RESEARCH BULLETIN 833 JULY, 1963

UNIVERSITY OF MISSOURI COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION

ELMER R. KIEHL, *Director*

Nematode Research From 1956-1962 in Missouri

LEE JENKINS

(Publication authorized July 2, 1963)

COLUMBIA, MISSOURI

CONTENTS

Nematode Research From 1956-1962 in Missouri

LEE JENKINS

INTRODUCTION

Nematodes are important microscopic parasites of man, animals, insects, plants, and other nematodes. They are also commonly known as round worms, thread worms, and eel worms. Thread worms and round worms are usually parasites of vertebrate animals. Eel worm is the name often applied to free living and plant parasitic nematodes which derive the name from their characteristic shape. Nematodes range in size from the smallest of about 1/125 of an inch long to those 30 feet in length infesting whales. Nematodes often attack livestock and may cause trichinosis in man if uncooked, infested pork is eaten. The hook worm is also a nematode parasite of man. Grasshoppers and other insects are often killed by internal nematode parasites. A few species of nematodes attack and kill other nematodes while some live entirely on organic matter and are important scavengers.

Nematodes are universally distributed but not all species are native to any one locality. The virgin soils of America contained many species of nematodes. When the land was brought under cultivation the nematodes frequently transferred from their native hosts to related cultivated crops. As time passed nematodes were also introduced from other lands on plant materials and in soil. There are now present in the United States plant parasitic nematodes that attack almost all crops, including trees and shrubs. The roots, stems, buds, leaves and in some cases the seeds of plants may be attacked by specific species. The most common injury to crops is to the roots, which are attacked by several species of nematodes. Every known plant parasitic nematode feeds by piercing the plant with a stylet which resembles a small hypodermic needle. Nematode saliva containing enzymes is then injected into the plant and plant sap is withdrawn through the stylet. Often more injury is caused to the plant by its reaction to the injected saliva than by the loss of plant sap. The cells in the feeding area may develop abnormally, as in root-knot nematode infestations, which results in the development of swellings or knots on the roots. Plant disease organisms often gain entrance into roots through punctures made by nematodes as in the case of the root-knot nematode which is associated with the destructive fusarium wilt of cotton.

Some nematodes feed on the outside of plant roots and are called ectoparasites. Others enter the roots where they feed upon the tissues from within and are called endoparasites. The females of some nematodes never move after they have become established in a root.

Kinds of Nematodes

Cyst-forming nematodes derive their name from the cyst-like body of the female which remains after death as a protective covering for the eggs remaining within her body. The mature females of cyst forms are visible on the roots of plants. They are pearly white to brown in color but are easily dislodged. The most important cyst nematodes in the United States are: the golden nematode of potatoes, which is found only on Long Island in New York; the sugar beet nematode of most sugar beet growing areas, and the soybean cyst nematode of North Carolina, Mississippi, Virginia, Kentucky, Tennessee, Illinois, Arkansas, and Missouri. Root-knot nematodes are of tropical origin and are the best known of the plant parasites. The females are sedentary endoparasites of underground plant roots and stems, usually causing swellings or galls on the roots. In some cases galls do not develop. The dagger nematodes are long, slender ectoparasites on the roots of trees, shrubs, and some other crops. Frazier and Maggenti (1962) reported that they transmitted yellow bud mosaic virus to strawberry.

There are other nematodes that feed on plants, their importance varying with the areas in which they are located.

Of the nematodes mentioned, the root-knot nematode, ***Meloidogyne incognita acrita,*** causes the most damage to crops in Missouri. It is especially destructive in greenhouses and in the sandy soil of southeastern Missouri. It has a wide range of hosts including cotton, soybeans, most of the garden crops, and some fruit trees. Another root-knot nematode, ***Meloidogyne hapla,*** is a pest on shrubs.

The soybean cyst nematode, ***Heterodera glycines,*** is a destructive pest of soybeans in southeastern Missouri. The dagger nematode, ***Xiphinema americanum,*** is common throughout the state. It is a vector of plant viruses in some areas and is probably important on the roots of shrubs and trees in Missouri.

Certain species of the genus ***Mononchus*** are predaceous on other nematodes.

NEMATODE CONTROL ON COTTON BY THE USE OF SOIL CHEMICALS AND RESISTANT VARIETIES

1956

In 1956 a seven-acre area in a field on the Edwards farm near New Madrid, Missouri was used for experimental work with nematocides for the control of root-knot nematodes, ***Meloidogyne incognita acrita,*** on cotton. Cotton grown on the experimental area had been severely damaged in irregular spots by the nematode-fusarium complex in 1955. Control measures were directed at the nematodes which punctured the roots and permitted the fusarium wilt to enter the plant. Control of the nematodes served as a control for the fusarium wilt. The experimental plots were replicated three times using three row plots for checks and two row plots for treatments. Soil fumigants were applied on March 31, 1956 using a tractor-operated pump and soil chisels. A single chisel was used in each row to place the chemical about eight inches deep. Cotton was planted two weeks later over the fumigated center of the row. DPL cotton was the variety used.

Small scale fumigation tests were made on cotton in 1956 on the Edwards farm at New Madrid but the area proved so variable in fusarium wilt damage that the yield records may not be entirely reliable as an indication of the relative value of the fumigants.

Applications were made using one anhydrous ammonia chisel in each row to a depth of 8-10 inches.

The average yield of DPL seed cotton per 1400 foot row is indicated in the following table:

TABLE 1

Treatment	No. of Replications	Gallons Fumigant per Acre	Yield per Row
Check	3	0	137 lbs.
DD	2	9	163 lbs.
DD	1	7	136 lbs.
Nemagon	3	1/2	163 lbs.
Fumazone	3	2	170 lbs.
Telone	2	7	153 lbs.
W85	3	2	139 lbs.
Dorlone	3	7	161 lbs.

1957

Nematode control on cotton by the use of soil chemicals was continued at the Edwards farm in 1957. A resistant variety, Coker 100 Wilt, was included in this test.

Cotton tests on the Edwards farm at New Madrid were planted on May 10, 1957. The first picking was made October 31. Heavy rains and continued wet weather prevented a second picking.

All soil treatments except the Nemagon granules and the Thimet granules were made on April 25 and 26. The Thimet granules and the Nemagon granules were applied on the day of planting, using an All Chem machine which put down a strip of granules eight inches wide and mixed them with the soil to a depth of four inches.

There was no evidence of phytotoxicity to the seedling cotton from the Nemagon granules.

There was some killing of the seedlings from the Thimet. Blooming and maturity were delayed and plants continued to die until near the end of the growing season from the nematode-fusarium complex.

The liquid forms of soil fumigants were applied by the use of a gravity flow kit using soil chisels to place the material eight inches deep in the soil.

Table 2 gives yield records for 1957. Table 3 gives the stand counts.

The following table gives the average number of plants in 30 feet of row in each of the eight treatments on cotton at the Edwards farm in New Madrid County. Counts were made on July 26, 1957.

Four plots were planted and the same tests repeated in each of the four. Each plot consisted of four rows. Two of the four rows were Coker 100 Wilt and two were DPL. Water damaged one plot so results from only three are recorded in this report. Each row was 150 feet in length.

TABLE 2 - 1957 RESULTS OF FUMIGATION TESTS FOR THE CONTROL OF NEMATODES ON COTTON AT THE EDWARDS FARM, NEW MADRID, MISSOURI

Cotton Variety	Treatment per Acre	Lb. Seed Cotton per Acre 3 Plot Average
DPL	Thimet granules 1.7 lbs. actual Thimet	210.0
Coker 100 Wilt	Thimet granules 1.7 lbs. actual Thimet	231.0
DPL	No treatment check	329.7
Coker 100 Wilt	No treatment check	791.0
DPL	DD solid treatment 16 gals. per acre	825.3
Coker 100 Wilt	DD solid treatment 16 gals. per acre	859.0
DPL	DD row treatment 8 gals. per acre	504.0
Coker 100 Wilt	DD row treatment 8 gals. per acre	646.8
DPL	Dowfume W-40 at 4 gals. per acre	602.8
Coker 100 Wilt	Dowfume W-40 at 4 gals. per acre	577.5
DPL	Nemagon granules, equivalent of 1/2 gal.	632.1
Coker 100 Wilt	Nemagon granules, equivalent of 1/2 gal.	604.8
DPL	Nemagon 1/2 gal.	756.0
Coker 100 Wilt	Nemagon 1/2 gal.	810.6
DPL	Nemagon 1/4 gal.	697.2
Coker 100 Wilt	Nemagon 1/4 gal.	739.2

1958

In 1957 the field at Diehlstadt used in these experiments was planted to a variety of cotton susceptible to the nematode-fusarium wilt complex. The crop was severely damaged by the combination of root-knot nematodes and fusarium wilt. This field was chosen for the study of variety resistance to nematodes and disease and to test chemicals for the control of nematodes in 1958.

Two varieties of cotton were used in the experiments on chemical control for nematodes. Auburn 56 was chosen as the resistant variety and DPL Fox as the susceptible variety. Four rows of DPL Fox cotton and four rows of Aubum 56 were included in each test plot. The two center rows were harvested from each variety.

The following chemicals were used as soil treatments: DD; Dowfume; Nemagon or Fumazone; 18133 (0, 0-diethyl 0-2-pyrazinyl phosphorothioate).

TABLE 3

Treatment	Coker 100 Wilt Living Plants	DP Living Plants
DD Row Treatment	50	24
Nemagon Liquid 1/2 Gal. Row Treatment	81	44
Thimet-Row Treatment 1.7 lbs. per acre	58	29.5
Nemagon Liquid 1/4 Gal. Row Treatment	85	42
Check No treatment	51	22
DD Broadcast 16 Gals. per acre	65	30
Dowfume W40 4 Gals. per acre Row Treatment	78	42
Nemagon granules at planting time 1/2 Gal. Nemagon equivalent per acre	54	36

All of the chemicals were used in the liquid form except the Nemagon which was used in the granular form on some plots. A soil chisel was used to put the liquid fumigants down to a depth of about 6 inches, using a single chisel to the row and planting directly over the chisel mark.

Nemagon granules were applied several ways: (1) With a horn seeder and bedding; (2) with a fertilizer attachment on a cotton drill as a side dressing; (3) using a corn planter with the Nemagon granules in the seed box applied two weeks before planting.

All applications of Nemagon granules were made at 50 pounds per acre of the 17½% formulation. Each of 12 plots was replicated three times. Two applications of 200 pounds per acre of 12-12-12 fertilizer were made as side dressings to the cotton during the growing season.

The soil was treated two weeks before planting except where the granules were applied as a side dressing at planting time.

The yields from the various treatments are shown in Table 4. Table 5 indicates the number of dead and wilted plants on September 11.

Table 6 records the average height of cotton plants in each treatment on August 13, 1958.

TABLE 4 - YIELD ON FUMIGATION EXPERIMENT, DIEHLSTADT, 1958

Treatment Rate per Acre	Pounds per Acre, Total Yield			
	Auburn 56		DPL Fox	
	Seed Cotton	Lint	Seed Cotton	Lint
DD, 8 gallons	2990	1097	2126	801
Nemagon Liquid, 1/4 gallon	2938	1052	2106	733
Nemagon Liquid, 1/2 gallon	3015	1088	2451	882
Nemagon Liquid, 3/4 gallon	2683	974	1966	719
Dowfume W85, 2-1/2 gallons	2892	1058	1991	723
American Cyanamid 18133, 8 pounds	2790	971	1439	508
Nemagon Granules, Fertilizer Attachment	2816	1019	1736	616
Nemagon Granules, Fertilizer Attachment	3096	1108	1390	495
Nemagon Granules, Horn Seeder, Bedded	2894*	1074	1400*	491
None	3118	1094	1425*	507
Nemagon Liquid, 1/2 gallon	2974	1091	2174	765
Nemagon Liquid, 1/2 gallon, Bedded	3037	1090	2186	769
Nemagon granules in planter seed box	--	--	2886	995

*Average of two replications only.

