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**METHYL BROMIDE FUMIGATION FOR ELIMINATING
MACADAMIA FELTED COCCID (ERIOCOCCUS IRON-
SIDEI WILLIAMS) FROM PROPAGATING MATERIAL**

by D. A. IRONside, Q.D.A.; G. SWAINE, B.Sc.; AND R. J. CORCORAN

SUMMARY

Infestations of *Eriococcus ironsidei* Williams were eliminated from *Macadamia integrifolia* seedlings by fumigating with methyl bromide at 55 gm^{-3} for 2 h at 20°C and 70% relative humidity. The treatment caused no damage to uninfested *Macadamia tetraphylla* seedlings nor to uninfested budwood of any of the four *M. integrifolia* varieties, Keauhou (246), Kakea (508), Ikaika (333) and Keaau (660). Considerable leaf burn was caused by the fumigant on heavily-infested *M. integrifolia* seedlings but only slight leaf burn on less heavily-infested seedlings.

The treatment is recommended to prevent the spread of the insect from the field to nurseries on budwood or scion wood and from nurseries to the field on grafted trees.

I. INTRODUCTION

The macadamia felted coccid, *Eriococcus ironsidei* Williams, is an important native insect pest of commercially-grown varieties of macadamia in south-eastern Queensland (Ironside 1970). The insect infests all above-ground parts of the tree and thrives in shaded places on the trunk and branches and on the underside of the leaves. Heavy infestation causes the death of seedlings, whilst the yield of mature trees is reduced significantly. The only known hosts are *M. integrifolia* and *M. tetraphylla*. Plantations derived from uninfested nursery trees have been observed to remain free of the insect for many years, provided infested material is not brought into contact with the trees. It is thus worthwhile to disinfect propagating material such as budwood, scion wood or nursery trees to prevent spread of the insect.

Spray or dipping treatments of seedlings with insecticides have not proved effective for disinfection (D. A. Ironside, personal communication 1976). Methyl bromide is effective for this purpose against a number of other pests (Munro 1969) and was therefore tested against *E. ironsidei* to find the effective dosage. Observations were also made on the phytotoxicity of methyl bromide to macadamia budwood and seedling material.

II. MATERIALS AND METHODS

Commercial grade methyl bromide (MB) was used.

Efficacy

One trial was carried out in June 1976 to indicate the effective dosage and a further trial was conducted in August 1976 to confirm that dosage.

Material used in the first trial comprised potted *M. integrifolia* seedlings moderately infested with *E. ironsidei*, and uninfested budwood of four commercially grown *M. integrifolia* varieties, Keauhou (246), Kakea (508), Ikaika (333) and Keaau (660). Methyl bromide was used at 27, 36, 46 and 55 g m⁻³ for 2 h at 20°C and the seedlings and budwood were conditioned to that temperature overnight before fumigation. Seedlings and budwood were allocated to the four fumigation treatments and to an untreated control at random. There were nine seedlings and approximately 68 g of each variety of budwood per treatment.

In the second trial only heavily-infested, potted *M. integrifolia* seedlings were used. The seedlings for each treatment were selected so that the treatments had similar infestations. As with the first trial the material was conditioned overnight to 20°C before fumigation. Nine seedlings were fumigated in each of two tests with 55 g m⁻³ for 2 h at 20°C.

Fumigations were carried out in a 0.16 m³ galvanised-iron chamber. A water-seal collar received the flanged, galvanised-iron lid and prevented gas leakage. Each seedling was held in a 13 cm diameter plastic pot containing 650 cm³ of soil. At each fumigation nine pots were placed on a 2.3-cm mesh metal grid located above a 17.8-cm diameter fan at the bottom of the chamber. Additionally, in the first trial only, budwood of the four varieties was placed on the pots. Measured volumes of cooled liquid MB were injected from a syringe through a silicone rubber septum in the lid of the chamber into a 75-ml beaker on a support directly below the septum. The air in the chamber was circulated for 15 min after the introduction of the fumigant by the fan on the floor of the chamber. Humidity inside the water-sealed chamber was checked in a separate 2 h test by means of a Rustrak Model 225 RH/TEMP recorder* and found to be 70% RH.

