side" of the barrier, the barrier is then relocated to enclose the new diseased area. Though the barrier cannot be considered as an absolute deterrent to *R. similis* spread, the migration of this nematode to healthy trees can be drastically reduced by the use of nematocidal and phytocidal toxicants in the soil.

The rate of spread of *R. similis* through the soil appears to be influenced by feeder root density. In the case of young trees, it was found that four years were required for *R. similis* to move laterally 20 feet through soil under field conditions. In mature groves, however, the average rate of migration was 35 to 40 feet per year (3). Thus, the spread of *R. similis* appears to be governed by available feeder roots as a food source and as a pathway to aid in migration through the soil. *R. similis* normally moves through the soil from root to root but, if the distance between roots is too great, the spread is greatly restricted or arrested. A barrier that is properly maintained would be a root-free zone of soil of a given width and depth. As such, the zone would be free of food and, therefore, a "starvation" area from the standpoint of *R. similis*. Under these conditions, *R. similis* could not, and would not, migrate any distance.

Once a barrier, or buffer zone, has been established, several factors can contribute to its failure. These are: (1) barrier not properly placed so that all of the diseased trees are not isolated from the healthy trees; thus, *R. similis* will be found in advance of the barrier; (2) *R. similis* can be spread by cultivation from diseased into healthy areas; (3) non-citrus weed hosts which can sustain *R. similis* populations in the barrier zone; (4) replanting with infected nursery stock in a grove that is being protected by a buffer zone; (5) *R. similis* might spread across a barrier by subsoil drainage (1).

Barriers, or buffer zones, are useful to restrict the spread of the burrowing nematode. While a barrier is not ideal since *R. similis* may be found on the "healthy side" of it, the barrier can be relocated to encircle the new area. It also appears that the success of a barrier is directly related to the width of the barrier, thus consideration should be given buffer zones of at least 30 feet or more in width.

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BURROWING NEMATODE PROGRESS REPORT

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The burrowing nematode (*Radopholus Similis* (Cobb)) was identified by the Citrus Experiment Station in 1953 as the cause of spreading decline. It continues to be the most destructive citrus pest in Florida. Decline symptoms become apparent as the burrowing nematodes destroy the feeder roots of the trees. The trees become progressively starved and wilt more readily than do healthy trees during periods of drought. Although infested trees do not die, as the infestation increases, their production is reduced up to 40 percent.

Following the Citrus Experiment Station's announcement, the State Plant Board, now the Division of Plant Industry, launched a program to determine the extent of infestation throughout the Florida citrus industry.

By April 1955, 438 groves comprising about 6,000 acres were found to be infested. Competent authorities estimated that without control measures 44,000 acres would be infested by 1965 from the natural spread of nematodes through the soil. It also was noted that the movement of infested nursery stock would increase the infested acreage to an even more staggering figure.

However, control measures were taken, and the spread of the burrowing nematode has been reduced greatly through the pushing and treating of many infestations and the establishing of buffers around other areas of decline. Of the estimated 9,605 infested acres, 7,053 acres have been buffered. Thousands of acres of healthy citrus also have been protected by restricting the movement of infested nursery stock.

The push and treat program, developed by research, remains the only method known of eradi-

cating the burrowing nematode from a known infested area. This involves pushing out all trees showing visible symptoms of the burrowing nematode, plus the four adjacent trees. The soil then is treated with a soil fumigant, DD (dichloropropene - dichloropropane), at the rate of 60 gallons per acre.

Any program that involves destruction of trees for corrective measures usually meets with resistance from some growers. The push and treat program has been no exception. Above-average prices paid for fruit for the past ten years have caused many growers to postpone pushing and treating. The hope that research will find a solution other than pushing and treating has caused other growers to hesitate. In many cases, a neighbor's refusal to cooperate has prevented a willing grower from pushing, because his property would be exposed to reinfestation.

In the spring of 1956, an injunction was issued prohibiting the Division from pushing out an infestation in a grove near Auburndale. In January 1957, the State Supreme Court ruled that the burrowing nematode is a dangerous pest; however, due to the slow rate of spread, the grower should be compensated for the trees destroyed. This brought a temporary halt to the compulsory phase of the push and treat program. Restoration of the control program was insured in 1957 when the State Legislature appropriated funds sufficient to continue the project and to provide a maximum of $1,000.00 per acre to compensate growers for healthy trees destroyed.

