X-Mate™ M.N.B.

Z-8-dodecenyl acetate

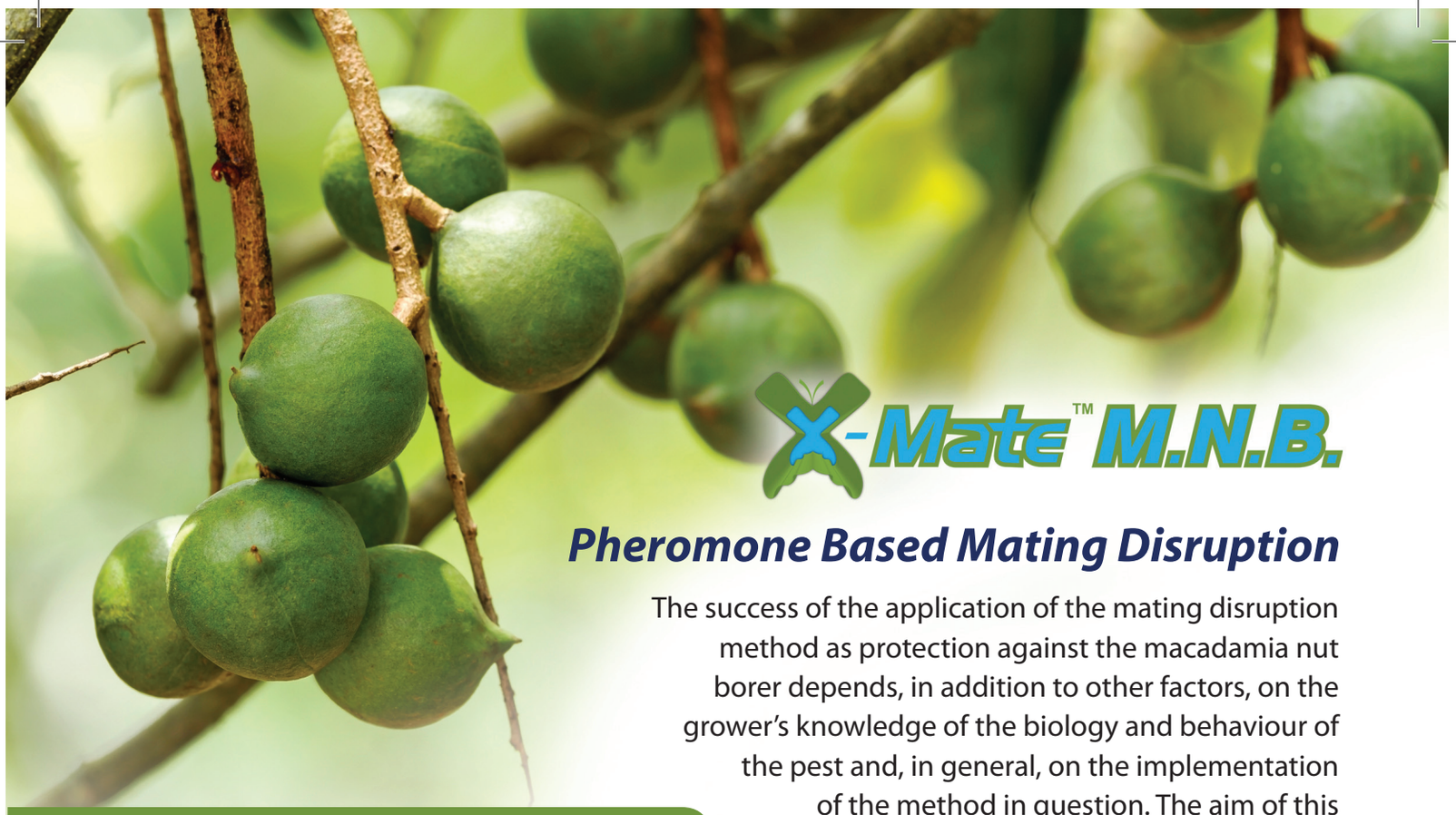
Reg No: L10319, Act 36 of 1947

Pheromone Based Mating Disruption

- *Pest specific*
- *Easy to apply*
- *Season long control*
- *Hinders chemical resistance*
- *Rain fast and no chemical drift*
- *No damage to the environment*

Manufactured by

INSECT SCIENCE®



X-Mate™ M.N.B.

Pheromone Based Mating Disruption

The success of the application of the mating disruption method as protection against the macadamia nut borer depends, in addition to other factors, on the grower's knowledge of the biology and behaviour of the pest and, in general, on the implementation of the method in question. The aim of this manual is to provide technical information relevant to achieving this success.

