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Leguminous Cover-Crop Residues in Orchard Soils: Nitrogen Release and Tree Uptake

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PROBLEM AND ITS SIGNIFICANCE

Cover crops in orchards can provide several benefits, including improvements in soil structure and water-holding capacity. A potential additional benefit of leguminous 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 hay, nitrogen-fixing cover crops can provide a net input to the soil N budget. Over time, site productivity can be enhanced. In an almond orchard, this could mean that tree N demand can be partially met by application of legume cover crops such as vetch. "Lana" woollypod vetch has been estimated to fix 230 lbs N/acre during a single growing season (Stivers and Shennan 1991).

There is a clear need to determine how cover-crop N is mineralized and made available to almond trees under the non-tillage, sprinkler-irrigated regimes that prevail in California. In orchard systems, soil nitrogen availability during the growing season is dependent not only on N input, but also on environmental conditions that influence decomposition and N mineralization. The effectiveness of cover crops as a source of nitrogen depends on the interaction between nitrogen release from the cover crop, nitrogen gain by the almond tree, and several types of nitrogen loss (see Fig. 1).

Nitrogen gains by almond trees. Total annual N use by almond trees is estimated to range from 80 to 130 lbs N/a (Weinbaum et al. 1992). Recent data indicate that patterns of nutrient uptake in almond trees are conditioned by patterns of organ nutrient demand (Weinbaum et al. 1984). Major periods of tree N demand are likely to occur during leaf expansion (March to mid-April), fruit (pericarp) growth (March-April) and nut fill (May through July, see Weinbaum & Muraoka, 1986).

Nitrogen losses. Loss of nitrogen by **volatilization of ammonia** from cover crops during decomposition could lead to inefficiency. **Leaching losses of nitrate** through the soil column can also be a major source of N loss, and nitrate pollution of groundwater.

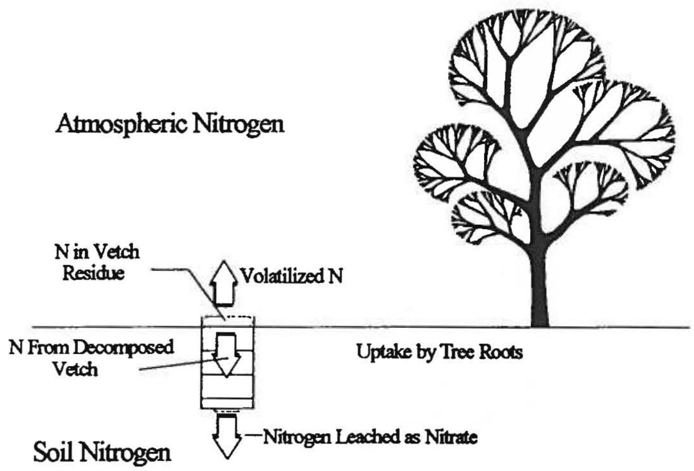


Figure 1. Gains and losses of nitrogen from vetch cover-crop hay in an almond orchard.

Over the past four years, we have answered for the first time some of the questions about the fate of nitrogen from cover-crops in almond orchard soil. With funding from the Almond Board, we have demonstrated that nitrogen is released from vetch hay rapidly, mainly during the first 2-4 weeks after the cover-crop is placed on the orchard soil; and that losses from ammonia volatilization are minimal.

PROJECT RESULTS

A. 1995-1997: EXPERIMENTS

Summary

1. Carbon and nitrogen turnover from vetch hay as a cover crop in almond orchards is usually very rapid. A major fraction of total N -- 50-75%-- is released within 2 weeks of hay application, and up to 90% by 4 weeks, if the moisture regime is adequate. This new information is critical to good management of cover crop nitrogen.

2. However, the rate of N turnover and hay biomass decomposition is proportional to irrigation and moisture regime. Slower rates of N release occurred in our experiments when no irrigation was added (20% over 2 weeks). Based on these findings, we have recommended at least one irrigation even in good rainfall years within 1-2 weeks after mowing the cover crop.

3. Ammonia volatilization was measured. Volatilization represented a small fraction of nitrogen turnover of the cover crop -- about 1% of N released during 2-3 weeks. Under typical almond orchard conditions in California, ammonia volatilization would not be expected to be a significant source of N loss during vetch cover-crop decomposition.

