1. Project details

Project File number: AGR-17173, Western Grains Research Foundation, Prairie Oat Growers Association
Project title: Continuing studies on intercropping for increasing yield and quality of grain and forage crops, and improving soil quality, by Fernandez et al.
Reporting period: April 1st, 2024-March 31st, 2025
Approved Project Date: New Amended CRDA signed by all parties in January 2024
Report prepared by: Myriam R. Fernandez

2. Specify project activities undertaken during this reporting period

This continues to be a very successful project under the ongoing drought conditions in this region.

a.) Methodology:

ALL TRIALS:

The severe hail damage on July 22nd, 2023 affected the execution of most of the main deliverables in all four 2023 trials (see the 2023 Annual Progress Report). Regardless, in 2024 we decided to still conduct the Phase 2 of these trials on the plots that had not been entirely destroyed by the hail so that we would not lose a whole year of data. The plots that were excluded from the Phase 2 trial of 2024 were the Lentil-Barley given that they had been the ones affected the most by the hailstorm. As in the past, this Phase 2 consisted of Durum wheat planted at the same rate on all plots. However, based on the damage caused by the hail storm, we requested an extension of this project to add another two years of trials and data (with no extra funding).

In this report, we have included results from all Phase 2 trials, despite the hail damage in 2023. We will make a decision regarding the inclusion of these data in the final analysis of all data collected throughout this project.

In addition, new Intercrop Phase 1 and Living Mulch Phase 1 field trials were conducted in 2024 on another organically-managed piece of land at SCRDC. This organic land had been under a similar green manure cocktail mix as in previous years, which consisted of a legume, a cereal, and a brassica, plowed down at flowering.

In all trials, the following measurements and sampling were successfully taken in 2024: number of seedlings emerged, plant height, photosynthetically active radiation above and below the crop canopy, Greenseeker measurements for crop N status, plant growth throughout the summer, incidence and severity of aboveground crop diseases, root rot incidence and severity and fungal identification, early weed ratings, weed identification and density and weed biomass, crop biomass, grain yield, grain protein concentration, 1000-kernel weight, test weight of cereals. Crop biomass was also submitted for analysis of NPK concentration.

As in previous years, before seeding of the 2024 trials, soil samples were taken at three depths from all plots to measure: moisture**,** N, P, K, S, Total N, Total C, Organic C, pH. Soil samples were also taken at the end of the growing season to conduct similar analysis. In the fall after harvest, soil samples were taken at 3 depths to measure moisture, N, P, K, S, Total N.

In addition, soil and plant tissue samples of three selected treatments from the intercrop Phase 1 trial were taken 4 times throughout the growing season for more thorough lab analysis to model plant growth and nutrient dynamics (by Guillaume Jégo, Quebec Research and Development Centre).

<u>From previous reports</u>: Our new plot seeder, acquired in 2021 for our Organic Research Program, by WGRF and AAFC, has allowed us to seed all these trials more accurately, consistently and effectively, and without any risk of contamination by synthetic chemicals due to the shared use of the previous seeders with non-organic programs. This new seeder is equipped with two cone splitters controlled by individual zero max drives to distribute seeds evenly among rows. It is able to simultaneously sow

crops with different seed sizes in the same row at different depths and at the same time, and different crop species in alternate rows.

Further detailed information on all the Intercrop and Living Mulch treatments were included in the presentation on these trials in the current and previous years made at the 2024 Organic and Low-Input Event on July 31st, 2024 **(Appendix C, D, E),** and in the main handout for that event **(Appendix B).**

b.) List and explain any deviations from the approved objectives:

Changes/additions from previous years:

INTERCROPS: Two additional mixed row treatments (Mustard85+Pea100 and Mustard65+Pea100) had been added to the Phase 1 in 2023 and were included again in the 2024 trial.

c.) Research results in the reporting period

Objectives	Progress
To determine if intercrops with crops or a living mulch can reduce weeds compared to sole crops, and in the following crop	In progress in 2024-25. This objective has been delayed due to the hail damage in July of 2023.
To determine the N benefit from legumes in intercrops or living mulch to the following crop compared to sole legume crops	In progress in 2024-25. This objective has been delayed due to the hail damage in July of 2023.
To determine if intercrops have less disease than monocrops, and their effect on diseases in the following crop	In progress in 2024-25. This objective has been delayed due to the hail damage in July of 2023.
To determine biomass and grain yield/quality of crops in intercrops at various ratios compared to monocrops and of following crop	In progress in 2024-25. This objective has been delayed due to the hail damage in July of 2023.
To determine optimal seeding ratio of intercrops with crops or living mulch for achieving greatest agronomic/economic benefit	In progress in 2024-25. This objective has been delayed due to the severe hail damage in July of 2023.
To develop growth and nutrient uptake models and determine optimum ratio(s) for intercrops compared to the respective monocrops	In progress in 2024-25. An analysis has been done and presented with crop and soil data from previous years.
To determine inter and intra-specific competition for nutrients and soil moisture in intercrops under various seeding ratios	In progress in 2024-25. Some analysis was done with data from previous years.

d.) RESULTS and DISCUSSION

Below are some highlights of the results from the 2024 trials:

All trials in 2024 were affected by the ongoing drought conditions, and heat at flowering/maturing.

