Advancing Cover Crop Systems in Ontario - Focus on Soil Nutrients (N+P), Soil Health, Insects and Nematodes

OSCIA Tier 2 Grant – St. Clair Region

Purpose:

Cover crops have numerous documented benefits including reducing soil erosion, increasing soil organic matter, inhibition of pests and altering nutrient availability. The popularity of using several cover crop species in a mix is increasing, thus this project was established to compare cover crop multi-species mixes to single species or simple mixtures in terms of various functions. The objectives of this project were:

1. To compare cover crop multi-species mixtures to single species or simple mixtures in terms of biomass growth
2. To determine the nitrogen credit of selected cover crop mixtures to the following corn crop
3. To measure the impact of cover crops on phosphorus loss
    a. Determine the impact of variable freeze-thaw magnitude on dissolved reactive phosphorus (DRP) export
    b. Find candidate cover crop species which best resist the impact of freeze-thaw cycles (FTC)
    c. Determine the effect of early termination of cover crops (via glyphosate application) has on DRP export compared to leaving plants green
4. To study the impact of cover crops on insects, slugs and soybean cyst nematode (SCN)
5. To promote the use of cover crops and provide information on how to grow cover crops successfully

Methods:

Multi-species mixtures: Three small plot, intensive sites, were setup in Winchester, Ridgetown and Thamesville. All three sites had four replications with 22 different treatments. Treatments included a no cover check plot and 21 different cover crop mixes ranging from 2-14 species per mix. Additionally, at Ridgetown and Thamesville, 6 treatments were added to each replication for a total of 28 treatments per replication. The additional 6 treatments were mixtures of radish, oats and crimson clover at varying ratios to determine if seed ratio had an effect on total biomass or individual species germination and growth. Table 1 lists all the species used in the mixes.

Additional to the three small plot sites, eleven satellite locations were established. These locations were strip trial plots with varying number of treatments and replications, Table 1 lists the various species used in these trials. The size of the plot and species used in mixes was at the discretion of the cooperator. Table 2 lists the eleven locations and the type of trial being performed at each.

Table 1: List of cover crop species used in small plot and satellite location mixes

Species		
oats	berseem clover	peas
rye	sweet clover	Brassica (kale/turnip)
radish	lentils	annual ryegrass
hairy vetch	flax	sorghum sudan
crimson clover	phacelia	mustard
sunflower	mung bean	sunnhemp
red clover	buckwheat	barley
faba beans	triticale	chickling vetch
white clover	cowpea	chickpea

Table 2: List of the eleven satellite locations and the type of trial at each

Location	Type of trial
Florence	comparing seeding rates of a 3-way mix
Thamesville	Nitrogen trial
Amherstburg	Nitrogen trial
Chatham	comparing species ratios in 3-way mixes
Lakeshore	comparing 3, 6, 9 and 12 -way mixes
Watford	comparison of different cover crop mixes and no cover
Kingsville	comparison of cover crop mixes that will not overwinter
Highgate	comparison of cover crop mixes that will not overwinter
Strathroy	comparing 3, 6, 9 and 12 -way mixes
Chatham	comparison of different cover crop mixes and no cover
Petrolia	comparison of cover crop mixes that will not overwinter

All locations were planted after wheat harvest between mid-August and mid-September. Counts of each species present in each mix were conducted at the three small plot locations in September to determine germination and compare with expected ratios from the seeding rates. Counts were conducted by counting the number of each species present in two 0.25m^2 quadrats per plot. Biomass harvest was done at all small plot and satellite locations, except for two, between mid-October and the beginning of December. Two locations were not sampled due to lack of adequate growth or availability. Sampling was done by collecting all above ground biomass in two 0.25m^2 quadrats per plot (the same ones as used for plant counts) for the small plot locations, and three 0.25m^2

quadrats per strip for the satellite trial locations. All biomass was dried to constant moisture and total dry weight biomass was recorded.

