Evaluating Cover Crop Options after Winter Wheat and in Standing Corn

(St Clair SCIA Regional Partner Grant - Final Report)

Purpose:

Cover crops can provide many benefits and interest in them has been growing in recent years. They protect the soil from erosion, add organic matter, stimulate soil life, provide nitrogen, scavenge or retain nitrogen, reduce compaction and improve water holding capacity and infiltration. Including a cover crop after winter wheat is the easiest way to start including cover crops in most typical field crop rotations. Red clover establishment in winter wheat has been variable in recent years; many farmers end up with a poor stand of red clover after wheat harvest, while others have abandoned the practice all together. There is still a desire to reap some of the benefits of red clover so farmers are looking to other cover crops to provide some or all of the benefits. There are a number of different cover crops options to choose from.

Planting date, managing cover crop growth and control afterwards are just a few of the things growers must consider when planting a cover crop. Depending on the species selected, the seed is relatively expensive in some cases so it is important to get the most out of the seeding. After winter wheat harvest the soil conditions are often not optimal for establishment, principally low in soil moisture. Planting a mixture may reduce establishment risk as some of the species may flourish when others struggle. The purpose of this project is to optimize establishment and provide the most benefit from cover crops following winter wheat.

Some growers are looking for ways to plant cover crops in other parts of their rotation. Establishing cover crops after grain corn is difficult as there is little or no growing season remaining in Ontario. There is interest in exploring the seeding of cover crops into standing corn. A recent research project was successful in establishing various cover crops interseeded into seed corn. There are units capable of broadcast seeding cover crops into corn a corn crop in Ontario. This concept was explored as a small sub project of this partner project. Several cover crops and mixtures (based on the results of the seed corn project) were seeded into standing corn and evaluated for stand establishment. A second purpose of the project is to evaluate options for establishing cover crops in standing corn.

Methods:

Cover crops were seeded following winter wheat harvest in the second half of August. This was done to avoid concerns with radish getting into tile drains. In 2014 an early planting of three different species occurred the last week of July and the first week of August at 4 locations. Management of volunteer winter wheat was investigated including comparisons of leaving it untouched, light tillage and herbicide control. In 2012 a commercially available mixture TillageMax Dover™ (Tillage Radish + seed oats) was used and another commercial mixture TillageMax Daytona™ (Tillage Radish™ + crimson clover) plus feed oats were compared to evaluate the establishment and other benefits. In 2013 two similar mixtures were used by combining the radish, variety Tillage, with locally sourced oats and similarly for the three way mixture of radish, var. Tillage, crimson clover and oats. A third treatment, a mixture of six cover crops (radish

var. Tillage, oats, crimson clover, Austrian Winter peas, sorghum sudan and sunflowers), was added to a number of plots in 2013. In 2012 the Dover mixture was seeded at 25 lbs/ac and the Daytona + oats was seeded 25 lbs/ac (5 lbs/ac Daytona + 20 lbs oats). In 2013 and 2014 the radish/oat mixture was seeded at 30 lbs/ac, the radish/oat/crimson clover mixture at 35 lbs/ac and the six way mixture at 40 lbs/ac. In 2014, the early planted treatments were: oats seeded at 50 lbs/ac; oats (35 lbs), kale (1lb.) and red clover (4 lbs.) at 40 lbs/ac; and a 6-way mixture (oats (20 lbs.), sorghum sudan (6 lbs.), sunflowers (2 lbs.), Austrian winter peas (10 lbs.), crimson clover (3 lbs.) and Sunn Hemp (3 lbs.) at 40 lbs/ac. The cover crops chosen provide different benefits. The oats provide a fibrous root to improve soil structure, take up nitrogen in the soil and produce significant biomass to return to the soil. The radish provides a deep tap root to open up the soil and takes up nitrogen. The crimson clover also has a tap root, has fibrous roots and produces some nitrogen. The six way mixtures were to provide multiple benefits. A check strip with no cover crop planted was left for comparison. There were three replications of each treatment. The treatment strips were 15' or 30' wide and most were 500" long. At several sites different other cover crop treatments were included. A soil nitrate test was taken prior to seeding to assess soil N levels. Nitrogen was applied (50 lbs N/ac) to ensure adequate cover crop growth. In 2013, nitrogen was applied to only three quarters of the plot, at most sites, leaving about a quarter of the plot without additional nitrogen. Cover crop biomass measurements were taken at two times, one in the middle of the growth period and one late fall. In 2014 biomass occurred just once per site from mid-October to late November. The above ground plant material was removed from four 0.25 m^2 areas in each replication of each cover crop strip.

