

LODI-WOODBRIDGE WINEGRAPE COMMISSION

FINAL REPORT: 2000-2001

Project Title: **Uptake of Cover-Crop Nitrogen by Wine Grapevines
in the Central Valley of California**

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SUMMARY OF MAJOR FINDINGS

In the first year's experiment, during the 2001 growing season, the following major findings were achieved:

1. In lysimeter studies, we found that nitrogen from cover crops is released rapidly and taken up rapidly by the grapevines.
2. The grapevines in the lysimeter study took up an average of 58% of the cover-crop nitrogen released after application, while 17% of the cover-crop nitrogen was found in the soil. This represents a high efficiency of nitrogen uptake from cover crops.
3. In field studies (Delta site, Sutter Homes Vineyard), even under a management system using drip fertigation in the berms and disking in the middles, the grapevines still took up measurable amounts of nitrogen derived from the cover crop.
4. Soil nitrogen cycling beneath a permanent clover cover-crop (Sutter site) appears to be substantially enhanced compared with cycling in a non-nitrogen-fixing cover-crop (tall grass mix). This enhanced nitrogen production increased soil and grapevine N content.

BACKGROUND

Cover crops in vineyards can provide numerous benefits, including improvements in soil structure and water-holding capacity, uptake of excess nitrate in fallow periods, weed suppression, enhancement of beneficial arthropods, improved trafficability in wet periods, and moderation of summer soil temperature and moisture (Bugg and Van Horn 1998). A potential additional benefit of legume cover crops is their capacity to "fix" nitrogen from the atmosphere, and convert it into a usable chemical form. Through decomposition of leaf litter and N release from the legume hay after mowing, nitrogen-fixing cover crops can provide a net input to the soil N budget. Over time, site productivity will be enhanced. In a vineyard, this means that grapevine N demand can potentially be substantially met by application of legume cover crops such as clover, vetch, peas, and beans.

The effectiveness of cover crops as a source of nitrogen depends on the interaction between nitrogen release from the cover crop, and nitrogen uptake and use by the grapevine. The critical period when cover-crop N is needed by the vines is during rapid growth, after bud break and before veraison. Christiansen and coauthors (1998) recommended that conventional fertilizer be applied anytime from bud-break (or after frost), until fruit-set.

The overall goal of this research project is to determine the timing of N release from cover-crop sources after mowing, and the pattern of uptake of N by the grape vines during the growing season, under current vineyard management practices.

EXPERIMENTAL DESIGN

Beginning in January, 2001, we grew the cover-crop mix in the Environmental Horticulture greenhouses at UC Davis, irrigating either with a ^{15}N -depleted fertilizer, or with unlabeled fertilizer. The cover-crop mix consisted of 23% common vetch, 22% 'Lana' woollypod vetch, 20% bell bean, 20% 'Cayuse' oats, and 15% Austrian winter pea.

Experiment 1: Lysimeter Studies

Lysimeter studies were established in parallel with the field studies (see below), under shade cloth in the Department of Environmental Horticulture. On April 25 we planted fifteen Chardonnay vines (C-5 rootstock, from Duarte Nursery, Hughson, CA) in lysimeters filled with soil collected from the Delta Ranch vineyard. On May 23, three cover-crop treatments were applied: 1) ^{15}N -depleted cover crop, 2) unlabeled cover crop, and 3) no cover crop. Grape leaf samples were taken every two weeks throughout the summer and dried, ground, and prepared for analysis.

In September, all the vines from the lysimeters were harvested and separated into leaves, shoots, vines, and roots. Dry weight, total N and ^{15}N analyses were carried out.

Experiment 2: Field Trials

Eight field plots were established in a vineyard of Chardonnay grapevines on C-5 rootstock, in Sutter Home's Delta Ranch. The vineyard is managed with alternating cover crop and "weed" middles and is drip-irrigated. Plots were set up as detailed in the Progress Report, August, 2001. On April 4, 2001, all of the field-grown cover crop in the eight plots was removed by mowing and raking. On April 7, the cover crops grown at UCD were harvested and incorporated in the appropriate experimental plots by tilling. There were 2 treatments: ^{15}N -depleted cover-crop (CC15ND); and cover-crop without any label (CCNL).