TABLE 5 - RECORDS OF DEAD AND WILTED COTTON PLANTS DURING THE GROWING SEASON AS RECORDED ON SEPTEMBER 11, 1958

Average of Replications 2 and 3 per 160 Foot Row

Treatment No.	DPL Fox		Auburn 56	
	Dead	Wilted	Dead	Wilted
1	41.00	63.00	3.00	2.50
2	13.00	41.00	0.00	3.00
3	7.25	24.75	1.25	0.75
4	1.75	13.50	1.00	2.50
5	22.25	35.00	1.00	2.50
6	48.25	52.25	3.50	0.50
7	31.75	51.75	1.25	0.50
8	69.50	77.25	2.00	0.75
9	56.00	48.50	3.00	1.25
10	76.00	61.25	4.00	1.25
11	5.75	18.75	1.25	0.75
12	20.25	40.25	0.75	0.75
13*	115.50	75.00	--	--

1. DD, 8 gallons
2. Nemagon liquid, 1/4 gallon
3. Nemagon liquid, 1/2 gallon
4. Nemagon liquid, 3/4 gallon
5. Dowfume W85, 2-1/2 gallons
6. American Cyanamid 18133, 8 pounds
7. Nemagon Granules (equivalent of 1/2 gallon liquid), Fertilizer Attachment
8. Nemagon Granules (equivalent of 1/2 gallon liquid), Fertilizer Attachment
9. Nemagon Granules (equivalent of 1/2 gallon liquid), Horn seeder, bedded
10. Check. No treatment
11. Nemagon liquid, 1/2 gallon
12. Nemagon liquid, 1/2 gallon, bedded
13. Average from two untreated border rows

*Border row.

TABLE 6 - AVERAGE HEIGHT OF COTTON PLANTS IN INCHES

Treatment Rate per Acre	Treatment No.	Replications 1, 2 & 3 6-24-58 DPL Fox	Replications 1, 2 & 3 6-24-58 Auburn 56	Replications 2 & 3 7-15-58 DPL Fox	Replications 2 & 3 7-15-58 Auburn 56	Replications 2 & 3 18-13-58 DPL Fox	Replications 2 & 3 18-13-58 Auburn 56
DD, 8 gallons	1	8.8	10.2	20.3	23.0	36.2	44.7
Nemagon Liquid, 1/4 gallon	2	8.5	10.25	17.5	20.5	37.0	44.0
Nemagon Liquid, 1/2 gallon	3	8.3	11.2	20.2	23.7	36.0	41.2
Nemagon Liquid, 3/4 gallon	4	7.1	8.9	17.2	20.8	36.7	41.2
Dowfume W85, 2 1/2 gallons	5	7.5	9.9	17.5	23.8	36.2	43.2
American Cyanamid 18133, 8 pounds	6	7.4	8.7	16.7	20.2	32.5	47.0
Nemagon Granules, Fertilizer Attachment	7	8.5	9.2	17.7	22.0	33.7	40.7
Nemagon Granules, Fertilizer Attachment	8	8.7	10.2	16.6	20.5	25.7	43.2
Nemagon Granules, Horn Seeder, Bedded	9*	6.5	9.5	18.0	20.7	31.0	42.7
Check	10	7.7	9.8	17.1	22.0	30.2	45.0
Nemagon Liquid, 1/2 gallon	11*	7.7	9.7	18.7	21.6	37.0	38.7
Nemagon Liquid, 1/2 gallon, Bedded	12	8.3	9.9	18.0	20.6	34.0	43.2

*Replications 2 and 3 only.

1959

Research on nematode control by the use of chemicals and the use of resistant varieties was continued with cotton and truck crops at Diehlstadt in 1959.

Cotton

Two varieties of cotton were used in the experiments at Diehlstadt using chemical controls for root-knot nematodes. Auburn 56 was chosen as a variety resistant to the nematode-fusarium complex and Fox was chosen as the susceptible variety. Four rows of Fox and four rows of Auburn 56 were included in each test plot. Records were taken from the two center rows of each variety. The cotton was all planted on May 6 and each treatment was replicated three times.

The following chemicals were used as soil treatments: ethylene dibromide, DD and dibromo chloropropane. The dibromo chloropropane (Nemagon or Fumazone) was used both as a liquid and in the granular form. Applications were made in some tests two weeks before planting.

Table 7 gives the yields of Auburn 56 and Fox cotton from the treated and untreated plots. Table 8 lists the average height and the number of dead and wilted plants in each plot on August 27.

TABLE 7 - EFFECTS OF VARIOUS ROOT KNOT NEMATODE CONTROLS ON COTTON YIELDS PER ACRE AT DIEHLSTADT IN 1959

Fumigant	Rate per Acre	Method of Application	Seed Cotton	
			Auburn 56	Fox
Applied 14 Days Before Planting				
DD	8 gals.	Soil Chisel	1549	1135
Dibromo chloropropane	1/4 gal.	Soil Chisel	1567	1050
Dibromo chloropropane	1/2 gal.	Soil Chisel	1484	1427
Dibromo chloropropane	3/4 gal.	Soil Chisel	1679	1669
Ethylene dibromide 85%	2-1/2 gals.	Soil Chisel	1522	1510
Dibromo chloropropane	1/8 gal.	Soil Chisel	1552	1136
Dibromo chloropropane	*50 lbs.	**Soil Chisel	1521	1410
Dibromo chloropropane	*25 lbs.	**Soil Chisel	1539	1322
Applied at Planting Time				
Dibromo chloropropane	*50 lbs.	**Soil Chisel	1523	1649
Dibromo chloropropane	1/2 gal.	Soil Chisel	1605	1478
Dibromo chloropropane	1/4 gal.	Soil Chisel	1526	1184
Check - No Treatment			1458	685

*Dibromo chloropropane (Nemagon or Fumazone) 17-1/2% granules.

**The soil chisel used was a chisel attachment on a two row International corn planter, used for deep application of fertilizer below the level of the seed. In this case the granules were placed about 6 inches below the surface of the soil and directly in the center of the row.

TABLE 8 - DEAD AND WILTED COTTON PLANTS - SEPTEMBER 12, FOLLOWING VARIOUS NEMATODE CONTROL TREATMENTS, DIEHLSTADT - 1959

Treatment	Row Average Fox No. Plants	Fox *Avg. Height	Fox Dead	Fox Wilted	Auburn 56 No. Plants	Auburn 56 *Avg. Height	Auburn 56 Dead	Auburn 56 Wilted
DD, 8 gals.	230	29"	79	100	233	36"	6	31
Dibromo chloropropane, 1/4 gal.	254	29"	83	145	282	33"	8	30
Dibromo chloropropane, 1/2 gal.	238	29"	22	91	259	34"	5	13
Dibromo chloropropane, 3/4 gal.	233	33"	21	80	252	35"	5	17
Ethylene dibromide 85%, 2-1/2 gals.	246	30"	21	67	280	28"	4	10
Dibromo chloropropane, 1/8 gal.	256	31"	64	131	253	31"	14	42
Dibromo chloropropane, **50 lbs. of 17-1/2% granules	238	29"	20	69	235	32"	5	12
Dibromo chloropropane, **25 lbs. of 17-1/2% granules	242	29"	41	105	253	34"	8	27
Applied at Planting Time				Treated May 6, at planting time				
Dibromo chloropropane, **50 lbs. of 17-1/2% granules	259	31"	17	47	255	33"	10	15
Check - No Treatment	229	22"	117	93	285	35"	14	33
Dibromo chloropropane, 1/2 gal.	326	27"	22	92	266	32"	5	20
Dibromo chloropropane, 1/4 gal.	252	29"	45	89	299	35"	8	28

*The average height was measured on August 27.

**Applied with a soil chisel attachment on a two-row International corn planter, ordinarily used for deep application of fertilizer below the level of the seed. In this case the granules were placed about six inches below the surface of the soil and directly in the center of the row.

1960

Three varieties of cotton were used in experiments at Diehlstadt in 1960 using chemical controls for root-knot nematodes. Auburn 56 was again chosen as the variety resistant to the nematode-fusarium complex. DPL 15 and Missouri 17-5211 were chosen as the susceptible varieties. Four rows, 168 feet long, of Auburn 56 and four rows of either DPL 15 or Missouri 17-5211 were included in each test plot.

All cotton was planted on May 2 but the DPL 15 failed to produce a stand and was replanted May 22. An area that had been row treated in 1959 was replanted to DPL 15 in 1960 in the exact rows of the 1959 plots. An area that was the untreated check in 1959 was included.

The following chemicals were used as soil treatments for nematode control in 1960. Ethylene dibromide, DD, dibromo chloropropane (Nemagon or Fumazone) and NIA 4606. The preplant applications were made April 14 and 15. The soil fumigants were applied to a depth of six inches using a single soil chisel in the center of each row and bedding over each row.

Table 9 gives the yield of seed cotton on the treated and untreated plots of both resistant and susceptible varieties of cotton.

TABLE 9 - NEMATODE CONTROL ON COTTON WITH SOIL CHEMICALS AND A RESISTANT VARIETY AT DIEHLSTADT - 1960

Fumigant	Rate Per Acre	Method of Application	Lbs. Seed Cotton Per Acre	
			DPL15	Auburn 56
DD	8 gals.	Soil Chisel	950	1721
Dibromo chloropropane	1/4 gal.	Soil Chisel	1055	1617
Dibromo chloropropane	1/2 gal.	Soil Chisel	1054	1633
Dibromo chloropropane	3/4 gal.	Soil Chisel	1031	1550
Ehtylene dibromide 85%	2-1/2 gal.	Soil Chisel	955	1147
Dibromo chloropropane	*50 Lbs. gran.	Soil Chisel	1120	1459
**Niagara NIA 4606	1 pint	Garden Sprinkler	259	1444
Check--no treatment			613	1614
***Dibromo chloropropane dust		Planter Seed Box	349	1514
			Mo. 17-5211	
Dibromo chloropropane	1/2 gal.	Soil Chisel	1450	1845
Check--no treatment			664	1280

*17-1/2% Dibromo chloropropane granules.

**NIA 4606 at 2 lbs. per gallon at planting time.

***This treatment consisted of a mixture of the following rates of chemicals per acre:

1/4 lb. Captan 50W
1/6 lb. Terrachlor 75W
1 lb. Dieldrin 50W
4 lbs. Nemagon 50% dust.

The chemicals above were mixed together and then mixed with the cotton seed in the planter box.

1961

The spring of 1961 was cool and damp until late in the season and may have been partly responsible for the reduction in nematode damage to cotton when compared with the cotton crop of 1960.

In 1961 work was continued with the use of resistant varieties of cotton and with the use of soil chemicals.

