



IPREFER

Integrated Pennycress Research
Enabling Farm & Energy Resilience

Quarterly Progress Report
Nov. 1, 2019 – Jan. 31, 2020

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NOTICE

This IPREFER project quarterly report was prepared by Western Illinois University and IPREFER research colleagues from CoverCress, Inc., Illinois State University, McLean County Soil and Water Conservation District, The Ohio State University, United States Department of Agriculture-Agricultural Research Service, University of Illinois, University of Minnesota, and the University of Wisconsin-Platteville in the course of performing academic research supported by Agriculture and Food Research Initiative Competitive Grant No. 2019-69012-29851 from the United States Department of Agriculture National Institute of Food and Agriculture (“USDA-NIFA”).

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Integrated Pennycress Research Enabling Farm and Energy Resilience (AFRI-CAP 2019-69012-29851)

Quarterly Report: November 1, 2019 – January 31, 2020

PROJECT ADMINISTRATION AND GOVERNANCE

We accomplished the following project governance and administrative tasks during the second quarter.

1. Planned Activities

- Complete sub-award agreement with USDA-MN.
- Continue our search for a plant breeder.
- Continue building content for the IPREFER website (<https://www.iprefercap.org>).
- Continue monthly meetings with the Advisory Board and the Executive Leadership Team (ELT). The Project Director and the Program Manager will continue to meet weekly.
- Add Lauren Lurkins from the Illinois Farm Bureau to the Advisory Board. Lurkins is the Director of Environmental Policy, Governmental Affairs and Commodities Division for the Illinois Farm Bureau.¹
- Continue implementing Material Transfer Agreements (MTAs) with collaborators.

2. Actual Accomplishments

- Completed a sub-award agreement with USDA-ARS MN.
- Continued adding and refining content for the IPREFER website. Content had been added to the IPREFER website as follows:
 - Frequently Asked Questions (FAQs) regarding pennycress development (<https://www.iprefercap.org/resources/faq/>),
 - Media Kit (<https://www.iprefercap.org/news-events/media-kit/>)

¹ Additional information regarding Ms. Lurkins is available at <https://www.iprefercap.org/about/advisory-board/>.

- Summer 2020 Undergraduate Research Experience internship program (IPREFER 2020 Internship).
- Held Advisory Board and Executive Team Leadership meetings. We also expanded the ELT to include members from each program area. The new ELT members are Cris Handel (Supply Chain), Will Perry (Ecosystem Services), and Rebekka Darner (Outreach/Education) Initial program policies have been established and continue to be developed as issues arise.
- Added Lauren Lurkins to the Advisory Board in December 2019.

3. Explanation of Variance

We continue having difficulties in locating a plant breeder at the Macomb, IL site.

4. Plans for Next Quarter

- Continue the search for a plant breeder.
- Continue building content for the IPREFER website.
- Continue Advisory Board, Executive Leadership Team, and Program Manager meetings.
- Begin organizing for spring 2020 outreach events and IPREFER 2002 Annual Meeting scheduled for August 3-5, 2020, at the University of Minnesota, Twin Cities campus.

5. Publications, Presentations and Proposals Submitted

- Dyer-Shinberger, Darcie and Jodi K. Pospeschil, A Crop Worth Millions, *Western*, Fall 2019, https://issuu.com/wiualumniassociation/docs/alumni_mag_web_fall_2019
- Houghton, Dean, A Place for Pennycress, *The Furrow*, Fall 2019, <https://www.johndeerefurrow.com/2020/01/07/a-place-for-pennycress/>.

OBJECTIVE 3.1 - AGRONOMIC MANAGEMENT

1. Yield Tradeoff Leveraging CRM and Desiccants (Objective 3.1.1)

Recent work suggests that corn grain yield and grain moisture at harvest are increased by 88 kg ha⁻¹ (1.4 bu ac⁻¹) and 0.5% respectively, per one-day increase in corn relative maturity (CRM). Although early- maturing corn hybrids have lower yield potential than full- season counterparts, they can be harvested earlier (e.g., late August). Application of desiccants can further shorten the time for corn to reach harvestability. The team will assess corn and

pennycress yield trade-offs through evaluating a range of corn CRM by assessing varieties differing in relative maturity in Ohio, Minnesota, and Illinois during Project Years 1 – 3.

A. Planned Activities

Schedule winter meetings to work through project details. Finalize treatment design and protocols for all sites.

B. Actual Accomplishments

During our winter meeting, Project Collaborator Russ Gesch outlined the entire study. He provided all protocols and designs for all sites and gave a template for the Morris, MN site. The IPREFER Agronomy Team agreed on the design and are ready to roll out the corn phase of the project this spring.

