Site-Specific Management Guidelines

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SSMG-20

Estimating the Timing of Weed Emergence

Summary

The basis for timing of many weed control operations is seedling emergence. However, weeds rarely, if ever, emerge in a synchronous and uniform flush. Instead, they emerge in "fits and starts," depending upon weather, soil, and management conditions. Recently developed computer software permits site-specific prediction of weed emergence and early seedling growth using on-farm weather data. Armed with this information, producers and crop consultants can estimate current weed emergence on a daily basis. They also can forecast forthcoming emergence. The software is sensitive to tillage system and soil type. Consequently, the variability of emergence, due to these factors, across fields can be estimated easily. Recognition of the asynchrony in timing of weed emergence helps producers and consultants make better management decisions for spatially variable fields.

Today there are more herbicide choices than ever before, and they are better and more convenient to use every year. You now expect at least 90 percent weed control with many of these herbicides, frequently get close to 100 percent control, and often need to apply them only after you can see the weeds. With such great control, and given the money and effort you've invested in weed management, shouldn't the weeds in your fields have disappeared by now?

Despite your best efforts, you probably still have weeds. Sure, their numbers may change from year to year, and sometimes the types of weeds even change, but every spring you still have weeds to control. Why? What's going on that forces you to spend time and money to solve the same problems year after year? Basically, the answer to this question is, "that's life," a weed's life to be specific, and knowing more about the lives of weeds will enable you to manage them better.

The study of the life of weeds is known as weed biology, and for the purposes of weed control, the most important aspect of weed biology is the emergence of seedlings (which come from seeds) or shoots (which arise from underground organs, such as rhizomes). Emergence represents the time when a weed begins to wean itself from food provided by its seed or rhizome and starts to become self-sufficient. For many forms of mechanical control, and nearly all forms of postemergence (POST) herbicide control, weed emergence sets the clock by which control operations should be timed. The trick, then, is predicting when weeds emerge.

How can weed emergence be predicted? Emergence is determined mostly by two factors: soil temperature and soil water availability. Although these two factors are regulated by weather, they are influenced by soil depth and soil type. Influences of soil depth and soil type are important because weed seeds are distributed at varying depths in soil and because soil types often vary within a single field. Consequently, weeds *never* emerge in a single synchronous "flush." Instead, they emerge over extended periods of time, often lasting several weeks, even within one soil type. Furthermore, emergence can be protracted over several months, depending upon weather conditions, if a number of soil types exist within a field. This aspect of variable emergence across a field will be discussed in more detail in a later section.

Variable weed emergence patterns have many consequences for site-specific weed management. Understanding the causes of differential weed emergence permits more informed decisions, more timely operations, and better management. Without the ability to predict weed emergence, management decisions are less efficient, less reliable, and often more prone to agronomic and financial risk. The following paragraph provides a general example of the importance of predicting weed emergence.

Weed control will be less than maximum if weeds emerge considerably earlier or later than a control operation, regardless of whether the control operation is chemical or mechanical. When weeds emerge early, they may be too large to be susceptible to preemergence (PRE) or POST herbicides, and they also may be tolerant of soil disruption through disking, harrowing, interrow cultivation, or rotary hoeing. On the other hand, when weeds emerge late, the residual effects of early herbicide applications may have dissipated, and crops often are too big for various tillage operations or too sensitive to risk late-applied herbicides. Although late-emerging weeds may not lower crop yields, they do produce seeds that will plague fields for yet another year. To complicate matters, differing weed species do not emerge uniformly. Some species emerge earlier than others. Even within a species, certain populations will emerge later than other populations within a field.

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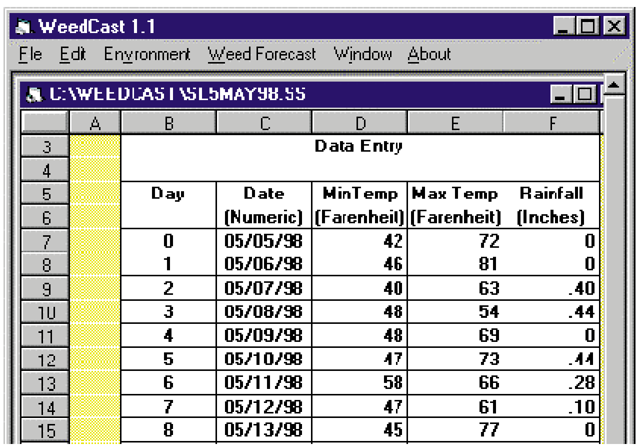
Development and Release of *WeedCast*

To aid producers, crop consultants, and others predict when weeds emerge and how fast they grow after emergence, computer software called "*WeedCast*" was developed. This software is self-contained, easy to use, and can be downloaded free-of-charge from the world wide web at the following address: www.infolink.morris.mn.us/~lwink/products/weedcast.htm

WeedCast uses local weather data to make predictions in real-time. In other words, you supply your own weather data each day and *WeedCast* will use these data to predict weed emergence as of the last date for which you listed the weather information. The types of weather data needed are simple: daily minimum and maximum air temperatures and rainfall (**Figure 1**). Normally, you start adding these data to *WeedCast* on the day you plant a specific field. You can also use forecasted weather data, which you might obtain from your local television or radio station, newspaper, or these days, from some Internet-based information service (the "Weather Channel," for example).



