Screening Soybeans for Resistance to Reniform Nematode Disease in the Philippines[1]

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Abstract: Sixty-five soybean varieties were tested in the field for resistance to *Rotylenchulus reniformis.* Criteria for resistance or susceptibility were root necrosis, nematode recovery from roots and soil, and egg production. Nine varieties were resistant, 13 moderately resistant, 26 moderately susceptible, and 17 susceptible. Linear correlations between resistance rating and each assessment parameter were highly significantly positive, suggesting that any of the parameters could be used to identify resistance. There were also highly significant positive linear correlations between any two combinations of parameters, indicating that they were reciprocally related. *Key Words:* soybean resistance, screening, *Rotylenchulus reniformis,* reniform nematode, assessment parameters, statistical correlations.

Soybean [*Glycine max* (L.) Merr.] is becoming an important crop in the Philippines because demand, particularly for livestock feed, exceeds production, and feed millers import soybean meal at an annual cost of $70 million in foreign exchange (3).

A potentially important pest of soybean is the reniform nematode, *Rotylenchulus reniformis* Linford & Oliveira (2, 14). *Rotylenchulus* spp. are the most widely distributed and abundant nematodes in the Philippines, in soils growing soybean and other nongraminaceous annual upland crops (4, 5, 10). In a field experiment, yield reduction in soybean due to *R. reniformis* was as high as 45% during the dry season (8). This nematode is believed to be as important as *Meloidogyne* spp. on soybean.

Several soybean breeding lines and varities showed resistance to *R. reniformis* in pot experiments conducted in the United States (1, 2, 13, 15). This study was designed to screen soybean varieties for resistance to *R. reniformis* under Philippine conditions, and to identify the most efficient parameters for determining varietal resistance.

MATERIALS AND METHODS

The experiment was conducted on an area of 17 × 40 m on Maahas clay loam soil at the International Rice Research Institute (IRRI) Experiment Station, College,

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Laguna, Philippines. The field had been planted to three successive crops of mung bean, cowpea, soybean, and peanut. The land was cultivated with a small rototiller, and three blocks were prepared, each 5.3 × 40 m, separated by 0.50-m bunds. Each block was subdivided into two 2.4 × 40-m plots, each surrounded by a 0.50-m drainage ditch. Forty 0.75 × 2.4-m beds, 0.25 m apart, were constructed per plot, making 80 beds per block.

The test plants were 80 soybean varieties obtained from the Asian Vegetable Research and Development Center (AVRDC), Tainan, Taiwan; Bureau of Plant Industry (BPI), Los Banos, Laguna, Philippines; and Department of Agronomy, UPLBCA, College, Laguna, Philippines. Seeds of each variety were planted in single rows, with 20 cm between hills, in an 11-hill row. Three seeds were sown per hill at a depth of 3 to 4 cm. A randomized complete block design with three replications (blocks) was used. Only 65 varieties germinated. The cropping period was 30 June to 15 September 1977.

Split application of an inorganic fertilizer containing 14% N, 14% P, and 14% K was done on a bedwise basis at 60-60-60 kg/ha. The first application was during land preparation, and the second and the third 1 and 2 months after planting. Handweeding was done whenever necessary. Insects and fungal diseases were controlled by foliar spraying, as needed, respectively with monocrotophos 16.8% EC at 1.0 kg ai/ha and with a coordination product (80% manganese and 20% zinc ethylene bisdithiocarbamate) at 1.5 kg ai/ha. Plants were watered by natural rainfall.

Initial population densities of plant-parasitic nematodes in the experimental area were determined after the beds were prepared. Each of the three blocks was divided crosswise into seven sections. Collected from each section were 60 randomly obtained 50-cc soil samples at a depth of 6 to 20 cm from the top of the bed. These samples were pooled, and nematodes were extracted from 300-cc composite sample by the combination of sieving and Baermann funnel techniques and quantified with a dissecting microscope. To account for nematode eggs, which could not be isolated from the soil by the extraction procedure used, the sieved soil samples were further assayed on the reniform nematode-susceptible mung bean (MG 50-10A) by a procedure described by Castillo et al. (7).

