Latest Research Results

organic SCIENCE CLUSTER 3

Optimizing tillage and competitive green manures for Canada thistle control

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Canada thistle (Cirsium arvense L.) is a highly adaptable and persistent noxious weed that is one of the most pressing concerns of organic field crop producers. Current Canada thistle management relies on intensive summerfallow, and/or rotation to perennial forages for several years. Tillage and summerfallow can have negative repercussions on soil fertility and quality, and perennial forages are not always an economically feasible option. Based on previous research, two possible control strategies exist. The first uses perennial legumes such as white clover and alfalfa, which are periodically mowed based on either calendar date, thistle height, or bud formation. Since perennial legumes take two to four years to establish, a biennial legume crop such as yellow sweet clover may be a more financially viable alternative. A second green manure management technique was developed by CETAB+ in Québec. Multiple tillage operations are performed at one- or two-week intervals in May and June, followed by late, dense seeding of annual legumes such as soybean or forage pea. The annual green manure is terminated the same year it is established, allowing field crops to be grown the following year. Both strategies reduced Canada thistle populations by 75% or greater. Selective in- or above-canopy clipping of Canada thistle stems exhibited potential in corn, reducing Canada thistle coverage by more than 60%. This study evaluated an integrated approach that uses strategic tillage combined with competitive green manures, and above- or in-canopy weed clipping.

Figure 1: Effect of clipping (right) on Canada thistle top-growth removal in spring wheat. Unclipped treatment on left. Photo credit: Eric Johnson August 11, 2020. (Despite strong visual effects, clipping did not increase wheat yield or have short or long-term benefits on Canada thistle infestations.)

Site-specific weed discrimination is an emerging approach that allows farmers to assess weed pressure and control weeds efficiently by mapping them precisely. Unoccupied Aerial Vehicles (UAVs) provide a non-destructive, high-throughput, and fast phenotyping platform to observe fields from an aerial perspective. Substantial progress in image analysis has occurred over the past few years, and successful mapping of perennial weed species has been achieved in published studies. The use of Convolutional neuronal networks (CNN), and Random Forest, a machine learning algorithm, have been used to analyze UAV images for weed detection.

This study aimed to develop a model from UAV imaging to accurately discriminate weed areas in the field throughout the growing season. Specifically, the objectives of this study were: **a)** to create an algorithm that can map site-specific Canada thistles using machine learning with spectral and spatial analysis; and **b)** to utilize the resulting maps to evaluate the effectiveness of clipping and cover crop practices on controlling Canada thistles.

The experiment was conducted at the Goodale organic research farm, University of Saskatchewan, from 2018 to

to 2022. It employed a two-way factorial design, examining the effects of a cover cropping system and clipping practices on Canada thistle. The cover crop sequences included a combination of annual green manure (fababean) that had differing seeding / termination dates and biennial sweet clover with differing termination dates. The cover-crop sequences included:

1. W-FL-W-FL-W
2. W-FGME-W-FGME-W
3. W-FGML-W-FGML-W
4. WSc – SCE – WSc- SCE-W
5. WSc-SCL-WSc-SCL-W

Abbreviations: W = Spring Wheat; FL = Fallow; FGME = fababean green manure seeded and terminated early; FGML = fababean green manure seeded and terminated late; WSc = wheat underseeded to sweet clover; SCE = sweetclover terminated early; SCL = sweetclover terminated late.

Plots were split in half, with one-half receiving a clipping treatment and the other half unclipped. Clipping was conducted in 2018 and 2020. It was planned for 2022; however, late emergence of the Canada thistle under the wheat canopy did not allow clipping treatments to occur without significant crop damage. In 2021, the sweetclover failed to establish due to late season drought in 2020 and severe drought in 2021. Therefore, we seeded barley, a competitive annual crop, on these treatments but maintained the early and late tillage timings. Early and late seeded fababean green manure was seeded in late May and late June, respectively. Early and late termination of the fababean green manure occurred in late July and late August, respectively. Early and late termination of sweetclover was conducted in mid-June and mid-July, respectively.

Unoccupied Aerial Vehicles (UAV) were used to capture digital images of the experiment. The images were processed and weed and crop polygons were determined using a Random Forest classification. This enabled the quantification of Canada thistle area. Canada thistle area was correlated with ground-truth data consisting of manual Canada thistle shoot counts done close to the time of image capture. It was determined that late season image capture was the most reliable time to quantify Canada thistle area, as the crop had senesced while the green Canada thistle patches maintained a high NDVI.

The correlation between image-estimated thistle area and ground-count weed density was quite acceptable, with r^2 values ranging from 0.74 to 0.76. This indicates a relatively high degree of accuracy for the UAV imaging analyses. Canada thistle area varied from year to year, with the highest area recorded in 2021.

Clipping had no effect on Canada thistle area in the year it was conducted, nor did it show any long-term benefit to reducing Canada thistle area. There appeared to be some visual benefit to clipping in 2020 (Figure 1); however, it did not improve wheat yield or reduce thistle area. Fallow every second year was able to reduce and maintain Canada thistle densities and area at low levels. Late seeded / late incorporated fababean green manure also maintained low densities and low Canada thistle area over the 5-year period. Late seeding allowed for early spring tillage in May and June, which may have been sufficient to manage thistle populations. All other cover-crop sequences had higher Canada thistle infestations and were not effective in managing the weed.

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