Site-Specific Management Guidelines

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Spatial Variability in Corn and Soybean Insect Pests: Precision Farming and Insect Pest Management for the Future

Summary

Public and private research effort is being invested in site-specific insect pest management, but progress in this area lags behind other aspects of site-specific agriculture. The existence of field-level spatial variability in populations of key pests of soybean and corn suggests that a site-specific approach to integrated pest management (IPM) is possible. Technological capability for Geographic Information and Global Positioning Systems (GIS/GPS) is available but has not been effectively combined into platforms incorporating economical scouting systems or real-time monitoring and mapping of pest variability. It has been suggested that optical sensors might be applied to detection of canopy-dwelling insect pests such as the bean leaf beetle. Targeted sampling can be directed by analysis of remotely sensed aerial images that identify anomalous areas indicative of severe pest infestations, provided the cost of the imagery can be kept at reasonable levels and still provide rapid turn-around. It will take time to overcome the barriers associated with site-specific insect management, but because of the potential benefits of this technology, research in this area will continue to move forward.

Introduction

Site-specific management of insect pests in corn and soybean is not as highly developed or studied as precision soil fertility or weed management. The goal of this guideline is to discuss spatial variability of corn rootworms and bean leaf beetles and to summarize the unique problems and expectations for a precision agriculture approach to IPM for these pests.

Densities of pest populations usually are considered as an average number of insects per unit area or per sample unit for an entire field. This number may change through time as the pest population develops. In reality, the actual densities vary spatially at any given moment, that is, they are not constant over the entire expanse of a field because landscape, soil, crop, and environmental factors are not constant within a field. It is precisely because insect densities vary within a field that site-specific approaches to IPM may be possible. However, uneven and patchy insect spatial distributions also make economical and reliable sampling, modeling, or management strategies difficult to develop at the scale and intensity required for site-specific IPM. Research projects on corn rootworms and bean leaf beetles at Iowa State University in Ames, and South Dakota State University and USDA-ARS at Brookings, South Dakota seek to answer questions related to these problems.

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Spatial Variability in a Corn Pest — Corn Rootworms

Corn rootworms are key pests in the Corn Belt that overwinter in the soil as eggs and hatch in May or June. They feed as larvae on corn roots, causing plant lodging and yield loss. Management options for corn rootworms include crop rotation with non-host plants, planting of rootworm-resistant Bt corn, and soil-insecticide treatment at planting time. These practices target the very young larvae hatching from eggs in the soil. However, scouting for corn rootworms usually depends on visual counts of adult insects on plants or monitoring of adult insects with sticky traps during the preceding year. Thus, farmers apply controls for corn rootworms as "insurance" before actual root damage has occurred.

Sampling a previous generation is problematic because management decisions are not made using knowledge about existing infestations. Sampling methodology for post-planting assessment of larval corn rootworm infestations is not available. The incorporation of site-specific management of corn rootworm into current production practice for continuous corn will require prediction of a subsequent year's potential infestation or damage by corn rootworm larvae before planting. Between-year experiments on within-field distribution of western corn rootworms were conducted in continuous cornfields in Iowa to identify agronomic, soil, insect, geographic, and weather factors that could be correlated with the

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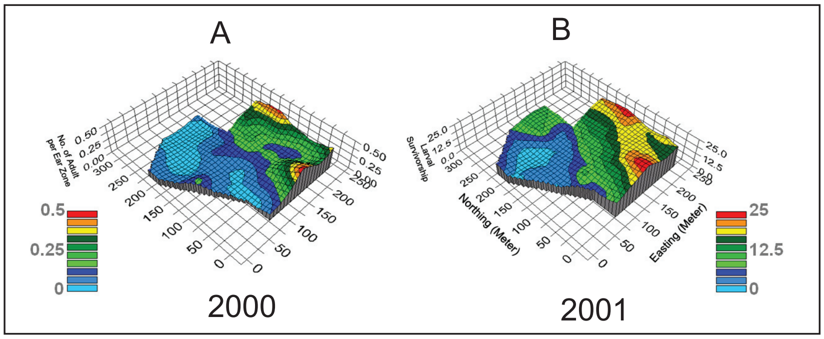

Figure. 1. Contour maps for western corn rootworm adults in the ear-zone at population peak (A) and subsequent year's adult emergence (B) from a 20-acre field of corn planted after corn. Note that there is high correlation between the two maps, indicating that it may be possible to predict a subsequent year's adult emergence by sampling and mapping adult dispersion at the peak population.