	A	B	C	D	E	F
3		Data Entry				
4						
5		Day	Date	MinTemp	Max Temp	Rainfall
6			(Numeric)	(Farenheit)	(Farenheit)	(Inches)
7		0	05/05/98	42	72	0
8		1	05/06/98	46	81	0
9		2	05/07/98	40	63	.40
10		3	05/08/98	48	54	.44
11		4	05/09/98	48	69	0
12		5	05/10/98	47	73	.44
13		6	05/11/98	58	66	.28
14		7	05/12/98	47	61	.10
15		8	05/13/98	45	77	0

Figure 1. Depiction of the internal spreadsheet in *WeedCast* for daily weather data. Only three variables are needed: minimum and maximum air temperature and rainfall.

WeedCast converts the air temperature and rainfall values into soil temperature and soil water content of the upper 2 inches (5 cm) of soil, as these are the factors that actually regulate weed emergence. The conversions occur automatically through a series of complicated equations that depend upon the general soil type, tillage system, and previous crop (residue type) that you select from drop-down menus (**Figure 2**). To make these selections, you simply choose and click with the mouse on your computer screen.

After clicking a couple more on-screen buttons, *WeedCast* will produce a graph for the weed species that you chose. The graph shows percent emergence for each day since the day you planted your crop. The same information is also stored automatically in a spreadsheet just in case you want to see the actual numbers. For most purposes the graph is all you need to see. It will give you a hint about what the weeds are doing, and it should be used as a rule-of-thumb, not gospel. If emergence is predicted to

Figure 2. The environment menu of *WeedCast* allows users to select from drop-down menu boxes the weed species, soil type, tillage system, and previous crop appropriate to their individual fields.

be 1 to 10 percent, then you probably can assume safely that emergence is just beginning and you ought to start thinking about scouting the field regularly. If the prediction is greater than 90 percent emergence, then the assumption that emergence is just about over is equally safe and that scouting for new flushes of seedlings may be unnecessary.

Knowing the extent of seedling emergence also provides some triggers for certain management operations. For example, the best time to control foxtails or pigeongrass (*Setaria faberi*, *S. glauca*, and *S. viridis*) with a rotary hoe is at 30 percent emergence and with an interrow cultivator at 60 percent emergence.

Another example is that of delayed PRE applications of Sencor/Lexone (metribuzin) in soybean. This herbicide should be sprayed just after planting, but it can be applied up to the time at which 40 percent of pigweed (*Amaranthus retroflexus*) seedlings have emerged and still control them excellently. Depending upon weather conditions, 40 percent pigweed emergence can be as late as two to three weeks after planting soybean.

As a last example, common sense dictates that if a short residual POST herbicide is applied when only 10 percent of weed seedlings have emerged, then full-season weed control won't be very high. Sometimes a delayed POST application, perhaps with a more expensive herbicide, may be more cost-effective that a cheaper herbicide that must be applied earlier. A good example of this is the control of foxtail in spring wheat. Foxtails can be managed with Stampede (propanil), which is cheap, or the more expensive Tiller (fenoxaprop). For crop safety reasons, Stampede must be applied relatively early, whereas Tiller can be applied only relatively late. If foxtail emergence exceeds about 60 percent by the time wheat reaches the 2- to 5-leaf stage of growth, then Stampede would be a wise choice. In contrast, if cool or dry conditions slowed foxtail emergence, then a delayed application of Tiller at the 6-leaf stage of wheat should be considered. This would allow as many foxtails as possible to have emerged by the time of the herbicide application. Although Tiller is more expensive than Stampede, the greater level of expected weed control with delayed emergence would justify the use of Tiller. Assuming that the availability of the two herbicides was equal, access to timely emergence information can help make better and more cost-effective management decisions.

Emergence Timing Varies Across Fields

Because many agricultural fields have two or more soil types, the timing of weed emergence across a field can vary considerably. This effect of soil type can be illustrated by a small field in Swan Lake township in Stevens County, Minnesota. The field was planted to continuous no-till row crops since 1992. It is approximately 200 feet wide and 800 feet long and has gently undulating terrain with distinct soil types, making it quite characteristic of much of the glaciated landscapes of the Great Plains and Midwest. The soils are (a) Sverdrup sandy loam on stony knolls, (b) Barnes loam over most of the field, (c) Aastad clay loam in toe slopes, and (d) a small area of Flom clay and clay loam at the bottom of a low area.

