Great Lakes Fruit, Vegetable & Farm Market EXPO

Michigan Greenhouse Growers EXPO

December 9 - 11, 2014

DeVos Place Convention Center, Grand Rapids, MI

Potato

Tuesday afternoon 2:00 pm

Where: Gallery Overlook (upper level) Room C & D

MI Recertification credits: 2 (1B, COMM CORE, PRIV CORE)
OH Recertification credits: 1 (presentations as marked)
CCA Credits: PM(1.5)

Moderator: Fred Springborn, Field and Vegetable Crops Educator, MSU Extension, Stanton, MI

2:00 pm Using the Entire Insecticide Toolbox for Colorado Potato Beetle: Planning A Three Year Resistance Management Program in Potato (OH: 2B, 0.5 hr)

- Anders Huseth, Entomology Dept., North Carolina State University

2:30 pm Enviro Weather Tools for Potato Growers

- Beth Bishop, Enviro-weather Coordinator, Entomology Dept., MSU

3:00 pm Potato Pathology Update (OH: 2B, 0.5 hr)

- William Kirk, Plant, Soil and Microbial Sciences Dept., MSU

3:30 pm Session Ends

Using the Entire Insecticide Toolbox for Colorado Potato Beetle: Planning a Three-Year Resistance Management Program in Potato

Anders S. Huseth[1], Russell L. Groves[2], and Brian A. Nault[3]

[1]Department of Entomology, North Carolina State University, Raleigh, NC email: ashuseth@ncsu.edu
[2]Department of Entomology, University of Wisconsin, Madison, WI email: groves@entomology.wisc.edu
[3]Department of Entomology, Cornell University, Geneva, NY email: ban6@cornell.edu

Introduction Colorado potato beetle (*Leptinotarsa decemlineata*, Say) insecticide resistance management plans in commercial potato are one critical component to effective potato pest management in the Great Lakes production region. For the past two decades, neonicotinoid insecticides (IRAC MoA Group 4A, http://www.irac-online.org) have been the primary tool for early-season pest management in potato. These at-plant, systemic neonicotinoid applications provide effective control of early-season potato pests (e.g., Colorado potato beetle; potato leafhopper, *Empoasca fabae*; colonizing aphids). Reliable pest control with neonicotinoids led to widespread adoption of this technology throughout the region and, as a result of long-term use, insecticide resistance has become an issue in several Colorado potato beetle populations (Szendrei et al., 2012; Huseth et al. 2013). Although field-level failures of neonicotinoids are uncommon, growers are likely experiencing a decline in the duration of control provided by these insecticides (Fig. 1; Huseth and Groves 2013). Loss of control over time can result in additional foliar insecticide applications for Colorado potato beetle and increase the season-long insecticide inputs and overall environmental impact of the pest management program (Huseth et al. 2014).

While neonicotinoid insecticides remain the most common chemical control strategy to manage Colorado potato beetle, several other conventional insecticides belonging to other Mode of Action classes can also provide excellent control (Table 1). Incorporation of newer, more reduced-risk neonicotinoid insecticide alternatives into the Colorado potato beetle insecticide toolbox can be an effective strategy to slow resistance development and limit additional insecticide use (Huseth et al. 2014). Since Colorado potato beetle is an annual pest in the potato production system, planning insecticide rotations in advance can be a very effective way to reduce selection pressure for insecticide resistance in potato. This article provides some recommendations for season-long resistance management plans that incorporate newer conventional insecticides to reduce reliance on at-plant neonicotinoids. Furthermore, these suggestions develop strategies to manage this pest in fresh-market (e.g., reds, heirlooms) potato production that may require a shorter interval of protection.

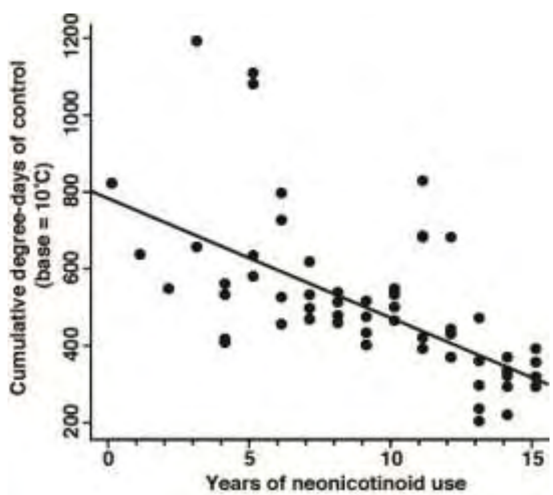

Figure 1. Duration of Colorado potato beetle control since registration of neonicotinoid insecticides in 1995 (i.e., year zero). Cumulative degree-days of control represent the period of time from at-plant neonicotinoid application until first foliar application for CPB control. Cumulative degree-days were calculated as summed growing degree-days where GDD = [(Temp$_{max}$-Temp$_{min}$)/2]-Temp$_{base}$.