Again the Division was taken to court. Then in August 1958, the Supreme Court ruled that the $1,000.00 per acre limitation was unconstitutional. They also ruled that the grower should be compensated for the value, if any, of the diseased trees destroyed. For all practical purposes, this brought to an end the compulsory phase of the push and treat program.

The months that followed were crowded with conferences with leaders of the citrus industry and State and Federal research personnel. These meetings resulted in a new approach to the spreading decline problem. It was decided that the Division should make an all-out effort to slow and, where possible, by the use of buffer zones, to stop the spread of the burrowing nematode.

Table No. I gives data concerning trees along the margin of pushed and treated areas. This data indicates improvement in survey and application of fumigant. Note the downward trend in number of trees percentage-wise found infested.

Many properties pushed and treated in the early part of the program have been planted back. The data presented in Table No. II shows the results. Note that the percentage increases in negative properties from December 1961 to December 1963.

Many positive properties had only a few positive trees. Of the 83 properties found positive, 526 trees or 1.02% were found positive. Four of the positive properties were complete breakdowns and represented 37% of the total trees found positive. The most encouraging aspect is that we have 74,862 trees on 164 properties that

TABLE I

MARGIN SURVEY

	Trees Insp.	Trees Pos.	Percentage
1957 - 1959	22,286	680	3.1
1959 - 1960	2,694	138	5.1
1960 - 1961	1,353	111	8.2
1961 - 1962	1,337	30	2.2
1962 - 1963	2,526	72	2.8
1963 - June 1964	2,943	54	1.8

TABLE II

RESET DATA

	Dec. 31, 1961	Dec. 31, 1963
No. Properties Reset	95	247
Properties Negative	49	164 (74,862 trees)
Properties Pos. (No Explanation)	35	54
Properties Pos. (Next to Infestation, margin, house, road, etc.)	11	29
Percentage of Properties Negative	52%	66%

have been sampled 100% and found negative. Many of these trees have had a second 100% inspection. The above data indicates improvement in the control part of the program. Continued improvement is expected for the following reasons.

1. An all-out effort was started late in 1961 toward getting the growers to maintain clean cultivation back of fumigation, and most growers have made an honest effort to do so.
2. Improvement has been made in the fumigation machine, particularly in the method of sealing the fumigant in the soil. Irrigation immediately following fumigation is now recommended.
3. In most cases clay roads next to the pushed and treated areas are being fumigated.
4. Research records indicate there is a wide variation in the population of burrowing nematodes per sample taken at different times of the year. The lowest population seems to be in April and May. Advantage will be taken of this information as rapidly as possible.

It is too early to evaluate the improvements made in the program as a two-year waiting period is required before replanting, and it takes one year for resets to become large enough for sampling.

The term "burrowing nematode buffer" has been used several times but has not been defined. A buffer is an area established, treated, and maintained for the purpose of preventing the spread of the burrowing nematode from one area to another. The approximately 200 miles of buffers now installed encircle 261 decline areas. Within the buffers are 615 infested groves comprising 7,053 acres. Outside and adjacent to the buffers are 869 noninfested groves which are being protected. The average length of these buffers is 3,855 feet. The widths vary from 16 to 100 feet. Approximately 65% are 16 feet wide, 25% are 24 to 50 feet wide, and the remaining are 50 feet and wider.

The buffers are treated at six-month intervals with a soil fumigant, EDB-85 (ethylene dibromide), at the rate of 50 gallons per acre for the initial application and 25 gallons per acre for each additional application. A herbicide (Cardi) is applied at the rate of 200 pounds per acre for the initial application and as often as needed thereafter. It now appears that the buffers will have to be treated with a herbicide every 12 to 18 months in order to keep them free of grass and weeds.

Table No. III is a summary showing total infestations by county, also areas and acres pushed and treated or buffered, and the number of properties and acres remaining.

The buffer phase of the spreading decline program is about 80 to 85% completed. Many of the remaining 341 infested properties are not threats to other properties. Following is a detailed survey of 126 buffers installed by the Division.

State and Federal officials connected with the program believe that the 109 positive trees found across the buffers were infested at the time the

TABLE III

BURROWING NEMATODE INFESTATION

(COMMERCIAL GROVES)

	NUMBER OF PROPERTIES				ACRES			
	Infested	Pushed and Treated	Buffered	Remaining	Infested (Estimate)	Pushed and Treated	Buffered	Remaining
Highlands	300	149	134	17	3,243	1,480	1,636	127
Hillsborough	19	8	7	4	294	128	136	30
Lake	192	86	71	35	1,033	455	320	258
Orange	84	35	23	26	646	165	286	195
Polk	1,210	597	373	240	10,650	4,300	4,550	1,800
All Others	36	10	7	19	353	86	125	142
TOTAL	1,841	885	615	341	16,219	6,614	7,053	2,552

buffers were installed. This points out the weakness of the survey techniques. Even though the most efficient sampling methods known are used, occasionally the presence of the burrowing nematode is not detected.

