Reducing nitrate leaching through winter cover cropping

Isaac Madsen (isaac.madsen@email.wsu.edu) WSU, Bill Pan WSU, and Hal Collins USDA-ARS

Potatoes, wheat, and corn are commonly grown under irrigation in cropping sequences in the Columbia Basin. Irrigated cropping systems offer special potential for intensification, as they are not water limited. Intensification through cropping makes use of the solar energy in the fall and the spring, which would otherwise fall idle on the fallow ground. The additional biomass introduced into the crop sequence increases the overall soil organic matter acting as a sink for atmospheric carbon dioxide (CO_2). Cover crops can also be used to reduce nitrogen fertilizer loss and potentially replace the use of fumigants as a pest control. The roots of cover crops, active after the harvest of the main crop in the fall and before planting in the spring, retain nitrogen in the upper layers of the soil profile, recycling it for the next year and reducing the concern of nitrate (NO_3^-) leaching into ground water. Reducing tillage also has the potential to increase soil organic matter and reduce emissions of nitrous oxide (N_2O, a greenhouse gas) from the soil.

IMPACT

Cover cropping has the potential for on- and off-farm benefits. The research presented here demonstrates the ability of cover crops to recapture nitrogen as it moves through the soil profile, potentially reducing the required fertilizer rate and negative externalities, such as nitrate leaching into groundwater.

In this study, potatoes, wheat, and corn were grown in rotation under hand line irrigation at the Washington State University Prosser Irrigated Research Station. Cover crops and reduced tillage were implemented in the rotation. Mustard was grown as winter cover after the corn and before potatoes. Triticale was grown following wheat and preceding corn. Winter wheat was grown after potatoes, providing winter cover for the third winter. Reduced tillage consisted of no-tilling during the wheat and corn years of the rotation and minimal tillage during the potato season.

In the data presented here, we examined the ability of cover crops to take up NO_3^-. In our preliminary results, when we compare plots grown with a winter cover crop to fallow plots, all plots showed a decrease in soil NO_3^- in the first foot, but the total increase in NO_3^- lower in the profile was greater in the fallow plots than in the cover-cropped plots (Figures 1 and 2). The increase in NO_3^- deeper in the soil in fallow plots suggests that mustard and triticale would prove effective at reducing the leaching of NO_3^- through the soil profile over the winter.

Winter wheat followed by an overwintering triticale and fallow treatment showed a decrease of 14.9 pounds of NO_3^- per acre and 10.6 pounds of NO_3^- per acre in the top foot. At 2-, 3-, and 4-foot depths, the NO_3^- in the fallow plots increased by 3.7, 9.0, and 1.9 pounds per acre, respectively. In the plots with overwintering triticale, the NO_3^- in the 2nd, 3rd, and 4th feet changed a negligible amount, decreasing by 0.2 pound per acre in the 2nd foot and increasing by only 0.45 and 1.10 pounds per acre in the 3rd and 4th feet (Figure 1). At harvest, the triticale contained 18.2 pounds of nitrogen per acre.

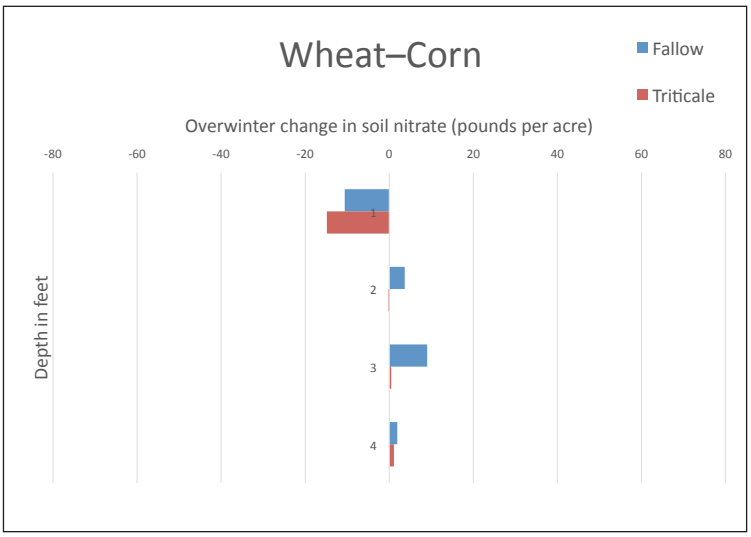


Figure 1. *Change in pounds of soil nitrate (NO_3^-) per acre at depths of 1 to 4 feet after in-season wheat and before corn, contrasting the cover crop (triticale) and the fallow.*

