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Survey of Indiana Producers and Crop Advisors: A Perspective on Winter Annual Weeds and Soybean Cyst Nematode (*Heterodera glycines*)

J. Earl Creech, William G. Johnson, Jamal Faghihi, and Virginia R. Ferris*

Growers and certified crop advisors (CCAs) across Indiana were surveyed during the winter of 2003 to 2004 to assess their perceptions about soybean cyst nematode (SCN) and use of SCN management practices. Most farmers (57%) and CCAs (72%) surveyed reported a moderate to high level of concern regarding SCN and its potential impact on soybean yield. The majority of those surveyed were also aware that some winter annual weeds can serve as hosts for SCN. Crop management practices specifically aimed at managing the impact of SCN were employed by 55 and 78% of growers and CCAs, respectively. However, only 21% percent of growers said that they had sampled a field for nematodes within the last two years. Growers from eastern and southern Indiana were less likely to be concerned about SCN, to implement SCN management strategies, and to have the soil tested for SCN than growers throughout the rest of the state. In addition, smaller farmers appear to be less concerned and knowledgeable about SCN than those who operate larger farms. The results of this survey suggest that the majority of Indiana growers would likely adopt winter weed control to manage SCN. Also, with respect to winter weed control, future Extension efforts should be focused on southern Indiana where both the risk for SCN reproduction on winter annuals and the need for education on SCN appear to be highest.

Nomenclature: Soybean, *Glycine max* (L.) Merr.; soybean cyst nematode, *Heterodera glycines* Ichinohe.

Key words: Crop rotation, integrated pest management.

Soybean cyst nematode (*Heterodera glycines*; SCN) is the most economically important pathogen of soybean in the United States, resulting in an estimated \$783.8 million in yield losses in 2002 (Wrather et al. 2003). SCN has been detected in most U.S. soybean production states and is especially common in Indiana where it currently infests at least 82 of 92 counties (Faghihi et al. 2006). Yield losses within fields infested with SCN can range from slight to near-total depending upon severity of infestation, soil type, soybean cultivar, weather conditions, and presence of other soybean pests (e.g., weeds, insects, and fungal pathogens) (Schmitt 1992; Schmitt and Riggs 1989).

Winter annual weeds have become more prevalent in crop production fields in recent years (Nice and Johnson 2005). These species germinate anytime between late summer and early spring, but typically emerge in the fall, over-winter as small seedlings, and complete their life cycles in the spring. This new-found abundance of winter annual weeds has resulted from a number of factors, including the widespread adoption of conservation tillage practices (Wicks et al. 1994), reduced reliance on herbicides with soil residual activity (Barnes et al. 2003), and the relatively mild winters experienced in recent years (Krausz et al. 2003).

One of the potential problems associated with winter annual weeds is that a number of these species have been identified as alternative hosts to SCN. In a recent experiment, the potential of purple deadnettle (*Lamium purpureum* L. LAMPU), henbit (*Lamium amplexicaule* L. LAMAM), field pennycress (*Thlaspi arvense* L. THLAR), and shepherd's-purse [*Capsella bursa-pastoris* (L.) Medik CAPBP]

to support SCN reproduction were confirmed (Venkatesh et al. 2000). Earlier reports had identified common chickweed [*Stellaria media* (L.) Vill. STEME] and smallflowered bittercress (*Cardamine parviflora* L. CARPA) as hosts to SCN (Riggs 1992). Current management recommendations for SCN include rotation with nonhost crops and use of SCN-resistant soybean cultivars (Faghihi and Ferris 2006; Niblack 1999). However, these control measures may be inadequate if SCN populations are able to increase on winter annual weeds when susceptible soybean is not present. A recent report confirmed the ability of SCN to reproduce on purple deadnettle under field conditions in Indiana (Creech et al. 2005). In addition, an increase in SCN population density has been observed in purple deadnettle infested research plots (Venkatesh et al. 2004). Thus, SCN management recommendations might need to be expanded to include winter weed control.

