Water Conservation and Efficiency in Ontario Agriculture

The Water Resource Adaptation and Management Initiative

PROJECTS OF 2013

FARM & FOOD Care ONTARIO

Ontario

Canada

Foreword

Like many environmental challenges facing farmers today, there is no "one-size-fits-all" solution to improving on-farm water management practices across the diversity of horticultural and livestock facilities in Ontario. Every farm and associated watershed is unique, and a mix of water demand and water supply solutions are needed to deal with increasing competition for water resources in a changing climate. Improvements in water efficiency also creates the benefits of decreased energy demands, greater reliability of limited water supplies and higher water productivity and competitiveness of farm operations. Given the potential for multiple benefits from an investment in water conservation and efficiency, the Water Resource Adaptation and Management Initiative (WRAMI) project was launched in 2012 with funding from Agriculture and Agri-Food Canada and the Ontario Ministry of Agriculture and Food and Ministry of Rural Affairs under the federal Agricultural Flexibility Agreement. The program was administered by Farm & Food Care Ontario.

The key objective of WRAMI was to help Ontario farmers be better prepared for low water response, drought conditions and adapt their water use practices to deal with the growing impacts of climate change by funding applied research projects with a focus of water efficiency, and hosting demonstration projects on innovations, or improvements to existing water efficiency management practices. As we moved from the initial application process to the field research portion of the initiative, the projects came to life. We had the opportunity to meet all the project teams, and benefited from their enthusiasm for issues surrounding water management, water supply, crop quality and agricultural waste water. We appreciated the education that growers gave us on the complexity of issues surrounding agricultural water use in Ontario.

Although the summer of 2013 was a normal to wet growing season in most of Ontario, the lessons learned by these projects are already impacting growers' equipment and management decisions for 2014. With the recent approval of Water Adaptation and Management Quality Initiative (WAMQI) for 2014, more water and nutrient projects will provide a better understanding of the complexity of agricultural water management in Ontario.

The Ontario Ministry of Agriculture and Food and Ministry of Rural Affairs and Agriculture and Agri-Food Canada thank Farm & Food Care Ontario for its efforts to make the WRAMI project a success and in so doing advance the farming community's knowledge of sustainable agricultural water use practices in Ontario. Farm & Food Care was delighted to be part of this important water conservation and awareness project in 2013.

Bruce Kelly
Farm & Food Care Ontario
Environmental Program Lead

Deborah Brooker
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The content featured in this report includes brief summaries of each of the projects. For full reports and results, including photos and videos, visit the Environment button at www.farmfoodcare.org.

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Biopolymer/Bio Filters for the Removal of Nutrients and Micronutrients in Greenhouse Wastewater

Introduction:

Chitosan is an inexpensive bio-polymer made from ground shellfish.

Chitosan is an inexpensive and abundant polymer obtained from the processing of the shells of shrimp, crabs, lobsters, etc. In addition, chitosan can be easily combined with other compounds to yield composites with different properties. In this WRAMI funded project, we tested the ability of various chitosan composites to remove nutrients and micronutrients from enriched agricultural wastewater streams.

The majority of the proposed goals in this study were completed, which will provide insight into potential solutions to agricultural water heavy in nutrients:

1. A variety of chitosan composites and derivatives were made including chitosan beads, cross-linked chitosan beads, chitosan flake derivatives and algae-chitosan complexes.
2. The dried, cross-linked chitosan beads could remove nutrients in approximately four hours. These beads were made up of: Cu^{2+}, Zn^{2+}, Mn^{2+} and Fe^{3+}.
3. Chitosan beads complemented with Cu^{2+} demonstrated a high capacity (approximately 2.27 ± 0.8 g/kg) for the removal of phosphate.
4. A more inexpensive type of chitosan known as chitosan flakes mixed with Cu^{2+} were found to have high capacity for the reversible removal of phosphate (PO_4^{3-})

   (~4.05 g ± 0.8g of PO_4^{3-}/kg chitosan-Cu-flakes, n=8). The chitosan-Cu flakes retained greater than 50 percent of their phosphate binding capacity after four regeneration cycles (wash with 0.1 M NaCl).
5. Two strains of algae, S. obliquus and C. vulgaris, were shown to remove 450 parts per million (ppm) of phosphate and approximately 50ppm nitrate within 100 hours. The addition of chitosan flakes into the algal medium doubled the amount of nutrient removal in approximately one quarter of the time (24 hours).

Methods:

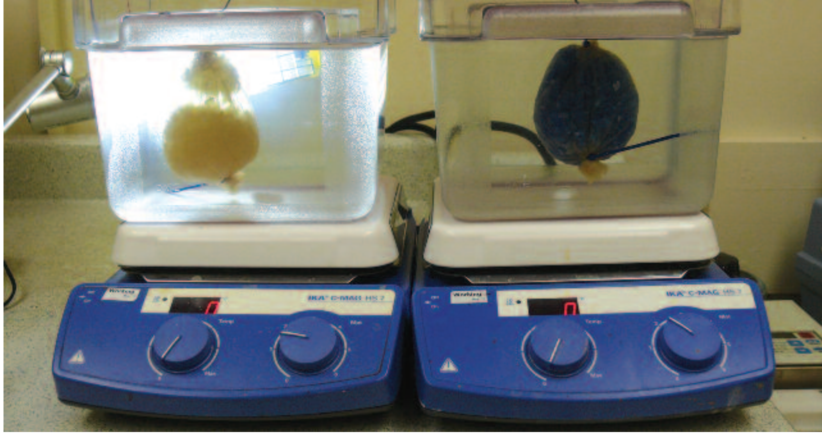
Algal growth: Algal Strains were obtained from the Canadian Phycological Culture Centre (CPCC). They were grown in BBM media or greenhouse waste water, with continuous light illumination aeration in two litre glass bottles.

Metal ion analysis: The sample is acidified with concentrated nitric acid (HNO_3) to a final concentration of two percent HNO_3. Atomic absorption (AA) standards (0.01 to 50 ppm) of the respective metals were prepared and the absorption vs [Metal] plots were determined with a Varian Spectra 55 AA Spectrometer. The metal concentration in the sample was estimated by comparing the standard curves for each micronutrient analyzed.

Phosphate analysis: The ANSA-molybdate reagent was used for phosphate analysis.

Working reagent: One part 2.5 percent ammonium molybdenum, one part 6N H_2SO_4, one part ten percent Ascorbic acid and two parts double distilled water. The working reagent is mixed 1:1 with the sample and incubated at 40 degrees Celsius for one hour. The absorbance was measured at 820 nm using a Varian UV-Vis spectrophotometer. The phosphate concentration in the sample was estimated by comparing to the standard curves (0.1 to 100ppm).

Nitrate analysis: Nitrate determinations were performed with a DR/890 portable spectrophotometer (HACH) using a NitraVer 5 nitrate reagent. The nitrate



Chitosan in the form of beads is suspended in water spiked with nutrients to determine its capacity to remove the nutrients and the length of time it takes to do so.

concentration in the sample was estimated by comparing the standard curves (0.1 to 100ppm).

Setup for determining micronutrient phosphate and nitrite removal: *Chitosan and derivatives:* The chitosan beads or flakes (10g) were placed inside a nylon bag and suspended in a square plastic container with four litres of water containing the micronutrients or nutrients.

Algae and Algae-Chitosan: The micronutrients or nutrients were added to the algae in their maximal growth phase. At various time intervals, 0.5 mL of the solution was removed. The algae in the sample were removed by centrifugation and the supernatant was analyzed for micronutrients or nutrients

Results & Conclusions:

In conclusion, chitosan in its various forms offers an inexpensive alternative to the removal of micronutrients and phosphate from wastewater.

This study demonstrates the versatility of chitosan forms in the removal of micronutrients as well as phosphate. Cross-linked Chitosan beads were able to rapidly remove the ions Cu^{2+}, Zn^{2+}, Mn^{2+} and Fe^{3+} from wastewater. Cross-linked chitosan beads once mixed with Cu^{2+} were able to remove phosphate from wastewater with high binding capacity (~2.27 ± 0.8 g/kg wet beads).

The research revealed a more inexpensive chitosan form, chitosan flakes, as a phosphate filter material for wastewater. The chitosan flakes complexed with copper could bind up to approximately four grams of phosphate for each kilogram dry chitosan flake.

Due to the fact that the leaching of copper from the chitosan flakes might deter its use as a wastewater filter, the release of copper from chitosan flakes with varying copper saturation was tested and a stable chitosan-copper complex (Type 20) that does not leach copper after four successive salt washes was found.

The Type 20 chitosan-copper complex was also tested for its ability to bind phosphate after undergoing repeated phosphate binding/ regeneration cycles. After four regeneration cycles the matrix retained more than 50 percent of its phosphate binding capacity.

The chitosan forms are now ready for field testing. We are currently designing chitosan-copper complex (Type 20) filter cartridges that will ensure that no copper from the filter will enter the treated water. This will be accomplished by a large chitosan flake section downstream of the chitosan-copper complex (Type 20) section. In this manner, any small amount of copper that leaches out will be trapped by copper-free chitosan flakes.

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"The release of nutrients and micronutrients from agricultural and other wastewater streams is a major environmental concern. We are pleased with the results of our WRAMI funded project, indicating that chitosan composites are a simple, efficient and inexpensive way to remove significant amounts of nutrients and micronutrients from agricultural wastewater. We are delighted at the prospect of a Made in Ontario solution that was seeded with the aid of WRAMI."

- Bulent Mutus

Showcasing Variable Rate Irrigation Technologies in the Ontario Potato Industry

Introduction:

This irrigation boom has been retrofitted to only apply water to the areas that need it, reducing water use and possibly reducing losses in storage from mold.

In Ontario, the average annual acreage of potatoes is 38,000 acres with a crop value of over $100 million. Potatoes require a sustained and adequate supply of water, resulting in a large sectoral need for irrigation. Simcoe County, the prime potato lands in the Beeton-Alliston-Angus corridor, is noted for low water conditions. South Simcoe County routinely experiences seasonally low summer rainfall/stream flow and competing high demand for irrigation.

The application of uniform rates of water to large areas through conventional center pivot systems results in water use inefficiencies. New irrigation technologies can enable the development of an agricultural system that account for within field variability, help to optimize profit, and potentially reduce environmental impacts.