Dr. Gesch received approval from USDA headquarters to hire a field technician for Pennycress studies being performed in Minnesota. The recruitment notice has been posted on USAJobs, and the search is currently underway with an application deadline scheduled for Feb. 27, 2020. The plan is to have the successful candidate onboard by early spring before corn planting.

C. Explanation of Variance

We determined that desiccants are not possible across all sites due to equipment limitations. We removed the desiccant treatment and added more CRMs. Otherwise, everything is moving forward as planned.

D. Plans for Next Quarter

We will hold a final meeting before planting in mid-March 2020. We will move all protocols to ASANA data and project management software.

2. Corn Residue Management ("DISC") (Objective 3.1.2)²

An increasing number of farms are now practicing no-tillage and other conservation tillage farming due to ecological and economic benefits. Establishing pennycress in no-till fields is a struggle, due primarily to the sheer amount of corn residue remaining after harvest. Several corn residue treatments will test the hypothesis that the residue can be sized small enough to not interfere with pennycress establishment. Pennycress establishment and subsequent seed

² DISC is the abbreviation we will use for the IPREFER corn stover management project. Nicholas Heller (University of Minnesota) leads this IPREFER objective.

yield in high-residue environments will be compared to reduced-surface stover treatments where its production has been proven to be successful (e.g., silage corn removal and prepared seedbeds).

A. Planned Activities

Schedule winter meetings to work through the project details. Discuss treatment designs and needed infrastructure across the network.

B. Actual Accomplishments

The Agronomy Team met and discussed how best to balance the deliverables and necessary infrastructure across the network. Even though we are still working through the design details, we have locked in five field sites across the network. We also agree on how the study will proceed. We have a planning meeting for DISC coming up. Project collaborator Nicholas Heller sent out a project plan and is waiting on feedback from the group. We will have designs locked in by Mid-March.

C. Explanation of Variance

We are still working through the optimal treatment designs that best balance the needs and limitations across the region. The core approach is still present.

D. Plans for Next Quarter

We will hold a final meeting before planting in mid-March. We will move all protocols to ASANA data and project management software.

3. Novel Seed Treatment for Improved Pennycress Performance ("PELLET") (Objective 3.1.3)³

The use of seed coating and fungicide treatments in concert with certain strategies may improve establishment, especially if planted in fall when rain can be sporadic. In other species like *Brassica juncea*, hydro-priming (controlled pre-planting hydration) improves germination even in water-stressed environments. Another issue that may impact pennycress production is crown disease. Deterioration of the crown may impact maturation, induce lodging, and hamper mechanical harvest. Preventing infection of a pathogen causing crown rot or other seedling pathogens in the fall through the use of seed treatment may improve establishment, crown integrity, and minimize losses at harvest due to lodging. A field trial

³ "PELLET" is the abbreviation we will use for the "Novel Seed Treatment for Improve Pennycress Performance" part of the project. This IPREFER objective is led by Alex Lindsey at Ohio State University.

will be established in Ohio, Illinois, and Minnesota to determine the impact of seed treatments on fall establishment, spring crown integrity, and lodging.

A. Planned Activities

Schedule winter meetings to work through the project details. Lock in protocols, and determine how many sites, treatments, and replicates for the microplot study.

B. Actual Accomplishments

Project Collaborator Alex Lindsey's (Ohio State University) program acquired a pelletizer, and Project Co-Director Wells delivered 10 lbs. of MN106 during December. Dr. Lindsey's team is refining the pelletization program. During our winter meeting we agreed that the first stage of the PELLET program will use the MN106 only, and test six pelletization treatments.

Details include:

- For micro-plots, there may be undergrad involvement: MN106, pelleted, eight treatments (2 x 2 x 2) Dormancy release treatment (w or w/o) - either GA, H₂O₂, or scarification based on trials this spring; Fungicide (w or w/o) - contacted Syngenta and getting two fungicides;
- PELLET (w or w/o) - working on getting the pelleting system set up. 8 treatments of the only MN106, 16 treatments if including a CoverCress line across states.
- CoverCress lines may only need to be evaluated in Ohio and Missouri trials. Morris, St. Paul, UW Madison, Dubuque, IA, Normal, IL., Ohio - yes, may add 1-2 locations in OH.
- Sampling protocols are still under development. The project will roll out this fall in well-prepared seedbeds.

C. Explanation of Variance

Nothing to report. Moving forward as intended.

