QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES
DIVISION OF PLANT INDUSTRY BULLETIN No. 495

STUDIES OF HOT-WATER TREATMENT AND SOIL FUMIGATION FOR CONTROL OF ROOT-KNOT IN GINGER

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SUMMARY

The root-knot nematodes *Meloidogyne javanica* (Treub) and *M. incognita* (Kofoid and White) in ginger seed pieces were controlled without adverse effects on germination by hot-water treatment at temperatures between 45°C and 55°C for times ranging from 50 to 10 min.

In a field trial in the 1964-65 season, treatment of infested seed pieces at 48°C x 20 min, 49°C x 20 and 15 min, 50°C x 15 and 10 min, 51°C x 10 min and 52°C x 10 min reduced subsequent root galling. Yields were increased by treatment at 48°C x 20 min, 50°C x 15 min, 51°C x 10 min and 52°C x 10 min.

Two field trials were set out in the 1965-66 season to assess the effects on root galling and on yield of seed piece treatment at 48°C x 20 min and 50°C x 10 min, the selection of planting material on the basis of nematode infestation and preplant soil fumigation.

Hot-water treatment did not affect the yield from heavily infested seed pieces and reduced yield from selected seed pieces.

Preplant fumigation with DD, EDB, Telone PBC and DBCP reduced root-knot. Yield from selected seed pieces was increased by preplant fumigation with EDB and Telone PBC in one trial and DBCP in the other.

In one trial, selection of planting material increased yield by 57%.

Hot-water treatment would have little if any value as a routine treatment for crops intended for processing but could be combined with soil fumigation for the production of better quality planting material.

I. INTRODUCTION

The root-knot nematodes *Meloidogyne javanica* (Treub) and *M. incognita* (Kofoid and White) are serious pests of ginger (*Zingiber officinale* Rosc.) in Queensland. Colbran (1961, 1962) stressed the importance of using nematode-free seed pieces. Root-knot, however, is so prevalent that it is difficult to obtain adequate supplies of suitable planting material.

Trujillo (1963) reported that *M. javanica* was killed by treating ginger seed pieces in water at 50°C for 10 min, but published data do not indicate the commercial value of this treatment.

Studies reported here were designed to obtain such data and additional information on the differential effects of nematocides, as earlier studies (Colbran 1962) had suggested phytostatic effects of EDB and DBCP on ginger.

II. MATERIALS AND METHODS

Nematocides.—The nematocides used in the field trials were:—

DBCP.—1, 2 dibromo-3-chloropropane, an emulsifiable concentrate containing 178·6% w/v active constituent.

DD.—A mixture of 1, 3 dichloropropene and 1, 2 dichloropropane.

EDB.—Ethylene dibromide in power kerosine, (27·1% w/v).

Telone PBC.—A mixture containing 80% w/w 1, 3 dichloropropene, 15% w/w chloropicrin and 5% w/w propargyl bromide.

Laboratory and glasshouse studies (June-October 1964).—Infested seed pieces were treated in a hot-water bath at unit temperature intervals from 45° to 55°C for 5 to 60 min at 5 min intervals. Half of the treated pieces were planted singly in pots of sand and maintained in a glasshouse until the majority had shoots exceeding 6 in. in length. The remaining pieces were sliced and the slices from each piece placed in a pot of sand around the roots of an established tomato seedling. One month later the tomato plants were washed free of sand and the number of single galls counted. Each millimetre of length of a multiple gall was taken as equivalent to a single gall.

Field trial I, Maroochy Horticultural Research Station, 1964-65 *season.*—The effects on root-knot development and yield of seven hot water treatments selected from the results of the laboratory and glasshouse tests were compared in soil which had been fumigated with DD at 40 gal/ac. The layout was an 8 x 4 randomized block with 60 datum plants per plot. The crop was grown under a sawdust mulch. Dates of field operations are given in Table 1 and treatments in Table 4.

Infested seed pieces were treated in hot water immediately prior to planting. Stand counts were made weekly until germination was complete. At harvest, the roots of all datum plants were examined for root-knot galls.

Field trial II, Palmwoods, 1965-66 *season.*—Trial II was based on a 3 x 2 x 5 factorial design with three hot-water treatments, two levels of seed-piece infestation ("infested" and "selected"), five soil treatments, two replicates and 60 datum plants per plot. Dates of field operations are given in Table 1 and treatments in Tables 5 to 9. The crop was grown without a surface mulch in sandy soil of low fertility.

Samples of 45 infested and 45 selected seed pieces used in this trial were peeled to a depth of 1–2 mm and the mean numbers of exposed infestation sites per piece were 19·0 and 0·4 respectively.