Nematode population densities were also determined at the last harvest, 11 weeks after planting. Sampling for nematodes was done by collecting about 100-cc soil samples containing feeder roots from each of five alternate hills along the plant row of each bed. The first and last hills of each bed were not sampled. The samples were pooled, and a composite 300-cc soil sample and a 1-g root sample were obtained. Soil samples were processed and examined for nematodes as in determination of initial densities except that no bioassay was made of the sieved soil. Root samples were stained in acid fuchsin-lactophenol and cleared in lactophenol (12). The presence and number of nematodes in or on the roots were determined by crushing a few root pieces at a time between two glass slides and examining them under a dissecting microscope. Data were also collected on numbers of egg masses/g of roots and eggs/egg mass.

Plants from the hills of each bed sampled for nematodes were carefully uprooted with a trowel, and the roots were washed and examined for disease symptoms with a magnifying glass (3X). The only symptom observed was necrotic discoloration, which was rated on a severity scale of 1 to 5 based on relative percentages of necrotic portions of root systems. Browning of the roots was interpreted as indication of root necrosis.

Data collected at the end of the experiment were analyzed statistically, and differences were determined among means of the varieties within each criterion. For objective comparison of the resistance of the varieties, indices were computed for necrosis, nematode recoveries (from roots, from soil, from both soil and roots), numbers of egg masses observed in roots, and eggs/egg mass. That was done by assigning arbitrary but standardized values to the statistical means of the varieties within each parameter and considering the average of the indices as the resistance rating of the variety concerned. On the basis of resistance ratings, four host categories were assigned to the varieties: resistant, moderately resistant, moderately susceptible, and susceptible.

To select the parameter that would be

TABLE 1. Root necrosis rating of soybean varieties grown in field infested with *Rotylenchulus reniformis* and nematode recovery and reproduction 11 weeks after seeding.[a]

