MAGNET®

INSECT ATTRACTANT TECHNOLOGY

Cotton Technical Manual

AG BIOTECH AUSTRALIA

Contents

Introduction

Magnet Insect Attractant Technology is a revolutionary integrated pest management tool that has been developed to manage *Helicoverpa* spp. (Heliothis) and other lepidopteran pests in a wide range of crops. The product is the result of years of research and development by a group of Australian Cotton CRC scientists based at the University of New England, Armidale, along with field development by Ag Biotech.

The research was focused around the understanding that moths are attracted to flowering plants as a source of nectar for energy. Insects perceive by olfaction (smell) volatile compounds that are released by plants. They are attracted to certain volatile compounds that indicate the presence of flowers and nectar.

The research involved screening about 40 plants (hosts and non-hosts of *Helicoverpa* spp. larvae) for attractiveness to female *H. armigera* moths in the laboratory, using a two-choice olfactometer (an apparatus to measure odour preference in moths - see *Figure 1*). This was followed by analysis and identification of the chemical compounds found in the attractive plants.

The olfactometer work showed that there were a number of compounds in common between the most attractive plants. Commercially available equivalents of these compounds were then combined into blends, which were tested in the olfactometer. After a long series of these trials, the most attractive blend, which gave levels of attraction comparable to the most attractive plants, was identified.

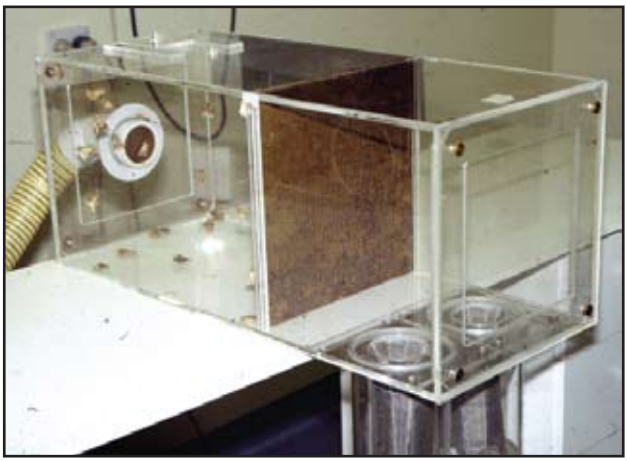

Figure 1 Olfactometer

The research team then tested the attractiveness of the volatiles to moths in the field. This work led them to develop an attract-and-kill formulation based on the best volatile blend, feeding stimulants and a toxicant.

How Magnet Works

Traditional methods of controlling caterpillar pests are based on application of foliar insecticides to kill larvae and eggs. Magnet is different. It targets the adult (moth) stage of the insect's life-cycle. By killing moths before they can lay their eggs, the reliance on foliar applied insecticides for larval control can be considerably reduced.

When moths are active in crops, they require energy (in the form of sugars) to allow them to fly in search of mates and egg laying sites. The primary sugar energy source for moths in the environment is in the form of nectar from flowers (see *Figure 2*). Laboratory study has shown that often, crops that are hosts for larvae aren't very attractive to the adults (moths) as a food source.

Figure 2 Heliothis moth feeding on flower nectar. Note the extended proboscis.

The plant volatiles in Magnet mimic the type of odour signals that male and female moths look for when seeking nectar rich flowers. This makes Magnet treated crop rows highly attractive zones that moths will move toward when needing an energy source. It is important to note that the volatile blend in Magnet is not a mimic of a particular plant. The best components from a number of different plants have been combined, resulting in a combination of plant volatiles not normally found in nature but highly attractive to moths.

The volatiles in Magnet attract moths that are in the vicinity of treated rows. Once a moth arrives at a Magnet treated row, it is stimulated to feed on Magnet deposits due to their high sugar content (see *Figure 3*). As a result, the insecticide added to Magnet (sold separately and added just prior to application) is ingested by the moth causing death (suitable insecticides include methomyl, spinosad and thiodicarb - refer to the Magnet label). Female *Helicoverpa* moths can lay over 1,500 eggs. By killing moths before they can lay their eggs, the number of eggs and larvae in the crop will be greatly reduced.