The distinct soil types of this field can be used to demonstrate variability in the timing of weed emergence. To do so, the *WeedCast* software program was used. Data from a thermometer and rain gauge next to the field were used in *WeedCast* to generate daily weed emergence percentages. Weather data began on May 5 (date of Roundup-Ready® soybean planting) and continued through June 29, 1998. In addition to weather data, soil type, tillage system, and previous crop (i.e., residue type) also were selected from drop-down menus within the *WeedCast* program. Once this was done, *WeedCast* estimated emergence sequences for two contrasting species, green foxtail (*Setaria viridis*) and giant ragweed (*Ambrosia trifida*), from a possible list of 15 species within the program. Both foxtail and ragweed are common throughout the Midwest.

Predicted cumulative seedling emergence patterns for both species are shown in **Figure 3** for the four main soil types in the field. Ragweed is an early-emerging species relative to green foxtail, as it can better tolerate low soil temperatures. However, ragweed is less tolerant of soil water stress than foxtail.

Emergence was most rapid for both species in clay and clay loam soil, intermediate in loam soil, and delayed in sandy loam soil. The reasons for these differences involve both soil temperature and soil water contents. However, low rainfall in May and early June 1998 was primarily responsible for the differences in emergence across soil types. Heavier soils, such as clay and clay loam, hold water much better than lighter soils, like loam and sandy loam. Once soil water tension at the 2 inch (5 cm) soil depth dropped below about -1.5 bars (-0.15 MPa water potential) and -50 bars (-5 MPa), emergence stopped for ragweed and foxtail, respectively. Because rainfall was sparse in May and June, this occurred first in the sandy loam, then in the loam, and to a minor extent in the clay loam. In the clay soil, ragweed reached 100 percent emergence before soil water tension had a chance to drop below -1.5 bars in late May. Moreover, the clay soil never dried to less than -50 bars, so foxtail emergence was never impeded by soil water stress.

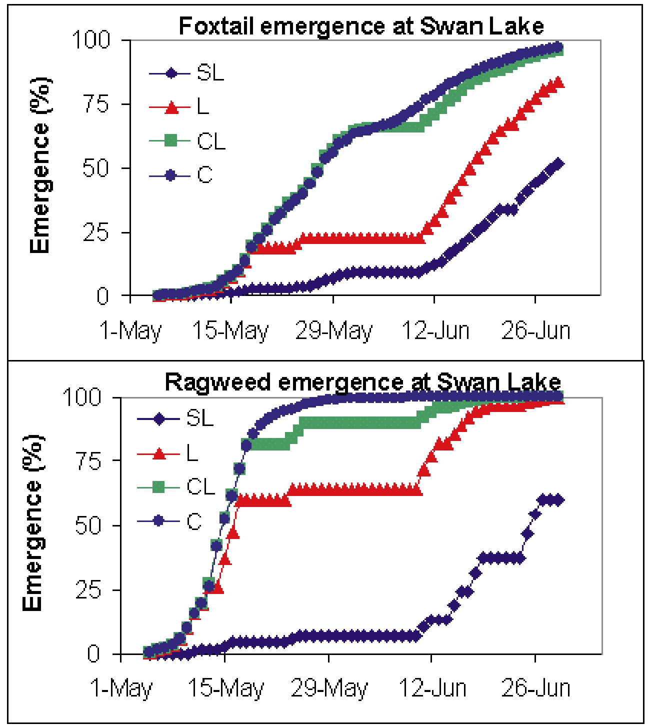


Figure 3. Time course of seedling emergence of giant ragweed and green foxtail in the four soil types that comprise the GIS field at the Swan Lake Research Farm near Morris, Minnesota.

Implications of Spatial Variability of Emergence

Spatial illustration of ragweed and foxtail cumulative emergence percentage categories across the field, described above, during three dates are valuable for understanding how differing emergence patterns may alter the consequences of certain weed management decisions. Thus, in **Figure 4,** five categories of emergence are depicted across the field for each of the following dates: May 23, June 5, and June 23. These dates represent times when early-POST, POST, and late-POST herbicide applications are likely to have been made in fields planted on May 5.

On May 23, ragweed emergence was about 50 percent across most of the field, which had loam soil (**Figure 4b**), but was less than 20 percent on sandy loam and nearly 100 percent on the clay soil. In contrast, foxtail emergence was less than 20 percent across most of the field (**Figure 4a**), and less than 40 percent on the heavy soils. If Roundup (glyphosate) or any other appropriate herbicide was applied on May 23, weed control would have been negligible for ragweed on the stony knolls and equally poor for foxtail over most of the field because so few seedlings had emerged by that time in those soil types.