Variety	Source of seeds	Necrosis rating[b]	Number of nematodes recovered from: 1 g roots	300 cc soil	Total	Number of egg masses/g of roots	Number of eggs/egg mass[c]
TK 5	UPLBCA	1.2 a	8.3 a	10.3 a	18.6 a	0.3 a	34.0 a-b
Strain 99	BPI	1.3 a-b	12.7 a-b	37.3 a-d	50.0 a-d	0.3 a	29.0 a
Strain 12	BPI	1.5 a-c	14.0 a-c	18.0 a-b	32.0 a-b	1.0 a-b	30.7 a
PI 200451	UPLBCA	1.3 a-b	14.0 a-c	28.0 a-c	42.0 a-c	1.0 a-b	34.5 a-b
GC 40078-40	AVRDC	1.5 a-c	13.0 a-b	20.0 a-b	33.0 a-b	1.7 a-c	39.6 a-d
EGSY 12	BPI	1.5 a-c	14.0 a-c	41.7 a-e	55.7 a-e	2.3 a-d	36.8 a-b
GC 40142-0-66	AVRDC	1.5 a-c	11.3 a-b	52.3 a-f	63.6 a-g	2.3 a-d	42.3 a-e
EGSY 6	BPI	1.6 b-c	20.0 a-f	68.0 a-g	88.0 a-h	2.0 a-c	45.2 a-g
UPL-SY 2	UPLBCA	1.6 b-c	19.3 a-e	39.3 a-d	58.6 a-f	2.7 a-e	49.5 b-h
K.E. 32	UPLBCA	1.8 c-d	21.7 a-g	70.0 a-g	91.7 a-i	4.3 a-h	38.3 a-c
Ross	UPLBCA	2.0 d-e	21.7 a-g	81.7 a-h	103.4 a-j	1.7 a-c	49.2 b-h
GC 40176-1-12	AVRDC	1.7 c-d	31.0 a-k	72.7 a-g	103.7 a-j	3.0 a-e	45.3 a-g
EGSY 78	BPI	2.0 d-e	18.7 a-d	86.3 a-i	105.0 a-j	2.7 a-e	55.3 d-j
Tainung 4 x Ross	UPLBCA	2.0 d-e	20.0 a-f	88.0 b-j	108.0 b-k	6.7 b-i	42.9 a-f
CES XVI-23 P	UPLBCA	2.5 f-g	23.0 a-g	98.7 c-l	121.7 c-m	1.7 a-c	53.4 c-l
GC 40142-0-158	AVRDC	2.5 f-g	24.7 a-h	89.3 b-j	114.0 b-l	1.7 a-c	62.0 g-k
GC 40142-0-32	AVRDC	2.3 e-f	19.3 a-e	120.0 e-n	139.3 e-p	3.3 a-f	48.1 b-h
Sankuo	UPLBCA	2.5 f-g	23.0 a-g	101.3 c-m	124.3 c-n	3.0 a-e	58.9 e-k
Tainung 4 x Gilbert	UPLBCA	2.7 g-h	29.3 a-j	119.7 e-n	149.0 g-r	3.0 a-e	55.1 d-j
CES XVI-24 PIN	UPLBCA	2.7 g-h	28.7 a-i	125.0 f-o	153.7 h-s	3.0 a-e	54.5 c-j
K 475	BPI	3.0 h-i	33.0 a-k	98.0 c-l	131.0 d-o	4.3 a-h	57.6 e-k
EGSY 15	BPI	3.2 i-j	33.0 a-k	102.3 c-m	135.3 d-o	3.3 a-f	62.0 g-k
Ogden	UPLBCA	2.7 g-h	32.7 a-k	108.0 d-n	140.7 e-q	4.0 a-h	57.3 e-k
GC 40142-0-159	AVRDC	2.7 g-h	39.0 b-n	127.0 f-o	166.0 h-s	3.3 a-f	53.5 c-i
S-13	UPLBCA	3.0 h-i	35.0 a-k	120.0 e-n	155.0 h-s	6.7 b-i	54.8 c-j
Multivar 80	UPLBCA	3.0 h-i	33.0 a-k	122.3 f-o	155.3 h-s	3.7 a-g	56.7 e-k
Woodworth	UPLBCA	3.0 h-i	35.0 a-k	129.7 f-o	164.7 h-s	4.3 a-h	56.9 e-k
Clark 63	UPLBCA	3.5 j-l	48.0 e-n	119.5 e-n	167.5 h-s	3.7 a-g	54.8 c-j
Cobb	UPLBCA	3.1 i	34.3 a-k	125.7 f-o	160.0 h-s	4.0 a-h	61.8 g-k
Williams	UPLBCA	3.0 h-i	34.3 a-k	138.3 g-o	172.6 h-t	5.0 a-i	59.6 f-k
T-8	UPLBCA	3.0 h-i	34.3 a-k	133.7 g-o	168.0 h-s	5.3 a-i	62.1 g-k
Strain 78	BPI	3.2 i-j	38.7 b-n	123.0 f-o	161.7 h-s	5.3 a-i	62.5 g-k
Taiwan	BPI	3.1 i	37.0 a-m	116.0 d-n	153.0 j-s	8.3 e-i	61.2 g-k
UPSL 85	UPLBCA	3.3 i-k	37.0 a-m	152.0 h-p	189.0 j-u	5.0 a-i	57.6 e-k
GC 40081-0-27	AVRDC	3.1 i	36.3 a-l	134.7 g-o	171.0 h-s	8.0 d-i	62.3 g-k
PI 400490	UPLBCA	3.5 j-l	40.3 b-n	140.3 g-o	180.6 i-t	6.0 a-i	60.4 g-k
VLCS 16	BPI	3.3 i-k	39.0 b-n	163.3 i-p	202.3 l-v	5.3 a-i	59.9 f-k
VLCS 12-A	BPI	3.3 i-k	46.3 d-n	161.0 h-p	207.3 m-v	4.0 a-h	62.7 g-k
BPI Sel. 1	BPI	3.5 j-l	43.7 c-n	169.0 j-p	212.7 m-v	5.0 a-i	56.8 e-k
GC 40142-0-87	AVRDC	3.6 k-l	46.3 d-n	155.3 h-p	201.6 l-v	6.0 a-i	61.5 g-k
Tainung 3	UPLBCA	3.5 j-l	49.3 f-o	165.0 i-p	214.3 n-v	4.7 a-i	58.3 e-k
PI 371609	UPLBCA	3.5 j-l	45.7 d-n	175.0 k-p	220.7 o-v	6.7 b-i	58.1 e-k
GC 40142-0-74	AVRDC	4.0 m-n	58.3 j-s	139.7 g-o	198.0 l-u	3.7 a-g	57.9 e-k
VLCS 12-B	BPI	3.6 k-l	46.3 d-n	187.7 m-p	229.0 p-v	4.0 a-h	62.8 g-k
Tainung 4	UPLBCA	3.5 j-l	49.3 f-o	178.7 l-p	228.0 p-v	5.7 a-i	60.4 g-k
CES XVI-38 P	UPLBCA	3.5 j-l	44.7 d-n	167.3 j-p	212.0 m-v	10.3 i	54.3 e-k
GC 40089-2-8	AVRDC	4.1 n	53.7 h-q	136.7 g-o	190.4 j-u	8.3 e-i	61.6 g-k
Lincoln	UPLBCA	4.5 o-p	66.0 m-u	129.7 f-o	195.7 k-u	4.3 a-h	65.0 h-k
GC 40085-2-10	AVRDC	4.0 m-n	50.3 g-p	129.7 f-o	180.0 i-t	9.7 h-i	67.6 i-k
I 346	BPI	4.5 o-p	77.0 o-u	132.0 g-o	209.0 m-v	6.0 a-i	57.7 e-k
CES XVI-112 PIN	UPLBCA	3.7 l-m	50.3 g-p	169.0 j-p	219.3 o-v	9.0 f-i	60.8 g-k
S-4	UPLBCA	4.0 m-n	59.0 k-t	172.3 k-p	231.3 q-w	4.3 a-h	61.7 g-k
CES 434	BPI	4.0 m-n	54.7 i-r	154.0 h-p	208.7 m-v	9.3 g-i	58.8 e-k
CES XVI-103 P	UPLBCA	3.7 l-m	57.3 i-r	170.3 k-p	227.6 p-v	8.0 d-i	60.0 g-k
PI 62204	UPLBCA	3.7 l-m	48.7 e-n	186.0 n-p	234.7 r-w	8.3 e-i	60.1 g-k
GC 40142-0-17	AVRDC	4.9 q	78.3 p-u	101.3 c-m	179.6 i-t	8.0 d-i	69.3 i-k