Grape leaf sampling was carried out on a biweekly basis for ten weeks and then monthly thereafter. Grape leaves were dried, and the ground tissue was analyzed for N content and nitrogen isotope ratio ($^{15}\text{N}/^{14}\text{N}$) by mass spectrometry.

Experiment 3: Perennial Clover Cover Crop

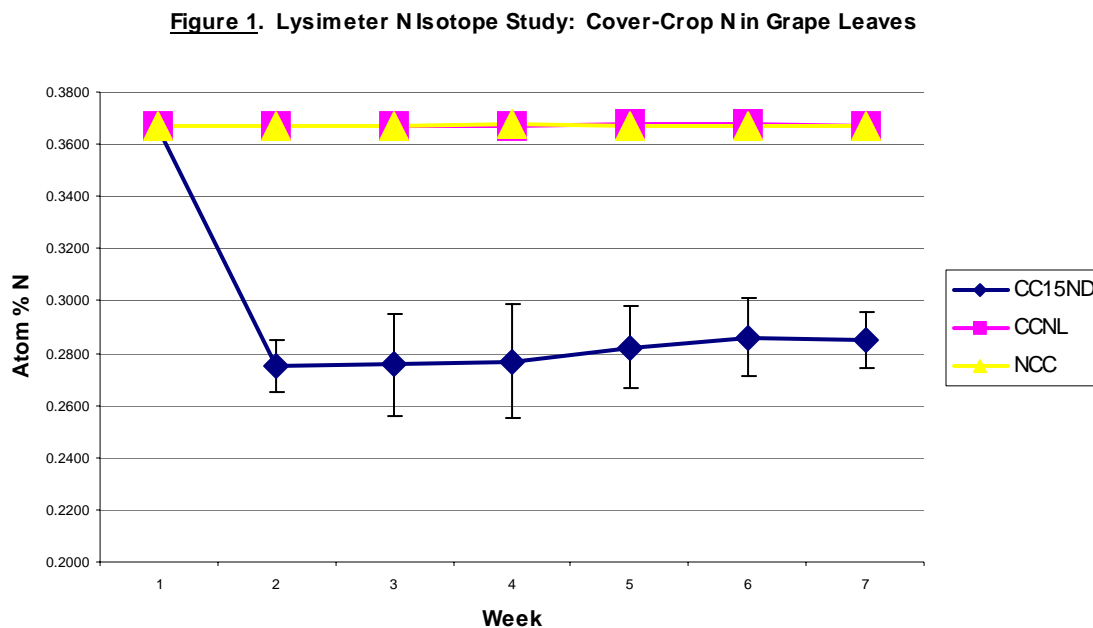
Two adjacent drip irrigated Chardonnay (1616C rootstock) vineyards in Sutter Home's Sutter Road Ranch have been managed with perennial cover crops for four years, one with a strawberry clover cover crop, the other with a 'Blando' brome cover crop. This afforded us the unique opportunity to apply and test the efficacy of ^{15}N natural abundance methods for the measurement of nitrogen dynamics in wine grapes. We established five plots in a completely random design in each of the vineyards in configurations similar to the plots in Experiment 1. Grape leaf samples were taken monthly. We also sampled the cover crop and soil in these vineyards.

EXPERIMENTAL RESULTS

1. Lysimeter Study

a. Cover-Crop Nitrogen Release and Uptake by Grapes

As shown in Figure 1, isotopically-labeled nitrogen (CC15ND) was detected in the grape leaves at the first 2-week sampling interval, indicating that there was very rapid release of cover-crop N and rapid uptake by the grapevines. Most of the nitrogen derived from the cover-crop was taken up during this first two-week period. There was no difference in isotopic ratio detected between the no-cover-crop treatment (NCC) and the unlabeled cover-crop treatment (CCNL), as we would expect.



b. Cover-Crop Nitrogen Use Efficiency by Grapevines

At the end of the growing season (14 weeks), we calculated the nitrogen in the grapevine tissue that was derived from the cover-crop, based on the whole grapevine biomass and the $^{15}\text{N}/^{14}\text{N}$ isotope ratio, using standard equations.