In 2012, four cover crops: common annual ryegrass, Tillage RootMax^{TM} annual ryegrass, feed oats and TillageMax Daytona^{TM} blend (Tillage Radish and crimson clover) were hand seeded into standing grain corn in plots that were four rows wide by 10 m long and replicated three times. One plot was seeded after silage harvest. Visual observations were made of cover crop growth in late fall. In 2013, at one site three cover crops (annual ryegrass, red clover and an annual ryegrass/crimson clover mix) were seeded at the six leaf stage of corn and then again just following tasseling. At another site two cover crops (annual ryegrass at 20 lbs/ac and red clover 10 lbs/ac) were seeded during corn tasseling. In 2014, four plot locations in the Chatham Kent area were seeded with cover crops into standing corn. The plots were laid out in commercial corn fields and broadcast by hand. The plots compared 3 different ryegrass types and 3 clovers and were replicated 3 times. Two locations had late June and late July seeding dates while two locations had late June, early July and late July seeding dates.

Results:

Planting and Establishment Seven sites were established across the St Clair Region (Essex, Kent and Lambton) in 2012 and 12 sites in 2013 and 2014. A variety of drills and planters were used. No-till drills with and without small seed boxes and air seeders were used. Generally all did a good job of planting. There was concern that the mixtures would separate out in the seed box so in a couple of cases the Daytona (radish/clover) seed was put through the small seed box. The oats are a relatively large seed, radish a small to medium sized seed and crimson clover is a small seed. Surprisingly, the seed did not appear to separate out. Stand establishment was equally as good when planted with and without the small seed box. The real challenge came with seeding depth. In a

few cases the cover crop seed was planted 2.5 cm (one inch) or deeper. In those cases the oats came up fine, the radish emergence was delayed or it did not emerge and the crimson clover did not emerge. At one site the soil was tilled before cover crop planting which dried out the soil and delayed emergence.

Nitrogen The 50 lbs. of nitrogen applied per acre produced good growth. In 2013, the area of the plots where no nitrogen was applied showed poor growth at soil nitrate levels of 5ppm or less, producing about half the biomass compared to where nitrogen was applied. Moderate growth was seen at the 8 to 10ppm level where one site had equal growth and the two others about 70% of the biomass with nitrogen. Growth was similar to where the 50 lbs/ac of nitrogen was applied where soil nitrate levels where 20ppm.

Cover Crop Biomass In October 2012 the Daytona + oats biomass was less than the Dover mixture, see figure 1. The same was true for the November biomass although not quite as much, see figure 2. The lower amount of biomass with the Daytona + oats could be due to the feed oats in this mixture either having a lower germination rate and lower vigour than the seed quality oats in the Dover mixture. Some of the treatments with feed oats had mustard or canola in them. As these came from the west it is possible that the canola could be Roundup Ready and may be difficult to control in the following crop if glyphosate is the only herbicide to be used. The two and three-way mixes were similar in biomass amount for the early and late harvest in 2013 and the six way mixture was higher than the other two at both harvests. Again the late harvest biomass amounts were significantly higher, see figure 3. Generally, in 2014 the cover crops were planted into moisture or received moisture soon after planting. A few of the fields received excess moisture at some point. Growth was good but the cooler temperatures reduced growth compared to 2013. Biomass harvest occurred only once per site this year. All but one was harvested between October 22 and November 5 and the last one was harvested November 28. The early biomass numbers were fairly consistent among sites. The mean for the check was 1100 kg/ha, oats 2500 kg/ha, oats + kale + red clover 3300 kg/ha and the six way mix no.1 was 3400 kg/ha, see figure 6 below. The biomass numbers are good but not as high as expected given the early planting. No nitrogen was applied to these plots so that may have reduced growth. The cooler growing season and excess moisture in some cases likely also had an effect. Most of these cover crops went to head or flower. An early frost, September 14th killed the Sunn Hemp, a warm season legume, and the sorghum sudan reducing the biomass of the six-way mix, see figure 4. The later plantings were consistent except for the Kingsville site which suffered from excess moisture. The mean biomass for those cover crops were: check 1000 kg/ha, oats + radish 3200 kg/ha, oats + radish + crimson clover 3100 kg/ha and the six-way mix no. 2 was 2900 kg/ha, see figure 5 below.

The checks were put in to evaluate what happens if there is no cover crop planted in a field. There was a range of what was seen in the checks at the various sites. Some sites had very little growth of volunteer wheat or weeds. A few had significant growth of weeds. Volunteer wheat growth ranged from very little to 2000 kg/ha of above ground biomass. In 2014 the check average was about 1000 kg/ha. Volunteer wheat is not going to put on a lot of growth until it is vernalized with cold temperatures so it doesn't provide much biomass as a summer cover crop. The planted cover crops can produced up to 6000 kg/ha of biomass by mid to late November. Not only did the cover crop produce a lot more organic material to feed the soil it also suppressed weed growth.