Building a multi-year resistance management plan

Resistance management plans presented here are designed to limit exposure of Colorado potato beetle populations to neonicotinoid insecticides. Each rotation plan assumes a two-generation Colorado potato beetle population common to the Great Lakes region. Suggested insecticides target larval growth stages of the insect life cycle (Fig. 2). The growing season has been divided into three different treatment windows, early generation, late generation, and spring trap crop (i.e., attract and kill colonizing adults outside main crop). In areas where only a single generation occurs each season, farmers may only need a single MoA to control Colorado potato beetle larvae. All insecticides included have the greatest efficacy on small larvae. However, one insecticide (i.e., novaluron, IRAC MoA group 15 – benzoylureas) has effects on several life stages including reduced female fertility, reduced egg survival, and molting disruption in larvae (Cutler et al. 2005, Alyokhin 2009). Novaluron is most effective when applied during the early treatment window. The current label for novaluron permits a series of three applications each season. Growers can take advantage of its activity on multiple Colorado potato beetle life stages by splitting the full season rate over three sprays beginning at 50% egg deposition and continuing the second and third applications at 7 day intervals during the early generation treatment window.

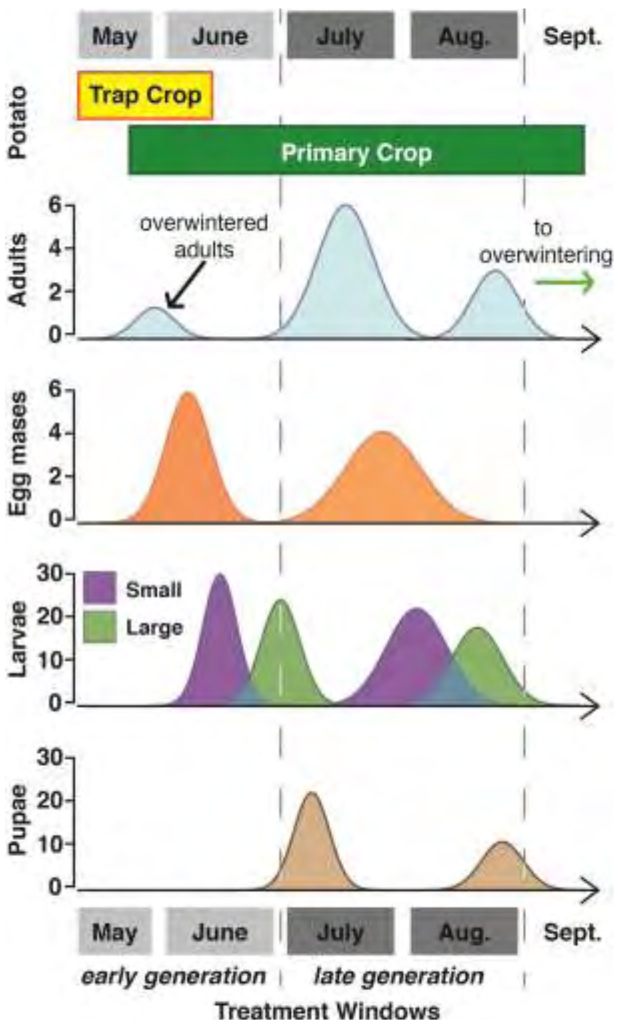

Figure 2. Insecticide application treatment windows for CPB larvae. Demographic curves represent a hypothetical pattern of life stages in commercial potato during an average growing season. Vertical axes show an average life stage count per ten plants. The light grey treatment window represents early CPB generations, dark grey is the late generation window, and yellow is the autumn trap crop window.

