Agriculture, Pêcheries et Alimentation Québec

Final report of research completed as part of the Prime-Vert Program, sub-section 11.1 – Supporting the development of phytosanitary agricultural strategies in Québec

PROJECT TITLE:
Development of two methods to combat perennial sow thistle (*Sonchus arvensis L.*) and Canada thistle (*Cirsium arvense*) in organic field crop production.

PROJECT NUMBER
CETA-1-LUT-11-1538

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DATE:
February 23, 2013

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MAIN FINDINGS (project summary)

Field experiments on two large-scale farms tested the use of two types of spring fallow to suppress sow thistle and Canada thistle. Spring fallow was followed by either buckwheat (for harvest) or a vigorous green manure crop. In 2011, spring fallow was followed with buckwheat. In 2012, both farms densely planted leguminous green manure crops (soybean or forage peas). The two experimental treatments were as follows: M0 – cultivate soils only in June; and M1 – cultivate soil in May and June. The buckwheat or green manure was sown directly after the June tillage event. The experiment consisted of four trials for sow thistle (2 farms * 2 years) and two trials for Canada thistle (1 farm * 2 years). The effect of M0 treatment was also observed in other fields besides the experimental field areas.

The experimental results indicate that following a short spring fallow with the planting of an aggressive green manure is effective for the suppression of Canada thistle or sow thistle. The number and timing of cultivation passes were important: to suppress sow thistle, two passes in June were sufficient, while an additional pass in May was necessary for Canada thistle. The results also indicates that it is very important to plant a competitive crop that is cultivated the following year.

Even though the perennial weed pressure was similar for both years for one of the farms and higher in 2012 than in 2011 for the other, the spring fallow was more effective in 2012 than in 2011, with a markedly greater reduction in thistle regrowth at the end of the season. Two factors may have been responsible: (1) the planting of more competitive crops following the experimental treatments; and (2) more effective tillage implements. In 2012, one tool, the Lemken Company's Kristall chisel proved to be very effective relative to the others tested (heavy cultivators or a disc harrow). This tool has very aggressive chisel points that extract large numbers of rhizomes, which are left to dry out on the soil surface. This tool seems to have great potential in the effort to suppress any rhizome-type weed. The chisel points selected for this tool should be configured, however, to allow rhizomes to be lifted above the soil surface. The other cultivator used in 2012, designed specifically to enable shallow tillage while cutting rhizomes, also yielded good results.

OBJECTIVE AND METHODOLOGY

This project's objective was to investigate effective methods for suppressing Canada thistle or sow thistle that involved a short spring fallow period. The hypothesis tested was that a combination of soil cultivation aimed at destroying Canada thistle or sow thistle during the active spring growth period, followed by the planting of an aggressive green manure crop, would facilitate control of these perennial weeds.

So as to not completely lose a growing season, the experiment was planned so that the crop planted afterwards could be harvestable buckwheat or a leguminous green manure that would enrich the soil with nitrogen for the next season. The experiments took place at Longprés Farm (Les Cèdres, in the western part of the Montérégie region) and at Mylamy Farm (Yamachiche, Mauricie region). Each farm had an experimental field. Canada thistle and sow thistle were monitored separately at Longprés Farm. Sow thistle was monitored at Mylamy Farm. In 2011, the Longprés Farm experimental field area measured 20 hectares, and the experimental area at

Mylamy Farm measured 2 hectares. In 2012, the experimental field at each farm measured 1 hectare. In 2012, at Longprés Farm, the M0 treatment was also applied to the rest of the field as well as to another neighbouring field (covering an area of about 8 hectares in total).

The two experimental treatments were as follows:

M0 – cultivate soil in June only; in 2011, the soil was only worked once. In 2012, the soil was worked twice in June. Those two cultivation events were spaced apart by a week at Longprés Farm and spaced apart by two weeks at Mylamy Farm.