Nitrogen Loss Experiments

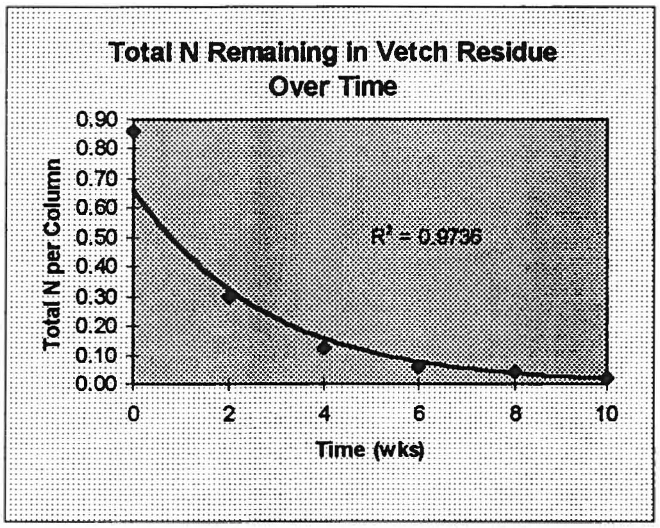


Fig. 2. Nitrogen loss from vetch hay.

As shown in Figure 2, 65-85% of the covercrop nitrogen was released during the first 2-4 weeks following hay application, in several experiments. High levels of enrichment of available N in the soil were observed in the first 2-4 weeks following hay application. After 6 weeks, the enhancement effect of the covercrop on soil available N declined, suggesting that there is a "window" of maximum availability of N for almond tree nutrition.

B. 1998-1999: NITROGEN UPTAKE EXPERIMENTS

The most important question that remains to be answered about the usefulness of cover-crops is to understand how the timing and extent of cover-crop nitrogen release in the orchard overlaps with periods when almond nutrient uptake takes place. Last year, we determined that nitrogen released from the vetch hay is taken up by the almond trees within 12 days after application.

This year, we have repeated the experiment with improved methods of consistent irrigation, and we have extended the time course. We used containerized stock of Nonpareil on Hansen rootstock, rather than bareroot. The almond trees were grown in soil columns in PVC cylinders that had been lifted from the AlmondEck orchard in Hilmar, CA, to preserve as much as possible the original soil stratigraphy. Trees were irrigated every 3-4 days, in a regime that matched tree water use. Vetch hay was applied to 3 of 6 trees on May 2, 1999, after the trees had grown in the cylinders for one month. We used 15N-enriched vetch as a source of nitrogen, which permitted us to detect and quantify the amount of leaf N that was derived from the vetch cover-crop hay.

The percent <u>n</u>itrogen <u>d</u>erived <u>f</u>rom the <u>v</u>etch (%Ndfv) was calculated, using equations adapted from Rennie & Rennie (1983) :

I. Atom percent 15N excess (enrichment)

A) atom % 15N ex = atom % 15N(sample) - atom % 15N (control)

B) T0 = 0; T14da = .2; T28da = .31

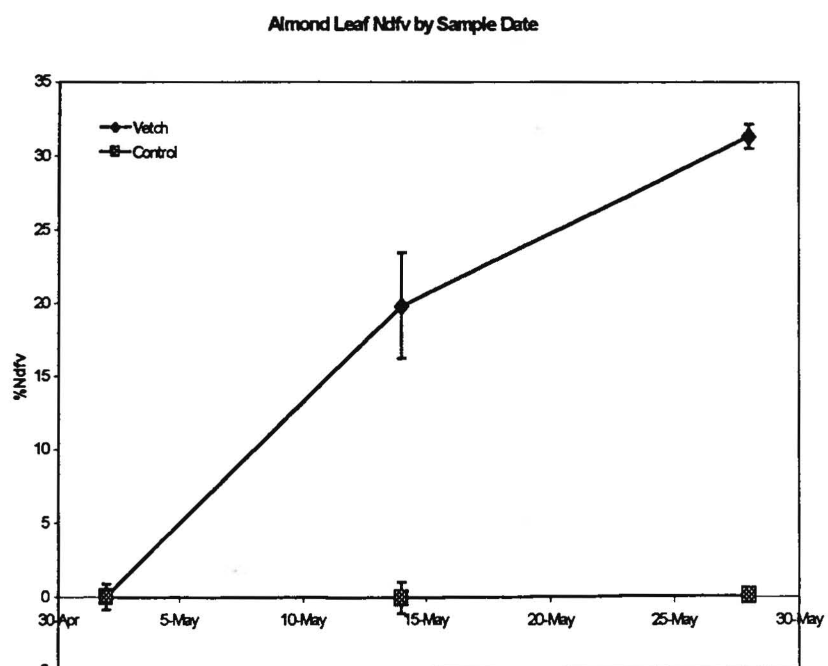
C) atom% 15N ex of vetch = 3.95.