Multiple-season Colorado potato beetle management plans are designed to limit exposure to MoA groups over consecutive generations. Here, populations are exposed to a given MoA group once every three to six generations (Fig. 4). Decisions on specific programs should be based on a reasonable estimate of neonicotinoid resistance observed or measured in potato fields. Presented are several different scenarios that are adapted to potato maturity, choice of application approach and the degree of field-level neonicotinoid insensitivity (Fig. 4, Table 2). For long-maturing cultivars, program options A-D and E-G are listed in descending order of neonicotinoid insensitivity. Option A and E would be selected for a population that is becoming less controllable with neonicotinoids, whereas Option D and G would be chosen for a population in which neonicotinoids are still very effective. For short-maturity cultivars, Option H would only need to target the early generation each year. Option H would also be very suitable for regions with only a single Colorado potato beetle generation per year, although timing of applications should be adjusted to coincide with presence of small larvae in the crop.

All foliar-applied compounds should be applied as a series of two, successive applications spaced 7-10 days apart to improve control of staggered life stages (e.g., eggs in development that will hatch over an interval of several days). Moreover, several RR compounds require specific spray tank conditions (e.g., pH of water source), companion adjuvants, and timing with vulnerable young larvae (e.g., first and second instar). Moreover, several of these compounds (e.g., diamides or spinosyns) may have less activity on other key potato pests (e.g., potato leafhopper and colonizing aphids); scouting and economic thresholds for secondary pests will remain a critical component of weekly field management activities. Although neonicotinoids have been the most common tactic to manage early-season piercing-sucking pests, a diversity of other MoA groups can be used to control these pests in potato. These alternate MoA groups should be incorporated as a replacement for at-plant neonicotinoids to minimize further selection for Colorado potato beetle neonicotinoid resistance through incidental exposure. The decision to apply any insecticide (except prophylactic, at-plant applications) should be completed for each field based on scouting results and established economic damage observed in that individual management unit. Reference individual product label specific for reentry and preharvest intervals (REI and PHI). Insecticides included represent formulations that are commonly available. Other active ingredient formulations may be labeled for these uses, and it is appropriate to consult individual state recommendations for a comprehensive list of registrations.

Specific information about insecticide formulation is a critical component of resistance management. The diversity of formulations for individual MoA groups and blends of MoA groups presents a challenge for resistance management (Table 1); therefore, the product label should always be consulted for specific information on resistance management and active ingredients in the formulation. For more information about Colorado potato beetle generation number in specific geographic regions, scouting procedures, application rates, reapplication intervals, preharvest intervals, and other recommendations consult respective state management guidelines.

Alyokhin, A., R. Guillemette, and R. Choban. 2009. Stimulatory and suppressive effects of novaluron on the Colorado potato beetle reproduction. Journal of Economic Entomology. 102: 2078-2083.

Cutler, C., G., C. D. Scott-Dupree, J. H. Tolman, and C. Harris. 2005. Acute and sublethal toxicity of novaluron, a novel chitin synthesis inhibitor, to *Leptinotarsa decemlineata* (Coleoptera: Chrysomelidae). Pest Management Science. 61:1060-1068.

Huseth, A. S., and R. L. Groves. 2013. Effect of insecticide management history on emergence phenology and neonicotinoid resistance in *Leptinotarsa decemlineata* (Coleoptera: Chrysomelidae). Journal of Economic Entomology. 106: 2491-2505.

Huseth, A. S., R. L. Groves, S. A. Chapman, A. Alyokhin, T. P. Kuhar, I. V. Macrae, Z. Szendrei, and B. A. Nault. 2014. Managing Colorado potato beetle insecticide resistance: new tools and strategies for the next decade of pest control in potato. Journal of Integrated Pest Management. DOI: http://dx.doi.org/10.1603/IPM14009

Szendrei, Z., E. Grafius, A. Byrne, and A. Ziegler. 2012. Resistance to neonicotinoid insecticides in field populations of the Colorado potato beetle (Coleoptera: Chrysomelidae). Pest Management Science. 68: 941-946.

Table 1. Registered products to manage Colorado potato beetle larvae.