Figure 3 *Helicoverpa armigera* moth feeding on Magnet.

How Magnet is Used

Applying Magnet

Magnet is applied in narrow (20 to 100 cm wide) strips on the crop with 72 (high knockdown rate) or 144 (pre-emptive rate) metre spacings between the strips. This equates to 1.4 or 0.7% respectively of the crop area being treated. By applying Magnet in this way, moths only have a relatively short distance to travel to reach a Magnet treated strip when they are in need of energy. Magnet is not attractive from larger distances in the way that pheromones are, so wider spacing of Magnet strips, or applying Magnet only to the border of the crop, are not effective strategies. Border strips will kill some moths entering a field, but will not be completely effective, and will not kill a large proportion of moths already present in the middle of the field.

Magnet is most effective when moth activity in the crop is high. During summer months, peak moth activity is at night time, while at other times of the year moth activity can decline during cooler nights, with more activity occurring during the day. To achieve the maximum result with Magnet during summer, it is best applied in the late afternoon prior to peak activity in the first part of the evening.

Magnet must be applied in coarse droplets, to provide large deposits on the crop that moths are able to locate and feed on. This application can be achieved through both ground and aerial application (see *Figure 4 and 5*). More detailed information regarding application can be found in the Application section of this manual and on the Magnet label.

Figure 4 Magnet mixture aerially applied to cotton plants

Figure 5 Magnet mixture applied to cotton plants by ground rig

Magnet deposits on the crop will dry out during the heat of the day in low humidity conditions. However water released by plants during respiration and higher night time humidity causes the sugary deposits to absorb moisture and re-liquefy making them available for ingestion by the moths. In this way, Magnet will continue to kill moths for 4-6 days after which time the plant volatiles will have dissipated.

Following the first application, subsequent applications should be made at intervals of 4 to 10 days, depending on the strategy being employed (see Application Timing and Schedule below). Reapplication of Magnet can be made to the same or different rows as previously treated rows. There is no advantage or disadvantage in reapplying Magnet to the same row repeatedly.

Magnet is highly water soluble and therefore NOT rain fast. Rainfall will wash the product from the plant surface and reapplication will be necessary to achieve ongoing control of moths.

Application Timing and Schedule

Female *Helicoverpa* spp. moths are capable of laying over 1,500 eggs during their fertile period, which equates to around 200 eggs per day. This means that a relatively small moth population of 500 moths (with a 50:50 male:female ratio) per hectare is sufficient to produce an egg lay of 5 eggs per metre in a single night. In addition, *Helicoverpa* moths are highly mobile and able to infest cotton fields in high numbers very rapidly. It is important to understand these characteristics of *Helicoverpa* moths when choosing the best strategy to employ with Magnet.

Figure 6 White *Helicoverpa* eggs on a cotton leaf

How Magnet is Used (cont...)

Using knowledge of *Helicoverpa* moth ecology combined with an understanding of Magnet performance, Ag Biotech has developed two strategies for Magnet's use in cotton. Magnet is ideally used under a pre-emptive strategy to provide ongoing suppression of *Helicoverpa* over a long period, or it can be used reactively as a knockdown product to limit the impact of a spike in pest numbers.

Higher rates of Magnet are more effective at quickly reducing a large moth population, however using the lower rate more regularly will provide a higher level of continual suppression, and be more cost effective. The theoretical data in *Figure 7* shows the difference in egg lay that could be expected between a low-rate/pre-emptive strategy and the selective use of higher rates, in comparison to what the theoretical untreated control egg counts would be.