(continued)

TABLE 1. (Continued)

Variety	Source of seeds	Necrosis rating[b]	Number of nematodes recovered from: 1 g roots	300 cc soil	Total	Number of egg masses/g of roots	Number of eggs/egg mass[c]
CES XVI-26 P	UPLBCA	4.3 n-o	58.3 j-s	171.3 k-p	229.6 p-v	9.0 f-i	58.9 e-k
PI 60273	UPLBCA	4.3 n-o	65.7 l-u	178.0 l-p	243.7 s-w	7.3 c-i	65.5 h-k
GC 40057-1-12	AVRDC	4.7 p-q	67.0 n-u	158.0 h-p	225.0 p-v	10.3 i	64.0 h-k
GC 40081-0-17	AVRDC	5.0 q	86.3 s-u	186.0 n-p	272.3 u-w	6.7 b-i	63.6 h-k
EGSY 99	BPI	4.9 q	82.0 r-u	133.0 g-o	215.0 o-v	9.7 h-i	74.1 k
L 114	UPLBCA	4.7 p-q	79.7 q-u	182.0 m-p	261.7 t-w	9.3 g-i	62.5 g-k
GC 40177-0-11	AVRDC	4.8 p-q	87.0 t-u	201.7 o-p	288.7 v-w	9.0 f-i	59.8 f-k
PI 200492	UPLBCA	5.0 q	93.3 u	343.0 q	436.3 x	8.0 d-i	67.2 i-k
Improved pelican	BPI	5.0 q	89.0 u	222.7 p	311.7 w	10.3 i	71.7 j-k