Treatment window	Active ingredient	IRAC MoA group	Delivery[a]	Common trade names
early generation	abamectin	6	F	Agri-Mek®, generics
	chlorantraniliprole	28	F	Coragen®
	cyantraniliprole	28	F, IF	Exirel®, Verimark®
	imidacloprid	4A	IF, ST	Admire® Pro, generics
	novaluron	15	F	Rimon®
	spinetoram	5	F	Radiant®
	spinosad	5	F	Blackhawk™, Entrust®
	thiamethoxam	4A	IF, ST	Platinum®, Cruiser Maxx® Potato
late generation	abamectin	6	F	Agri-Mek®, generics
	chlorantraniliprole	28	F	Coragen®, Voliam Xpress®[b]
	cyantraniliprole	28	F	Exirel®
	imidacloprid	4A	F	Admire® Pro, generics
	indoxacarb	22A	F	Avaunt®
	spinetoram	5	F	Radiant®
	spinosad	5	F	Blackhawk™, Entrust®
	thiamethoxam	4A	IF, ST	Actara®, Endigo® ZC[c]
	tolfenpyrad	21B	F	Torac™
trap crop	indoxacarb	22A	F	Avaunt®

[a]Foliar (F), In-furrow (IF), and Seed treatment (ST).
[b]Contains lambda-cyhalothrin, use when potato leafhopper and CPB are at threshold.
[c]Contains cyfluthrin, use when potato leafhopper and CPB are at threshold.

Table 2. Three-year Colorado potato beetle resistance management programs. Programs are sequentially ordered by observed neonicotinoid efficacy in the field (low to high control). All descriptions correspond to Figure 2.

Program	Description
In-furrow + Foliar management programs	
A.	Neonicotinoid (F, IF, or ST)[a] used with very limited success. Management plan rotates away from the neonicotinoid group over four consecutive treatment windows.
B.	Neonicotinoid (F, IF, or ST) was used in prior year with limited success. Early season colonization has been historically high at specific field location. Prepack neonicotinoid + pyrethroid could be used in year two if potato leafhopper numbers are high.
C.	Populations easily controlled with at-plant neonicotinoids. Torac was placed behind in-furrow diamide to manage any larvae that persist through in-furrow diamide.
D.	Use only if neonicotinoid (F, IF, or ST) was not used in year zero and populations are still susceptible. Years two and three can be switched depending on in-furrow diamide availability.
Foliar management programs	
E.	Full foliar program if Colorado potato beetle resistance is suspected in a group of fields. If fields are relatively close (<1,500 m), use the same MoA rotation scheme uniformly to avoid selection over less than 4 generations.
F.	Full foliar program if neonicotinoids have limited efficacy.
G.	Neonicotinoids maintain satisfactory efficacy annually. Prepack neonicotinoid can be switched with foliar neonicotinoid if potato leafhopper (*Empoasca fabae*) numbers are low in year two.
Short maturity-single generation program	
H.	Full foliar program for short maturing cultivars and regions with only a single Colorado potato beetle generation each year. In areas where colonization pressure is low, early season applications in the first treatment window may be satisfactory to manage beetles until harvest. Follow up applications of another mode of action group (cross-hatched box) should be completed only if an economic damage is likely to be reached. Companion groups could be foliar neonicotinoid, prepack neonicotinoid, or abamectin. A foliar diamide should only be used in the late season treatment window of year three.