D. Plans for Next Quarter

We will hold a final meeting before planting in mid-March. We will move all protocols to ASANA data and project management software.

4. Tools for Integrated Weed Management ("WEEDS") 3.1.4

Where herbicides are used as the primary weed management tool, there will be herbicide residues in the soil that may impact the successful establishment of pennycress similar to the impact that herbicide residues may have on the establishment of more traditional winter cover crops. We will evaluate commercial pennycress varieties for their tolerance to likely concentrations of common corn herbicides that will be found in the soils of pennycress fields. Identifying herbicides to which pennycress is less sensitive will allow us to develop herbicide recommendations for the preceding crop that will decrease the likelihood of pennycress injury or death during its establishment. We will test the effects of common corn herbicides used to control summer annual weeds and quantify pennycress population density and biomass in the fall, survival of plants the following spring, and pennycress seed yield.

A. Western Illinois University

- **Planned Activities**

Schedule winter meetings to work through the project details. Check-in with the WEEDS project and assess how many locations across the network have both weeding fields and pennycress.

- **Actual Accomplishments**

Project Collaborator Mark Bernards (WEEDS) informed the group during our winter meeting that he reserved 0.75 ac of pennycress for weed and herbicide experiments. In addition, he stated that he will reserve space following wheat for 2020 planted weeds studies. His team is starting spray trials in the greenhouse.

- **Explanation of Variance**

Nothing to report. Moving forward as intended.

- **Plans for Next Quarter**

We will hold a final meeting before planting in mid-March 2020. We will move all protocols to ASANA data and project management software. We will also send data from the UMN Weeds team to Dr. Bernards.

5. Monitor Soybean Cyst Nematode (*Heterodera Glycines*, SCN) in the cropping rotation ("SCN") (Objective 3.1.5)

Pennycress has been reported to be a poor to moderate host for SCN in greenhouse studies. Research is underway to determine its impact on SCN populations under field conditions in the corn-soybean production systems. Preliminary results indicate that there was no increase of SCN population density in pennycress as compared with no cover crop treatment. It is

possible that pennycress as a winter cover crop does not support SCN reproduction, or it may even function as a trap crop during the cool season. Currently funded research is investigating the ability of SCN to infect pennycress in the field and is evaluating the role of temperature in SCN reproduction. Field-scale and microplot experiments are being conducted to evaluate the reproduction and life cycle development of SCN in the fall and spring months. Pennycress's role as a trap crop or alternate host will be discovered through these experiments.

A. CoverCress

- **Planned Activities**

It is too cold to have any nematode growth during this quarter, so activities are on hold for now.

- **Actual Accomplishments**

See above.

- **Explanation of Variance**

None noted.

- **Plans for Next Quarter**

We will take soil samples to learn what happened to the nematode population over the winter months.

- **Publications, Presentations and Proposals Submitted**

None at this time.

B. Minnesota

- **Actual Accomplishments**

We received matching funding from the Minnesota Department of Agriculture to establish field experiments in Minnesota to evaluate pennycress/SCN. These field experiments are also being set up at 1-2 locations in Illinois through a partnership with a nematology collaborator from Southern Illinois University.

- **Explanation of Variance**

None noted.

- **Plans for Next Quarter**

The field experiments will begin this spring with the planting of corn. The pennycress will be interseeded in the fall of 2020.

- **Publications, Presentations and Proposals Submitted**

None at this time.

6. **Contribute to the identification and development of soybean varieties specifically adapted to pennycress inter-cropping systems ("SELECT") (Objective 3.1.6)**

Minimizing yield trade-offs between pennycress and soybean in a relay cropping system is paramount. Recent research detected sizeable differences in light transmittance-related properties between pennycress crop canopies. This indicates that both canopies represent different stress environments for the relay-planted soybean, potentially requiring different soybean cultivars to be relay-planted. Further, the good performance of the relay-planted soybean cultivars suggests a stronger competitive ability that might decrease the yield potential of the cover crop. Taken together, those findings highlight the possibility of optimizing the cover crop-cash crop associations by identifying summer crop-cover crop cultivar combinations that maximize yields. To address the yield gap, a soybean selection (i.e., SELECT) was initiated fall of 2019 with the bulk planting of pennycress 'MN106'. A large number of soybean cultivars are slated for relay cropping into the pennycress spring of 2020 with the expressed goal of revealing large variations in soybean yield response to relay-planting. A large number of cultivars will, therefore, increase chances to identify uniquely superior cultivars. In addition, such group size will maximize the chances of identifying superior cultivars.

A. **USDA-ARS**

- **Planned Activities**

Schedule winter meetings to work through the project details. Update the team to the Ph.D. student search.