Earlier research has shown that variable-rate irrigation saves between nine and 26 percent of irrigation water, with accompanying energy savings, as well as reducing runoff and drainage by up to 55 percent, which reduces the risk of nitrate leaching (Fraser, 2011).

This project represents a new and innovative approach to potato crop irrigation through the application of Variable Rate Irrigation (VRI), which has yet to be demonstrated or tried in Ontario for potato crop. Through showcasing a demonstration site of VRI technologies via various knowledge technology transfer opportunities, it is envisioned that the benefits of VRI will be potentially incorporated by other producers for enhanced on-field water management/application and environmental sustainability both for other high value crops and for other regions besides Simcoe County.

Specific objectives of the project included:

1. Develop and field test an adaptable, reliable and user friendly variable rate center pivot irrigation system.
2. Evaluate the impact of variable rate irrigation on crop production, including yield, quality, uniformity and other benefits.
3. Assess the environmental benefits of variable rate irrigation in combination with other agriculture management practices.

Methods:

Variable rate irrigation (VRI) is precision agriculture as applied to irrigation. The water is manipulated so that individual parts of a field receive the amount appropriate for the site-specific soil and crop conditions at that location. VRI enables micro-management techniques on a site-specific basis to account for the natural and human-induced variations which exist in agricultural fields.

Regarding the development of the spatial management zones for VRI, the first task identified in this project was to focus on designing management zones across the field that best represented potato productivity due to the inherent characteristics of the soil (i.e. texture, moisture holding capacity) and the landscape (i.e. topography, slope). There were three steps taken to develop a VRI prescription map.

- Step 1: Compile a management zone map that depicts productivity across the field. Several spatial layers of information can be used to define management zones for VRI: elevation (slope), soil type and texture, aerial imagery (early spring / bare ground), existing yield maps, etc.
- Step 2: Using a Geographic Information System (GIS), analysis between those spatial layers defined in step (1) is used to divide the field into management zones that then form the basis for the VRI prescription (i.e. how much water would be applied to each management zone across the field).
- Step 3: The precision irrigation strategy was then complemented with the installation of real-time in-field soil moisture monitors at specific depths and locations across the field which attempted to represent the management zones defined by the GIS analysis and farmers' knowledge.

Results & Conclusions:

More work is required in terms of decision making with respect to when to irrigate and how much to differentially apply in each VRI management zone. Real-time monitoring of soil moisture was included in this project in part to help form the basis of determining what in-season technologies may be necessary to help farmers with decision making. Going forward, this will be very valuable in quantifying the benefits of VRI to the field/farm over the long term.

Regarding the soil moisture monitoring aspect of the project, this type of "water balance" information could help a farmer to determine how to avoid letting the crop become moisture stressed. Also, it could provide information to determine if the irrigation event added enough water to cope with moisture stress, or alternatively, added too much or not enough at that time in the growing season to optimize tuber development of potatoes.

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Homer Vander Zaag stands next to his variable rate irrigation system, which utilizes a prescribed map specifically designed for his potato field in Alliston, Ontario to apply variable amounts of water to difficult soil types within the irrigated area.

Subsurface Drip Irrigation for Field Crop Production in Southern Ontario

Introduction:

Difference in seed quality and yield with the use of subsurface drip irrigation.

The objective of this project was to demonstrate the benefits of subsurface drip irrigation (SDI) for corn production in the Sand Plains Region of Ontario. WRAMI funding helped to fund the infrastructure needed to conduct SDI research. SDI is a new technology for Ontario where water is applied below the soil surface by micro-irrigation emitters. It is a low-pressure, high-efficiency system that uses buried polyethylene drip lines [>12″ (30cm) depth] to meet crop water needs. SDI can deliver water with an efficiency of 95% or higher and keep the corn root zone closer to optimum soil moisture. Low rainfall is devastating to many corn crops in the Sand Plains Region and other drought-prone areas of Ontario.

Methods:

Drip tape was installed 35 centimeters (14 inches) deep in a 2.5 acre block of land at the Simcoe Research Station on April 30, 2013. The tape was installed at two spacings of 112 (44 in.) and 168 (66 in.) centimeters apart and two different flow rates of 0.68 and 0.94 litres per hour. Pioneer seed corn (cv. PO216HR) was planted in a 2.5 acre site (replicated plots) at the Simcoe Research Station on May 3, at 93,000 plants per acre with 11.6 kg/acre of mini-map 11-52-0. Primextra at 1.2 liters/acre was applied on May 6. Corn was planted at La Salette, ON (Judge Farms on-farm demonstration site) on a 75 acre site (six different irrigation zones) on a coarse textured sandy loam soil. Drip lines were placed 112 cm (44 in.) apart and 35 cm (14 in.) deep. A non-irrigated check plot was included. Time Domain Reflectometry (TDR) sensors were installed in the SDI plots. Each monitoring station consisted of five moisture probes. The medium location probes (at 25cm and 45cm below the soil surface) were used to monitor and schedule irrigation events while the 91 cm (36 in.) deep probes were used to indicate potential leaching events.

Subsurface drip irrigation was used to keep the available soil moisture at 75 to 80 percent of field capacity. This was achieved by using both evapotranspiration and moisture sensor data. Evapotranspiration values were determined by averaging two different ET models (Priestly-Taylor and Penman-Monteith). Data for both models was obtained from a local weather station on a daily basis. The evapotranspiration was then multiplied by the appropriate crop coefficient for the growth stage of the crop to give the daily crop requirements. Real-time soil moisture monitoring was accomplished by connecting the TDR sensors to a wireless cellular data logger that was used for the scheduling of irrigation. Soil moisture data was monitored and collected by a Decagon data logger coupled with TDR probes. Monitoring continued throughout the growing season. Natural rainfall and irrigations events were monitored in real time. On July 5, all plots

Corn Plot Results- Subsurface Drip Irrigation Plots - Simcoe Research Station: Harvest Date November 15, 2013								
Plot	Weight in lbs	Plot Size feet	Area - Acres	Moisture %	100 Seed Weight grams	Bushel Wt. in lbs	Yield bushels	Average bushels
44 inch x .18 gph West	2510	259 x 30	0.178375	19.80	33.80	58.20	240.50	
44 inch x .18 gph East	2460	257 x 30	0.176997	18.80	33.20	57.60	238.50	239.50
44 inch x .25 gph West	2430	259 x30	0.178375	19.50	31.80	57.30	231.70	
44 inch x .25 gph East	2370	257 x 30	0.176997	18.80	32.40	57.30	229.80	230.80
Non-irrigated West	2170	257 x 30	0.176997	18.80	30.30	57.80	210.40	
Non-irrigated East	2330	257 x 30	0.176997	19.80	31.00	56.50	223.10	216.80
60 inch x .18 gph West	2400	257 x 30	0.176997	20.00	33.20	57.50	229.20	
60 inch x .18 gph East	2480	257 x 30	0.176997	18.80	34.30	58.00	240.40	234.80
60 inch x .25 gph West	2320	252 x 30	0.1735554	19.30	32.40	57.80	228.00	
60 inch x .25 gph East	2580	257 x 30	0.176997	19.40	35.30	60.00	248.30	238.20

Yield data for subsurface drip irrigation corn in Ontario sand plains, November 15, 2013.

received a liquid solution of 5.5% Calcium, 2% Magnesium and 0.5% Boron at 1 liter/acre to correct a potential magnesium deficiency. During the season there were 31 irrigation events, including 10 fertigation events, adding approximately 80 kg of nitrogen by way of liquid 28% N. Probes at 25 cm (10 in.) below the soil surface, between drip lines, indicated that there was adequate moisture across the row, even at 152 cm (60 in.) spacing. The 91 cm (36 in.) deep probes indicated no leaching events took place. Crops were harvested at physiological maturity and yield and quality parameters recorded. Data on 100 seed weight, moisture percentage and grain yield was collected.

Results & Conclusions:

In 2013, rainfall in the area of research was higher than normal. Nevertheless, SDI resulted in a 23 bu/acre yield increase over the non-irrigated plots at the Simcoe Research Station. Quality was also improved. Hundred seed wt. in grams was higher for the SDI plots. Drip tape spacing of 44 versus 60 inches or flow rate in GPH had no impact on yield. Yields at Judge Farms were 275 bu/acre versus 165 bu/acre in a side by side comparison between SDI corn and non-irrigated corn.

SDI maximizes the benefits of added water and other crop inputs such as N and micronutrients, producing maximum yields and quality while labour needs and environmental impact are reduced. SDI improves corn yield and quality, irrigation and nutrient application efficiency and reduces risk and vulnerability for corn production in coarse-textured soils. This allows corn growers to adapt their water use practices to the impacts of climate change, producing maximum yields, even in drought situations and expand corn production in the Sand Plains Region and other drought prone areas in Ontario. It can reduce risk and vulnerability in corn production, producing maximum yields in coarse-textured soils. Knowledge transfer to the end users of this technology will benefit corn growers, help promote its use in the Sand Plains Region and other areas of Ontario and can be extended to the production of other crops. This research will develop water and crop nutrition guidelines on the most environmentally sustainable and efficient use of water and fertilizer.

"Subsurface drip irrigation proved to increase corn production even in a wet year like 2013. The insurance this system provides to growers, and the ability to apply nutrients on an as needed basis, will only prove more valuable as we return to drier weather conditions in the coming years."

- Peter White

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Evaluating Irrigation Water Use Efficiency in Vineyards

Introduction:

Developing strategies for efficient use of water is essential for the long-term viability and competitiveness of Ontario's viticulture industry and is becoming a greater priority due to the more frequent extremes in precipitation and temperature that are affecting the fruit quality and longevity of Ontario's vineyards. In August of 2012, the Grape Growers of Ontario initiated an irrigation committee composed of growers and government representatives. The purpose of the committee is to enhance on-farm water management and improve access to raw water for agricultural irrigation in the Niagara Region.

The objectives of this WRAMI project were to:

- Assess the water requirements for viticulture through a comprehensive grower survey.
- Assess irrigation water use efficiency by quantifying water inflow and outflow on grower cooperator demonstration sites.
- Provide Ontario grape growers with information on the efficiency, accuracy, cost and user friendliness of various different types of soil moisture sensors.
- Develop whole farm water management strategies for efficient use of water in vineyards.
- Encourage growers to adopt on-farm strategies to conserve water and meet crop needs.