M1 – cultivate soil in May in addition to the June M0 treatment. Some photos of the cultivators used in 2012 are presented in Table 1 of Appendix 2. Buckwheat or green manure crops were sown directly after the treatments in June. In 2011, both farms opted to plant harvestable buckwheat. In 2012, both farms densely planted leguminous green manure crops (soybeans on the Longprés farm and an oat- pea mixture on the Mylamy farm).

Experimental design

The experimental design consisted of randomized blocks with four replications. Each block consisted of an area of approximately 30 m by 50 m in which the presence of Canada thistle or sow thistle was dense and homogenous. Blocks were divided in half and the two treatments were carried out within the appropriate halves of each block. For each site, there were 8 plots (2 treatments * 4 blocks)

The experiment was carried out 4 times for sow thistle (2 farms * 2 years) and twice for Canada thistle (2 farms * 1 year).

Parameters measured. Total numbers of Canada thistle and sow thistle plants, their stage of development and the percentage of ground covered by the thistles were recorded on at least three different dates: (1) Prior to treatments, (2) in the fall, and (3) in the following spring. For more details on the methodology, consult Appendix 1. No data for Canada thistle are presented for Mylamy Farm, where data were only collected for sow thistle.

SUMMARY OF SIGNIFICANT RESULTS

Detailed results and photos are presented in Appendices 2 and 3.

Longprés Farm

2011 Experiment

Canada thistle and sow thistle pressure was average in the field area used in 2011: these two weeds were localised in small sections of the field. A heavy cultivator was used to work the soil for the fallow period. The buckwheat crop planted after the M0 and M1 treatments emerged well and grew into a dense stand that quickly provided 100% soil coverage. The buckwheat did not, however, prevent the regrowth of sow thistle or Canada thistle during the growing season. In fact, during the summer, these perennial weeds reached a height surpassing that of the buckwheat plants. Upon seed maturation, the buckwheat plants thinned in shape, allowing light to penetrate, thus enabling weed growth. In August 2011, the field area also contained a lot of giant foxtail, which grew taller than the buckwheat. The following year, soybeans were planted after the M0 and M1 treatments; the soybeans emerged well and grew into a dense stand. Some photos of the field areas and the effects of the treatments on Canada thistle and sow thistle are presented in Appendix 2, Tables 3 and 4.

Treatment effects on Canada thistle

The regrowth of Canada thistle plants was significantly weaker for the M1 treatment compared to the M0 treatment (Table 1).

The effect of soil cultivation in May 2011 was very visible in the field and remained so up until October 2012. The number of Canada thistle plants present also significantly decreased over time ($P \leq 0.01$); this was true for both the M0 and M1 treatments. By the fall of 2012, almost no Canada thistle remained in the field areas to which the M1 treatment had been applied. The competitiveness of the soybeans planted in 2012 (the year following the treatments), clearly reinforced the effects of the 2011 treatments in suppressing Canada thistle.

Table 1. Canada thistle: effect of treatments on the number of plants/m² and the percentage of ground area covered for each observation date - Longprés Farm 2011.

	Plants/m² (1)		% of ground area covered (1)	
	M0	M1	M0	M1
2011-05-15	47(2)	47(2)	32(2)	32(2)
2011-10-24	68a	16b	72a	14b
2012-05-14	28a	12b	11a	5b
2012-10-17	8a	1b	3a	0a

(1) For results reported for the same date, the average values followed by different letters are significantly different ($P \leq 0.05$).
(2) Only one average count was done for each plot.

Treatment effects observed for sow thistle

A technical problem prevented the proper delineation of treatment areas in two of the four blocks, making it difficult to draw a conclusion with regard to effect of the May soil cultivation treatment (M1). Similar to the results for Canada thistle, the average number of sow thistle plants decreased significantly over the time of the study period ($P \leq 0.05$) and was nearly nil by Autumn 2012 (Table 2). The highly competitive effect of soybeans sown in 2012, the year following the treatments, clearly helped to reinforce the effect of the treatments performed in 2011 in reducing sow thistle pressure.

Table 2. Sow thistle: average number of plants/m² and the percentage of ground area covered for each observation date (average of two treatments) – Longprés Farm 2011.

