REACTION OF SWEET POTATO SELECTIONS TO DIFFERENT POPULATIONS OF MELOIDOGYNE INCOGNITA ACRITA AND TO OTHER SPECIES OF MELOIDOGYNE

BY

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INTRODUCTION

Root knot, caused by the nematode, Meloidogyne incognita acrita Chitwood, is recognized as a major disease of sweet potato. Breeding for resistance to this disease is one of the objectives of the sweet potato breeding program at the Oklahoma Agricultural Experiment Station. It is recognized that a thorough knowledge of the host, the pathogen, and the disease is essential to approach this objective more intelligently.

Previous investigations (12, 23) have disclosed that resistance to M. incognita acrita in sweet potato is characterized by varying amounts of necrosis in the host roots and by a failure of most of the invading nematodes to survive and develop to maturity in host tissue. Resistance in the sweet potato variety Nemagold (10) is associated with these features.

Only a limited amount of evidence is available relative to the susceptibility of sweet potato varieties to root-knot species other than M. incognita acrita (16, 25). Up to the present, in addition to M. incognita acrita, only M. incognita incognita (Kofoid & White) Chitwood and M. hapla Chitwood have been found in Oklahoma. Since at least 5 species of root-knot nematodes are known to occur commonly throughout the southern United States, it is important that a satisfactory sweet potato variety be resistant to as many of these as is possible.

With the demonstration (17, 19, 20,24) of physiological specialization in root-knot nematode species, it becomes important in any study of resistance that an attempt be made to investigate and define the nematode populations involved. The local races and race populations have not been investigated relative to sweet potato.

In light of the foregoing discussion it is evident that knowledge is lacking in several areas relative to resistance to root-knot nematodes in sweet potato. Such knowledge is considered essential to further advances in the sweet potato breeding program.

The present investigation was initiated to determine: 1) the possible existence in sweet potato breeding lines of resistance other than that typified by necrosis and failure of the nematodes to develop, 2) the situation relative to physiologic specialization in *M. incognita acrita*, and 3) the reaction of certain sweet potato lines to *M. incognita incognita* and *M. hapla*.

REVIEW OF LITERATURE

All root-knot nematodes were considered as being a single species up to 1949. This was considered to be Hetrodera radicicola (Greef) Muller till 1924. At this time a new genus was established so that the designation was then Caconema radicicola (Greef) Cobb. This genus was synonymized with Heterodera in 1932 and root-knot nematodes were designated as H. marioni (Cornu) Goodey. Experiments by Christie (4), Christie and Albin (6), and Christie and Havis (7) demonstrated that "races" existed in the species H. marioni.

Chitwood (3) demonstrated, in 1949, that there were morphological differences between these so-called races and on the basis of these differences described 5 species and one subspecies of root-knot nematodes which, because of priority, he placed in the genus Meloidogyne. His species were based on 3 morphological characters, the most useful and commonly used one being the perineal pattern.

Allen (1) in studies with single-egg mass populations found considerable variation in perineal patterns within single root-knot nematode species. Dropkin (13), while reporting variation in perineal patterns of a single species, considered that patterns were consistent enough to be useful in classifying species. Recently Sasser (Personal Communication) has suggested that M. incognita be considered a species complex in which would be included both *M. incognita* and *M. incognita acrita*. The reason for this suggestion was that while certain populations of *M. incognita* can be readily distinguished from *M. incognita acrita* on the basis of perineal patterns, other populations are so variable in this character that identification becomes extremely difficult.

Evidence that *M. incognita acrita* is made up of at least several physiologic races was presented by Sasser and Nusbaum (26) working with tobacco, by Martin (20) working with cotton, by Dropkin (14) working with soybeans and Lider (19) working with grapes. Goplen et al (17), observed 3 races of *M. incognita acrita*, 2 of *M. javanica*, and 2 of *M. hapla* through the use of 5 differential alfalfa varieties. Riggs and Winstead (24), working with root-knot resistant tomato, were able to select races of *M. incognita incognita*, *M. incognita acrita*, and *M. arenaria arenaria* which readily attacked the resistant variety. There can be then no question as to the existence of physiological specialization in root-knot nematodes. The problem becomes one of more accurately defining the races and determining their distribution. Physiological specialization further emphasizes the possible need for different types of resistance in a breeding program.

Prior to 1939 little attention was given to the nature of resistance to nematodes. Steiner (29), in 1925, made the statement "that plants may resist nematodes by some chemical or mechanical means." Tyler (30) defined resistance with special reference to root-knot nematodes as "the ability of the plant to obstruct the invasion of the parasites."

Barrons (2) clearly showed that resistance could not be defined merely as the failure of the parasite to enter the host. In studying 30 plant varieties Barrons observed that as many nematodes entered root-knot resistant plants as entered susceptible plants. He suggested that resistance was due to the ability of the plant to starve the nematode after they had entered.

Christie (5) agreed with Barrons' ideas relative to resistance to root-knot nematode, but pointed out that this did not exclude those cases in which nematodes are prevented from entering. Christie spoke of "suitable" or "unsuitable" rather than susceptible or resistant hosts. Nematode development and maturation was prolonged in less suitable host. Development in unsuitable hosts might be so delayed that only a very few individuals ever reached sexual maturity and reproduced. Christie related resistance to the ability of host tissue to respond to the stimulus of infection. If the salivary secretion of the nematode fails to induce normal giant cells or if the plant reacts in a manner unfavorable for continued nematode feeding, restricted nematode development or death results.