[a]Data are means of three replicates. Means followed by the same letter do not differ at the 5% level by Duncan's multiple-range test.
[b]Based on a severity scale of 1 to 5 determined from relative percentages of necrotic portions of root systems as follows: 1 = 0% (no necrosis); 2 = 1–25% (light necrosis); 3 = 26–50% (moderate necrosis); 4 = 51–75% (severe necrosis); and 5 = over 75% (very severe necrosis).
[c]Means of counts from all egg masses found.

most reflective of resistance, statistical analyses were made of correlation of resistance rating and necrosis rating, nematode recoveries from 1 g roots, 300 cc soil, and both 1 g roots and 300 cc soil, and numbers of egg masses/g of roots and eggs/egg mass, based on r values (correlation coefficients). The r values of the different assessment parameters for determining resistance were also analyzed to determine the correlations of these parameters.

RESULTS AND DISCUSSION

Rotylenchulus predominated over the other plant-parasitic nematode genera before the experiment. The average initial population density/300-cc soil sample of this nematode was 41 compared with an average total of only 7 for all other genera encountered: *Helicotylenchus, Meloidogyne, Tylenchorhynchus, Hoplolaimus, Hemicriconemoides, Pratylenchus,* and *Criconemoides.*

At the end of the experiment, root necrosis ratings, *R. reniformis* recoveries from 1 g roots, 300 cc soil, and both 1 g roots and 300 cc soil, and numbers of egg masses/g of roots and eggs/egg mass differed significantly among varieties (Table 1). Relations were generally positive for necrosis, nematode recovery, and nematode reproduction. The deviations from this trend observed in certain varieties may indicate a variability in tolerance to the nematode in these varieties. There were no apparent increases in population densities of other nematode genera over the initial densities.

Resistance ratings differed greatly among the varieties (Table 2). Nine varieties (TK 5, Strain 99, Strain 12, PI 200451, GC 40078-2-40, EGSY 12, GC 40142-0-66, EGSY 6, and UPL-SY 2) were resistant and 13 were moderately resistant. Twenty-six and 17 varieties respectively showed moderately susceptible and susceptible reactions.

TK 5, Strain 99, and Strain 12 were also recently found (6) resistant to the root-knot nematodes *Meloidogyne incognita, M. arenaria,* and *M. javanica* in pots. Those varieties are therefore potentially useful in nematode control and breeding programs.

Three successive croppings of TK 5 resulted in increased populations of *R. reniformis,* although the increase was less than that on mung bean (9). In a subsequent field experiment involving this variety, no significant yield reductions occurred in soil infested predominantly by *R. reniformis* during two successive wet-season plantings, although yield loss was as high as 45% in the succeeding dry-season planting (8). In mung bean, yield reductions had been significant since the first wet-season planting and were much higher (as high as 75%) than in TK 5 during the dry-season planting. While those observations suggest

TABLE 2. Resistance rating and host category of soybean varieties to *Rotylenchulus reniformis*, based on indices of root necrosis, nematode recovery, egg mass production, and egg production.[a]