Cover Crop Nitrogen Credit: The two nitrogen trial sites consisted of field-scale strips with check (no cover crop) strips and strips of a cover crop mixture. In order to isolate the nitrogen credit, a no cover crop check versus planting a cover crop mixture replicated 4 times was established. In the spring of 2016, corn will be planted with five nitrogen rates to determine the nitrogen credit if any from the cover crop.

Phosphorus: To date, a laboratory experiment has been conducted to examine the effects of cover crop species, type of freeze-thaw cycle, and the effects of termination prior to freezing on phosphorus export. These variables were tested for both phosphorus and nitrogen release. Much of the lab work has been completed and two conference presentations (IAGLR, CGU) are in preparation. The field component of the phosphorus study will begin in the fall of 2016. At present, a series of field trials have been initiated on the University of Waterloo campus to determine an appropriate set of instrumentation for the leaching studies. We are currently seeking a co-operator and field for the trials to begin in late 2016.

Insects: In the spring of 2015 sampling was performed in cover crop trials at seven locations to assess insect presence. These locations had strips of cover crop mixtures and within each strip, two $0.25m^2$ holes were dug to a depth of 6". The soil from these holes was examined by hand and all insects were placed in 95% ethanol and transported to the lab for identification.

SCN: With the increase in cover crops usage and interest in field crops it is important to understand if the cover crop species listed in table 1 are inadvertent hosts for plant diseases and nematodes. In 2015, the same cover crop species were planted in two locations (Highgate and Rodney) and assessed for suitability as a host for Soybean cyst nematode (SCN - *Heterodera glycines*) and root lesion nematode (RL- Pratylenchus penetrans) as well as the fungal disease sudden death syndrome (SDS- *Fusarium virguliforme*).

Promotion of Cover Crops: Demonstration farms will be established to show different cover crops and their management. Presentations will be made at various soil and crop and other meetings

Results:

Multi-species mixtures: All sites had some level of cover crop establishment by late November; however stand quality and total growth varied widely. The variable growth, as well as difficulties in establishment could be in part due to the lack of moisture seen at and after planting. At the three small plot locations (Ridgetown, Thamesville and Winchester) total dry matter varied between 790-13,875 lbs/ac. While at the eleven satellite locations total dry matter varied between 852-9,625 lbs/ac.
Comparing across all treatments at the three small plot locations there was no significant difference in cover crop biomass dry weight between mixes with 3, 6, 9, or 10+ species (Figure 1); however, biomass dry weight in all cover crop plots was significantly higher than the no cover plots where volunteer wheat was the only species present. Additionally

there was no correlation between increasing number of species in the mix and total dry weight biomass. Counts of species present in each treatment were also performed at the small plot locations. Comparison of the expected number of plants per quadrat and the actual count was performed; however, this did not appear to be a simple method of determining best mix or predicting growth. Further analyses of these counts may provide insight into determining which mixes provide the most diversity. Furthermore, these counts may help with economic analyses of mixes.