Sasser and Taylor (27) related resistance to root-knot nematodes with several phenonmena. Among these were failure of nematodes to penetrate roots, penetration by a small number of larvae followed by weak or no development, or pentration by great numbers of larvae with few or none subsequently developing.

Riggs and Winstead (24) have suggested a possible chemical by-product of host-parasite interaction which might be toxic to the nematode in root-knot resistant tomato. Shibuya (28) postulated a similar mechanism operating in root-knot resistant sweet potato.

Shibuya also reported that in root-knot resistant sweet potato root-knot larvae entered as readily as they did in susceptible sweet potato. However, in resistant lines nematode development was retarded. This work has been confirmed by Dean (11), Dean and Struble (12), and Radewald (23). These latter workers further reported varying amounts of host necrosis associated with resistance in sweet potato.

Recently Dropkin and Nelson (15) have suggested that the development and type of giant cells produced in soybeans by root-knot nematodes may be related to resistance or susceptibility.

From the foregoing it is quite evident that resistance to root-knot nematode has been found associated with a variety of responses on the part of the host, the pathogen, or both.

Ample evidence that resistance to root knot is available in sweet potato has been presented (8, 9, 18, 22, 31). Whether these different sources of resistance actually represent different types of resistance has not been investigated.

MATERIALS AND METHODS

Four populations of M. incognita acrita and 1 population each of M. incognita incognita and M. hapla were used in the present investigation. To establish pure cultures representative of the field population, several single egg masses were selected from each mass population and increased individually on tomato. Four single-egg mass cultures were then selected for each population on the basis of trueness of type of perineal pattern and pooled. This procedure was followed in establishing populations except where otherwise stated.

Population I was obtained on tomato from the farm of L. Lorenz, Isabella, Okla. The principal reason for obtaining a culture from this source was that Mr. Lorenz had reported the sweet potato line Okla. 65 to be susceptible to root knot on his farm. This line had been found resistant in trials at the University Farm at Perkins. While this population has been tentatively identified from perineal patterns as M. incognita acrita, the patterns vary from typical M. incognita acrita to typical M. incognita incognita. This population seems to be one which should probably be designated as being of the M. incognita complex.

Population II originated from a single egg mass on Allgold sweet potato in soil from the University Farm at Perkins and has been maintained in the greenhouse since 1950. Population III was established in 1956 from 5 selected egg masses from cotton grown in root-knot infested soil from Hollis, Okla. Both populations II and III were identified as typical M. incognita acrita and had been further selected in 1958 by pooling for each the progeny of 4 single egg masses cultured individually on tomato. Further selection was not made in the present work. Population VI was started in 1959 from tomato grown on the farm of R. Dubois near Cameron, Okla. and was identified as typical M. incognita acrita.

The only culture of M. incognita incognita used, population V, came from soil from a peach orchard of I. L. Thomson near Valliant, Okla., in 1959. Population IV, identified as M. hapla was established in 1959 from soil from a peanut field of E. and J. Wells near Sickles, Okla.

Each population was maintained on Rutgers tomato in steam sterilized soil in wood-lined metal trays 36 in. x 18 in. x 6 in. in the greenhouse. Proper precautions were taken at all times to prevent cross contamination of any of the population boxes. For inoculum, infected tomato roots were chopped and used at the rate of 1 g per 4-inch pot of steamed soil.

The sweet potato lines or varieties used in this work were selected because all of them, with the exception of Allgold, had been demonstrated to be resistant in field tests at the University Farm at Perkins. The sweet potato selections were chosen so that possibly several sources of resistance might be represented. The lines used were as follows: Nemagold, Orlis, Tininan (P.I.NO.

153655), Kandee, Okla. 29, Okla. 65, P-80, Okla. 5-66, NC 172, and Allgold. Allgold was used throughout as a susceptible control.

All tests were conducted in the greenhouse at air temperatures ranging from 21° to 38°C. Four plants of each sweet potato line in the test were used in each test. Rooted cuttings, 2 per 4-in. pot, were planted in steamed soil plus inoculum and allowed to grow for 35 days. Plants inoculated with different nematode populations were maintained in different metal trays.

Root systems were carefully removed from the soil, washed, and observed for galling and necrosis. Relative severity of galling of each root system was rated on a scale of from 1 to 5. A score of 1 was used for no galling, 2 for a trace of galling, 3 for moderate galling, 4 for severe galling, and 5 for very severe galling. A mean root-knot index was calculated from these scores for each variety with each population.

Each root system was chopped into pieces of approximately 5 mm in length. These pieces were well mixed and a 200 mg sample was taken from them for staining and microscopic examination. Roots were stained according to the method of McBeth, et al (21) except that 1 ml instead of 5 ml of acid fushsin stock solution was used per 100 ml of lactophenol.