Breeding lines to be entered into the pennycress intercropping field study are being selected. Seed will be packaged during March and April. A set of candidate graduate students has been identified, and students are being interviewed in person and via teleconference.

- **Actual Accomplishments**

During the Agronomy winter meeting, we discussed the size of the fall pennycress plantings at both Morris, and Rosemount, MN. Project Collaborator Aaron Lorenz (UMN - Soybean Breeder) is currently recruiting a Ph.D. student to work on the program and has determined the soybean entries for both sites.

- **Explanation of Variance**

Nothing to report. Moving forward as intended.

- **Plans for Next Quarter**

We will hold a final meeting before planting in mid-March. We will move all protocols to ASANA data and project management software. We will hire a Ph.D. student.

B. University of Wisconsin – Platteville (UWP)

- **Planned Activities**

- **Project Management.** Apply for the Scholarly Activity Improvement Fund (SAIF) grant through the University of Wisconsin-Platteville to help further fund pennycress work and undergraduate researchers in Wisconsin.
- **Research Activities**
 - ◆ Analyze germination data collected after first frost at Lancaster, WI
 - ◆ Analyze germination data collected after first frost at Madison, WI.
- **Education Activities.** Contribute content to the IPREFER website in the form of an informational video on how to produce biodiesel from pennycress.

- **Actual Accomplishments**

- **Project Management.** Received SAIF funding for two undergraduate researchers for July 30, 2020-June 30, 2021.
- **Research Activities**
 - ◆ Using ImageJ, 10 random rosettes diameters were determined per plot for each replication at Lancaster, WI for the multi-location study.
 - ◆ Using ImageJ, 10 random rosettes diameters were determined per plot for each replication at West Madison, WI for the planting date trial.

- **Education Activities.** We created a set of four videos to demonstrate how to make biodiesel from pennycress. Three undergraduate students helped to create these videos.

- **Explanation of Variance**

None noted.

- **Plans for Next Quarter**

Plan the Corn Residue Management (CRM) experiment to take place at Lancaster, WI.

7. Publications, Presentations and Proposals Submitted (Agronomic Management Objective)

- **Publications**

- Moore, S., M.S. Wells, M. Wilson, R. Gesch and R. Becker. “Pennycress picks up after sweetcorn.” *Minnesota Crop News* (Blog), December 2019. <https://blog-crop-news.extension.umn.edu/2019/12/pennycress-picks-up-after-sweetcorn.html>.
- Moore, S., M.S. Wells, M. Wilson, R. Gesch and R. Becker. “Double cropping Pennycress.” *Minnesota Crop News* (Blog), February 2020. <https://blog-crop-news.extension.umn.edu/2020/02/double-cropping-with-pennycress.html>.
- Moore, S., M.S. Wells, M. Wilson, R. Gesch and R. Becker. “Double-cropping short-season high-value summer annuals with pennycress.” *Renewable Agriculture and Food Systems* (In review).

- **Professional Conferences /Meetings**

- Wells., M.S. “New Cash Crop Opportunities: Pennycress and Beyond.” 32nd Annual Integrated Crop Management Conference, Iowa State University, Ames, IA. December 2019. Two sessions, approximately 100 people. Covered topics on corn/soybean environmental externalities. Offering potential new ways forward with cash cover crops. Developed the relationships between ecosystems services and cover crop (i.e., pennycress) biomass accumulation. Questions ranged from SCN to market availability.
- Gesch, R.W. “Closing agronomic and breeding gaps for commercialization of pennycress and camelina.” 1/23/20. Invited Presentation, Cargill Foods Innovation Team, Plymouth, MN, January 23, 2020. About 25 persons in attendance.

OBJECTIVE 3.2 - BREEDING AND GENOMICS – PENNYCRESS IMPROVEMENT

1. Illinois State University

A. Planned Activities

Our research teams have generated high-yielding pennycress breeding lines through multi-state testing and identified/validated trait-improving mutations and natural variants. These were our planned activities for the second quarter:

- Utilize marker-assisted selection and CRISPR gene editing to complete introgression of these traits into elite breeding lines.
- Extend our replicated yield testing program to a cooperative regional program and rapidly identify the best lines for each Midwest location (IL, MN, OH, WI) in conjunction with commercial launch.
- Perform field evaluations and seed increases of lines with commercial potential.
- Develop additional genetic/genomic resources for long-term breeding programs success.