After each fumigation the chamber was aired for 30 min by drawing air through 4.5-cm inlet and outlet ports with a suction fan. The fumigated seedlings were then held at 20°C for 24 h in separate wooden insect-proof cages, screened with Swiss organdie. Subsequently they were held at an average daily temperature of 24 to 25°C. The four varieties of budwood were packed in moist vermiculite in separate, ventilated plastic boxes and held at 20°C for 24 h. Twenty buds of each variety were then grafted on to seedlings in a nursery.

In trial 1 insect counts were made on the treated and untreated seedlings after 19 days and again on the treated seedlings only after 33 days. Counts were made after 28 days in trial 2. In biology studies at an average temperature of 24°C all eggs of *E. ironsidei* had hatched by the seventeenth day. To detect any live immature insects which had hatched from eggs surviving fumigation, or from eggs oviposited by surviving females, the leaves and stems of the fumigated seedlings were examined under a stereo microscope. Because of the large numbers of insects present on the untreated seedlings of trial 1, the live immature insects were counted on the bottom leaf only, of each seedling. The adult females were

*Gulton Industries Inc., Gulton Industrial Park, East Greenwich, R. 1 02818, England.

also examined under a stereo-microscope and classified as live or dead, mortality being determined by the discolouration and desiccation of the dead insects. These counts were made on all fumigated and untreated seedlings in trial 1, and on all fumigated seedlings which were alive and on 8 of the 11 untreated seedlings in trial 2.

Phytotoxicity

Observations were made on the effect of MB fumigation in trials 1 and 2. For seedlings these observations were concerned with leaf burn, the effect of the fumigant on new growth and the survival of the plants. An additional observation was also made on six uninfested *M. tetraphylla* seedlings fumigated with 55 g m^{-3} MB for 2 h at 20°C . These seedlings were in 15-cm diameter plastic pots containing approximately $1\,500 \text{ cm}^3$ of soil. Six potted seedlings of similar size and condition were used as unfumigated controls. For uninfested budwood the effect of MB fumigation was determined, after 6 to 7 weeks, by comparing the number of successful grafts obtained from each of the treated and untreated samples.

IV. RESULTS AND DISCUSSION

Effect of MB fumigation on *E. ironsidei*

In the first trial only the highest dosage of MB (55 g m^{-3}) resulted in seedlings free of living insects (table 1). With the 36 and 46 g m^{-3} treatments no living adults were found and eggs were shrunken and discoloured. However, it is apparent from the presence of live immature insects that some eggs survived these two dosages. The 27 g m^{-3} dosage failed to eliminate all adult insects, as well as allowing the survival of immature stages. In the second trial (table 2) 55 g m^{-3} MB for 2 h killed all the adult females and immature stages, thus confirming the result obtained in trial 1. At the 95% probability level no survivors out of 4 133 individuals treated (table 2) is equivalent to a mortality of 99.92%.

Effect of MB fumigation on macadamia seedlings

In the first trial with moderately-infested *M. integrifolia* seedlings, only the 46 and 55 g m^{-3} treatments caused a small amount of leaf burn, but all the fumigated seedlings continued to put out new growth. Only 22.2% of the untreated seedlings showed new growth, thus reflecting the injurious effect of the insect (table 3).

TABLE 1
TRIAL 1—THE EFFECT OF DIFFERENT DOSAGES OF METHYL BROMIDE ON
THE MACADAMIA FELTED COCCID

Dosage of MB for 2 h, 20°C (g m^{-3})	No. of Specified Stage of Coccid on 9 Plants after Fumigation		
	Dead Females	Live Females	Living Immature Males and Females
0	106	284	448*
27	231	15	117
36	209	0	14
46	303	0	6
55	390	0	0

Counts were made after 19 days

* Number on the bottom nine leaves only.