Cleared, stained roots were crushed between microscope slides and examined under a dissecting microscope to determine the number and relative development of nematodes present. Developmental stages of the nematodes were classified according to the method of Christie (4). "Group A includes second stage larvae to the stage where they still possess a more or less conical tail. Group B includes larvae from the stage where they have aquired a more or less hemispherical posterior end, terminated by a spike, to the stage where they are about to complete the final molts. Group C includes females from the stage where they have completed the molts to the stage where they are almost, though obviously not quite, fully grown. Group D includes females that are fully grown or almost fully grown but have not yet laid eggs. Group E includes egg-laying females." These developmental groups are shown in Fig. 1.

A value designated as reproduction index was assigned each sweet potato line in each test. An index of 1 was used where there was no reproduction, an index of 2 indicated small egg masses only or small egg masses with 1 or 2 normal size egg masses, an index of 3 was given where there were not more than an average of 2 egg masses per plant, an index of 4 indicated moderate reproduction with not more than an average of 3-7 egg masses per plant, and an index of 5 indicated normal reproduction with an average of 8 or more normal egg masses per plant.

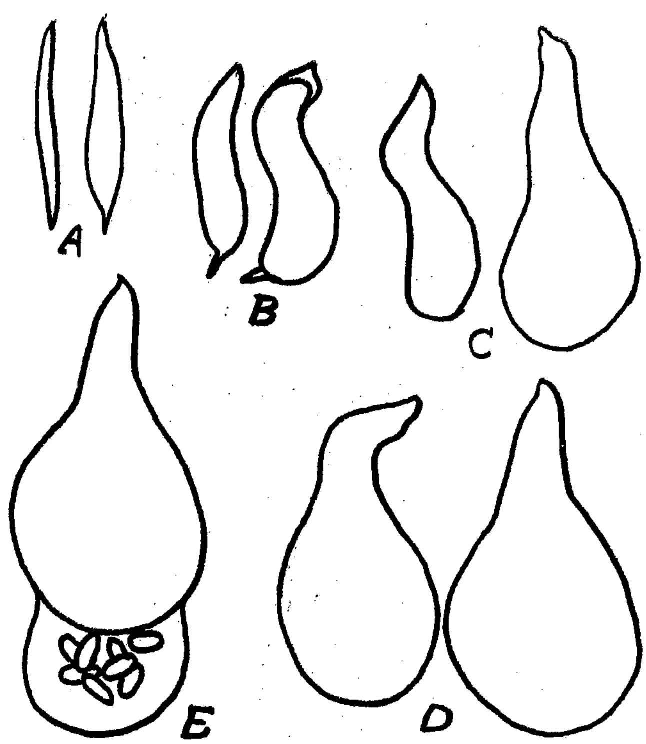

Fig. 1. Classes into which nematodes were grouped according to the amount of development they had undergone. (After Christie)

RESULTS

Host-Parasite Reactions Associated With Resistance to Root-Knot Nematode in Sweet Potato

It has already been pointed out that in sweet potatoes resistance to *M. incognita acrita* is associated with little or no gall formation, necrosis of host tissue, and failure of most of the nematodes to reach maturity. In the present work data have been obtained for each of the sweet potato lines against each of the nematode populations on these points. These data, along with egg mass size and reproduction index, are presented in Table I. Reproduction index was defined in the section on Materials and Methods. Egg mass size seems to be correlated with resistance in that abnormally small egg masses, 2 to 50 eggs, are regularly observed with mature females in some resistant plants; normal egg masses in susceptible and even in some resistant plants have 400 or more eggs.

From the evidence presented in Table I it is apparent that resistance to the root-knot nematodes tested may be associated with little or no galling, some necrosis of invaded roots, failure of many or most of the invading larvae to reach maturity, little or no reproduction, and reduced size of egg masses. All sweet potato lines previously shown to be resistant to *M. incognita acrita* reacted to all nematode populations tested with little or no galling and moderate to severe root necrosis. Necrosis in resistant lines is confined to root tips and does not involve whole roots. In susceptible lines, such as Allgold, with severe root knot, whole roots became necrotic presumably as a consequence of secondary invaders in the root. Typical necrosis due to root knot in resistant lines is shown compared with necrosis encountered in susceptible lines in Fig. 2, 3, 4. With all resistant lines against most of the nematode populations few nematodes reached maturity and relatively few of these laid eggs. The exceptions to this generalization are considered in the section on physiological specialization.

Radewald (23) had noted that in resistant sweet potato lines many larvae died within 10 to 12 days after entry. Although dead nematodes were found in the present work, because of the fact that the plants were constantly exposed to inoculum over a 35-day period it was not possible to demonstrate how many nematodes had died or when they had died.

TABLE I

HOST-PARASITE REACTIONS WITH EACH OF 10 SWEET POTATO LINES TESTED AGAINST DIFFERENT SELECTIONS AND SPECIES OF ROOT-KNOT NEMATODE

Sweet Potato Line and Nematode Population	No. of Plants Observed	No. of Testing Periods	Mean Root-Knot Index[a]	Root Necrosis[b]	Reproduction Index[c]	Relative Nematode Development[d] Immature	Mature	Egg Mass Size
						No.	No.	
ALLGOLD								
M. incognita acrita								
I	8	2	4.0	1	5	209	279	Normal
II	10	3	4.9	1	5	270	589	Normal
III	12	3	4.75	1	5	436	491	Normal
VI	6	1	4.5	1	5	270	262	Normal
M. incognita incognita	12	3	4.66	1	5	660	587	Normal
M. hapla	12	3	3.83	1	5	330	77	Normal
NEMAGOLD								
M. incognita acrita								
I	8	2	1.0	2	2	46	3	Small