INTERCROP TRIALS PHASE 2 (following the Phase 1 in 2023) – This trial in 2024 had Durum wheat (AC Transcend) grown over the intercrops treatments of the previous year (2023). The hailstorm that occurred in July of 2023 greatly affected the growth of all intercrops. The Lentil-

Barley intercrop ratios were the most affected and thus no Phase 2 on these plots was done in 2024. The other intercrop treatments, although not affected as much, were still damaged by the hail.
Thus, the data and preliminary analysis below have to be interpreted with caution.
Please note that a final decision regarding the inclusion of each of the 2023 datasets will be made when the formal analysis of all the data is done at the end of this project.

Treatments in 2023 followed by Durum wheat (AC Transcend) in 2024:
Pea100 (monoculture)
Oat100 (monoculture)
Pea125+Oat15 (mixed rows)
Pea100+Oat5 (mixed rows)
Pea100+Oat15 (mixed rows)
Pea60+Oat25 (alternate rows)
Pea50+Oat50 (alternate rows)
Mustard100 (monoculture)
Mustard85+Pea100 (mixed rows)
Mustard100+Pea100 (mixed rows)
Mustard85+CV(chickling vetch)80 (mixed rows)
Mustard100+CV(chickling vetch)50 (mixed rows)

Weed species: In 2024, the most common weeds present in this trial were purslane (55%), green foxtail (15%), stinkweed (9%), and Russian thistle (8%).
Early weed ratings: Durum grown after the Oat monoculture and the alternate Pea-Oat intercrop had among the lowest early weed ratings.
Weed density: Durum grown after the Mustard monoculture and most of its intercrops with legumes had the lowest weed density, followed by the Oat monoculture, and then the intercrops of Pea-Oat.
Weed biomass: The higher the ratio of legumes in the intercrops of Oat and Mustard with Legumes the higher their weed biomass.
Plant height, crop biomass, grain yield: in most cases there were no statistically significant differences in the height, crop biomass or grain yield of Durum among the intercrop treatments of the previous year.
Kernel weight: Durum grown after the Pea monoculture and most ratios of Pea-Oat and Pea-Mustard showed significantly higher kernel weight compared to Durum grown after the non-legume monocultures (Oat100, Mustard100).
Root rot: Evaluation of root rot revealed that Durum wheat grown after the Oat monoculture had higher root rot levels (mean of 51.6% for moderate to severe discolouration of subcrown internodes) than when grown after the Pea-Oat intercrops (26.1% to 32.3%), or after the Pea monoculture (33.5%). Isolation, identification and quantification of the fungi present in affected subcrown internodes is in progress.
Soil nutrients in the spring of 2024 before seeding of the Durum wheat: is not yet available at the time this report was submitted.

INTERCROP TRIALS - PHASE 1

Treatments:
Lentil100 (monoculture)
Lentil125+Barley15 (mixed rows)
Lentil100+Barley5 (mixed rows)
Lentil100+Barley25 (mixed rows)
Lentil60+Barley25 (alternate rows)
Lentil50+Barley50 (alternate rows)

Barley100 (monoculture)
Pea100 (monoculture)
Pea125+Oat15 (mixed rows)
Pea100+Oat15 (mixed rows)
Pea100+Oat5 (mixed rows)
Pea60+Oat25 (alternate rows)
Pea50+Oat50 (alternate rows)
Oat100 (monoculture)
Mustard100 (monoculture)
Mustard85+CV80 (mixed rows)
Mustard100+CV50 (mixed rows)
Mustard100+Pea100 (mixed rows)
Mustard85+Pea100 (mixed rows)

Cultivars:
Lentil (CDC Maxim)
Barley (AC Metcalfe)
Mustard (AC Andante)
Chickling Vetch (AC Geenfix)
Pea (CDC Lewochko)
Oat (AAC Oravena)

Weed species: The most common weeds in the 2024 trial were purslane (44.5%), pigweed (43.9%), and lambsquarters (9.2%).

Weed biomass: The Barley monoculture (Barley100) had the lowest weed biomass, while the intercrops Lentil100+Barley25 (mixed rows) and Lentil50+Barley50 (alternate rows) had lower weed biomass than most of the other Lentil-Barley treatments and were not significantly different than in the Barley monoculture. The highest weed biomass was observed in the less competitive Lentil monoculture (Lentil100) and the intercrop with the lowest Barley ratio (Lentil100+Barley5).

In the Pea-Oat intercrops, the lowest weed biomass was observed in the competitive Oat monoculture (Oat100) and Pea50+Oat50 (alternate rows), while the highest weed biomass was observed in the less competitive Pea monoculture (Pea100) followed by Pea-Oat intercrops with the lowest ratios of Oat.

Most of the Mustard intercrops with Legumes were not significantly different for weed biomass than the Mustard monoculture (Mustard100).

Weed density: The highest weed density was observed in the treatments with a Legume monoculture and intercrops with a high ratio of Legumes: Lentil100, Lentil100+Barley5, Pea100, Pea125+Oat15, Pea100+Oat5. The lowest weed density was observed in the Oat monocrop (Oat100) and the Pea50+Oat50 (alternate) treatment.

Crop development and productivity: The treatments of Barley and Oat intercropped with Lentil and Pea, respectively, showed higher productivity based on multiple parameters:

Plant height: In most cases, Barley, Oat and Mustard intercropped with a Legume were taller than their respective monocultures. The Pea monoculture and its intercrops with lower ratios of Oat were taller than the rest of the Pea-Oat treatments. Pea intercropped with lower ratios of Mustard were also taller than when intercropped with higher ratios of Mustard.