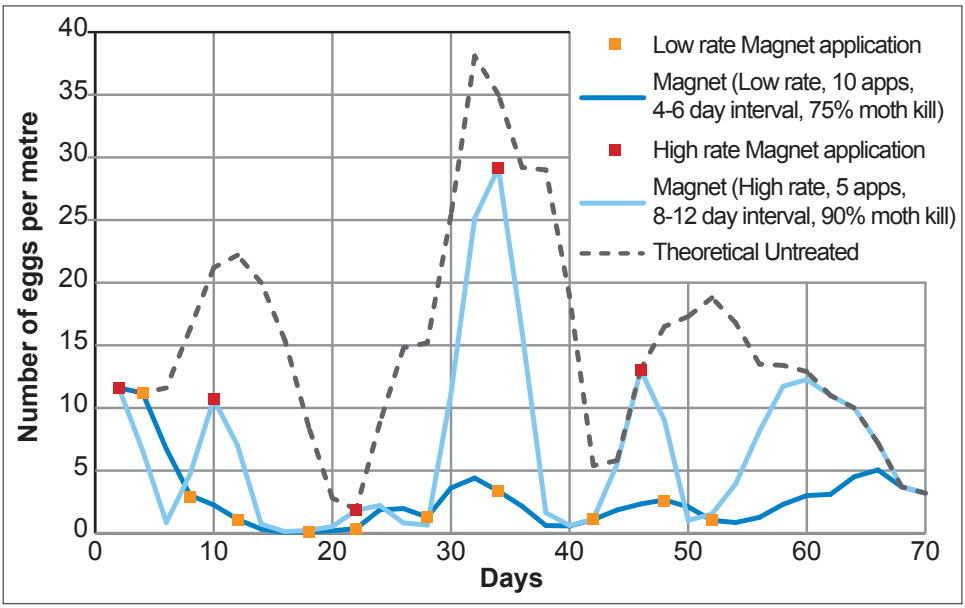

Figure 7 Theoretical trial data, showing egg counts under a low rate (pre-emptive) strategy (applications at orange markers) versus a strategy using fewer high rate applications (red markers).

This theoretical data was generated using an understanding of moth ecology and Magnet performance, and using identical moth infestation levels for each scenario. This type of comparison is not possible in the field due to the area wide impacts of Magnet and high moth mobility.

The theoretical data in *Figure 7* shows that the low rate of Magnet (pre-emptive strategy) applied on a tight schedule and giving 75% moth kill, provides continual suppression of egg lay (<5 eggs/m). In comparison, the high rate, applied less often and providing a higher moth kill (90%), is very effective at quickly reducing egg lay during high moth activity but can allow moth numbers to recover between applications, resulting in significant egg lay. It is important to note that the two strategies use the same total quantity of Magnet (low rate = half rate applied 10 times versus high rate applied 5 times).

Pre-emptive Strategy

Commercial scale trial work has shown that using a low rate of Magnet (that is, 1 treated strip every 144 metres) on a tight schedule of 4 to 6 days provides a high level and continual suppression of *Helicoverpa* moths. This pre-emptive strategy for Magnet fits with *Helicoverpa* moth ecology and also corresponds with the 4 to 6 day period that Magnet remains effective (with nil rain).