TABLE I (Continued)

Sweet Potato Line and Nematode Population	No. of Plants Observed	No. of Testing Periods	Mean Root-Knot Index[a]	Root Necrosis[b]	Reproduction Index[c]	Relative Nematode Development[d] Immature	Mature	Egg Mass Size
						No.	No.	
NEMAGOLD (Continued)								
M. incognita acrita								
II	12	3	1.08	2	4	92	62	Normal
III	11	3	1.0	2	3	33	6	Normal
VI	6	1	1.0	2	1	31	0	No Eggs
M. incognita incognita	12	3	1.0	2	3	120	21	Normal
M. hapla	12	3	2.33	2	4	326	133	Normal
ORLIS								
M. incognita acrita								
I	8	2	1.0	2	3	90	20	Normal
II	7	2	1.57	2	5	79	135	Normal
III	7	2	1.0	2	2	9	4	Small
VI	6	1	1.0	2	1	85	6	No Eggs
M. incognita incognita	8	2	1.0	2	3	32	7	Normal

TABLE I (Continued)

Sweet Potato Line and Nematode Population	No. of Plants Observed	No. of Testing Periods	Mean Root-Knot Index[a]	Root Necrosis[b]	Reproduction Index[c]	Relative Nematode Development[d] Immature	Mature	Egg Mass Size
						No.	No.	
ORLIS (Continued)								
M. hapla	8	2	1.5	2	4	385	139	Normal
P-80								
M. incognita acrita								
I	8	2	1.0	2	4	305	78	Normal
II	8	2	1.57	2	3	61	23	Normal
III	8	2	1.0	2	3	175	24	Normal
VI	6	1	1.0	2	1	203	1	No Eggs
M. incognita incognita	7	2	1.0	2	4	98	63	Normal
M. hapla	8	2	1.5	2	2	44	7	Small
TINIAN								
M. incognita acrita								
I	8	1	1.1	2	3	353	15	Small
II	8	2	1.0	2	2	108	3	Normal

TABLE I (Continued)

Sweet Potato Line and Nematode Population	No. of Plants Observed	No. of Testing Periods	Mean Root-Knot Index[a]	Root Necrosis[b]	Reproduction Index[c]	Relative Nematode Development[d] Immature	Relative Nematode Development[d] Mature	Egg Mass Size
						No.	No.	
TINIAN (Continued)								
M. incognita acrita								
III	8	2	1.0	2	2	90	30	Normal
VI	4	1	1.0	3	2	79	1	Small
M. incognita incognita	8	2	1.0	2	3	75	22	Normal
M. hapla	8	2	1.66	2	3	112	9	Normal
KANDEE								
M. incognita acrita								
I	8	1	1.1	2	2	143	17	Small
II	8	2	1.0	2	4	113	48	Normal
III	8	2	1.37	2	3	169	5	Normal
VI	4	1	1.0	2	2	93	4	Small
M. incognita incognita	8	2	1.75	2	4	232	76	Normal
M. hapla	8	2	1.1	2	3	44	22	Normal

TABLE I (Continued)

Sweet Potato Line and Nematode Population	No. of Plants Observed	No. of Testing Periods	Mean Root-Knot Index[a]	Root Necrosis[b]	Reproduction Index[c]	Relative Nematode Development[d] Immature	Relative Nematode Development[d] Mature	Egg Mass Size
						No.	No.	
OKLA. 29								
M. incognita acrita								
I	8	2	1.0	2	1	230	1	No Eggs
II	8	2	1.1	2	3	267	5	Normal
III	8	2	1.1	2	1	232	4	No Eggs
VI	6	1	1.0	3	2	177	7	Small
M. incognita incognita	7	2	1.57	2	1	196	6	No Eggs
M. hapla	8	2	1.2	2	1	60	0	No Eggs
OKLA. 65								
M. incognita acrita								
I	8	1	3.1	2	3	681	60	Normal
II	7	2	2.1	2	3	187	34	Normal
III	12	2	1.75	2	1	623	1	No Eggs
VI	6	1	2.5	3	1	544	5	No Eggs

TABLE I (Continued)

Sweet Potato Line and Nematode Population	No. of Plants Observed	No. of Testing Periods	Mean Root-Knot Index[a]	Root Necrosis[b]	Reproduction Index[c]	Relative Nematode Development[d] Immature	Mature	Egg Mass Size
						No.	No.	
OKLA. 65 (Continued)								
M. incognita incognita	12	2	1.83	2	4	717	113	Normal
M. hapla	12	2	1.66	2	3	367	47	Normal
OKLA. 5-66								
M. incognita acrita								
I	6	1	1.0	2	2	205	53	Small
II	8	2	1.1	2	3	153	5	Normal
III	8	2	1.0	2	2	128	7	Small
VI	4	1	2.0	2	2	211	12	Normal
M. incognita incognita	8	2	1.1	2	2	233	21	Normal
M. hapla	8	2	1.1	2	2	90	19	Normal
NC 172								
M. incognita acrita								
I	8	1	1.0	2	1	83	0	No Eggs

TABLE I (Continued)