Ragweed emergence by June 5 was greater than 60 percent over most of the field, but was still less than 20 percent on the stony knolls (**Figure 4b**). Foxtail emergence on this same date was still less than 40 percent over most of the field, and less than 60 percent even on the a.

b.

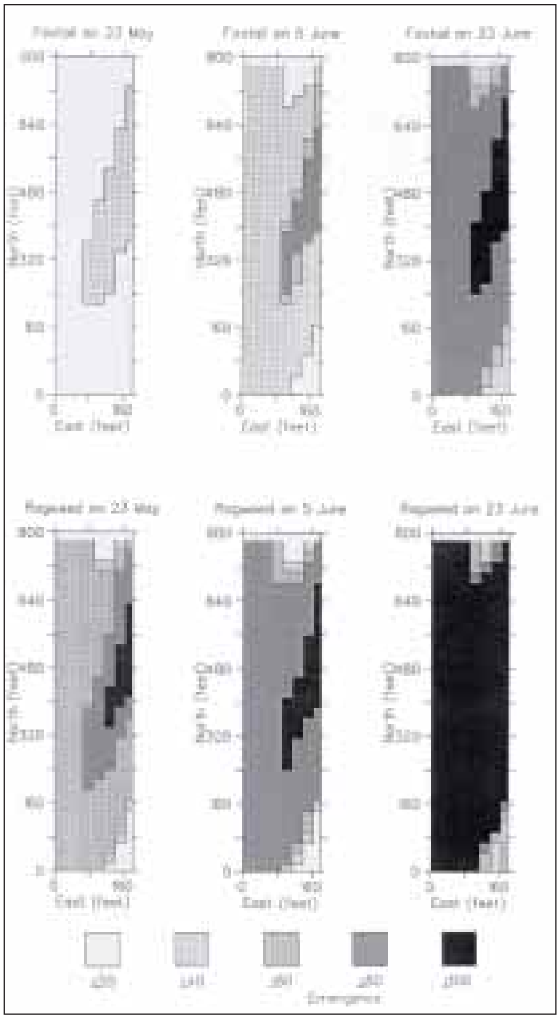


Figure 4. Spatial illustration of giant ragweed and green foxtail emergence in a small field in Stevens County, Minnesota. Emergence was estimated for three dates (see Figure 3) for each species on each of the four major soil types in the field. Maps were generated by GS+ software after kriging emergence values that were estimated on a 20-foot grid system (410 points) across the field.

clay soil (**Figure 4a**). Even though June 5 was a month after planting, POST herbicide applications at this time probably would have resulted merely in adequate ragweed control and only poor foxtail control over most of the field (loam and sandy loam). However, excellent ragweed control might have been possible in areas with heavier soils where emergence was greater than 80 percent.

Nearly 50 days after planting (June 23) emergence of ragweed was almost complete over most of the field (**Figure 4b**). At the same time, green foxtail finally exceeded 60 percent over much of the field, and exceeded 80 percent on the heavy soils (**Figure 4a**). POST herbicide application at this time probably would have provided good to excellent control in these areas. However, recognition of tardy emergence (<60 percent on the sandy loam soils) is important because this would represent the most likely cause of less than desirable ragweed and foxtail control at these sites. Although a healthy crop canopy would tend to inhibit growth of late-emerging weeds on these light soils, even the small plants resulting from late-emerging seedlings produce seeds that will plague producers during subsequent growing seasons.

Future Research Needs

These examples of the timing and spatially variable emergence of weed seedlings used soil types as the basic factor that induces variability, but other factors can be equally important. For instance, variable distributions of crop residues and soil compaction, especially in reduced tillage fields, may influence the timing of weed seedling emergence. Unfortunately, the effects of these factors on the timing on weed emergence are not documented very well. In any event, the examples shown in **Figures 3 and 4** for a single field in western Minnesota easily represent what might be expected to occur in almost any field in the glacial-till soils of the Midwest or northern Great Plains. In these instances, crop advisors and producers need to be aware that timeliness of many weed control operations is spatially variable and depends on the timing of weed seedling emergence. In some cases, POST operations may need to be performed more than once, and the length of residual control from soil-applied herbicides may need to be considered carefully. For producers, agribusiness, and other practitioners of weed management, easy access to site-specific information on weed emergence and early seedling growth is essential. Software products such as *WeedCast* represent a “start” in this activity, in that they can use site-specific soil and weather data in real-time and forecasted time to estimate weed emergence and growth. However, to make these information generation and retrieval systems fully functional for producers and others, they need to be linked directly, automatically, and daily to interpolated and geo-referenced soil and weather data for any point in the Midwest and Great Plains. The technology for such linkages currently exists. What is missing is the incentive from the agricultural industry to facilitate the research that will enable the connections to be made. ■

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