

Vineyard Weed Management Practices Influence Soil Nitrogen Retention

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Cultivation has been shown to reduce soil organic matter content and labile carbon pools, which are important factors in soil nitrogen (N) retention. Cultivation also causes changes in soil bulk density, effecting changes in soil porosity which can influence soil water and nutrient movement. Using herbicides for weed control instead of cultivation avoids the soil disturbance caused by cultivation. Therefore, we hypothesized that soil N dynamics would differ between these weed management practices. We also investigated the effects of the two weed management practices (i.e., cultivation and herbicide) on soil N dynamics during a fertigation event.

We tested this hypothesis in a Chardonnay vineyard planted on Teleki 5C rootstock in Greenfield, Monterey Co., CA. In the cultivated treatment ('Clemens'), the Clemens[®] vineyard cultivator was used to mechanically cultivate the vineyard rows as needed during the season (i.e. 4-6x). In the herbicide treatment ('Standard'), simazine (2.0 lbs a.i./A) + oxyfluorfen (1.5 lbs a.i./A) was applied in the winter. In summer, post emergence applications of 2% glyphosate + 0.25% oxyfluorfen were applied as needed. These treatments had been established and repeated annually four years prior to the current study as part of a separate experiment. Thus, the current study occurred during the fifth year of this original study. In November 2005, emitters on one side of each grapevines (4 total in each treatment) were plugged, leaving one emitter open on the opposite side of the grapevine. At this time, soil characteristics were characterized to a depth of approximately 1-1.5 meters. These included cation exchange capacity, exchangeable cations (X-cation) (i.e., X-Mg, X-Ca, X-K), total carbon (C) and N, bulk density, inorganic N pools [i.e., ammonium (NH₄⁺-N) and nitrate (NO₃⁻-N)], and soil texture. Anionic resin bags were inserted at 1 m depth to determine the amount of inorganic N moving through the soil profile from November 2005 to November 2006. At the conclusion of the experiment in November 2006, soil bulk density, dissolved organic C, potential soil respiration as a measure of labile C pools and inorganic N pools were measured in the soil profile. During the main fertigation event in July 2006, soil inorganic N pools, nitrous oxide (N₂O) efflux, and soil moisture were documented in the upper 20 cm of the soil profile. The vineyard was fertigated at a rate of 28.32 lbs. N per acre (UN32: 32% total N, of which was 44.3% NH₄NO₃ and 35.4% Urea). The soil type was the Elder loam with gravelly substratum (Coarse-loamy, mixed, superactive, thermic Cumulic Haploxeroll).

We found that most soil characteristics varied with soil depth, but few differences occurred between the 'Clemens' and 'Standard' treatments. Cation exchange capacity ranged between 15.1 – 17.2 cmol_c kg⁻¹. Exchangeable Mg ranged between 3.4 cmol_c kg⁻¹ and soil pH ranged from 7.6 – 7.7. The only noted difference was in total soil C, which was approximately 0.8% g C g⁻¹ in 'Clemens' and only 0.7% in 'Standard' in the upper 20 cm. Exchangeable K was greater in the upper 30 cm (ca. 0.44 cmol_c kg⁻¹) than the lower depths (ca. 0.21-0.28 cmol_c kg⁻¹, 30-105 cm). Also, total soil N decreased with depth, ranging from 0.063-0.078% g N g⁻¹ in the upper 30 cm, and 0.051-0.056% g N g⁻¹ in the lower depths (30-105 cm). Bulk density decreased with increasing depth, but did not differ between treatments. Soil texture among all depths and treatments was approximately 60% sand, 25% silt, and 15% clay.

During the fertigation event, soil gravimetric water content in the upper 20 cm decreased from 30% to 15% over three days, remaining at a similar value for the subsequent two weeks. Soil ammonium concentrations increased to 80-100 $\mu\text{g NH}_4^+\text{-N}$ during the first three days after irrigation, decreasing over the next two weeks to pre-fertigation levels, and no difference between treatments was observed. Soil nitrate concentrations were greater in 'Standard' than 'Clemens' three days after irrigation, increasing to approximately 75 $\mu\text{g NO}_3^-\text{-N g}^{-1}$ in 'Standard' and 40 $\mu\text{g NO}_3^-\text{-N g}^{-1}$ in 'Clemens'. In both treatments, these values decreased to pre-irrigation concentrations after approximately 10 days, and then showed small increases to approximately 20 $\mu\text{g NO}_3^-\text{-N g}^{-1}$, potentially due to upward movement of soil nitrate during soil drying or mineralization of urea. Nitrous oxide efflux was greater in the 'Standard' than 'Clemens'. At its greatest efflux rate after fertigation, which occurred one day after fertigation, N_2O efflux from 'Standard' was approximately 4.3 $\mu\text{g N}_2\text{O-N m}^{-2} \text{s}^{-1}$ while it was about 2 $\mu\text{g N}_2\text{O-N m}^{-2} \text{s}^{-1}$ in 'Clemens'. Nitrous oxide efflux decreased thereafter, reaching pre-irrigation values ten days after fertigation in both treatments. There were no noted changes in soil N pools and water content in soils where the emitter had been plugged.

When soil resin bags were removed in November 2006, inorganic N concentrations were greater in the 'Standard' than 'Clemens'. The resin bags in 'Standard' had collected approximately 1300 $\mu\text{g NO}_3^-\text{-N}$ while in 'Clemens' they had $<1 \mu\text{g NO}_3^-\text{-N}$, indicating that less $\text{NO}_3^-\text{-N}$ had reached that soil depth. This suggests that the 'Clemens' treatment had increased soil N retention than the 'Standard'. Preliminary estimates suggest that approximately 4-10% of the total N added to the vineyard soil during the growing season was captured by the resin in 'Standard'.

These preliminary findings suggest that weed management practices had impacts on N_2O efflux as well as soil N retention. Few differences in soil characteristics that are often linked to movement (i.e., bulk density) and retention (i.e., soil C content, DOC, labile C by respiration) of soil N were detected in the two treatments. We suggest that the increased weed biomass (K. Steenwerth, personal observation) and weed frequency (R. Smith, personal communication) underneath the grapevines in 'Clemens' captured some fraction of the fertilizer-derived N. Interestingly, it appears that the grapevines did not show any clear response to these respective weed treatments in the four years prior to this experiment (L. Bettiga and R. Smith, personal communication). In addition, total C was greater in the 'Clemens' than 'Standard', suggesting that the 'Clemens' soil may support greater soil microbial biomass, which could then immobilize relatively greater soil N within their biomass than in 'Standard'. In conclusion, the 'Clemens' treatment provided an unexpected service of increased soil nitrogen retention. Further study is required to quantify the role that weeds play in N retention, the temporal dynamics of decomposition and N release, and potential long-term effects on grapevines in the 'Clemens' system.