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Distribution of *Heterodera glycines* Races in Illinois

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Abstract: Because the race scheme for *Heterodera glycines* was expanded recently from 5 to 16 races, the occurrence and distribution of races in Illinois need clarification. Forty-four populations of *H. glycines* were collected from sites in 23 of the 88 infested counties. Populations were tested using the differential soybean lines Pickett 71, Peking, PI 88788, and PI 90763. Lee 68 and Williams 82 were used as standards. Seedlings were grown in 7.5-cm-d clay pots and inoculated with 1,000 eggs and second-stage juveniles obtained from *H. glycines*-infested field soil. Plants were maintained in a greenhouse at 22–28 C. After 1 month, the number of first-generation white females that developed on each differential was determined and the race of the population was designated. Twenty-eight populations were race 3, twelve were race 1, two were race 5, one was race 2, and one was race 4. Populations of races 3 and 1 were widely distributed in the state. In 26 of the 28 race determinations, race designations using Williams 82 and Lee 68 were the same, indicating that if Lee 68 is not available, Williams 82 may be a suitable alternative for race tests done in the north central United States.

Key words: distribution, *Glycine max*, *Heterodera glycines*, nematode race, soybean cyst nematode.

The soybean cyst nematode *Heterodera glycines* Ichinohe was first reported in Illinois in 1959 (1). Since then, the nematode has been found in 88 of the 102 counties in the state (4). Races 1, 2, 3, 4, and 5 of *H. glycines*, as well as some uncharacterized populations, had been reported previously in Illinois (4). These populations were characterized using the race scheme first established by Golden et al. (5) to describe races 1–4 and later expanded to include races 5 and 7 (2,6). The scheme employs four soybean differential lines to determine the race of an *H. glycines* population based on the ability of females to reproduce on the soybean differentials relative to a susceptible standard. Riggs and Schmitt (8) recently expanded the race scheme by designating the 16 races that were theoretically possible when using four soybean differentials. The expansion of the race scheme to 16 races provides the means to identify previously unclassified races. The objectives of the research reported herein were to clarify the distribution of *H. glycines* races in Illinois and to determine whether Williams 82 soybean can be substituted for Lee 68 as a standard in race determinations.

MATERIALS AND METHODS

Forty-four populations of *H. glycines* were collected from sites in 23 Illinois counties during 1989 and 1990. Soil samples from infested fields were obtained from county extension advisers and through the University of Illinois Plant Diagnostic Clinic. Samples ranged in size from 4 to 20 liters of soil. Depending on the date of collection, samples were stored in plastic containers at 5 C for 1–10 months prior to initiating experiments. Cysts were extracted from soil using the wet-sieving technique (3) and were hand-crushed in Syracuse watch glasses containing double distilled water. Second-stage juveniles (J2) and eggs were washed onto a modified Baermann funnel; after 24 hours, J2 and eggs were collected and stored for 2 days at 4 C prior to inoculation. Seeds of the soybean differentials Pickett 71, Peking, PI 88788, and PI 90763 (5) and two standards (Lee 68 and Williams 82) were germinated, and after cotyledons expanded, seedlings were transferred individually into 7.5-cm-d clay pots containing autoclaved sand. Plants were inoculated 2 days later with a mixture of 1,000 J2 and eggs in 5 ml of water. Plants were arranged in a completely randomized design and growth in a greenhouse at 22–

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28 C. Replications for individual populations varied from three to six, depending on the amount of inoculum available. One month after inoculation, females were washed off roots and extracted from soil using the gravity-sieving technique with nested 850-μm-pore and 250-μm-pore sieves.

An index (I; 8) was determined for the average number of females that developed on each differential line by dividing the average number of females recovered from the standard and multiplying by 100. A separate value of I was calculated for Lee 68 and for Williams 82.

The value of I for each plant (experimental unit) was calculated, and the average of all the replications determined the index of the differential. If I ≥ 10, the differential was assigned a +, and if I < 10, the differential was assigned a −.

Results

The 44 populations of *H. glycines* were separated into five distinct groups using the four soybean differentials (Table 1). Of the populations tested using Lee 68 as a standard, 28 (64%) were race 3, 12 (27%) were race 1, two (5%) were race 5, one was race 2 (2%), and one was race 4 (2%). Races 6–16 as described in the expanded race scheme (8) were not identified during the study.