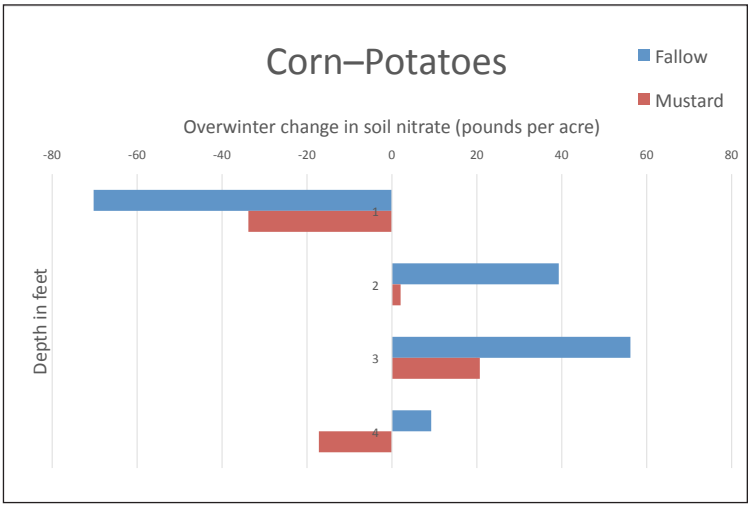


Figure 2. *Change in pounds of soil nitrate (NO_3^-) per acre at depths of 1 to 4 feet after in-season corn and before potatoes, contrasting the cover crop (mustard) and fallow.*

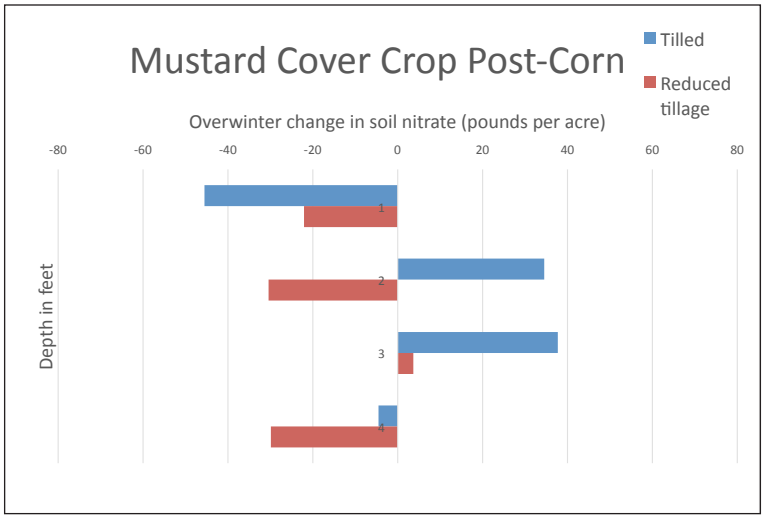


Figure 3. *Change in pounds of soil nitrate (NO_3^-) per acre at depths of 1 to 4 feet after in-season corn and before potatoes in plots with an overwinter cover crop of mustard and under contrasting tillage practices.*