Winter came early in the fall of 2013 and night time temperatures dipped to -5C or lower in the second half of November. This terminated the growth of all of the cover crops except the crimson clover and the Austrian winter peas. The sorghum sudan and the sunflowers were terminated by earlier frosts.

Figure 1. Cover Crop Biomass (kg/ha) Harvest, Second half of October 2012

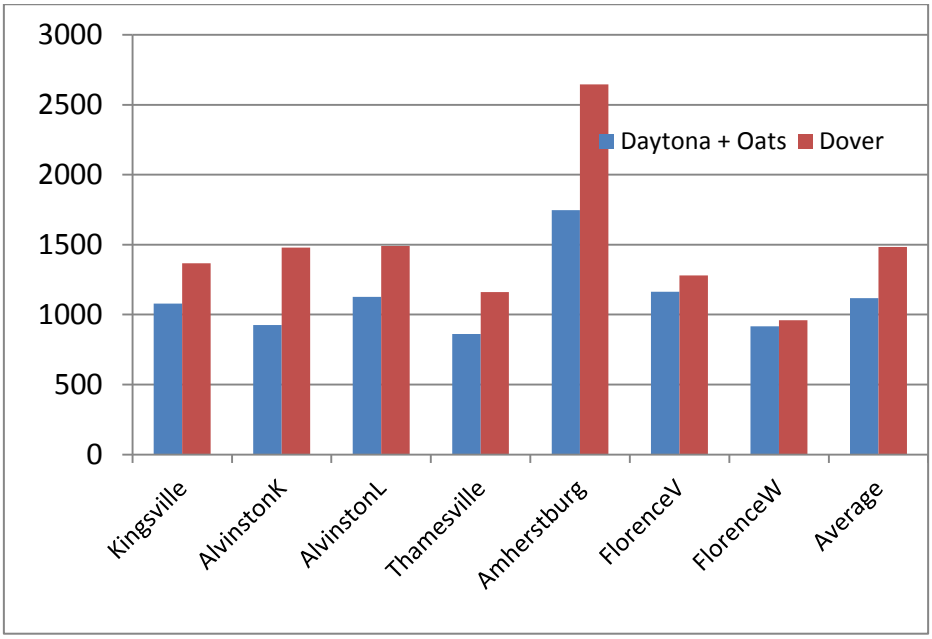


Figure 2. Cover Crop Biomass (kg/ha) Harvest, mid-November 2012

