# Brassica Cover Crops: Impacts on Plant Nutrition and Pest Management

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**Introduction**
Cover cropping is an age old agricultural practice that provides benefits to cropping systems such as increasing nitrogen supply to subsequent crops, conserving and cycling nutrients (Ingles et al. 1994), improving soil physical properties (Lal et al. 1991) and reducing erosion (Meisinger et al. 1991). However, cover crops have disadvantages that limit their use, such as direct cash costs and lost opportunity while the cover crop is growing. In the Salinas Valley, cover crops are utilized on about 5% of the acreage (Tom Hearne, personal communication). However, growers are interested in cultural practices that allow them to improve lettuce rotations and that may suppress *Sclerotinia minor*, Lettuce Drop, the key soilborne disease. Unfortunately, given economic pressures such as high land rents and lower returns for rotational crops, effective rotations are not always possible. Mustard cover crops (*Brassica and Sinapis spp.*) have been researched for a number of years in Europe, Australia and the Pacific Northwest as a means of suppressing nematodes and certain soilborne diseases, and they are now being examined in the Salinas Valley for benefits that they may provide lettuce rotations.

Plants in the mustard family, Brassicaceae, contain chemicals such as glucosinolates. Numerous studies have indicated broad biocidal activity of the breakdown products of glucosinolates (Brown and Morra, 1997). Glucosinolates are not phytotoxic themselves, but as the plant cells are ruptured, they are enzymatically converted to isothiocyanates (ITCs), thiocyanates, and other compounds that may provide control of soilborne diseases and weeds. ITCs are generally regarded as the most toxic of the glucosinolate breakdown products. Over fifteen soilborne diseases have been documented in the literature as suppressed by residue from mustard cover crops. Some of these experiments were simple laboratory experiments, but increasingly there are field studies that indicate the impact of mustard residues on soilborne diseases. Diseases that have been shown to be controlled in part by mustard cover crops include: *Sclerotinia sclerotiorum* (Smolinska and Horbowicz, 1999) and *Verticillium dahliae* (Olivier et al. 1999). Mustard cover crops also have impacts on weeds. For instance, rapeseed foliage incorporated into the soil controlled common lambsquarters (*Chenopodium album* L.) and redroot pigweed (*Amaranthus retroflexus* L.) to a level nearly equal that of a standard herbicide treatment (Boydston and Hang 1995). However, more modest control (i.e. 30 – 40%) of redroot pigweed and velvet leaf (*Abutilon theophrasti* Medik.) was observed in soybeans (Krishnan et al. 1998). The levels of ITCs that are found in soils following incorporation of mustard cover crop residues are typically much lower than levels of ITCs applied as commercial fumigants (i.e. Vapam): 1 nmol/gram soil from mustard cover crops versus 517 to 1294 nmol/gram soil for mustard cover crops and Vapam, respectively. This fact coupled with the low residence time of the ITCs in the soil following incorporation - less than 4 days (Morra and Kirkegaard, 2002) have prompted researchers to investigate additional explanations for the beneficial effect observed from mustard cover crops. For instance, Smolinska (2000) observed a weakening of fungal spores and sclerotia by ITCs followed parasitization by soil microbes.

There are no reports in the literature of control of Lettuce Drop with mustard cover crops. However, growers are motivated by the potential that mustard cover crops have for controlling this disease and the number of acres planted to mustard cover crops in the Salinas Valley has increased significantly in the last two years. The potential for control of soilborne disease provides an economic incentive for growers to invest in cover crop production on additional acres on their ranches. Broccoli is a significant rotational crop for growers in the Salinas Valley with 55,000 acres of production in 2002, and it has been shown to and provides suppression of *Verticillium dahliae* (Subbarao et al. 1999) and *Sclerotinia minor* (Hao and Subbarao, 2003). However, broccoli production is not always as remunerative as would be desirable, and growers are looking at substituting mustard cover crops in lettuce rotations because they are inexpensive and fast to grown and may allow them to potentially rotate back to lettuce more quickly.