	Plants/m² (1)	% of ground area covered (1)
2011-05-15	103	35
2011-10-24	27	15
2012-05-14	15	3
2012-10-17	1	0

(1) The decrease over time in the number of sow thistle stems and in the percentage of ground area covered by sow thistle statistically significant ($P \leq 0.05$).

Observations on the effectiveness on the M0 treatment for the whole field.
In setting up this experiment, the M0 and M1 treatments were applied to the appropriate areas as demarcated within the field test area. In addition, the M0 treatment was applied throughout the rest of the field. When the soybeans were threshed in 2012, according to the harvest yield sensor, there was no decrease in yield related to the presence of sow thistle or Canada thistle. Back in 2010, harvests had been seriously and negatively affected due to sow thistle and Canada thistle. During the 2012 harvest, the producer noted the near disappearance of sow thistle across the entire field. The producer also observed that the Canada thistle density had decreased and that it competed less with the main crops relative to previous years.

Importance of providing competition for Canada thistle and sow thistle in the year following treatments

In 2012, a portion of the test field area involved in 2011 was planted to squash instead of soybeans. The squash plants grew poorly, never covering the soil and were destroyed in August. In this area that had been planted to squash, sow thistle was present and grew up through the observation date in October 2012, in contrast to the rest of the field where the soybeans grew vigorously (and in which sow thistle was clearly suppressed, see Appendix 2 Table 3). This example made it possible to observe the important role played by the competition potential of other crops in achieving effective suppression of sow thistle. Cultivation of soybeans during the 2012 season also probably complemented the competitive effect of soybeans in suppressing these two perennial thistles.

2012 Experiment

Compared to the field areas used in 2011, the Canada thistle and sow thistle pressure was much stronger: the 2012 field test area was completely overrun by Canada thistle and sow thistle. For the fallow, the tool used to work the soil was a goose-foot cultivator, specially made to be able to work the soil a shallow depth while cutting through the thistle rhizomes. This cultivator was a more effective tool that that used in 2011.

The soybean green manure mixture sown following the treatments emerged well and grew into a dense stand that quickly provided complete soil coverage. This green manure effectively competed with sow thistle and Canada thistle throughout the growing season. Photos of the plots and the effect of treatments on Canada thistle and sow thistle are presented in Appendix 2, Table 5.

Treatment effects on Canada thistle

Prior to the treatments, there was no significant difference in Canada thistle density for the plots used for the M0 and M1 treatments. In 2012 as in 2011, Canada thistle regrowth was significantly weaker in areas that received the M1 treatment relative to areas receiving only M0 treatment ($P \leq 0.05$). Canada thistle plant counts also decreased significantly over time for the M1 treatment ($P \leq 0.01$). The effect of the May 2012 cultivation treatment (M1) was visually obvious in the field. The M1 treatment effect remained clearly observable; in October 2012, and in the next year (2013,) Canada thistle was absent in the M1 plots, but abundant in the M0 plots.

Even though the results of this experiment indicate that the M0 treatment does not have a significant effect on the suppression of Canada thistle, observations of a neighbouring field receiving the M0 treatment in 2011 indicate that Canada thistle pressure actually did decrease noticeably in the year following this treatment. Further investigation of the effects of this treatment is required in 2013.

Table 3. Canada thistle: average number of plants/m² and percentage of ground area covered by Canada thistle for each treatment – Longprés Farm 2012

	Plants/m² (1)		% of ground area covered (1)	
	M0	**M1**	**M0**	**M1**
2012-05-14	77a	69a	31a	32a
2012-07-23(2)	55a	11b		
2012-08-22	33a	2b	45a	0b
2012-10-29	69a	6b	11a	1b

(1) For results reported for the same date, the average values followed by different letters are significantly different ($P \leq 0.05$). The decrease over time in the number of Canada thistle sprouts and in the percentage of ground area covered by Canada thistle was statistically significant for the M1 treatment ($P \leq 0.01$).

(2) Data for the ground area coverage percentage were not taken on this date.