Crop biomass: Lentil50+Barley50 (alternate rows) and Lentil60+Barley25 (alternate rows) had similar to higher crop biomass of Barley than the Barley monoculture (Barley100).

Grain yield: The treatments of Lentil seeded in alternate rows with Barley (Lentil50+Barley50, Lentil60+Barley25) or in mixed rows with Barley (Lentil100+Barley25) also had statistically similar to higher grain yield of Barley than the Barley monoculture (Barley100), despite having lower ratios of this crop than its monoculture. Similarly, the treatments with Pea seeded in alternate rows with Oat (Pea50+Oat50, Pea60+Oat25) had similar to higher grain yield of Oat than the Oat monoculture

(Oat100), despite having lower ratios of this crop than its monoculture. As expected, the lowest grain yield of Barley and Oat was observed at their lowest ratios when intercropped with the Legume (Lentil100+Barley5 and Pea100+Oat5). However, as observed in previous years, both barley and oat yielded more than expected based on their seeding ratios in the intercrops.

LIVING MULCH TRIALS:

All trials in 2024 were affected by the ongoing drought conditions and high heat during flowering/maturing of the crops.

The treatments in these trials involved Oat or Wheat seeded at 100% (x100) or 60% (x60) rate, each of them seeded with a Clover, or both Clovers. The Clovers were: Subterranean clover, a.k.a. Subclover at 100% (x100), 150% (x150), or 200% (x200) rate, and Crimson clover at 100% (x100), 150% (x150), or 200% (x200) rate.

Crop and Clover Full rate: Bread Wheat (AAC Brandon) 120 kg/ha, Oat (AAC Oravena) 140 kg/ha, Subclover 9 kg/ha, Crimson Clover 9 kg/ha.

List of treatments:

Oat100 (monoculture)
Oat100+Subclover150
Oat100+Crimson150
Oat60 (monoculture)
Oat60+Subclover200
Oat60+Crimson200
Oat60+Subclover100 + Crimson100
Wheat100 (monoculture)
Wheat100+Subclover150
Wheat100+Crimson150
Wheat60 (monoculture)
Wheat60+Subclover200
Wheat60+Crimson200
Wheat60+Subclover100+Crimson100

LIVING MULCH PHASE 2 (durum wheat grown in 2024 after the living mulch treatments of Clovers with Oat or Wheat in 2023):

Soil sampling in the spring after the Living Mulch treatments (before seeding of the Durum wheat) was done in all plots. Analysis of soil samples taken in the spring, right before seeding of the Durum wheat, determined that some of the Clover with Oat treatments were significantly different from the sole Oat. In the 30-60 cm layer, soil NO_3-N was significantly higher for the Oat100+Crimson100 (22.0 kg/ha) than for the sole Oat (12.7 kg/ha). Soil P (PO_4-P) was higher at 0-15 cm for Oat100+Crimson100 (77.4 kg/ha) than for the sole Oat (59.9 kg/ha). There were no significant differences in soil P among the Wheat treatments.
Weed species: the most common weeds in the 2024 trial were purslane (52%), pigweed (24%), lambsquarters (9%), Russian thistle (6%), and bindweed (5%).
Durum wheat growth and **weed populations**: Most differences in among treatments were not statistically significant. Durum wheat grown after Wheat100+Crimson100 had a significantly greater crop biomass than after the sole Wheat (24% difference). There were similar trends for grain yield and 1000-kernel weight but were not statistically significant. There were also no significant differences among treatments for weed biomass.

LIVING MULCH PHASE 1 (Living Mulch treatments of Clovers with Oat or Wheat)

Weed species: the most common weeds in the 2024 trial were: pigweed (66%), lambsquarters (31%), bindweed (8%), and Russian thistle (3%).
Weed ratings at the beginning of the season were lower for the Clover with Cereals treatments than the sole Cereal crops, for both Oat and Wheat. However, there were few significant differences for **weed biomass** or **weed density**. In all cases, there was a tendency for lower weed density in the Clover with Cereals treatments than the sole Cereal crops. In turn, the higher Cereal seeding rates (x100) had an impact on weed biomass. Clovers did not seem to impact weed density or biomass within the Cereal treatments. Thus, the cereals were able to outcompete weeds more than the clovers.
Plant height: Oat plants with a Clover living mulch were taller than the sole Oat plots (greatest difference was 8 cm taller for Oat100+Sub150 than the sole Oat). Wheat plants were also taller in the living mulch plots (greatest difference was 7.5 cm taller for Wheat100+Crimson100 than the sole Wheat plots).
Flowering: Oat100+Subclover150 flowered 8.1 days later than Oat100. Oat60+Subclover200 flowered 7.5 days later than Oat60
Crop biomass: Crop biomass was statistically similar between the Clover living mulch plots underseeded to Oat and the sole Oat, which indicates that the growth of the Clover plants did not affect Oat growth negatively. Crop biomass of Oat in Oat100+Subclover150 was higher (5912 kg/ha) than for the sole Oat (5337 kg/ha).
Biomass of the Clovers: For Oat, the Clover biomass was 99 kg/ha for Oat100+Subclover150 vs. 34 kg/ha for Oat100+Crimson100. For Wheat, Clover biomass was 71 kg/ha for Wheat100+Subclover 150 vs. 92 kg/ha for Wheat100+Crimson100. Comparison with a lower ratio of the Cereals (x60) showed that the full seeding rate (x100) of the Cereals had a negative impact on the Clover biomass. In the treatment with both Clovers together seeded with a lower ratio of the Cereals (Oat60+Sub100+Crim100), biomass was 75 kg/ha for Crimson and 47 kg/ha for Subclover. For Wheat, Crimson had a biomass of 110 kg/ha and Subclover 104 kg/ha in Wheat60+Sub100+Crim100. This resulted in a total higher Clover biomass in the combined Clover treatments for Oat and Wheat. Thus, having both Clovers grown with Oat or Wheat at 60% seeding ratio of these cereals resulted in more Clover biomass than when these Clovers were seeded individually with a full rate of the Cereal crops. These results show that the Cereals were able to suppress clover growth to a certain extent.
Grain yield: Differences among treatments were not statistically significant, again indicating no negative impact of the Clovers on crop productivity. However, the grain yield of Oat in Oat100+Subclover150 tended to be higher (1469 kg/ha) than of the sole Oat (1245 kg/ha). For Wheat, the Wheat100+Crimson100 treatment tended to have a higher grain yield (1439 kg/ha) than the sole Wheat (1332 kg/ha).
Kernel weight: the positive impact of the Clovers was also manifested in the grain weight of the cereals. The treatments with Clovers tended to have a higher 1000-grain weight than the sole Cereals.
Greenseeker crop sensor to assess crop health (it measures the reflection of red and infrared light from a crop canopy, providing a normalized difference vegetation index (NDVI) value that indicates crop vigor): In our trials, NDVI values were higher in the Clover treatments with cereals than in the sole Oat or Wheat, measured on July 4, 2024 but there were no significant differences in the measurements taken at later growth stages, possibly attributed to the drought conditions experienced throughout crop growth.
Please note: At the time of submission of this report, some of soil analysis report from this project had not yet been received.