Mustard cover crops also may also have significant impacts with regards to cycling nitrogen. Preliminary data indicates that mustard cover crops are capable of absorbing large quantities of nitrogen into the above ground biomass and mineralizing it rapidly upon incorporation into the soil. This may be a useful characteristic of mustards and it merits more investigation; the nitrogen that they mineralize, if accounted for, could potentially affect fertilization practices of subsequent vegetable crops. Over the past two seasons we investigated the impact of mustard cover crops on Lettuce Drop and weeds and have made preliminary observations on their nitrogen cycling characteristics. The results of these studies are reported here.

**Objectives**

1. To evaluate the impact of mustard cover crops on Lettuce drop and weeds in lettuce
2. To evaluate the nitrogen cycling characteristics of mustard cover crops

**Materials and Methods**

The following are details on trials that are reported in this article: ***Soilborne pests:*** *Trials No. 1)* Three trials were established in 2003 to evaluate the impact of mustard cover crops on the incidence of Lettuce Drop and weeds. The mustard blend Caliente 119 (see table below) was compared with a bare control or Merced Rye. Lettuce was planted following incorporation of the cover crop and was evaluated for weed emergence at thinning and for the incidence of Lettuce Drop at harvest. In addition, four pot studies were conducted in the greenhouse in which various mustard cover crops and Merced rye residues applied at field-equivalent rates to pots that were seeded with burning nettle (*Urtica urens* L.), common purslane (*Portuaca oleracea* L.) and shepherds purse (*Capsella bursa-pastoris* L.). Subsequent weed emergence was evaluated. ***Nitrogen Cycling:*** *Trials No. 2)* Eight trials were conducted in 2002 to evaluate the productivity of mustard cover crop in various planting slots and locations in the Salinas Valley. Small plots (3.3 to 6.6 feet wide by 25 to 30 feet long) of six species of mustard cover crops were planted on three planting dates and three locations (cool, moderate and warm sites in the Salinas Valley).
The cover crops were evaluated for biomass production and nitrogen content. *Trials No. 3)* Two trials were established in the fall of 2001 and 2002 comparing the following cover crops: mustard cover crop, Caliente 105; Merced rye (Secale cereale); Cayuse oats (*Avena sativa*); and a legume mix (35% Bell Beans (*Vicia faba*), 25% Magnus peas (*Pisum sativum*), 15% common vetch (*Vicia sativa*), 15% Lana vetch (*Vicia villosa* ssp. *dasycarpa*), 10% Cayuse oats). At various intervals during the growth cycle, they were evaluated for biomass production, weed competition, and nitrogen accumulation. At maturity, they were flail chopped and rototilled into the soil. Mineralization of nitrogen was evaluated every two weeks for 8 weeks following incorporation into the soil. *Trial No. 4)* A trial was established in the winter of 2002 in which areas cover cropped to Pacific Gold and bare control were subsequently cropped to spinach. The cover cropped and bare areas were fertilized with 80 lbs of N/A at mid-growth of the cover crop and no additional fertilizer was applied for the remainder of the trial. The cover crop was flail chopped

and rototilled into the soil in early March, 2003 and was planted to the spinach variety Bolero two weeks later. The yield of spinach, the nitrogen content of the spinach and the nitrate and ammonium content of the soil were evaluated in early May (40 days following planting).

Mustard cover crops used in these studies

| **Mustard Cover Crop** | **Type** | **Species** |
|---|---|---|
| Caliente 105 | Indian and white blend | *Brassica juncea and Sinapis alba* |
| Caliente 119 | Indian and white blend | *B. juncea and S. alba* |
| Erica | Canola | *B. napus* |
| Humus | Canola | *B. napus* |
| Ida Gold | White | *S. alba* |
| ISCI 61 | Indian | *B. juncea* |
| Martigena | White | *S. alba* |
| Pacific Gold | Indian | *B. juncea* |

**Results**

***Soilborne Pests:*** *Trial No. 1.* There was a low incidence of Lettuce Drop in the trials conducted in 2003. However, there was a slight but significant reduction in the incidence of Lettuce Drop in one of the three trials (table 1). These results are encouraging, but preliminary, and it will be necessary to evaluate the impact of mustard cover crops at sites with greater disease pressure. Mustard cover crops also slightly reduced the emergence of weeds in these three trials (data not shown). In four greenhouse evaluations, mustard cover crops significantly reduced emergence of shepherds purse and burning nettle over the untreated and Merced Rye cover crop treated pots (figure 1). There were some slight differences in weed emergence among the two species of mustard cover crops that were tested, but in general, it appeared that Indian and white mustards equally suppressed weed emergence.