Introduction

The macadamia nut borer (MNB), *Thaumatotibia* (=*Cryptophlebia*) *batrachopa* (Meyrick, 1908) (Lepidoptera: Tortricidae) forms part of the nut borer complex which also includes the false codling moth (FCM), (*Thaumatotibia leucotreta*); litchi moth, (*Cryptophlebia peltastica*) and carob moth, (*Ectomyelois ceratoniae*) (Hepburn, Radloff, & Moore, 2010). MNB is a known pest in tree nuts, litchi, guava and feijoa in Africa.

In previous years MNB has been controlled partially by the use of conventional registered pesticides for stinkbugs e.g. pyrethroids and organophosphates. However, the pressure to phase out chemical control on edible crops has increased significantly over the past few years (Hepburn, Radloff, & Moore, 2010). This has increased the need to identify alternative, integrated pest management (IPM) methods for the future control of this pest in South Africa and Africa as a whole.

X-Mate™ M.N.B. is a ready-to-use, pheromone based, mating disruption product, which disorientates male MNB resulting in the failure of the male moths to locate the female moths and thus reducing mating. X-Mate™ M.N.B. is ideal to be used in an IPM programme and has a significant advantage over conventional pesticides due to not having any residue within the edible crop.

Economic Importance

In Malawi, MNB is a major pest contributing to up to 20 % of the loss in macadamia production (De Villiers & Joubert, 2003). South Africa which is currently a major production area for macadamias suffers a smaller loss of ± 5% (Source, 2016). However, it is suggested that the damage caused by MNB is higher than the estimated 5% in South Africa due to nut-drop not accounted for in the benchmark study completed by Source (J. Winter, personal communication, April 10, 2017). Schoeman (2009) estimated that total damage caused by the moth complex could be as high as 16%. The monetary loss suffered by the South African Macadamia Industry is estimated to be in excess of R 200 million/annum (US$ 15 million) at processor level assuming a back-on-farm income of R195.50 per kg kernel.

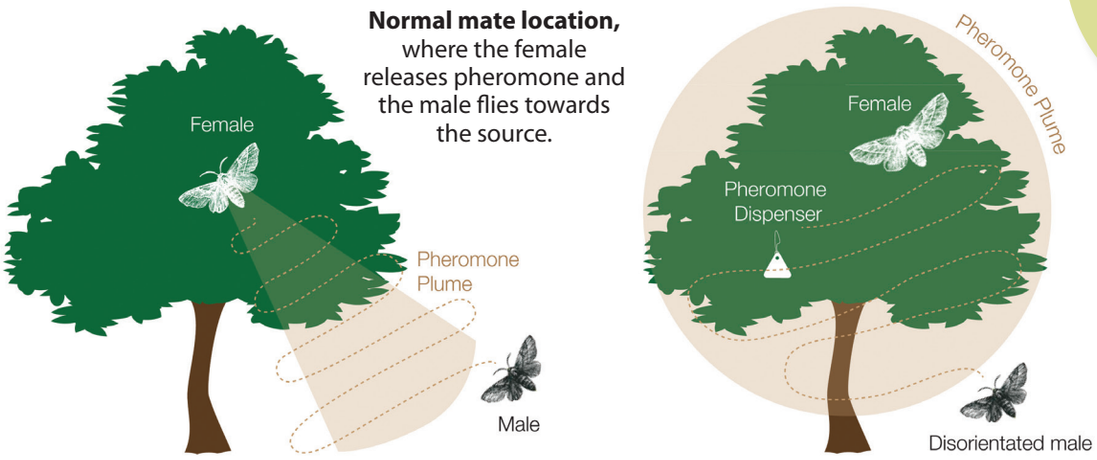
Identification and monitoring of MNB in South African orchards is essential in order to preserve current export markets. Similar to FCM, phytosanitary risks associated with MNB could have serious negative impacts on prospective and current export markets (Timm, Warnich, & Geertsema, 2007).

Principals of the mating disruption method

Male moths find potential mates by following the trail of a scent (pheromone) emitted by the female of the same species. In this insect species, the principal chemical component is Z-8-dodecenyl acetate. This substance attracts males, causing them to initiate a particular sequence of behaviour that begins with their guided flight and ends with mating. Mating disruption consists of disturbing mating by saturating the atmosphere with synthetic pheromones released by dispensers. In an atmosphere saturated with this pheromone, the males cannot locate the females, which emit pheromones at a lower concentration than the dispenser. The aim is to prevent mating so that no eggs or larvae are formed, thus, no damage is incurred in the area covered by the pheromone.

