CHEMICAL CONTROL OF NEMATODES IN SOUTH QUEENSLAND PINEAPPLE FIELDS

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SUMMARY

The nematode complex associated with the Smooth Cayenne variety of pineapple in Queensland includes the root-knot nematode Meloidogyne javanica **(Treub), the root-lesion nematode** Pratylenchus brachyurus **(Godfrey), the spiral nematode** Helicotylenchus nannus **Steiner and a ring nematode,** Criconemoides ornatum **Raski.**

In field trials on replant land in South Queensland, soil fumigation with DD, EDB and "Nemagon" prior to planting or shortly afterwards reduced the nematode populations and increased the size of the fruit. When fumigants were injected around 7-month-old plants heavily infested with Meloidogyne javanica **and** Pratylenchus brachyurus **there was a marked response to "Nemagon" (a yield increase of 9-18 per cent.), but not to EDB and "Vapam."**

I. INTRODUCTION

A problem associated with the culture of the pineapple (*Ananas comosus* L.) is that of declining yields and fewer ratoons on replant land. High populations of ectoparasitic and endoparasitic nematodes are a feature of many replant areas.

Godfrey (1929) described the root-lesion nematode *Tylenchus brachyurus* and demonstrated that it was a factor contributing to root failure in pineapples in Hawaii. The effect of root-knot nematodes was studied by Godfrey and Oliveira (1932) and Godfrey and Hagan (1937). Johnson and Godfrey (1932) showed that the use of chloropicrin prior to replanting controlled the root-knot nematode *Heterodera marioni* (Cornu) and resulted in increased pineapple yields. In 1945, Carter reported on the value of DD and this material is now widely used in Hawaii.

In Puerto Rico, Alvarez-García and López-Matos (1954) reported increased yields of the Red Spanish variety of pineapples on replant ground following preplant treatment with DD, EDB and methyl bromide.

Three field trials reported in this paper were designed to compare DD, EDB and "Nemagon" as preplant treatments; the fourth to determine whether the yield of an established planting heavily infested with a nematode complex could be increased by treatment with either EDB, "Nemagon" or "Vapam".

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II. SPECIES INVOLVED

During 1959-60 a nematode survey was carried out to determine the distribution of the probable pest species in South Queensland plantations. In the 50 plantings sampled the only species present in sufficient numbers to affect seriously the growth of the plants were the root-knot nematode *Meloidogyne javanica* (Treub), the root-lesion nematode *Pratylenchus brachyurus* (Godfrey), the spiral nematode *Helicotylenchus nannus* Steiner and a ring nematode, *Criconemoides ornatum* Raski.

Meloidogyne javanica is widely distributed, occurring in more than 90 per cent. of the plantings sampled, and must be regarded as the most important of these species.

Pratylenchus brachyurus was found in 30 per cent. of the plantings. Some areas of unsatisfactory growth were associated with high populations of this pest.

Helicotylenchus nannus was found in every pineapple plantation sampled, and in most instances was the common nematode in the complex, up to 5000 per 400 ml being extracted from soil samples. Frequently large numbers of this ectoparasite were found feeding on pineapple roots. *Criconemoides ornatum* was abundant in two plantings at Beerwah. The pathogenicities of *Helicotylenchus nannus* and *Criconemoides ornatum* have not been established.

In addition to these four species the following were found in association with pineapple roots:—*Hemicycliophora truncata* Colbran, *Psilenchus tumidus* Colbran, *P. magnidens* Thorne, *Pseudhalenchus minutus* Tarjan, *Ditylenchus myceliophagus* J. Goodey, *Aphelenchus avenae* Bastian, *Aphelenchoides saprophilus* Franklin, *Pratylenchus zeae* Graham and *Trichodorus minor* Colbran.

The reniform nematode *Rotylenchulus reniformis* Linford and Oliveira occurs as a parasite of tomatoes and papaws in the Rockhampton area but has not been found in pineapple fields. There is no record of the pin nematode *Paratylenchus minutus* Linford, Oliveira and Ishii from Queensland.

III. MATERIAL AND METHODS

(a) General

The nematocides used were:—

DD.—A mixture of 1,3 dichloropropene and 1,2 dichloropropane containing 50-59 per cent. 1,3 dichloropropene and 55-60 per cent. weight of total chlorine. Sp.gr. 1·2.