Dibromo chloropropane was used as the standard for comparison and a chemical known as [1]TD-183 tetrachlorothiophene was used in one replication. Another replication contained 1,2-dibromo-3-chloropropane, Terrachlor (pentachloronitrobenzene $C_6Cl_5NO_2$), and dieldrin as a dust mixture. A third dust combination contained dieldrin and Terrachlor. The object was to see whether the dust formulations mixed with the seed at planting time would reduce nematode damage. All treatments using the dust applications mixed with the seed in the planter box caused many of the young cotton plants to die. The dibromo chloropropane alone reduced the yield of DPL 15 more than any other dust formulation tested. Later in the season the plants continued to die from the nematode-fusarium complex in all three of the dust plots which were planted to DPL 15.

Table 10 gives the results of nematode control on cotton for 1961.

TABLE 10 - RESULTS OF NEMATODE CONTROL ON COTTON BY THE USE OF CHEMICALS AND RESISTANT VARIETIES AT DIEHLSTADT, MISSOURI IN 1961

Chemical	Rate per Acre	No. of Replications	Average Yield of Seed Cotton per Acre
	DPL 15		
Dibromo chloropropane	1/2 gal.	5	1,551
Dibromo chloropropane	1 gal.	2	1,563
*Dust Dibromo chloropropane Terrachlor Dieldrin	2 lbs. 1.2 lbs. .6 lb.	1	1,014
*Dust Dibromo chloropropane	2 lbs.	1	542
*Dust Dieldrin Terrachlor	.6 lb. 1.2 lbs.	1	1,122
Check		3	913
**Penn Salt TD-183	2-1/2 lbs.	1	1,766
	Auburn 56		
Dibromo chloropropane	1/2 gal.	3	1,842
Check		3	1,708

*The dust was mixed with the cotton seed in the planter box and drilled in with the seed.

**The Penn Salt TD-183 was applied as a row treatment with a hand injector.

The dibromo chloropropane was applied with a soil chisel 6 inches deep as a row treatment two weeks before planting.

[1]TD-183 was supplied by Pennsalt.

1962

Three varieties of cotton were used in the experiments at Diehlstadt to study nematode control on cotton in 1962.

Auburn 56 again used as a variety resistant to the nematode-fusarium complex. A new Missouri variety, Auburn M, was planted to determine its resistance to nematode damage. The susceptible variety was DPL 15. Treatments were replicated three times using 4 row plots with rows 168 feet in length. The check plots on Auburn 56 and DPL 15 were replicated five times.

Records were taken from the middle two rows of each plot. Soil treatments were made on April 18 and 19 except the Bayer 25141 which was applied on April 18 and an additional application was made at planting time. The cotton was planted on May 8. Conditions were good for the cotton to come up quickly and all varieties started off with a good stand.

Early season nematode damage to susceptible varieties of cotton was light. However, damage increased toward the latter part of the growing season, resulting in rather heavy loss by the end of the season.

The chemicals used for soil treatments at Diehlstadt were DBCP and Bayer 25151. The DBCP was applied in the liquid form using a soil chisel to place it six inches deep as a row treatment. The Bayer 25151 was applied with a sprinkling can and worked into the soil.

TABLE 11 - NEMATODE CONTROL ON COTTON BY THE USE OF SOIL CHEMICALS AND RESISTANT VARIETIES IN 1962

		Lbs. of Seed Cotton per Acre		
Soil Chemical	Rate per Acre	DPL 15 Lbs.	Auburn 56 Lbs.	Auburn M Lbs.
Check	0	717	1775	1914
DBCP	1/2 gal.	1550	1929	1766
Bayer 25151	4 lbs.	969	--	--

Soybeans

Among the problems confronting soybean growers in Missouri is the nematode problem. Prior to 1957 the root-knot nematode, ***Meloidogyne incognita acrita,*** was the most destructive nematode on soybeans in Missouri. The soybean cyst nematode, ***Heterodera glycines*** Ichinohe, was first found in the United States in North Carolina in 1954. It was discovered in Tennessee and Mississippi in 1956; in Arkansas, Kentucky, and Missouri in 1957; in Virginia in 1958 and in Illinois in 1959. The known infested acreage in June of 1961 was 60,215 acres with 12,119 acres in Missouri located in the 6 southeastern counties of Dunklin, Mississippi, New Madrid, Pemiscot, Scott, and Stoddard.

Prior to its discovery in the United States the soybean cyst nematode caused serious losses to soybean production in Japan, Korea, and Manchuria. After it was found in Tennessee and Missouri, research work was initiated on life histories and control by the United States Department of Agriculture in Jackson,

Tennessee. In 1958 an infested field was chosen in Missouri for testing soybean varieties for resistance. Dr. Leonard Williams and Professor Arnold Matson planted over 3,000 varieties of soybeans which were examined by digging the plants and examining the roots for the presence of the white females. A variety known as Peking was found to be resistant and work was started by Dr. Williams to incorporate the resistance of Peking to the commercial seed varieties grown in Missouri.

Prior to 1959 symptoms of soybean cyst nematode damage in Missouri were not evident in soybean fields except in a few small spots in a few fields.

In 1959 over two-thousand acres of soybeans in southeast Missouri showed symptoms of damage from the soybean cyst nematode. The damage ranged from slight to so severe that some fields were plowed under in early June. Soybeans that showed some damage in later May seemed to recover to some extent in June and July. Many plants that were severely damaged either died or remained stunted throughout the growing season.

Early planted soybean plants that were severely damaged were removed from an area in a field at Conran and the area replanted to soybeans on June 23. Some of the new plantings were put in where the original row had been planted. Other rows were planted midway between the original rows. A 20-foot length on the end of each row was treated with dibromo chloropropane at the rate of ½ gallon per acre row treatment. The plantings midway between the original rows grew noticeably faster for the first month than those planted on the original rows. All new plantings outgrew the beans left from the original plantings. By late August there was very little difference between the size of the plants midway between the original rows and those replanted in the original row. The soybean plants on the treated soil grew twice as large as any on the untreated areas of the rows.

In 1960 soybeans were planted on three different dates at Conran to see what influence date of planting would have on soybean yields in a field heavily infested with soybean cyst nematodes.

In 1960 the damage was light when compared with that in 1959. Only a few fields were observed that showed definite symptoms of soybean cyst damage. Most of the fields that had serious damage in 1959 were not planted to soybeans in 1960. Cooler weather early in the season appeared less favorable for nematode development. At the experimental field at Conran, where the soybean crop was so severely damaged in 1959 that it was plowed under except for the experimental planting, there was considerable stunting and some definite symptoms of early soybean cyst damage. Most of the plants grew out later and, except for some stunting, had the appearance of nearly normal plants at harvest time. The plants in a few spots in the field were noticeably stunted at the end of the season.

The Lee variety of soybeans was used as the susceptible variety in a study of the effect of date of planting on soybean cyst nematode damage. Each planting contained five row plots replicated three times. In the first planting all but the fourth rows were treated with dibromo chloropropane at ½ gallon per acre. In the second and third plantings the first three rows were treated and the

fourth and fifth rows were untreated. The dibromo chloropropane was placed six inches deep in the row with a hand injector at planting time. The treated rows grew taller than the untreated but all plantings appeared normal except for the size of the plants. Harvest records are given in Table 12.

TABLE 12 - SOYBEAN YIELDS FROM THREE DATES OF PLANTING PLOTS ON SOIL INFESTED WITH SOYBEAN CYST NEMATODES - 1960

	Yield Per Acre		
Date of Planting	Plot 1	Plot 2	Plot 3
April 23 - Treated	17.7 bu.	19.5 bu.	19.5 bu.
Check	16.6 bu.	15.3 bu.	15.9 bu.
June 3 - Treated	18.2 bu.	18.2 bu.	27.1 bu.
Check	7.5 bu.	17.8 bu.	22.6 bu.
June 16 - Treated	17.4 bu.	18.7 bu.	25.5 bu.
Check	9.8 bu.	8.9 bu.	28.2 bu.

Plots 1, 2, and 3 are replications of the dates of planting.

In addition to the soybean cyst nematode the root-knot nematode, *Meloidogyne incognita acrita,* has caused appreciable losses to soybean crops in southeast Missouri, especially when grow on sandy soil. Observations and experimental work indicated that some varieties were more susceptible to damage than others. Table 13 lists the results from experimental plots grown on nematode-infested soil at Diehlstadt.

In 1961 the Scott variety of soybeans, which is very susceptible to the root-knot nematode, *Meloidogyne incognita acrita,* was planted at Diehlstadt. Four rows were treated with dibromo chloropropane at ½ gallon per acre; an untreated four-row check was compared with the treated. There was no noticeable difference between the treated and untreated plots at harvest time. In 1960 in the same field the untreated Scott soybeans were severely damaged by root-knot nematodes.

In 1962 Scott and Lee were the two varieties grown at Diehlstadt to observe the damage caused by root-knot nematodes. The Scott variety was planted on 54 rows 168 feet long. Four of the rows were treated with dibromo chloropropane at ½ gallon per acre. The Lee variety was planted on untreated soil. There was very little difference between the appearance of the treated and untreated rows of Scott. Examination of the roots indicated that the treated rows remained undamaged all seasons. The untreated rows had light damage on most all roots on June 30. By July 14 the root-knot infestation ranged from a trace to heavy and on August 25 the root-knot infestation was rather uniform on all the plants.

Untreated Lee soybeans were almost free of nematode damage to the roots throughout the growing season.

The average yield on the 54 rows of Scott soybeans was 56 bushels per acre in spite of fairly heavy populations of root-knot nematodes, *Meloidogyne in-*

TABLE 13 - EFFECT OF ROOT-KNOT NEMATODE ON SOYBEANS - DIEHLSTADT, MISSOURI - 1958[1]

	Yield Bu.	Maturity[2]	Lodging Score	Height In.	Nematode Score[4]	Nodulation Score
Clark-treated[3]	46.6	15	1.3	47	0	3.3
Difference	-4.2	-2	0	-1	+2.4	+.2
Anderson-treated	37.4	25	2.3	51	0	3.3
Difference	-0.5	0	-.2	0	+0.1	+.2
Scott-treated	48.9	30	1.6	49	0	3.0
Difference	-15.0	-5	-.5	0	+5.0	+.5
D53-526-treated	46.2	31	1.9	42	0	3.5
Difference	-7.0	0	-.4	-1	+0.8	0
Dorman-treated	38.8	39	3.3	48	0	3.0
Difference	-4.4	-1	-.3	-3	+1.5	+.3
Hood-treated	43.0	53	2.5	43	0	3.5
Difference	-0.9	0	-.7	+2	+1.9	0
Ogden-treated	39.2	52	2.3	49	0	3.5
Difference	-5.0	0	-.8	0	+1.3	0
Lee-treated	37.1	55	2.6	41	0	4.0
Difference	-2.3	0	-.8	+3	+2.9	0

[1]Work carried on by Dr. Leonard Williams, Professor Arnold Matson and Dr. Marvin Whitehead.

[2]Maturity - days after August 31.

[3]Treated May 1 with 6 gallons per acre of Dow W85 in the row. Paired rows, four replications.

[4]Scoring method for rating nematode and nodulation development on the roots was as follows: 0, no nematodes; 1, light damage; 2, moderate damage; 3, heavy, and 4, severe.

Nodulation: The range is from 0 to 4 with 4 indicating the highest rating.

cognita acrita. The yield on the treated rows was 51.2 bushels per acre. Records were taken from the middle two rows of the 4 rows that were on treated soil.

NEMATODE CONTROL ON SUGAR BEETS BY THE USE OF SOIL CHEMICALS AND DATE OF PLANTING

1961

Four 168-foot rows of sugar beets were planted on the Diehlstadt field to study the importance of root-knot nematodes on the yield and quality of harvest beets.