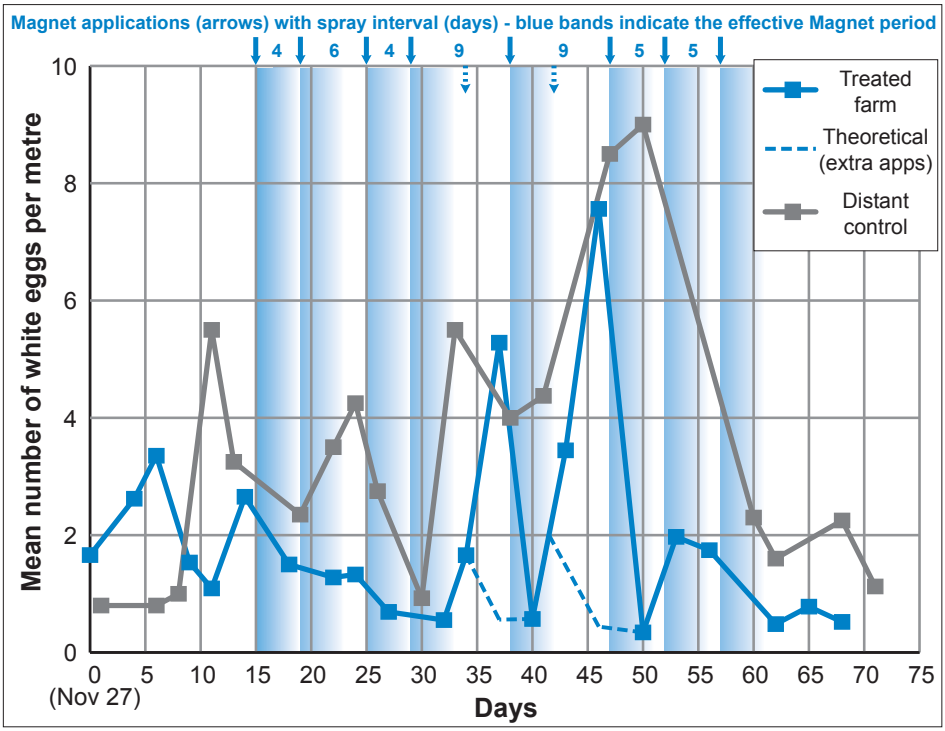

Figure 8 Trial data showing mean white egg counts on a cotton farm treated with Magnet (pre-emptive strategy) vs a distant control farm (120 km away). Dashed line shows theoretical egg counts if Magnet had been applied at 34 and 42 days (full spray programme). Rollestone, Qld, 2008-09 season.

Pre-emptive Strategy *(cont...)*

Figures 8 and *9* show the results for a trial conducted in Rollestone, Central Queensland, in the 2008/09 season to evaluate Magnet under a pre-emptive strategy. Due to the isolated nature of the trial farm, it was not possible to include a nearby untreated control. A distant control farm near Emerald (120 km away) with a significant conventional cotton area was used to give an indication of regional *Helicoverpa* pressure.

White egg count data for both farms is presented in *Figure 8* - white egg counts are used to provide an immediate and sensitive measure of the moth population. The results show that each application of Magnet significantly reduced egg lay. In particular, applications at 38 and 47 days showed large reductions in the level of egg lay and the high pressure on the treated farm corresponds to a period of consistently high pressure on the distant control farm. During this high pressure period (Days 34 to 59), two scheduled Magnet applications were not applied. The data shows that during this period of sustained moth activity, egg numbers recovered after about 7 days following Magnet application, with reapplication reducing levels back below threshold. This result highlight's the ability of Magnet to continually suppress egg lay when applied on a tight 5 day schedule, and the fast recovery of *Helicoverpa* numbers under a wider application window.

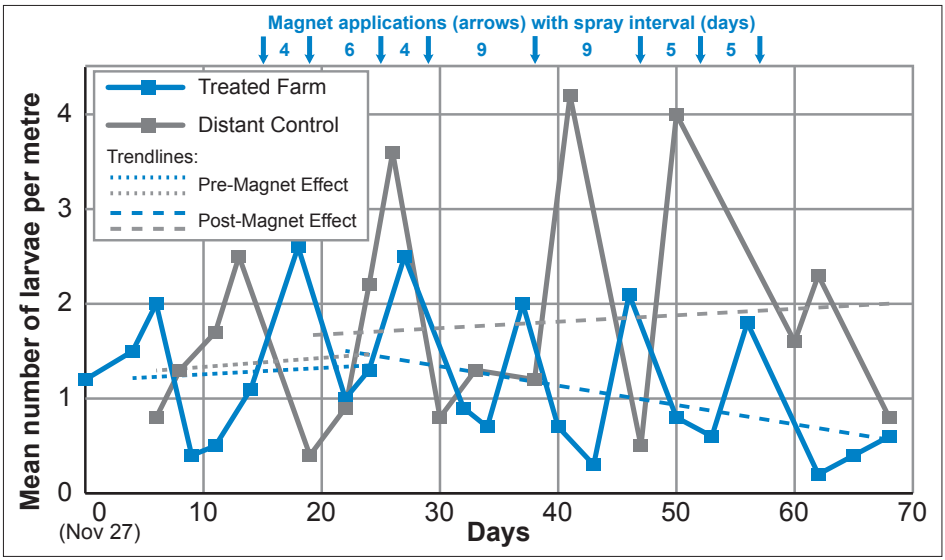

Figure 9 Trial data showing mean larval counts on a cotton farm treated with Magnet (pre-emptive strategy) vs a distant control farm (120 km away). Rollestone, Qld, 2008-09 season.

