

# New Soybean Accessions Identified with Resistance to *Heterodera glycines* Populations



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## INTRODUCTION

Soybean cyst nematode (SCN, *Heterodera glycines* Ichinohe) is the most pervasive pest of Soybean [*Glycine max* (L.) Merr.], in the USA and worldwide. First reported in North Carolina (Winstead et al., 1955), SCN has since spread throughout most of the soybean production states. In 2012, SCN reduced soybean yields in USA by an estimated 10.34 million bushels (Koenning, 2013). These losses have remained stable at the current levels with the use of resistant cultivars, but, over time, nematodes will adapt to deployed resistance alleles. Therefore, more broad and durable resistance in soybean is required to mitigate shifts in nematode populations. We have evaluated newly available accessions from the USDA Soybean Germplasm Collection in the greenhouse for reaction to two nematode populations (Race 1 and Race 3) or HG Types (Niblack et al., 2000) to identify new sources.

## MATERIALS AND METHODS

We have previously reported methods for nematode collection and culture in the greenhouse for developing near homogeneous populations for stable reactions (Arelli et al., 2000). Two-hundred thirty-nine accessions from USDA Soybean Germplasm Collection were bioassayed in this research. Bioassays were performed in the greenhouse for two SCN populations: Races 1 and 3 (HG Types 2.5.7 and 0, respectively), during 2011-2014. The methods used were already described in Arelli et al. (2015). In brief, for each nematode population, seven seedlings were evaluated for each of 239 accessions, susceptible control, and indicator lines (Figure 1a). Each seedling within a genotype represented a single replication; the test was completely randomized and repeated twice. Approximately 30 d after inoculation, plant roots were individually washed with a strong jet of water to dislodge white females and cysts (Figure 1b). These were counted under a stereomicroscope, and a female index (FI%) was calculated for the number of females developed on each line in each replication (Golden et al., 1970). Data were combined for the two tests for each nematode population for ANOVA of female indices by the Statistical Analysis System software (SAS, 1991) and means were separated with Fisher's LSD based on a significant F test (Table 1). Ratings of resistant (FI=0-9%), moderately resistant (FI=10-30%), moderately susceptible (FI=31-60%), and susceptible (FI>60%) used to classify the reaction of accessions were based on Schmitt and Shannon (1992).



Figure 1. Seedlings inoculated with *H. glycines* eggs grow in clay pots in the greenhouse (a). *H. glycines* cysts adhere firmly to soybean roots, and must be dislodged with a strong jet of water (b).

Table 1. Race 1 (HG Type 2.5.7) and Race 3 (HG Type 0) greenhouse screening results for 239 accessions, indicator lines, and susceptible control.