e.) List summary of findings, implications, and briefly discuss any conclusions

INTERCROPPING PROJECT:

There is not much information on the benefits of intercropping to organic crop production in semiarid regions. Outcome of this cropping system will depend on crop species, their competitiveness in combinations, seeding ratios, effect of soil and environmental conditions on their growth, among other factors.

In general, results obtained in 2024 agree with those observed in previous years (See **Appendix C** for an overview of this project and some results from previous years). In most cases throughout the last few years, Legumes in the intercrops performed less than expected, while Non-Legumes performed more than expected. Dry conditions negatively affected the competitiveness of the Legumes in the intercrops, even when they were present at high ratios. This has resulted in the highest crop biomass and grain yield observed mostly in the Non-legume monocultures, and lowest crop biomass and grain yield mostly in the Legume monocultures, with a higher total crop biomass and grain yield in the intercrops than in the Legume monocultures. In addition, weed biomass in the monocultures was highest in the Legumes and lowest in the Non-legumes, and there were fewer weeds in the intercrops than in the Legume monocultures, and fewer weeds in the alternate than mixed row intercrops.

The results from this project in the last few years so far support that the practice of intercropping is beneficial in suppressing weeds, and that there is a potential for intercrops to successfully produce high amounts of crop biomass with low weed biomass. However, under drought conditions, there is a lower ability to convert assimilates into grain when there is not enough soil water for grain filling. Therefore, if dry conditions persist throughout the summer, any enhanced vegetative growth might not fully transfer to grain yield, and thus a low harvest index might be expected.

There was a similar crop biomass and grain yield in alternate rows and Non-legume monocultures. In regards to alternate vs. mixed rows, the cereal companion would have more access to N from the Legumes in the mixed than the alternate rows, and alternate rows are expected to reduce competition between the Legume and the companion Non-legume, resulting in better Legume growth and yield. An even greater benefit from the Legume would be expected under better environmental conditions. These observations from the previous years of this project did not occur to their full extent in 2024 due to the more severe drought conditions over the summer which affected the growth of the Legumes to a greater extent than in the previous few years.

Relative to the monocultures, grain weight of Barley and Oat grown in mixed rows with Legumes increased in all years of this project, including 2024.

In addition to the popular articles on this project, listed on this and previous annual reports, available on the SaskOrganics website or on demand from myriam.fernandez@agr.gc.ca, we have recently published results from our Intercropping studies in two peer-reviewed manuscripts in Agronomy Journal:

- Fernandez, M.R., Lokuruge, P., Abdellatif, L., Waelchli, N., Leeson, J.Y., Schellenberg, M.P., & Chalmers, S. (2025). Intercropping of oat or mustard with legumes under organic management in the semiarid Canadian Prairie. *Agronomy Journal (in press)* DOI: 10.1002/agj2.70056

- Fernandez, M.R., Lokuruge, P., Lobna Abdellatif, L., Waelchli, N., Leeson, J.Y., Zvomuya, F., & St. Luce, M. (2025). Cereal crop following organic intercrops and their respective monocrops in the semiarid Canadian Prairie. *Agronomy Journal (in press)* DOI: 10.1002/agj2.70032

LIVING MULCH PROJECT:

Living mulch using Clovers adapted to this region is a regenerative agriculture technique that has proven to be successful in increasing yield, mitigating weed density, and increasing soil nitrogen. Undersowing cash crops with Legume mulches could be a sustainable strategy for improving the quality of non-legume grain or forage crops, which could provide an alternative to the lack of economic returns of green manure and the poor weed suppression ability of legumes.

Results from this study will be applicable to other regions and management systems, including regenerative conventional low-input production.

