Nature and Control of Anthurium Decline

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ABSTRACT

Aragaki, M., Apt, W. J., Kunimoto, R. K., Ko, W. H., and Uchida, J. Y. 1984. Nature and control of anthurium decline. Plant Disease 68:509-511.

Stunted plants producing few, small blossoms have been a serious and persistent problem in the culture of anthurium (*Anthurium andraeanum*) in Hawaii. Examination of roots and lower stems revealed a consistent association with the burrowing nematode (*Radopholus similis*). In greenhouse inoculation experiments, burrowing nematodes increased by as much as 12-fold and induced weakened plants with dry weights significantly lower than those of uninoculated controls. On declining plants in the field, applications of the nematicide fenamiphos at 2.9–11.6 kg a.i./ha resulted in increased vigor and increased flower yield.

Poor vegetative growth accompanied by decreased flower yield has been a common and persistent problem in the cultivation of anthurium (*Anthurium andraeanum* Lind.) in Hawaii. Affected plants have only a few, small, dull green leaves; older leaves turn yellow and the plants produce small flowers. This problem, called anthurium decline, has been particularly severe on the island of Hawaii, the major production center in the state. The disease is common in plants older than 3 yr and in areas of high rainfall.

New plantings established from large terminal shoots are vigorous and may be productive for 2–3 yr; however, plants established from basal cuttings are usually less vigorous and start declining sooner. In fields with vigorous plants, unthrifty anthuriums may be present in pockets, which are usually associated with poor drainage. Raising the planting bed level by replenishing the growing medium results in development of young, vigorous, functional roots and large, healthy leaves. This response is temporary, however, and within 3–4 mo, the plants decline again.

Examination of declining plants revealed that most of the roots and basal stem were rotted. Few, if any, functional roots existed. Isolations from root lesions yielded *Pythium ultimum* Trow, *P. splendens* Braun, other *Pythium* spp., and *Rhizoctonia* sp. (binucleate) in abundance. Occasional isolations of *Phytophthora cinnamomi* Rands and *Calonectria crotalariae* (Loos) Bell & Sobers were also made. Inoculations with these fungi showed that *Pythium splendens*, *Phytophthora cinnamomi*, and *C. crotalariae* were pathogenic to anthurium roots, causing root lesions that expanded to rots; however, the fungi did not rapidly move into the stem and stunt the plants. Applications of etridiazole, quintozene, and combinations of these in a field with the decline problem did not reduce the severity of the disease.

Attention was then given to the role of nematodes, specifically the burrowing nematode, *Radopholus similis* (Cobb) Thorne, first reported to occur on anthurium by Sher in 1954 (4). He observed high nematode populations in planting media and root lesions associated with declining and dying anthuriums. Because of its frequent occurrence in anthurium and the possibility that the nematode would be spread to citrus areas in southern California, quarantine

Journal Series 2539 of Hawaii Institute of Tropical Agriculture and Human Resources.

Accepted for publication 19 December 1983.

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regulations on the shipment of potted anthuriums were established.

Assays of declining anthurium plants from several growers on the island of Hawaii in 1976 revealed burrowing nematodes in all samples, although infestation levels varied considerably. Infected plants had roots with elongated dark brown lesions or roots that were completely necrotic. Young lesions yielded no fungal organisms when surface-sterilized and plated out on water agar. Internally, stems of diseased plants were brown and somewhat spongy. The vascular bundles generally remained white although the surrounding tissue was brown and collapsed. Microscopic examination of affected tissue adjacent to healthy stem parts revealed abundant *R. similis*. No other nematode species was observed in diseased stem tissue adjacent to healthy tissue. Several preliminary tests with fenamiphos (Nemacur) were established using different formulations, application methods, and rates. In 3–4 mo, plants in the nematicide-treated plots had developed large, vigorous leaves, whereas plants in control plots remained stunted. Yield data collected for 9 mo showed 25–60% increases in flower yields of treated over untreated plots.

With these encouraging signs, greenhouse inoculation studies were made and two nematicide tests were installed in growers' fields to verify these initial observations and to obtain quantitative data.

MATERIALS AND METHODS

Greenhouse studies. Pathogen-free plants of anthurium cultivar Marian Seefurth were established by aseptic shoot-tip culture and transplanted from flasks into 5-cm (100-cm^3) pots with a peat-vermiculite planting mix. In the first pathogenicity test, plants were in the four- to six-leaf stage; in the second, plants had five to seven leaves.

R. similis was extracted from anthurium plants by incubating diseased tissue in plastic bags and individually selecting the emerged nematodes. Vials containing 10 or 100 nematodes in water were emptied into 1-cm-diameter holes in the planting mix, one vial per pot. Each treatment, including an uninfested control, contained nine individual plants. Test plants were maintained in a greenhouse with ambient temperatures of 20–30 C. The first test was terminated after 16 wk and the second after 19 wk.

Burrowing nematodes were extracted by incubating the roots and stem of each plant and counted. Individual plants were washed, then dried to constant weight at 85–90 C.