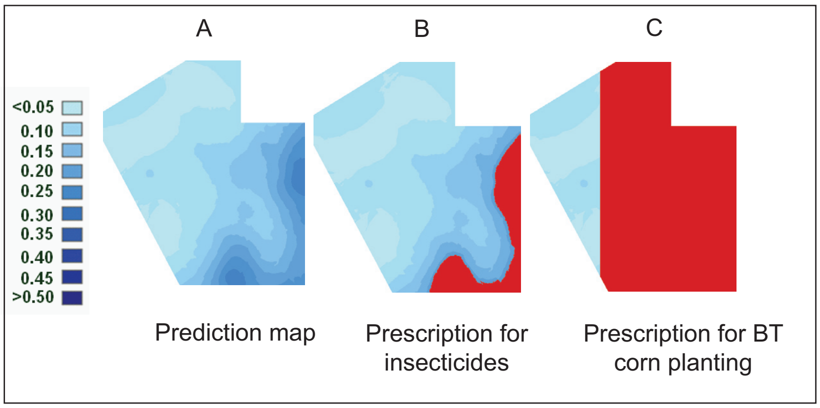

Figure. 2. Prediction map with number of western corn rootworm adults per ear-zone (A) and prescription maps with a recommended insecticide-treatment zone (B, red-colored area) and recommended planting zone for Bt corn (C, red-colored area).

subsequent year's spatial distribution of adult emergence. Current adult distributions were best predicted by sampling and mapping the distribution of the previous year's adult emergence when populations peaked in the field (**Figure 1**). Based on maps predicting a subsequent year's adult emergence (**Figure 2A**), prescription maps to define management zones can be generated with GIS and based on economic injury level (EIL) as shown in **Figure 2B**. By applying insecticides to approximately 30% of the field, farmers could avoid economic loss by rootworms. The placement of Bt corn-planting zones also could be generated based on the refuge shape and sizes. Currently, at least 20% of refuge (non-Bt corn) is required by EPA (Environmental Protection Agency). Planting zones for Bt corn can be located where high adult populations are predicted (**Figure 2C**).

The soil-dwelling stages of insect pests are ideal candidates for site-specific management because they do not move as do adult corn rootworms and other insects capable of flight. Knowledge about soil properties gained from grid sampling may lead to new ways of predicting the risk of insect infestation and help to target scouting efforts for insect pests by concentrating on high risk areas of the field. In rotated corn, adult northern corn rootworms show spatial variation in grid-sampled fields (**Figure 3**). However, use of adult counts to predict the following year's infestation is complicated by the fact that northern corn rootworm eggs are subject to mortality in the soil during an extended diapause (dormancy) over two winters. The lowest adult emergence densities often occur in wetter, low-lying areas or on ridge-tops, and the highest densities are found where soil is better-drained (**Table 1**). Because survival of these soil-dwelling insects is determined at least in part by soil conditions, information about soil properties gained through grid sampling should be useful for decision-making regarding management of corn rootworms.

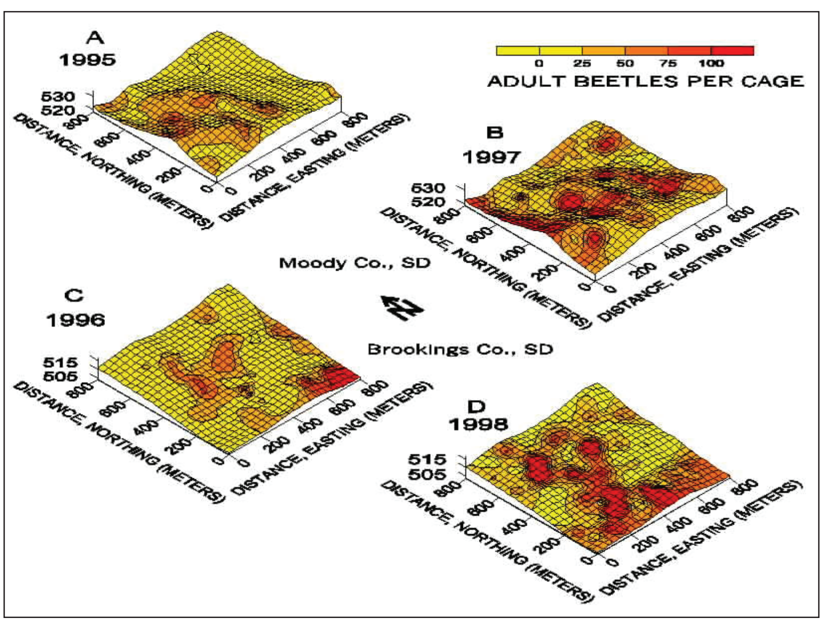

Figure 3. Contour maps for emergence density of adult northern corn rootworms from the soil in two 160-acre corn/soybean rotated fields in eastern South Dakota. Maps A and B, Moody County; Maps C and D, Brookings County. Area under each emergence cage was about 0.5 square meters.