Two rows were treated with DD as a row treatment at the rate of 8½ gallons per acre on the basis of 38-inch rows. One soil chisel per row was used more than two weeks before planting to place the DD six inches directly under the row. The beets were seeded May 11 and harvested October 27.

The following table gives the yield in pounds per row and the sucrose content.

TABLE 14

	Yield Lbs. per Row	No. of Beets*	Sucrose Content	Apparent Purity
Check	99.5	78	9.75%	89.2
DD treated	199.8	104	14.4%	98.8

*Many of the plants died in the untreated rows.

1962

Sugar beets were grown in cooperation with Mr. Detroy Green and Dr. Thomas Wyllie of the Field Crops Department. An attempt was made to determine the influence of date of planting on root-knot nematode, ***Meloidogyne incognita acrita,*** damage to sugar beets. The plantings were replicated three times in randomized 12-row plots with 15 foot rows. The spacing between rows was 24 inches. Each series of plots was grown on untreated soil and on treated soil. The treated area was given a broad cast treatment of 25 gallons of DD per acre the fall before planting. The dates of planting were March 22, April 4, and April 20. There was a poor stand of beets due to many of the plants dying soon after they came up. The loss of seedling plants was much more severe in the untreated plots than in the plots treated with DD. Growth was poor on all plots and at harvest time it was difficult to take any records due to lack of uniformity on all the plots. A sample of plants from each date of planting was examined at harvest time. The beets from all three dates of planting grown on the untreated soil were severely damaged by root-knot nematodes.

NEMATODE CONTROL ON TRUCK CROPS BY THE USE OF SOIL CHEMICALS AND RESISTANT VARIETIES

1958

In 1958 nematode control work has started on truck crops at the Babb farm near Diehlstadt.

Each plot consisted of two 168-foot rows for the check and two rows treated. A soil fumigant was placed six inches deep under the row two weeks before planting except as indicated on the sweet corn.

Muskmelon plants in the untreated rows were severely damaged by root-knot nematodes. Many of the untreated plants died before harvest was completed on the treated rows. Yield records are given in Table 15.

Cabbage plants of the variety Copenhagen were set May 9. By June 3 the plants in the treated rows were noticeably larger than those in the check. Heads

TABLE 15 - RESULTS OF SOIL TREATMENT FOR NEMATODE CONTROL ON TRUCK CROPS

Crop	Treatment per Acre	% Increased Yield		% Decreased Yield
		Weight	No. of Fruits	
Muskmelons	*DBCP 1/4 gal.	39	28	0
Cabbage	DBCP 1/2 gal.	31	-	0
Peppers	DBCP 1/2 gal.	-	-	14
Sweet Corn	DBCP 1/2 gal.	18	-	-
Sweet Potatoes	DBCP 1/2 gal.	-	-	20
Tomatoes	DBCP 1/2 gal.	17		

*DBCP is an abbreviation for dibromo chloropropane which is supplied under the trade names Nemagon and Fumazone.

began forming on the plants in the treated row about one week ahead of those in the check. At harvest time there was not as much difference in the appearance of the treated and untreated rows as was indicated by the weight of the heads. The cabbage heads on the treated rows were much more compact than the check. Plants were pulled from the treated and untreated rows at harvest time. There was severe root-knot damage in the check but no evidence of nematode damage in the treated rows.

Pepper plants of the variety California Wonder were set on May 9. By June 4 the plants treated with dibromo chloropropane were slightly yellow and smaller than the check. As the season progressed the plants in the treated rows seemed to recover from the stunting effect of the dibromo chloropropane and were producing about as many peppers in mid-August as the untreated plants. Dibromo chloropropane at ½ gallon per acre as a row treatment was toxic to pepper plants set two weeks after the soil was treated. The results are listed in Table 15.

Sweet corn of the Golden Bantam variety was planted on May 15 immediately following dibromo chloropropane row treatment with a hand injector at the rates of ½ gallon per acre and at 1 gallon per acre. By June 3 there was evidence of stunting on the treated rows. No injury was observed where the chemical was applied two weeks ahead of planting.

Sweet potato plants of the All Gold variety were set on May 15 in rows treated with ½ gallon of dibromo chloropropane per acre. The yield was reduced in the treated rows as compared to the check. Most of the good tubers in the treated rows were developed on the outer edges of the row. Those in the center of the row were mostly so stringy that they were of no value. Sweet potatoes that were produced in the check rows were rougher but more nearly normal in shape. There were some badly cracked and rough tubers in the check rows.

The yields are given in Table 15.

Tomatoes of the Rutgers variety showed slight browning of the roots where dibromo chloropropane was used as a row treatment two weeks before planting. Table 15 gives a comparison of yields on the treated and untreated rows.

1959

Muskmelons were planted in treated and untreated rows on May 13. Three rows were treated with ¼ gallon dibromo chloropropane per acre and three were left untreated. On one of the three untreated rows the plants were dying as a result of nematode damage by June 5. The other untreated rows and the treated rows appeared normal. Later in the season spray injury was so severe that no reliable harvest records were obtained.

Cabbage of the All-Season variety was started by seeding in the row May 13. Root-knot nematodes did not cause a visible difference between the plants growing in treated and untreated rows. Harvest records are shown in Table 16.

TABLE 16 - NEMATODE CONTROL ON TRUCK CROPS AT DIEHLSTADT - 1959

Crop	Treatment per Acre	Percent Increased Yield by Weight	Percent Decreased Yield
Beets	DD, 8 gals.	48%	--
Bush Beans	Dibromo chloropropane, 1/2 gal.	31%	--
Peanuts	Dibromo chloropropane, 1/2 gal.	11%	--
Cucumbers	Dibromo chloropropane, 1/4 gal.	51%	--
Okra	Dibromo chloropropane, 1/2 gal.	46%	--
Cabbage	Dibromo chloropropane, 1/2 gal.	9%	--
Peppers	DD, 8 gals.	No Difference	--
Tomatoes	DD, 8 gals.	--	6.7%
Tomatoes	Dibromo chloropropane, 1/2 gal.	11.5%	--
Squash	Dibromo chloropropane, 1/4 gal.	10%	--

Pepper plants of the California Wonder variety were planted May 13 on treated and untreated rows. There was no noticeable difference in the growth and appearance of the rows. The roots of plants from the untreated rows were examined after harvest in September. There was little evidence of root knot damage. Harvest records are given in Table 16.

Beets of the Cosby Egyptian variety were planted May 13 and harvested July 22. At harvest time the tops were of about uniform height and there was no distinguishable difference in general appearance. However, the beets from the treated rows were generally larger than those from untreated rows. Harvest results are shown in Table 16.

Bush beans of the Top Crop variety were planted May 13. By June 3 the bean plants on the treated rows were slightly larger than on the untreated. By July 30 most of the leaves had dropped from the untreated rows while the treated rows retained their leaves. There was severe root damage to plants on the untreated rows. Results are shown in Table 16.

Tomatoes of the Rutgers variety were planted May 13. No noticeable difference was observed in the appearance of the plants on treated and untreated rows during the growing season. Plants examined after harvest had little evidence of root-knot nematode damage even on the untreated rows.

Tomato plants of several other varieties were tested for resistance to root-knot nematodes. All of the common varieties tested were susceptible. The varie-

ties Anahu and Kalohi from Hawaii were highly resistant. No harvest records were made on this planting.

Sweet potatoes of the All Gold variety were grown in comparison with Nemagold plants. The Nemagold variety produced much smoother potatoes than the All Gold. Nemagold potatoes also were highly resistant to nematodes. All Gold is quite susceptible to root-knot nematodes. (See Table 17.)

TABLE 17 - NEMATODE CONTROL ON TRUCK CROPS AT DIEHLSTADT - 1959

Crop	Treatment per Acre	Yield Lbs. per Acre
All Gold Sweet Potatoes	DD, 8 gallons	15148
All Gold Sweet Potatoes	Ethylene dibromide, 2-1/2 gals.	16481
Nemagold Sweet Potatoes	DD, 8 gallons	19229
Nemagold Sweet Potatoes	No Treatment	32571
All Gold Sweet Potatoes	No Treatment	16660

The land at Diehlstadt was sandy. Root knot nematode infestations were unusually uniform over the field.

Soil fumigation treatments for vegetables were applied over three weeks before the vegetables were planted.

Squash plants of an early variety looked equally well on treated and untreated rows where the fumigant was dibromo chloropropane at ¼ gallon per acre. A comparison of yields from treated and untreated rows is in Table 16.

Okra was planted May 13 and by June 3 the plants on the treated rows were somewhat larger than those on the untreated rows. On July 30 there were several dead and some stunted plants in the untreated rows. The treated rows had larger plants and fewer dead ones. Table 16 includes a yield comparison.

Carrots grown on rows treated with ½ gallon dibromo chloropropane per acre were smooth and of good quality. Carrots on untreated rows were stunted and rough with the typical appearance of carrots heavily infested with root-knot nematodes.

Peanuts grown on rows treated for nematode control had darker green leaves than plants on untreated rows. Results are listed in Table 16.

1960

Beets of the variety Early Blood Turnip were seeded May 4. Two rows were treated two weeks before planting with DD, eight gallons per acre, and two rows were left as untreated checks. Observations June 15 indicated the treated rows had larger beets and were free from nematode damage. Root-knot nematodes were abundant on the untreated rows and the plants were stunted. The yield was almost doubled on the treated rows.

Bush beans of the variety Top Crop were planted May 4. Two rows were planted on rows treated with dibromo chloropropane, ½ gallon per acre, and two rows were untreated checks. By June 15 there was a noticeable difference in size and color of the plants on the treated rows. The check rows had smaller plants with lighter colored leaves than the treated plants. By July 7 the plants on treated rows appeared normal but root-knot nematode damage was severe on

roots of the check, and many of the plants were dying.

Table 18 gives harvest records of bush beans and beets.

Tomatoes of the varieties Stone and Fireball were planted May 7. One row of each variety was treated with DD and one row was left as a check. Several hybrid tomato plants were tested for resistance to root-knot nematodes. These included 15 plants of each of the following: Hawaii N-11, Hawaii N-44, Mozark X Anahu, Morton hybrid, TF X Kalohi, TF X Anahu, and Fireball. These were all planted on untreated soil. Yields are recorded in Table 18.

Sweet potatoes of the varieties All Gold, Nemagold, and NC 171 were grown on rows treated with eight gallons of DD per acre, and on an untreated check. The All Gold sweet potatoes on the treated rows were much smoother than those in the check and no nematodes were found in the tubers. The untreated All Gold potatoes were heavily infested with root-knot nematodes and many were very rough. No nematodes were found in the tubers of the untreated check of the varieties Nemagold and NC 171. Table 18 gives harvest records.

Carrots grown on rows treated with ½ gallon of dibromo chloropropane were larger and smoother than those in the check. The untreated check produced stunted, knotty, and deformed carrots. No harvest records were taken due to the poor stand on both the treated and the check rows.

Cucumbers of the variety Straight Eight were grown on rows treated with ½ gallon of dibromo chloropropane per acre, and on an untreated check. The check was severely damaged by root-knot nematodes while the plants on the treated rows appeared normal. Table 18 gives harvest records.

Okra plants grown on rows treated with ½ gallon of dibromo choloropropane per acre were more vigorous and lived longer than plants on the untreated check. Plants on the check rows were smaller and many died early in the season. Table 18 gives harvest records for okra.