B. Actual Accomplishments

- We continue to make good progress in stacking the core domestication traits (low erucic, low fiber, low glucosinolate) into top breeding lines, using different genetic combinations to determine which are the best performing. We have confirmed solutions for reducing seed oil erucic acid and fiber.
- Reducing seed glucosinolate levels has proved challenging due to genetic redundancies and possible fitness issues with some genetic changes. Therefore, we have increased our efforts in this area. We are currently assessing mutations in seven glucosinolate biosynthetic genes (individual mutations and combinations) to determine which may be commercially viable. Studies include field trials at the ISU Horticulture Center field plot.
- Are working to find a CRISPR-based solution to reducing pod shatter by carrying out “promoter bashing” experiments. Unfortunately, all the knock mutations we have made in pod shatter genes reduce shatter by too much (in other words, the seeds are not extractable from the pods using a standard combine).
- Have isolated homozygous CRISPR-induced mutations that we predict will provide tolerance to herbicide carryover. Will soon be collecting seeds from these plants and

testing for increased tolerance in the lab before moving to the field with proper permissions.

C. Explanation of Variance

See glucosinolate challenges noted above.

D. Plans for Next Quarter

Continue work as stated above, as much as is possible, given the severe restrictions associated with the COVID-19 lockdown.

E. Publications, Presentations and Proposals Submitted

- Sedbrook, J.C. and T.P. Durrett. “Pennycress, carbon wise: Labeling experiments reveal how pennycress seeds efficiently incorporate carbon into biomass.” *J. Exp. Botany*. (In Press).
- Chopra, R., E.B. Johnson, R. Emenecker, E.B. Cahoon, J. Lyons, D.J. Kliebenstein, E. Daniels, K.M. Dorn, M. Esfahanian, N. Folstad, K. Frels, M. McGinn, M. Ott, C. Gallaher, K. Altendorf, A. Berroyer, B. Ismail, J.A Anderson, D.L. Wyse, T. Ulmasov, J.C. Sedbrook, M.D. and Marks. “A large-scale multi-faceted screen identifies crucial domestication traits needed to make *Thlaspi arvense* into a new eco-friendly oilseed crop.” *Nature Food*. 1 (2020). 84-91. <https://doi.org/10.1038/s43016-019-0007-z>. This paper was the subject of a “News & Views” article: <https://www.nature.com/articles/s43016-019-0016-y>.
- Sedbrook, John. “Employing CRISPR Gene Editing to Rapidly Domesticate Pennycress into an Oilseed Cash Cover Crop.” National Alliance of Independent Crop Consultants (NAICC) Conference. San Antonio, TX, January 22, 2020.
- Sedbrook, John. “Employing CRISPR Gene Editing and EMS Mutagenesis to Rapidly Domesticate Pennycress As an Oilseed-Producing Cash Cover Crop.” ASA, CSSA & SSSA International Annual Meeting, San Antonio, TX, November 12, 2019.

F. Grant proposal submitted:

Submitted proposal to the US DOE (FOA NUMBER DE-FOA-0002214, DOE). “Systems Biology Research to Advance Sustainable Bioenergy Crop Development. Proposal entitled, “Interrogating pennycress natural and induced variation to improve abiotic stress tolerance and oilseed bioenergy crop resilience.” \$15 million, submitted April 1, 2020.

2. University of Minnesota

A. Planned Activities

Our research teams have generated high-yielding pennycress breeding lines through multi-state testing and identified/validated trait-improving mutations and natural variants. These were our planned activities for the second quarter:

- Utilize marker-assisted selection and CRISPR gene editing to complete introgression of these traits into elite breeding lines.
- Extend our replicated yield testing program to a cooperative regional program and rapidly identify the best lines for each Midwest location (IL, MN, OH, WI) in conjunction with commercial launch.
- Perform field evaluations and seed increases of lines with commercial potential.
- Develop additional genetic/genomic resources for long-term breeding program success.

B. Actual Accomplishments

- We are in the process of stacking alleles into MN106 and two elite breeding lines using allele-specific markers (KASP). We are focusing on the traits that will improve the oil quality (reduced glucosinolates and reduced poly-unsaturated fatty acids), reduce glucosinolate levels in the seeds, reduce seed pod shatter, mature early and low fiber in the seeds. We already have several combinations of alleles stacked in MN106, including erucic acid/reduced glucosinolate/reduced shatter/early maturity which have been increased and are being evaluated for healthy growth habits. With the crosses completed in January 2020, we have stacked reduced erucic acid and poly-unsaturated fatty acids /reduced glucosinolate/reduced shatter/early maturity into two Minnesota breeding lines and will begin additional backcrosses.
- The 2019-2020 variety strip trial (Rosemount and Morris, MN) have been under complete snow cover since November 2019. We expect excellent winter survival.
- Approximately 250 M₁ plants transplanted into greenhouse produced seeds. We have begun to plant M₂ seeds from each one of the M₁ plants and hope to have everything planted in the greenhouse by March 31, 2020, for selecting progenies for further observations and whole-genome sequencing.
- We have analyzed 120 M₂ individual plants from 2018 EMS treated M₁ plants and data suggests that we have achieved 3.9 mutations per Mb using 0.2% EMS concentration. At this mutation rate we have achieved mutations in 75% of the pennycress predicted genes with at least one allele.