Blue dye is used to display drainage patterns in the cored soil. This knowledge assists growers in improving how water reaches the roots of the plant to improve water efficiency and improve yield.

Methods:

A grower survey was conducted at the Ontario Fruit and Vegetable Growers Convention in February of 2013. The purpose of the survey was to recognize areas of potential industry vulnerability and future opportunities to improve management practices. It also provides a benchmark for individual growers with which to measure their soil and nutrient management styles. The final survey data set represents 16 percent of the total number of 2012 grape growers and 24 percent of the total grape acreage. The survey results provided the following observations:

1. The main source of water used by growers is surface water. Twenty-four percent of surveyed growers representing 26 percent of the surveyed acreage identified having no access to irrigation water.

   Twelve percent of the respondents (representing 21 percent of the acreage) are accessing municipal water for irrigation. Of those growers who selected municipal water as a source of irrigation water, 100 percent were from Niagara. Of the Niagara growers surveyed, 15 percent indicated municipal water access, 47 percent surface water, eight percent well water and 30 percent had no access.

2. Half of the respondents do not have access to on-farm storage of water.

3. Responses to questions related to water

management indicate that there is no overall agreement on how water may be conserved in grape production systems, indicating a need for additional research and extension efforts in this area.

4. Improved vine health is indicated as the most common reason for irrigation in vineyards.
5. Cultural practices in vineyards represent a relatively low risk to nutrient and soil loss.
6. Twenty-eight percent of the surveyed acreage is on sandy or loam soils which may require more irrigation water and more frequent irrigation in dry years than clay soils. This may be a result of grapes being planted into traditional tender fruit land, and suggests that previous irrigation equations that have been developed for clay soils need to include a factor for soil type.

The project included testing an automated system of recording soil moisture readings and linking the data collection through GrapeTracker, GGO's online spray recordkeeping system. This system was designed locally for use with both the Tender Fruit and Grape Tracker systems, and will provide a low cost alternative for collecting individual and automated on-farm soil moisture data.

Results & Conclusions:

A variety of types of soil moisture metres were used at each of the grower co-operator sites throughout the summer of 2013. As the 2013 growing season had significant rainfall, only one (1) of the grape growers irrigated, and did so based on soil moisture and pressure bomb readings. The general perception amongst growers was that with the frequency of rainfall in 2013, there was no need to irrigate, however soil moisture readings did suggest that there were dry periods during the summer when irrigation was warranted.

The results are varied with differing conclusions suggesting that it would be beneficial to continue to collect data over a number of seasons. The differing conclusions also points to the value of site specific data for growers to make the best possible irrigation decisions.

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"Water is essential for the long-term viability and competitiveness of Ontario's viticulture industry. The WRAMI project is helping develop strategies for efficient water use."
- Bill Schenck, Chair, Irrigation Committee

Whitemans Creek Pilot Project for Drought Contingency Planning

Introduction:

Whitemans Creek is an important source of irrigation water for farmers in Brant County. During dry years, irrigators must look to alternative sources to water their fields to preserve the ecological function of the water course.

The Whitemans Creek subwatershed in the Grand River watershed is an area with a rich variety of agricultural production. Low water conditions are a perennial issue in this subwatershed impacting both agriculture and the cold water trout fishery and wildlife that depend on creek flows. In 2007 and 2012, the creek fell to Ontario Low Water Response (OLWR) Level 3 conditions (less than 30 percent of average summer low flow and receiving less than 40 percent of long term average precipitation in a 30 to 60 day period). This pilot project offered a proactive approach to a reocurring issue of low water in the Whitemans Creek subwatershed. The project took place over eight months and every holder of a Surface Water Permit To Take Water (PTTW) was contacted. The goal of the project was to increase drought preparedness as well as to increase communication with the Conservation Authorities, Ministries and local groups, increasing education and outreach, and increasing understanding for both water users and regulators of how water is used in the Whitemans Creek subwatershed.

Methods:

Increased communication was achieved through regular site visits and continual contact by Hajnal Kovacs, Drought Contingency Specialist, as she collaborated with the farmers to build a drought contingency plan.

Educational flyers and one-on-one meetings with the farmers increased education regarding irrigation systems, calculating watering demands, introduction to soil moisture monitoring, PTTW applications/amendments and the process involved in pond creation/renovation. Two farmers participated in the irrigation system assessments that were offered by the Ontario Ministry of Agriculture and Food as part of this pilot project. These assessments gave the farmers an opportunity to see the ways in which their irrigation systems (both centre pivots on potato fields) could be modified to work more efficiently.

Three farmers participated in soil moisture monitoring throughout the growing season. This resulted in tracking the soil moisture of six different fields: tobacco, seedling ginseng, two-year-old ginseng, overhead irrigated tomatoes, drip tape irrigated tomatoes, and drip tape irrigated peppers. These farmers experienced the benefits of soil moisture monitoring and how useful it can be in making irrigation decisions.

Five farmers expressed interest in being involved with the advertised pond renovation that offered cost-sharing to either create a contingency source or modify an existing one to have a greater storage capacity. Four of the renovations were completed in the fall of 2013 and one will be completed in 2014.

Results & Conclusions:

The results of the knowledge gained from these farmers were used in forming a plan to improve drought preparedness for all farmers. Four steps have been highlighted as key components to a drought contingency plan:

1 Ensuring an irrigation system is in place and working accurately.

2 Using Best Management Practices (BMPs) year-round.

3 Securing a reliable water source with a Permit To Take Water.

4 Writing down what options exist if the regular water supply is not able to provide the watering needs.

With a total of nine farmers involved in the project, the findings indicate the importance of proactive thinking and planning within an agricultural community, especially in the case of drought planning.

Hajnal Kovacs explains how soil moisture probes assist farmers in conserving water and improving crop quality and yield.

"From WRAMI support, the multi-agency steering committee was able to develop a drought contingency plan during a proactive pilot in the Whitemans Creek Subwatershed in cooperation with nine volunteer farmers and communication between Conservation Authorities, Ministries, local groups and the agricultural community regarding drought preparedness was improved." ***- Hajnal Kovacs***

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Outdoor Container Nursery Production Water Use Efficiency and Best Practices Benchmarking Study

Introduction:

Water captured from greenhouses and outdoor beds is transferred to this treatment pond.

An extensive study of container nursery production water quality during the 2013 growing season demonstrated that the level of nutrients in their post-production water is of low environmental risk. Results indicate output water quality is similar to the Ontario Ministry of Environment's (MOE's) greenhouse storm water effluent targets.

From the survey component of this study, it was evident that nursery growers are working diligently to protect the environment. Most growers are investigating ways to decrease their water and nutrient use, and to minimize their potential environmental impact. Nursery growers have adopted numerous Best Management Practices (BMPs) to conserve the use of water and nutrients. Current trends include the use of fertilizer dibbling, grading/berming to improve runoff recapture and experimentation with different sprinkler heads and layouts to decrease water losses from evaporation.

Due to high water needs, outdoor container nursery growers are great examples of water recyclers in Ontario. Their practices of whole farm water management, collection of runoff water, storage and extent of re-use are not well documented and need to be understood as a model. Therefore, the data captured by this study will not only be used to evaluate the risk of this sector's potential for nutrient loading to non-target water systems, but also to demonstrate the potential for recycling and ultimately lead to more efficient water use. The results of this study will provide an opportunity for government policy makers to base regulations on scientific results of the analysis of post-production wastewaters in Ontario.

Methods:

This project had two main components: a research trial and a survey. The research trial consisted of a water sampling program, characterizing water supply (source) and comparing it to runoff (on-farm drain water) from the growing areas and the discharges off the farm (outlet). Container nursery sites were chosen that had similar production systems and crops (established deciduous flowering shrubs irrigated by overhead sprinkler systems). In addition, an on-site, detailed grower survey was executed to determine the water management practices in place and obstacles that prevent more efficient water use by this sector.

Twelve sites were chosen for the sampling component of the study based on crop production, access and availability of the source, on-farm drain and outlet samples, geographic location and farmer cooperation. Samples were taken from each of the sites using clean sample bottles (triple rinsed), and were placed immediately in an electric cooler to maintain temperatures below 10 OC. Records of weather, presence or absence of flow (for on-farm drain and outlet samples) were maintained for each visit. Bi-weekly sampling of 1) source, 2) on-farm drain/bed runoff and 3) outlet water (where possible, i.e. when drain/outlet was running) took place for 12 nurseries from April to October. Samples were analyzed for nutrients, pH and EC (soluble salts), as well as other elements of potential concern to the environment. The samples were analysed and compared with the Ontario Ministry of Environment's Greenhouse Effluent Preliminary Objectives for Storm water. Temperature (Environment Canada data) and precipitation (as measured by rain gauges at each site) were also recorded. The survey of outdoor container nurseries was also important to this study.

The survey of 18 nurseries in Southern Ontario was designed to collect information on:

a) Production systems
b) Irrigation systems, efficiencies
c) Types of fertilizers used and placement
d) Water balance (inputs and outputs)
e) Technologies used to conserve use of irrigation water and reduce pressure on external source water systems
f) Technologies used to maximize collection and re-use of post-production water, and
g) Obstacles to becoming more water efficient Ultimately, this survey was designed to collect information on what nursery producers do in regards to water and nutrient use, how they do it, and what best management practices (BMPs) are currently being implemented.

Results & Conclusions:

This study concluded that successful irrigation management depends on the person responsible for the task of watering. It is quite often quoted as being the most important job at the nursery. Drive-by irrigation monitoring and reliance on automated technology are not adequate to determine crop water needs. Even those nurseries with high-tech automated systems will still invest the time in visual inspections (crop canopy, sprinklers), walk-throughs, lifting of pots to check for relative weight and removing the pot to examine the physical wetting front and saturation level of pot. These checks are best done before and during every irrigation event. Where growers utilize night watering to prevent evaporative losses, these irrigation checks are conducted during the daylight hours preceding the irrigation event.

Aside from the desire to increase storage capacity and improve recapturing of water, nursery growers are looking for benchmarking information to see how much water container nursery growers are applying to their container crops, how much leachate is released and how much recapture actually occurs. The data from this survey and other studies will help growers improve their environmental stewardship practices and compare their operations to others in the industry.