Clearly the overall purpose of Magnet application under a pre-emptive strategy is to reduce larval pressure in the crop through reduction in egg lay caused by suppression of the moth population. The data presented in *Figure 9* is from the same Central Queensland trial, and shows average larval numbers from the Magnet treated and distant control farms.

The results show that the Magnet treated farm had similar larval numbers to the distant control farm in the period prior to Magnet having an impact on larval numbers. It also shows that in this period, the trend (short dash lines) was showing a slight overall increase in larval numbers on both farms. Note that the "Pre-Magnet Effect" trendline for each farm extends beyond the first Magnet application, since an impact on larval counts from Magnet application is not observed until about 1 week after application, due to the development life-cycle of *Helicoverpa* (that is; moth kill impacts egg lay for the following 1 to 4 nights, and eggs take 3 to 4 days before hatching to larvae).

Figure 10 *Helicoverpa* larva feeding on a cotton square

In this trial, the trend for larval counts on the treated farm shows a substantial decline during the effective Magnet period (long dash lines). This contrasts with the distant control, which shows a continuation of the rising trend in larval numbers. The treated farm also shows significantly lower peaks in larval counts compared to the distant control, due to lower egg lay spikes from Magnet's impact on moth numbers. The differences in larval counts would have been significantly larger had the full spray programme of Magnet been applied, whereas two applications were missed during the period of highest activity, resulting in egg lay spikes on the treated farm (see *Figure 8*). It is important to note that insect management on both farms was conducted by the same consultant team.

The results from this large scale commercial trial confirm results seen in other large scale work conducted. For example, commercial use of Magnet as a pre-emptive strategy on a farm west of Walgett, NSW, resulted in season long suppression of egg lay (see *Figure 11* overleaf).