Variety	Necrosis index	Nematode recovery indices: Roots	Soil	Roots and soil	Egg mass production index	Egg production index	Resistance rating (Av.)	Host category[b]
TK 5	0.71	0.57	0.71	0.50	1.33	1.64	0.91	R
Strain 99	1.07	0.86	1.78	1.25	1.33	1.09	1.23	R
Strain 12	1.42	1.14	1.07	0.75	2.00	1.09	1.25	R
PI 200451	1.07	1.14	1.42	1.00	2.00	1.64	1.38	R
GC 40078-2-40	1.42	0.86	1.07	0.75	2.67	2.73	1.58	R
EGSY 12	1.42	1.14	2.13	1.50	3.33	1.64	1.86	R
GC 40142-066	1.42	0.86	2.49	2.00	3.33	3.27	2.23	R
EGSY 6	1.78	2.00	2.84	2.25	2.67	4.36	2.65	R
UPL-SY 2	1.78	1.71	1.78	1.75	4.00	5.45	2.75	R
K.E. 32	2.49	2.28	2.84	2.50	6.00	2.18	3.05	MR
Ross	3.20	2.28	3.20	2.75	2.67	5.45	3.26	MR
GC 40176-1-12	2.49	3.42	2.84	2.75	4.00	4.36	3.31	MR
EGSY 78	3.20	1.43	3.55	2.75	4.00	7.63	3.76	MR
Tainung 4 x Ross	3.20	2.00	4.26	3.25	7.33	3.82	3.98	MR
CES XVI-23 P	4.62	2.28	5.33	4.00	2.67	6.54	4.24	MR
GC 40142-0-158	4.62	2.54	4.26	3.50	2.67	9.81	4.57	MR
GC 40142-0-32	3.91	1.71	6.75	5.25	4.67	5.45	4.62	MR
Sankuo	4.62	2.28	5.68	4.25	4.00	8.72	4.93	MR
Tainung 4 x Gilbert	5.33	3.14	6.75	6.25	4.00	7.63	5.52	MR
CES XVI-24 PIN	5.33	2.85	7.46	6.75	4.00	7.09	5.58	MR
K 475	6.04	3.42	5.33	4.75	6.00	8.72	5.71	MR
EGSY 15	6.75	3.42	5.68	4.75	4.67	9.81	5.85	MR
Ogden	5.33	3.42	6.39	5.50	6.00	8.72	5.89	MS
GC 40142-0-159	5.33	4.56	7.46	6.75	4.67	6.54	5.89	MS
S-13	6.04	3.42	6.75	6.75	7.33	7.09	6.23	MS
Multivar 80	6.04	3.42	7.46	6.75	5.33	8.72	6.29	MS
Woodworth	6.04	3.42	7.46	6.75	6.00	8.72	6.40	MS
Clark 63	7.81	5.42	6.75	6.75	5.33	7.09	6.53	MS
Cobb	6.39	3.42	7.46	6.75	6.00	9.81	6.64	MS
Williams	6.04	3.42	7.81	7.00	6.67	9.27	6.70	MS
T-8	6.04	3.42	7.81	6.75	6.67	9.81	6.75	MS
Strain 78	6.75	4.56	7.46	6.75	6.67	9.81	7.00	MS
Taiwan	6.39	3.99	6.39	6.75	9.33	9.81	7.11	MS
UPSL 85	7.10	3.99	8.52	7.75	6.67	8.72	7.13	MS
GC 40081-0-27	6.39	3.71	7.81	6.75	8.67	9.81	7.19	MS
PI 400490	7.81	4.56	7.81	7.25	6.67	9.81	7.32	MS
VLCS 16	7.10	4.56	8.88	8.50	6.67	9.27	7.50	MS
VLCS 12-A	7.10	5.13	8.52	8.75	6.00	9.81	7.55	MS
BPI Sel. 1	7.81	4.85	9.23	8.75	6.67	8.72	7.67	MS
GC 40142-0-87	8.17	5.13	8.52	8.50	6.67	9.81	7.80	MS
Tainung 3	7.81	5.99	8.88	9.00	6.67	8.72	7.85	MS
PI 371609	7.81	5.13	9.59	9.25	7.33	8.72	7.97	MS
GC 40142-0-74	9.59	8.27	7.81	8.25	5.33	8.72	8.00	MS
VLCS 12-B	8.17	5.13	10.30	9.50	6.00	9.81	8.15	MS
Tainung 4	7.81	5.99	9.94	9.50	6.67	9.81	8.29	MS
CES XVI-38 P	7.81	5.13	9.23	8.75	12.00	8.72	8.61	MS
GC 40089-2-8	9.94	7.13	7.81	7.75	9.33	9.81	8.63	MS
Lincoln	11.01	9.69	7.46	8.00	6.00	10.36	8.75	MS
GC 40085-2-10	9.59	6.56	7.46	7.25	11.34	10.90	8.85	S
I 346	11.01	10.26	7.81	8.75	6.67	8.72	8.87	S
CES XVI-112 PIN	8.88	6.56	9.23	9.25	10.00	9.81	8.96	S
S-4	9.59	8.84	9.59	10.00	6.00	9.81	8.97	S
CES 434	9.59	7.70	8.52	8.75	10.67	8.72	8.99	S
CES XVI-103 P	8.88	7.70	9.59	9.50	8.67	9.81	9.03	S
PI 62204	8.88	5.42	10.65	10.25	9.33	9.81	9.06	S