C. Explanation of Variance

No variance has been noted.

D. Plans for Next Quarter

We will continue moving the projects forward as stated above. During the upcoming field season, we will evaluate spring stand count, date of first flowers, plant height, and other traits on the variety strip trial in two locations and our mutant lines in four locations.

E. Publications, Presentations and Proposals Submitted

- **Publications**

Tyl, C., L. DeHann, K. Frels, P. Bajgain, M.D. Marks and J.A. Anderson. “Emerging crops with enhanced ecosystem services: Progress in breeding and processing for food use.” *Cereal Foods World*. (In press).

- **Professional Conferences /Meetings**

- Frels, Katherine. “New cash cover crops in the Forever Green Initiative.” Green Lands Blue Waters Conference, Minneapolis, MN, November 2019.
- Tandukar, Zenith. “Understanding the genetic basis of natural variation in seed size and oil content in Pennycress” (Poster presentation). Plant and Animal Genome Conference, San Diego, CA, January 2020.
- Tandukar, Zenith. “Understanding the genetic basis of natural variation in seed size and oil content in Pennycress.” National Biodiesel Conference & Expo, Tampa, FL, January 2020.

- **Proposals**

Two proposals were successfully funded by the UMN-Forever Green Initiative to support the breeding program (\$309,034) and the evaluation of SCN susceptibility across different growing regions. (\$184,717).

3. Western Illinois University

A. Planned Activities

- Continue effort to hire a plant breeder.
- Begin greenhouse breeding line seed increases for Illinois State University for traits of interest, including seed coat color, early flowering, and seed oil traits.

- Initiate purchase of Pulsed NMR for seed analysis and plot combine purchase.

B. Actual Accomplishments

- Continued efforts to hire a plant breeder. The position reopened in December 2019 and is closing in March 2020.
- We evaluated WIU research plots for emergence and stand counts.
- We prepared WIU greenhouse to received ISU pennycress lines in February 2020.

C. Explanation of Variance

- Seedlings from ISU were not ready for planting in January. WIU will take delivery on February 11, 2020.

D. Plans for Next Quarter

- Begin greenhouse breeding line seed increases for ISU for traits of interest, including seed coat color, early flowering, and seed oil traits.

E. Publications, Presentations and Proposals Submitted

• Publications

- Britt, Anne B. “From stinkweed to oilseed.” *Nat Food* 1, 24–25 (2020).
<https://doi.org/10.1038/s43016-019-0016-y>.

• Educational Presentations

- Phippen, Win. “*CONS-305 Sustainable Agriculture*.” Classroom guest lecturer for 50 min lecture on the IPREFER project and advances in pennycress production. Western Illinois University, Macomb, IL, November 1, 2019. 30 undergraduate students.
- Phippen, Win. Presentation to John Deere and Montag Manufacturing regarding new cash cover crop opportunities. Boone, Iowa, November 13, 2019. 50 sales personnel and producers present.
- Phippen, Win. Distributed a slide set introducing pennycress as a viable new cash crop to TruAg dealers for presentation at farm shows in Peoria, IL; Des Moines, IA, Quad Cities, IL and Cedar Falls, IA. The presentations will take place in the winter 2020.

- Phippen, Win. Prepared a blog “flat sheet” for the Illinois Soybean Association membership newsletter which was distributed to 4,000 + members. November 2019.
- Phippen, Win. “Pennycress as a New Cash Cover Crop.” Webinar for members of the Commercial Aviation Alternative Fuels Initiative (CAAFI). December 5, 2019.
- **Proposals Submitted**
 - None to report.

OBJECTIVE 3.3 - CHARACTERIZATION OF PENNYCRESS ECOSYSTEM SERVICES

The primary goal of the ecosystem services project at Illinois State University is to ensure good stands of pennycress growing on the plots and applying spring nitrogen as the weather dictates.