Sweet Potato Line and Nematode Population	No. of Plants Observed	No. of Testing Periods	Mean Root-Knot Index[a]	Root Necrosis[b]	Reproduction Index[c]	Relative Nematode Development[d] Immature	Mature	Egg Mass Size
						No.	No.	
NC 172 (Continued)								
M. incognita acrita								
II	8	2	1.0	2	1	63	1	No Eggs
III	8	2	1.0	2	1	33	1	No Eggs
VI	4	1	1.0	2	2	50	2	Small
M. incognita incognita	8	2	1.0	2	1	23	7	No Eggs
M. hapla	8	2	1.0	2	3	25	10	Normal

[a] 1 indicates no galling; 2 indicates slight or traces of galling; 3 indicates moderate galling; 4 indicates severe galling; and 5 indicates very severe galling.

[b] 1 = Whole root necrosis associated with severe galling; 2 = Moderate tip necrosis; 3 = Severe tip necrosis.

[c] 1 = No reproduction; 2 = Small egg masses only or small egg masses with 1 or 2 normal egg masses; 3 = Slight reproduction (an average of 0.1-2 egg masses per plant); 4 = Moderate reproduction (an average of 3-7 egg masses per plant); and 5 = Normal reproduction (an average of 8 or more egg masses per plant).

[d] Immature nematodes are groups A, B, and C; Mature nematodes are D and E groups (After Christie).

Fig. 2. Nemagold root showing
tip necrosis.

Fig. 3. Nemagold root system
showing root-tip necrosis.

Fig. 4. Allgold root system
showing dead roots.

Physiological Specialization in M. incognita acrita

Certain populations of M. incognita acrita behaved differently on certain resistant sweet potato lines. Selected pertinent data on this point are presented in Table II. It is suggested that on the basis of the reproduction index population II on varieties Nemagold, Orlis, and Kandee is different from all other populations of M. incognita acrita tested. There was moderate reproduction on 2 of these varieties, Nemagold and Kandee, while on the third, Orlis, there was normal reproduction. On 2 of these varieties, Nemagold and Orlis, with this population, there was barely perceptible galling while no galls were ever found on Kandee. Nemagold and Orlis macroscopic reactions to all populations of M. incognita acrita are shown in Fig. 5 through 12.

Population I on Okla. 65 appears different from the other 3 on the basis of galling alone. Reproduction on this line was only slight. All other populations produced only a trace or less of galling on Okla. 65 (Fig. 17 through 20). With this same population on P-80 caused only very slight galling, but reproduction was at the moderate level. Macroscopic reactions of P-80 to all populations of M. incognita acrita are shown in Fig. 13 through 16.

TABLE II

REACTION OF SWEET POTATO LINES TO EACH OF 4 POPULATIONS OF MELOIDOGYNE INCOGNITA ACRITA

Sweet Potato Line	Mean root-knot index[a] for each nematode population				Reproduction index[b] for each nematode population			
	I	II	III	VI	I	II	III	VI
Allgold	4.0	4.9	4.75	4.5	5	5	5	5
Nemagold	1.0	1.08	1.0	1.0	2	4	3	1
Orlis	1.0	1.57	1.0	1.0	3	5	2	1
P-80	1.1	1.1	1.37	1.0	4	3	3	1
Tinian	1.1	1.0	1.0	1.0	3	2	2	2
Kandee	1.0	1.0	1.37	1.0	2	4	3	2
Okla. 29	1.0	1.1	1.1	1.0	1	3	1	2
Okla. 65	3.1	2.1	1.75	2.5	3	3	1	1
Okla. 5-66	1.0	1.1	1.0	2.0	2	3	2	2
NC 172	1.0	1.0	1.0	1.0	1	1	1	2

[a] 1 indicates no galling; 2 indicates slight or traces of galling; 3 indicates moderate galling; 4 indicates severe galling; and 5 indicates very severe galling.

[b] 1 indicates no reproduction; 2 indicates small egg masses only or small egg masses with 1 or 2 normal sized egg masses; 3 indicates slight reproduction (an average of 0.1-2 egg masses per plant); 4 indicates moderate reproduction (an average of 3-7 egg masses per plant); and 5 indicates normal reproduction (an average of 8 or more egg masses per plant).

Fig. 5. Nemagold root reaction to M. incognita acrita population I.

Fig. 6. Nemagold root reaction to M. incognita acrita population II.

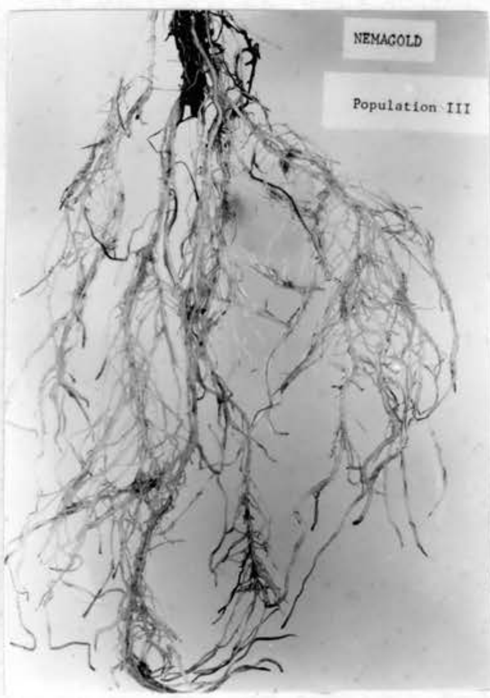

Fig. 7. Nemagold root reaction to M. incognita acrita population III.