Three varieties of watermelons were grown on rows treated with 1/6 gallon of dibromo chloropropane per acre and on untreated checks (Table 18). Black Diamond plants lived longer on the treated rows but were so severely damaged by wilt that very few matured. The Charleston Grey showed little difference in appearance beween the treated and the untreated rows.

Two varieties of muskmelons were included in the tests at Diehlstadt. The variety Hale Jumbo was severely injured by nematodes, reducing production to about ⅓ of normal.

The variety Market Queen was only slightly reduced in yield by nematodes on the roots.

1961

Truck crops such as cucumbers, watermelons, muskmelons, peppers, bush beans, cabbage, garden beets, and sweet potatoes were grown at Diehlstadt on treated and untreated rows again in 1961.

Nematode damage was somewhat lighter on some of the crops than had been the case in previous years. The early part of the season was cold and wet. There was such a poor stand of muskmelons that no reliable records could be obtained. The following table lists the crops, the chemical treatments used, and

TABLE 18 - RESULTS OF NEMATODE CONTROL ON TRUCK CROPS AT DIEHLSTADT IN 1960

Crop	Variety	Treatment		Yield/Acre
		Chemical	Rate/Acre	
Muskmelon	Hale Jumbo	Dibromo choropropane	1/4 gal.	22,269 lbs.
Muskmelon	Hale Jumbo	Check--no treatment		7,800 lbs.
Muskmelon	Market Queen	Dibromo chloropropane	1/4 gal.	21,996 lbs.
Muskmelon	Market Queen	Check--no treatment		20,728 lbs.
Peppers	California Wonder	DD	8 gals.	14,118 lbs.
Peppers	California Wonder	Check--no treatment		14,586 lbs.
Cabbage	All season	Dibromo chloropropane	1/2 gal.	19,266 lbs.
Cabbage	All season	Check--no treatment		17,940 lbs.
Beets	Early blood turnip	DD	8 gals.	4,095 lbs.
Beets	Early blood turnip	Check--no treatment		2,223 lbs.
Bush beans	Top Crop	Dibromo chloropropane		7,371 lbs.
Bush beans	Top Crop	Check--no treatment		2,909 lbs.
Tomatoes	Stone	DD	8 gals.	663 bu.
Tomatoes	Stone	Check--no treatment		704 bu.
Tomatoes	Fireball	DD	8 gals.	361 bu.
Tomatoes	Fireball	Check--no treatment		272 bu.
Sweet potatoes	All Gold	Check		189 bu.
Sweet potatoes	Nemagold	Check		363 bu.
Sweet potatoes	NC 171	Check		346 bu.
Sweet potatoes	All Gold	DD	8 gals.	306 bu.
Sweet potatoes	Nemagold	DD	8 gals.	389 bu.
Sweet potatoes	NC 171	DD	8 gals.	611 bu.
Cucumbers	Straight eight	Dibromo chloropropane	1/2 gal.	17,940 lbs.
Cucumbers	Straight eight	Check--no treatment		1,404 lbs.
Okra	Perkins dwarf	Dibromo chloropropane	1/2 gal.	4,758 lbs.
Okra	Perkins dwarf	Check		2,959 lbs.
Watermelons	Charleston Grey	Dibromo chloropropane	1/6 gal.	39,134 lbs.
Watermelons	Charleston Grey	Check		33,014 lbs.
Watermelons	Black Diamond	Dibromo chloropropane	1/6 gal.	2,418 lbs.
Watermelons	Black Diamond	Check--all plants dead		0
Watermelons	Seedless	Dibromo chloropropane	1/6 gal. 11 plants	344 lbs.
Watermelons	Seedless	Check	10 plants	183 lbs.

TABLE 19 - UNTREATED TOMATO PLANTINGS AT DIEHLSTADT TO STUDY VARIETIES RESISTANT TO THE ROOT-KNOT NEMATODE (MELOIDOGYNE INCOGNITA ACRITA)

Variety	Number of Plants	Nematode damage to roots	Yield per acre
Hawaii N 11	15	Trace	1,056 bu.
Hawaii N 44	15	Trace	983 bu.
Mozark X Anahu	15*	Severe	315 bu.
Morton Hybrid	12	Severe	902 bu.
TF X Kalohi	15	Trace	912 bu.
TF X Anahu	15	Trace	1,191 bu.

These plants were started in the greenhouse and were transplanted to the field May 19. *By June 15 five of the 15 plants of the variety Mozark X Anahu were dead. All of the plants of the other varieties grew well and showed no signs of wilting. Observations on the condition of the plants on September 22 were:

Hawaii N 11 - Large plants with green leaves at tops. These were the best looking plants of any variety.

Hawaii N 44 - Very few leaves; stems and leaves diseased.

Mozark X Anahu - All plants dead.

Morton Hybrid - Large plants with very few leaves.

TF X Kalohi - Similar to Hawaii N 11.

TF X Anahu - Very few leaves; stem green.

the yields on the treated and on the check plots. All chemical treatments were on the row using a single chisel in the center of the row at least two weeks before planting.

Tomato plants supplied by Dr. Victor Lambeth of the Department of Horticulture were grown on the research field at Diehlstadt to determine their susceptibility to the root-knot nematode, *Meloidogyne incognita acrita.* Plants were grown in individual pots in the greenhouse until they were about six inches high. They were transplanted to the field on May 11 and examined for the presence of nematodes on the roots August 29. The plants were dug and rated as 0, 1, 2, 3, or 4. The meaning of each number used in rating is as follows:

0—No nematodes evident
1—A slight infestation
2—Moderate infestation
3—Heavy infestation
4—Severe infestation

1962

Tomatoes were grown on untreated soil at the Babb farm to study the resistance of hybrid plants furnished by Dr. Victor Lambeth of the Department of Horticulture. Rutgers tomatoes were used to check on the nematode damage to a susceptible variety.

The tomato production was lower on all tomatoes grown in 1962 than in 1961 in the same field. Production records are listed in Table 22 along with

TABLE 20 - RESULTS OF NEMATODE CONTROL ON TRUCK CROPS AT DIEHLSTADT - 1961

Vegetables	Variety	Treatment per Acre	Pounds per Acre Yield
Cucumbers	Straight Eight	Check	6,817
Cucumbers	Straight Eight	*1/2 gallon DBCP	16,770
Watermelons	Tri X 317 Seedless	Check	15,678
Watermelons	Tri X 317 Seedless	*1/2 gallon DBCP	17,550
Watermelons	Charleston Grey	Check	13,337
Watermelons	Charleston Grey	*1/2 gallon DBCP	18,135
Peppers	California Wonder	Check	14,820
Peppers	California Wonder	8-1/2 gallons DD	14,381
Bush Beans	Top Crop	Check	3,802
Bush Beans	Top Crop	1/2 gallon DBCP	3,482
Cabbage	All Season	Check	22,651
Cabbage	All Season	1/2 gallon DBCP	21,372
Sweet Potatoes	All Gold	Check	13,260
Sweet Potatoes	All Gold	8-1/2 gallons DD	7,690
Sweet Potatoes	Nemagold	Check	11,287
Sweet Potatoes	Nemagold	8-1/2 gallons DD	11,122
Sweet Potatoes	Centennial	Check	18,166
Sweet Potatoes	Centennial	8-1/2 gallons DD	16,177
Sweet Potatoes	Nugget	Check	9,594
Sweet Potatoes	Nugget	8-1/2 gallons DD	24,257

*The rate of application per 100 feet of row is based upon the amount used per acre on 38 inch rows. On watermelons this would be about 1/6 gallon per acre.

Dibromo chloropropane is listed in the table as DBCP.

ratings on nematode damage to the roots. High temperatures during mid season probably reduced the set of fruit.

Muskmelons were again planted using the varieties Hale's Best and Harvest Queen. Observations were made to determine whether the Harvest Queen variety was resistant to nematodes. Early season nematode damage to the small

TABLE 21 - TEST TO DETERMINE THE SUSCEPTIBILITY OF TOMATOES TO ROOT-KNOT NEMATODES

Variety	0	1	2	3	4
TF X Anahu	10 plants	2 plants			
Rutgers			8 plants		1 plant
Tucker Forcing		1 plant	6 plants		3 plants
Mozark X Anahu	9 plants	1 plant			
Kalohi	10 plants				
N-11	10 plants				
TF X Kalohi	10 plants				

Observations on the growing plants on August 10, 1961 indicated that TF X Anahu was the best in appearance of any. All varieties were badly defoliated.

TABLE 22 - UNTREATED TOMATO PLANTINGS AT DIEHLSTADT TO STUDY VARIETIES RESISTANT TO ROOT-KNOT NEMATODES (MELOIDOGYNE INCOGNITA ACRITA). EXAMINED FOR NEMATODES SEPTEMBER 6, 1962

Variety	No. of Plants	No. of Fruits	Total Wgt. in Lbs.	Nematode Rating			
				Clean	Trace	Medium	Severe
2-20 BK	29	250	81.8	14			
Rutgers	31	107	29.7				12
STEP 352	30	429	142.0	13	1		
2-13-14-15 BK	30	431	102.0	15			
N-11	30	526	134.0	12	1	2	
Anahu	30	179	50.8	12	Most Plants Dead		
Kalohi	30	168	52.8		2	All Dead	
2-7-2 BK	27	252	76.7	16	1		
2-12 BK	30	192	44.3	15			
2-2-2 BK	30	707	152.0	15	Most Plants Dead		
2-18-19 BK	30	418	115.4	12	3		

plants indicated that the Harvest Queen variety was not resistant to the root-knot nematodes present in the soil at Diehlstadt. The yields from he muskmelon plots are recorded in Table 23.

TABLE 23 - RESULTS OF NEMATODE CONTROL ON TRUCK CROPS AT DIEHLSTADT, MISSOURI - 1962

Crop	Treatment per Acre	Yield Lbs. per Acre
Top Crop Green Beans	DBCP* 1/2 gal.	4,223
Top Crop Green Beans	Check	3,575
Fordhook Lima Beans	DBCP 1/2 gal.	3,275
Fordhook Lima Beans	Check	2,558
California Wonder Peppers	DD 8-1/2 gals.	13,976
California Wonder Peppers	Check	17,236
Cucumbers	DBCP 1/4 gal.	21,648
Cucumbers	DBCP 1/4 gal.	23,862
Cucumbers	Check	18,450
Cucumbers	Check	18,327
Butternut Squash	DBCP 1/4 gal.	73,554
Butternut Squash	Check	63,222
Summer Crookneck Squash	DBCP 1/4 gal.	42,660
Summer Crookneck Squash	Check	42,000
Charleston Grey Watermelons	DBCP 1/6 gal.	27,575
Charleston Grey Watermelons	Check	28,532
Tri X 317 Seedless Watermelons	DBCP 1/6 gal.	18,303
Tri X 317 Seedless Watermelons	Check	18,330
Hale's Best Muskmelons	DBCP 1/4 gal.	15,839
Hale's Best Muskmelons	DBCP 1/4 gal.	14,650
Hale's Best Muskmelons	Check	12,697
Hale's Best Muskmelons	Check	9,472
Harvest Queen Muskmelons	DBCP 1/4 gal.	18,380
Harvest Queen Muskmelons	DBCP 1/4 gal.	17,680
Harvest Queen Muskmelons	Check	11,913
Harvest Queen Muskmelons	Check	11,160
Eggplant	DBCP 1/2 gal.	17,876
Eggplant	Check	17,863
L489 Sweet Potatoes	DD 8-1/2 gals.	15,655
L489 Sweet Potatoes	Check	12, 833

*DBCP is an abbreviation for dibromo chloropropane.