Knowledge of farmers' perceptions about SCN and their level of adoption of current SCN management tactics are essential to predict the rate of grower implementation of winter weed control if it were added to SCN management guidelines. This knowledge is also important to develop educational strategies to promote new SCN management practices in our Extension programs. A report from Missouri showed that approximately 90% of growers plant SCN-resistant soybean but less than 10% had conducted a soil test for SCN within the previous five years (Heinz et al. 2006). However, this report did not address grower concern about SCN, use of crop rotation, or awareness of the interaction between SCN and winter annual weeds. The specific objectives of our research were to (1) determine grower awareness and concern regarding SCN and its interaction with winter annual weeds and (2) document adoption of SCN management practices in Indiana. This information will be used to guide Extension programming aimed at increasing awareness and knowledge of this subject.

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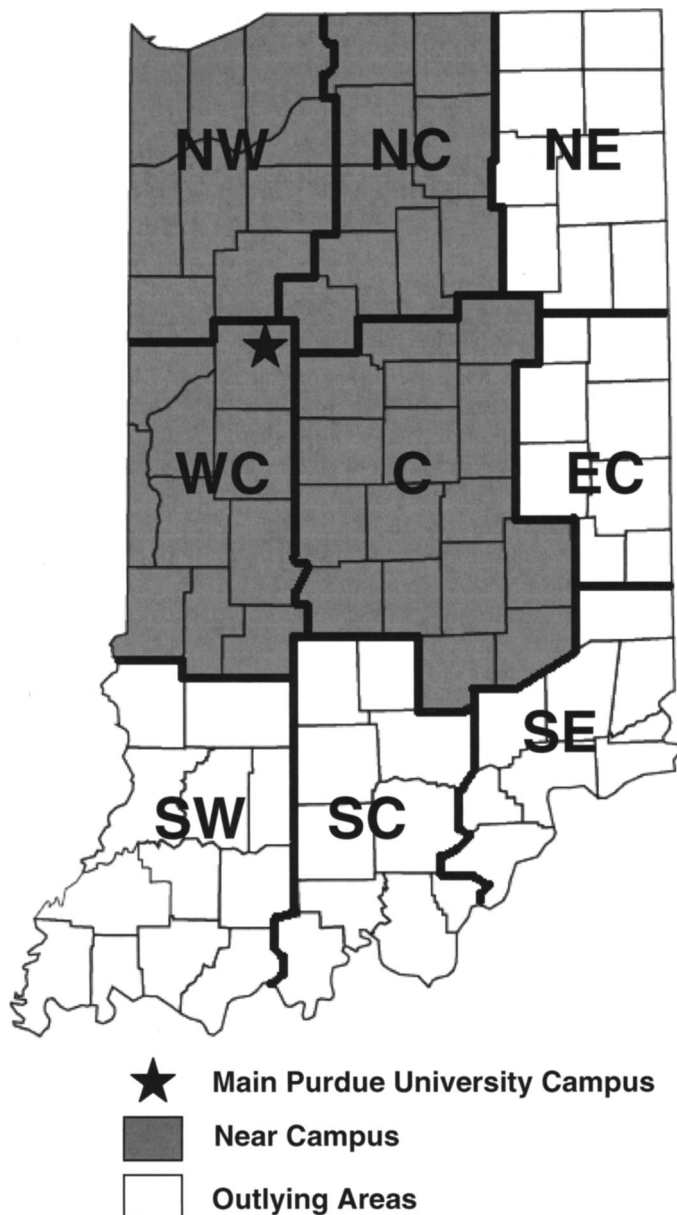


Figure 1. Map of Indiana showing the counties in Extension reporting districts near the main Purdue University campus in West Lafayette and in outlying areas. Abbreviations for Extension reporting districts are NW, North West; NC, North Central; NE, North East; WC, West Central; C, Central; EC, East Central; SW, South West; SC, South Central; and SE, South East.