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Outdoor container nursery crops are a high value crop and require water with balanced nutrients. This project has aimed to provide that and reduce the environmental risks of irrigation water discharge.

"The WRAMI funding was so timely for this project. The nursery sector needed data over the course of a growing season to establish its level of risk for their wastewater. Not only were we able to demonstrate the low risk nature of their irrigation ponds, we were able to document all the good things these farmers are doing to conserve water and reduce water use."

- Jeanine West

Water Balance Case Study at an Outdoor Ornamental Nursery

Introduction:

Soil moisture probes like this one are placed throughout the beds to determine distribution uniformity of overhead sprinkler irrigation.

This project provided an opportunity to perform a case study at a typical container nursery to evaluate water use efficiencies and techniques for water conservation. The exercise allowed for the observation of on-site methods for water balance parameter measurement, and an evaluation of effectiveness for interpretation and incorporation of this information into an irrigation schedule. This study enabled the creation of a simple factsheet for container nursery growers to get started on their own farm assessment of water use.

Distribution uniformity and leaching fraction tests illustrated that the distribution of water from overhead sprinklers was less uniform than expected, despite consistent flow and pressure levels across a growing zone. Heavy irrigation was required to ensure all crops watered sufficiently, so an obvious opportunity for conserving water would be to test sprinkler layout design and different nozzle options for outdoor production, taking into account exposure and weather factors. Unfortunately, more efficient micro-irrigation systems (e.g. drip) are not feasible for production of small container pot sizes. Moisture sensors, when placed carefully within a crop and calibrated correctly, may help identify areas of the beds that are in shadow or dry along the edges compared with areas that typically receive sufficient water. This information could allow the grower to reduce irrigation volumes to the entire bed by identifying areas that require additional water (through manual application or system design changes).

While difficult to obtain, information on water use/efficiency and degree of recycling is critical to understanding the true impact of container nursery production. This project included several components to aid nursery growers in completing self-assessments, including:

a) Water balance case study at a typical Ontario container nursery.
b) Detailed assessment of overhead irrigation uniformity and efficiency.
c) Development of a factsheet for farmers to assess their own water use efficiency.
d) Overview of automated technology's role in irrigation scheduling.

Methods:

The project scope was an isolated area of three hectares, with limited inputs and the ability to channel all outputs through one point. The test area included twelve open growing beds, thirteen minimal heat coldframes (hoop houses) and a recycle pond.

The water balance study was based on solving the following equation:

Irrigation + Precipitation = Runoff + Change in water content of pots/soil + Evapotranspiration

Flow meters were installed at each irrigation water input line to provide the total volume of water applied to the area per day. The flow meters were linked wirelessly to data loggers and set to collect water flow over 10-minute intervals between September 2 and October 30, 2013. To maximize the runoff collection, an excavator was used to grade and berm around the test area.

Evapotranspiration was measured using an ET-Gage Atmometer (model E), filled with distilled water and connected to a stand-alone HOBO datalogger. Soil moisture probes were used to estimate water content in the pots. One unit was placed in a nursery bed and another placed in a hoop house.

Catch-can tests to determine low quarter distribution uniformity (DUlq) in the cold frames were set up with 20 litre pails spaced three metres apart, in the centre of the bed, 1.5 metres from the sprinkler and lateral, and out to the edges of the bed in the same pattern, for a total of eight pails. Catch-can tests to determine DUlq in the open beds were set up in with 20 litre pails spaced three metres apart, in the centre of the bed, 1.5 metres from the sprinkler and lateral, and out to the edges of the bed in the same pattern, for a total of nine pails.

Results & Conclusions:

The current trend toward cyclic or pulse irrigation suggests that less fertilizer and less water may be required for optimal plant growth than are currently used. More conservative and uniform applications of water and greater nutrient management will improve consistency and canopy growth and result in more marketable, compact plants.

Unfortunately, poor sprinkler distribution uniformity results explain the need and common practice of lengthy irrigation cycles that ensure the entire crop receives adequate water. Some growers will add an extra line of emitters on the west side, some will use nozzles with a heavier droplet size and others will employ some method of pulse irrigation or spot watering in dry areas. Soil moisture measurements will help indicate whether the individual pots are being under or over watered, but the grower needs to decide whether to water according to the needs of the driest pots in the beds, or the wettest.

The question for a grower is whether to irrigate to the level of need in the 'dry' plants in a growing area or irrigate to the need level of the average pot. Container nursery growers usually opt for the former, considering the high value of the crop, the difficulty in re-wetting the media, and the general belief that more water is better than not enough. As water quantity becomes limiting, growers look to recapturing more water, water conservation techniques and precision irrigation for managing water use. The use of evapotranspiration information and soil moisture data can lead to more informed decisions regarding how much, where and when to water, but only after uniformity of application has been achieved. Further, software and service provider support are critical in the access and management of useful information for the volumes of data collected. Future studies to address distribution uniformity, exposure impacts, crop canopy, stage of growth, and media should take place to evaluate the effectiveness of water reaching the root zone in overhead systems.

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"This WRAMI project provided an opportunity to highlight the new and emerging technologies available to container nursery growers today, and provide a realistic insight into how to implement and interpret the data. As new technologies emerge, it is important to understand their great potential as well as their limitations, for the benefit of all farmers."

- Jeanine West

Crop Residue Cover Assessment with a Mobile Technology Application on Ontario Farmland

Introduction:

Soil conservation specialists recommend that farmers maintain at least 30 percent soil cover throughout the year to reduce farmland topsoil and nutrient losses that impact water quality. Available crop residue level measurement methods are labourious and time consuming. Farmers, agricultural specialists and researchers need a reliable, convenient and rapid residue measurement tool. Today's handheld mobile devices are equipped with digital cameras and global positioning systems (GPS). This mobile technology provides an opportunity for crop residue cover assessment using a digital approach.

The goals of the project were to:

- Demonstrate/pilot an innovative mobile application technology that will provide the farmers who manage large portions (~70%) of the province's cropland (i.e. corn, soybean, dry bean, wheat and other grains) with the means to evaluate their crop residue cover easily.
- Increase a farmer's ability to make informed tillage decisions.
- Provide farmers with a convenient means of recording the results of the soil and water conservation practices applied on their farms (crop residue cover after planting).
- Take advantage of mobile computing/communication technologies (tablets, smart phones) that are already being purchased and used by landowners for other farm-related activities, to collect and organize their field level operations.
- Provide opportunities for farmers to collaborate with researchers and government agencies to assess progress concerning on-farm soil and water conservation efforts.

Methods:

The key steps to achieving the project goals were:

- The development of an easy-to-use mobile application to capture images and perform crop residue analysis.
- Testing and calibrating the image analysis algorithm.
- To incorporate the analysis algorithm within a farm management system.

The targeted developing environment for this project was to use a hybrid approach. A hybrid aims to combine the convenience of developing with HTML5, Javascript and CSS with power of native apps access to the device's APIs and sensors. This application will operate in Windows, Android and Apple operating systems.

Features of the crop residue application module include:

- The ability to select photos from local storage or take a photo using a camera application.
- The ability to add and remove feature training points from the images that represent either crop residue or soil background.
- Perform image classification that returns a crop residue coverage interpretation.

- The option of being able to adjust the colour boundary sensitivity to adjust for edge clarification.
- A post processing filter to allow the user to verify that the training points and boundary sensitivity settings are producing appropriate results.

The results of each image classification include the estimated crop residue, GPS location, field name, date and classified image which are currently saved on the device.

The crop residue module has been integrated into a basic farm management mobile application which allows the user to organise their data by farm, fields and residue. Some of the Farm Management application features include:

- Ability to show the field boundaries in a map window.
- Field boundaries may be traced from on-screen imagery or uploaded from Shapefiles.

Results & Conclusions:

A functional prototype has been created. It has demonstrated that mobile devices can perform sophisticated digital crop residue analysis within acceptable performance expectations. The Application has been developed using sample images from corn fields. It will require further field testing and validation for corn and other field crops.

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The application being developed for this project will greatly improve farmers' ability to determine crop residue cover.

Alternative Watering and Surface Water Collection for Cattlemen

Introduction:

The main goal was to provide livestock producers with information on the importance of water conservation and protection and to demonstrate alternative watering systems that can be installed to cope with drought situations. The demonstration was designed to display good sustainable practices for watering livestock.

Darrell Saunders stands in front of a pond that will become an alternative water source for his cattle.

Methods:

To prevent cattle from accessing a creek, a culvert was installed which met specifications of the Grey Sauble Conservation Authority. At both ends of the culvert, large rocks were used to prevent erosion around the culvert and the top of the culvert was covered in gravel for cattle to cross. At the crossing, a pole fence on both sides prevented cattle from getting into the creek and prevented injury if cattle were pushed into the fence. Along the sides of the creek, there were two strands of high tensile electric fence. Around the pond, three strands of high tensile wire were installed. For the fencer, a Solar Powered Gallagher was installed. The unit consisted of two solar panels, one energizer and two car batteries. The batteries are used to store energy for the days when the sun's rays do not reach the station. For water collection, a 30′ x 30′ and 10′ pond was dug. The pond was used to store the water collected from rainfall as well as surface and field tiles. A shore well was placed in the pond, from which the water was pumped to livestock. In the bottom of the shore well was a cloth and gravel filter to ensure clean drinking water for the cattle. The water was pumped from the shore well using a solar powered water pump. When the water trough lost enough water, an electronic float system sent a signal to the pump to add water. To ensure clean drinking water and also as a backup if the pond became dry, a windmill was constructed. The windmill can also be used to pump water from an existing well on the property to fill the pond or the water station if needed. At the watering station, a 16′ x 12′ plot of topsoil was removed. Landscape fabric was used to prevent the gravel from disappearing into the dirt allowing for better drainage. On top of the gravel cement, cattle slats were used to keep livestock from eroding the banks and polluting the water source.

Results & Conclusions:

Upon allowing cattle access to pasture, everything worked as planned. It only took two weeks until the pond was overflowing into the new overflow ditch that was made and fenced. A minor adjustment to the overflow will be made in the spring.

This demonstrative site highlights the best practices in watering cattle at a remote location without hydro using only solar-powered equipment. Cattle can be watered without impairment of water quality to either the pond or adjacent stream.