Crop	Treatment per Acre	Yield Lbs. per Acre
Nugget Sweet Potatoes	DD 8-1/2 gals.	13,653
Nugget Sweet Potatoes	Check	15,382
Portorico Sweet Potatoes	DD 8-1/2 gals.	18,240
Portorico Sweet Potatoes	Check	23,310
Nemagold Sweet Potatoes	DD 8-1/2 gals.	8,200
Nemagold Sweet Potatoes	Check	4,551
Peanuts	DBCP 1/2 gal.	2,361
Peanuts	Check	2,423
Connecticut Field Pumpkins	DBCP 1/2 gal.	34,200
Connecticut Field Pumpkins	Check	29,000

Watermelons included Tri X 317 Seedless and Charleston Grey and were planted on treated and untreated land. The seedless variety were limited to one 168 foot row on treated soil and one row on untreated. There were 4 rows of Charleston Grey watermelons treated and four untreated. The yield records are given in Table 23.

Cabbage, carrots, parsnips and garden beets were such poor stands that no reliable records could be taken. These crops were seeded in mid May when the sandy soil dried quickly and the temperature was too high for seeds of such crops to grow. The okra had to be replanted and had only light nematode damage to the roots.

Top Crop bush beans were injured less by nematodes than in 1961. The yields are given in Table 23.

California Wonder peppers were planted on DD treated soil and on untreated soil. The yields are recorded in Table 23.

Cucumbers of the V8 variety were grown on two row plots replicated twice on treated and untreated soil. The yield records are listed in Table 23.

Connecticut Field pumpkins were grown on treated and untreated plots. There was no difference in the appearance of the treated and untreated rows. The nematode damage to the roots was very light on the untreated rows. Harvest records are listed in Table 23.

Squash of two varieties, Butternut and Summer Crookneck, were grown and harvest records are given in Table 23. The untreated and treated rows were similar in appearance during the growing season.

Eggplant seeds were planted in rows in the field on May 10. The plants were thinned to a distance of three feet apart in the row. No root-knot nematode damage was observed on the roots of the untreated rows when the plants were dug for inspection in September. Harvest records are listed in Table 23.

Sweet potato plants were furnished by Dr. Victor Lambeth of the Horticulture Department. The varieties included in the planting were Nugget, Nemagold, L489, and Portorico. The treated rows had DD at 8½ gallons per acre applied with a soil chisel two weeks before planting. Harvest records are included in Table 23.

In addition to the work at Diehlstadt, experimental work was done at the Noah Heath farm in southeastern Missouri. Dibromo chloropropane was used as a soil fumigant for green beans. The chemical was applied in the row with a hand injector after the beans were planted. The first crop of beans showed no results from the soil treatment. The second crop was good on the treated rows but most of the plants died on the untreated rows.

The Green Giant Company had 300 acres of green beans under contract in the area near Bucoda, Missouri. Random samples were taken from all the fields for root examination to determine possible nematode damage. There was no damage from root-knot nematodes that could be detected by examining the roots.

Vol. 43, No. 10--PLANT DISEASE REPORTER--Oct. 15, 1959 1095

CHEMICAL DIPS FOR THE CONTROL OF NEMATODES ON BARE ROOT NURSERY STOCK[1]

Lee Jenkins[2] and H. W. Guengerich

There is an increasing need for a satisfactory method of treating nematode-infested nursery stock before it is shipped to the customer. Damage to slightly infested trees or shrubs may be negligible when delivered to the customer. Detection of slight infestations is practically impossible where millions of trees and shrubs, many with innumerable small roots, are involved. These slightly infested plants may become seriously injured soon after planting, due to a build-up of the initial nematode infestation. An effective treatment would provide a means of insuring nematode-free nursery stock. Systematic use of such a treatment would prevent the spread of nematodes in shipments of trees and shrubs from the nursery.

Renninger, Coffey and Sokoloff[3] reduced Radopholus similis, the burrowing nematode, 94.9 percent on citrus roots by treating the soil with a soluble hydrogenated fish oil.

Tests to explore the possibilities of using a chemical as a dip on bare root nursery stock were started by the authors in 1958. Experimental materials from the Union Oil Company of Brea, California, known as G6822, G1676 and 279, were tested. The American Cyanamid Company furnished an emulsifiable organic phosphate experimental nematocide 18133 (O, O-diethyl O-2-pyrazinyl phosphorothioate) and Boris Sokoloff of the Southern Bio-Research at Lakeland, Florida furnished hydrogenated fish oil for our tests. Of those materials tested, the 18133 seemed to be the most promising when both plant tolerance and nematode control are considered. The treatments were directed for the most part toward the control of root-knot nematodes, Meloidogyne sp.

MATERIALS AND METHODS

The materials Union Oil G6822, G1676, 279 and American Cyanamid 18133 were tested in 1958. Weigela hybrida (var. Eva Rathke) plants that were heavily infested with root-knot nematodes were taken from storage on March 10 and dipped in Union Oil Company's formulation G1676 diluted at the rate of 14 grams of the 25 percent material per gallon of water. Union Oil G6822 was diluted at the same rate as the G1676. Five Weigela plants were used for each treatment. The whole plants were soaked for 5 minutes, then removed and drained. Five plants were soaked in water for 5 minutes as a check. After draining, the plants were permitted to dry for 1 hour and then were packaged. Forty-eight hours later all the plants were unpacked, dipped in activated charcoal (1 pound in 20 gallons of water), and repacked. The activated charcoal was used to reduce the objectionable odor of the chemicals used as a dip. All plants were placed in 6 1/2-inch plots of steam sterilized soil on March 14 and put in a greenhouse where they were grown for 3 months.

The material Union Oil Co. 279 was diluted with water at the rate of 2 2/3 ounces in 15 gallons of water.

American Cyanamid 18133 in the 50 percent emulsifiable form was used at three rates as follows: 9 ounces of 18133 in 15 gallons of water; 4 1/2 ounces of 18133 in 15 gallons of water; and 2 1/4 ounces of 18133 in 15 gallons of water.

The plants were soaked for 5 minutes in the above concentrations. No activated charcoal was used following treatment.

TABLE 24 - RESULTS OF CHEMICAL DIPS ON BARE ROOT NURSERY STOCK FOR THE CONTROL OF ROOT-KNOT NEMATODES

Date Treated	Chemical and Rate	Minutes Treated	No. of Plants	Condition of Plants When Checked	No. of Female Root-Knot Nematodes Observed
April 30, 1958	American Cyanamid 18133 9 oz. 50% in 15 gal.	5	5 Weigela	All dead	0
April 30, 1958	American Cyanamid 18133 4-1/2 oz. 50% in 15 gal.	5	5 Weigela	3 dead - 2 alive	0
April 30, 1958	American Cyanamid 18133 2-1/4 oz. 50% in 15 gal.	5	5 Weigela	3 dead - 2 alive	1
April 30, 1958	Union Oil 279 2-2/3 oz. in 15 gal.	5	5 Weigela	5 dead	0
March 10, 1958	Union Oil G6822 14 grams 25% per gal.	5	5 Weigela	4 dead - 1 alive	Numerous
March 10, 1958	Union Oil G1676 14 grams 25% per gal.	5	5 Weigela	5 dead	Numerous
March 10, 1958	Check - Water Only	5	5 Weigela	2 dead - 3 alive	Numerous
April 11, 1959	Hydrogenated Fish Oil 1%	15	5 Weigela	5 alive	1 nematode on each of 2 plants
April 11, 1959	American Cyanamid 18133 4-1/2 oz. 50% in 15 gal.	15	5 Weigela	5 alive	4 nematodes on one small root
April 11, 1959	Water Only	15	5 Weigela	2 dead - 3 alive	Numerous
April 11, 1959	Water Only	15	2 Fire Thorn	2 dead	--a
April 11, 1959	Hydrogenated Fish Oil 1%	15	2 Fire Thorn	2 dead	--a
April 11, 1959	Hydrogenated Fish Oil 1%	15	2 Talisman Rose	1 dead - 1 nearly dead	0
April 11, 1959	American Cyanamid 18133 4-1/2 oz. 50% in 15 gal.	15	2 Talisman Rose	1 dead - 1 alive	0
April 11, 1959	Water Only	15	2 Talisman Rose	1 dead - 1 alive	0

[a]The Fire thorns died soon after planting and were not in condition favorable for nematode development.

On April 10 of 1959 American Cyanamid 18133 and the hydrogenated fish oil furnished by Boris Sokoloff were used. The 18133 emulsifiable was used at the rate of 4 1/2 ounces of the 50 percent in 15 gallons of water at a temperature of 52° F. The plants were soaked for 15 minutes.

The hydrogenated fish oil was dissolved in rain water to avoid forming a precipitate when tap water was used. The plants were soaked for 15 minutes at a temperature of 115°. The check plants were dipped for 15 minutes in water at 52°. The higher temperature was used for the hydrogenated fish oil because it was difficult to dissolve.

Included in this test were Talisman rose, Weigela hybrida (var. Eva Rathke), and Fire thorn. These plants were used because they were heavily infested with root-knot nematodes.

---

[1] Contribution from Missouri Agricultural Experiment Station, Journal Series No. 2059. Approved by Director.

[2] Department of Entomology.

[3] Renninger, George, John Coffey, and Boris Sokoloff. 1958. Effect of hydrogenated fish oils on citrus-tree destroying nematodes. Plant Disease Reptr. 42: 1057 - 1065.

Vol. 43, No. 10--PLANT DISEASE REPORTER--Oct. 15, 1959 1097

The plants were treated April 10 and planted in sterilized soil in 8-inch plots on April 13. They were left in these plots until June 16, and then were examined for the presence of female root-knot nematodes in the roots. All roots showing evidence of damage by root-knot nematodes were examined under the microscope using a dissecting needle to tear the root tissues apart and expose the nematodes.

In addition to the plant material from Missouri, four budded Mazzard cherries from California were furnished by Paul S. Jorgensen of Stockton, California. These cherry trees were infested with the lesion nematode Pratylenchus penetrans. Two of these trees were soaked in a solution of 4 1/2 ounces of 50 percent American Cyanamid 18133 for 15 minutes and two were soaked in a 1 percent concentration of hydrogenated fish oil for 15 minutes. After treating, the trees were returned to Dr. Jorgensen, who grew them for 2 months in moist "sponge rok." There were no untreated checks in this experiment.

RESULTS

The Mazzard cherries checked by Dr. Jorgensen had no nematodes present on the roots after growing for 60 days in "sponge rok" in either of the treatments using American Cyanamid 18133 or hydrogenated fish oil. The hydrogenated fish oil caused damage to the roots and an area about 2 inches above and 2 inches below the soil line. The Mazzard cherry trees treated with American Cyanamid 18133 had good root growth and fair top growth.

Table 1 gives the results of the tests in 1958 and 1959.

1960

Plants of three species of nursery stock were soaked for 15 minutes in 4½ ounces of 50% emulsifiable 18133 in 15 gallons of water. The plants were then removed from the dip and allowed to air dry before being packed for shipping. They were treated on April 1 and planted in pots containing sterile soil on April 5. They were grown in the greenhouse till June 24, 1960. The roots of the plants were then examined for the presence of root-knot nematodes.

