1982, 1984) involved crosses between male-sterile lines developed in China, which possessed restricted polymorphism and male parents of different geographical origins. In those studies, isozymes were markers of genetic diversity associated with the geographic diversity and, thus, may be related to heterosis. Such results, however, are of value only if the complementary yield factors brought together in these hybrids are controlled by genes tightly linked with isozyme genes, which only would allow persistence of the isozyme (yield factor associations) during the improvement of parental populations. Our results were obtained using mostly IRRI developed lines resulting from complex crosses involving parents of various geographic origins. These crosses provided the opportunity for extensive recombination among genes during various cycles of breeding. This would have led to breakup of any association between isozyme marker loci and gene blocks involved in heterosis for yield. It is, therefore, understandable why our studies did not show any relationship between isozyme variation and yield heterosis in indica rice.

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SOYBEAN PLANT INTRODUCTIONS WITH RESISTANCE TO RACES 4 OR 5 OF SOYBEAN CYST NEMATODE

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Abstract

Soybean cyst nematode (*Heterodera glycines* Ichinohe) (SCN) is a serious pest of soybean [*Glycine max* (L.) Merr.] in the southern USA. A major portion of the U.S. soybean collection has not been screened for races of SCN. Approximately 9000 soybean plant introductions (PIs) were screened for their reaction to SCN races 4 and 5 in the greenhouse. The seedlings were grown in soil infested with SCN, and white females on the roots were counted. We found 21 PIs with some level of resistance to either race 4 or 5. A total of seven resistant, three moderately resistant, and two moderately susceptible PIs for race 4 were identified. Two PI's were heterogeneous for resistant and moderately resistant reactions. For race 5, seven PIs were resistant, two showed moderate resistance, two were moderately susceptible, whereas one segregated for resistant and moderately resistant reactions. All PIs showing resistance to races 4 or 5 were earlier reported to be resistant to race 3 and are in either Maturity Group II, III, or IV. PI 437654 was resistant to both races 4 and 5. In additional tests, it was found to be resistant to five races (races 1 through 5) of SCN. PI 437654 is the only PI resistant to all five recognized races of SCN and would be a good source in resistant cultivar development. These PIs are available to the researchers from the USDA soybean germplasm collection.

Additional Index Words: ***Glycine max*** **(L.), Merr.** ***Heterodera glycines*** **Ichinohe, Disease screening, Germplasm.**

SEVERAL SOYBEAN cultivars resistant to soybean cyst nematode (SCN) races 3 or 4 are in production in the USA. Each has genes for resistance from 'Peking' or PI 88788 (5). Epps and Hartwig (4) studied more than 3000 soybean plant introductions (PIs) and found 8 of them to be resistant to race 4. Several other PIs were reported to be resistant to races 3, 4, and 5 (3). The number of PIs in the USDA soybean germplasm collection has increased appreciably in recent years. Most of these PIs were screened for reaction to SCN race 3, and 45 resistant and moderately resistant PIs were identified (2). It seemed desirable to determine the reaction of the entire collection of over 9000 accessions to SCN races 4 and 5 in order to identify additional sources of resistance.

Materials and Methods

Soybean PIs in the USDA-ARS collection in Maturity Groups 000 through IV maintained at the University of Illinois, Urbana, IL, and those in Maturity Group V through X that are maintained at Stoneville, MS, were evaluated for reaction to SCN races 4 and 5. A total of 9153 PIs through PI 458024A were screened. Each SCN race was developed

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and maintained on a specific susceptible soybean host in the greenhouse. The host line was grown in a 1 × 3-m bed filled with SCN infested soil containing one race. After 30 to 35 d, the plants were gently pulled and the white females on the roots were picked and returned to the soil. A portion of the soil was used for screening and the bed was again filled with soil that was previously sterilized with methyl bromide. In each case, Broseley fine sandy soil (loamy, mixed, thermic Arenic Hapludalf) obtained from the Rhodes Farm was used for maintaining and increasing the inoculum. Soybean cyst nematode race 4 was collected from the Rhodes Farm of the University of Missouri near Clarkton, MO, and maintained on PI 90763. Race 5 was isolated from the roots of 'Bedford' and was maintained on PI 88788. Soybean cyst nematode races 1 and 2 were obtained from Donald P. Schmitt, Department of Plant Pathology, North Carolina State University, Raleigh, NC, and were maintained on 'Essex' for inoculating PI 437654. The results of screening for race 3 had previously been reported (2).