The 28 populations identified as race 3 were found in 18 of 23 counties surveyed and were distributed in all regions of the state (Fig. 1). Their distribution ranged from the southern tip (Pulaski Co.) to the northern limits (Lee Co. and Whiteside Co.) and from the western (Adams Co.) to eastern (Clark Co., Edgar Co., and Iroquois Co.) borders as well as to the majority of the centrally located counties included in the study.

The 12 race 1 populations were identified in 10 different counties in the north, central, and west-central regions of the state. The two northernmost counties included in the study (Lee Co. and Whiteside Co.) each contained two race 1 populations.

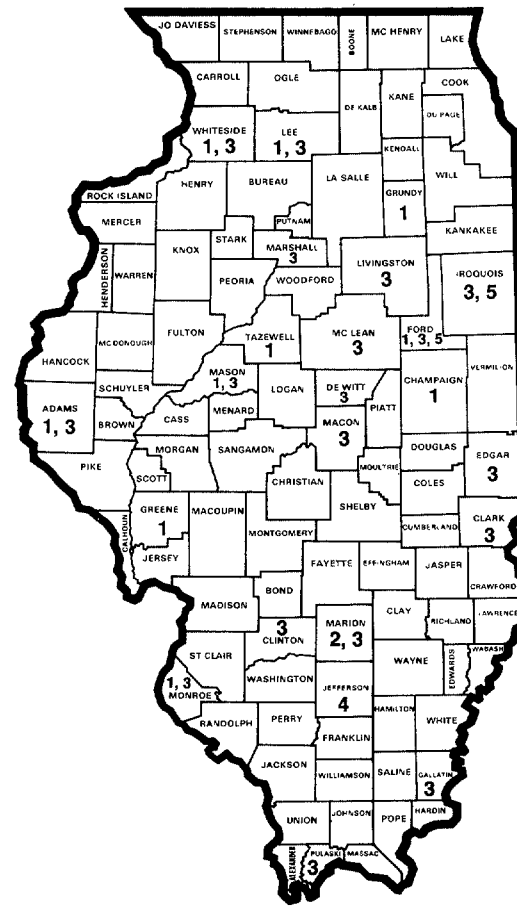

FIG. 1. Distribution of *Heterodera glycines* races in Illinois, 1989–1990.

Both race 5 populations were found in adjacent counties (Ford Co. and Iroquois Co.) in the east-central region of the state. Ford Co. was the only county to have three different races (1, 3, and 5).

The race 2 (Marion Co.) and race 4 (Jefferson Co.) populations were from the south-central region of the state. The race 4 population was collected from research microplots at the USDA nematology farm in Urbana, Illinois (Champaign Co.) in October 1989. The population was collected originally in Jefferson Co. in 1979 and established on the research farm, where it has been maintained for 11 years.

Race determinations for a population were the same for 26 of 28 tests when Lee 68 and Williams 82 were used concurrently

TABLE 1. Developmental index for *Heterodera glycines* populations on four soybean differentials in relation to susceptible soybean standards Lee 68 and Williams 82 and race designation in Illinois, 1989–1990.