Pre-emptive Strategy *(cont...)*

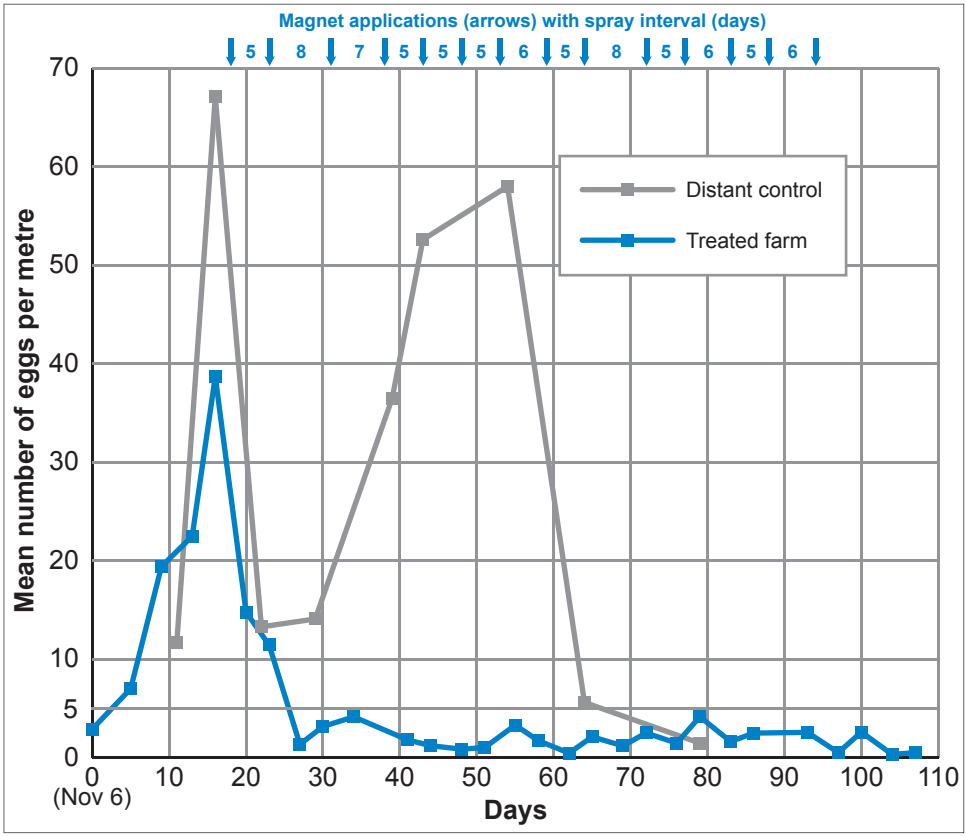

Figure 11 Commercial evaluation trial showing mean egg counts on a Magnet treated farm vs a distant control (40 km away). Brewarrina, NSW, 2005-06 season.

The data summarised in *Figure 11* shows that the Magnet treated farm experienced low level egg lay throughout the period that Magnet was applied. This region usually experiences consistent, moderate egg lays with large spikes in egg pressure (generally from *H. punctigera*) also occurring, as seen on the distant control farm. The 14 Magnet applications applied pre-emptively over 11 weeks (average 5.4 days between applications) were effective in maintaining egg counts below 5 per metre (average of 2.8 eggs per metre after the first application) and resulted in greatly reduced larvicide requirements throughout the season.

Pre-emptive Strategy - Summary

- Application on a 4 to 6 day schedule
- Apply at a rate of 1 Magnet strip every 144 metres for most applications times
- Use the high rate (1 treated strip every 72 metres) under higher pest pressure
- Suggested initial application at first flower
- Recommended minimum treated area of 200 ha to maximise area wide impact
- Suggested schedule of 10 applications providing about 8 weeks control

Knockdown Strategy

Magnet can be used more selectively in a targeted approach when an increase in pest numbers occurs, such as a spike in the moth population or with an observed increase in egg numbers. This strategy will be most successful where effective monitoring enables immediate application of Magnet prior to a large increase in egg lay occurring on the treated farm. Examples of the type of monitoring that may allow successful use of a knockdown strategy include; where a spike in egg lay occurs on other crops in the area, or where observation or monitoring of *Helicoverpa* moth activity indicates a rise in the population (pheromone traps are often not suitable for this purpose).

Under a knockdown strategy, it is recommended to user the higher rate (1 Magnet strip every 72 metres), which provides higher percent control and faster knockdown, since the knockdown strategy will generally be targeting higher populations than the pre-emptive strategy, requiring a more rapid reduction in the population to minimise a potential spike in egg lay.

Days after trt	Species	1st Magnet trt Day 0	2nd Magnet trt Day 16	3rd Magnet trt Day 36	Cumulative
Day 1	*H. armigera*	10,062	935	4,202	15,199
	H. punctigera	2,349	2,021	1,777	6,147
Day 2	*H. armigera*	8,775	483	3,692	12,951
	H. punctigera	536	873	1,443	2,851
Day 3	*H. armigera*	7,606	572	3,238	11,417
	H. punctigera	560	1,352	126	2,037
Day 4	*H. armigera*	2,007	not assessed	3,081	5,088
	H. punctigera	44	not assessed	1,052	1,096
Total	***H. armigera***	**28,451**	**1,990**	**14,213**	**44,654**
	H. punctigera	**3,489**	**4,245**	**4,397**	**12,132**
	All Helicoverpa	**31,940**	**6,235**	**18,610**	**56,786**

Figure 12 Number of moths killed in a Magnet treated cotton field (42 ha) over 4 days following 3 applications at a rate of 1 Magnet strip every 72 metres. Darling Downs, 2002/03 season.