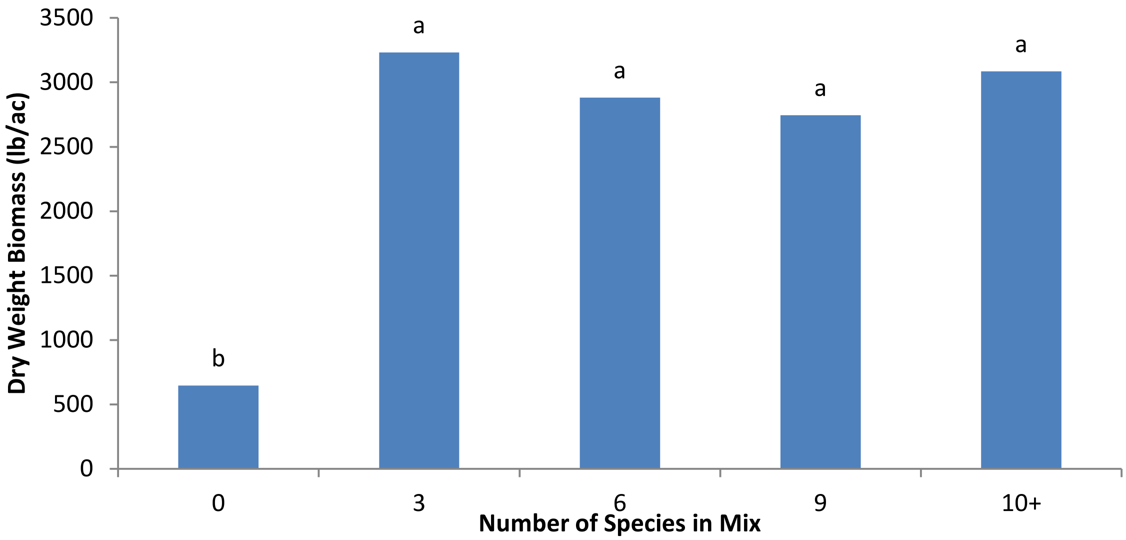

Figure 1: Average cover crop dry weight biomass for mixes with varying number of species at three small plot locations. Biomass values followed by the same letter were not significantly different at the 5% level.

The eleven satellite trials were all set-up slightly differently due to grower preference. Consequently it was difficult to compare total dry weight biomass across locations. Furthermore, harvest times varied between locations with at least 6 weeks separating the earliest harvested location and the latest. This increases the difficulty in accurately comparing cover crop growth across locations. Figure 2 is a graph of all treatments at all locations organized by number of species in the mix (1-12). Similar to the small plots, there was no correlation between number of species in the mix and total dry weight biomass and there was no significant difference in cover crop biomass dry weight between mixes with 3, 6, 9, or 10+ species.

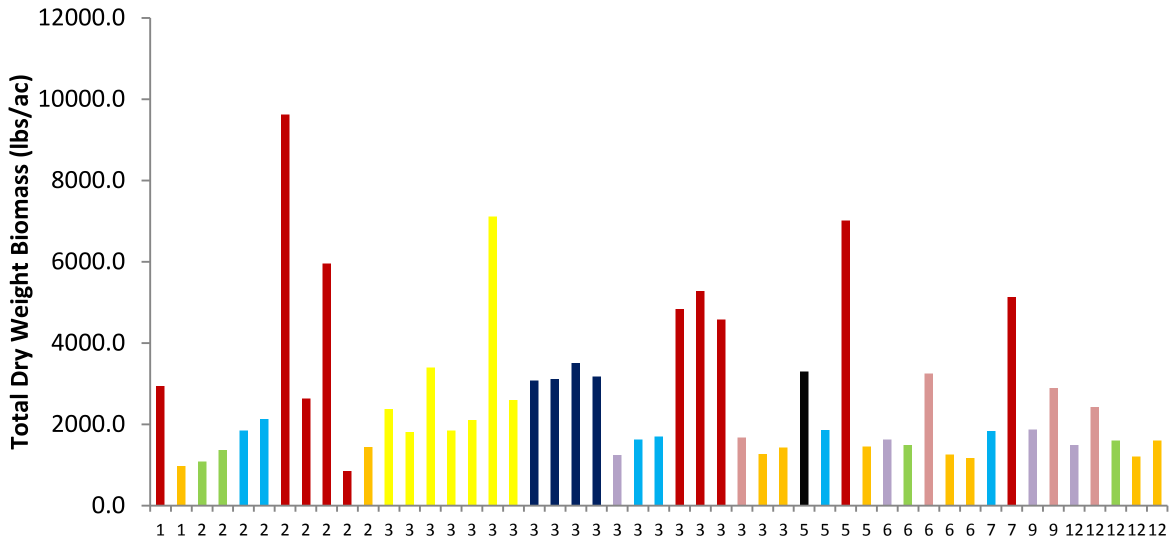

Figure 2: Cover crop dry weight biomass for each treatment across all sites. The number on the x-axis represents total number of species in the mix and each colour represents a different location.