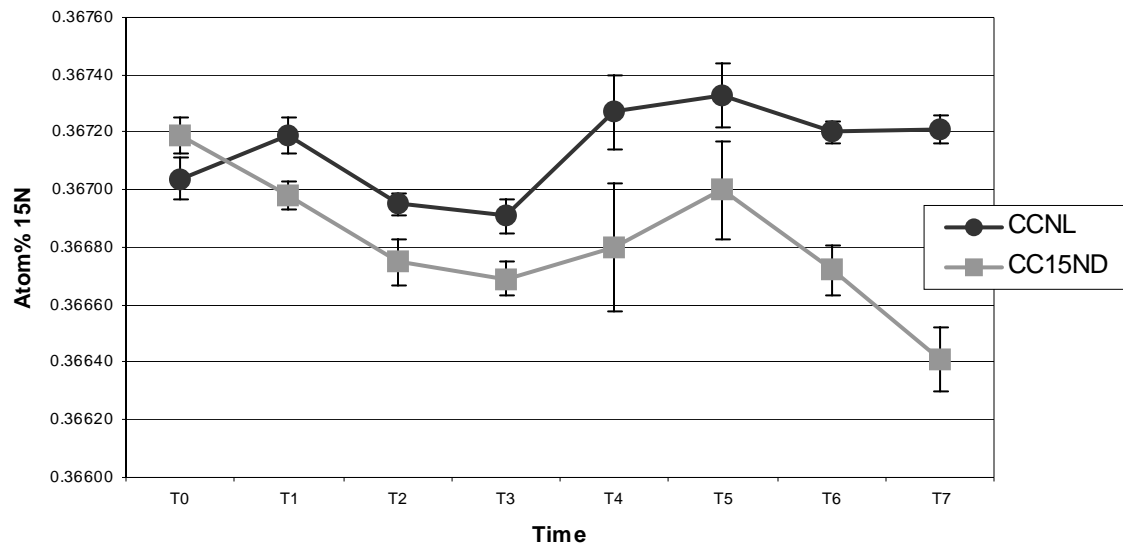
63% of the nitrogen applied as cover-crop N was released over the course of the 14-week period. **Of the cover-crop nitrogen that was released, 58% was recovered in the grapevine tissue.** This represents a very efficient recovery of cover-crop N by the grapevines. Approximately 17% of the nitrogen derived from the cover crop was recovered in the upper 15 cm of soil. The remaining 25% of the released cover-crop N

was unaccounted for, either due to leaching from the system, or loss through volatilization.

2. Field Pilot Study: Cover-Crop Nitrogen Uptake by Grapes

We observed a rapid response by grapevines to cover-crop application in the field plots. As shown in Figure 2, the grape leaves in plots receiving isotopically-labeled cover crop (CC15ND) showed a decrease in isotopic signature compared with leaves from plots where the cover crop was unlabeled (CCNL), especially during the first two weeks (T0-T1) following cover-crop application. The timing of this response was very similar to what was observed in the lysimeters.