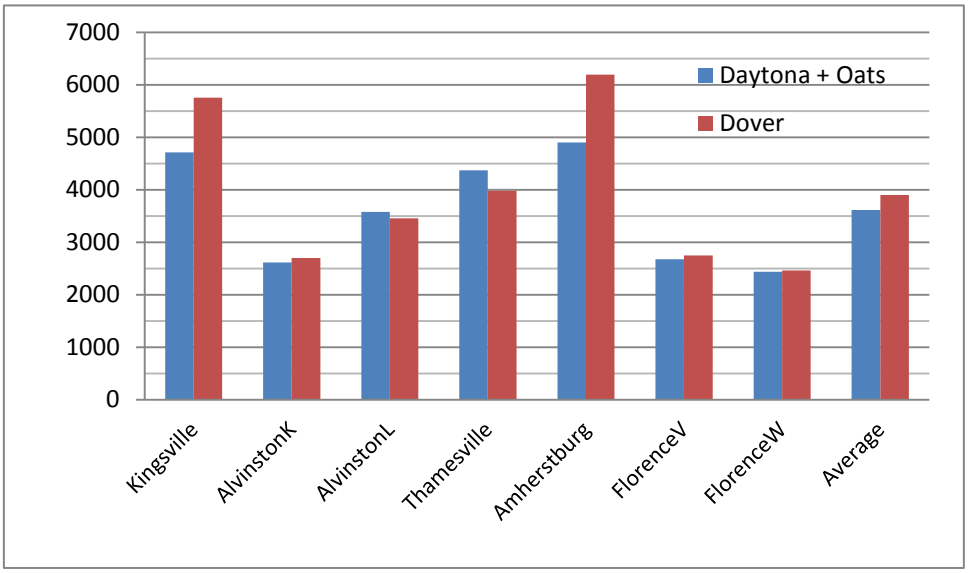


Figure 3. Cover Crop Biomass (kg/ha) November 2013

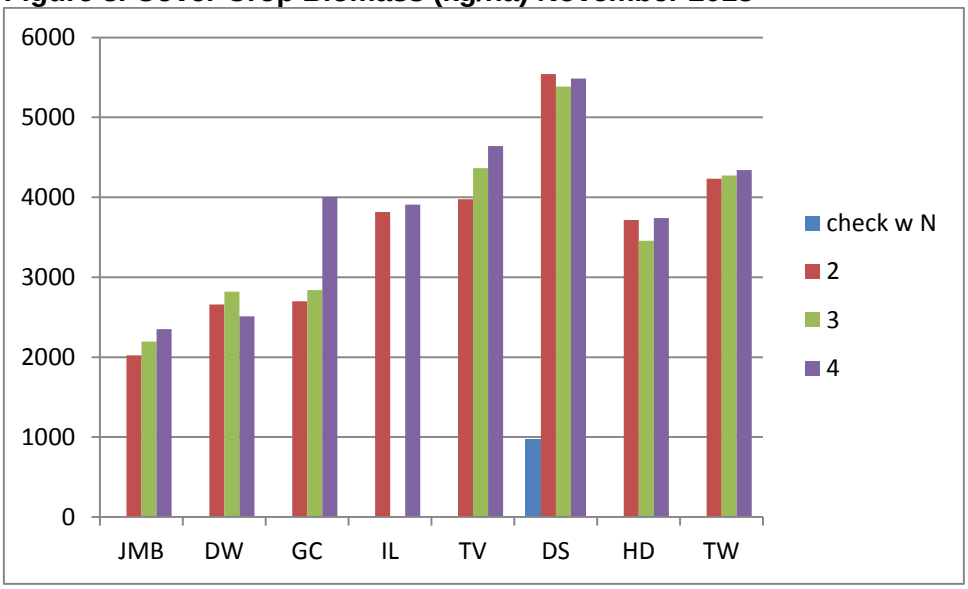
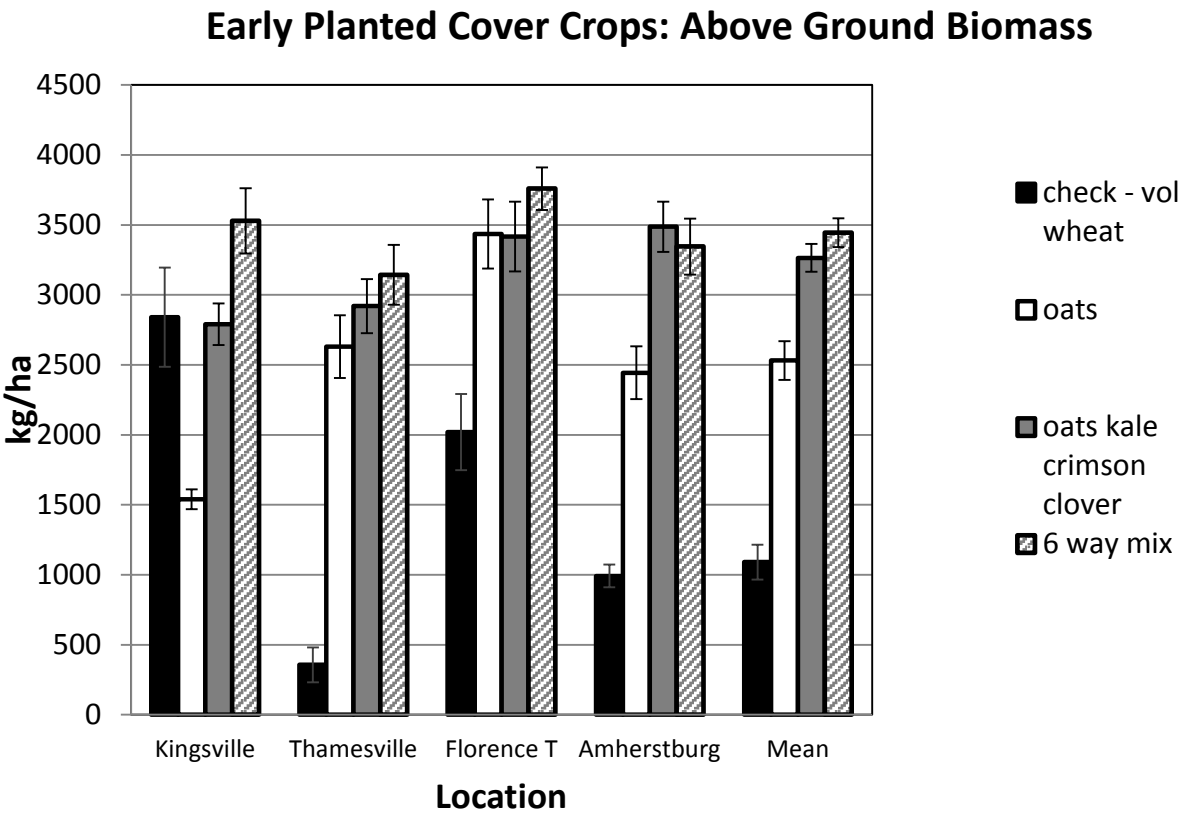
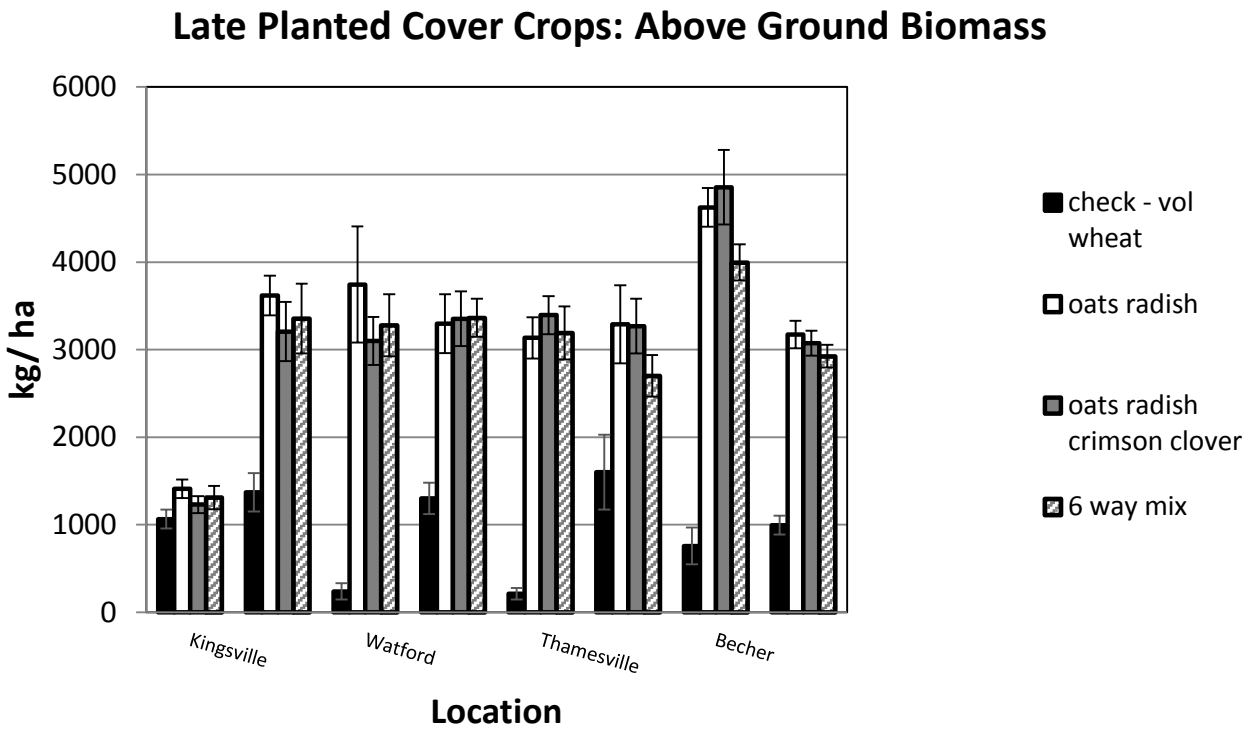