Fig. 8. Nemagold root reaction to M. incognita acrita population VI.

Fig. 9. Orlis root reaction to M. incognita acrita population I.

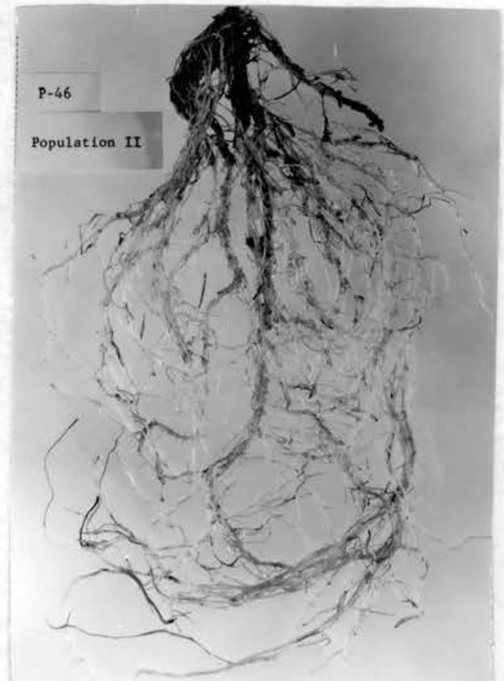

Fig. 10. Orlis root reaction to M. incognita acrita population II.

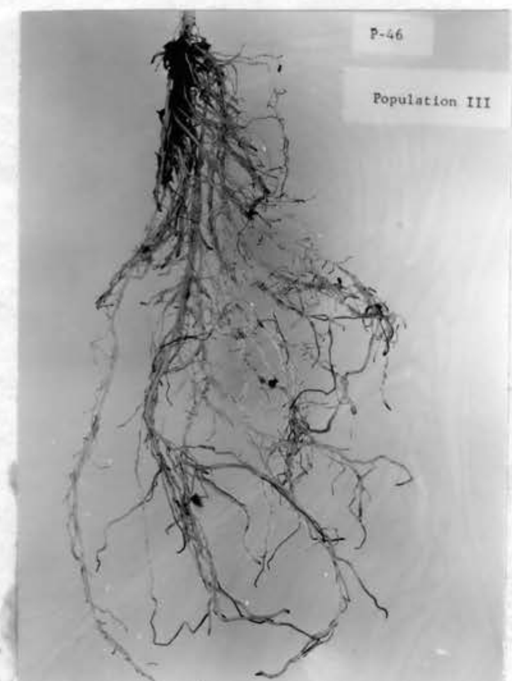

Fig. 11. Orlis root reaction to M. incognita acrita population III.

Fig. 12. Orlis root reaction to M. incognita acrita population VI.

Fig. 13. P-80 root reaction to M. incognita acrita population I.

Fig. 14. P-80 root reaction to M. incognita acrita population II.

Fig. 15. P-80 root reaction to M. incognita acrita population III.

Fig. 16. P-80 root reaction to M. incognita acrita population VI.

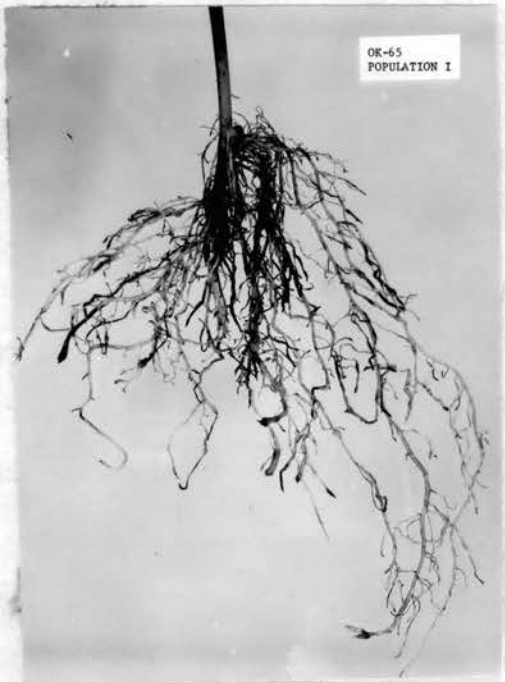

Fig. 17. Galling and necrosis reaction of Okla. 65 to M. incognita acrita population I.

Fig. 18. Reaction of Okla. 65 roots to M. incognita acrita population II.

Fig. 19. Okla. 65 reaction to M. incognita acrita population III.

Fig. 20. Severe necrosis reaction of Okla. 65 to M. incognita acrita population VI.

Reaction of Sweet Potato Lines to M. incognita incognita and M. hapla

The same 10 sweet potato lines used in other parts of this investigation were tested against M. incognita incognita and M. hapla. As previously noted, on the basis of field trials, 9 of these lines had been identified as resistant to M. incognita acrita and Allgold as susceptible.

