
Project Summary

The use of soil fumigants in the wheat-potato rotation on the Fort Hall Indian Reservation has been the standard practice for over twenty years. The consistent use of chemical fumigants is expensive for potato farmers and has resulted in soils with little biological diversity or activity. After the identification of nitrate and pesticide contaminated ground water on the Reservation, the Shoshone-Bannock Tribes initiated a demonstration project to explore alternative production practices and cropping sequences.

In this demonstration project, green manure crops were explored as possible alternatives to chemical fumigant treatment. Two green manures, mustard and radish, were selected for their biofumigant properties and ability to grow during the fall in between the wheat and potato crops. The green manure crops were each planted on forty acres in August 2002 following wheat harvest and incorporated into the soil in October 2002. Potato yields and quality, economic returns, soil biological parameters and plant and soil nutrient levels from soils amended with the mustard or radish were compared to nontreated, metam sodium and carbofuran treated soils. In April 2003, fields were planted to Russet Norkotah potatoes and harvested in September 2003.

Net yields from five acres of each treatment were highest in the carbofuran, mustard and metam sodium treated areas, respectively, while the nontreated control and radish produced fewer potatoes. The highest percent of US #1 potatoes were found in the mustard, metam sodium and carbofuran treated fields, respectively. Gross economic returns from a September 24, 2003 sale showed the best returns for the carbofuran, mustard and metam sodium treated fields, respectively. No major differences were found between treatments in soil beneficial or plant pathogenic nematodes, *Verticillium* levels or total fungal levels. A slight stimulation of total bacteria and predatory nematodes in mustard and radish amended soils was found. Sampling of potato petioles and soil nutrient levels showed that no nutrients were limiting.

This demonstration project tracked only a single rotation sequence of mustard and radish green manures compared to other soil chemical treatments, so some caution must be taken in placing significance on these findings. This project did show that it is feasible for farmers to add a mustard or radish green manure crop to their wheat-potato rotation on the Reservation. Mustard and radish crop management fits into the timing of fall activities of the operation. No overall stimulation of beneficial soil microorganisms was seen in the green manure amended soils. This may be an indication that several years of soil building with green manures is necessary to realize such a change. When soil sampling indicates that plant pathogenic organism levels are low, metam sodium treatment may be unnecessary. With the reduced production costs from not fumigating with metam sodium, the nontreated control provided a net return of \$95 per acre more than metam sodium treatment. Mustard or radish can be grown for less than treating with metam sodium, due to the high cost of metam sodium. Consequently, if the mustard and radish crops produce yields similar to metam sodium, the green manure crops can be a viable economic alternative. Gross returns were greater from mustard, but less for radish as compared to metam sodium. In this demonstration project, net returns from mustard amendment resulted in \$280 per acre more than metam sodium treatment, while radish amendment resulted in \$240 per acre less than metam sodium treatment. Overall, this project indicated that adding a mustard green manure crop to the wheat-potato rotation and not fumigating is worth further consideration.

Project Rationale

After the detection of nitrate and pesticide contaminated wells in the late 1980s on the Fort Hall Indian Reservation, a report of potential actions was prepared by the USDA Natural Resources Conservation Service (formerly the Soil Conservation Service) (USDA SCS, 1991). In this 1991 report, agricultural chemical usage was listed among the most likely contributing factors to the water quality problem. The potential for contamination of ground water with other agricultural chemicals was noted, due to the excess nitrates appearing in numerous Reservation wells. To address this potential future contamination source and reduce the threat, the 1991 study recommended that alternative crops and crop sequences be explored. In response to this recommendation, Tribal leaders initiated a demonstration field project on the Reservation to study the effectiveness and feasibility of alternative cropping practices. This report on the use of green manures in the conventional two-year wheat-potato crop rotation on the Fort Hall Indian Reservation is the first report on findings from the demonstration field.

Project Question

Is a mustard or radish green manure an effective and economical alternative to chemical fumigant use in a wheat-potato rotation on the Fort Hall Indian Reservation?