The concept of mating disruption. Within the cloud of pheromone released by the dispensers, the male cannot locate the pheromone released by the female.

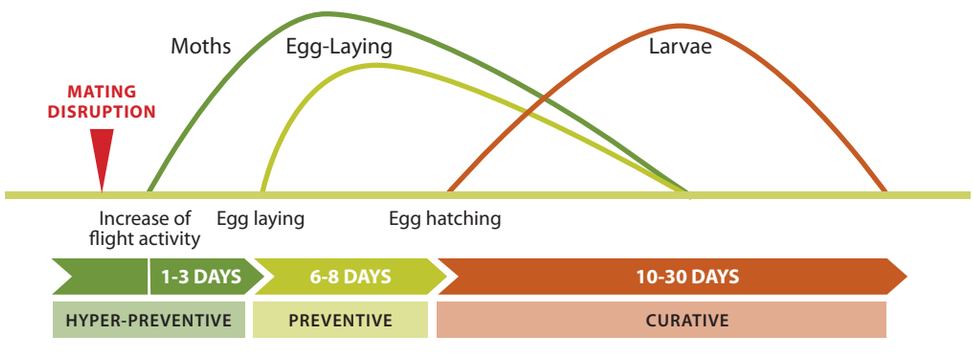
Mating disruption concept



Normal mate location, where the female releases pheromone and the male flies towards the source.

In **mating disruption**, pheromone is released from dispensers that act as false sources, or pheromone is released at such a high rate that the male is disorientated or unable to detect the plume of the calling female.

The use of mating disruption in the protection of crops against pests, particularly against macadamia nut borer, is considered a hyper-preventive means of protection.



Strategies of protection against macadamia nut borer

Dispensers

The synthetic pheromone used in the orchard is distributed by dispensers. Several types of dispenser are currently available in the market. The dispensers most frequently used against similar Lepidoptera species such as false codling moth are ISOMATE, commonly known as "spaghetti". Although nothing has been developed for macadamia nut borer in South Africa until recently. The use of mating disruption against the macadamia nut borer has now been registered by Insect Science (Pty) Ltd in South Africa.

X-Mate M.N.B. Release devise

Application density

Each X-Mate™ M.N.B. dispenser covers an average area of 400 m^2. Thus, the dispensers should be applied at a density of 25 dispensers per hectare, with an increase of approximately 20% around the edges of orchard where heavy prevailing winds are present or steep slopes are being treated to prevent part of the orchard atmosphere from not being saturated by the pheromone.

Factors to consider in the installation

- **Size of the orchard**
  The area of intervention should be sufficiently large and isolated to prevent the entry of fertilised females from adjacent orchards. The recommended minimum area for the effective application of mating disruption varies depending on the homogeneity of orchards. This area should reflect factors such as the shape of the orchard, their slope and relief, climatic conditions (wind speed), and the population density and flight capacity of the pest. The larger the area covered by the method, the greater the possibilities of its successful application. For ***X-Mate™ M.N.B.*** it is recommended that this area be at least 10 hectares.

- **Climate**
  The wind has an effect identical to the border effect, preventing the pheromone cloud from maintaining the necessary concentration. Thus, it is recommended that the application start on the outer side of the boarder. The wind and temperature in the orchard influences the pheromone release rate, which influences the persistence of the pheromone. It is essential for the pheromone release period to cover the entire mating period.

- **Border or security zone**
  For the reasons cited above, it is convenient to increase the number of dispensers (20% more) in a strip along the border. It is also necessary to install dispensers in other sources of pest infestation near the orchard, such as hedges and trees that may act as alternative hosts.

- **Dispenser placement date**
  The dispensers should be placed in the field before the start of the first peak flight to prevent the first mating in August - September. As a precaution, it is advisable to install a Yellow Delta Trap and M.N.B. PheroLure® (Reg No L8257) that detects the start of flight at the end of July.

- **Population density**
  As the population density of the pest increases, the probability that a male will find a female increases, whereas at low population densities, the likelihood of casual encounters between individuals is reduced. Consequently, in the case of high population densities, the success of mating disruption may depend on the application of an insecticide treatment aimed at reducing the population.

Application density

To prevent the population growth, the pheromone must be present in the atmosphere before the temperatures start to increase and the moth flights increase.