"Nemagon."—A compound containing 97 per cent. by weight of 1,2 dibromo-3-chloro-propane. Sp.gr. 2·08. Impurities are mainly related hydrocarbons; inert compounds not exceeding 1 per cent. by weight.

EDB.—Ethylene dibromide in power kerosene. (EDB (sp.gr. $\frac{25}{25}$ 2·17) content 12·5 per cent.v/v).

"Vapam."—A solution containing 5 lb sodium N-methyl dithiocarbamate per gal.

Pineapples were grown on the double-row system with 6 ft between bed centres, 20-24 in. between rows in each bed and 9-12 in. between plants in the row. Each trial plot consisted of one double row.

Fumigants were applied either by hand injector in four rows per bed, each row 6 in. from a plant row, and injections 1 ft apart in the row; or by a Bowen Auchincruive gravity injector in three rows, one down the middle of the bed fed by two tubes and two each 6-9 in. outside the plant rows fed by single tubes. The machine injector was used after planting and it was not practicable to use two tines between the rows in the bed.

Soil samples to a depth of 9 in. between the plants in the row were taken with a small auger. Each plot sample consisted of 10 sub-samples. Nematodes were extracted by the Seinhorst ehrlenmeyer method (Seinhorst 1956). As "Nemagon" kills nematodes at a slower rate than DD or EDB, soil samples were not taken until 6-9 months after treatment.

(b) Trial 1, Beerwah

The trial site had been planted with tops in December 1955. By July 1956 the plants were of poor colour and vigour. A root examination showed that the majority of plants were heavily infested with *Meloidogyne javanica,* typical plants having an abundance of short extension roots with terminal galls. This trial was designed to determine whether plants in this condition would respond to EDB, "Nemagon" or "Vapam". These chemicals were applied at a depth of 6 in. by means of a hand injector. Three injection patterns were used:—

(*a*) *Between the plants.*—One injection midway between the plants in each row.

(*b*) *At the plant base.*—One injection as close to the stem as possible without mechanically injuring the plant.

(*c*) *Three-row.*—The fumigant applied in three rows along each bed with injections in each row 12 in. apart; one row down the middle of the bed; the others each 6-9 in. from the row on the outer side. Injections were opposite the middle of the interplant space in the adjacent row.

The layout was a 5 x 4 rectangular lattice with 4 replications of 20 treatments including 5 control plots. Each plot contained 45 datum plants. Treatments were applied on July 11, 1956. Growth ratings were made on November 29, 1957. The ratings used, 1-5, correspond to an increase in vigour and desirable colouration. Root samples for nematode counts were taken on the same date. The nematodes were extracted by macerating the roots in a blender and separated from the plant material by flotation and the use of the Baermann funnel technique. Harvesting of the plant crop extended from February 6, 1958, to April 8, 1958, and of the first ratoon from January 28, 1959, to March 31, 1959.

(c) Trial 2, Beerwah

The layout was a split-plot design with 5 replications. The two whole-plot treatments corresponded to time of fumigation, namely (A) hand injector on September 11, 1957, and (B) gravity injector on October 1, 1957. The four sub-plot treatments were concerned with fumigants, and each sub-plot contained 140 datum plants. The trial was planted on September 18, 1957.

Harvesting of the summer section of the plant crop extended from January 28, 1959, to April 29, 1959, and of the winter section from May 20, 1959, to October 21, 1959.

Soil samples were taken on June 30, 1958. Excess slips and suckers were removed and weighed on December 9, 1959.

(d) Trial 3, Woombye

This trial was established on replant land at Woombye, and was based on a 4 x 6 randomized block layout. Each plot was two chains in length. The fumigants were applied by hand injector on November 21, 1957. Tops were planted two days later. Soil samples were taken for nematode counts on July 29, 1958, and leaf measurements on August 14, 1959. Harvesting of the winter section of the plant crop extended from August 19, 1959, to December 2, 1959, and of the summer section from December 9, 1959, to March 16, 1960.

(e) Trial 4, Kandanga

A 4 x 6 randomized block layout, with plot length of 122 ft, was used. Suckers were planted on October 28, 1957, and the fumigants were applied by gravity injector on November 6, 1957. Soil samples were taken on August 12, 1958. The harvesting of the plant crop extended from February 23, 1959, to November 11, 1959.