The following table gives the results of the treatments:

Hypericum Sungold plants were treated by dipping and soaking them for 15 minutes in NIA 4606 using the emulsifiable concentrate containing 24.8% active ingredient. The emulsifiable concentrate was used at three different rates; one quart to 15 gallons of water, two qutrts to 15 gallons of water and four quarts to 15 gallons of water. All four plants treated were dead at the concentrations of two quarts and at four quarts of NIA 4606 in 15 gallons of water. One plant out of four was alive at one quart of NIA 4606 in 15 gallons. However, this plant was quite late in starting growth and the roots were very poor. No nematodes were found on this one living plant.

Peony roots were treated April 20 with the 18133 dip and grown in sterile soil in pots as reported for the plants listed above. The plants grew as well as the check in this treatment. No nematodes were found on any of the treated plants.

Four peony plants were treated in water at 47° C. for 30 minutes. No nematodes were found on the roots.

1961

Work was continued on this investigation during 1961. Mr. Harry Guengerich of Stark Brothers' Nurseries cooperated in furnishing shrubs and trees and in treating the plants. The shrubs selected were heavily infested with root-knot nematodes, *Meloidogyne hapla.*

American Cyanamid nematocide 18133 was used at two different concentrations as a treatment for nematode control and as a test for phytotoxicity on several species of plants. The plants were dipped in water containing 4½ ounces of 50% 18133 in 15 gallons of water for 15 minutes at 55° F. Another test was made using 6.75 ounces of 18133 in 15 gallons of water. The untreated check

TABLE 25

Species of Plant	No. of Plants	Plant Condition	Nematodes
		Treated 18133	
Hypericum, Sungold	6	Good tops and roots	0
Hypericum, Sungold	2	Poor tops and roots	0
Hypericum, Sungold	3	Dead	
		Check	
Hypericum, Sungold	8	Plants Dead	
Hypericum, Sungold	6	Poor tops and roots	Nematodes on 5 plants
Hypericum, Sungold	2	Good tops and roots	Nematodes on 2 plants
		Treated 18133	
*Blue Mist	6	Good tops and roots	0
Blue Mist	1	Poor tops and roots	0
Blue Mist	1	Plant Dead	
		Check	
Blue Mist	6	Good tops and roots	All plants with nematodes
Blue Mist	1	Poor tops and roots	Nematodes present
		Treated 18133	
Roses	6	Good tops and roots	0
Roses	4	Poor tops and roots	0
Roses	2	Dead	
		Check Untreated	
Roses	5	Very poor tops and roots	Nematodes on 4 out of 5
Roses	1	Dead	

*Blue Mist, Caryopteris incana

TABLE 26 - 1961 RESULTS FROM TREATMENTS ON BARE ROOT NURSERY STOCK FOR THE CONTROL OF NEMATODES

Variety of Shrub	Treatment (Oz. 18133 in 15 Gals.)	Condition of Plants When Checked	Nematodes
*Blue Mist	Check	5 good	Heavy
Blue Mist	Check	3 fair	Heavy
Blue Mist	Check	3 dead	None
Blue Mist	4.5	6 good	None
Blue Mist	4.5	3 fair	None
Blue Mist	4.5	4 dead	None
Blue Mist	6.75	4 good	None
Blue Mist	6.75	3 fair	None
Blue Mist	6.75	1 poor	None
Blue Mist	6.75	3 dead	None
Hypericum, Sungold	4.5	1 good	None
Hypericum, Sungold	4.5	3 poor	None
Hypericum, Sungold	6.75	2 poor	None
Hypericum, Sungold	Check	1 poor & 2 dead	None

*Blue Mist, Caryopteris incana

TABLE 27 - PLANTS TREATED TO DETERMINE THE PHYTOTOXICITY OF 18133

Effect on Plants		
No, or Slight, Damage	Doubtful	Severe Damage
Apple	Deutzia	Butterfly Bush
Apricot	Euonymus, Winged Dwarf	Eyonymus Patens
Cherry	Euonymus, Radican (Bittersweet)	Hydrangea, Pink Mon.
Peach, Dwarf	Euonymus, Radicans (Sarcoxie)	Hydrangea, Snowhill
Peach, Standard		Hypericum, Sungold
Pear, Dwarf		Privet, Regal
Pear, Standard		Spirea, Anthony Waterer
Plum, Japanese		
Plum, European		
Althea		
Barberry, Green Leaf		
Beauty Bush		
Coralberry, Improved		
Forsythia, Showy Border		
Honeysuckle, Red Tart.		
Lilac		
Mockorange, Sweet		
Ninebark		
Potentilla, Gold Drop		
Privet, Amur River		
Privet, Golden Vicary		
Pyracantha, Firethorn		
Quince, Flowering Jap.		
Rose		
Spirea, Vanhoutte		
Spirea, Blue Mist		
Strawberry		
Weigela, Red		
Weigela, Dwarf Variegated		
Willow, Blue Arctic		

was dipped in water for 15 minutes at 55° F. After dipping, the plants were air dried outdoors and packed for later planting in the greenhouse where they were grown in sterile soil for three months.

Soil samples were taken from pots where the treated Blue Mist were grown and washed for nematode recovery. No nematodes were recovered from the soil samples. The plants were carefully examined for the presence of living root-knot nematodes in galls.

The root-knot nematodes present on the checks were identified by A. Morgan Golden as *Meloidogyne hapla.*

Root samples were kept in a moist container for 3 days and then checked for nematodes. A few nematodes were recovered but none were plant parasitic as determined by A. Morgan Golden. The nematodes found were probably present in the wood shavings packed around the roots of the plants to keep them from drying out before planting.

Forty-one varieties of fruit trees and shrubs were treated with American Cyanamid 18133 to determine the phytotoxicity of this chemical when applied to the plants at the concentration used to kill nematodes. One group of five plants from each variety was treated with 4½ ounces of the 50% 18133 and one

was treated with 6¾ ounces in 15 gallons of water. The trees and shrubs were planted in the nursery row and observations made regarding the conditions of the plants in mid-summer and again in September.

The following is a list of the plants and the results of the treatments:

The use of American Cyanamid 18133 gave a high degree of control of nematodes when used as a bare root dip on nursery stock. Out of 41 species of nursery plants tested, 31 showed little or no phytotoxicity, four were slightly injured, and seven were damaged severely.

Root-knot nematode problems are more severe on sandy soils in the southeastern part of the state. The most important species, aside from the soybean cyst nematode, is the one prevalent on cotton, ***Meloidogyne incognita acrita.*** It is present in most of the sandy soil where cotton has been grown and has been responsible for the nematode-fusarium problem on cotton.

Row treatment using soil fumigants was effective for only one season. Cotton grown in rows treated the previous season was only slightly better than cotton grown on the check plot of the previous season. For best results, soil fumigants should be placed six inches below the surface and the chisel marks sealed.

The nematode damage to crops was measured by comparing an untreated plot with a plot where the nematodes were controlled by the use of a soil fumigant.

The value of the crop grown will determine whether it will pay to use a soil fumigant to control root knot nematodes or susceptible crops in problem fields. In 1963 the cost of row treatment with rows 38 inches apart ranged from 10.00 to 13.00 dollars per acre for the chemicals. For over all field treatment the cost would be from 30.00 to 39.00 dollars per acre.

CONCLUSIONS

The nematode-fusarium wilt problem on cotton can be controlled by the use of a soil fumigant or by the use of a resistant variety. The use of a resistant variety such as Auburn 56 has been the most practical solution under Missouri conditions. Results from experimental work indicate no increase in yield from the use of soil fumigants on this variety.

Damage to soybeans by the soybean cyst nematode is quite variable from one season to another. Observations and experimental evidence indicate that presently available soil chemicals are too expensive for practical use.

There is a wide difference in the susceptibility of soybean varieties to the root-knot nematode, ***Meloidogyne incognita acrita.*** The Scott variety was severely damaged by root-knot nematodes under conditions where the varieties Lee and Hood were only slightly damaged.

Sugar beets grown on sandy soil in southeastern Missouri are often severely damaged by root-knot nematodes. The use of DD at 8½ gallons per acre as a row treatment gave satisfactory control of root-knot nematodes on sugar beets where the rows were spaced 38 inches apart.

Truck crops such as carrots, beets, okra, bush beans, sweet potatoes, muskmelons, cucumbers, and tomatoes are very susceptible to injury from root-knot

nematodes when grown on sandy soil in southeastern Missouri. A soil fumigant such as dibromo chloropropane has given satisfactory control of nematode problems on all of the above crops except sweet potatoes and beets. DD was used successfully to treat areas planted to sweet potatoes and beets. Peppers showed no increase in yield when grown on soil treated with DD.

The following varieties of tomatoes when compared to Rutgers were resistant to root knot nematodes; Kalohi, N-11 and TF x Kalohi.

BIBLIOGRAPHY

Allen, M. W. and Maggenti, A. R. 1959. Plant Nematology in California. Calif. Agric. Vol. 13, No. 9:1-28.

Bergeson, G. B. and Warren, G. F. 1962. Studies on the Use of Nematocides for the Control of Root Knot Nematodes on Muskmelon. Down to Earth, Vol. 18, No. 1:25-27.

Bruce, James R. and Hart, W. H. 1959. A Possible Association of Nematodes with the Spread of Peach Yellow Bud Mosaic Virus. Plant Disease Reporter, 43:989-990.

Christie, J. R. 1960. Invisible Worms Cost Farmers Millions. Agric. Leaders Dig. April. p. 10-11.

Christie, J. R. 1959. Plant Nematodes, Their Bionomics and Control. Agr. Expt. Sta., Univ. of Fla., 256 p.

Christie, J. R. and Taylor, A. L. 1952. Controlling Nematodes in the Home Garden. U.S.D.A. Farmers' Bull. No. 2048, 10 p.

Davis, R. A. and Jenkins, W. R. 1960. Nematodes Associated with Roses. Univ. of Md. Agr. Expt. Sta. Bull. A-106, 16 p.

Frazier, N. W. and Maggenti, A. R. 1962. Nematode Transmission of Yellow Bud Mosaic Virus to Strawberry. Plant Disease Reporter, Vol. 46, No. 5: 303-304.

Jenkins, Lee and Guengerich, Harry W. 1959. Chemical Dips for the Control of Nematodes on Bare Root Nursery Stock. Plant Disease Reporter, Vol. 43, No. 10:1095-1097.

Newhall, A. G. 1930. Control of Root-Knot Nematode in Greenhouses. Ohio Agr. Expt. Sta. Bull. No. 451, 60 p.