Clovers seeded together with Oat or spring Wheat in the same rows have been shown to positively impact both cereal crops and soil quality. However, not all parameters for a given Clover treatment are going to result in a significant positive outcome compared to the sole cereal in each year, especially under the dry conditions of the years these trials were conducted.

We have shown that Clover treatments had a positive impact on most crop growth and soil parameters measured, especially in the Oat treatments, compared to the respective monoculture, while having a negative impact on weeds.

The largest impacts in the Oat treatments were observed in Oat100+Sub150. This treatment had the greatest, or among the greatest, plant height, crop biomass, grain yield, and 1000-kernel weight amongst the Oat treatments, and had the lowest weed density. For Wheat, the largest impact occurred for Wheat100+Crim100, which had the highest, or among the highest, grain yield and height values, highest 1000-kernel weight among all the Wheat100 treatments with Clovers, in addition to the lowest weed ratings and weed biomass and amongst the lowest weed density of the Wheat100 treatments.

Our results in 2024 are similar to those observed in 2022 when there was no yield penalty for Oat or Wheat at x60 than x100 seeding rate, and a mulch with Clovers did not result in a lower grain yield or crop biomass of Oat or Wheat (see **Appendix D**). In 2022, both Clovers were associated with a significantly lower weed biomass when grown with Wheat100 than in its monoculture (Wheat100). SubClover150+Oat100 had among the lowest weed biomass and weed density (both years). There were fewer weeds in the Oat than the Wheat treatments. In most cases, Clover biomass, especially of Subclover, was similar or higher than the Weed biomass, so Clovers were able to outcompete the weeds. Grain yield of Subclover150+Oat100 was significantly higher than of the Oat100 monoculture (38% increase).

NEST STEPS:

Although there were several consistencies among years, given the severe hail damage in 2023 we would like to have more data before reaching definite conclusions. All trials in this project will continue in 2025 with mostly similar treatments as in 2024. Results from these trials will allow us to confirm our observations thus far.

Based on all the positive results of the Living Mulch trials in the last few years, a Letter of Intent has been submitted to the Agricutlure Development Fund and other potential funders on: "**Living mulch for regenerative cereal production in the western Prairies**" (PI: M.R. Fernandez, and M. St. Luce and A. Alemu, collaborators), to continue with Living Mulch studies using other crop species for living mulch and other cash crops.

In addition, based on the very significant decrease in pathogen isolations from roots and subcrown internodes in these studies (not reported in this annual report), another Letter of Intent has been submitted to the Agriculture Development Fund and other potential funders on: **"Investigating soil and management factors suppressing root rot pathogens:"** (PI: M.R. Fernandez, co-PI: B. Cade-Menun, and M. Hubbard, collaborator) to investigate the impact of soil factors such as pH in conventional vs. organic methods on the development of root rot in legume and cereal crops.

<u>Development of growth and nutrient uptake models</u> – by Guillaume Jégo, Quebec Research and Development Centre

Objectives:

1. The first modelling objective is to develop a new set of parameters in the STICS crop model (https://stics.inrae.fr/eng) to simulate the growth and N uptake of pea, oat and the pea-oat intercrop.
2. The second objective, once the model has been properly calibrated and evaluated, will be to simulate several scenarios of plant density of the pea-oat intercrop to estimate the better seeding ratio in terms of yield. During the 2024-2025 fiscal year the first objective was addressed.

Materials and methods:

Three years (2021-2023) of field data at Swift Current for pea, oat and pea-oat intercrop are currently available. A fourth year (2024) will be available soon. These datasets include leaf area index, above ground and grain biomass and their N content as well as surface soil moisture and mineral N content.

The model used to simulate the growth and the N uptake of the two crops is the STICS soil crop model (Brisson et al., 1998; Beaudoin et al., 2022). It simulates at a daily time step the crop growth and the C, N and water balance at the field scale (Figure 1).

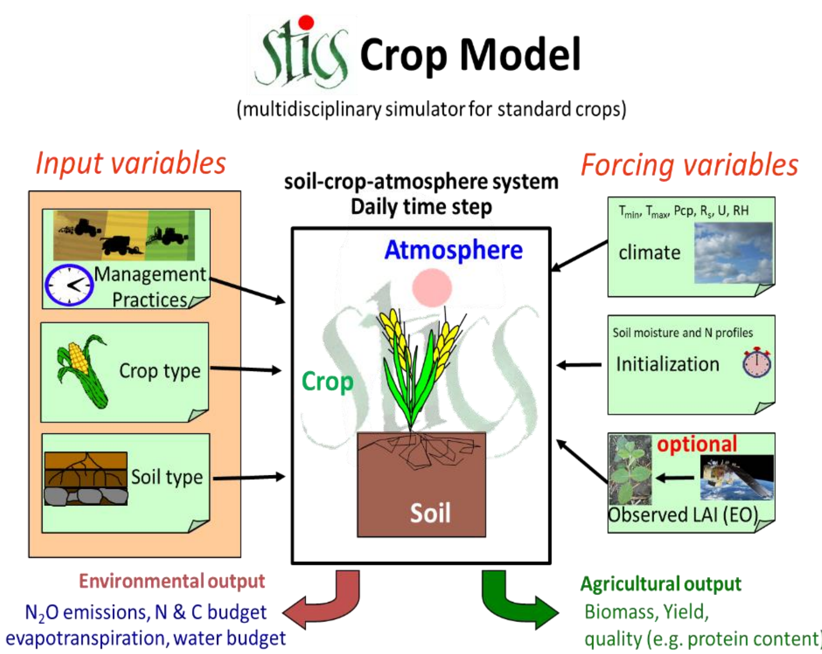

Figure 1. Description of the STICS crop model.