***Nutrient Cycling:*** *Trial No. 2.* Mustard cover crops accumulate large quantities of nitrogen in the above ground biomass (table 2). For instance, the cover crops grown in Soledad and King City accumulated over 50 lbs of N in the first 30 to 38 days and by maturity, had routinely accumulated over 250 lbs of N/A. *Trial No. 3* Mustard cover crops mineralized nitrogen at a faster rate than cereals, but slower than legumes in both years of this trial (figure 2). *Trial No. 4* Indian mustard cover crop rapidly mineralized significant quantities of nitrogen and improved the yield and total nitrogen content of a subsequent 40-day spinach crop (table 3).

**Discussion**

Mustard cover crops have distinct attributes from cereals and legumes. Cereals are generally regarded for high biomass production, fibrous root system and long-lasting beneficial impacts on soil tilth and water infiltration, while legumes are notable for their nitrogen fixation attributes. Mustards provide distinct attributes from cereals and legumes. They can have high biomass, but generally maintain higher concentrations of nitrogen in the above ground biomass which can result in high total N content in their biomass. The nitrogen in their biomass mineralizes nitrogen more quickly than cereals, but not as quite as rapid as legumes. The rapid mineralization of N from mustards can be a source of N for subsequent crop growth as was seen in the spinach trial reported here. This is an area that deserves more investigation as efficient cycling of nitrogen from cover crops to subsequent cash crops is a technique that could reduce the nitrate “leakiness” of vegetable cropping systems. However, the rapid mineralization of nitrogen from mustards could be a negative attribute. In the Salinas Valley, mustard cover crops are frequently grown in the fall following the cropping season. They are then incorporated into the soil (i.e. in November) and the soil is left fallow over the winter. Under this scenario, there exists the potential for nitrogen contained in the mustards to rapidly mineralize and for nitrate losses to occur with the winter rains. Nitrogen leaching in the winter from mustard cover crops was observed in Eastern Washington (Weinert et al. 2002). However, in another study in Quebec, lower levels of N were seen in leachate water from forage radish plots than the bare control (Isse, 1999).

Mustard cover crops provide a significant input of carbon (C) to vegetable production rotations (table 2). It has been shown that management practices that increase the levels of C to crop production systems helps to retain N in the soil system (Poudel et al. 2001). Lettuce returns low quantities of C to the soil (Mitchell et al. 1999) and mustard cover crops could provide a needed source of C for vegetable crop rotations in the Salinas Valley. The potential that mustard cover crops provide for control of soilborne diseases is an added economic incentive for growers to utilize mustard cover crops in situations where they may not ordinarily consider their use. In these initial studies, mustard cover crops did not have dramatic impacts on weeds or the incidence of Lettuce Drop. However, these studies are preliminary and more long-term studies need to be conducted to examine the cumulative effects of their impacts on soilborne pests. In addition, there may be potential to improve the pest management capabilities of mustard cover crops. For instance, it has been estimated that only 1% of the glucosinolates contained in mustard cover crops is released to the soil (Morra and Kirkegaard, 2002). It is possible that there is untapped potential in mustard cover crops and future research on improving the release of glucosinolates to the soil and improving the residence time of the released toxic breakdown products may improve the control of soilborne pests.

In summary, mustard cover crops have distinct attributes from cereal and legume cover crops. They have the potential to provide a level of control of soilborne diseases and weeds. This may be an added incentive for growers to utilize them, thereby increasing the levels of C that are added to the soil in cool season vegetable production systems. Mustards also have distinct nitrogen cycling characteristics from cereal cover crops which deserves further study to better understand how they may improve nitrogen fertilization practices of cool season vegetables.