County and population	Developmental index (%)†								Race‡	
	Pickett 71		Peking		PI 88788		PI 90763			
	L68	W82	L68	W82	L68	W82	L68	W82	L68	W82
Adams-26	0.0	0.0	0.0	0.0	3.2	1.4	0.0	0.0	3	3
Adams-42	0.0		0.0		30.3		0.0		1	
Champaign-2	3.7	6.9	3.8	6.9	22.6	39.8	0.3	0.8	1	1
Clark-24	1.2	0.0	0.0	0.0	6.0	10.8	0.0	0.0	3	1
Clark-51	1.5		0.4		6.4		0.0		3	
Clinton-27	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3	3
Dewitt-31	6.5		0.0		0.0		0.0		3	
Edgar-17	0.0	0.0	0.0	0.0	6.3	0.0	0.0	0.0	3	3
Edgar-28	0.0		0.0		2.9		0.0		3	
Ford-14	13.0	18.7	3.9	5.9	19.1	27.6	0.0	0.0	5	5
Ford-22	0.0		0.0		10.3		0.0		1	
Ford-29	0.0	0.0	0.0	0.0	3.3	8.2	0.0	0.0	3	3
Gallatin-12	0.0	0.0	0.0	0.0	9.8	16.1	0.0	0.0	3	1
Greene-18	5.0	6.8	0.0	0.0	12.5	17.2	0.0	0.0	1	1
Grundy-7	4.2		4.2		53.1		2.1		1	
Jefferson-54	52.4		18.0		16.1		15.7		4	
Iroquois-10	23.4	22.5	1.7	1.9	32.9	36.1	0.7	1.1	5	5
Iroquois-48	1.8		0.0		9.0		0.0		3	
Lee-3	3.6	4.9	0.0	0.0	45.5	81.6	0.0	0.0	1	1
Lee-6	2.1	1.9	0.3	1.9	41.8	23.7	0.0	0.0	1	1
Lee-21	4.5		0.0		0.0		0.0		3	
Livingston-4	0.3	1.1	0.8	1.1	5.8	6.4	0.2	0.4	3	3
Livingston-36	0.0	0.0	0.0	0.0	4.9	8.0	1.5	0.0	3	3
Livingston-45	1.0		0.0		0.0		0.0		3	
Livingston-49	0.0		0.0		9.6		0.0		3	
Macon-16	0.0		0.0		6.3		0.0		3	
Marion-8	40.3	55.7	25.8	27.4	40.2	47.4	1.3	1.6	2	2
Marion-46	0.0	0.0	0.0	0.0	6.1	4.0	0.0	0.0	3	3
Marshall-15	0.7	0.5	1.3	1.1	6.3	5.1	1.0	0.8	3	3
Marshall-20	0.0	0.0	0.0	0.0	3.5	4.4	0.0	0.0	3	3
Marshall-25	2.4	5.0	0.0	0.0	0.3	0.2	2.4	5.0	3	3
Marshall-38	0.8	2.3	1.5	4.6	0.0	0.0	0.0	0.0	3	3
Mason-19	0.0	0.0	0.0	0.0	36.4	44.8	0.0	0.0	1	1
Mason-41	0.0	0.0	0.0	0.0	2.9	2.4	0.0	0.0	3	3
McLean-40	0.0		0.0		6.1		0.0		3	
Monroe-9	1.0	1.0	0.0	0.0	5.0	5.1	0.0	0.0	3	3
Monroe-30	0.4	1.1	0.0	0.0	11.4	17.5	0.6	1.6	1	1
Monroe-44	0.0	0.0	0.2	1.2	2.8	5.2	0.0	0.0	3	3
Pulaski-3	0.8	0.5	0.0	0.0	3.3	4.1	0.0	0.0	3	3
Pulaski-39	0.0		0.0		5.3		0.0		3	
Tazewell-13	3.3		0.0		13.3		0.0		1	
Whiteside-1	0.5	1.2	0.0	0.0	16.6	13.3	0.0	0.0	1	1
Whiteside-23		0.5		0.0		3.5		0.0		3
Whiteside-35	1.8		0.0		11.7		8.2		1	

† Values are percentage of females that developed on a soybean differential in comparison to Lee 68 (L68, first value) or Williams 82 (W82, second value).

‡ Race designation according to use of either Lee 68 (L68) or Williams 82 (W82) as the standard.

as standards. In two cases (Clark-24 and Gallatin-12), the population was designated as race 3 when Lee 68 was used as the standard and was designated as race 1 when Williams 82 was used. The differences in race designation were attributable to values of I for PI 88788. For Clark-24, I was 6.0 when Lee 68 was the standard and 10.8 when Williams 82 was used. For Gallatin-12, I was 9.8 when Lee 68 was used and 16.1 when Williams 82 was the standard. Substantial differences in I between Lee 68

and Williams 82 were observed for Champaign-2, Lee-3, and Lee-6, but these differences did not affect the outcome of the race designations for the three populations. For the 28 populations, average development of females on Williams 82 was approximately 91% of that recorded on Lee 68.

Discussion

Prior to this study, race 3 was believed to be the dominant race of *H. glycines* in Illinois, and the majority of infestations in Illinois were either designated as races 3 or 4 (4). Although races 1, 2, 5, and a number of undescribed populations had been identified, they were not distributed widely in the state (4). Based on the results of this study, it is apparent that race 3, composing 64% of the populations tested, is the most common race in Illinois. It also is evident that race 1 constitutes a substantial portion (27%) of *H. glycines* infestations in Illinois. The study also showed that populations of races 2, 4, and 5 constitute less than 10% of the *H. glycines* infestations in Illinois. Races 6–16 were not found during this study, indicating that, if present, these races occur in low frequencies.