Soil samples taken from the trial site in late July contained 194 *Meloidogyne* larvae/lb.

Nematocides were applied by hand injector in holes 6 in. deep and 1 ft apart. At harvest all plants were dug, the roots rated for galling and yields of ginger recorded. Root-knot indices were calculated from the ratings after the method of Smith and Taylor (1947).

Field trial III, Buderim, 1965-66 *season.*—Trial III was similar to trial II, except that the crop was grown under sawdust mulch on a fertile latersol. Dates of field operations appear in Table 1.

The mean numbers of exposed infestation sites for the infested and selected seed pieces used in trial III were 11·8 and 0·2 respectively.

Soil samples taken from the trial site in late July contained 593 *Meloidogyne* larvae/lb.

TABLE 1

DATES OF FIELD OPERATIONS, TRIALS I–III

Operation	Dates		
—	Trial I (1964-65)	Trial II (1965-66)	Trial III (1965-66)
Fumigation ..	Sept. 2	Sept. 2	Sept. 9
Planting	Sept. 16	Sept. 22	Sept. 23
Harvesting ..	Mar. 11, 12	Mar. 1, 2	May 16,17

III. RESULTS

Laboratory and glasshouse tests.—Data from the laboratory and glasshouse tests are presented in a condensed form in Tables 2 and 3, which show for each unit of temperature from 45° to 55°C the minimum immersion time at which a high level of nematode control was achieved and the maximum immersion time at which treated seed pieces germinated.

Field trials.—Results are presented in Tables 4-9.

In trial I, hot-water treatment advanced germination but did not affect eventual stands (Table 4). All treatments reduced subsequent root galling (Table 4). Treatment of seed pieces at 50°C x 15 min, 52°C x 10 min, 48°C x 20 min and 51°C x 10 min increased yields (Table 4).

TABLE 2

LABORATORY TESTS: MINIMUM IMMERSION TIMES FOR NEMATODE CONTROL IN GINGER SEED PIECES

Temperature (°C)	Minimum Times for Nematode Control (min)	Seed Pieces Treated	Galled Indicator Plants	Galls/Infested Indicator Plant
45	50	6	0	0
46	35	6	2	2
47	25	6	0	0
48	20	7	1	2
49	15	6	0	0
50	15	6	0	0
51	10	8	1	1
52	10	8	0	0
53	10	8	0	0
54	10	7	0	0
55	10	7	0	0
Control	..	6	6	100

TABLE 3

GREENHOUSE TESTS: MAXIMUM IMMERSION TIMES AT WHICH SEED PIECES GERMINATED

Temperature (°C)	Minimum Times for Nematode Control (min)	Maximum Safe Treatment Time (min)	Seed Pieces Treated	Seed Pieces Germinated
45	50	60+	8	8
46	35	60+	8	8
47	25	60+	8	8
48	20	60+	7	6
49	15	60+	7	6
50	15	45	5	5
51	10	25	6	5
52	10	25	6	5
53	10	20	8	6
54	10	10	7	7
55	10	10	7	5

+ Maximum time tested in the initial studies. In a later test, seed pieces germinated after treatment at 45°, 46° and 47°C for 120 min.

In trial II, hot-water treatment of infested seed pieces advanced germination (Table 5) and reduced galling (Table 7) but did not affect final stands (Table 5) or yields (Table 7). Hot-water treatment of selected seed pieces reduced yields (Table 8). Selected seed pieces germinated faster than infested seed pieces (Table 5) and outyielded them by 57% (Table 6). EDB, DD and Telone PBC gave a higher level of nematode control than DBCP (Table 9). EDB and Telone PBC increased yields (Table 9).

TABLE 4

TRIAL I: EFFECTS OF HOT-WATER TREATMENT ON STAND, YIELD AND ROOT GALLING

Treatment		Plants per plot		Yield	Percentage Infested Plants
Temperature (°C)	Time (min)	9.xi.64	Final Stands	(lb/plot)	
52	10	33·5	59·8	47·5*	6·9
51	10	36·8*	59·5	48·8**	6·3
50	10	24·2	59·5	43·9	6·2
50	15	26·2	57·5	45·9*	3·6
49	20	29·5	58·0	40·0	6·5
49	15	31·0	58·0	45·1	13·1
48	20	42·5**	59·2	47·5*	8·9
Untreated		24·8	56·8	39·0	66·4
Necessary differences for significance	1%	14·1	n.s.	8·6	
	5%	10·4		6·3	

