Western SARE Project SW22-940

University of Idaho, Palouse Conservation District & Producer Partners

PaNDAS at a Glance

Cover cropping is an important tool for mitigating soil erosion, reducing reliance on synthetic inputs, and improving soil fertility, soil health, and on-farm biodiversity. The practice is just being explored by producers and researchers for inland Pacific Northwest (iPNW) cereal production systems.

Adoption of cover crops in these systems has been slow because of the unique environmental challenges and relative lack of experience and science. To address these challenges, the PaNDAS project is conducting research collaboratively with scientists and producers and making its findings accessible through this website and other outlets. With funding from the Western Sustainable Agriculture Research and Education (Western SARE) program, the project recently completed a three-year study to assess the effects of spring cover crop mixtures and termination dates on soil moisture, insect pests and weeds, and yield in the follow-on cash crop. The work was performed in replicated on-farm plot trials in eastern Washington and northern Idaho

Project Scope

- 8 on-farm research sites across two precipitation zones (4 farms each), one in which business as usual (BAU) farming is a mixture of annual cropping and alternate year fallow (annual transition) and one in which BAU is annual cropping, rotating cereals with pulses or brassica crops.
- Comparisons of low-diversity, high-diversity, and producer-designed cover crop mixes within and among the farms
- Three termination timings
- Measurements: cash crop, cover crop, and weed biomass, soil and cover crop nitrogen, continuous soil moisture monitoring at three depths, insects.
- Educational and outreach: Interviews and surveys of producers

Most Important Findings

- Termination timing of spring cover crops matters more than cover crop diversity for balancing biomass production and soil water use.
- Mid-season termination (around early July, varying by zone) provided the best balance between biomass production and manageable soil water use.
- Following wheat crop yields were unaffected by cover crop, in general.
- Soil N levels were either unaffected or enhanced by cover crops
- Cover crops, particularly high diversity mix, host more abundant and diverse insects than BAU.
- Next phase priorities
    - Evaluate fall-planted cover crops
    - Expand research on soil biological processes and diversity including arthropods
    - Refine termination timing tools
    - Continue PaNDAS decision support platform development

PaNDAS Project Summary

A full project report was provided to Western SARE (LINK to be added on approval). Following is summary of that report.

1. Why This Project Matters

Cover crops are widely recognized for improving soil health, reducing erosion, increasing biodiversity, and strengthening resilience to climate stress. Yet adoption in the inland Pacific Northwest (iPNW) has lagged behind other regions.

Our cropping systems are different. Many areas receive limited annual precipitation. Long-established cereal rotations dominate. Summer fallow remains common in lower rainfall zones. Producers rightly prioritize soil moisture for winter wheat.

Growers participating in this project wanted practical answers to practical questions: How much water do cover crops use? When should a spring-planted cover crop be terminated to obtain cover crop benefits without depleting soil moisture that would affect the follow-on cash crop? How much biomass can we realistically grow in our climate? What is the impact of cover crop on following wheat yields? What happens to nitrogen in the soil and to overall nutrient cycling? How do cover crops affect insects—both pests and beneficial species? What is the effect of varying cover crop mixture composition and diversity (number of species)?

Two research objectives emerged:

1. *Compare cover crop mixtures and termination dates for effects on cover crop performance, water infiltration rates, bulk density, nitrogen availability, weed and insect biodiversity and performance of the subsequent cash crop*
2. *Compare the effects of treatments in Objective 1 on soil moisture profiles during the season and after different termination dates*

This project established replicated on-farm strip trials across eight working farms spanning two precipitation zones. Over three field seasons (from 2023-2025) we measured cover crop growth, soil moisture, nitrogen cycling, weed and insect communities, and winter wheat yield following cover crops.

2. What We Tested

Across two precipitation environments (Annual Cropping and Fallow Transition), we compared a low-diversity 3-species mix, a high-diversity 9-species mix (same functional groups as low diversity mix), and a producer-designed mix. We evaluated early, mid-season, and late termination timings. Following termination, winter wheat was planted using standard producer practices. Measurements included weed and cover crop biomass, nitrogen pools, soil moisture, insect communities, and crop yield in subsequent seasons.