Figure 2. Field N Isotope Study: Cover-Crop N in Grape Leaves

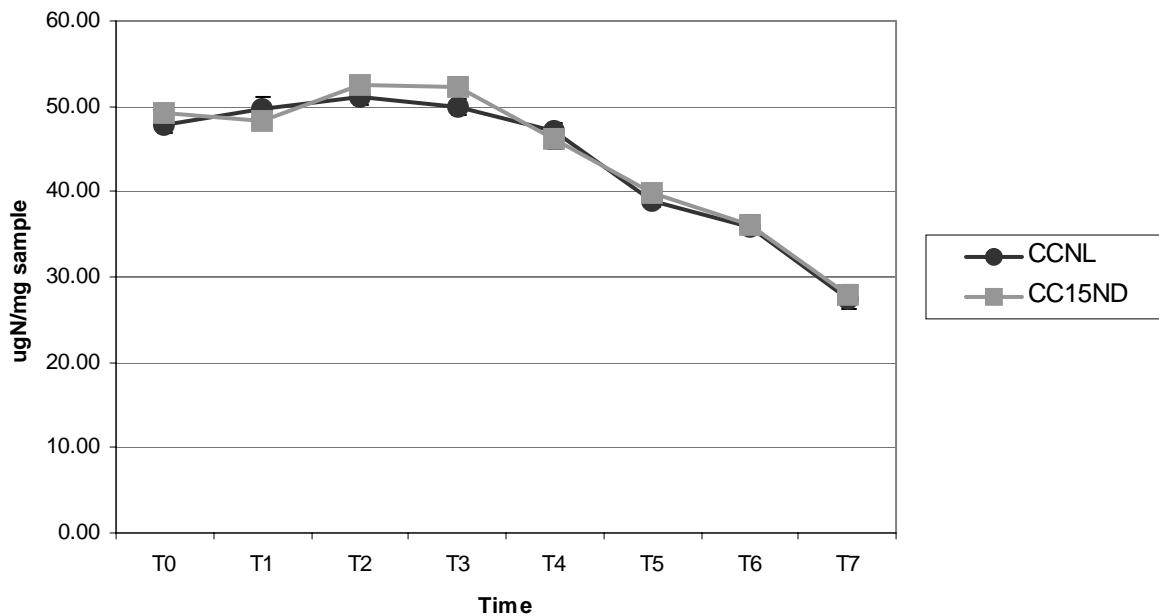


The field data were complicated, because fertilizer was applied through the irrigation lines to all the field plots between T1 and T2 (UN32 at 10 GPA), and then again between T6 and T7 (UN32 at 5 GPA). Because of the fertilizer application, we were not able to quantify the actual amount of nitrogen derived from cover-crop, as we were able to do with the lysimeter grapevines.

There appears to be a second phase of nitrogen enrichment of the grape leaves from the N pool derived from the labeled cover crop, apparent as a drop in isotope signature of CC15ND, beginning in T5. This may represent retranslocation of previously taken-up N from different plant parts, as new leaves are formed. We will continue these observations in the current season's experiments.

We also measured %N in the grape leaves over the growing season. As shown in Figure 3, there was no difference in the leaf % N between the two cover-crop treatments (CC15ND and CCNL), as we would expect.

Figure 3. Field Study: N Content of Grape Leaves



3. Permanent Cover-Crop at Sutter Ranch site

At the Sutter Ranch site, with permanent cover crops, we found the following results:

1. As shown below in Figure 4, the isotope signature of the nitrogen-fixing cover crop (clover) was markedly more negative than that of the non-fixer (Bromus) at all sampling dates, indicating a high proportion of atmospheric nitrogen, consistent with nitrogen fixation, in the clover tissue.
2. In addition, the N content of the clover leaf tissue was much higher than that of the Bromus (Figure 5) at all sampling dates.
3. The N content of the grape leaves grown in the clover cover-crop area was significantly higher than N content of grape leaves grown with Bromus, on the June and July sampling dates (Figure 6).
4. Finally, the soil N content was 20% greater in the clover-treated vineyard than in the Bromus vineyard.
5. We have not yet calculated the %N derived from N-fixation, but it is clear that the clover cover-crop is fixing substantial amounts of N.

We have data also on the $^{15}\text{N}/^{14}\text{N}$ isotope ratios of the tissues. This has proved to be of interest because the $^{15}\text{N}/^{14}\text{N}$ ratio is extremely positive in the grape leaves taken from clover plots, the opposite of what we would predict. This may indicate a high flux of N in the clover soils. However, a difference in water table between the clover and Bromus sites may also influence the isotopic signature. We are continuing work this year to understand this finding.