Upgrades to the pasture such as fencing prevent the cows from entering the nearby creek.

"The Water Resource Adaptation and Management Initiative created the opportunity for the Grey County Cattlemen's Association to undertake a project as a demonstration site showing sustainable grazing of cattle while maintaining surface water quality and utilizing a solar powered watering system. The features of fenced watercourses, a fenced surface water collection pond, a windmill for pond aeration and solar powered fencing and water pumping provide a single site for farmers to view water conservation and livestock watering technologies." ***- Bill Herron***

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Precision Fertigation: Performance Improvement Through the use of Fourier Transform Infrared (FTIR) Spectroscopy for Rapid Nutrient Solution Analysis in Closed Bag Culture

Introduction:

"Our WRAMI project focused on investigating the use of precision fertigation to allow for efficient use and reuse of greenhouse nutrient solution. Without the support from WRAMI this valuable research would not have been possible."

- Leanne Wilson

Hydroponic or bag culture of greenhouse vegetable production in Ontario is usually conducted using rockwool and coco bags. All nutrients are supplied as dissolved nutrients in the irrigation water (Fertigation). The composition, the volume and the timing of fertigation is determined by numerous factors such as the type of plant grown, the stage and size of the plant, the amount of light and the temperature of the growing environment. Greenhouse vegetable growers apply 25 percent more nutrient solution than what is required by the plant. The excess nutrient solution is necessary to maintain the uniformity of the nutrient and moisture profile within the growing media. This solution is collected, analyzed for pH, EC, and nutrient composition and reconstituted with fresh water and fertilizers and reapplied to the crop. Recycling the excess nutrient solution has decreased or minimized the amount of fertilizer wasted.

Nutrient uptake by the plant is influenced by the type of crop grown, the age of the plants and the stage of production, as well as the quantity and supply of the nutrients within the solution. The composition of water supply will influence the fertilizer added to create the final nutrient solution. A poor quality water source (when recycling the nutrient solution) will cause the nutrient solution to become unbalanced sooner (faster accumulation of non-absorbed ions) shortening the lifespan of the nutrient solution, requiring frequent discharge.

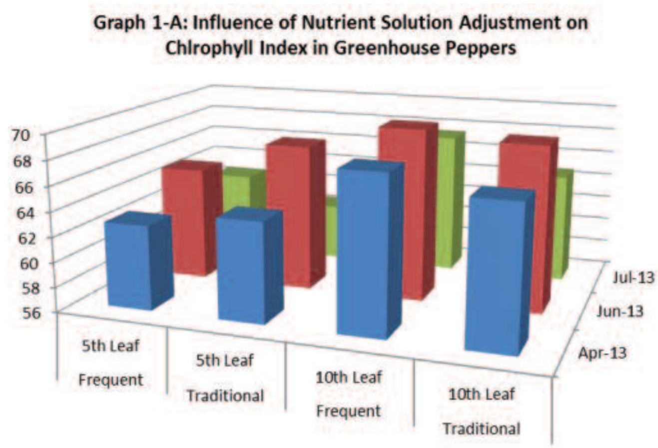
A fundamental problem to decreasing the rate of nutrient solution imbalance is the lack of an on-site, rapid, accurate and inexpensive analyzer that a grower can use with direct linkage to the irrigation system which will allow the nutrient application to be adjusted according to use by the crop. The Harrow Fertigation Manager (HFM©) was designed as a computer controlled fertigation system that allowed a predetermined fertilizer recipe to be applied to the crop as it progressed through the season. The HFM© or similar fertigation system linked with a direct analyzer can apply the fertilizer at a rate the crop is consuming without the need for weekly laboratory analysis. The frequent precise additions will decrease over or under compensation of nutrient levels in the solution, thus decreasing plant stress and allowing the nutrient solution to be used for a longer period before there is a need to discharge the solution.

An innovative option for growers may be the use of Fourier Transform Infra-Red Spectroscopy to rapidly analyze the solution at the greenhouse and allow the grower to apply the correct fertilizer recipe in almost real-time. The suitability and performance of this system was the topic of this study.

Methods:

To find a solution for growers, two studies were designed. In the first study, peppers grown in rockwool were subjected to a nutrient solution application that was adjusted frequently ("frequent" treatment) and this was compared to normal frequency-adjusted solution ("traditional" treatment). In the second study, cluster tomatoes were grown in rockwool and coco and comparisons were made between the frequent and traditional treatments.

In the first study, greenhouse pepper transplants (cultivar Healey) were grown in rockwool bags in six mini greenhouses at the Greenhouse and Processing Crops Research Station in Harrow, Ontario. The pepper plants were planted



This project studied the effects of many factors influencing greenhouse vegetables and how recirculating water and balancing nutrients affected their growth.

January of 2013 and terminated July of 2013. In the second study, the cluster cultivar (Kommeet grafted on Maxifort) was planted October of 2013 in a glass greenhouse equipped with artificial lights. The grafted seedlings were topped at the cotyledon stage to provide two stems per rootstock and were planted in rockwool and coco bags. Plant growth characteristics and yield data was collected in both studies.

For both studies, a complete nutrient solution was applied to the crop as determined by the greenhouse, stage and size of plant, the sunlight and temperature conditions. For the frequent treatment, the nutrient solution was frequently sampled (more than once a week), analyzed, and the results were used to adjust the solution before it was reapplied to the crop. For the traditional treatment, normal testing practices were followed with samples being taken every one or two weeks. Samples were collected, tested and the nutrient solution adjusted as required.

Results & Conclusions:

In the first study using the frequent treatment, pepper plants were shorter and slightly thicker initially, but were taller and thinner at the end of the study. There were no significant differences in the number of flowers, fruits and nodes. Leaf size was not affected by the treatments. Leaf chlorophyll measurements were conducted on the fifth and tenth leaves on three separate occasions. Chlorophyll index of the fifth and tenth leaves increased as the season progressed and then decreased at the end regardless of treatment. Nutrient solution adjustment does not show a significant impact on chlorophyll index.

The frequently adjusted nutrient solution resulted in larger sized fruit than the traditional adjusted nutrient solution grown plants. A similar trend was found when looking at fruit weight. The frequently adjusted nutrient solution had more fruit weight in the larger size categories than the traditional adjusted nutrient solution.

In the second study, plants grown with frequently adjusted nutrient solution were more generative (thinner stem, earlier to flower and had a more open growth habit). Total marketable fruit weight, average cluster size, average fruit weight and total fruit weight was negatively affected by the frequently adjusted nutrient solution treatment. The total number of clusters and the total number of marketable clusters was higher in the frequently adjusted nutrient solution.

Increasing the frequency of nutrient adjustments resulted in an increase in pepper production but a decrease in tomato production. Plant growth characteristics were slightly influenced by the treatment, but this did not correlate to production. The concept of frequent adjustment of the nutrient solution appears to be good in theory but in our study the results did not show an economic return.

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Field Estimation of Drought Resilience for Efficient Row Crop Management

Introduction:

Soil moisture monitoring devices can record more than just water deficit. This penetrometer measures water resistance in the soil profile.

With increasing frequency of extreme weather events associated with climate change, making the connection between soil management, health and moisture availability is essential. In particular, summer droughts can cause devastating declines in field crop yield, quality and can result in significant financial losses to field crop producers. There is an increasing need for Ontario field crop producers to better understand factors contributing to the damaging effects of growing season drought. A critical aspect of drought preparedness is applied research for growers to understand, monitor and improve the drought resilience of their soils under different soil conservation management practices.

A simple way to assist producers in making these connections is through the use of detailed soil coring for the determination of soil water retention curves paired with periodic soil moisture and compaction monitoring to measure plant-available water capacity. The objective of this study was to assess the feasibility (validation of methodology, assess producer uptake potential) of applying innovative soil coring techniques and assessment of soil physical quality (SPQ) parameters paired with periodic soil moisture and compaction monitoring to measure plant-available water capacity. The coring and laboratory analyses could be conducted every five to ten years and soil moisture and resistance monitoring could be measured monthly or bi-monthly, by the producer or local agronomist. The coring will be assessed for its potential as an on-farm tool for row crop producers to track plant stress associated with low soil moisture or drought conditions in a range of soil types and conservation management practices.

Methods:

In the 2013 growing season, ten field sites were selected to represent a wide range of conservation management practices (rotation, tillage, controlled vehicle trafficking), soil types and to ensure maximum geographic dispersion across Ontario. Rotation differences were compared at four sites on which corn or soybeans were grown on a field for at least three years continuously adjacent to a field with a more diverse rotation (most commonly corn-soybeans-wheat). Tillage differences were compared at three sites where a minimum tillage field was adjacent to a conventional tillage field and one location where the co-operator practiced strip tillage. Two controlled vehicle trafficking sites were also included where the trafficked row was compared to an area of the field without traffic.

Intact soil cores (10 cm diameter by 10 cm long) were collected at five to 15 cm (with some additional cores at 15-25 cm at select locations) in the spring and summer of 2013. At each field site a minimum of six cores were obtained (n=6-12) with three cores for each comparison factor. Regular measurements of soil moisture, using a Field Scout time-domain reflectometer, and penetration resistance, using a RIMIK Cone Penetrometer, were collected in 2013. Laboratory analyses of soil cores were conducted by Dr. Dan Reynolds, Agriculture and Agri-Food Canada, Harrow, ON., in the summer and fall of 2013. The SPQ parameters reported include dry bulk density, BD (Mg m^{-3}), organic carbon content, OC (wt. %), air capacity, AC (m^3 m^{-3}), plant-available water capacity, PAWC (m^3 m^{-3}), permanent wilting point, PWP (m^3 m^{-3}), relative field capacity, RFC (-), and saturated hydraulic conductivity, KS (cm s^{-1})

Results & Conclusions:

While many of these parameters are able to provide valuable information on the overall physical soil health of the soils, the major benefit to producers is the ability to track the plant available water over the growing season. Producers can monitor when soil moisture is insufficient to sustain the crop or there is insufficient drainage possibly limiting root zone aeration.

Analysis across conservation management practices and soil types are presented in the final project report but due to the high variability in SPQ measurements and limited replication, few conclusions can be made for soil type influences on soil moisture availability. Management comparisons for SQP were greatest with differences in tillage practices.