3. How We Tested

Our team includes 8 producer co-PIs who were involved from the very beginning to establish the research and outreach aims of PaNDAS. Each producer co-PI established a standardized replicated plot design on their farms on which the treatments were implemented (Fig. 1). The standard low and high cover crop mixtures each included either one or three species of brassica, one or three species of grass, and one or three species of legume. The producer-choice treatment was entirely determined by each producer co-PI. These ranged from a single species, tillage turnip, to more than 10 species. Each cover crop in each of two years was terminated, typically chemically, at three termination dates. The specific dates differed by zone and were adjusted during the project slightly to respond to cover crop growth and development. In the year following each cover crop year, winter wheat was planted over the plots. Approximate locations of farms are shown in Fig. 2.

On each farm some plots were equipped with sensors to continuously soil moisture at three depths. Soil moisture, bulk density, penetration was also measured based soil samples. Above ground biomass of cover crop by species and weeds was measured before terminations. Soil N and organic matter and cover crop plant tissue N were measured in these samples. Insects were surveyed using sweep nets above ground in cover crops and surrounding BAU field twice in year 1 and once in year 2.

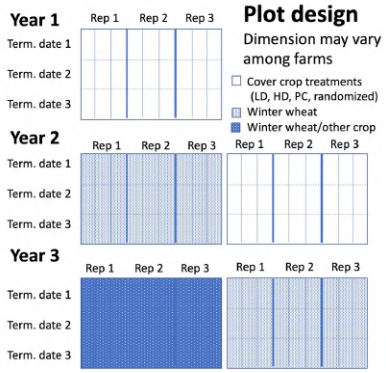

Figure 1. Standard plot design on each cooperating farm with treatments in each year.

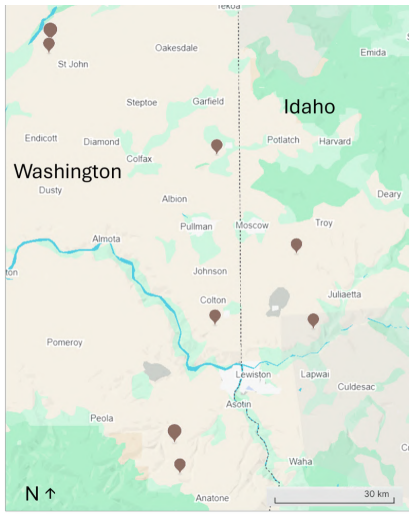

Figure 1. Schematic of plot design for each of 8 cooperator farms (total area of reps 1-3 ≈ 4 acres

Some of the work on PaNDAS when under way.

3. Key PaNDAS Research Findings

Cover crop biomass, nitrogen, insects, crop yield and water use

- Above-ground cover crop biomass in both zones and years increased with TD (Fig. 1), so without considering soil moisture (Objective 2), or potential for cover crop reseeding, longer growth before termination allowed more cover crop biomass to accumulate. This pattern was evident regardless of the cover crop mixture. Brassicas and grasses contributed most to cover crop biomass.
- Stored available N was increased in BAU systems with a crop as BAU (annual cropping), in the winter wheat following cover crops in Fall 2024 (Fig. 2). In systems with a fallow for BAU (fallow transition), N storage in soil and fertilizer was similar between fallow and cover crop fields in Fall 2023, declined by fall of 2024, even including N in harvested grain. Cover crops appear to reduce soil available N but some of this will be stored in organic forms not accessible to leaching but that may become available for future crops. Cover crop diversity did not impact cover crop N uptake, or following winter wheat yield. A simple 3-way mix may provide an economical option for growers interested in cover crops to gain nutrient cycling and soil health benefits.
- Insects were consistently more abundant in cover crops, particularly in high diversity and producer's choice mixes, than in BAU treatments (Fig. 3). The increased abundance includes pests but also beneficial groups, pollinators and predators. Overall, these findings highlight the potential value of diverse cover-crop mixtures supporting insect communities, particularly the beneficial insects such as predators and pollinators.
- Effects of cover cropping on follow-on wheat yields varied, imposing a non-significant penalty in following the 2023 cover crops but no effect on yield after the 2024 cover crops in either zone (Fig. 4). 2025 winter wheat yields were low in general due to dry summer growing conditions, but preceding cover crop treatments did not reduce yields compared to preceding summer fallow.