TABLE 5

TRIAL II: EFFECTS OF HOT-WATER TREATMENT AND SEED-PIECE INFESTATION ON PLANT STAND

Treatment	Seed Category	Plants per Plot		
		8.xi.65	16.xi.65	6.i.66
51°C x 10 min	Infested	27·5	37·8	53·5
	Selected	39·9	45·8	57·3
48°C x 20 min	Infested	30·3	38·2	53·3
	Selected	42·3	49·7	56·8
Untreated	Infested	20·6	32·8	52·5
	Selected	40·5	50·5	58·3
Necessary differences for significance	1%	7·4	4·9	3·2
	5%	5·5	3·6	2·3

TABLE 6

TRIALS II AND III: EFFECTS OF SEED-PIECE INFESTATION ON ROOT GALLING AND YIELD

Type of Seed Piece	Root-knot Indices		Yield (tons/ac)	
	Trial II	Trial III	Trial II	Trial III
Selected	13·4	14·57	5·14**	35·38
Infested	16·8	19·77**	3·28	35·61
Necessary differences for significance 1%	6·0	6·66	0·42	1·79
5%	4·4	4·97	0·31	1·33

In trial III, hot-water treatment of infested seed pieces had no significant effect on germination (Table 5), root galling (Table 7) or yields (Table 7). Treatment of selected seed pieces at 51°C x 10 min reduced yields (Table 8). DD, EDB, DBCP and Telone PBC controlled root-knot (Table 9). Yields of selected seed pieces was increased by preplant fumigation with DBCP (Table 9).

TABLE 7

TRIALS II AND III: EFFECTS OF HOT-WATER TREATMENT OF INFESTED PIECES ON ROOT GALLING AND YIELD

Treatment	Root-knot Indices		Yield (tons/ac)	
	Trial II	Trial III	Trial II	Trial III
Control	27·4	21·60	3·19	34·87
48°C x 20 min	12·0**	21·50	3·10	36·43
51°C x 10 min	11·1**	16·20	3·53	35·52
Necessary differences for significance 1%	10·3	11·54	0·73	3·10
Necessary differences for significance 5%	7·7	8·56	0·54	2·30

TABLE 8

TRIALS II AND III: EFFECTS OF HOT-WATER TREATMENT OF SELECTED SEED PIECES ON YIELD

Treatment	Yield (tons/ac)	
	Trial II	Trial III
Control	5·83	36·08
48°C x 20 min	5·12*	36·39
51°C x 10 min	4·47**	33·66*
Necessary differences for significance 1%	0·73	3·10
Necessary differences for significance 5%	0·54	2·30

TABLE 9

TRIALS II AND III: EFFECTS OF NEMATOCIDES ON ROOT GALLING AND YIELD FROM SELECTED SEED PIECES

Treatment	Gal/ac	Root-knot Indices		Yield (tons/ac)	
		Trial II	Trial III	Trial II	Trial III
DD	25	2·6**	9·0**	4·74	35·44
EDB	25	2·4**	7·5**	6·18**	35·58
DBCP	2·5	19·7**	12·8**	4·51	37·09**
Telone PBC	20	4·9**	13·3**	5·77**	35·72
Control		37·4	31·2	4·50	33·06
Necessary differences for significance 1%		13·3	14·9	0·95	4·00
Necessary differences for significance 5%		9·9	11·1	0·70	2·97

IV. DISCUSSION

In trials I and II, nematode infestation of untreated seed pieces was responsible for considerable root galling at harvest. This is at variance with the conclusions of Huang (1966) that secondary inoculum is limited because egg masses are not discharged externally, larvae being trapped in the internal lesions.

The lower yield response in trial III compared with that in trial II could be attributed to the higher level of soil fertility and lower level of nematode infestation in the planting material.

The results show the adverse effect of nematode infestation in the seed pieces on yield, and support earlier work by Colbran (1962). Hot-water treatment of heavily infested planting material is not a satisfactory solution to the problem as this type of material appears to lack the vigour to produce good plants except under exceptionally good growing conditions.

Hot-water treatment could be combined with soil fumigation for the production of better planting material. It would have little value as a routine treatment for crops intended for processing.

The results do not indicate any consistent differential effects between DD, EDB, Telone PBC and DBCP.

V. ACKNOWLEDGEMENTS

The authors acknowledge the assistance of Mr. D. A. Ironside (Experimentalist) and Mr. W. O'Donnell (Field Assistant) in the field trials, the Biometry Branch for statistical analyses, and Messrs. H. Ham, Buderim, and R. P. Rowland, Palmwoods, on whose farms the trials were set out.

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(Received for publication June 20, 1968)

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