This report addresses the following factors, which were monitored during the addition of a green manure crop to the conventional wheat-potato rotation on the Fort Hall Indian Reservation.

- ✓ soil health
- ✓ plant health
- ✓ economics

Project Background

After a period of growth, green manure crops are turned into soil to improve soil fertility and overall soil characteristics. Leguminous green manure crops are selected for their ability to build soil nitrogen, while other crops are selected for their ability to suppress diseases, pests and weeds or to stimulate beneficial bacterial and fungal populations. Of particular concern to Idaho potato growers is *Verticillium dahliae*, which is suppressed by a number of different green manure crops (Davis et al., 1994; Davis et al., 1996). Green manures are grown for different lengths of time; some grow all season, while others are utilized only during the spring or fall.

Due to Reservation potato growers' interest in maintaining the existing two-year wheat-potato rotation, green manures that could be added to the current rotation without extending the rotation were selected. Two green manure crops, mustard and radish, were selected for their ability to grow during the cooler temperatures and shorter days of fall in southeastern Idaho (Finnigan et al., 2003).

Radish, cultivar Colonel, was selected for use in this demonstration project due to its biomass accumulation during fall and suppression of plant-parasitic nematodes. Idaho farmers have been adding radish to their sugar beet rotations for years, while potato farmers have recently begun utilizing radish in their cropping sequence. The radish green manure has been shown to be an effective control of cyst nematode in sugar beets. When turned into the soil, radish suppresses the cyst nematode by stimulating cyst nematode egg hatching, but not supporting cyst nematode growth (Hafez, 1999). Radish has also been shown to reduce Columbia root-knot nematode levels and increase potato yields and quality compared to fallow (Al-Rehiyani and Hafez, 1998).

Mustard green manure crops have been grown by potato farmers in Washington state. Recent studies by Washington State University Cooperative Extension Educator, Andrew McGuire, and a central Washington potato farmer have documented the use of mustard as an alternative to metam sodium (McGuire, 2002; McGuire, 2003). The mustard improved soil quality as determined by higher infiltration rates and produced yields similar to fields treated with metam sodium. While Russet Norkotah was grown in the Washington state study and is considered susceptible to *Verticillium dahliae* (potato early dying), yields were not reduced by early dying.

Project Goal and Objectives

The goal of this demonstration project was to determine whether radish and mustard green manures are viable alternatives to chemical fumigant use in potato production on the Fort Hall Indian Reservation.

The specific objectives of this study were to determine if mustard and radish green manures

- grow sufficiently under the climatic conditions on the Reservation,
- suppress early dying,
- suppress plant-parasitic nematodes,
- enhance beneficial soil microorganism population levels,
- fit timing of fall management required in a wheat-potato rotation,
- produce potatoes of similar yields and quality as treatment with chemical fumigant, and
- offer an economically viable alternative to chemical fumigant use.

Project Design and Methods

Treatments

The effects of five different soil treatments were assessed.

1. Mustard green manure – *Sinapis alba* and *Brassica juncea* blend Caliente Brand 119
Forty acres of mustard were planted in August 2002. After 9 weeks of growth, the mustard was chopped and incorporated into the soil. Mustard was selected for its biofumigant properties as it releases glucosinolates when chopped and disced into soil.
2. Radish green manure – *Raphanus sativus* cv. Colonel
Forty acres of radish were planted in August 2002. After 9 weeks of growth, the radish was chopped and incorporated into the soil. Radish was selected for its soil pathogen suppressing properties.
3. Vapam (Metam sodium)
Forty acres were soil-injected with 38 gallons per acre in late October 2002. Metam sodium was selected for use as a contact fumigant, insecticide and nematicide for potatoes.
4. Furadan 4F (Carbofuran)
Thirty acres were treated with 2 quarts per acre along with the starter fertilizer at potato planting markout in spring 2003. Carbofuran was selected for use by the farm manager as a systemic insecticide and nematicide in potatoes.
5. Nontreated control
Ten acres were not treated with metam sodium, carbofuran or planted with a green manure crop.

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