Two locations (Strathroy and Lakeshore), allowed for a comparison of total biomass dry weight across 3, 6, 9 and 12 way mixes. The 6 and 9-way mixes at these two sites had significantly higher biomass as compared to the 3-way mix, while the 12-way mix was not significantly different than any of the other mixes.

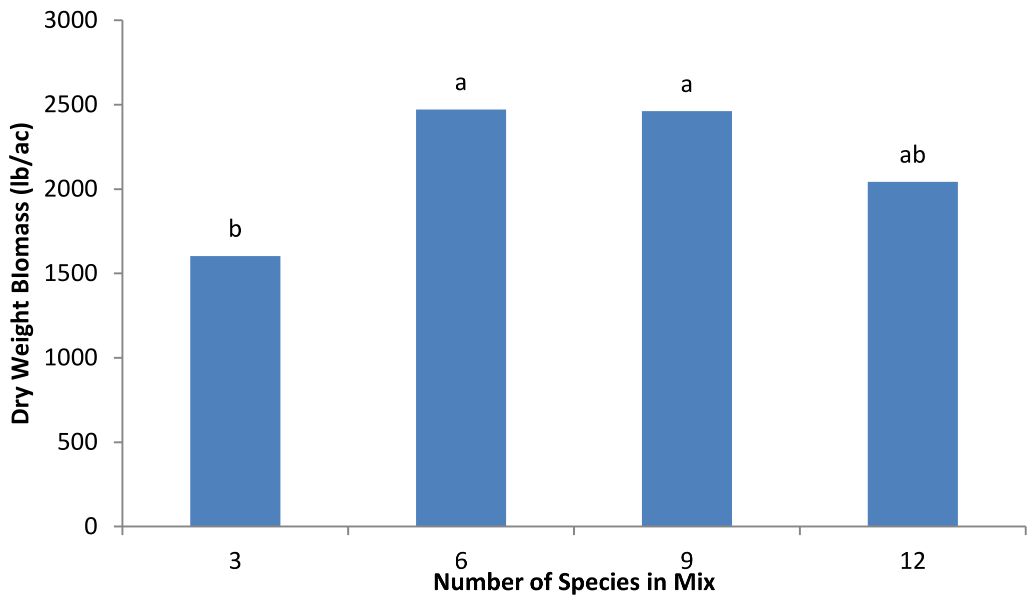

Figure 3: Average cover crop dry weight biomass for 3, 6, 9 and 12-way mixes at two strip trial locations. Biomass values followed by the same letter were not significantly different at the 5% level.

Insects: Analysis of pest by treatment has not yet been completed but some general observations can be stated. Millipedes made up the vast majority of the specimens found at the research sites. Millipedes can be considered both beneficial for breaking down organic matter and as pests, choosing to feed on crop seeds if conditions are ideal.

Wireworm specimens were sent to Wim van Herk, Agriculture *and Agri-Food Canada,* Agassiz, B.C. for species identification. All seven locations had wireworms present at varying degrees of infestation. A total of sixty-five wireworm specimens collected (Figure 4). Interestingly, each location was made up of predominately one wireworm species instead of a combination of wireworm species. Overall, the most abundant wireworm found was the eastern field wireworm, *Limonius agronus.*

As for other insects or pests found, slugs were next most abundant, though populations were below damaging levels and a few (n=3) predatory ground beetles or larvae were captured.