The 2021 field data have been used to perform a first calibration of some model parameters to predict crop growth and N uptake of monocrops.

Data from the other years (2022, 2023 and 2024) will be used to evaluate the model performance. Depending on the preliminary results one or two of these years could be used to refine the calibration.

Preliminary results:

A total of 5 parameters have been calibrated for pea and 13 for oat (Tables 1 and 2). These parameters mainly control leaf, stem and root growth. They have been calibrated by minimizing the difference between the observed and simulated leaf area index, aboveground biomass and grain biomass.

Table 1. Crop growth parameters calibrated for pea monocrop.

Parameter	Definition	Initial value	Calibrated value
abscission	senescent leaf proportion falling on the soil (0 to 1)	0	0.8
sensrsec	root sensitivity to drought (1=insensitive)	0.4	0.7
tigefeuil	stem (structural part)/leaf proportion	0	0.5
vitircarb	rate of increase of the carbon harvest index (g grain g plant^{-1} day^{-1})	0.022	0.016
croirac	growth rate of the root front (cm degree day^{-1})	0.12	0.15

Table 2. Crop growth parameters calibrated for oat monocrop.

Parameter	Definition	Initial value	Calibrated value
tgmin	minimum threshold temperature for germination and emergence (°C)	4.8	3
vlaimax	ULAI* at the inflexion point of the function DELTAI=f(ULAI)	2.496	2.06
pentlaimax	parameter of the logistic curve of LAI growth	3.047	6.84
udlaimax	ULAI* from which the rate of leaf growth decreases	2.248	3
slamin	minimum specific leaf area of green leaves (cm^2 g^{-1})	300	400
irazomax	Maximum nitrogen harvest index (0-1)	0	0.5
stlevamf	Cumulative thermal time between the stages LEV (emergence) and AMF (maximum acceleration of leaf growth, end of juvenile phase) (degree days)	300	100
stamflax	Cumulative thermal time between the stages AMF (maximum acceleration of leaf growth, end of juvenile phase) and LAX (maximum leaf area index, end of leaf growth) (degree days)	200	350
phosat	saturating photoperiod for development (hours)	20	18
dlaimaxbrut	maximum rate of LAI (m^2 leaf plant^{-1} degree day^{-1})	0.0008	0.001
slamax	maximum specific leaf area of green leaves (cm^2 g^{-1})	400	500
tigefeuil	stem (structural part)/leaf proportion	0.05	0.5
vitirazo	rate of increase of the nitrogen harvest index (g grain g plant $^{-1}$ day^{-1})	0	0.01

ULAI = normalized leaf development unit.
Cultivar parameters in italics

After this calibration aboveground and grain biomass simulated in 2021 were generally well predicted with a small bias (0.1 t ha^{-1}), a low root mean square error (RMSE = 0.59 t ha^{-1}) and good model efficiency of 0.72 (a value of 1 being a perfect model) (Figure 2). However, the decline in biomass at the end of the growing season was not well simulated because the senescent biomass is included in model's outputs but not in field measurements. If these last aboveground biomass values are excluded the statistics are even better with an RMSE of 0.37 t ha^{-1} and a model efficiency of 0.91.

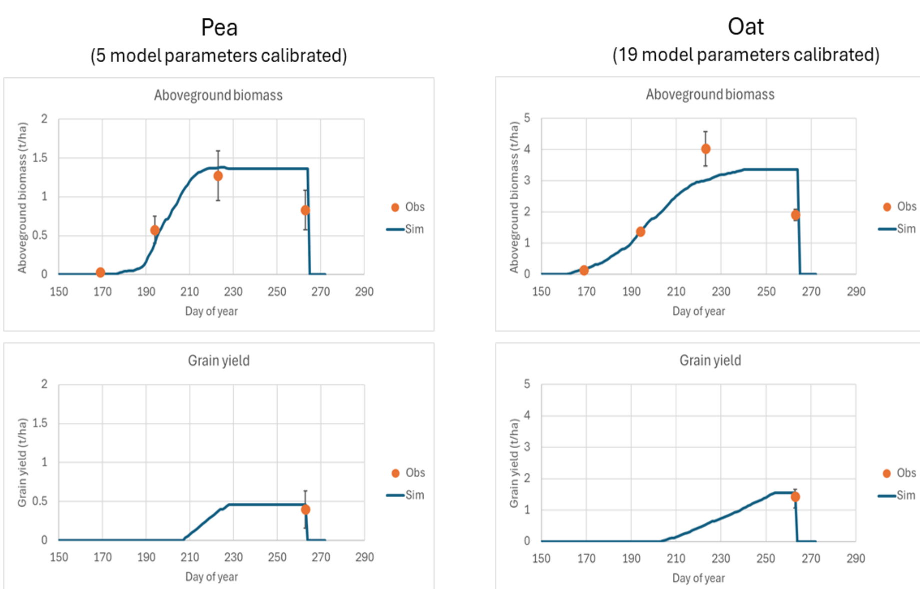

Figure 2. Measured and simulated aboveground and grain biomass in 2021 for pea and oat.

Concerning plant N uptake, no parameters have been calibrated yet, but the model performance has been evaluated. For Pea, there is a clear trend of the model to overestimate the plant N uptake (Figure 3). On the other hand, for Oat, the predictions are quite good even without calibration (Figure 3).

