available to both plants for growth and development compared to grape plants only.



A **B**

Figure 1 (A, B). Soil macronutrients over time. Soil K was not quantified above 700 ppm for 2003 and 2004. In all figures (1-7) the error bars indicate the standard error of the mean of 3 repetitions for each treatment



A **B**

Figure 2 (A, B). Plant available macronutrients over time.

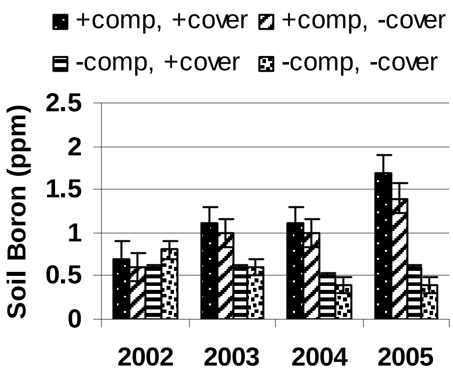


Figure 3. Soil Boron over time.

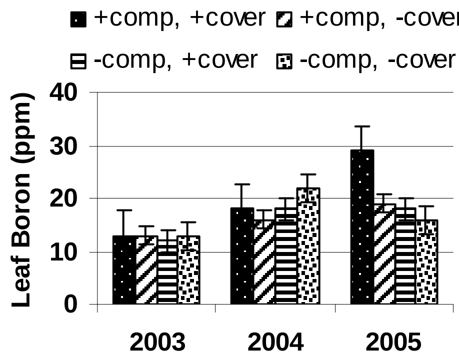


Figure 4. Plant available Boron over time.

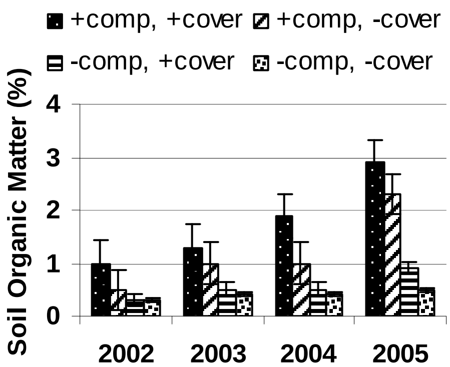


Figure 5. Organic Matter content of vineyard soils over time.

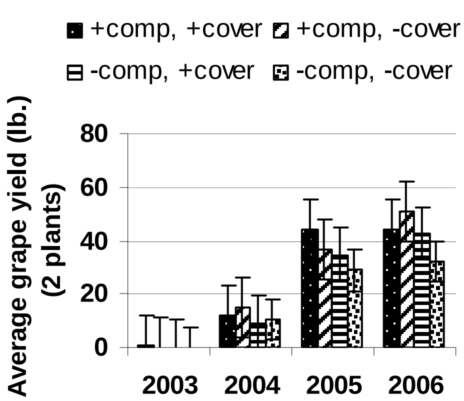


Figure 6. Grape yield over time.

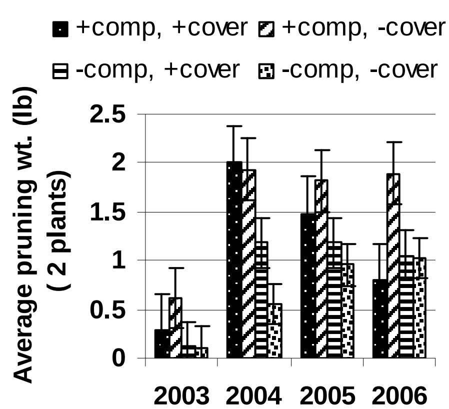


Figure 7. Pruning weight over time.

SUMMARY AND CONCLUSIONS

The use of compost and/or cover crops will significantly increase the organic matter content in vineyard soils over time. The use of these amendments is particularly well-suited to the goals of organic viticulture in that the increased organic matter content of the soil may encourage more efficient water use, provide for a more biologically active soil profile and create a greater nutrient holding capacity. Further, the use of low rates (~4 tons/acre) of compost was found to be generally effective in providing sufficient mineral nutrition for grape production. Compost may be produced inexpensively with locally procured materials, including agricultural waste products, thereby decreasing production costs for the viticulturalist.

Leguminous cover crops, when used as perennial mulch without added nutrient amendments, did not contribute significantly to soil mineral nutrition or organic matter content. However, the cover crop used in this study did not compete for nutrients to a degree that detracted from yield. Environmental benefits of cover crops, though not measured in this study, may be achieved from cover cropping without negative production effects. In addition, the use of cover crops with compost amendments will provide adequate mineral nutrition and increase soil organic matter as well as provide for ecological gains. Correlations between soil test K and plant tissue K need to be researched further to explain low plant tissue K despite high ammonium-acetate extractable soil K.

REFERENCES

Christensen, P. 2005. Use of Tissue Analysis in Viticulture. Proc. Of Varietal Winegrape Production Short Course. University of California Davis Extension.

Gavlok, R., D. Horneck, R.O. Miller, J. Kotuby-Amacher. 2003. Soil, Plant and Water Reference Methods for the Western Region. WREP 125. 2nd Edition WCC-103 Publication.

Hirschfelt, D.J. 1998. Soil Fertility and Vine Nutrition. *In:* Cover Cropping in Vineyards: A Grower's Handbook. Oakland: Univ. of Calif., Div. of Ag. and Nat. Resources. Pub: 3338.

Ingels, C.A., K.M. Scow, D.A. Whisson, R.E. Drenosky. 2005. Effects of Cover Crops on Grapevines, Yield, Juice Composition, Soil Microbial Ecology, and Gopher Activity. Am. J. Enol. Vitic. 56: 19-29.

Krohn, N.G., D.C. Ferree. 2005. Effects of Low-growing Perennial Ornamental Groundcovers on the Growth and Fruiting of 'Seyval blanc' Grapevines. HortScience. 40: 561-568.

Mullins, M.G., A. Bouquet, L.E. Williams. 1992. Biology of the Grapevine. Cambridge: Cambridge University Press.

Pinamonti, F. 1998. Compost Mulch Effects on Soil Fertility, Nutritional Status, and Performance of Grapevine. Nutrient Cycling in Agroecosystems. 51: 239-248.

Pongracz, D.P. 1978. Practical Viticulture. Cape Town: David Philip Publisher.

Schaller, K. 2000. Intensive Viticulture and its Environmental Impacts; Nitrogen as a Case Study. Acta Horticulturae. 512: 39-46.

Smart, D.R., E. Schwass, A. Lakso, L. Morano. 2006. Grapevine Rooting Patterns: A Comprehensive Analysis and a Review. Am. J. Enol. Vitic. 57: 89-104.

White, R.E. 2003. Soils for Fine Wines. Oxford: Oxford University Press.

Winkler, A.J., J.A. Cook, W.M. Kliewer, L.A. Lider. 1974. General Viticulture. Berkeley: Univ of Caliornia Press.

PROCEEDINGS

OF THE

WESTERN NUTRIENT

MANAGEMENT CONFERENCE

Volume 7

MARCH 8-9, 2007
SALT LAKE CITY, UTAH

Program Chair:
John Hart
Oregon State University
Corvallis, OR
(541) 737-5714
john.hart@oregonstate.edu

Publicity Chair:
Richard Koenig
Washington State University
Pullman, WA
(509) 335-2726
richk@wsu.edu

Coordinator:
Phyllis Pates
International Plant Nutrition Institute
Brookings, SD
(605) 692-6280
ppates@ipni.net