1. Planned Activities

The following are the activities we planned on completing this quarter:

- Obtain baseline cover crop biomass estimates with a drone fitted with a multispectral sensor.
- Obtain a high-resolution digital elevation model for the site (+/- 2.5 cm) to estimate soil loss.
- Install water samplers to sample tile water starting in the spring from each plot beginning in February as the soil begins to thaw and runoff occurs.
- Install lysimeters to sample pore water of each treatment plot to understand the effectiveness of pennycress in central Illinois compared to Minnesota and other experimental areas. This will allow us to compare the responses of porewater nutrient concentrations which may respond faster to pennycress as a cover crop than tile water nutrient concentrations.

2. Actual Accomplishments

We have completed most of our planned objectives and will be ready to begin sampling as the soil thaws. We have gathered all baseline soil nitrogen and phosphorus estimates for the plots. We have also determined soybean cyst nematodes populations in each of the plots. The north plots have higher levels than the south plots.

In the late fall, Wondy Seyoum (Illinois State University, Department of Geography, Geology, and the Environment) gathered baseline biomass estimates and a detailed digital elevation map of the site which will be useful in estimating soil loss and biomass growth over time.

The pennycress cover crop was planted on the treatment plots in late October 2019 in the north blocks of plots and in February in the south block of plots.

We have begun assembling lysimeters and will install them in March 2020 to sample pore water. We will be installing the tile water samplers in March and are working to obtain added funding to accomplish a finer scale sampling of the water loss from the plots.

We have also taken on one graduate student to do the pore water sampling and have had three undergraduates working on projects related to ecosystem services.

3. Explanation of Variance

The only deviation from our plans was a slight delay in installing the tile water samplers due to a lack of funds. We are working out solutions with our university (Illinois State University) to recover some indirect costs and to make use of older equipment to further reduce costs. We will transfer money from within our project to almost cover all of the costs.

4. Plans for Next Quarter

The ISU ecosystem services group will determine:

- Pennycress biomass in treatment plots using quadrat (1m²) and using a multispectral sensor mounted on a drone.
- Nitrogen uptake in pennycress crops.
- Weed biomass and diversity in all treatments.
- Pore water nitrogen and phosphorus.
- Tile water nutrient losses and water losses from treatments.

In addition, we will help install beehives near the pennycress fields to assist Project collaborator Frank Forcella (Minnesota).

5. Publications, Presentations and Proposals Submitted

- **Publications**

None this quarter.

- **Professional Conferences /Meetings**

None this quarter.

- **Proposals**

Wang, Jack, Stephanie Van Wolvelear and Bill Perry. 2020. “Development of infrastructure to test sustainable farming practices using a new cash cover crop (pennycress) to reduce nutrient export to streams.” Student Sustainability Fund Application. ISU. 25,677, (Pending).

OBJECTIVE 3.4 - LIFE CYCLE SUPPLY CHAIN DEVELOPMENT

The IPREFER supply chain team held a conference call to discuss the work being conducted in the second quarter. The University of Minnesota has started specific seed drying tests and will have results by next quarter. CoverCress has offered to share their grain drying results and grain samples from larger bin drying efforts conducted about three years ago.

CoverCress is now establishing efforts to map the whole supply chain needs from the farm to the grain processor and will have updates on modeling and costs by the third quarter.

We are forming a broader supply chain team with other interested individuals in the IPREFER group. The full list of individuals and meeting schedules will be shared next quarter along with the progress made.

OBJECTIVE 3.5 AND 6 - EDUCATION, EXTENSION AND OUTREACH

1. Planned Activities

A. Illinois State University

- Create an inventory of existing cover crop educational materials.
- Write/draft one 4H module, recruit participants, and implement the module in January-February 2020.
- Conduct a short, introductory activity for 1-4 4H clubs to recruit into SPIN club(s).
- Conduct a short, introductory activity for parents attending 1-4 4H club meetings.
- Assisted in recruitment for the IPREFER 2020 Internship program.

B. University of Minnesota

Conduct the groundwork for the IPREFER 2020 Internship program.

C. Ohio State University

- Assisted in recruitment for the IPREFER 2020 Internship program.
- Build relationships with STEM outreach groups for eventual dissemination of educational activities.