Accession ID	MG <sup>†</sup>	Seed Coat Color <sup>‡</sup>	Race 1 (HG Type 2.5.7)		Race 3 (HG Type 0)	
			FI % <sup>§</sup>	Rating <sup>¶</sup>	FI % <sup>§</sup>	Rating <sup>¶</sup>
PI567706B	III	G	87	S	25	MR
PI567707	IV	Y	146	S	43	MS
PI567708	IV	Y	112	S	34	MS
PI567709	IV	Y	171	S	24	MR
PI567710	IV	Y	142	S	21	MR
PI567711A	IV	Y	156	S	25	MR
PI567711B	IV	Y	132	S	25	MR
PI567712	III	Y	129	S	38	MS
PI567713A	III	Y	177	S	56	MS
PI567713B	IV	G	146	S	90	S
PI567713C	IV	Y	140	S	83	S
PI567713D	IV	Y	90	S	81	S
PI567713E	IV	Y	145	S	59	MS
PI567714	IV	Y	83	S	18	MR
PI567715	IV	Y	76	S	16	MR
PI567716A	IV	Y	111	S	18	MR
PI567716B	IV	Y	118	S	13	MR
PI567717A	III	Y	105	S	16	MR
PI567717B	IV	Y	119	S	17	MR
PI567717C	IV	Y	130	S	22	MR
PI567718	IV	Y	115	S	25	MR
PI567719	IV	Y	127	S	13	MR
PI567720A	III	Y	123	S	14	MR
PI567720B	IV	Y	114	S	15	MR
PI567721	IV	Y	143	S	15	MR
PI567722	IV	Y	106	S	24	MR
PI567723	IV	Y	67	S	24	MR
PI567724	IV	Y	93	S	28	MR
PI567725	IV	Y	161	S	41	MS
PI567726	IV	Br	56	MS	6	R
PI567727A	IV	Y	85	S	23	MR
PI567727B	IV	Y	85	S	16	MR
PI567728	IV	Y	72	S	16	MR
PI567729	III	Y	77	S	21	MR
PI567730	IV	Y	77	S	12	MR
PI567731	III	Y	130	S	16	MR
PI567732	III	Y	102	S	26	MR
PI567733	IV	Y	125	S	37	MS
PI567734	IV	Y	52	MS	16	MR
PI567735	IV	Y	46	MS	19	MR
PI567737	IV	Y	65	S	8	R
PI567738A	IV	Y	101	S	44	MS
PI567738B	IV	Y	103	S	36	MS
PI567739A	IV	Gn	42	MS	25	MR
PI567739B	IV	Gn	51	MS	33	MS
PI567740	IV	Y	106	S	20	MR
PI567741	IV	Y	6	R	15	MR
PI567742A	IV	Y	85	S	29	MR
PI567743	IV	Y	68	S	40	MS
PI567744A	IV	Y	83	S	13	MR
PI567744B	IV	Y	75	S	16	MR
PI567745	IV	Y	68	S	35	MS
PI567746	IV	Y	83	S	41	MS
PI567748	IV	Y	-	NA	23	MR
PI567749A	IV	Y	45	MS	115	S
PI567749B	IV	G	77	S	40	MS
PI567750	IV	Y	72	S	46	MS
PI567751A	IV	Y	85	S	36	MS
PI567751B	IV	Y	100	S	69	S
PI567752	IV	Y	95	S	48	MS
PI567753A	II	Y	35	MS	29	MR
PI567753B	III	Y	96	S	36	MS
PI567753C	IV	Y	89	S	26	MR
PI567754	IV	Y	64	S	21	MR
PI567755A	IV	Y	70	S	39	MS
PI567755B	IV	G	103	S	24	MR
PI567756A	IV	Y	84	S	34	MS
PI567756B	IV	?	-	NA	76	S
PI567758	IV	G	-	NA	40	MS
PI567760	IV	Y	112	S	55	MS
PI567761	III	Rbr	45	MS	24	MR
PI567762A	IV	Y	40	MS	40	MS
PI567762C	IV	Y	52	MS	68	S
PI567765A	III	Y	87	S	72	S
PI567765B	IV	Y	77	S	83	S
PI567765C	IV	Y	77	S	37	MS
PI567765D	IV	Y	75	S	46	MS
PI567767A	IV	Y	67	S	26	MR
PI567767B	IV	Y	52	MS	57	MS
PI567767C	IV	Y	49	MS	24	MR
PI567768	III	Y	72	S	46	MS
PI567769	IV	Y	73	S	28	MR
PI567770A	III	Y	52	MS	16	MR
PI567770B	II	Y	67	S	68	S
PI567770C	IV	Y	69	S	49	MS
PI567771A	II	Y	52	MS	37	MS
PI567771B	III	Y	92	S	23	MR
PI567771C	IV	Y	67	S	9	R
PI567771D	IV	Y	79	S	39	MS
PI567771E	IV	Y	48	MS	16	MR
PI567772	IV	Gn	48	MS	14	MR
PI567773	IV	Y	78	S	7	R
PI567774A	III	Y	45	MS	26	MR
PI567774B	III	Y	68	S	37	MS
PI567775A	III	Y	167	S	23	MR