Treatment effects on sow thistle

In July and August, the number of sow thistle plants growing back in plots receiving the M1 treatment was significantly less compared to plots where only the M0 treatment was applied (Table 4). During the summer, a small amount of sow thistle remained visible in the M0 plots but no sow thistle was visible in the M1 plots. By summer's end, sow thistle had disappeared from both treatment areas. Similar results were observed in a neighbouring field receiving M0 treatment in 2011, which corroborate the experimental observations. In 2012, there was no regrowth of sow thistle in this neighbouring field.

Table 4. Sow thistle: average number of plants/m² and the percentage of ground area covered for each treatment – Longprés Farm 2012

	plants/m² (1)		% of ground area covered (1)	
	M0	**M1**	**M0**	**M1**
2012-05-14	77a	69a	8a	10a
2012-07-23(2)	6a	0b		
2012-08-22	3a	0b	0a	0a
2012-10-29	1a	0a	0a	0a

(1) For results reported for the same date, the averaged values followed by different letters are significantly different ($P \leq 0.05$). The decrease over time in the number of sprouts and in the percentage of ground area covered over time is statistically significant ($P \leq 0.01$).

(2) Data for the percentage of ground area covered were not recorded on this date.

Mylamy Farm

2011 Experiment

The sow thistle pressure in the 2011 field test area was very strong: the field area used for the experiment was completely overrun with sow thistle. For the fallow, the tool used to work the soil was an Amazone brand disk harrow. Buckwheat sown after the treatments emerged well, but the density of the stand was variable. Notably, in areas where the buckwheat was dense, practically no sow thistle grew; meanwhile, sow thistle was dense where the buckwheat grew poorly. Hemp sown in 2012 emerged well and grew into a dense stand.

Treatment effects on sow thistle

The number of sow thistle plants/m^2 was not significantly different for the two treatments. Similar to the data from Longprés Farm, plant counts decreased significantly ($P \leq 0.01$) as the summer progressed (Table 5). Hemp sown in 2012, the year after the treatments, has a competitive growth habit that clearly helped to reinforce the effectiveness of the treatments performed in 2011 at reducing sow thistle pressure.

Table 5. Sow thistle: average number of plants/m^2 (values shown are averaged for two treatments) – Mylamy Farm, 2011

	Plants/m^2 (1)
2011-05-20	64a
2011-09-26	14b
2012-05-14	24b
2012-10-12	0c

(1) The decrease over time in the number of plants is statistically significant ($P \leq 0.01$).

In 2011, the use of a crop with a thicker growth tendency relative to buckwheat would probably have been effective at suppressing sow thistle.

2012 Experiment

In 2012, sow thistle pressure was very strong: the 2012 field test area was completely overrun with sow thistle. After the experimental treatments, a pea/oats mixture was sown heavily. The cultivation tool used for the fallow was a Lemken Kristall, which proved to be very effective relative to the others tested (heavy cultivators or a disc harrow) (See Table 1 of Appendix 2). This tool's very aggressive chisel points extracted large quantities of rhizomes that are left to dry on the soil surface. The potential of this tool to assist efforts to suppress rhizome-type weeds is very interesting. Some photos of the plots and the effects of the treatments on Canada thistle and sow thistle are presented in Appendix 2, Table 6.

Treatment effects on sow thistle

In July and August, sow thistle regrowth numbers and the percentage of ground area covered by sow thistle were both significantly less for the M1 treatment compared to the M0 treatment ($P \leq 0.05$). At the end of the season, the number of plants was nil (or nearly nil) for both treatments (Table 6).

Table 3. Sow thistle: average number of plants/m² and of the percentage of ground area covered for each treatment— Mylamy Farm 2012

	Plants/m² (1)		% of ground area covered(1)	
	M0	M1	M0	M1
2012-05-25	76a	75a	69a	64a
2012-07-25	35a	5b	15a	1b
2012-10-07	1a	0b	0a	0a

(1) For results reported for the same date, the average values followed by different letters are significantly different ($P \leq 0.05$). The decrease over time in the number of sprouts and in the percentage of coverage was statistically significant ($P \leq 0.01$).