II. % Ndfv = [(atom % 15N ex (almond leaf)) / (atom % 15N ex (vetch leaf))] x100.

Results

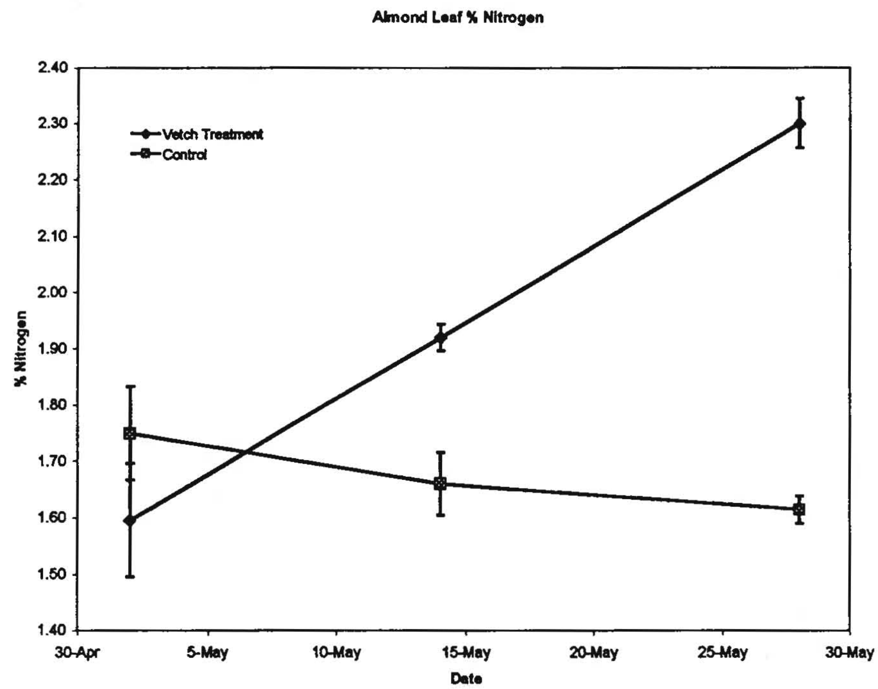
1. 15N isotopic enrichment data showed that there was a steady and dramatic increase in almond leaf nitrogen derived from vetch (%Ndfv). As shown in Fig. 3, by two weeks after application of vetch hay, the average leaf %N derived from vetch in the treated almonds was 20%, while by 4 weeks the average had climbed to 31%. The control plants lacking vetch hay (baseline) showed no enrichment. We are currently analyzing the 6-week leaf samples.

Fig. 3. Percent of N in Almond Leaves Derived from Vetch



2. The nitrogen content of the vetch-treated almond leaves also showed a dramatic change, increasing by 44% over 4 weeks (see Fig. 4), while the N content of the control leaves decreased by 8%.

Fig. 4. %Nitrogen in Leaves, Vetch-Treated vs. Control



General Conclusion

Over 30% of the leaf nitrogen was derived from vetch after 4 weeks, in our most recent experiments. We are currently still sampling. At the conclusion of the experiment, we will sample almond stem and root tissue in addition to leaf tissue, for isotope analysis. We will harvest the entire plants, separating them into leaf, stem and root fractions, dry and weigh each fraction, to determine the relative partitioning of nitrogen derived from the vetch hay, and the total amount of vetch-N taken up by the trees. This experiment should provide us with exciting information on the dynamics of cover-crop derived nitrogen in relation to almond tree N uptake and accumulation.

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