It now is known that cultivation spreads the burrowing nematode. The Division of Plant Industry and the U. S. Department of Agriculture are quite concerned with those growers who cultivate across buffers. All grove owners should make certain that, regardless of the circumstances, all cultivation across buffers is discontinued. Grove owners also should instruct their supervisors and tractor drivers to thoroughly clean all equipment before moving it from an infested grove to a noninfested grove. If possible, separate equipment should be used.

Prior to 1961, when the Division entered into

TABLE IV

BUFFER SURVEY

Number of buffers checked to date	126
Number of properties involved	584
Linear feet of buffers	495,256 or 94 miles
Number of citrus trees adjacent to buffers	15,551
Number of properties protected (Properties adjacent to or cornering on buffers)	519
Number of acres protected	12,778
Number of positive trees across buffers	109 or 0.7 of 1%

the buffer program, several buffers had been placed and were being maintained by private industry. Data collected from these buffers is very encouraging. In 1953, a buffer 12 feet wide and 900 feet long was installed in Orange County. In 1955, burrowing nematodes were found in one tree against the buffer. By May 1958, ten trees were found positive against the buffer. In May 1961, 14 trees were found infested, and by May 1964, all 36 trees against the buffer were found infested. All trees across the buffer on the healthy side checked negative. In 1961, the Division took over the maintenance of this buffer and increased the width to 16 feet.

Another buffer, 50 feet wide and ½ mile long, installed in Polk County in 1957 was sampled recently with negative results. There are 68 positive trees against this buffer on the positive side.

A third buffer, 50 feet wide and 1,200 feet long, installed near Winter Haven in 1957 also was sampled. All trees against the buffer were infested. The healthy side checked negative with the exception of the end tree which is adjacent to dooryards. This buffer was abandoned recently for possible subdivision.

In conclusion, the Division of Plant Industry feels that it is too early to evaluate the effectiveness of buffers installed by the Division. In many cases, the burrowing nematode has not yet reached the buffer or it has not been in contact with the buffer long enough for worthwhile data to be collected. However, with the many miles and various widths of buffers now installed, it will be only a matter of time until more definite data can be collected.

STIMULATIVE AND NEMATOCIDAL EFFECTS OF ETHION ON CITRUS SEEDLINGS PARASITIZED BY THE BURROWING NEMATODE

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Of the many complex problems arising from infection of citrus in Florida by *Radopholus similis* (Cobb), the burrowing nematode, elimination of the pathogen from the host is one of the most important. One aspect of this problem concerns decontamination of young citrus stock so that the nematode will not be spread when such plants are placed in new sites. The Florida State Department of Agriculture regulates the sale and dissemination of diseased plants. Nurserymen with nematode-infected citrus in containers or in nursery beds generally have had these plants decontaminated by immersion in hot water (1) prior to sale. Yet, this treatment is applicable only to bare-rooted plants.

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The organic phosphates show much promise for controlling nematodes. Earlier work was with parathion (2, 9, 14), systox (4, 11), and VC-13 (6, 16). More recent tests have dealt primarily with zinophos (5, 7, 8, 10, 12). This compound has eradicated nematodes from citrus seedlings grown under greenhouse conditions (13) and was found to stimulate development of the citrus plant root system (3). Unfortunately, zinophos has an LD_{50} of 12 mg/kg in the same range of acute oral toxicity as parathion and, *ipso facto*, is regarded a hazardous chemical. Hence, it seemed relevant to investigate the nematocidal potency of some related organophosphates having a lower mammalian toxicity than zinophos.

Ethion (0, 0, 0′, 0′,-tetraethyl S, S′-methylene bisphosphorodithioate) has been reported to be an effective insecticide on vegetable and fruit crops, and gives excellent control for chinch bugs on turf in the southeast. It has an LD_{50} of 96 mg/kg, which makes it eight times as safe to handle as zinophos or parathion.

The following report describes several greenhouse tests in which ethion in aqueous emulsion was applied in various ways to nematized citrus seedlings. All rates given indicate the actual amount of technical ethion applied. The experiments were conducted independently, the senior