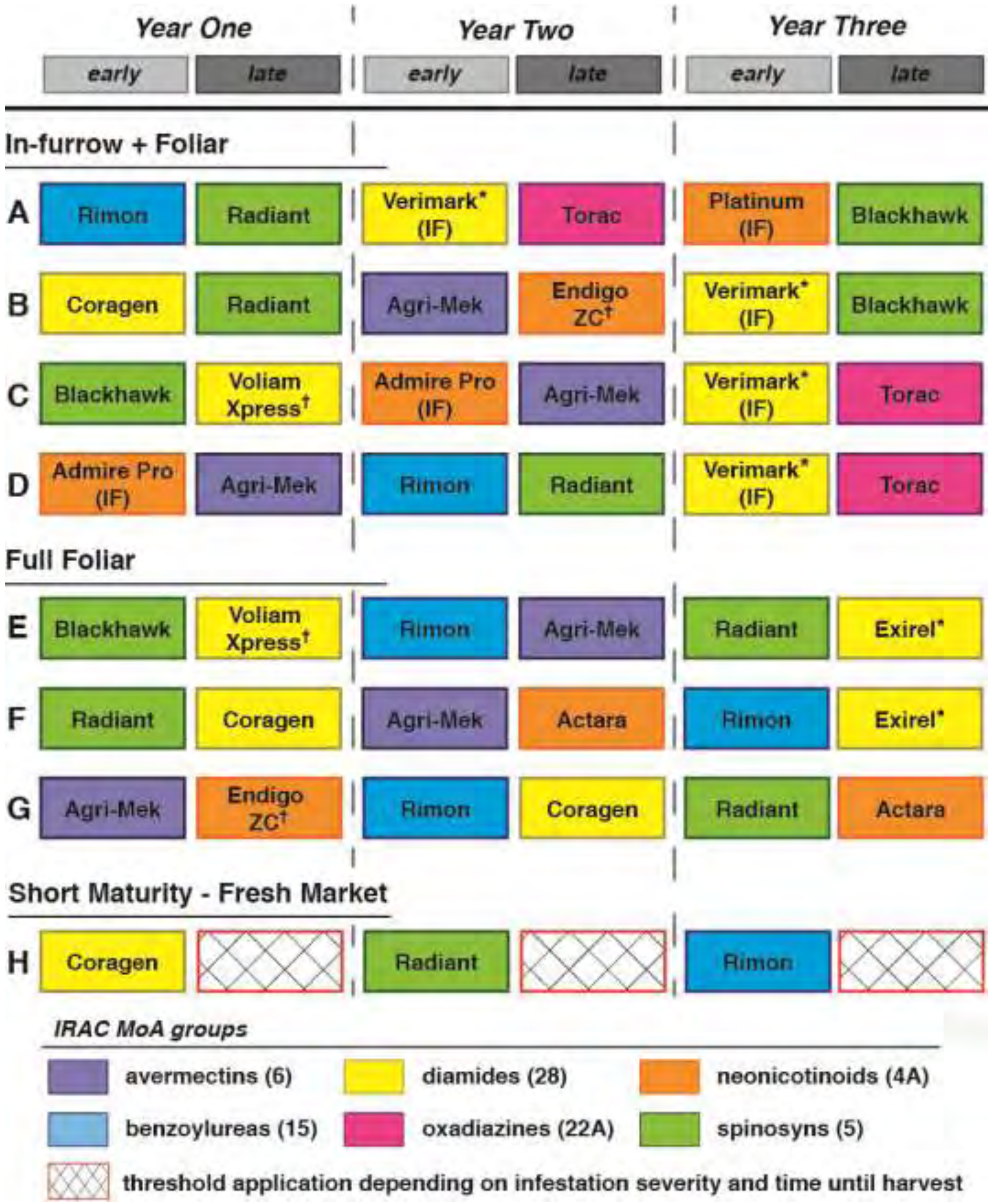

Figure 3. Product rotation suggestions to manage Colorado potato beetle larvae. Programs A-E alternate IRAC Mode of Action (MoA) across several early and late generation treatment windows in each season. Short maturity cultivars (e.g. Reds, heirlooms) may not require application of another MoA for later generation CPB. Foliar neonicotinoid or other insecticides can be used in seasons when populations reach threshold after initial applications. Check label restrictions for preharvest intervals (PHI). In-furrow, at-plant insecticides are designated with IF. Active ingredients pre-packed with lambda-cyhalothrin are designated with a dagger (†). Cyantraniliprole diamides (*) will not have a federal registration until the 2015 growing season and may not have registration until 2016. Insecticides included represent formulations that are commonly available, other active ingredient formulations may be labeled see the state Management Guidelines for a comprehensive list of registrations.

Enviro-weather Tools for Potato Growers

Beth A Bishop
Enviro-weather Coordinator, Michigan State University
eweather@msu.edu (517) 432-6520

The Michigan potato industry suffers losses of $1.5 to $2.5 million each year due to weather-induced crop stress, in particular, those caused by excessive heat. Crop stress negatively impacts crop quality and causes potatoes to deteriorate in storage. Specific information about potential stresses potatoes are exposed to, currently or in the past, can help growers manage their crops and minimize losses before harvest and during storage.

Michigan State University's Enviro-weather program provides potato growers with access to local, real-time weather information through its website: www.enviroweather.msu.edu. Enviro-weather operates a network of weather stations throughout Michigan that continually measure and record local weather data. The data is sent to a central server on the MSU campus on a regular basis (every 30 to 60 minutes during the growing season). The data is organized, stored and archived. The Enviro-weather website displays current weather data and uses the archived data in on-line tools and applications that give growers information about their crops.