Reactions of the sweet potato lines to M. incognita incognita and M. hapla are summarized in Table I. With a few exceptions all lines reacted to M. incognita incognita as they had to M. incognita acrita. Generally the resistant lines had little or no galling, moderate necrosis, few mature nematodes, and a low reproduction index. The reproduction index went to a moderate level on P-80, Kandee, and Okla. 65. This however, was the only respect in which these lines differed from what might be expected to be a resistant reaction.

Reactions to M. hapla, with 2 exceptions, were about as they had been to M. incognita acrita. Data for these are in Table I. Allgold gave a susceptible reaction. All lines resistant to M. incognita acrita with the exception of Nemagold and Orlis reacted with the same responses to M. hapla. There was slightly more than a trace of galling, relatively more nematodes reached maturity and a moderate amount of reproduction occurred with Nemagold. Orlis reacted similarly to Nemagold except that only slight galling was found. These data suggest that Nemagold and Orlis are not as resistant to M. hapla as they are to M. incognita acrita.

In all cases where galls were produced with M. hapla, the galls were typical of those found in association with this nematode on other plant species. That is, the galls were small and with characteristic excessive production of secondary roots.

DISCUSSION

In the present investigation several host-parasite reactions have been demonstrated in association with resistance to root-knot nematodes in sweet potato. Reactions previously observed by other workers (4, 12, 23) have been confirmed. The present work has added the observation that egg mass size in resistant lines is commonly reduced.

Even though several possible sources of resistance were represented in the sweet potato lines investigated, there was no evidence that any of the lines were appreciably different in so far as expression of resistance was concerned. This does not necessarily preclude the possibility that different biochemical mechanisms might be responsible in different sources of resistance to bring about the same ultimate phenomena observed here.

Evidence presented supports the conclusion that the 4 populations of M. incognita acrita represent 3 different physiological races. This phenomenon has not been previously demonstrated with sweet potato as the differential host. This discovery is of significance to the breeder because it emphasized the importance of testing new sweet potato varieties against several root-knot populations. Also emphasized is the necessity of further knowledge relative to the occurrence and distribution of these or similar races in nature. It has been demonstrated (24) that it is possible to select within a root-knot population for races capable of attacking resistant plants. At present the potential variation in field populations of root-knot nematodes remains largely unknown.

Evidence also has been presented that sweet potato lines react differently to different root-knot nematode species. This fact points up the need for testing against different species as well as for testing against different populations of the same species.

Several different host-parasite relations have been observed in the present work. While it is important that these phenomena be discovered and studied, ultimately it is necessary to determine the relation of these to resistance and which if any of these are useful criteria in identifying resistance. It is possible that a given sweet potato line could support a moderate level of nematode infection and reproduction and still be satisfactory from a grower standpoint. Field experience, over the past 10 years, in evaluating sweet potatoes for their reaction to root knot has shown that those lines which are only tolerant are unsatisfactory for grower use. While it is believed that each of the reactions found associated with resistance is useful in an evaluation, the use of any or all of them will not likely substitute for at least some field testing. Root-knot index alone, as demonstrated with Okla. 65 against population I, could possibly be misleading in determining resistance. Even with a moderate galling with this population on this line only a relatively few nematodes reached mature stages and reproduced. It would seem that reproduction index is an important factor which cannot be ignored in studies of resistance.

This work has demonstrated, then, the necessity for evaluating for root-knot resistance against different species and different populations of the same species and has pointed up the necessity for laboratory and greenhouse studies in conjunction with field tests.

SUMMARY

Ten sweet potato lines, 9 of which had been demonstrated to be resistant to *Meloidogyne incognita acrita* in field trials, were tested for their reaction to 4 populations of *M. incognita acrita* and 1 population each of *M. incognita incognita* and *M. hapla*.

Several different host-parasite reactions were observed associated with resistance. These were: trace or less amounts of galling on the host; moderate to severe root necrosis; generally failure of nematodes to reach mature stages; little or no reproduction by the nematode; and, in several instances, reduced numbers of eggs where reproduction did occur. These phenomena are considered important in the evaluation of sweet potato lines for resistance to root-knot.

Three physiologic races have been identified from the populations of *M. incognita acrita*. Generally, resistant and susceptible sweet potatoes reacted to *M. incognita incognita* with the same responses as shown with *M. incognita acrita*. With 2 exceptions, lines resistant to *M. incognita acrita* also were resistant to *M. hapla*.

LITERATURE CITED

1. Allen, M. W. 1952. Observations on the genus Meloidogyne Goeldi 1887. Proc. Helminthol. Soc. Wash. D.C. 19: 44-51.

2. Barrons, K. C. 1939. Studies of the nature of root-knot resistance. J. Agr. Research 58: 263-271.

3. Chitwood, B. G. 1949. "Root-knot nematodes". Part I. A revision of the genus Meloidogyne Goeldi, 1887. Proc. Helminthol. Soc. Wash. D.C. 16: 90-104.

4. Christie, J. R. 1946. Host-parasite relationships of the root-knot nematode, Heterodera marioni. II. Some effects of the host on the parasite. Phytopathology 36: 304-352.

5. Christie, J. R. 1949. Host-parasite relationships of the root-knot nematodes, Meloidogyne spp. III. The nature of resistance in plants to root-knot. Proc. Helminthol. Soc. Wash. D.C. 16: 104-108.