2. Actual Accomplishments

A. Illinois State University

- The creation of the inventory of existing cover crop educational materials is underway. Integrated into this effort is the creation of a poster presentation that will provide a curricular map of existing *Ag-in-the-Classroom* lessons and activities that can be used to teach cover crop science. This poster will be presented at Bradley University's STEM/STEAM Conference for K-12 Educators on March 6, 2020 in Peoria, IL.
- A curriculum for a 4H special interest (SPIN) club on cover crops entitled "Cover Crop Scientists" has been drafted, and recruitment is underway. We plan for this club to be offered in Farmington, IL, February 29 – April 18, 2020. We are tentatively planning to offer this club in Normal, IL this spring as well, dates to be determined. We are seeking IRB approval to collect evaluative field notes on the curriculum so that the evaluation may be publishable in the future.
- At the Fulton-Mason-Peoria-Tazewell Counties 4H Clover Clinic on February 15, 2020, we led *Cover Crop Trivia*, for 100+ 4H members during pick-up time, with their parents in attendance. While technology challenges prevented this from being as effective as it could have been (we had to read the questions out-loud rather than them being projected onto a screen), the game fulfilled the intent of creating awareness about the upcoming Cover Crop Scientists SPIN Club.
- Project collaborator Rebekka Darner distributed the IPREFER 2020 Internship program information to ISU STEM Alliance, the Louis Stokes Alliance for Minority Participation (LSAMP) community led by Chicago State University, and the Louis Stokes Midwest Regional Center of Excellence, which serves the state of Indiana.

B. Ohio State University

- Project collaborator Alex Lindsey discussed highlighting educational efforts at professional meetings and at the Science Education Conference of Ohio in 2020, but the dates overlap with the ASA meeting in Phoenix, so he will look for alternate opportunities to present IPREFER material.
- Lindsey distributed IPREFER 2020 Internship program information to undergraduates at OSU, resulting in at least one application for which he supplied a letter of recommendation and a research summary.
- Lindsey has started building connections with STEM outreach groups in Ohio to start to implement/distribute IPREFER educational activities.

C. University of Minnesota

Applications for the IPREFER 2020 Internship program are open, and several applicants have completed their applications, which are due February 28, 2020. Project collaborator Mary Brakke has drafted a structure for the introductory internship “bootcamp” that will be held at UMN at the beginning of the internship period (May/June 2020).

3. Explanation of Variance

A. Illinois State University

We have yet to conduct a short, introductory activity for parents attending a 4H club meeting. We plan to integrate this into the SPIN club activities, which are scheduled to begin February 29, 2020. No other variance has been noted.

4. Plans for Next Quarter

A. Illinois State University

- Complete the inventory of existing cover crop educational materials, which will include the poster presenting a curricular map of *Ag-in-the-Classroom* lessons. We are considering writing a review of the inventoried materials and submitting a manuscript for publication in the *Journal of Agriculture Education*, which likely will not occur until the summer of 2020.
- Project collaborator Matthew Hagaman will present the poster of *Ag-in-the-Classroom* lessons to teach cover crop science and lead a hands-on demo of seed crushing/oil extraction at Bradley University’s STEM/STEAM Conference for K-12 Educators on March 6, 2020, in Peoria, IL.
- The Cover Crop Scientists SPIN club will be offered in Farmington, IL, February 29 – April 18, 2020. Hagaman will lead the club while Rebekka Darner will assist in

club facilitation and take field notes to inform an evaluation of the developed curricular materials. We expect to revise the curriculum before its dissemination to other 4H club leaders.

B. Ohio State University

- Work with Illinois State to develop educational materials for presentation and dissemination.
- Support undergraduate research effort on seed treatment project.

C. University of Minnesota

Upon the close of the IPREFER 2020 Internship applications, the team will select interns for the summer research opportunity. Then we will begin making logistical arrangements with selected interns. All team members will likely play a role in this, given that we expect interns to be placed across all partner institutions.

- Co-Project Director Scotty Wells is preparing for two *Forever Green* Oilseed Field Days in Minnesota in which IPREFER will be the focus; educational information and meeting details will be sent out before the events.
- Wells is also working on an informational questionnaire that can be used project-wide and standardized across the network.

5. Publications, Presentations, & Proposals Submitted

- Hagaman, Matthew. “Cover Crop Trivia.” Fulton-Mason-Peoria-Tazewell Counties 4H Clover Clinic, East Peoria, IL, February 15, 2020.
- Hagaman Matthew and Rebekka Darner. “Hands-on with Cover Crops and Biofuels.” STEM/STEAM Conference for K-12 Educators: Innovations in K-12 STEM Education and Green Chemistry, Bradley University, Peoria, IL, March 6, 2020.
- Wells M.S. “New Cash Crop Opportunities: Pennycress and Beyond.” 32nd Annual Integrated Crop Management Conference, Iowa State University, Ames, IA, December 3, 2019.

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“Our mission is to optimize off-season pennycress oilseed production

By overcoming production and supply chain bottlenecks.”