TABLE 2

TRIAL 2—THE EFFECT OF METHYL BROMIDE FUMIGATION ON HEAVY INFESTATIONS OF THE MACADAMIA FELTED COCCID AND ON THE SURVIVAL OF INFESTED SEEDLINGS OF *M. integrifolia*

MB at 55 g m ⁻³ , 20°C for Specified Time (h)	No. of Plants Examined for Insects	Adult Female Insects		No. and Condition of Seedlings		
		Total	% Dead	Live Seedlings	Dead Seedlings	Seedlings with New Growth
0	8	3 698	7.1	11	*7	1
2	16	4 133	100	16	†2	8

Counts were made after 28 days

* Death due to heavy insect infestation

† Death due to fumigant burn

TABLE 3

TRIAL 1—THE EFFECT OF DIFFERENT DOSAGES OF METHYL BROMIDE ON *M. integrifolia* SEEDLINGS MODERATELY-INFESTED WITH THE MACADAMIA FELTED COCCID

Dosage of MB for 2 h, 20°C (g m ⁻³)	Mean Number of Leaves per Seedling	Mean Number of Female Insects per Seedling	Leaves Damaged by MB (%)	Seedlings with New Growth (%)
0	10	43.3	0	22.2
27	15	27.3	0	100
36	18	23.2	0	100
46	14	33.7	2.4	100
55	14	43.3	4.8	100

Counts were made after 19 days

By contrast, MB fumigation of heavily-infested *M. integrifolia* seedlings (55 g m⁻³ for 2 h) resulted in considerable leaf burn and killed 2 of the 18 seedlings treated (table 2). The heavy insect infestation killed 7 of the 18 seedlings in the untreated control. Elimination of the infestation by fumigation resulted in fewer seedlings dying and an increase in new growth compared with the untreated plants (table 2).

There was no leaf burn and no obvious plant damage after fumigating uninfested, potted *M. tetraphylla* seedlings with 55 g m⁻³ MB for 2 h at 20°C.

Effect of MB fumigation on uninfested budwood of four varieties of *M. integrifolia*

No obvious damage was caused by the fumigant. The number of successful grafts from each of the MB treated and untreated samples of the four varieties is given in table 4. Differences were not significant at the 5% level. The effect of MB treatment on infested budwood was not investigated. Good horticultural practice would necessitate the use of budwood that was either uninfested or only very lightly infested. On a commercial scale it would be difficult to be absolutely sure that all samples of budwood were completely free of the insect. Fumigation with MB would ensure that this was so.

TABLE 4

TRIAL 1—THE EFFECT OF DIFFERENT DOSAGES OF METHYL BROMIDE ON THE VIABILITY OF UNINFESTED *M. integrifolia* BUDWOOD

Dosage of MB for 2 h, 20°C (g m ⁻³)	Total No. of Successful Grafts of Specified Treated Variety of Budwood from 20 Grafts				
	Keaouhou (246)	Kakea (508)	Ikaika (333)	Keaau (660)	Means
0	18	18	10	8	13.50
27	16	18	13	17	16.00
36	20	7	14	14	13.75
46	13	10	10	10	10.75
55	14	17	10	7	12.00
Means ..	16.2	14	11.4	11.2	13.20

Treatment means 13.2 ± 1.64. Differences not significant (P = 0.05)

V. CONCLUSION

Fumigation with methyl bromide at 55 g m⁻³ for 2 h at 20°C was found to be effective in eliminating *E. ironsidei* from infested macadamia seedlings. The treatment caused no obvious damage to uninfested *M. tetraphylla* seedlings. With *M. integrifolia* slight leaf burn occurred on moderately-infested seedlings while moderate to severe leaf-burn and plant death occurred with heavily-infested seedlings. There was no damage to uninfested budwood.

The treatment is recommended for disinfecting seedlings and grafted trees from the nursery and budwood or scion wood from the field. To avoid excessive damage, plants should not be allowed to become heavily infested before fumigating with methyl bromide.

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The authors are members of Entomology Branch, Queensland Department of Primary Industries. The senior author is stationed at Nambour, and the junior authors at Indooroopilly, Brisbane.