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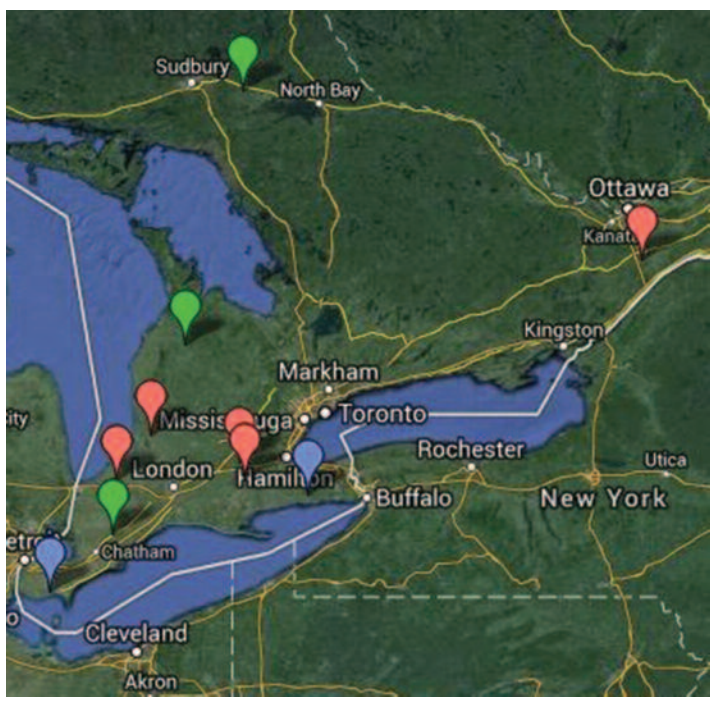
"Developing resilience in soils for both drought and surplus rainfall is essential for long term sustainability. The WRAMI project introduced a new element of science to advance our understanding at the farm level. We hope to continue this important work."

- Harold Rudy, Executive Director, Ontario Soil and Crop Improvement Association



A map of the project sites across Ontario.

Technology-Driven Strategic Water Management for Ontario Potato Producers

Introduction:

This project provided online tools for Ontario potato growers with the goal of promoting more sustainable and efficient use of water on farms. Weather data was collected through a network of automated observation stations and presented along with analysis and advisories through Weather Innovations' website, *www.ONpotatoes.ca*.

The collection of an entire season's weather data provides opportunities for an analysis of the weather factors over the season in Ontario's potato-growing regions. Graphical interpretations of the data and discussion were provided to growers to illustrate the weather conditions that shaped this year's potato season.

Methods:

One of the key outputs of this project was the online toolkit of weather information and agronomic calculations, delivered through the website, *www.ONpotatoes.ca*. Tools are openly available to all visitors to the website, thanks to the funding received from WRAMI and the support of sponsor Syngenta Canada.

ONpotatoes.ca utilized 11 weather monitoring locations managed by WIN. The locations were selected to cover the major potato-growing regions of the Province. For each location, weather data was collected, analyzed, and provided to growers through the website in the forms of interactive maps, graphs and charts.

This project included the purchase of soil moisture and weather monitoring equipment for four locations on Ontario potato farms, to demonstrate their integration with irrigation scheduling.

Results & Conclusions:

This project's deliverables comprised an array of enhancements to the website, moving the *ONpotatoes.ca* program forward to include:

- Mobile-friendly programming and user interface.
- Additional points in Ontario of weather data and interpretation.
- Prototyping of a late blight advisory model.

In terms of extending the website's reach to growers, the project proved very successful. 2013 was the second operational season for ONpotatoes.ca. It was launched in 2012 through research collaboration between the Ontario Potato Board and Weather INnovations Consulting LP (WIN). The improvements made through the support of the WRAMI program contributed to a 45 percent increase in traffic to the website during the main growing season (May 1 to September 1). Enhancements for next season are currently in development, such as the capability for users to register an account and save their site-specific field locations and calculations, and the addition of a radar-based precipitation estimation tool.

Given the wet conditions during the 2013 growing season, the project team is satisfied with the results of this initiative to assist in educating producers on the benefits of technologically-enhanced production management on Ontario potato farms.

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No Spray - Winds too Low | Poor | Fair | Good | No Spray - Winds too High

Arrows point to the direction the wind is going (e.g. wind is coming from S and moving N)

Friday

	a.m.												p.m.											
Hour	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Fine	FAIR			FAIR			NO SPRAY			POOR			POOR			POOR			POOR			FAIR		
Medium	GOOD			GOOD			NO SPRAY			FAIR			FAIR			FAIR			FAIR			GOOD		
Coarse	GOOD			GOOD			NO SPRAY			GOOD			GOOD			GOOD			GOOD			GOOD		
Wind Speed (km/h)	6	6	6	5	4	3	2	2	1	7	10	11	13	14	15	15	15	13	9	6	6	5	5	5
Wind Direction																								
Precip (mm)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Temp (°C)	4	4	3	3	3	3	3	4	7	10	12	13	14	14	14	14	14	14	12	11	10	9	8	8

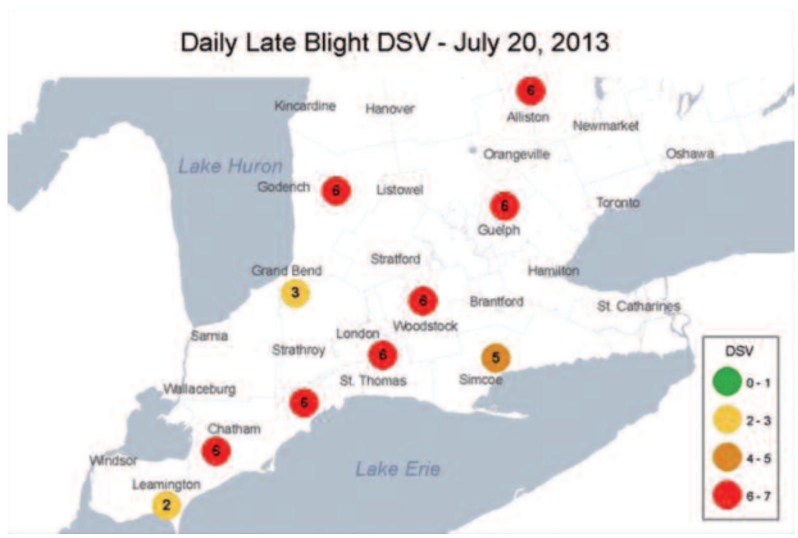
Saturday

	a.m.												p.m.											
Hour	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Fine	FAIR			FAIR			FAIR			POOR			POOR			POOR			POOR			POOR		
Medium	GOOD			GOOD			GOOD			FAIR			FAIR			FAIR			FAIR			FAIR		
Coarse	GOOD			GOOD			GOOD			GOOD			GOOD			GOOD			GOOD			GOOD		
Wind Speed (km/h)	4	5	5	5	6	6	5	5	4	3	4	7	10	13	14	14	13	12	9	7	7	8	8	8
Wind Direction																								
Precip (mm)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Temp (°C)	7	7	7	7	7	7	7	7	10	13	14	15	16	16	16	16	15	15	13	12	11	11	11	10

Sunday

	a.m.												p.m.											
Hour	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Fine	POOR			POOR			POOR			NO SPRAY			NO SPRAY			NO SPRAY			NO SPRAY			NO SPRAY		
Medium	FAIR			FAIR			FAIR			NO SPRAY			NO SPRAY			NO SPRAY			NO SPRAY			NO SPRAY		
Coarse	GOOD			GOOD			GOOD			NO SPRAY			NO SPRAY			NO SPRAY			NO SPRAY			NO SPRAY		
Wind Speed (km/h)	7	7	7	7	6	6	6	7	8	16	19	20	23	23	22	22	22	21	21	18	19	19	20	20
Wind Direction																								
Precip (mm)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Temp (°C)	10	10	10	10	10	9	9	9	12	16	17	17	18	18	18	18	18	18	17	15	15	16	16	17

SprayCast is a tool developed by Weather Innovations Inc. to inform potato growers when to spray their crop to maximize effectiveness and improve yield.



The websites used in this project feature useful tools and information for Ontario potato growers such as this late blight advisory.

An Online Platform for Sustainable Water Management for Ontario Sod Producers

Introduction:

This monitoring station gathers rainfall, soil moisture and temperature data.

From 2001 to 2007, the acreage of sod farms in Ontario increased by 26 percent to 36,000 acres. A survey conducted with funding from the Ontario Turfgrass Research Foundation found that one of the most commonly stated obstacles for further expansion of sod farms was water use policies and the cost of water. In 2007, irrigation was used on 24.9 percent of the typical farm. The primary source for irrigation is ponds followed by wells, lakes, rivers, reclaimed water sources, and waste water (Tsiplova et. Al, 2008).

The goal of this project was to create a sod-specific online platform for weather monitoring where participants can access data in near-real-time to monitor conditions remotely on their fields. This was provided by the website www.turfmonitor.com. Users can view weather conditions and rainfall-dependent models of crop water demand and soil water balance. The website also provides access to geospatially-gridded weather forecasting and radar data.

Project Objectives:

1. Deploy and evaluate a network of automated environmental monitoring equipment, in three different station configurations, on Nursery Sod Growers Association of Ontario member farms.
2. Develop and promote a website of weather, irrigation and agronomic tools customized for sod growers.
3. Collect benchmark data of water-related parameters in sod production.
4. Launch an outreach campaign to sod growers and the general public to highlight the efforts WRAMI is making through this project to improve sustainable water use in agriculture.
5. Attract corporate sponsor(s) to allow continuation and/or expansion of the program.

Methods:

A network of automated monitoring equipment was installed. Three different configurations were used. The first is a "full" weather station measuring rainfall and irrigation, wind speed, temperature, relative humidity and solar radiation, as well as soil moisture at 10cm, 20cm and 30cm depths. The second type of station is a "Rain and Soil Moisture" station measuring rainfall, irrigation, and soil moisture at 10cm, 20cm, and 30cm. The final station type is a "rain only" station.

A website to divulge the information recorded by weather stations and probes was created and available to both the public and growers (growers have unique access options).

Results & Conclusions:

Soil moisture, evapotranspiration, temperature and radar were recorded in depth. The information from weather stations and soil probes was made available to growers online at www.turfmonitor.com.