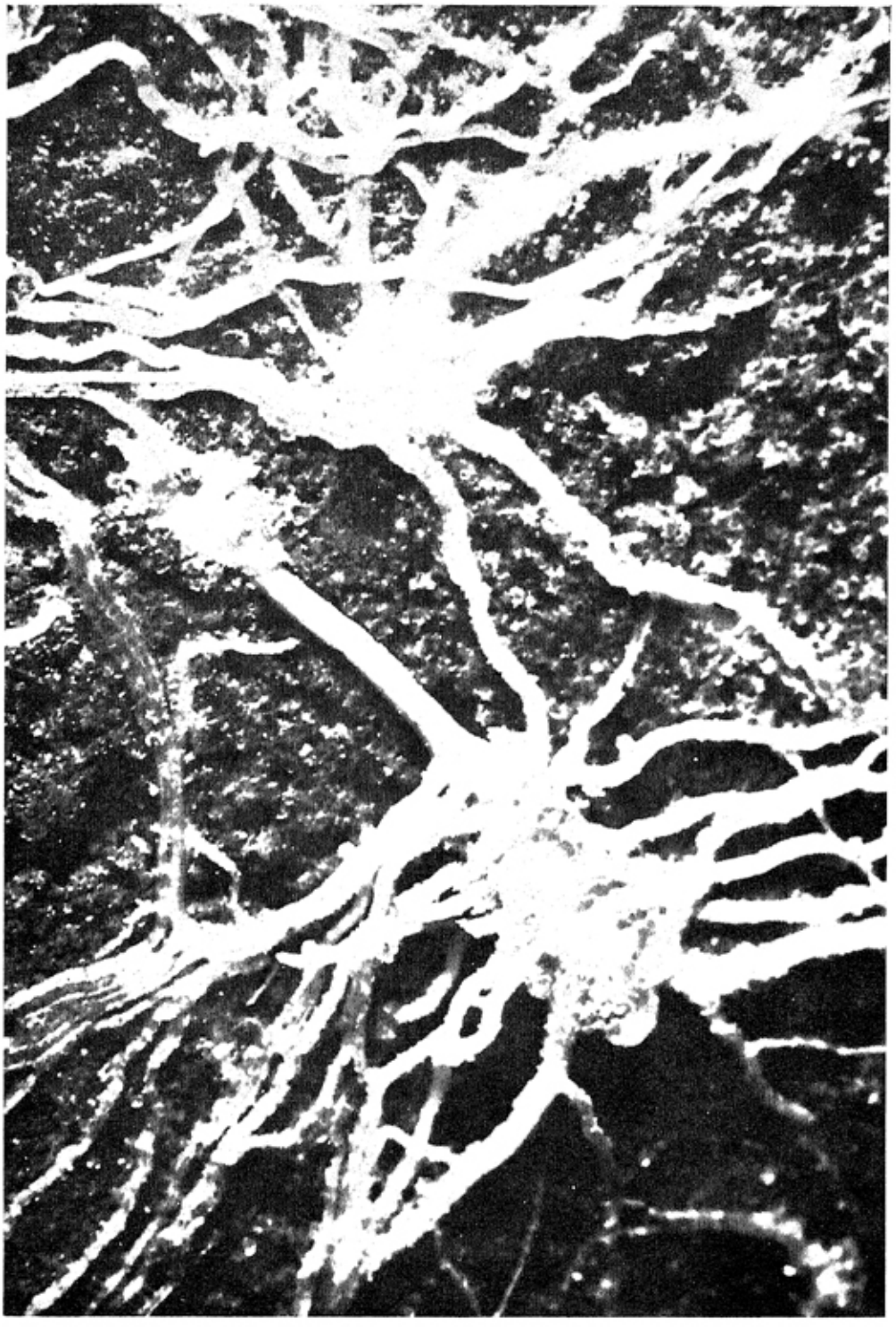
Riggs, R. D. and Winstead, N. N. 1959. Studies on Resistance in Tomato to Root-Knot Nematodes and on the Occurrence of Pathogenic Biotypes. Phytopathology, Vol. 49:716-724.

Slack, D. A. 1959. Damage to Soybeans by the Soybean-Cyst Nematode. Sept.-Oct. Arkansas Farm Research, Vol. 8, No. 5:2.

1961. Soybean Cyst Nematode Progress in Research and Control. ARS Special Report ARS22-72:20 p.

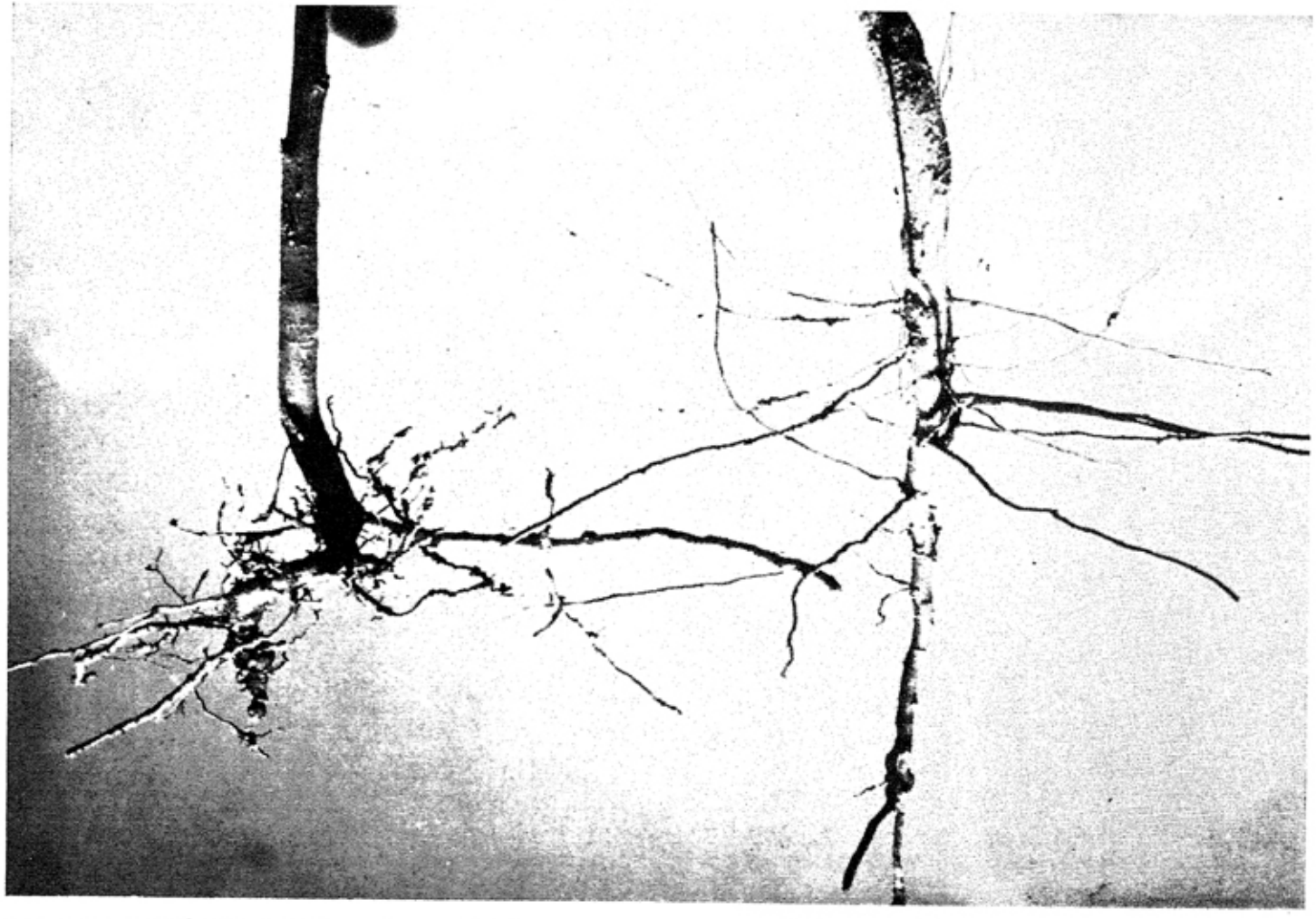
Tyler, Jocelyn. 1933. The Root-Knot Nematode. Univ. Cal. Coll. Agr. Circ. 330: 34 p.

Tyler, Jocelyn, 1941. Plants Reported Resistant or Tolerant to Root Knot Nematode Infestation. U.S.D.A. Misc. Publication No. 406: 91 p.

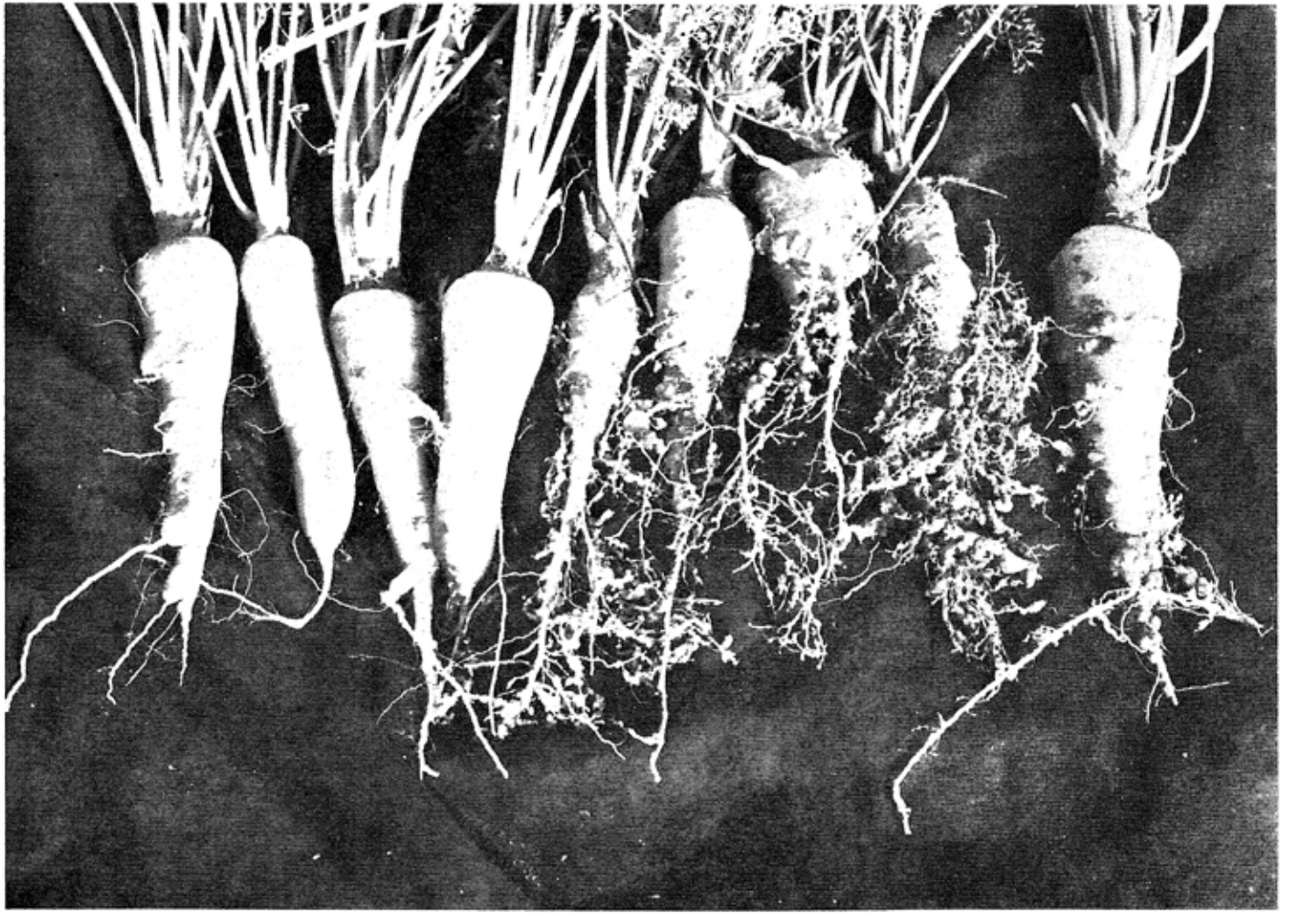


Root-knot nematode *(M. hapla)* on bluemist roots

Soybeans damaged by soybean cyst nematode *(Heterodera glycines)*



Root-knot nematode *(M. incognita acrita)* damage to cotton roots left—normal root—right



Carrots on right damaged by Root-knot nematodes *(Meliodogyne incognita acrita)*