Enviro-weather has long provided online, weather-based summarizes to help potato grower's analyze crop stress. For example, Enviro-weather's Heat Stress Summary table gives comparisons among years of heat and water stress (as measured by total rainfall, high night temperatures, and high daytime temperatures) (Figure 1).

Entrican Heat Stress Summary Assist Chart (Report issued 11/21/2014 15:04)

Year	Degree Days Base 40 F Number of days with DD > 35	Degree Days Base 40 F Total DD	Temperatures greater than 90 F Number of hours	Temperatures greater than 90 F Number of days	Night temperatures greater than 70 F (10 PM - 8 AM) Number of hours	Night temperatures greater than 70 F (10 PM - 8 AM) Number of days	Rainfall (in.)
2014	1	2422	0	0	43	13	8.74
2013	8	2522	14	3	112	21	7.67
2012	18	2552	70	15	124	24	7.95
2011	15	2692	14	4	140	23	6.58
2010	16	2786	0	0	187	35	7.98
2009	4	2281	6	1	39	13	9.24
Average of 5 years, not including current year	11.8	2566.5	20.8	4.6	120.4	23.2	7.88

Figure 1. Enviro-weather's heat stress summary tool display for Entrican, MI for the period of June 1 through Aug 31 each year.

Enviro-weather's Daily Heat and Moisture table shows daily air temperatures (maximum, minimum and average), soil temperatures, rainfall and soil moisture.

Because of the usefulness of the Heat Stress Summary, and based on grower need, the Michigan Potato Industry Commission (MPIC) obtained a specialty crop block grant from the Michigan Department of Agriculture and Rural Development (MDARD) to improve potato growers access to information about crop stress though Enviro-weather. The grant enabled purchase and installation of four additional weather stations in key potato growing regions of Michigan (Mecosta, MI, Kalkaska, MI, Gaylord, MI and McMillan, MI). Funds also allowed development of a new, improved potato stress evaluation tool on Enviro-weather. The Potato Maturity and Stress graphical tool provides customized and detailed information about the stresses experienced by a potato crop in graphical form (Figure 2).