Materials and Methods

A four-page direct-mail survey was sent to 3,000 corn and soybean growers in Indiana in December 2003. The survey questions were developed in consultation with the Indiana Agricultural Statistics Service¹ (IASS). IASS generated a mailing list, distributed the survey, and conducted follow-up phone calls to clarify answers and obtain at least 30 responses from each of Indiana's nine Extension reporting districts (Figure 1). In addition, a questionnaire containing an abridged list of questions was distributed to 750 attendees at Certified Crop Advisor (CCA) meetings in Indiana in January

2004. The survey contained a number of questions designed to assess perceptions and practices regarding various agronomic and weed management issues. This manuscript presents data from questions related to grower concern about SCN, grower adoption of SCN management practices, and awareness of the interaction between SCN and winter annual weeds. Survey results were summarized by group (grower or CCA), extension reporting district, and farm size. Chi-square analysis was used to determine if group, district, or farm size was significant in survey responses. Data were pooled over farm size or district if Chi-square was not significant at the 0.1 level.

Results and Discussion

Survey Response Rate. Growers returned 612 out of 3,000 survey questionnaires for a response rate of just over 21% (data not shown). This response rate was similar to or higher than the response rates for grower surveys reported by Aref and Pike (1998) (7%), Bourgeois et al. (1997) (25%), Czapar et al. (1997) (27%), and Norsworthy (2003) (14%).

Comparison of Grower and CCA Responses. Most of the farmers (57%) and CCAs (72%) surveyed reported a moderate to high level of concern regarding SCN and its potential impact on crop yield (Table 1). However, 13% more CCAs expressed a "great deal" of concern about SCN than their farmer counterparts. Similarly, 10% more farmers classified themselves as "not concerned" about SCN than CCAs. The difference in response between these two groups is likely the result of disparate levels of education and training. SCN is a microscopic organism that can be detrimental to soybean yield without causing visible injury symptoms to the plant (Niblack 1999). Because the organism and its effects are not always visible in the field, awareness and concern about SCN are generated through off-farm education. Thus, the high-level of training and recertification required for CCAs has likely increased concern regarding SCN over that of the typical grower. However, as this survey assessed "concern" rather than "awareness," some of the growers or CCAs surveyed might have been more aware than concerned about SCN based upon personal knowledge of their own farm or territory.

A few years ago, a report was published that certain winter annual weeds could serve as alternative hosts to SCN (Venkatesh et al. 2000). When asked if they were aware of this report, 62% and 86% of the growers and CCAs, respectively, responded in the affirmative. This level of knowledge of the SCN and winter weed interaction was somewhat surprising to us because it had not been a major part of the Extension emphasis in Indiana prior to the time that these surveys were distributed. However, the agricultural industry has used this knowledge in advertising and marketing strategies as the impetus for the adoption of fall-applied herbicide programs. In addition, farm media outlets such as newspapers and magazines have served as a source of information on the interaction between winter annual weeds and soybean cyst nematodes. This illustrates the powerful influence that agricultural industry and the media can have on grower knowledge and awareness of agronomic issues.

Table 1. Responses to questions regarding SCN and adoption of SCN management practices asked in a direct mail survey of Indiana growers in 2003. Questions 1, 2, and 3 were included in a separate questionnaire distributed to Indiana CCAs in 2004.

	Grower		CCA	
	%	Usable responses	%	Usable responses
1. How concerned are you about nematodes impacting your soybean production? ^a				
a) great deal	16	95	29	106
b) moderate	41	242	43	161
c) a little	29	176	24	88
d) not concerned	14	82	4	16
2. Were you aware that some winter annual weeds can serve as hosts for nematodes? ^b				
a) yes	62	281	86	314
b) no	38	169	14	53
3. Do you employ crop management strategies specifically aimed at managing the impact of nematodes on soybean production? ^c				
a) yes	33	148	46	166
b) sometimes	22	95	32	115
c) no	45	201	22	80
4. In the last 2 years, have you had the soil in any soybean fields sampled for the presence of soybean cyst nematode?				
a) yes	21	95		
b) no	79	358		
A) In 2003 did you have any fields that were planted to soybeans for 2 or more consecutive years?				
a) yes	35	207		
b) no	65	302		
B) If yes, how much of your 2003 soybean crop did this consist of (%)?				
	36	189		
C) What is the average number of years these fields have been in continuous soybean production (years)?				
	2.6	176		
D) Do these fields have more problems with winter annual weeds than fields in a crop rotation?				
a) yes	17	29		
b) no	65	111		
c) not sure	18	30		

^a Chi-square = 40.92 (df = 3), significant at P = 0.001.