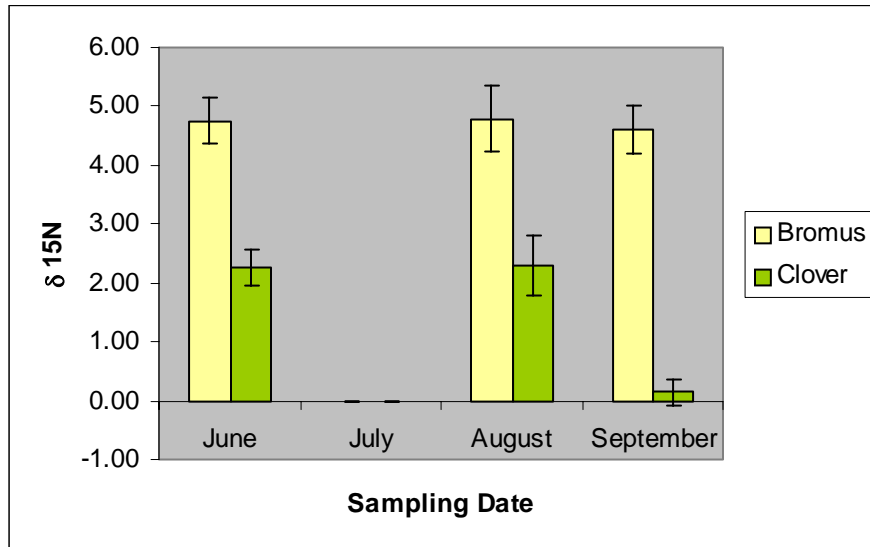


Figure 4.

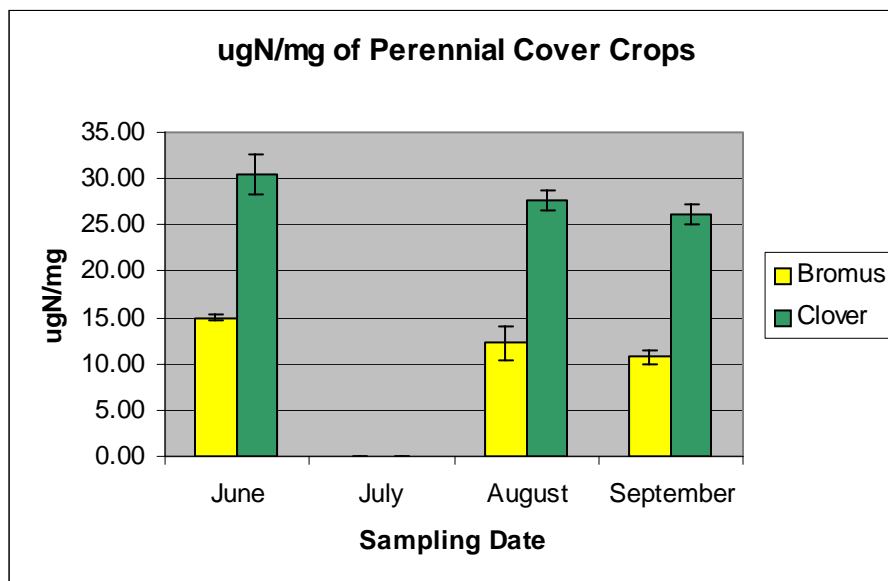


Figure 5.