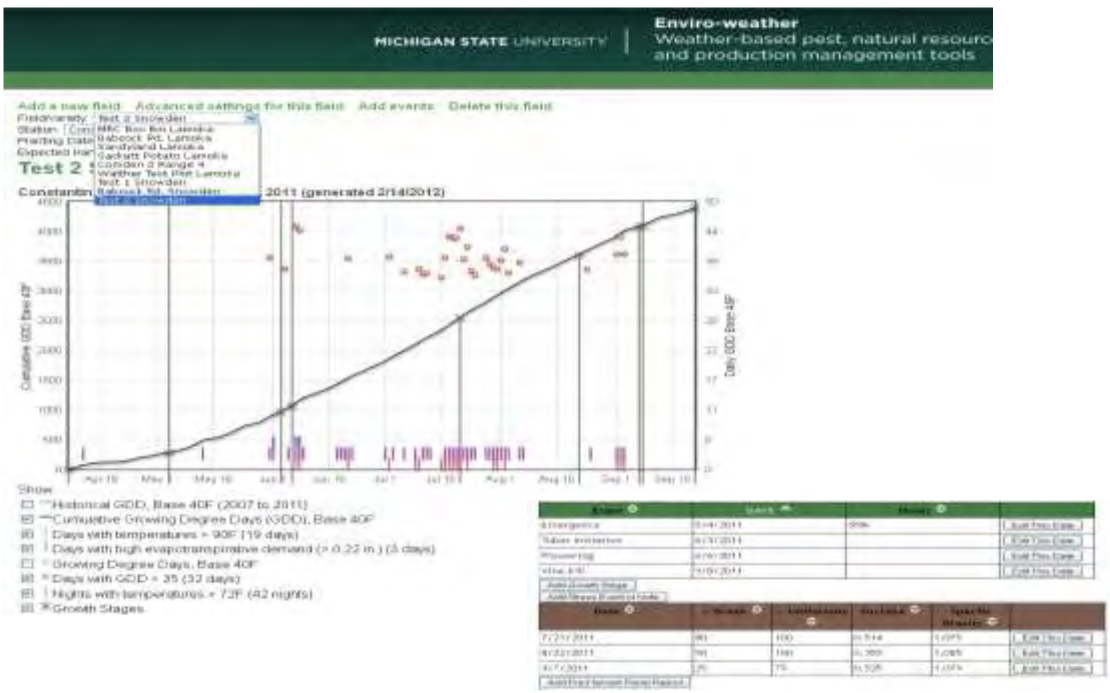

Figure 2. Existing output of Potato Maturity and Stress Graphical Tool on the Enviro-weather website. Critical stress events for a potato crop in one field are displayed relative to growth and maturity of the crop.

Potato growers have used the Potato Maturity and Stress graphical tool for the past three years. Based on feedback from users, Enviro-weather is completing modifications to the tool. Modifications will allow growers' to compare potatoes grown in different fields and/or in different growing seasons to retroactively learn how stress events affect potato crop yield and quality. Users will be able to choose two or more individual crops grown in different fields or different years and compare them (crop development, timing of stress events) in side-by-side graphs and on the same graph (Figure 3).

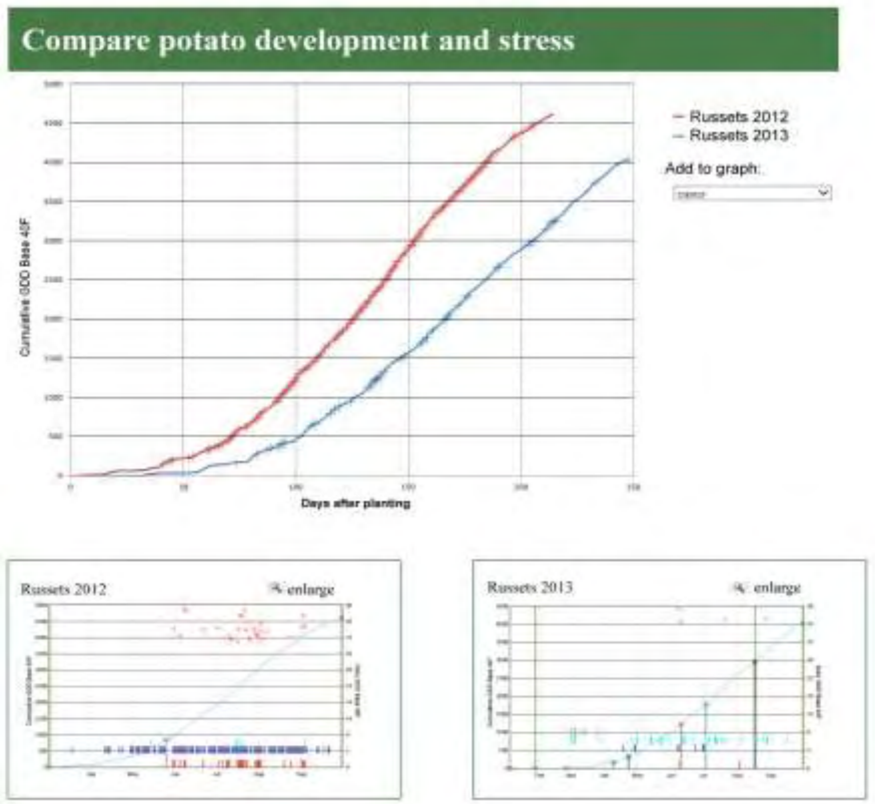

Figure 3. Draft of output of revised Potato Maturity and Stress Graphical Tool on Enviro-weather. Critical stress events for two or more potato crops (different fields and/or years) are depicted on the same graph. Users will be able to stack smaller graphs and to click on smaller graphs to enlarge.

Such analysis will allow growers to visualize differences more easily and ultimately, to use the information gleaned to make informed decisions about future crops.

The modifications are currently under development. We expect the modifications to be finished by early 2015 and to be available to users before the 2015 growing season.

The potato maturity and stress graphical tool was funded by support from the Michigan Potato Industry Commission, a Michigan Department of Agriculture Rural Development Block Grant, and Project GREEEN.

As always, we at Enviro-weather welcome your questions, concerns and comments. Contact Beth Bishop, Enviro-weather Coordinator at (517) 432-6520 or eweather@msu.edu.