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Table 1. Lettuce Drop evaluations at harvest at three sites

| Cover Crop Treatment | Chualar | Gonzales | Somavia Rd. | |
|---|---|---|---|---|
| | No. of diseased plants/30 feet of row | No. of diseased plants/50 feet of row | No. of diseased plants/100 feet of row | Percent infected heads |
| Merced Rye | 0.4 | ---- | ---- | ---- |
| Mustard Cover Crops | 0.6 | 1.2 | 9.7 | 2.0 |
| Bare Control | ---- | 2.4 | 13.1 | 2.8 |
| LSD (0.05) | n.s. | 0.9 | n.s. | n.s. |

Table 2. March 2002 planting date biomass and nitrogen content evaluations

| Variety | Salinas | | | | Soledad | | | | King City[2] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | May 2 (35)[1] | | June 4 (68) | | May 10 (38) | | June 10 (69) | | May 10 (30) | |
| | Biomass T/A | N content Lbs/A | Biomass T/A | N content Lbs/A | Biomass T/A | N content Lbs/A | Biomass T/A | N content Lbs/A | Biomass T/A | N content Lbs/A |
| Caliente 105 | 0.45 | 32.6 | 4.02 | 219.8 | 0.69 | 66.3 | 3.38 | 264.0 | 0.73 | 76.2 |
| Martigena | ---- | ---- | ---- | ---- | 0.75 | 60.5 | 3.70 | 278.9 | 0.58 | 61.5 |
| IdaGold | 0.60 | 38.2 | 3.58 | 227.9 | 0.82 | 59.7 | 4.54 | 310.0 | 0.87 | 88.8 |
| Pacific Gold | 0.49 | 41.1 | 4.22 | 189.4 | 0.65 | 61.8 | 3.27 | 291.0 | 0.85 | 79.3 |
| Humus | 0.37 | 25.6 | 3.61 | 239.4 | 0.56 | 48.3 | 2.62 | 261.6 | 0.46 | 53.4 |
| Ericka | ---- | ---- | ---- | ---- | 0.62 | 59.5 | 2.85 | 259.0 | 0.65 | 74.0 |
| LSD (0.05) | 0.04 | 5.8 | 0.33 | 31.2 | 0.04 | 3.5 | 0.33 | 29.8 | 0.07 | 7.2 |

1 - number in parenthesis are days after planting; 2- trial was terminated before cover crop matured

Table 3. Spinach yield, mineral nitrogen in soil, and nitrogen in spinach tissue at harvest on May 5, 2003

| Cover Crop Treatment | $NO_3$ in Soil | $NH_4$ in soil | Spinach yield (tons/acre) | Percent N in Leaves | Nitrogen/A in Spinach Leaves |
|---|---|---|---|---|---|
| Uncover cropped | 0.7 | 0.42 | 1.6 | 3.3 | 105.6 |
| Mustard | 2.4 | 1.12 | 2.5 | 4.9 | 245.0 |
| LSD (0.05) | 1.4 | 0.32 | 0.4 | 0.5 | 40.5 |