Table 1. Northern corn rootworm egg and adult population densities, soil electrical conductivity (EM-38), and larval injury to corn roots in relation to landscape position for the Moody County, SD field. Adult emergence numbers were seasonal mean totals and eggs were sampled in the fall. Numbers in parentheses are standard errors; means within columns followed by the same letter were not significantly different, Fisher's protected LSD (p<0.05).					
Landscape position	Elevation, m	EM-38, mS m^{-1}	Eggs per L soil	Adults per 0.5 m^2	Root injury
Footslope/toeslope	<525	41.08a (0.18)	5.1a (1.8)	66.8a (9.4)	3.9a (0.2)
Backslope	525 - 530	35.90b (0.17)	5.0a (1.2)	107.0b (13.2)	4.0a (0.2)
Shoulder/summit	>530	31.02b (0.07)	4.8a (1.4)	115.5b (18.1)	4.5a (0.3)

Spatial Variability in a Soybean Pest — Bean Leaf Beetle

The bean leaf beetle is one of the most important soybean insect pests in the Midwest. Bean leaf beetle population dispersion was examined as part of on-farm site-specific management studies in Iowa. Beetles were sampled on a 0.5 acre grid in 30 to 50 acre field areas and interpolated maps of their dispersion were created. Using such maps, farmers may be able to identify probable areas of persistent pest infestation within a season or over multiple years, and thus focus pest management tactics on those areas.

Once a persistent insect problem has been identified, the next step is to determine what factors cause the pattern. Evidence for spatial persistence of bean leaf beetles has been found both within a season and over multiple years (**Figures 4 and 5**). In two central Iowa fields, high beetle density (**Figure 4**) was associated with areas where plants were shorter and soybean cyst nematode density was high. In a western Iowa field, high beetle densities (**Figure 5**) were associated with areas with fewer weeds. Beetle populations were aggregated in all three fields, but other field attributes associated with the beetle aggregations were different among fields. Site-specific information about relationships and interactions between factors, such as bean leaf beetles and weeds or soybean cyst nematodes, which also affect crop yield, may provide a means for farmers of the future to coordinate IPM efforts for multiple pests .

Information from the Iowa State University soybean study was used in a computer spreadsheet model to examine the potential return from a precision IPM program targeted to second generation bean leaf beetles in soybean (**Table 2**). Initial start-up costs for precision farming technologies were not included in the analysis. Calculations of net return per acre were based on the average price of soybeans and field-collected yield data in each year. Loss from bean leaf beetles was estimated from actual field populations and from previous research on injury to soybean by bean leaf beetles. Uniform insecticide treatment during 1997 produced an increased net return because the whole-field beetle population was above the economic injury level (EIL). The 1998 field-mean beetle population was below the EIL and treatment would have resulted in a slight net loss. In both years a site-specific approach, ignoring sampling costs, would have resulted in an increased net return. When estimated sampling costs were added to other site-specific management costs, however, the expense of intensive sampling negated any benefit from site-specific management. Scouting for insects is a time-consuming task, but with the need for increased numbers of samples in a precision farming program, scouting time increases even more. Furthermore, the insects collected must be counted and identified in the field. Methods to scout for soybean insects include the use of devices such as beat sheets and ground cloths that are difficult to implement on

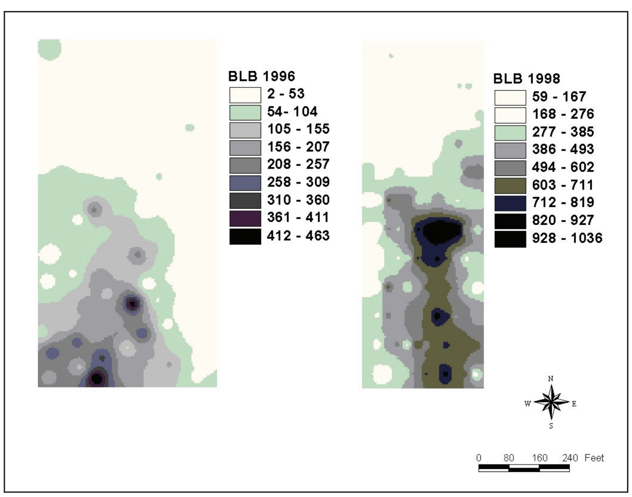

Figure 4. Bean leaf beetle (BLB) population dispersion in study areas of a central Iowa soybean field during September of two different years (1996, 50 acres; 1998, 32 acres). Beetle populations were aggregated in the southern portions of the fields in both years.