The extensive distribution of race 1 and the apparent reduction in frequency of occurrence of races 3 and 4 may be due, in part, to an increased awareness of the *H. glycines* problem in the state. Growers and county advisers are more aware of the presence of the nematode and may have become overdependent on the use of race 3 and 4 resistant cultivars such as Fayette and private lines developed from it and its parent, L77-994 (7). Proper use of these cultivars in a rotation scheme involving both nonhost crops and *H. glycines*-susceptible soybean cultivars will reduce the nematode population without causing a shift in its gene frequency (10). However, continuous cropping of a resistant cultivar and its overuse in a cropping sequence can lead to the development of a population that can attack the resistant cultivar (4). Increased planting of cultivars with the PI 88788 source of resistance may explain the distribution and frequency of race 1 in Illinois and the reduced distribution of races 3 and 4. However, results also suggest that race 1 is more common in the northern third of the state, where limited planting of resistant cultivars has occurred. Previous race tests may not have been accurate. The level of resistance to race 1 in cultivars with the Peking source of resistance and adapted to the Midwest was never evaluated critically. Thus, moderate levels of developmental indices on a cultivar such as Franklin may have been attributed to race 4 when the level of resistance to race 1 also may have been low. Because there are few choices for resistance to race 1, additional race determinations for populations from the southern half of the state are needed. Management strategies may need revision if race 1 is widespread.

In order to standardize race tests, it is desirable to use a single source of pure seed of all lines used in the tests (9) and to use Lee as the standard control (5,9), but Lee and Lee 68 are not readily available. Williams 82 is a maturity group III cultivar commonly grown in central Illinois that is susceptible to *H. glycines.* Because of its availability and the geographical area to which it is adapted, Williams 82 has been used as the susceptible standard in place of Lee 68 in race tests in the north-central region. Results indicate that when using both cultivars, race determinations were in agreement 92% of the time. This would indicate that if seed of Lee 68 is not available, Williams 82 can be substituted for Lee 68 as the susceptible standard in race tests in the north-central United States without adversely affecting proper use of resistant soybean to manage *H. glycines* in the region (4,7).

Literature Cited

1. Brewer, F. L. 1981. Special assessment of the soybean cyst nematode *Heterodera glycines* problem. Joint planning and evaluation staff paper. U.S. Department of Agriculture, Washington, DC.

2. Chen, P. H., D. S. Zhang, and S. Y. Chen. 1987. First report on a new physiological race (race 7) of soybean cyst nematode (*Heterodera glycines*). Journal

of Chinese Academy of Agricultural Sciences 20:94 (Abstr.).

3. Cobb, N. A. 1918. Estimating the nema population of soil. Agricultural Technology Circular No. 1, Bureau of Plant Industry, U.S. Department of Agriculture, Washington, DC.

4. Edwards, D. I., G. R. Noel, and E. J. Sikora. 1990. The soybean cyst nematode problem. Illinois Cooperative Extension Service Report on Plant Disease No. 501. University of Illinois, Urbana.

5. Golden, A. M., J. M. Epps, R. D. Riggs, L. A. Duclos, J. A. Fox, and R. L. Bernard. 1970. Terminology and identity of infraspecific forms of the soybean cyst nematode (*Heterodera glycines*). Plant Disease Reporter 54:544–546.

6. Inagaki, H. 1979. Race status of five Japanese populations of *Heterodera glycines*. Japanese Journal of Nematology 9:1–4.

7. Noel, G. R., and E. J. Sikora. 1990. Evaluation of soybeans in maturity groups I-IV for resistance to *Heterodera glycines*. Supplement to the Journal of Nematology 22:795–799.

8. Riggs, R. D., and D. P. Schmitt. 1988. Complete characterization of the race scheme for *Heterodera glycines*. Journal of Nematology 20:392–395.

9. Riggs, R. D., D. P. Schmitt, and G. R. Noel. 1988. Variability in race tests with *Heterodera glycines*. Journal of Nematology 20:565–572.

10. Triantaphyllou, A. C. 1975. Genetic structure of races of *Heterodera glycines* and inheritance of ability to reproduce on resistant soybeans. Journal of Nematology 7:356–364.