Autonomous Weed Scouting Project Report – Year 1

Project Partners

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Other Researchers and Extension Personnel Collaborating on this Project:

- Kristen Obeid and Mike Cowbrough, Weed Specialists, OMAFRA
- Dr. Francois Tardif, University of Guelph – Professor, Plant Agriculture
- Shaun Sharpe, AAFC Weed Scientist, Saskatoon, Saskatchewan

Personnel additions since proposal:

- Dr Medhat Moussa, University of Guelph – Professor, Engineering

Facility additions since proposal:

- University of Guelph - Elora Research Farm
    - Used for lima bean control plots. These plots were imaged in addition to Nortera's commercial fields to have a more comprehensive training dataset.

Overall Research Summary

The multifaceted challenge to address weed escapes in lima bean production fields was defined by an inter-disciplinary team from academia (University of Guelph), government/regulatory (OMAFRA), growers (Nortera Foods) and industry (Haggerty AgRobotics) stakeholders. This group worked together to plan the technologies, processes and expertise required to address this challenge.

The following methodology was/will be followed:

1. Collect in-field images of pigweed species, Eastern black nightshade, and horsenettle at different times throughout the season. All three weed species cause significant harvestability and processing issues.
2. Use images to develop a model to detect weed zones in the field – weed density map.
3. Use weed density maps to inform herbicide application and harvest decisions.

4. Compare historical losses associated with pigweed species, Eastern black nightshade and horsenettle to the new method utilizing the weed density map.
5. Compare herbicide costs of conventionally managed versus autonomously scouted lima bean crop.

The first step in addressing this challenge was to create a database of overhead images of lima beans in the various environments they are produced in Ontario. This was done by utilizing a designated (controlled) research plot at the Elora Research Station, in addition to several commercial fields across SW Ontario. The research plot and a commercial lima bean field was imaged each week. The research plot allowed for the database to include the complete progression of lima bean growth, with various treatments applied to the crop. The commercial sites provided images to the database that would include the variability found in real-life, commercial applications. For both sets of imaging sites, the crop management schedule was made in accordance with industry standards set by OMAFRA and followed by Nortera Foods.

Imaging took place after first planting in May, until the first week of October – just before lima bean harvest.

For the imaging apparatus, teams from the University of Guelph and Haggerty AgRobotics collaborated to build the prototype imaging implement, create the data collection protocol, and build the software needed to control the imaging system. Images were collected from two different cameras simultaneously as the imaging implement was driven across the fields. The two types of cameras were a standard RGB camera, and a higher-end near-infrared capable camera. All the images were to be geolocated with RTK.

The implement was attached to an all-terrain vehicle to image the larger commercial sites, which had varying weed varieties and densities. The implement was interfaced with an autonomous platform to collect lima bean images in the control site at Elora, where the plot had two of the weed species.

In addition to building the database for training the pattern recognition model, the team also used the data-collection process to collect information towards optimizing the next iteration of the imaging implement. Speed of image collection and height of the cameras were investigated. The commercial fields were imaged at three different speeds, and a camera height of 6' to assess the widest possible camera field-of-view and fastest speeds possible while giving accurate enough images for scouting. Ideally, each camera has a very wide field of view so that less cameras can be used, and less passes across the field can be made. Also, the faster the platform can run, without sacrificing the image quality, the faster fields can be scouted.

Dr. John Sulik's team imaged the same fields using Phantom4 and Mavik3 drones to compare the efficacy of drone images to the ground-based system being focused on for this project.

These images will be used to build the pattern recognition model that will be used to prescribe herbicide application maps for early-stage lima-bean crop protection, and harvest stage contaminant avoidance mapping.

During the first year of the project, we received additional funding support from Nortera, Haggerty AgRobotics and the OMAFRA Supply Chain Stability and Adaptability Program administered by the Agriculture Adaptation Council. The University of Guelph has also been able to leverage funding support from the Ontario Innovation Center to develop the imaging software needed to build the mapping capacity for this project.

This work will be presented during grower organization annual general meetings and industry conferences (Ontario Processing Vegetable Industry Conference, Ontario Fruit and Vegetable Convention, Ontario Pest Management Conference, etcetera). Demonstrations of this project have occurred during the Ontario Weed Tour and Canada's Outdoor Farm Show.

Next Steps

The team at the University of Guelph will be designing and training the model used for detecting weeds in a way that makes the output actionable by growers. This process will include trialing different weed identification architectures and parameters to optimize it for this application. A critical component of this will be speed of processing, for this application, the images must be converted to a weed density map within 1-2 days in order for the map to be practically actionable by a sprayer and combine. Part of the processing and program to be developed will be to stitch the identified weed images into a geolocated map. This map is known as the weed density (heat) map. This map will be converted into a .shp file, which modern sprayers and combines use to automate herbicide application at each nozzle and lift the combine headers when they are over a dense area of weeds.

While the team at the University of Guelph are labeling and assessing the image dataset, they will determine the optimal camera height and the fastest speed the cameras can pass over the field, while maintaining adequate image quality. The team at Haggerty AgRobotics will use this information to configure the autonomous platform to run at this speed and create the commercial scale imaging implement.

The pattern recognition model, necessary peripheral programming and imaging boom will be created this winter and used in the 2024 growing season for herbicide application maps and harvest avoidance maps. The weed identification model and output programming will continue to be optimized throughout the 2024 growing season.