(continued)

TABLE 2. (Continued)

Variety	Necrosis index	Nematode recovery indices: Roots	Soil	Roots and soil	Egg mass production index	Egg production index	Resistance rating (Av.)	Host category[b]
GC 40142-0-17	12.00	10.55	5.68	7.25	8.67	10.90	9.18	S
CES XVI-26 P	10.34	8.27	9.59	9.50	10.00	8.72	9.40	S
PI 60273	10.34	9.41	9.94	10.50	8.00	10.36	9.76	S
GC 40057-1-12	11.72	9.98	8.52	9.50	12.00	10.36	10.35	S
GC 40081-0-17	12.00	11.40	10.65	11.00	7.33	10.36	10.46	S
EGSY 99	12.00	11.12	7.81	9.25	11.34	12.00	10.59	S
L 114	11.72	10.83	10.30	10.75	10.67	9.81	10.68	S
GC 40177-0-11	11.72	11.69	11.01	11.25	10.00	9.27	10.82	S
PI 200492	12.00	12.00	12.00	12.00	8.67	10.90	11.26	S
Improved pelican	12.00	12.00	11.36	11.50	12.00	11.45	11.72	S

[a]Indices for necrosis, nematode recoveries from roots, soil, and both soil and roots, egg mass production, and egg production were determined from the statistical means (differentiated by letters) in Table 1 for necrosis rating, numbers of nematodes recovered from 1 g roots, 300 cc soil, and both 1 g roots and 300 cc soil, number of egg masses/g of roots, and number of eggs/egg mass, respectively, by assigning an arbitrary value of 12 to the highest mean and equally divided lower values (determined by the number of statistically different means involved) to the succeeding different means. Indices of means designated by two or more letters were determined by dividing the sum of the corresponding values by the number of letters involved.

[b]Based on the resistance ratings using the following scale: 0–2.93 = R (resistant); 2.94–5.86 = MR (moderately resistant); 5.87–8.79 = MS (moderately susceptible); and 8.80–11.72 = S (susceptible). The ranges were based on the quotient (2.93) obtained by dividing 11.72 (highest resistance rating) by 4 (number of categories).

that TK 5 may possess greater tolerance than resistance to *R. reniformis*, according to the categorization of Dropkin and Nelson (11), they were not supported by the results of the present experiment.

The use of resistance ratings, based on indices of the assessment parameters used in this study, appears to be potentially useful in determining the relative host categories, other than tolerance, of crop varieties to *R. reniformis*. This method compares varietal resistance based on several criteria. Comparisons of crops' resistance to nematodes are usually limited to single parameters, and it is sometimes difficult to determine which parameter should be assigned most importance. Basing indices for the different parameters on statistical means reduced the chances of assigning different values to statistically similar means. Objectivity was enhanced by the determination of the ranges of resistance ratings to which the host categories were assigned, based on a value derived from the data. The use of indices instead of actual values in determining resistance ratings, however, has the disadvantage of favoring the parameter concerning which lower numbers of statistically different means are involved.