^b Chi-square = 54.57 (df = 1), significant at P = 0.001.

^c Chi-square = 46.98 (df = 2), significant at P = 0.001.

As a separate section of the survey, farmers were asked to list the three most problematic winter weeds on their farm. The results of this question were discussed in a companion paper but the five most common species included by growers were chickweed, horseweed, dandelion, henbit, and purple deadnettle (Gibson et al. 2005). Grower response to the question regarding the knowledge of the SCN and winter annual weed interaction was compared to the problematic winter weeds listed by the growers. Growers who were aware of the SCN and winter annual weed interaction listed all five species with higher frequency than those who were not aware of the interaction (Table 2). However, growers who knew of the interaction between SCN and winter weeds were approximately three-times more likely to list henbit or purple deadnettle as a problematic weed on their farm than farmers who were unaware of the interaction. Henbit and purple deadnettle are the two most proficient known winter weed

Table 2. Cross-tabulation of problematic winter annual weeds listed by growers and grower awareness of the interaction of SCN and winter annual weeds.

	Problematic weed				
	Chickweeds	Dandelion	Deadnettle	Henbit	Horseweed
Were you aware that some winter annual weeds can serve as hosts for nematodes? ^a					
a) yes	53	18	13	23	27
b) no	29	13	4	7	17

^a Chi-square = 10.84 (df = 4), significant at P = 0.05.

hosts of SCN (Venkatesh et al. 2000). Thus, these species were more likely to be viewed as problematic on farms where growers were aware that winter annuals can serve as hosts to SCN.

The current management recommendations for SCN are rotation to a nonhost crop and use of SCN-resistant soybean cultivars. These long-standing strategies for SCN management have been adopted, on at least a part-time basis, by 55 and 78% of the growers and CCAs surveyed, respectively (Table 1). Interestingly, 77% of farmers who expressed a moderate to high level of concern about SCN also utilize SCN management practices (data not shown). Thus, those growers who are concerned about SCN also typically adopt some type of management practice for the pest. Therefore, if winter weed control was demonstrated to be an important SCN management tactic, we would expect that roughly half of Indiana farmers would implement such a practice. However, adoption of winter annual weed management might be influenced by other factors such as the time and expense required to make an additional herbicide application.

Twenty-one percent of growers said that they had sampled a field for SCN within the last two years. Although the only means of positively confirming and monitoring an SCN population in the field is through a laboratory soil test, 73% of growers who expressed a moderate to high level of concern about SCN fail to sample their field soils (data not shown). Some of these growers might have confirmed an SCN infestation through sampling in the past and have made the assumption that SCN will always be present and require management on their farm. Others might never have sampled but have concluded that SCN is probably present on their farms because it is problematic throughout the state. In a recent survey from Missouri, 6% of farmers reported sampling for SCN in the last five years (Heinz et al. 2006). The higher percentage of farmers who have sampled in Indiana than Missouri is likely due to the economics of the testing procedure. For many years, the Indiana Soybean Board covered the cost of conducting SCN analysis for Indiana growers at the Purdue Nematology Laboratory through check-off funds. In Missouri, no such commodity group support has been available and growers have borne the cost of soil testing. As of 1 January 2006, the Indiana Soybean Board no longer provides funding for SCN analysis. We expect that this will result in a decrease in the percentage of growers who sample for SCN in Indiana.

To assess the occurrence of crop rotation, growers were asked if they had planted continuous soybean in any field in

2003. Thirty-five percent of growers responded that they had done so. These fields had been in continuous soybean production for an average of 2.6 years and comprised 36% of the soybean production hectareage of these growers. The 2003 growing season was above normal in terms of precipitation in the spring (Anonymous 2005) and planting was delayed for many growers in the state. Thus, this is probably a higher percentage of continuous soybean hectareage than under normal circumstances because growers might have shifted intended corn hectares to soybean because of the shortened growing season.

Growers who had planted continuous soybean in 2003 were also asked if they perceived winter weeds to be more problematic in monoculture fields than in fields where a crop rotation was utilized. Most growers felt that winter annuals were equally problematic, regardless of the crop sequence. This concurs with an observation made in a recent field survey of Indiana corn and soybean production fields where all winter weeds except cressleaf groundsel [*Packera glabella* (Poir.) C. Jeffrey SENGL] were found in equal abundance regardless of previous crop (Creech and Johnson 2006).