6. Christie, J. R., and F. E. Albin. 1944. Host-parasite relationships of the root-knot nematode, Heterodera marioni. I. The question of races. Proc. Helminthol. Soc. Wash. D.C. 11: 31-37.

7. Christie, J. R., and L. Havis. 1948. Relative susceptibility of certain peach stocks to the races of the root-knot nematode. Plant Disease Reptr. 32: 510-514.

8. Cordner, H. B., R. B. Struble, and L. Morrison. 1951. Reaction of sweet potato varieties and seedlings to root-knot nematodes. (Abstr.) Proc. Assoc. Southern Agr. Workers. 48: 119.

9. Cordner, H. B., F. B. Struble, and L. Morrison. 1954. Breeding sweet potatoes for resistance to the root-knot nematode. Plant Disease Reptr. Suppl. No. 227: 92-93.

10. Cordner, H. B., F. B. Struble, Ruth Reder, H. B. Sorensen, and L. Morrison. 1958. The origin and development of Nemagold sweet potato. Oklahoma Agr. Expt. Sta. Bull. B-507. 12 p.

11. Dean, J. L. 1951. Resistance and susceptibility to root-knot nematodes in tomato and sweet potato. Master's Thesis, Oklahoma State Univ. 54 p.

12. Dean, J. L., and F. B. Struble. 1953. Resistance and susceptibility to root-knot nematodes in tomato and sweet potato. (Abstr.) Phytopathology 43: 290.

13. Dropkin, V. H. 1953. Studies of the variability of anal plate patterns in pure line of Meloidogyne spp. The root-knot nematode. Proc. Helminthol. Soc. Wash. D.C. 20: 32-39.

14. Dropkin, V. H. 1959. Varietal response of soybeans to Meloidogyne-A bioassay system for separating races of root-knot nematodes. Phytopathology 49: 18-23.

15. Dropkin, V. H., and P. E. Nelson. 1960. The histopathology of root-knot nematode infections in soybeans. Phytopathology 50: 442-447.

16. Giamalva, M. J., W. J. Martin, and T. P. Hernandez. 1960. Reaction of 8 sweet potato selections to five species of root-knot nematodes. (Abstr.) Proc. Assoc. Southern Agr. Workers 57: 234.

17. Goplen, B. P., E. H. Stanford, and M. W. Allen. 1959. Demonstration of physiological races within three root-knot nematode species attacking alfalfa. Phytopathology 49: 653-655.

18. Kushman, L. J., and J. H. Machmer. 1947. The relative susceptibility of 41 sweet potato varieties, introductions, and seedling to the root-knot nematode H. marioni (Cornu) Goodey. Proc. Helminthol. Soc. Wash. D.C. 14: 20-23.

19. Lider, L. A. 1954. Inheritance of resistance to a root-knot nematode (M. incognita var. acrita Chitwood) in Vitis spp. Proc. Helminthol. Soc. Wash. D.C. 21: 53-60.

20. Martin, W. J. 1954. Parasitic races of Meloidogyne incognita and M. incognita var. acrita. Plant Disease Reptr. Suppl. No. 227: 86-88.

21. McBeth, C. W., A. L. Taylor, and A. L. Smith. 1941. Notes on staining nematodes in root tissues. Proc. Helminthol. Soc. Wash. D.C. 8: 26.

22. Poole, R. F., and R. Schmidt. 1927. The nematode disease of sweet potatoes. Phytopathology 17: 549-555.

23. Radewald, J. D. 1957. The nature of resistance and susceptibility to the root-knot nematode (Meloidogyne incognita var. acrita Chitwood) in sweet potato. Master's Thesis, Oklahoma State Univ. 51 p.

24. Riggs, R. D., and N. N. Winstead. 1959. Studies on resistance in tomato to root-knot nematodes and on the occurrence of pathogenic biotypes. Phytopathology 49: 716-724.

25. Sasser, J. N. 1954. Identification and host-parasite relationships of certain root-knot nematodes (Meloidogyne spp.). Maryland Univ. Agr. Expt. Sta. Tech. Bull. A-77. 31 p.

26. Sasser, J. N., and C. L. Nusbaum. 1955. Seasonal fluctuations and host specificity of root-knot nematode populations in two-year rotation plots. Phytopathology 45: 540-545.

27. Sasser, J. N., and A. L. Taylor. 1952. Studies on the entry of larvae of root-knot nematodes into roots of susceptible and resistant plants. (Abstr.) Phytopatholoty 42: 474.

28. Shibuya, M. 1952. Studies on the varietal resistance of sweet potato to the root-knot nematode injury. Mem. Fac. Agr. Kagoshima Univ. 1: 1-22.

29. Steiner, G. 1925. The problem of host selection and host specialization of certain plant-infesting nemas and its application in the study of nemic pests. Phytopathology 15: 499-534.

30. Tyler, Jocelyn. 1941. Plants reported resistant or tolerant to root-knot nematode infestation. U. S. Dept. Agr. Misc. Publ. No. 406. 91 p.

31. Weimer, J. L., and L. L. Harter. 1925. Varietal resistance of sweet potatoes to nematodes, Heterodera radicicola (Greef.) Muller, in California. Phytopathology 15: 423-426.

VITA

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Master of Science

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