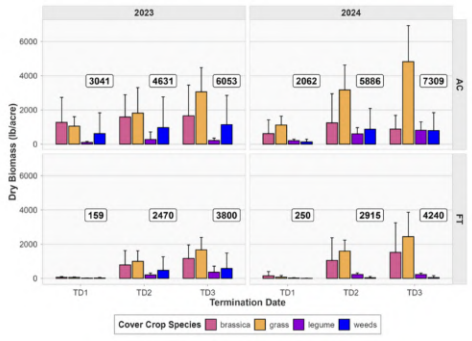

Figure 1. Mean dry aboveground biomass (lb/acre) of plant family groups in cover crop mixes, averaged across high and low diversity treatments. Error bars represent 95% confidence intervals of means. Values in boxes above TD groups are mean total biomass of the cover crop mix.

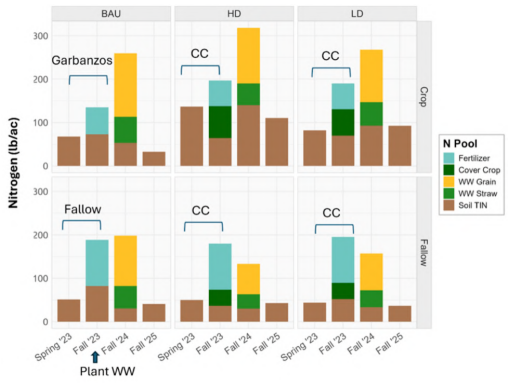

Figure 2. Nitrogen storage pools in BAU, High Diversity and Low Diversity plots. Top panels are fields where BAU included a crop, and bottom panels are where BAU was summer fallow. Stacked bars are mean N pools starting in spring 2023 at cover crop planting, through fall 2025, showing N storage pools during cover crop phases and two subsequent years of crop production.

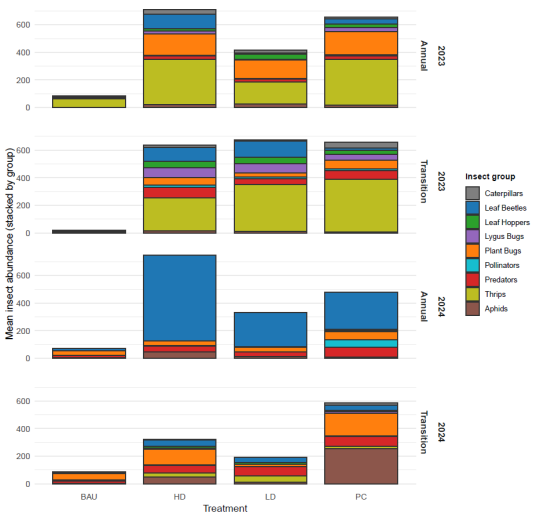

Figure 3. Insect abundance, partitioned by taxonomic or functional groups in each of the treatments by production zone and year.

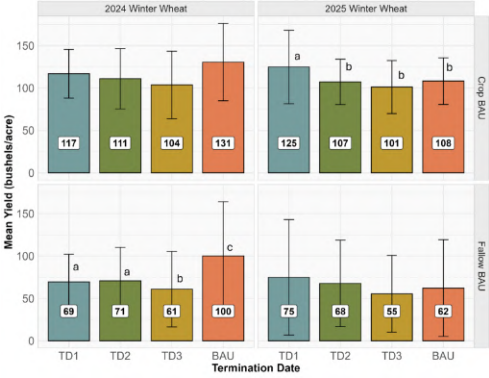

Figure 4. Yield of winter wheat in 2024 and 2025 following cover crop TD treatments in the previous year. Field sites were grouped by locations where BAU was a crop (5 sites), or BAU was summer fallow (3 sites). Values inside the bar represent mean yield in bushels per acre. Error bars represent 95% confidence intervals of means. Columns with the same letter were not statistically different ($p > 0.05$).