Figure 4. Early Planted Cover Crop: Above Ground Biomass 2014



In 2013, beside one of the plots there was an excellent stand of red clover. 3900 kg/ha of biomass was harvested mid-October compared to 1500 kg/ha biomass harvested from the cover crop mixtures. One of the additional plots evaluated seeding rate of a commercial oat/radish mixture. Seeding rates of 25, 30, 40, and 50 lbs/ac were planted. The seeding rate we used, 30 lbs/ac, in the plots produced the most biomass.

Figure 5. Late Planted Cover Crops: Above Ground Biomass 2014



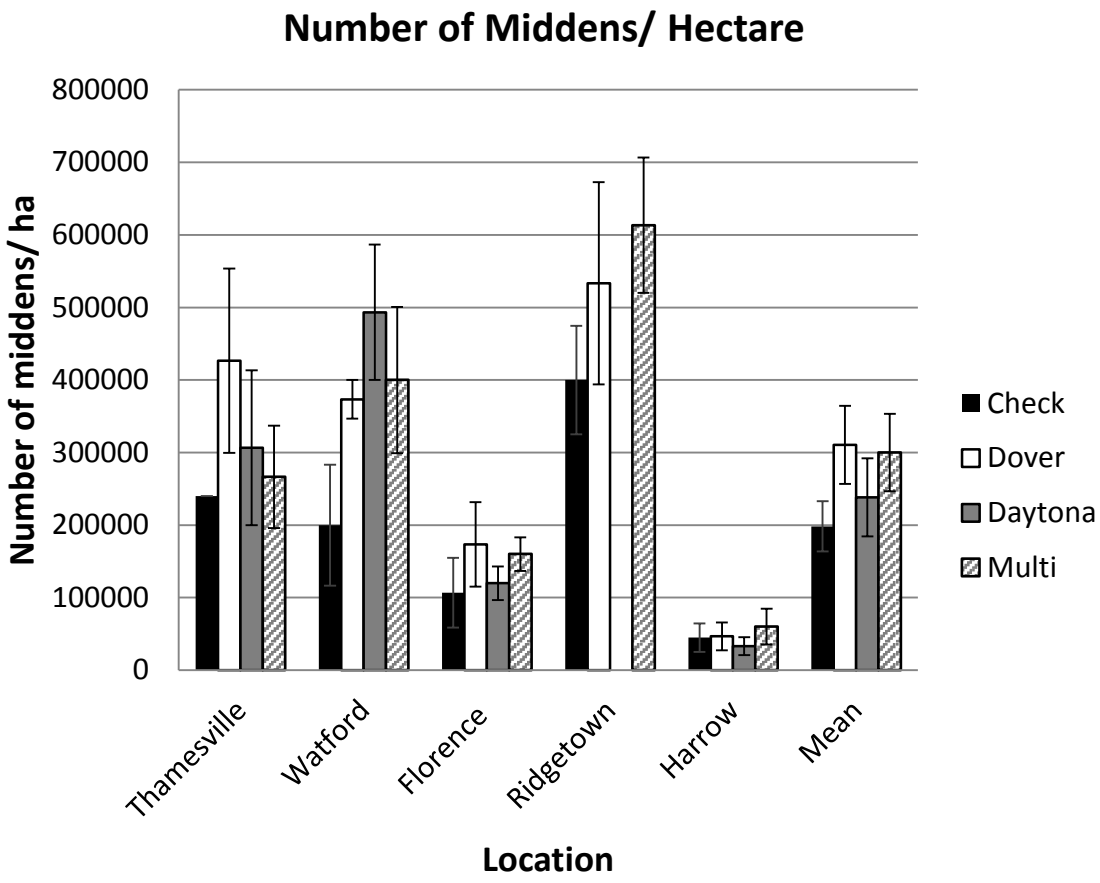
Earthworm Counts and Water Infiltration Measurements In the spring of 2013 some additional measurements were taken to try to identify cover crop benefits for the soil. Earthworm counts were done on an area 0.25m^2 by shovel depth. On a sandy loam soil there were on average 20% more earthworms on the knolls where there was a cover crop compared to no cover crop. In the depression areas of the field there were almost twice as many earthworms. Measurements completed in the spring of 2014 looked at soil cover and earthworm counts. Cover crops increased the number of earthworm middens compared to the check. See figure 6.

Some limited infiltration measurements were taken where there were cover crops versus no cover crop. In some situations the cover crop improved water infiltration into the soil.

Spring Soil Cover crop residue in the spring was not as much to deal with as some growers thought it would be. Several cooperators no-tilled the next crop into the residue without any problem. The crimson clover that survived the winter on sandy loam soils

produced a very nice fibrous root system. Measurements taken in the spring of 2014 showed cover crops increased soil cover particularly where some tillage was done before cover crop planting, see figure 7.

Figure 6. Number of earthworm middens per hectare.