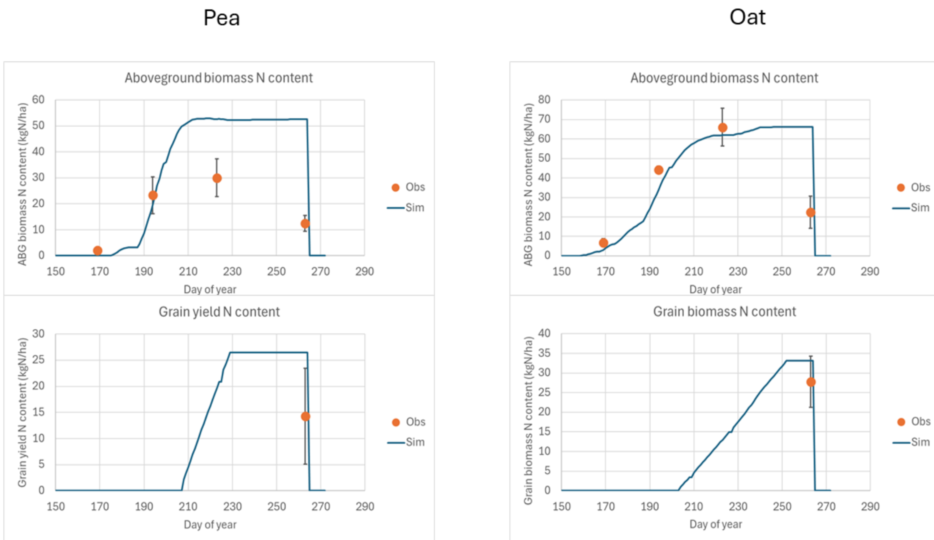

Figure 3. Measured and simulated aboveground and grain biomass N content in 2021 for pea and oat.

Preliminary results of the 2022 simulations showed that the growth was delayed in the simulation compared to the observation (Figure 4). Some parameters that control the early stage of development of both crops may need to be adjusted. Therefore the 2022 data will be included in the calibration step and the 2023 (only the first dates of measurements due to a hail storm later in the season) and the 2024 data will be used to evaluate the model performance after the refinement of the calibration.

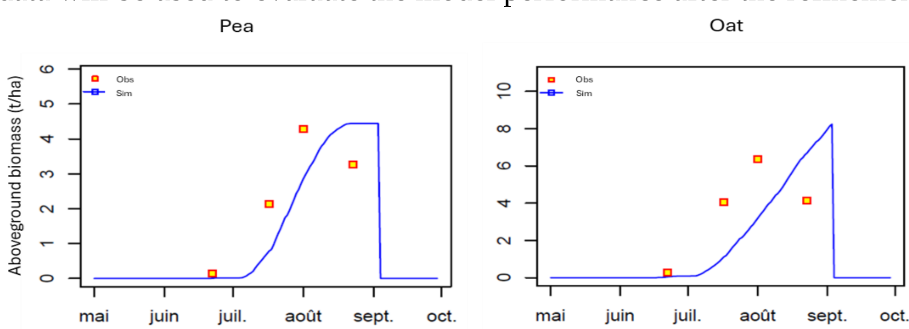

Figure 4. Observed and simulated aboveground biomass of pea and oat monocrops in 2022.

Next steps for 2025-2026 in the development of growth and nutrient uptake models:

In 2024-2025 the plan is 1) to refine the monoculture calibration by including the 2022 data in the calibration step, 2) to initiate the calibration of the model parameters related to intercropping using the 2021 and 2022 data, 3) format the 2024 data to verify the model performance using both 2023 and 2024 data and 4) simulate scenarios with various plant densities to determine the best ratio for the pea-oat intercrop.

References

Beaudoin N., Lecharpentier P., Ripoche D., Strullu L., Mary B., Leonard J., Launay M., Justes E., eds. (2022). STICS soil-crop model. Conceptual framework, equations and uses, Versailles, Éditions Quæ

Brisson N., Mary B., Ripoche D., Jeuffroy M.H., Ruget F., Nicoullaud B., Gate P., Devienne-Barret F., Antonioletti R., Durr C., Richard G., Beaudoin N., Recous S., Tayot X., Plenet D., Cellier P., Machet J.M., Meynard J.M., Delécolle R. (1998). STICS: A generic model for the simulation of crops and their water and nitrogen balances. I. Theory and parameterization applied to wheat and corn. Agronomie 18:311-346. DOI: 10.1051/agro:19980501.

3. List any technology transfer activities undertaken in relation to this project:

For previous tech transfer activities, please see the 2021-22, 2022-23, and 2023-24 progress reports.

An **Organic and Low-Input Field Day** (all day) was planned and organized for July 31st, 2024 at the Swift Current Research and Development Centre. This tech transfer event was co-hosted by the Organic Research Program at SCRDC, SaskOrganics, and TCO Chapter 8/Southwest Sask Organic Producers Inc.