The installation of the dispensers to make the pheromone last longer is not advisable because the release rate depends on the temperature. At the start of the programme (September), the temperature is relatively low. As a result, a later application of the dispensers does not produce significant gains in the economies of the dispenser load.

Several years of consecutive application of the method helps to reduce the damage caused by the pest. Therefore, mating disruption can be considered a means of protection with a cumulative effect. However, this cumulative effect can only be achieved if the dispensers are installed just before the increased moth activity, otherwise the moths will continue to settle in the orchard and the effectiveness of the method will be threatened.

In South Africa, the flight of macadamia nut borer begins to increase as the days temperatures rise, peaks in November December and starts to slow down as winter starts to set in or early June. The dispenser persistence is approximately 150 - 180 days (4-5 months), which is sufficient for the MNB season.

Calculation of the number

Practical examples

The distance between dispensers should be calculated according to the plant spacing. This calculation will be illustrated on the product packaging for the grower's convenience. The spacing tables can be seen below in and it is important to remember that each dispenser covers an area of 400 m^2.

Macadamia orchard placement guideline

Row spacing (m)	Tree spacing (m)	Trees per ha	Dispenser per Ha	Instruction (1 dispenser per 400 m^2)
5	5	400	25	Start application in 2nd row tree no 2 there after in every 4th tree in the row. Repeat application in every 4th row.
6	3	555	25	Start application in 2nd row tree no 2 there after in every 6th tree in the row. Repeat application in every 4th row.
6	4	416	25	Start application in 2nd row tree no 2 there after in every 5th tree in the row. Repeat application in every 3rd row.
7	3,5	408	25	Start application in 2nd row tree no 2 there after in every 6th tree in the row. Repeat application in every 3rd row.
7	4	357	25	Start application in 2nd row tree no 3 there after in every 5th tree in the row. Repeat application in every 3rd row.
8	3	416	25	Start application in 2nd row tree no 2 there after in every 6th tree in the row. Repeat application in every 3rd row.
8	4	312	25	Start application in 2nd row tree no 3 there after in every 4th tree in the row. Repeat application in every 3rd row.
9	4	278	25	Start application in 2nd row tree no 3 there after in every 4th tree in the row. Repeat application in every 3rd row.
10	5	200	25	Start application in 2nd row tree no 2 there after in every 4th tree in the row. Repeat application in every 2nd row.

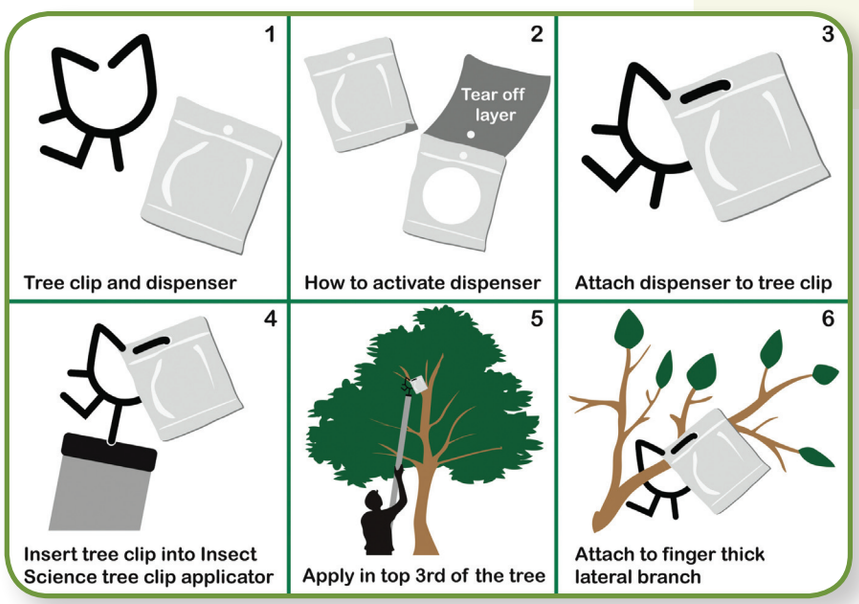
Installation of the dispensers

It is advisable for the installation of dispensers in the orchard to be supervised by a technician responsible for coordinating the personnel who will carry out the work. A brief advance meeting with the personnel should be held to explain the importance of the correct manner of application of dispensers along the row and the management of the borders. See below for insulation instructions.