IV. RESULTS

(a) Trial 1

Results (Tables 1 and 2) show that the injection of "Nemagon" at rates of 0·50 ml and 0·75 ml per hole resulted in improved growth and mean fruit weight, irrespective of the injection pattern. The increase in mean fruit weight in the plant crop ranged from 9 to 18 per cent. "Nemagon" at 0·50 ml per hole (3-row) and 0·75 ml (between plants, plant base) also increased mean fruit weight in the first ratoon crop. The use of EDB and "Vapam" did not improve the plants.

Counts of nematodes from root samples four months after fumigation with "Nemagon" showed a marked reduction in infestation of root-lesion nematodes. The method used proved unsuitable for determining severity of root-knot nematode infestation.

Table 1

TRIAL 1: EFFECT OF FUMIGATION AROUND 7-MONTH-OLD PINEAPPLE PLANTS ON MEAN FRUIT WEIGHT

Fumigant	Injection		Mean Fruit Weight for Plant Crop	Mean Fruit Weight for First Ratoon Crop
	Rate (ml)	Placement	(oz)	(oz)
EDB	2	Between plants	43·7	41·8
EDB	2	Plant base	47·0	40·5
EDB	2	3-row	46·7	44·5
" Nemagon " ..	0·25	Between plants	48·6	42·2
" Nemagon " ..	0·25	Plant base	47·7	42·2
" Nemagon " ..	0·25	3-row	50·1	42·2
" Nemagon " ..	0·50	Between plants	52·2	46·5
" Nemagon " ..	0·50	Plant base	54·1	45·0
" Nemagon " ..	0·50	3-row	54·1	49·5
" Nemagon " ..	0·75	Between plants	54·1	50·0
" Nemagon " ..	0·75	Plant base	54·1	48·8
" Nemagon " ..	0·75	3-row	56·5	47·5
" Vapam " ..	1·5	Between plants	47·8	44·5
" Vapam " ..	2·2	Between plants	45·6	43·2
" Vapam " ..	3·0	Between plants	50·1	45·2
Control	..	..	48·0	43·7
Necessary differences for significance 5%			2·6	4·9
Necessary differences for significance 1%			3·4	6·6

Table 2

TRIAL 1: EFFECTS OF FUMIGATION AROUND 7-MONTH-OLD PINEAPPLE PLANTS ON GROWTH AND NEMATODE POPULATION

Fumigant	Injection		Growth Rating		Root-lesion Nematodes (1 oz roots)	
	Rate (ml)	Placement	$\sqrt{x+\frac{1}{2}}$	Equiv. Rating	log (1 + x)	Equiv. Rating
EDB	2	Between plants	1·56	1·9	2·76	567·9
EDB	2	Plant base	1·71	2·4	2·01	101·3
EDB	2	3-row	1·80	2·7	1·16	13·6
" Nemagon " ..	0·25	Between plants	1·86	3·0	1·98	95·6
" Nemagon " ..	0·25	Plant base	1·87	3·0	0·90	6·9
" Nemagon " ..	0·25	3-row	2·05	3·7	1·05	10·2
" Nemagon " ..	0·50	Between plants	2·12	4·0	0·00	0
" Nemagon " ..	0·50	Plant base	2·24	4·5	0·00	0
" Nemagon " ..	0·50	3-row	2·29	4·8	0·00	0
" Nemagon " ..	0·75	Between plants	2·23	4·5	0·94	7·7
" Nemagon " ..	0·75	Plant base	2·24	4·5	0·00	0
" Nemagon " ..	0·75	3-row	2·35	5·0	0·00	0
" Vapam " ..	1·5	Between plants	2·06	3·7	2·24	174·8
" Vapam " ..	2·2	Between plants	1·92	3·2	2·00	100·2
" Vapam " ..	3·0	Between plants	1·83	2·9	2·03	106·2
Control	..	..	1·82	2·8	2·12	131·4
Necessary differences for significance		5%	·27	..	1·50	..
		1%	·36	..	2·04	..

(b) Trial 2

Soil treatment with DD, EDB and "Nemagon" reduced the soil population of root-knot nematode larvae and spiral nematodes and increased the mean fruit weight for both the summer and winter sections of the plant crop (Tables 3 and 4). The increase ranged from 16 to 27 per cent. A greater weight of slips and suckers was stripped from plants in the fumigated plots than in the untreated plots, indicating that the benefits of fumigation would be carried over into the first ratoon crop. The plants in plots treated with "Nemagon" and EDB were superior at this stage to those in the DD-treated plots.