- **Appendix A1 -** First poster, Save the Date, distributed widely.
- **Appendix A2 -** Poster with registration distributed widely.
- **Appendix B** – 14 page main handout on "2024 Organic and Low Input Field Day at the Swift Current Research and Development Centre – co-hosted by the Organic Research Program at SCRDC, SaskOrganics, and TCO Chapter 8/Southwest Sask Organic Producers Inc. - distributed to all participants. Field map and info on all trials being toured, including the Intercropping and Living Mulch studies on pages 8 and 9. July 31st, 2024.
- **Appendix C** – 2 page handout on "Organic Intercropping in the Brown Soil Zone" - distributed at the Organic and Low Input Field Day on July 31st, 2024.
- **Appendix D** – 2 page handout on "Living Mulch Project (2021-2026)" - distributed at the Organic and Low Input Field Day on July 31st, 2024.
- **Appendix E** – "Simulation of the pea-oat intercrop with the STICS soil-crop model"

The information material prepared for the Field Day was distributed to participants during registration, in the field, and/or at the indoor event in the afternoon. Since then, these handouts have been widely distributed by e-mail. In addition, handouts from previous tech-transfer events were also available to participants of our 2024 Field Day.

Presentations given in the field in the morning and indoors in the afternoon of July 31st, 2024:

- Overview of New Intercropping Project – Presentation given by Fernandez in the field and indoors at the 2024 Organic and Low-Input Field Day on July 31st, 2024.
- Overview of Living Mulch Project – Presentation given in the field and indoors by Fernandez at the 2024 Organic and Low-Input Field Day on July 31st, 2024.
- Weeds in Intercropping trials – Oral presentation given by Julia Leeson in the field at the 2024 Organic and Low-Input Field Day on July 31st, 2024.
- Weeds in Living Mulch trials – Oral presentation given by Julia Leeson in the field at the 2024 Organic and Low-Input Field Day on July 31st, 2024.
- Description of management of the intercropping trials given by Noe Waelchli, field technician in charge of these trials.
- Description of management of the living mulch trials given by Noe Waelchli, field technician in change of these trials.
- Demonstration of measurements taken by the Greenseeker given by Noe Waelchli, field technician, and Mackenzie Metke, summer student.
- Presentation by Dr. Mervin St. Luce on "Crop Modelling Research in our Organic trials" (being conducted by Dr. Guillaume Jégo, page 4 of our main Field Day handout.
- Extensive discussion of the intercropping and living mulch trials, and other organic trials, with participants of the afternoon portion of the Organic and Field Day 2024.

Other miscellaneous relevant articles in 2024-25 include:

- Article by M.R. Fernandez on: "Pathogens and Disease in Organic Field Crops: An Interconnected View-Issue" Summer 2024 Pathogens and diseases in Organic Field Crops.Summer 2024.pdf Pages 13-14 of Abundance Magazine.
- Article on Prairie Post – East Edition, on "2024 Organic and Low-input Field Day at the Swift Current Research and Development Centre on July 31st, 2024". This covered a quarter of a page of this publication. No link is available given that this publication is not available online without subscription.
- Article on Prairie Post – East Edition, right after our 2024 field day, with pictures of this event on a whole page of this paper. Please note that there is no link available given that this publication is not available without a subscription.

https://saskorganics.org/event/organic-low-input-field-day-2/
https://organicalberta.org/article/organic-and-low-input-field-walks-july-31-in-swift-current-sk/
https://organicalberta.org/article/organic-low-input-field-day-swift-current/
https://www.smallfarmcanada.ca/events/organic-low-Input-field-day-swift-current/
https://cog.ca/blog/july-2024-event-listing/
https://ca.linkedin.com/company/saskorganics-association-inc
https://www.topcropmanager.com/events/organic-and-low-input-field-day-2/
https://saskorganics.org/event/organic-low-input-field-day-2/
https://www.snapinfo.ca/action-events-news/events/2024/1419
https://www.country-guide.ca/events/organic-low-input-field-day/
https://www.canadiancattlemen.ca/events/organic-low-input-field-day/
https://www.swiftcurrentonline.com/articles/organic-and-low-input-field-day-attracts-prairie-producers
https://www.topcropmanager.com/researcher-looks-to-improve-organic-farming-on-the-prairies/
https://cog.ca/blog/july-2024-event-listing/
https://www.manitobaorganics.com/events
https://organicalberta.org/article/organic-and-low-input-field-walks-july-31-in-swift-current-sk/

- See below information on our field day posted on AAFC social media (please note that our event was called "Open House" rather than Field Day).

- Follow-up interactions regarding the article on: "Biocontrol agents show promise against fungal diseases - Non-chemical control option could help control disease in field crops". Top Crop Manager. By Julienne Isaacs, published on March 14th, 2023.

- Ongoing consultations on intercropping and living mulch from organic and low-input conventional producers, in addition to extension agrologists, by phone or e-mail, continued throughout the year. These have been from various locations in Saskatchewan, Alberta, Manitoba, and Montana.
- Invitation to give a presentation at a summer field tour in Lac La Biche, Alberta to present results from our intercropping research on August 1, 2024. Had to decline because of a conflict with our own field day on July 31st, 2024.
- Invitation by the Lakeland Agricultural Research Association to give a presentation in person at their Lakeland Agronomy Update event in Smoky Lake, AB on March 13, 2025 (due to a conflict with another local research commitment this invitation had to be declined).
- Fernandez gave an invited presentation on our research at a noon webinar on March 19, 2025 organized by the Lakeland Agricultural Research Association.
- Invitation to attend field tours this coming summer at Smoky Lake, Fort Kent and St. Paul, Alberta, to present information on living mulch and intercropping.

Please note that acknowledgment of funding for the Intercrop and Living Mulch projects from WGRF and POGA was always included in all articles, presentations, and communications.

4. List any changes expected to industry contributions, in-kind support, collaborations or other resources

No major changes are expected in 2025-26.