At the preparatory meeting, the following points should be specified:

- The dispensers should be applied in the top third of the canopy of the orchard by using the Insect Science (Pty) Ltd X-Mate™ applicator.
- If there is no tree where a dispenser was supposed to be placed, the dispenser should be placed on the tree situated just before or after the space. The dispensers should only be applied to a diagonal tree if there is a large space of more than 15m without a tree.
- The placement of the dispensers must begin on the orchards with the greatest susceptibility and history of attacks and to ensure the number of dispensers used on those orchards are as previously calculated.
- In the border zone, where strong prevailing winds or steep slopes are present be sure to start the application outside of the treatment block, the distance between dispensers must be in accordance with plant spacing.

Instulation of X-Mate M.N.B.



How to test the effectiveness

The first evaluation of the method's effectiveness involves the observation of the pheromone base traps located in the orchard treated with mating disruption and the comparison of the number of captures with those obtained in traps located outside the area treated with mating disruption.

Captures in pheromone traps

If the method works well, the male moths will not be able to locate the pheromone trap, and there will be no captures in the orchard where mating disruption is applied. This result means that the males will also be unable to find the females, and therefore no mating or damage will occur.

Calculation of damage

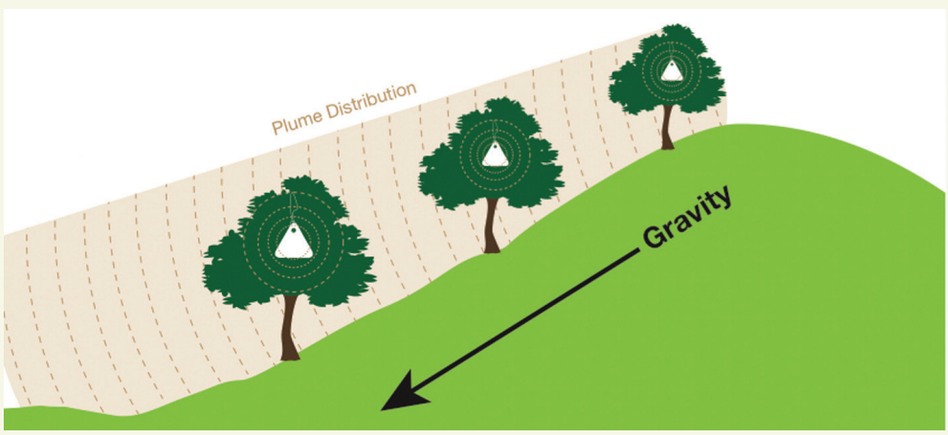
The absence of captures in a trap is not a guarantee that a particular orchard has not been infested. If the pheromone is not uniformly distributed in the orchard and certain conditions are present the risk of mating will increase. Thus, in addition to monitoring the pheromone traps, sampling should be conducted to assess the damage in each generation. The samples should be collected both in orchards treated with mating disruption and in control orchards.

Advantages of the method

- Does not affect Beneficial's, safeguarding the presence of predators and parasitoids that limit the presence of macadamia pests. **Its use enables a balance between the pest and his antagonists to be achieved in time.**
- **Non-toxic** to the labour applying the product.
- **Does not leave marks** or residues on the fruit.
- Has a **cumulative effect** if used repeatedly over the course of several years.
- The **pest does not develop immunity** or **resistance** to the product.
- It is **easy and rapid to apply**, and application is required only once a year, at the start of the programme, and at a time when there is little work in the orchard to be done.
- Can be used as a commercial argument to promote agricultural production through the use of an "**environmentally friendly**" means of protection against pests.

Limitations of the method

- The **minimum area** required is **10 ha**.
- Orchards with **less ideal conditions** (very windy, steep slope, or varied orchards) make it **difficult to maintain** the pheromone cloud on the site see figure below.
- On sites with high levels of attack, the **1st year of application** generally **requires application of an insecticide** to reduce the initial population.
- Under **certain conditions** (e.g., significant pest density, small orchards, strong winds, or late placement of dispensers), mating disruption **may not guarantee the** required **effectiveness**.
- Due to its specific characteristics, mating disruption **does not ensure protection against other pests**.



Effect of gradient on pheromone plume distribution and concentration

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Active ingredients

Z-8-dodecenyl acetate (100 %) 1250 mg
Each dispenser contains a minimum of 1250 mg active ingredients.

Product information

Ready-to-use Male Mating Disruption: ***X-Mate™ M.N.B.*** is a ready-to-use, pheromone based, mating disruption product, which disorientates male Macadamia Nut Borer (*Thaumatotibia batrochopa*) resulting in the failure of the male moths to locate the female moths and thus reducing mating. ***X-Mate™ M.N.B.*** is used in Macadamias and is ideal where Integrated Pest Management programs are followed.

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