- Water use increased with termination date in all zones and depths (Fig. 5), so benefits of cover cropping need to be assessed against potential effects of soil moisture depletion on the follow on crops and overall system performance.

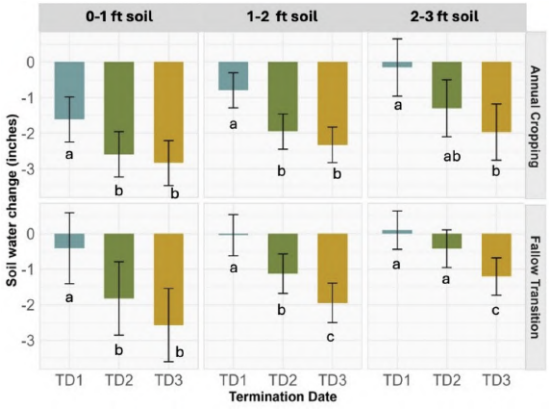

Figure 5. Soil water use by soil depth and cover crop termination in Annual Cropping and fallow-transition precipitation zones, averaged across years (2023 and 2024 cover crop plots). This is the difference in soil moisture (represented in inches of water stored in the soil) between cover crop seeding and cover crop termination date. Error bars represent 95% confidence intervals of means. Columns with shared letters within a single panel did not differ significantly (p>0.05)

Summary and implications for cover crop implementation in iPNW cereal systems

- Considering potential benefits of cover cropping together with the evidence for soil water use, the project results suggest there are optimal termination dates for spring cover crops.
- In one of the study years, later termination date corresponded to further reductions in following winter wheat yield, indicating that earlier termination dates are preferrable for moderating soil water storage and the impacts to cash crop yield. Cover crop replacement of fallow resulted in drier soils during fall winter wheat planting, but by mid-winter, soil moisture was generally similar among cover crop and fallow treatments (data not shown).
- In the more water limited areas (FT sites), TD2 provided the best balance between producing substantial cover crop biomass and minimizing water loss compared to fallow.
- In the Annual Cropping sites, TD2 was also the optimal timing (though occurred generally 2 weeks later than FT sites) for producing cover crop biomass with low CN ratio and not risking mature seed development.

4. Spreading the Word

A third objective of PaNDAS was to: (3) *Use information from Objectives 1 and 2, existing literature and data, and grower workshops and interviews to develop the first comprehensive online support system for inland Pacific Northwest cover crop management*

This objective has been met by annual presentations at the Palouse Alternative Cropping Systems Symposium at which participant surveys were administered to gauge interest in cover cropping and challenges to implementing it in our region. In total five invited presentations are large meetings were made by project personnel, including producer co-PIs. The project was also promoted at cereal schools in northern Idaho each year. Two podcasts were posted by PNW Farmers' Network series hosted by Washington State University. A project website was created and improved over the life of the project based on user input where are hosted vetted resources about cover cropping relevant to the iPNW, all project outputs, results of producer surveys, descriptions of project activities, and links to all reports generated by the PaNDAS project, including this file These efforts have reached an estimated 200 producers and agricultural service providers. We have certainly learned together, with our producer co-PIs who gained knowledge, and through this project altered their approaches to implementing cover crops on their farms.

- PaNDAS website: https://pnwcovercrops.org
- Podcast 1: https://rss.com/podcasts/pnwfarmersnetwork/1370203/
- Podcast 2: https://rss.com/podcasts/pnwfarmersnetwork/1548661/

5. Looking Ahead

The PaNDAS project has provided answers to its motivating questions that can guide implementation of spring-planted cover crops in iPNW cereal systems. As with most good projects, new questions have opened up and gaps have been identified. The PaNDAS team is committed to seeking funding to address these questions with future projects. Key questions and needs for research and outreach going forward:.

- Extend the scope to include fall-planted as well as spring-planted cover crops.
- Expand research to include soil biological processes and diversity, including arthropods.
- Develop quantitative models to support cover crop decisions including timing of operations, cover crop species and mixtures, nutrient managaement.
- Conduct economic analyses for longer term implementation of cover crops.
- Maintain and augment the PaNDAS website as new information and tools are developed.