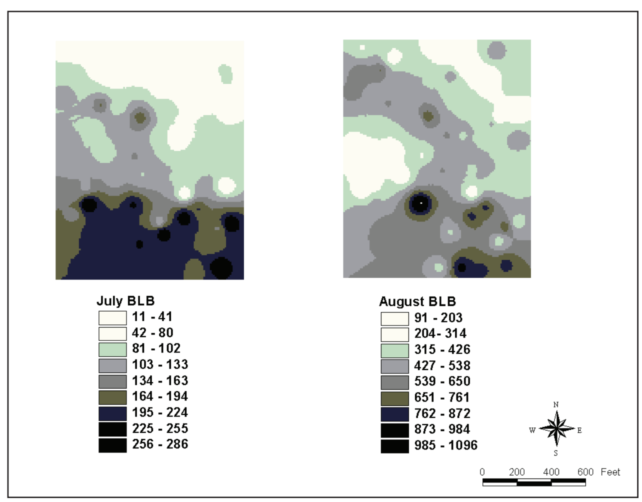

Figure 5. Adult bean leaf beetle dispersion in a 30-acre western Iowa soybean field during July (left) and August (right) of 1998. Populations were more concentrated in the southern portion of the field in both months.

Table 2. Comparison between uniform and site-specific management for second generation bean leaf beetle in soybean, based on a spreadsheet model incorporating yields, average soybean prices, insecticide treatment costs, and grid-sampled bean leaf beetle densities from typical western Iowa fields. Values are expressed as average increase or decrease in net return per acre.

	Difference in return		
Year	Uniform insecticide treatment vs. no insecticide treatment	Site-specific management (Cost of sampling ignored) vs. Uniform insecticide	Site-specific management (Cost of sampling included) vs. Uniform insecticide
1997	+$34.44	+$0.96	-$52.56
1998	- $0.44	+$2.42	-$22.80

the scale needed for grid sampling to support a precision approach to integrated soybean pest management.

Barriers to Overcome

Despite the potential benefits of site-specific insect management, there are significant barriers to implementation. A primary obstacle to implementation of precision IPM is the high cost of obtaining site-specific information about insect pest populations. The cost of manual sampling and scouting in terms of labor and time is a serious constraint to obtaining data at the intensity necessary for accurate characterization of spatial variability in pest populations. Ideally, capability for real time in-field decision making would allow immediate implementation of timely management practices. Remote-sensing technology linked to GIS/GPS technology offers great promise for near real-time monitoring of pest populations to facilitate map-driven application technology. Digital aerial photography or satellite images offer great potential for identification of insect-stressed plants in areas that may be targeted for intensive sampling**.** Sampling of insect pests that targeted to high risk areas of a field may reduce the number of samples required.

A second barrier to implementation is the lack of equipment capable of site-specific insecticide application. Insecticides are the most effective control method for most soybean insects when populations exceed the economic threshold. This presents a problem in soybean because late-season insecticide treatments usually are done by aerial application. At present, technology capable of site-specific aerial insecticide application is not commercially available. In the corn system, most insecticide application equipment is designed for planting-time application, well before assessments of early-season rootworm activity are feasible. Precision application of insecticides may need to be done at cultivation time or may require an additional passage of equipment over the field in no-till systems. Site-specific insecticide applications may be possible at planting time for corn rootworm larval control using maps of the previous season's adult densities with a GIS to drive computer control of the Smart Box™ applicators. Theoretically, management zone maps as presented above would allow a computer to control the rate of flow of insecticides based on planter speed and to appropriately turn the Smart Box™ applicator off and on.

Summary

Public and private research effort is being invested in site-specific insect pest management, but progress in this area lags behind other aspects of site-specific agriculture. Intensive grid-sampled information about insect dispersion in soybean and corn fields provides valuable knowledge, but the usefulness of the information is overshadowed by problems related to implementing precision farming programs for insects. The existence of field level spatial variability in populations of key pests of soybean and corn suggests that a site-specific approach to IPM is possible. The necessary GIS/GPS capabilities are available, but have not been effectively combined into systems incorporating economical scouting methods or real-time monitoring and mapping of pest variability. It has been suggested that optical sensors might be applied for detection of canopy-dwelling insect pests such as the bean leaf beetle. Targeted sampling can be directed by analysis of remotely sensed aerial images that identify anomalous areas indicative of severe pest infestations, provided the cost of the imagery can be kept at reasonable levels and still provide rapid turn-around.

It will take time to overcome the barriers associated with site-specific insect management, but because of the potential benefits of this technology, research in this area will continue to move forward. ■

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