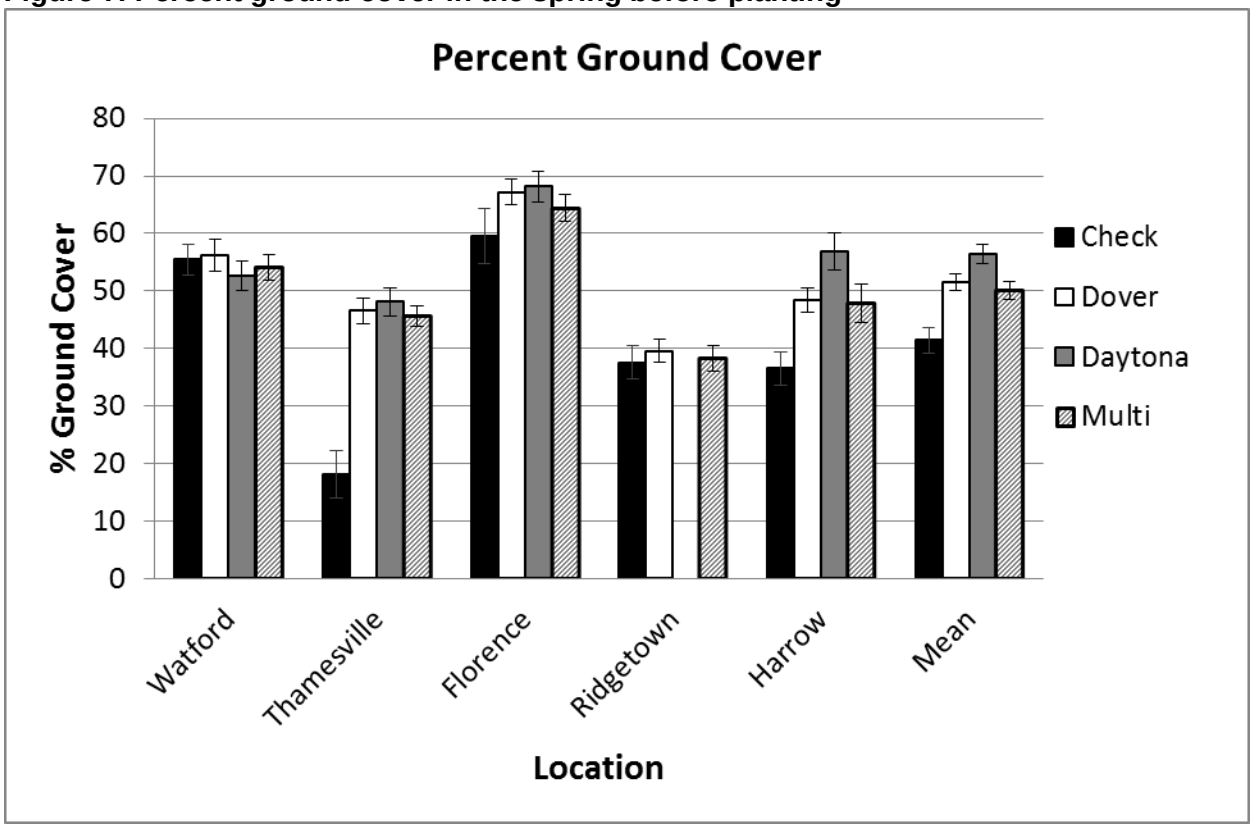


Corn Yields Following Cover Crops Corn was planted following the cover crops on five of the sites. There were a number of issues with the plots including corn rows not lining up with the cover crop treatment strips and stand issues due to equipment and weather. So it was difficult to draw any conclusions on the impact of the cover crop on corn yield in 2013.

Corn was planted on the 2013 cover crop plots which had good growth so yields could be taken where the three cover crops were grown and compared to the checks. There was no significant difference in yield between the cover crops or compared to the check. So the cover crop did not increase yield nor did it have a negative effect on yield. This is to be expected as the cover crop was only in the ground for a short period of time, late August until freeze up making it difficult to measure a yield benefit. The benefits of cover crops are accrued with continued use over time.

Cover Crops in Corn in 2012, the cover crops were hand seeded into four grain corn fields and after silage harvest at another site from the last week of August to the middle of September. The cover crop establishment was sparse at all four sites. The plants that did establish had minimal growth. The annual ryegrass had the best growth and establishment of the cover crops tested. Overall the growth was reasonable considering the late planting. The cover crops planted after corn silage had reasonable growth.

Figure 7. Percent ground cover in the spring before planting



In 2013, at one site three cover crop treatments were set up. The cover crops were broadcast into grain corn at the six leaf stage and again just after tasseling. The three treatments were annual ryegrass, red clover and an annual ryegrass/ crimson clover mix. Cover establishment and crop growth for all three was good in the early seeding but was nonexistent for the later seeding. The annual ryegrass and the clover/ryegrass mixture were about 15cm tall by early September and the red clover was at the 6 leaf stage see figure 8. At another site similar cover crops were seeded after tasseling with disappointing results.

Herbicide programs can play a large part in the potential success. One location showed virtually no cover crop establishment, probably due to the herbicides used while another location had very successful establishment for everything except the Red Clover. The Red Clover seed, sourced late spring, came coated and it is suspected that the coating interfered with germination under less than moist soil conditions. Establishment is only a part of the challenge with interseeding in corn; after harvest very little of the cover crop

is visible and in a year with later harvest like 2014, little time is left for further cover crop growth after harvest. Pictured below: modest to good growth of the ryegrasses, modest growth of the Huia clover, minimal growth of the crimson clover and no red clover establishment.