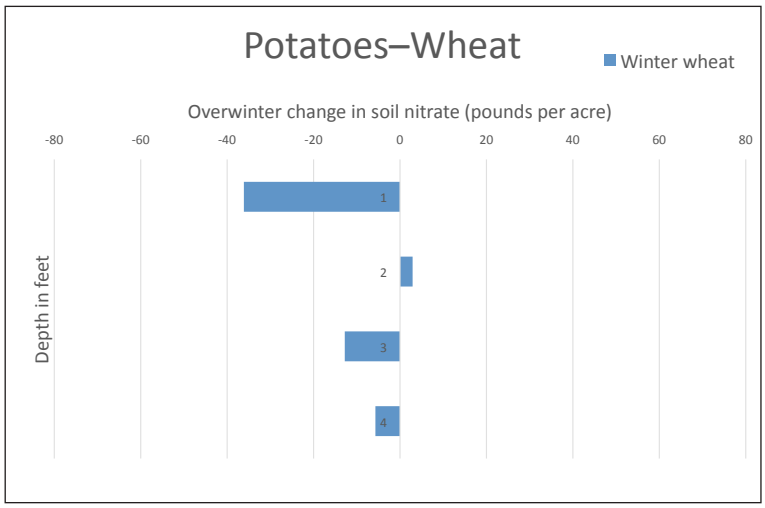
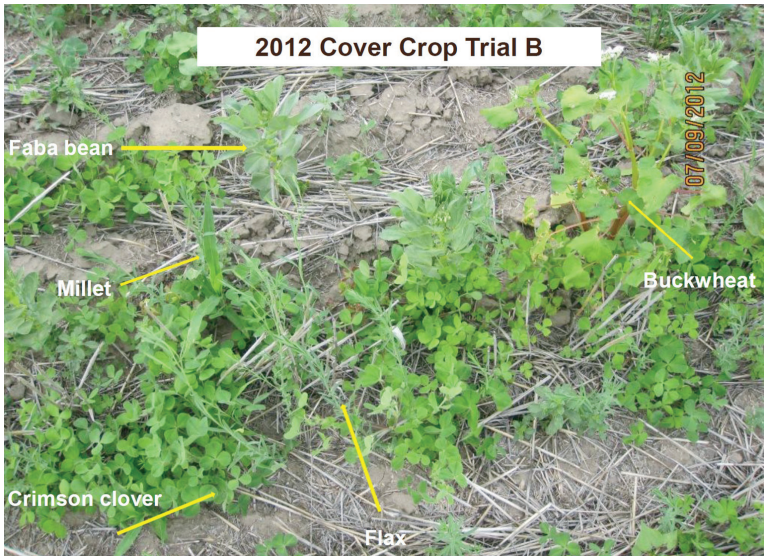


Figure 4. *Change in pounds of soil nitrate (NO_3^-)per acre at depths of 1 to 4 feet after in-season potatoes and during winter wheat.*



Wilke Farm cover crop trial. Photo by Diana Roberts.

Overwintering mustard following corn and preceding potatoes showed a similar result: a decrease in NO_3^- levels in the top foot by 33.8 pounds per acre, with a decrease in the top foot of fallow of 70.2 pounds per acre. The total NO_3^- at 2-, 3-, and 4-foot depths in the fallow increased by 39.3, 56.2, and 9.25 pounds per acre, respectively. In the plots covered with overwintering mustard, the 2- and 3-foot depths increased by 2.04 and 20.69 pounds per acre, respectively, while the 4-foot depth decreased by 17.2 pounds per acre (Figure 2). The mustard biomass tilled back in at springtime had a nitrogen yield of 56.3 pounds per acre. In the plots with overwintering mustard, it appears that reduced tillage may have compounded the reduction of NO_3^- in the soil profile. Plots with overwintering mustard and reduced tillage showed overwinter decreases in NO_3^- of more than 20 pounds per acre in the 1st, 2nd, and 4th feet, with only a small increase in the 3rd foot (3.67 pounds per acre). However, tilled plots showed increases in the 2nd and 3rd feet and a decrease in the 4th foot. Although the tilled plots with overwintering mustard showed an increase in the 2nd and 3rd feet, the increases in the corresponding fallow/tilled plots were still greater (Figure 3).

Isaac Madsen collects biomass samples of cover crops in Prosser, WA. Photo by Lauren Young.

In plots grown with potatoes and followed by winter wheat, overwinter levels of NO_3^- decreased at depths of 1, 3, and 4 feet by 36.1, 12.8, and 5.7 pounds per acre, respectively, and increased slightly in the 2nd foot by 2.9 pounds per acre (Figure 4).

In conclusion, a loss from the first foot and redistribution of NO_3^- in the 2nd and 3rd feet was the pattern in the fallow plots, while in the plots containing mustard and triticale the reduction in the 1st foot of the soil profile did not redistribute further down the profile. Results also indicate that there may be an interaction between the tillage system employed and the overwinter cover. Both cover cropping and reduced tillage are conservation practices that contribute to the buildup of soil organic matter, potentially increasing the sequestration of atmospheric CO_2. Cover cropping and reduced tillage also have on-farm benefits of mitigating erosion and nitrogen loss.