***Knockdown Strategy** (cont...)*

The data in *Figure 12* shows the moth killing capacity of Magnet when applied at the knockdown rate (1 band every 72 metres) on a relatively small cotton field. The majority of moths are killed during the first two nights after application, with the total number killed dependent on the available population of moths. The reduced moth kill generally seen on the third and fourth nights is largely due to the declining population caused by Magnet. In situations where moth are continually infesting the treated field (e.g. 3rd treatment for *H.a.*), Magnet's ongoing moth killing capability until at least the fourth night after application can be seen.

It is recommended to apply a minimum of 2 Magnet applications under a knockdown strategy, since a spike in moth numbers will often persist longer than the Magnet effective period (4 to 6 days), Depending on pest pressure and Magnet residual performance, it is recommended to apply a second and subsequent Magnet applications at 5 to 7 days after the previous application to ensure continuity of control. In general smaller areas (<200 ha) will require a shorter interval between applications due to the higher likelihood of reinfestation occurring quickly from surrounding areas.

Knockdown Strategy - Summary

- Apply immediately when an increase in moth numbers, or a nearby spike in egg lay occurs
- Apply at a rate of 1 Magnet strip every 72 metres
- Apply a minimum of two applications at a 5 to 7 day interval

Figure 13 *Helicoverpa armigera* moth feeding on a Magnet deposit

Mixing Magnet

Magnet Insect Attractant Technology requires the addition of a small proportion of water, and also addition of an insecticide (see product label). The small amount of water required is to allow rinsing of the empty Magnet drum and addition of the rinsate to the spray tank. The insecticide is the toxicant that provides the "kill" when moths feed on Magnet deposits.

Pour the required quantity of Magnet into the spray tank. One litre of water is required to be added to every 10 litres of Magnet. Rinsings from the empty Magnet container can be used for this purpose. A 200 L drum of Magnet will make 220 litres of Magnet Mixture (200 litres of Magnet + 20 litres of water from rinsing), and the 220 litres of Magnet Mixture is sufficient to treat 317 hectares at the general rate (158 hectares at the high rate). **Important:** To maximise user safety, when applying by ground rig use this Magnet Mixture to calibrate the nozzle prior to adding the insecticide. The mixture used to calibrate the nozzle should be returned to the mixing vat.

After calibrating the nozzle, add the required amount of insecticide as specified in the Insecticide List on the product label and mix thoroughly. The mixture should be agitated during mixing and application to avoid settling of any components. The product should be applied as soon after mixing as possible.

Applying Magnet (refer also to Page 4)

General Guidelines

The Magnet + insecticide Mixture (see above) should be applied in narrow strips on the crop at a rate of 500 mL (of Magnet Mixture) per 100 metres. The Magnet strips should be between 20 and 100 cm, depending on the application method, and strips should be applied at 144 (pre-emptive rate) or 72 (knockdown rate) metre spacings. Deposits of Magnet will be apparent on the plant surface for a number of days after application. Some localised leaf damage may be noticed around Magnet deposits, but this effect is transient and will have a negligible impact on the overall health of the treated plants.

Magnet can be applied by ground or aerial application and instructions for each are provided overleaf. Remember that Magnet is ideally applied in the late afternoon and that large deposits on the crop will provide the best results (*Figures 4 and 5*).

Aerial Application

Aerial application is a highly effective application method for Magnet in cotton. Application by air can be used once canopy closure has reached about 50%. Prior to full canopy closure, Magnet is ideally applied perpendicular to the direction of the rows to maximise the amount of Magnet depositing on the crop. For boom set-up, see *Figure 14* and *Figure 15* below. Use one nozzle positioned midway along the wing of the aircraft where minimum turbulence is experienced. It is recommended to use stainless steel 3/8 inch tubing attached to a CP nozzle body diaphragm (or equivalent), so the Magnet Mixture is delivered in thick streams. The end of the tube should be horizontal to the ground (outlet facing toward the rear of the aircraft) in order to minimise shattering.