Highly significant positive linear correlations existed between resistance rating and any of the assessment parameters (Fig. 1). This suggests that, under the conditions of the experiment, any of the parameters could be used to identify resistance. From the analyses of significance of differences between correlation coefficients, nematode recovery from 1 g roots, total recoveries from 1 g roots and 300 cc soil, and necrosis rating were equally the most efficient parameters. Among these, use of necrosis rating is apparently the simplest and least time-consuming. However, since necrosis could be caused by various other factors (secondary invading organisms such as fungi and bacteria), it is necessary to supplement necrosis rating with nematode recovery from 1 g roots. The high efficiency of nematode recovery from 1 g roots as a parameter could probably be attributed to the fact that this criterion is the most indicative of the relative degree of nematode infection. Number of egg masses/g of roots was the least efficient parameter. This was perhaps partly related to the differences in the rates of nematode development in the different varieties.

Highly significant positive linear cor-

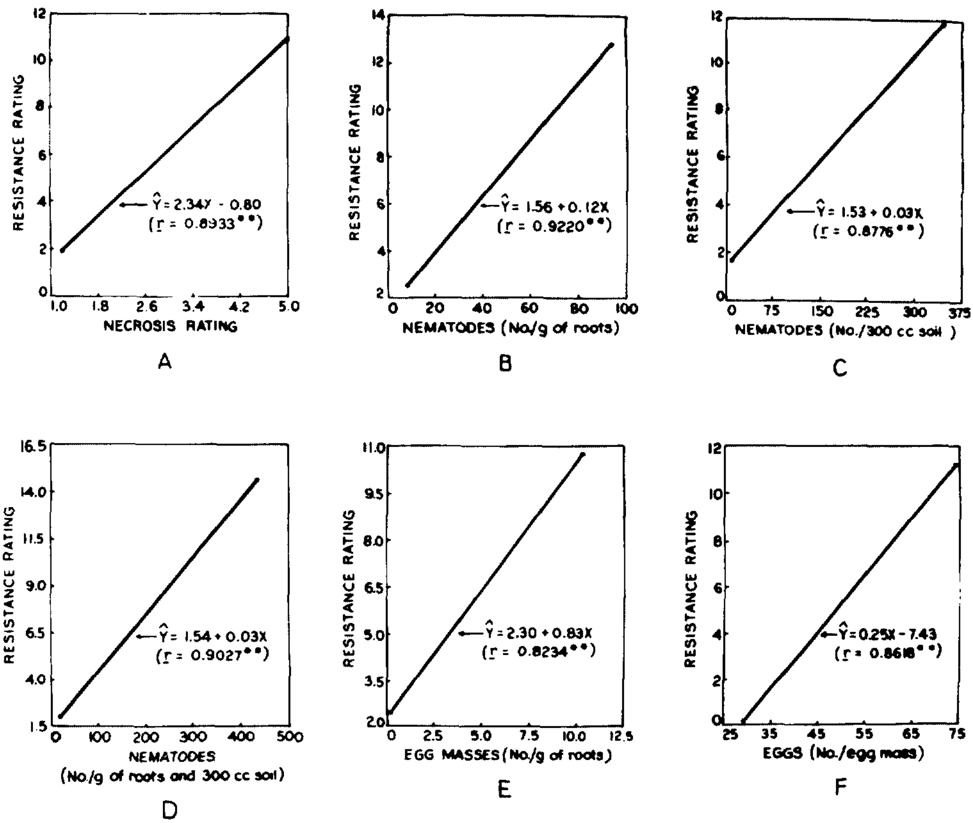

FIG. 1. Correlation between resistance rating and each of the six assessment parameters used in the study: A) necrosis rating; B) number of nematodes/g of roots; C) number of nematodes/300 cc soil; D) number of nematodes/g of roots and 300 cc soil; E) number of egg masses/g of roots; and F) number of eggs/egg mass.

relations were also observed between any two combinations of parameters. This observation agrees with the general trend of relationships in Table 1.

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