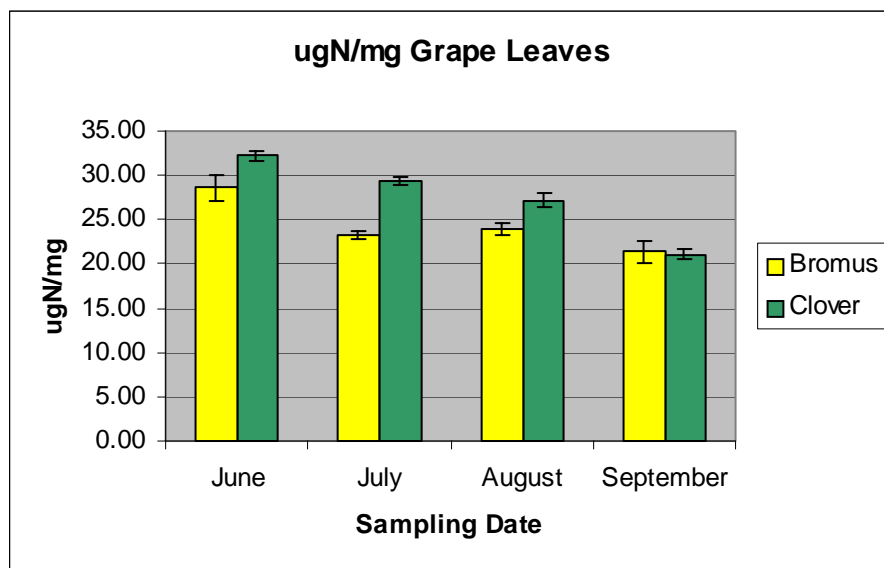


Figure 6.

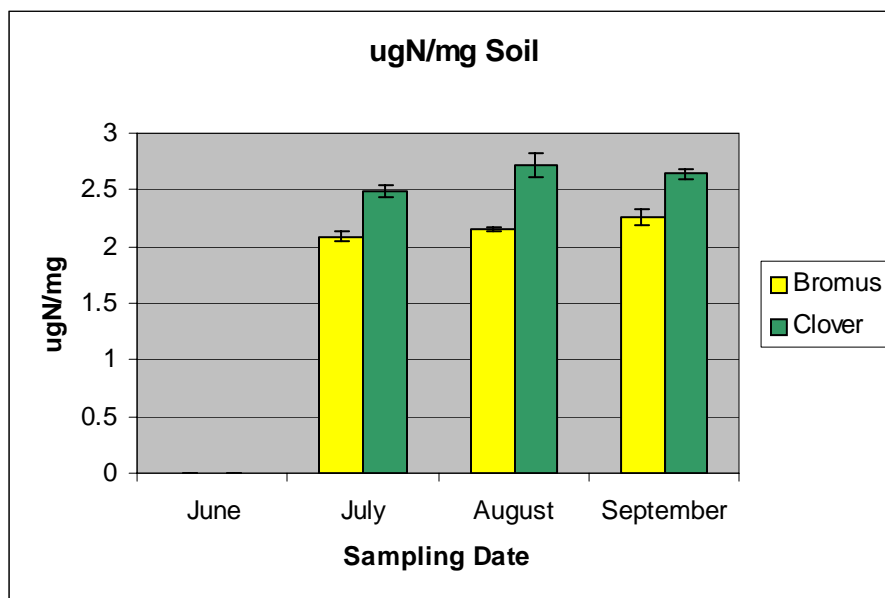


Figure 7.

PROJECT GOALS FOR 2001-2002

1. This year, we will determine nitrogen release and uptake dynamics in an unfertilized vineyard, which will allow us to make calculations similar to the lysimeter studies. This year also the experiments are expanded to include a no-cover-crop treatment in the field.
2. We will determine patterns of whole-vine nitrogen uptake efficiency and allocation in the field this year, by destructive sampling of whole vines.
3. We will estimate the nitrogen fixed by cover crop in the field and in experimental plots.
4. We have added a controlled experiment on cover-crop decomposition dynamics in the field.
5. One aspect of decomposition and nitrogen release is the form of nitrogen released. We are analyzing inorganic vs. organic N content of soil after cover-crop incorporation.
6. This year's experiment has been set up to allow us to monitor the fate of cover-crop nitrogen in soil and grapevines over a 2-year period.

References

Bugg RL and M Van Horn. 1998. Ecological soil management and soil fauna: best practices in California vineyards. In: R. Hamilton, L Tassie and P Hayes, eds. Proceedings, ASVO Viticulture Seminar, Viticultural Best Practices. Australian Society of Viticulture and Oenology, Adelaide. Pp 23-34.

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