PI567775B	IV	Y	167	S	140	S
PI567776	III	Y	127	S	140	S
PI567778	III	Y	174	S	65	S
PI567779A	IV	Y	146	S	71	S
PI567779B	IV	Y	172	S	35	MS
PI567780B	IV	Y	138	S	36	MS
PI567781	IV	Y	108	S	72	S
PI587981	III	Y	126	S	91	S
PI594647A	IV	Y	126	S	-	NA
PI597452C	III	Gn	112	S	148	S
PI603292	O	Y	95	S	100	S
PI603300	O	Y	108	S	76	S
PI603343B	II	Y	143	S	86	S
PI603353	I	Y	113	S	79	S
PI603390B	II	Y	109	S	35	MS
PI603422C	II	Bl	91	S	32	MS
PI603422D	II	Bl	84	S	40	MS
PI603444E	III	Bl	125	S	146	S
PI603614B	IV	Y	145	S	200	S
PI603777	IV	Y	-	NA	1	R
PI603780	IV	Bl	141	S	115	S
PI603781	IV	Bl	169	S	-	NA
PI603784	IV	Bl	79	S	-	NA
PI605743A	III	Lgn	127	S	98	S
PI605743B	IV	Lgn	5	R	87	S
PI605745A	III	Lgn	140	S	130	S
PI605745B	II	Lgn	103	S	244	S
PI605745C	III	Lgn	144	S	126	S
PI605750	I	Y	83	S	194	S
PI605752	III	Y	128	S	118	S
PI605759	III	Y	140	S	129	S
PI605765A	I	Lgn	102	S	67	S
PI605770	IV	Y	108	S	-	NA
PI605771	IV	Y	117	S	78	S
PI605780A	IV	Y	115	S	-	NA
PI605780C	IV	Y	71	S	-	NA
PI605782B	IV	Y	154	S	135	S
PI605788	IV	Y	105	S	145	S
PI605792A	IV	Y	121	S	80	S
PI605792D	IV	Y	131	S	-	NA
PI605794	IV	Y	103	S	168	S
PI605795	IV	Y	100	S	-	NA
PI605796	II	Y	165	S	167	S
PI605799A	IV	Y	129	S	-	NA
PI605800A	IV	Y	111	S	-	NA
PI605800B	III	Y	153	S	141	S
PI605801A	III	Y	115	S	112	S
PI605801B	IV	Y	120	S	39	MS
PI605803	IV	Y	110	S	121	S
PI605804A	IV	Y	107	S	198	S
PI605804B	IV	Y	94	S	64	S
PI605806A	IV	Y	150	S	108	S
PI605811	IV	Y	94	S	2	R
PI605815	III	Y	167	S	-	NA
PI605816	IV	Y	92	S	-	NA
PI605817A	IV	Y	159	S	-	NA
PI605817B	IV	Y	164	S	97	S
PI605818A	IV	Y	161	S	113	S
PI605819A	O	Y	119	S	89	S
PI605819B	O	Y	100	S	52	MS
PI605819C	O	Y	101	S	59	MS
PI605821A	IV	Y	80	S	168	S
PI605821B	IV	Y	127	S	40	MS
PI605822	II	Y	82	S	2	R
PI605824B	IV	Y	130	S	141	S
PI605825A	IV	Y	119	S	-	NA
PI605825B	IV	Y	100	S	27	MR
PI605825C	IV	Y	136	S	-	NA
PI605826A	IV	Y	120	S	14	MR
PI605826B	IV	Y	88	S	159	S
PI605826C	IV	Br	91	S	-	NA
PI605826D	IV	Br	98	S	67	S
PI605827A	IV	Y	186	S	98	S
PI605828B	IV	Y	159	S	76	S
PI605830A	IV	Y	110	S	69	S
PI605831C	IV	Y	163	S	58	MS
PI605832B	IV	Y	108	S	-	NA
PI605834A	IV	Y	124	S	149	S
PI605834C	IV	Y	104	S	-	NA
PI605835	IV	Y	151	S	124	S
PI605837A	IV	Y	128	S	50	MS
PI605837B	IV	Y	124	S	-	NA
PI605837C	IV	Y	113	S	12	MR
PI605839A	IV	Gnbr	111	S	162	S
PI605840B	IV	Y	115	S	114	S
PI605840C	IV	Gn	79	S	-	NA
PI605840D	IV	Y	74	S	-	NA
PI605840E	IV	Y	95	S	56	MS
PI605840F	IV	Y	113	S	110	S
PI605840G	IV	Y	144	S	28	MR
PI605841A	IV	Y	119	S	39	MS
PI605842A	IV	Y	84	S	153	S
PI605842B	IV	Y	78	S	199	S
PI605842C	IV	Y	220	S	167	S
PI605843	IV	Bl	101	S	180	S
PI605844A	IV	Y	101	S	139	S
PI605844B	IV	Y	90	S	198	S
PI605844D	IV	Y	103	S	275	S
PI605844E	IV	Y	64	S	210	S
PI605844F	IV	Y	51	MS	116	S
PI605845A	IV	Y	80	S	-	NA
PI605845B	IV	Y	96	S		