Field studies. Test plots were established at two anthurium farms near Hilo, HI. Examination of specimens revealed the presence of *R. similis* at both locations. Ozaki, a red cultivar widely grown commercially (1) but severely affected by the decline problem, was the test cultivar.

At location 1, fenamiphos (Nemacur 15G) was applied at 0, 2.9, 5.8, and 11.6 kg a.i./ha in a randomized block design with five replicates. Each replicate plot was 1.2 × 1.8 m with about 40 plants, separated by one or two border rows between treatments.

At location 2, fenamiphos was applied at 0, 5.8, 11.6, and 23.2 kg a.i./ha in a randomized block with four replicates. Each treatment unit was 1.5 × 2.1 m with about 36 plants, separated by a single border row between treatments. Both tests were initiated in October 1977 and a second application at the same rate was made in both tests about 6 mo later.

Collection of yield data began after 2 mo at location 2 and after 5 mo at location 1. These were the intervals between initial applications of fenamiphos and earliest plant responses—larger leaf blades and longer petioles. Yield data were collected for 12 mo. Flowers were harvested and sized according to commercial grades and results were statistically analyzed with respect to total numbers of flowers and weighted values according to flower size.

RESULTS AND DISCUSSION

Greenhouse studies. Plants inoculated with 100 nematodes were severely stunted and had blackened and deteriorated roots. Plants inoculated with 10 nematodes were less seriously affected; dry weights of inoculated plants in both tests were significantly lower ($P<0.05$) than in the uninoculated controls (Table 1). Burrowing nematode populations from these artificially inoculated plants were extremely variable in both tests, ranging from 30 to more than 1,000 nematodes per pot. There were about 12-fold and fivefold average increases in the nematode population over the introduced inocula levels of 10 and 100 nematodes per pot, respectively (Table 1). Thus, the burrowing nematode was pathogenic to and reproduced on anthurium. This strongly implicated the burrowing nematode as the cause of anthurium decline.

Field studies. Two months after the initial application of fenamiphos at location 2 and 5 mo after initial application at location 1, anthurium plants in all nematicide-treated plots showed renewed vigor. Statistical analyses of accumulated yields (number of flowers per square meter per year) revealed that the variance due to treatment was significant ($P<0.05$) compared with the variance for the untreated control at location 1 and highly significant ($P<0.01$) at location 2. Analyses of dollar-adjusted yield values per square meter per year (weighted according to flower size) revealed that differences between means of treated plots and untreated control means were highly significant ($P<0.01$) at both locations.

After 1 yr, plots treated with fenamiphos at 11.6 kg a.i./ha produced 50% more flowers than the untreated plots at both locations (Table 2). Furthermore, the commercial value of these flowers was about 60% greater.

The efficacy of fenamiphos in controlling the burrowing nematode, as demonstrated by O'Bannon and Tarjan

Table 1. Dry weight of anthurium and numbers of burrowing nematodes extracted after artificial inoculations

Inoculum level (no. of nematodes/plant)	Dry weight (g)		No. of nematodes recovered/infected plant[a]
	Test 1	Test 2	
0	0.29 ± 0.04[b]	0.58 ± 0.03	0
10	0.18 ± 0.02	0.51 ± 0.04	127
100	0.13 ± 0.02	0.39 ± 0.05	562

[a] Combined test averages.
[b] Means and standard errors.

Table 2. One-year anthurium flower yields in response to fenamiphos applications

Fenamiphos (kg a.i./ha)	Location 1		Location 2	
	No. flowers/m^2/yr (YF_1)[a]	Weighted value of flowers/m^2/yr[b] (YD_1)	No. flowers/m^2/yr (YF_2)	Weighted value of flowers/m^2/yr (YD_2)
0	89.3	19.12	53.0	11.52
2.9	106.1	23.20	...	...
5.8	108.9	23.77	76.8	17.71
11.6	136.3	30.65	76.2	17.33
23.2	...	...	79.7	18.15
	$P<0.05$[c]	$P<0.01$	$P<0.01$	$P<0.01$

[a] Regression equations omitting consideration for zero levels: $YF_1 = 93.13 + 3.88X$, $YD_1 = 19.47 + 0.97X$, $YF_2 = 75.83 + 0.19X$, and $YD_2 = 17.48 + 0.03X$.
[b] Flowers were graded according to size, then weighted by prevailing wholesale prices of April 1978 in dollars per dozen.
[c] Probability levels for significant differences between variances of treatments and untreated controls.

(3), has been extended to application on anthurium. Reliance on control by fenamiphos should be reduced as much as practical to minimize health hazards and to forestall environmental contamination. Where possible, clean top cuttings should be used in anthurium propagation. When these cuttings are unavailable, hot-water-treated (50 C for 10 min) cuttings (2) should be used to establish nematode-free plantings.

ACKNOWLEDGMENT

We thank John T. Kunisaki, Department of Horticulture, University of Hawaii, for providing pathogen-free anthurium plants.

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