Conclusion

A short spring fallow followed by the planting of an aggressive green manure is an effective method for suppressing Canada thistle or sow thistle. For sow thistle, two cultivation passes in June were sufficient to achieve suppression, while for Canada thistle, an extra pass in May was required for this suppression method to be effective. The planting of crop that can be cultivated the following year seems to play an important role in achieving more complete suppression. A fall cultivation pass may be helpful to eliminate any thistle seedlings that germinate beneath the cover crop.

Though the perennial weed pressure in 2011 and 2012 was similar for one of the farms, and stronger in 2011 than in 2012 for the other farm, the fallow periods used in 2012 were more effective compared to 2011 at suppressing perennial weeds, with less thistle regrowth by the end of the season. Three factors could be responsible for such results: (1) planting a more competitive after the cultivation, (2) the use of more effective soil cultivation tools, and/or (3) the use of a greater number of cultivation passes. The Kristall cultivator from the Lemken company that was used for the fallow period in 2012 distinguished itself from the others (heavy cultivator, disc harrow) used in this experiment. The Kristall cultivator is equipped with aggressive chisel points that can extract large quantities of rhizomes from the soil, leaving them to dry on the soil surface. The potential of such a tool seems very interesting for the suppression of rhizome-type weeds. The points used for this tool, however, should be selected such that rhizomes are left on the soil surface. Another tool used in 2012 (a goose-foot cultivator), specially constructed for depth control during cultivation while cutting rhizomes also appeared to provide good results.

POSSIBLE INDUSTRY APPLICATIONS AND FOLLOW-UP INFORMATION

The results of these experiments are promising, because they indicate that a short spring fallow combined with planting dense green manure is an effective method for suppressing sow thistle and Canada thistle. Up until now, only a long fallow or a three-year prairie had given good results in terms of suppressing Canada thistle or sow thistle without the use of herbicides. A short spring fallow combined with the planting of a green manure is a good method for soil conservation and may even improve soil if nitrogen is provided to the next crop, which is a bonus relative to placing fields in a long fallow. Compared to a three-year prairie, the short-fallow/green manure combination only results in the loss of one harvest year.

This project permitted the validation of the hypothesis that using spring cultivation to destroy sow thistle and Canada thistle during their active growth period in the spring, followed by the planting of an aggressively-growing crop is effective at suppressing these perennial weeds. Buckwheat did not prove, however, to be aggressive enough: it was better to sow a dense green manure. To achieve suppression of sow thistle, two cultivation passes in June appear to suffice; meanwhile, for Canada thistle, the addition of an additional cultivation pass in May is beneficial.

The short spring fallow combined with planting an aggressive green manure makes it possible achieve greater suppression of Canada thistle and/or sow thistle without the use of herbicides. This finding could have major repercussions for organic agriculture, which is currently in the grips of a serious problem in terms of finding ways to suppress perennial weeds with deep rooting habits in large cropping areas not planted as prairies for hay. As long as adequate yields are maintained, organic agriculture meets the expectations of the Prime-Vert program because of its reduced use of herbicides.

An outcome of this project is that it is possible to envisage the reduction of herbicide use in conventional cash crop systems and minimizing yield losses in organic systems. This technique could be become interesting in conventional agriculture if the green manure crop sown in June can be replaced with an early-maturing soybean crop.

As follow-up to these initial results, it would be useful to:

- test the importance of soil cultivation in the fall preceding the short spring fallow as well as of soil cultivation the following fall;
- verify whether a single cultivation pass in June would suffice instead of two for the spring fallow,
- test the use of different tools for the fallow;
- test the possibility of sowing soybeans as a harvest crop after the fallow;
- use a GPS to ensure that the row where the crop was seeded is cultivated the following year (sow thistle does not tend to regrow between the previous year's rows of plants where the soil has been cultivated).

THANKS TO OUR FUNDING PARTNERS

This project completed as part of the framework of the Prime-Vert program, sub-topic 11.1 – Supporting the development of phytosanitary agricultural strategies in Québec, with financial support from the ministry of Agriculture, Fisheries and Food.

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