Interseeding in Corn plot – Glencoe planted June 26, 2014 Pictures from 2nd rep

The seed cost per acre of the Dover mixture was $10.50 and the Daytona plus oats mixture was $20.00 and the six way mixture $32.50/ac. The early planted seed costs were oats at $19.00, oats, kale and red clover $33.75 and the six way with the Sunn Hemp was $34.50. The cost of 50 lbs of urea per acre was $34.50/ acre in 2012 and custom application $10 per acre. Approximately $10 per acre worth of herbicide will control the crimson clover.

Communication of Results The results of the project were communicated at the annual meetings of the Kent and Essex all three years and at the Lambton annual meetings the first year and at cover crop information meetings the second two years. Information was also included in the St Clair SCIA newsletter and in cover crop presentations given across the province. In 2014, a series of Cover Crop Coffee Breaks were held in the spring and again in the fall. The meetings were organized for 10 am in the field at plot locations near Kingsville and Thamesville and the third at a grower's cover crop field near Merlin. Coffee and donuts were provided and the attendees had the opportunity to hear about the project results, listen to the farmer's comments as well

as researchers. Attendees could see firsthand what the cover crops looked like in the spring, see what the soil looked like as well as seeing infiltration demonstrations. The three meetings were well attended with lots of good discussion. They were held April 15 to 17. In the fall, Cover crop coffee breaks were also held at two of the sites, one near Kingsville and the other near Watford. These were held October 29 and 31. The first one was poorly attended but the second one had reasonable attendance. Two of the sites were included in a cover crop tour on October 30th which ended at the University of Guelph, Ridgetown Campus.

Figure 8. Annual Ryegrass Growth September 3 (seeded in to corn June 24, 2013)

Summary:

Cover crops planted in the second half of August can produce a significant amount of biomass by the middle to end of November. October biomass averaged 1500 to 2000 kg/ha over the two years and 3600 to 3900 kg/ha in November. Looking at the mixtures there is no biomass advantage to adding the crimson clover to the oats and radish but the clover would provide a little nitrogen. The crimson clover in the Daytona mixture without the oats added would have less competition and the opportunity for more growth and to produce a bit more nitrogen. Planting the cover crop at the correct depth is important to ensure the cover crop germinates rapidly. When the mixtures in a plot were planted too deep the crimson clover did not emerge and the radish was delayed so the oats grew to begin providing cover and helped fill in where the other species growth was poor or missing. The type of drill or planter does not seem to matter as anything from drills without a small seed box to 30' air seeders were able to successfully plant the cover crops.

The Dover mixture is killed by cold temperatures. The crimson clover is usually in a weakened state in the spring but will have to be killed with a herbicide. Cover crops increased the number of earthworms compared to no cover crops. Volunteer winter wheat does not provide as much growth as a cover crop planted in August.

After one year of evaluating soil nitrate levels and cover crop growth it appears that soil nitrate levels at 5ppm or below require the 50 lbs N/ac to provide good cover crop growth. Nitrate levels around 10 ppm do not provide as much growth as the 50 lbs of nitrogen did but produced what could be called adequate growth. Cover crops grown in soil with nitrate levels around 20ppm of nitrogen do not require additional nitrogen to achieve good growth.

Cover crops will grow when inter seeded in grain corn. Not all cover crops will tolerate the shade well or germinate well on the soil surface. Dry soil conditions limited cover crop germination in 2013. Annual ryegrass and clovers seem to tolerate the shade well. Seeding these cover crops at the six leaf stage of corn shows promise.

Next Steps:

Earthworm counts, infiltration measurements and the cover provided by each mixture will be assessed in the spring. The corn yields following the cover crops will be measured where possible. The mixtures will be assessed to determine their performance and other cover crops will be evaluated to see if they should be included in 2014 trials. Further evaluation of cover crops that will establish well in corn will be completed. An attempt will be made to rent a seeder to inter seed cover crops into standing corn mid-season for field scale evaluations.

Acknowledgements:

Thanks to the co-operators for their commitment to planting these plots. The funding for this project was provided by the OSCIA regional partner grant and a grant from the Southwest Agricultural Conference. Thank you to Speare Seeds for supplying the seed at a discounted price. Thanks also to Anne Verhallen, OMAFRA for her assistance with project design and biomass harvest and to Erika DeBrouwer for her assistance with the project through the summer. Thanks to SGS Agri-Food Laboratories for assistance with the cost of soil nitrate analysis and to Ridgetown Foodland for providing paper grocery bags (for biomass harvest) at a reduced cost. The oat seed donation from Chad Anderson was greatly appreciated as well as the assistance from Agris, Thamesville and Wanstead Co-op.

Project Contacts:

Adam Hayes, OMAFRA, adam.hayes@ontario.ca