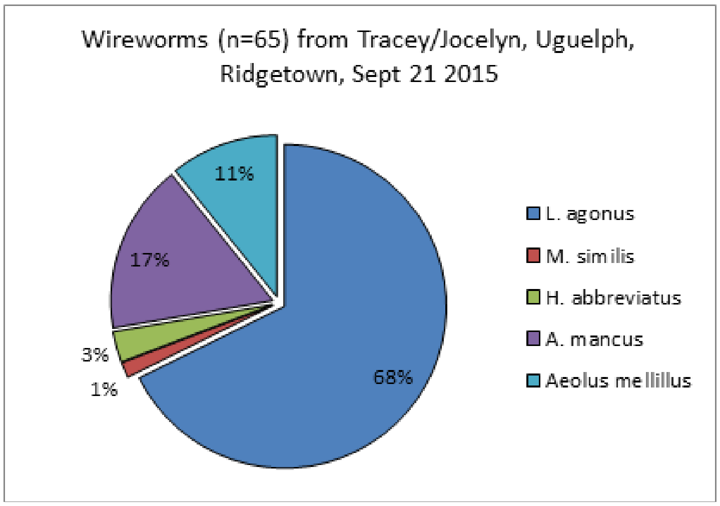

Figure 4: Wireworm species collected from cover crop sites in 2015

SCN: At both locations (Highgate and Rodney), SCN reproduction was only observed on the broadleaf legume, crimson clover and at very low levels. Roots were also processed to determine the average number of SCN larvae (juveniles) in the root. Hairy vetch had the highest number followed by red clover. The other clovers (sweet yellow, crimson and white) along with faba beans had the low levels of SCN larvae in the roots. No SCN larvae were found associated with brassicae and grass cover crop roots. Although these results from this one year study show low or little risk for SCN reproduction it is important to note that broadleaf legume cover crop species such as hairy vetch, red clover, field pea, crimson clover, white clover, sweetclover and faba beens have been reported to be SCN hosts. In addition to planting SCN resistant varieties, growers who use these species should routinely take a SCN nematode sample to note changes in nematode population levels.

Root lesion nematodes were detected in all 26 cover crop species ranging from a high of over 15,000 nematodes per gram of root to a low of 75 nematodes per gram of root. Seven cover crop species had root lesion numbers averaged above 1000 nematodes per gram of root. The highest by far was Sunn Hemp which was over 15,000 nematodes/g root followed by Field peas (7,352) and Faba Beans 4,072). Four other cover crop species hairy vetch, white clover, red clover and oriental mustard ranged from 1,921 to 1,429 root lesion nematodes per gram of root whereas the remaining 19 cover crop species were all below 1,000 nematodes per gram of root. Sunn Hemp has been shown to be effective against various nematode species particularly those nematodes which stay and feed in one place in the root system (sedentary endoparasitic nematodes) such as root knot nematode (Meloidogyne spp) and SCN. This study will be repeated in 2016.

Promotion of Cover Crops: Presentations were made at Essex, Kent and Lambton Soil and Crop annual meetings. No demonstration farms were established. The St Clair Region Conservation Authority Soil and Water tour visited one site.

Summary:

Cover crop mixes planted after winter wheat harvest can produce variable amounts of biomass depending on moisture, timing of planting and time of harvest. Fall harvest biomass ranged from 790-13,875 lbs/ac. After one year of evaluating cover crop biomass and plant counts, it is difficult to determine the optimal mixes. Initial analysis of 3, 6, 9 and 12-way mixes suggest 6 and 9 way mixes will produce the largest amount of biomass; however, further studies are needed to analyze this relationship. Finally, extremely variable biomass between treatments and locations did not allow for adequate comparison of mixes to determine optimal species mix and rate.

Next Steps:

Data and laboratory analysis is ongoing for samples collected in the fall of 2015. SCN counts from collected soil samples are currently being done. Analysis of plant counts is ongoing to evaluate cover crop mixes. In the spring of 2016 cover crop residue will be recorded. Further soil and plant sampling will be done in 2016 and corn yield will be measured. Analysis of 2015 and spring 2016 data will be used to optimize mix choice for the 2016 planting of cover crops after winter wheat.

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