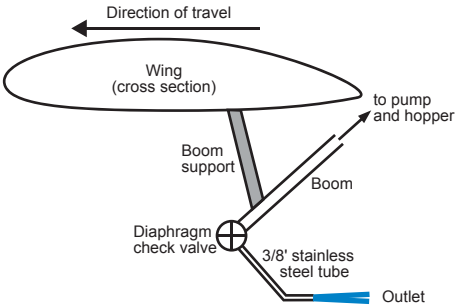

Figure 14 Schematic diagram for Magnet boom setup on an aircraft

Figure 15 Magnet boom setup on an aircraft

Ground Application

A dedicated Magnet line and nozzle is recommended to achieve coarse deposits and minimise wastage. Only one nozzle is required to apply Magnet - a recommended nozzle type is shown in *Figure 16*. Magnet application by ground can be done as a separate operation, or in conjunction with other operations (such as herbicide and insecticide sprays and inter-row cultivation) by mounting a separate Magnet spray setup to the rig. A Magnet applicator can be constructed with tanks, pumps and lines available off the shelf or alternatively, many assembled quad-bike spray tanks are sufficient to perform the task (check pump capacity).

Figure 16 StreamJet nozzle - suitable for applying Magnet by ground rig (2/3 actual size)

For ground application in cotton, the nozzle should be positioned directly over a crop row at a height ensuring the mixture is deposited on the crop and not on the surrounding soil. For operator ease, and to minimise inaccurate application due to boom movement, it is recommended to position the Magnet nozzle close to the centre of the tractor or spray rig.

Figure 17 Magnet ground application using a customised ag bike

Mixing and Applying Magnet - Summary

- Mix Magnet + water (for rinsing drum) + insecticide (see label)
- Apply in narrow (<1 m) strips on the crop at a rate of 500 mL per 100 metres
- Spacing of Magnet strips at 72 m (k'down strategy) or 144 m (pre-emptive)
- Apply by ground rig or by air after 50% canopy closure
- Apply in course droplets

Magnet and User Safety

IMPORTANT: Read the safety directions on the Magnet label before use and the relevant insecticide label before mixing with Magnet.

Magnet Volatiles

Magnet Insect Attractant Technology has been formulated to maximise user safety. The volatile blend is at a relatively low concentration and the other formulation components are harmless. The volatile compounds exhibit very low toxicity (they are approved for use in food as flavouring agents), however it is still important to treat the product carefully as these compounds can cause skin sensitisation and skin and eye irritation. It is also important to avoid inhaling the volatiles.

Due to the potential to cause irritation and alergic disorders with repeat exposure, when opening and mixing Magnet it is important to wear appropriate personal protective equipment. This includes wearing cotton overalls buttoned to the neck and wrist and a washable hat, and elbow-length gloves. Avoid inhaling the vapour and spray mist during mixing and application.

Magnet and User Safety (cont...)

Magnet plus Insecticide

While Magnet itself is a low risk product, preparation of the Magnet Mixture substantially increases user risk due to the addition of the insecticide. Magnet application by ground should be calibrated prior to the addition of the insecticide to reduce the risk of exposure. It is important to read the relevant safety and other directions on the insecticide label prior to opening the insecticide container to ensure appropriate safety measures are employed.

Re-entry Period

(Extract from the Magnet product label)

Avoid entering Magnet (plus insecticide) treated rows until 1 day after application. Entry to other (untreated) rows can be made immediately after treatment. Avoid entering treated rows up to 3 days after application when the Magnet deposits are moist from dew, light rainfall or high humidity. When prior entry is necessary, wear overalls buttoned to the neck and wrist (or equivalent clothing) and chemical resistant gloves. Clothing must be laundered after each day's use. Magnet treated rows are distinguished by the blue dye used in the product. It is also recommended to mark treated rows with a peg to identify them. Re-entry periods that have been recommended for pesticides to be used in combination with this product must be observed following use.

Contact Details

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Under licence from the Cotton Catchment Communities CRC

Always read the product label prior to using

Magnet Insect Attractant Technology

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