Soil moisture: Diurnal fluctuations indicate that the soil moisture increases in the morning as the surface temperature warms until a certain maximum point, at which point the soil moisture begins to drop as the temperature cools. When the sod is using moisture from the soil, the fluctuations in soil moisture will be opposite those of diurnal fluctuations, and the soil trend will show a downward slope indicating a net loss of moisture. For sod growers, it seems advantageous to use the website to watch as the fluctuations change from diurnal to crop water use. It is at this point that the growers should closely monitor their evapotranspiration loss and the forecast to see when irrigation will be necessary.

Evapotranspiration: Evapotranspiration estimation is another very useful tool in helping growers to make decisions about efficient irrigation. Ideally, the amount of evapotranspiration lost will match the amount of water gained by rainfall and irrigation to create a balanced water budget for the sod.

Temperature: The graphical view the website provides is useful for sod growers as it is a tool that can be used to help visualize the conditions on their field and how they compare to normal years. Graphs easily help the grower identify periods which may be warmer or cooler, drier or more wet than normal and become a powerful tool to help the grower make irrigation decisions accordingly.

Radar: Under the radar section on the website, users can compare the amount of rain that their rain gauge measured to the amount of rain that the radar predicted it would receive. Since sod growers know that radar is not always a perfect match to rainfall, showing that it can be up to 80-98% accurate should be a promising incentive to use it as a tool.

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Use of Ground Covers and Remote Soil Moisture Monitoring Equipment to Maximize Water Use Efficiency in Peach Orchards

Introduction:

Ground covers such as woodchips and mushroom compost were used to determine their effectiveness in retaining moisture for peach trees.

This project featured two objectives:

1. Document the effectiveness of ground covers (mushroom compost, wood chips) in maintaining soil moisture and minimizing irrigation water inputs in a commercial peach orchard.
2. Evaluate soil moisture monitoring equipment and irrigation decision-making software to simplify irrigation application decisions to improve water use efficiency in a commercial peach orchard.

Methods:

Trials were established at an established peach orchard at the University of Guelph's Cedar Springs Research Station. The orchard contains the processing variety "Virgil", and was planted in 2006 at row spacings of 4.3 m and in-row spacings of 3.0 m, which gives a tree population of 768 trees/ha. The site contains a Fox Gravelly Loam soil (47.8 percent sand, 38.1 percent silt and 14.1 percent clay), which has a high gravel content and requires constant irrigation to maintain adequate soil moisture.

The existing drip irrigation system was modified to accommodate the trial. Treatments included irrigated and non-irrigated plots, which were superimposed with mulch treatments of wood chips, spent mushroom compost and no mulch. The irrigation system consisted of 4.5 litre/hour emitters spaced a metre apart.

Soil moisture and temperature monitoring equipment was installed by Weather Innovations Inc. and data was collected from May 22 to November 18, 2013. Sensors were placed 30 cm below the soil surface. Field capacity of this soil was calculated to be 26.01 percent, and irrigation treatments would be initiated when the soil moisture in an individual treatment reached 75 percent of field capacity or 19.51 percent.

The trees were harvested repeatedly as the fruit grew. This occurred on August 15, 21 and 28. At harvest, the fruit was size graded into the following categories:

Large: diameter greater than 7.0 cm (2 ¾ inches)

Medium: diameter less than 7.0 cm (2 ¾ inches) but greater than 5.4 cm (2 1/8 inches)

Small: diameter less than 5.4 cm (2 1/8″)

Total weight and fruit numbers for each category were recorded. Fruit pressure (using a 5/16 inches plunger) was taken at two locations from ten randomly selected large fruits per plot.

The experimental design was a randomized complete block split-plot design with irrigation as the main plots and ground cover as sub plots. An experimental unit was three trees. Two trees were included as buffers between irrigation and mulch treatments. Treatments were replicated at least four times during the trial.

Results & Conclusions:

Due to adequate rainfall throughout the 2013 growing season, the soil moisture did not reach a level where the irrigation would need to be turned on. As a result, irrigated and non-irrigated treatments were combined within each mulch treatment, and essentially the trial became solely focused on evaluating the impact of mulch treatments on peach productivity.

Mulch treatment had an effect on the proportion of large and medium sized fruit. The tonnage of large fruit was doubled when spent mushroom compost was applied, but medium size fruit was reduced with the same treatment. Fruit size tended to be larger using the mushroom compost treatment, but this difference was not statistically significant. Compost type had no effect on the amount of sugar in the fruit at harvest (oBrix), but the fruit was firmer when mushroom compost was used.

When averaged across the entire period that soil moisture was recorded, wood chips maintained higher soil moisture and mushroom compost resulted in drier soil. This trend was noted during shorter periods in the summer. It is assumed that when the crust of the mushroom compost dries, it "sheds" water. Similar effects have been noted using peat as a ground cover. Drip irrigation would alleviate this issue if soil moisture levels become too low.

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"The WRAMI project allowed us to assess practical methods of maintaining soil moisture while reducing water use on the farm."
- John Zandstra

Evaluation of Pathogen Removal by DE Nitrification Bioreactors and Constructed Wetlands Under Ontario Conditions to Promote Water Reuse and Good Management

Introduction:

The objective of this WRAMI project was to conduct an in-field evaluation of the ability of established bioreactors and wetlands to remove plant pathogens and/or human enteric pathogen indicator organisms from agricultural wastewaters and runoff, and correlate effectiveness with parameters affecting pathogen removal performance (e.g. media, residence time, temperature, oxygen, pH, depth). The information is needed to support the design of on and off-site systems that will consistently remove plant and enteric pathogens from agricultural runoff and wastewaters in order to facilitate its reuse and protect surface and ground water resources from contamination. Given sufficient information on parameters controlling performance, they could be designed for the dual roles of removing nutrients and other agri-chemicals and pathogens.

This treatment pond breaks down and removes harmful pathogens from livestock truck washwater.

Methods:

Site selection included six constructed wetlands (three targeting the examination of plant pathogen removal capability and three for enteric microorganisms), five woodchip bioreactors (two targeting plant pathogens and two for enteric microorganisms) and one hybrid constructed wetland-woodchip bioreactor (plant pathogens).

Water sampling programs were established and samples were taken from the inlet and outlet of each system; where multiple sampling locations were possible at a single treatment system, intermediate stages were sampled as well.

Samples were immediately analyzed for indicators of either enteric or plant pathogens, as required. E.coli and Total Coliforms were enumerated using either the 3M Petrifilm method or mFC plate count agar for high and low levels of organisms, respectively. Yeast and Mold counts (3M Petrifilm™ method) were used as a surrogate for plant pathogens for routine analysis. Samples were periodically sent to the University of Guelph Laboratory Services Division for DNA multiscan for the detection of specific fungal plant pathogens.

Samples were also submitted for analysis of a standard suite of nutrients (greenhouse solution: pH, total salts, NO_3-N, NH_4-N, TP, K, Ca, Mg, bicarbonate, chloride, sulphate, Na, Zn, Mg, Cu, Zn, Fe, B, Mo, and Si) on a monthly basis. This suite of parameters was chosen because each is significant for irrigation water quality in the greenhouse industry

Results & Conclusions:

In general, for constructed wetlands, residence time (as calculated by flow rate, treatment system size, and estimated void volume) is important for removal of microbial contaminants and NO_3-N. For the systems with consistent flow rates, correlations cannot be done within the system. Between systems, only CWR-1&3 had a significantly lower residence time than the rest (and did not remove nutrients but did remove some microbial contaminants). Temperature correlations were not strong for a number of reasons: relatively insulated systems (size, in-ground) and/or data not available for cold periods for most systems. For the wetland systems, the pH values remained within a fairly narrow range and therefore no correlations could be made with nutrient or microbial removal rates.

For DE nitrification bioreactors, residence time is likely important for the removal of microbial contaminants, but there is insufficient data in this study to determine what the residence time needs to be to achieve a desired level of pathogen removal. Because these are biological systems, temperature and redox potential will strongly interact with residence time to achieve good treatment. Temperature strongly affects NO_3-N removal rates, but this was only shown for one system where over-winter data was available. Anaerobic conditions are of course a requirement for DE nitrification. Phosphorus removal tended to be correlated with higher pH values where there was a sufficient pH range.

Monitoring of several accessible systems should be conducted for another season, including during colder months to improve the data set and correlations. Continuous temperature recording devices installed within the systems would improve the data set

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"The demonstration of effective, low-cost treatment systems that can remove pathogens as well as nutrients from agricultural runoff and wastewaters is necessary to facilitate its reuse and/or protect surface and ground water resources from contamination." ***- Ann Huber***

This constructed wetland removes 99.9 percent of E. coli from livestock truck wash water.

Increasing Preparedness to Manage Low and Excess Water Conditions for Non-Irrigated Field Crop Production

Introduction:

This planter has a prescribed map designed for this field to apply corn seeds in a way that will maximize yield potential: More seeds in the dips and less on the knolls.

The purpose of this project was to develop strategies for field crop production that mitigate both low and excessive water conditions. In excessive water conditions, site-specific nutrient management can help to mitigate the risk of leaching nutrients into ground water or into neighbouring water bodies leading to reduced water quality and lost crop productivity potential. Identifying variable soil texture and moisture conditions across a field using site-specific seeding strategies can improve crop production during low water stress conditions.

Site-specific nitrogen management in corn to reduce the potential of N leaching and site-specific population strategy to improve water use efficiency and address soil moisture field variation effectively

This project characterized the spatial variability of the field to be able to site-specifically adjust the management strategies required for optimal grain production during adverse weather conditions. Several factors influence optimal seeding rates across a field such as varying texture, soil moisture holding capacity, slope and organic matter. Not all agricultural fields or even portions of fields have the same economically optimal plant density. Similarly, nitrogen (N) requirements across a field can vary considerably for very similar reasons. Successful variable rate nitrogen strategies for corn need to be carefully customized to fit local soil, climate and agronomic considerations.

Hybrid mixing strategies to improve drought mitigation by increasing pollen supply and duration of pollen shed through hybrid mixing to overcome detrimental effects of dry weather during the relatively short pollination window.