As differences in mean fruit weight due to time of fumigation were not significant, separate means are not included in Tables 3 and 4.

Table 3

TRIAL 2: EFFECTS OF FUMIGATION ON MEAN FRUIT WEIGHT AND WEIGHT OF SURPLUS SLIPS AND SUCKERS

Treatment	Mean Fruit Weight (oz)		Slips and Suckers (lb)
	Summer	Winter	
EDB 16·6 gal/ac	68·9	77·9	406·0
DD 16·6 gal/ac	64·6	78·9	315·5
" Nemagon " 4 gal/ac	65·7	78·5	417·1
Control	54·1	67·2	261·8
Necessary differences for significance 5%	1·7	5·3	66·3
Necessary differences for significance 1%	2·2	7·1	90·9

Table 4

TRIAL 2: EFFECT OF FUMIGATION ON NEMATODE POPULATIONS

Treatment	Root-knot Nematode Larvae ($\frac{1}{2}$ lb soil)		Spiral Nematodes ($\frac{1}{2}$ lb soil)	
	$\sqrt{x + \frac{1}{2}}$	Equiv. No.	$\sqrt{x + \frac{1}{2}}$	Equiv. No.
EDB 16·6 gal/ac	6·03	36	7·80	60
DD 16·6 gal/ac	7·23	52	9·25	85
" Nemagon " 4 gal/ac	4·41	19	7·33	53
Control	9·31	86	14·58	212
Necessary differences for significance 5%	3·49	..	5·30	..
Necessary differences for significance 1%	4·73	..	7·18	..

(c) Trial 3

Treatment with EDB, DD and "Nemagon" reduced the soil population of root-knot nematode larvae and spiral nematodes, and increased the size of the plants and the mean fruit weight by 5-19 per cent. (Tables 5 and 6.)

Table 5

TRIAL 3: EFFECT OF SOIL FUMIGATION ON MEAN FRUIT WEIGHT

Treatment	Mean Fruit Weight (oz)	
	Winter Plant Crop	Summer Plant Crop
EDB 16·6 gal/ac	81·0	54·9
DD 16·6 gal/ac	78·3	52·0
" Nemagon " 5 gal/ac	82·1	55·9
Control	74·6	47·0
Necessary differences for significance 5%	4·5	3·4
Necessary differences for significance 1%	6·2	4·7

Table 6

TRIAL 3: EFFECTS OF SOIL FUMIGATION ON NEMATODE POPULATIONS AND LEAF LENGTH

Treatment	Root-knot Nematode Larvae (½ lb soil)		Spiral Nematodes (½ lb soil)		Mean Length of Longest Leaf (cm)
	$\sqrt{\bar{x}}$	Equiv. No.	$\sqrt{\bar{x}}$	Equiv. No.	
EDB 16·6 gal/ac ..	10·9	118	5·5	30	90·5
DD 16·6 gal/ac ..	12·7	162	16·7	279	89·0
" Nemagon " 5 gal/ac	7·7	59	5·2	27	91·8
Control	16·2	262	22·0	483	81·5
Necessary differences for significance 5%	4·7	..	8·2	..	3·8
Necessary differences for significance 1%	6·6	..	11·4	..	5·2

(d) Trial 4

Results (Table 7) indicate a lack of response to fumigation. This failure was due probably to the dry condition of the soil when the treatments were applied and incomplete filling of the furrows behind the tines delivering the fumigants.

Table 7

TRIAL 4: EFFECTS OF SOIL FUMIGATION ON NEMATODE POPULATIONS AND MEAN FRUIT WEIGHT

Treatment	Root-knot Nematode Larvae (½ lb soil)	Spiral Nematodes (½ lb soil)	Mean Fruit Weight (oz)
EDB 16·6 gal/ac	453	46	62·9
DD 16·6 gal/ac	310	98	61·7
" Nemagon " 5 gal/ac	617	190	59·5
Control	480	214	59·0

V. CONCLUSION

Results of the survey and these trials are the basis of recommendations for the commercial control of nematodes in South Queensland pineapple fields (see Colbran 1960).

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