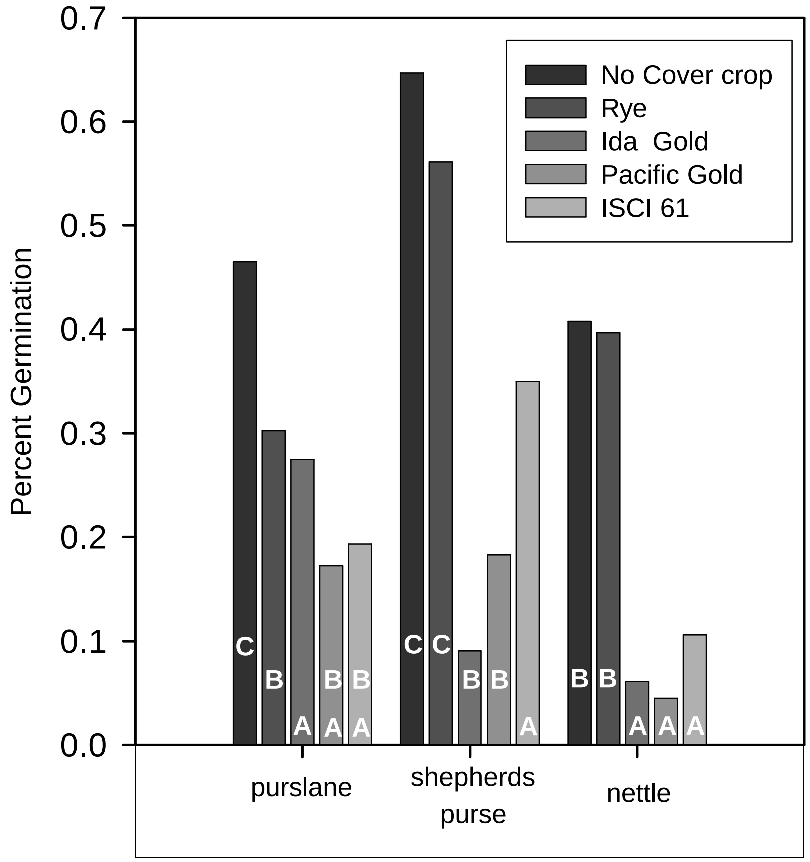


Figure 1. Percent germination of three weeds in pots amended with various cover crops.

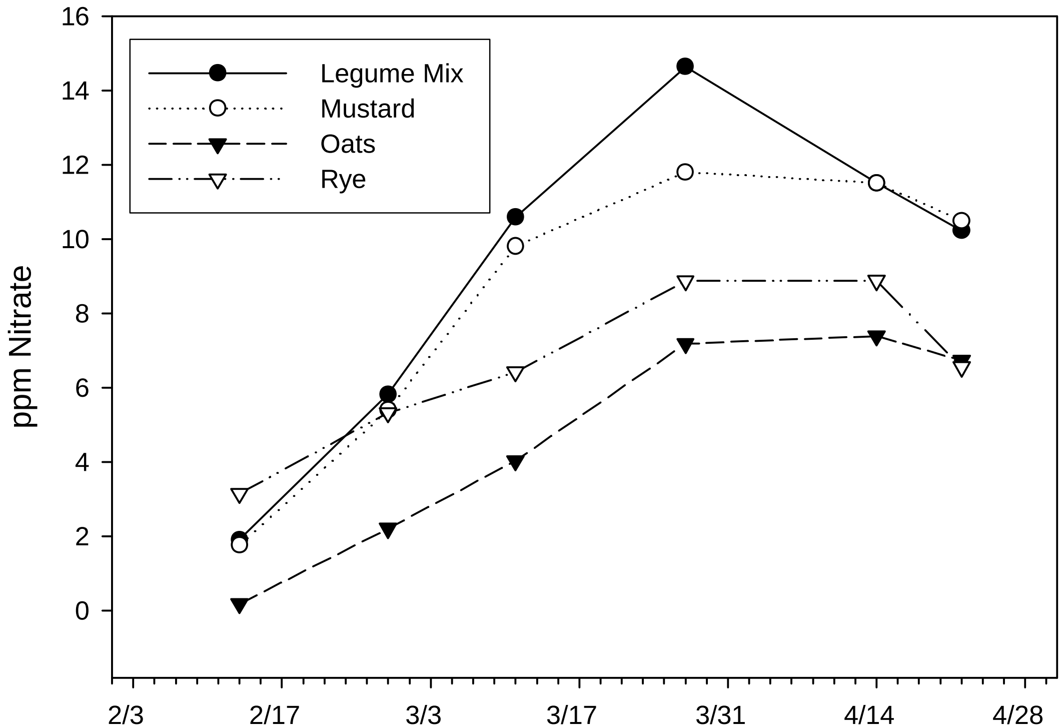


Figure 2. Nitrate release to soil following incorporation of cover crops, 2003 trial