Climate change may lead to greater variability in precipitation (timing, duration, volume, intensity) which may result in a greater incidence of drought during growing seasons. For corn, reproductive timing is well recognized as a critical period for yield loss due to low moisture stress (Shaw and Newman). One theory to extend pollen shed would be to mix the field (i.e. mixed seed or rows) with a small portion of a later-maturing hybrid which would take longer to reach pollen shed. The attractiveness of planting mixed-maturity hybrids as an insurance option is that it is a simple and low-cost practice that could be readily adopted by any corn producer.

Methods:

1. Site-specific nitrogen management in corn to reduce the potential of N leaching:
   - Location: Oxford County/ Waterloo Region border, near village of Washington
   - Tillage: reduced tillage system.
   - Crop rotation: corn/soybeans/wheat
   - Starter N: 23 kilograms

One year of yield data and elevation were limiting factors. Zones were created based on elevation data and the soil was sampled (i.e. fertility and surface texture composite across each zone). A new Nitrogen Potential Assessment (Brookside Laboratories) test was also done for each sample/zone. Using the farmer's yield goal (200-210 bushels per acre) and Nitrogen Potential Assessment, a prescription map was created by Premier Equipment for the field's nitrogen requirements.

2. Site-specific corn population strategy to improve water use efficiency and address soil moisture field variation effectively:
   - Location: Oxford County, near Woodstock.
   - Tillage: no till or reduced till.
   - Crop rotation: corn/soybeans/wheat and some edible beans.

In this case, all corn yield years (1998, 2000, 2002, 2005, 2007, 2010) were normalized (against the mean in a given year) to create a multi-temporal management zone map. A population prescription map for the field was designed for three yield zones: low, medium and high. A higher population was put in zones where the zone consistently produced a high yield over time and vice versa for the consistently low yielding zones over the six historical corn years. Low yield zones were prescribed a plant population of 32,000 seeds per acre, 36,000 seeds per acre and 40,000 seeds per acre. Fixed rate strips were placed down the length of the field to address all management zones so yield response analysis could be completed between the conventional and variable rate population approach.

3. Hybrid mixing strategies to improve drought mitigation by increasing pollen supply and duration of pollen shed through hybrid mixing to overcome detrimental effects of dry weather during the relatively short pollination window.

Three locations were established in 2013 to investigate tassel and silk emergence timing, grain yield and grain moisture in response to including a later maturing hybrid mixed within a standard maturity field. Treatments at each location included a standard maturity hybrid, a standard maturity hybrid mixed with 25 percent of a 50-100 later CHU hybrid, and a later-only hybrid. Each treatment was replicated at least twice at each location.

Results & Conclusions:

Each of the precision agriculture strategies tested showed incremental benefits relevant to the co-operators' objectives in many parts of the field. These benefits are both economic and environmental. By further developing processes to efficiently and objectively analyze precision agriculture datasets we will be better able to identify where synergies may be achieved through the use of more than one approach (e.g. future opportunities to combine variable rate fertilizer and population strategies where they make sense in that field). Depending on the co-operators' goal(s), precision agriculture strategies may be able to increase yield in areas that typically do not outperform the standard. However, achieving that goal in a specific management zone is still very dependent on the growing season conditions and the precision agriculture variable (i.e. fertilizer, seed, chemical) that is being manipulated. This work only shows one growing season, one year of spatial data analysis, and one commodity. Future work should consider more crops and additional years of data collection with varying growing season conditions to better define the overall trends and the approach for each field.

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This unmanned aerial system (UAS) has a camera that can precisely determine the heat of the plants.

"Increased water efficiency in crop production is critical to the future of Ontario agriculture. The opportunity for industry to partner with Oxford Soil and Crop Improvement Association, producer cooperators and OMAF staff to evaluate new cropping strategies and precision agriculture technologies, in real world conditions has been invaluable."

- Greg Kitching, Integrated Solutions Consultant, Premier Equipment Ltd.

The Evaluation of Soil Moisture Monitoring Devices in Tender Fruit Orchards in Ontario

Introduction:

Soil moisture information is recorded periodically to ensure the crops receive the water they need to grow to their potential.

The objective of this project was to provide growers with information regarding the accuracy, cost and ease of use of different types of soil moisture monitoring devices used in various soil types and growing regions.

Methods:

A total of seven tree fruit orchards were monitored daily throughout the season to record soil moisture levels. Orchards included Kingsville (apples, sandy soil, drip irrigation), Ridgetown (peaches, sandy soil, drip irrigation), Renton (pears, clay soil, drip irrigation), Simcoe (apples, loam soil, drip irrigation), Niagara-on-the Lake (peaches, sandy loam soil, overhead irrigation), Beamsville (nectarines, clay loam soil, drip irrigation) and Grafton (apples, loam soil, drip irrigation). A variety of soil moisture testing devices was evaluated at each site including tensiometers, Time Domain Reflectometry sensors (TDR) (Gro-Point) and capacitance based sensors (Decagon EC 5). Probes were buried in soil at 30cm (12 in.) and 61cm (24 in.) depth at each site. Probes were evaluated based upon accuracy, ease of use, longevity and cost. A capacitance profile probe (EnviroSMART) provided by Weather Innovation Network (WIN) was evaluated at a two sites. At two sites, Decagon EC 5 probes were automated to the FruitTracker system to allow growers to access real-time soil moisture data online.

Results & Conclusions:

The 2013 growing season had considerable rain, so only two of the seven sites used irrigation. Due to delays in getting the equipment from suppliers, we were not able to have some of the sites operational until middle to late summer. As a result we will be continuing the project in 2014, which will allow us to collect more data.

From the data that we were able to collect, we noted that the various soil moisture probes provided considerably different numerical results with respect to soil moisture levels. However similar trends (highs and lows) were observed at each site using different probes. In sandy soil sites there were fewer differences in soil moisture readings between the 30cm and 61cm probes.

There were differences in the range of soil moisture levels in different orchards throughout the season. Soil moisture levels ranged from 15.1 percent to 22.8 percent in a sandy soil site to a clay site in which moisture levels ranged from 21.5 percent to 40.1 percent.

Ideal irrigation application timings were calculated to acquire a better understanding of when the growers should be irrigating based on soil moisture levels in their vineyard.

Only two of the seven sites used irrigation in 2013. However the data we collected suggests that irrigation may have been beneficial in six of the seven sites. The data collected indicated that at four of the seven sites, additional irrigation may have benefitted the crop. In three additional sites the trigger to irrigate occurred late in the season and as a result growers may have decided not to irrigate due to the proximity to harvest, or because the crop had already been harvested and the benefits of irrigating would be minimal.

Rebecca Shortt, Water Engineer with OMAF, conducts an interview regarding this project and its importance for irrigators of tender fruit in Ontario.

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With Thanks

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nsga Nursery Sod Growers Association of Ontario
SRG Soil Resource Group
Ontario Tenderfruit Producers marketing board
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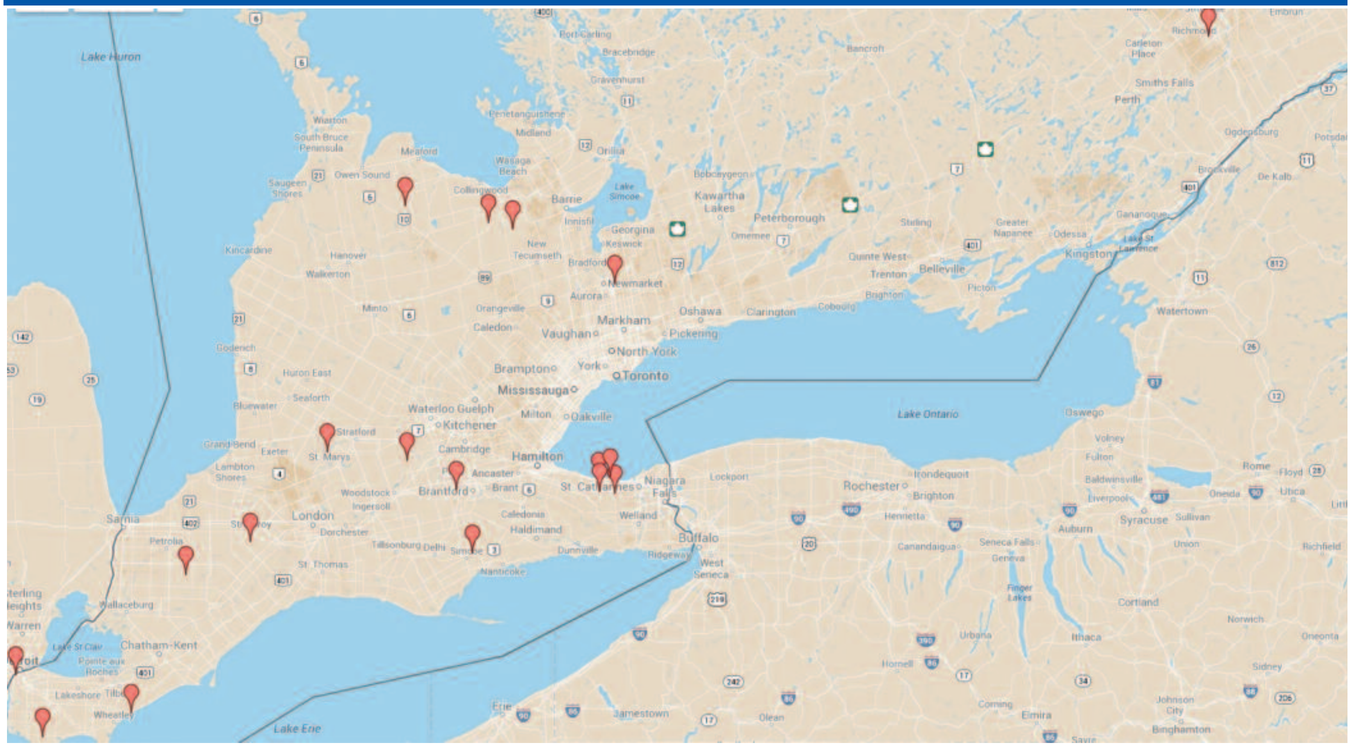
WRAMI project locations



For the purpose of this report, only one location has been chosen for each of the 17 WRAMI projects.
For a full list of project locations and more information, visit the Environment button at www.farmfoodcare.org

The Water Resource Adaptation
and Management Initiative