Soybean seedlings were grown in 7.5-cm clay pots filled with soil containing 20 to 30 cysts per 100 g of soil. Two seeds of each soybean PI were planted in each of 10 pots that were thinned to a single seedling after emergence. Plantings were made in the greenhouse that was maintained at 24 °C ± 4. Thirty days after planting, the roots were exposed by gently shaking them free of soil. The white females on the roots of each seedling were counted and compared with those on Essex (a susceptible cultivar), 10 plants of which were tested each time a new soil lot was used. The rating scale was based on (no. of white females per test plant/no. of white females on Essex) × 100, using the following classes, resistant: < 10%; moderately resistant: 10 to 25%, and moderately susceptible: 26 to 50%. The PIs with ratings above 50% were classified as susceptible. The entire screening took approximately 3 yr (1983 to 1985).

Results

The reaction of the soybean PIs that were at least moderately resistant to either SCN race 4 or 5 along with their reaction to SCN race 3 as previously reported (2) are listed in Table 1. In the majority of cases, uniform reactions for SCN infection was obtained for all the plants within a given PI. However, in a few cases the PIs appeared to be heterogeneous for the type of reaction. These PIs were again screened to confirm the results for the reaction types. None of the race 3 susceptible PIs were found to be resistant to races 4 or 5. This was attributed to the lack of genes for parasitism in race 3 of known resistant germplasm (6). A total of 21 PIs were found to have some level of resistance to either race 4 or 5. Of those, six were completely susceptible to race 4 and nine were completely susceptible to race 5. Of the remaining six (with some degree of resistance to both races), only PI 437654 had a high level of resistance to both races 4 and 5. All PIs listed in Table 1 have a black or brown seed coat and are in either Maturity Group II, III, or IV. Studies are underway to determine whether newly identified PIs have genes for resistance to SCN different from those previously identified.

PI 437654, which was found to be resistant to SCN races 3, 4, and 5, was evaluated for reaction to SCN races 1 and 2 and was found to be resistant to these races also. This is the only soybean PI with resistance to all five known races of SCN and would be an excellent source of resistance in breeding resistant cultivars.

Seed of resistant PIs in Maturity Group 000 through IV may be obtained by contacting Dr. R.L. Bernard, USDA-ARS, Department of Agronomy, 1102 S. Goodwin Ave., University of Illinois, Urbana, IL 61801.

Table 1. Description of soybean PIs and their response to races 4 and 5 of the soybean cyst nematode.

Soybean line	Maturity group	Received from	Year received	SCN Race 3†	SCN Race 4	SCN Race 5
Ilsoy (PI 6387 sel.)	III	Korea	1901	R‡	MR	S
Cloud (PI 16790 sel.)	III	China	1905	R	R§	S
Peking (PI 17852B sel.)	IV	China	1906	R	S	R
PI 87631-1	III	Japan	1930	R	R§	S
PI 88788	III	China	1930	R	R§	S
PI 89772	IV	China	1930	R	S	R§
PI 90763	IV	China	1930	R	MS	R
PI 209332	IV	Japan	1953	R	R	S
PI 339868B	IV	Korea	1968	R	S	MR
PI 398680	IV	Korea	1974	R	MR,R¶	S
PI 404166	III	Russia	1975	R	S	R§
PI 404198A	IV	Russia	1975	R	MS	R§
PI 404198B	IV	Russia	1975	R	MR	MS
PI 407729	IV	China	1976	R	MR,R¶	MS
PI 416762	II	Japan	1977	R	R§	S
PI 437654	III	Russia	1980	R	R§	R§
PI 437655	III	Russia	1980	R	R§	S
PI 437679	IV	Russia	1980	R	S	MR,R¶
PI 437690	III	Russia	1980	R	S	MR
PI 438489B	IV	Russia	1980	R	MR,MS¶	R§
PI 438503A	III	Russia	1980	R	MR	S

† SCN race 3 reaction reported by Anand and Gallo (2).
‡ Resistant (R) = 0 to 10% white females; moderately resistant (MR) = 10 to 25% white females; moderately susceptible (MS) = 26 to 50% white females/plant compared with those on Essex; S = susceptible.
§ Resistance has been reported previously (1, 3, 4).
¶ Segregating.

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