Effect of Farm Size and Extension District on Responses.

Survey respondents who farmed 400 or more hectares were more likely to be concerned about SCN, have knowledge of the interaction between SCN and winter annual weeds, and adopt SCN management practices than smaller farmers (data not shown). However, only 6% of the nearly 60,000 growers in Indiana farm more than 400 hectares and these growers account for 45% of the total hectareage in the state (Anonymous 2002). As the small farmer appears to be the least knowledgeable about SCN but represents the majority of Indiana growers in both number of farms and overall hectareage, Extension efforts should be directed toward increasing awareness of SCN and adoption of SCN management practices among this group.

Although an objective of university Extension is to provide educational resources for clientele throughout the state, it is likely that these resources and opportunities are not equally utilized across all Extension reporting districts. To determine how distance from the main University campus influences farmer knowledge and concern about SCN, grower responses from the four Extension reporting districts near Purdue University in West Lafayette were compared to responses from growers in the five extension reporting districts in eastern and southern Indiana (Figure 1). According to the Chi-square statistic, growers near Purdue were more likely to be concerned about SCN, to implement SCN management strategies, and to have the soil tested for SCN than growers in eastern and southern Indiana (Table 3). However, knowledge of the SCN and winter weed interaction was not influenced by distance from the University. SCN awareness, detection, and management have been prominent components of Extension programming at Purdue University for many years. With this established program, its influence appears to decline as proximity to the Purdue University campus in West Lafayette decreases. On the other hand, the interaction between SCN and winter weeds is new information that had

Table 3. Grower response to questions regarding SCN and the adoption of SCN management practices presented by Extension reporting district.

	Districts	
	Near campus ^a	Outlying areas ^b
	%	
How concerned are you about nematodes impacting your soybean production? ^c		
a) great deal	20	12
b) moderate	40	41
c) a little	30	29
d) not concerned	10	18
Were you aware that some winter annual weeds can serve as hosts for nematodes? ^d		
a) yes	65	59
b) no	35	41
Do you employ crop management strategies specifically aimed at managing the impact of nematodes on soybean production? ^e		
a) yes	39	26
b) sometimes	40	52
c) no	21	22
In the last two years, have you had the soil in any soybean fields sampled for the presence of soybean cyst nematode? ^f		
a) yes	25	16
b) no	75	84

^a Consists of the North West, North Central, West Central, and Central Extension reporting districts.

^b Consists of the South West, South Central, South East, East Central, and North East Extension reporting districts.

^c Chi-square = 12.02 (df = 3), significant at P = 0.01.

^d Chi-square = 1.84 (df = 1), not significant at P = 0.1.

^e Chi-square = 7.90 (df = 2), significant at P = 0.025.

^f Chi-square = 6.00 (df = 1), significant at P = 0.025.

not been included in Extension efforts in Indiana prior to the distribution of this survey. Thus, growers demonstrated equal awareness of the issue across the state.

From this survey, it is evident that the majority of growers and CCAs in Indiana are concerned about SCN, regularly employ SCN management practices, and are aware of the interaction between SCN and winter annual weeds. The value of winter weed management as an SCN management tactic is currently unknown. If ongoing research suggests that the presence of winter weeds can result in an SCN population increase, we predict that the majority of Indiana growers would be willing to include winter weed control as a component of their SCN management program. The warmer temperatures present in southern Indiana likely place these growers at higher risk for SCN reproduction on winter weeds than growers in northern Indiana (Creech and Johnson 2006). The results of this survey suggest that the growers in the south are also less likely to be concerned about SCN or to adopt crop management practices directed toward SCN than their northern counterparts. Thus, future Extension efforts should be focused on southern Indiana where both the risk for SCN reproduction on winter annuals and the need for education on SCN are highest.

Sources of Materials

¹ Indiana Agricultural Statistics Service, 1435 Win Hentschel Blvd., Suite B105, West Lafayette, IN 47906-4145.

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