GENERAL PRINCIPLES OF CODLING MOTH CONTROL

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Development of IFP codling moth thresholds pre-dated Taiwan market access. They were never designed to keep codling moth infestation below detectable levels for a market with zero tolerance. The following principles on control are some suggested best practice guidelines for trying to keep fruit free of codling moth. Damage occurs when there is a lack of adequate crop protection. This occurs when:

- there is too much reliance on pheromone trap monitoring alone
- application intervals go beyond the expected period of product efficacy
- spray deposition is below the correct product rates and coverage required

Immigration

- Walnuts in HB are an important host crop with up to 50% nut damage
- Most codling moth adults move less than 100m if apples are present
- If oviposition sites are scarce then movement of 300m or more is possible
- Immigration of mated females results in greater damage on block edges
- Damage more often occurs in the upper parts of trees (spray coverage!)

Monitoring recommendations

- Codling moth populations are patchy within orchards – use one trap per ha
- Traps placed high in trees catch more moths than those on lower tiers
- Pheromone trap efficiency may be inadequate at low population densities
- IFP thresholds and controls are the minimum recommended measures
- More intervention is acceptable and may be needed for zero-tolerance markets
- A pre-harvest visual inspection for fruit damage in 'at risk' sites is important
- Sampling from fruit in bins at harvest gives a poor assessment of larval risk

Spray coverage

- Most insecticides used in IFP must be ingested, they do not kill on contact
- Complete coverage for complete freedom from codling moth damage
- Codling moth damage is more common in the upper tree canopy
- Application volumes should be based on tree-row-volume calculations
- Concentrate applications require greater operator care for consistent control
- Spray volumes below 800L/ha will not give effective control in 4-5m trees
- Product rates below the recommended per ha will result in poor control
- High volume 'dilute' application decrease the risk of codling moth damage

Trapping and spray timing

- Codling moth male flight requires evening temperatures above 13^{o}C
- Codling moth mating and egg laying requires temperatures above 16 ^{o}C
- Flight activity in spring is low and variable with changeable temperatures
- Low spring temperatures may reduce the efficiency of pheromone traps
- Target the first generation of codling moth – especially in Hawke's Bay
- Do not push the first recommended insecticide application envelope
- Apply first insecticide at beginning of BIOFIX + 80-110 GDD period
- Use a products with both ovicidal and larvicidal activity when possible
- 'Gaps' in insecticide cover (>14-21 days) provide 'opportunities' for larval infestation

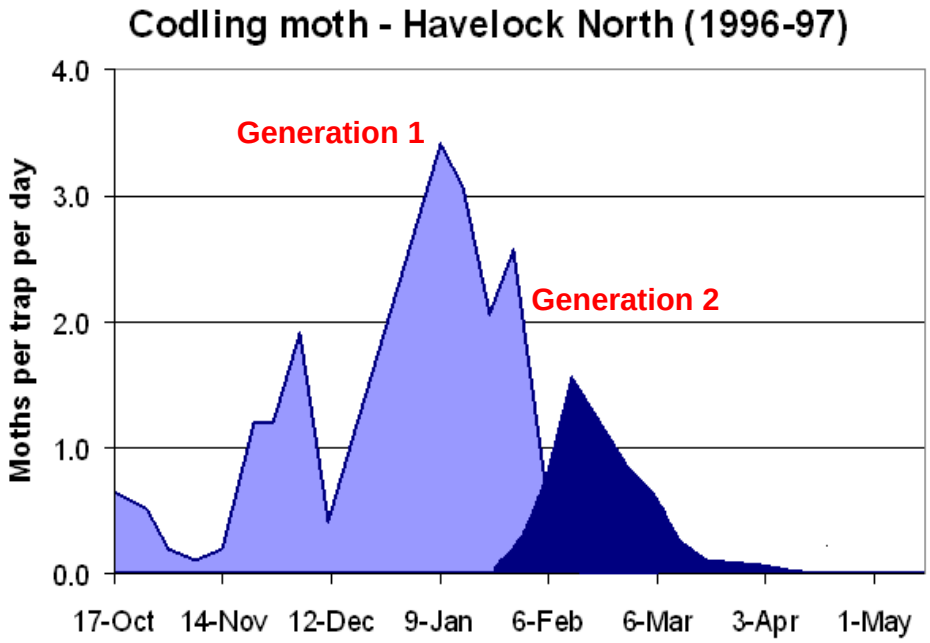
CODLING MOTH PHENOLOGY

Emergence in spring

- Adults emerge from their over-wintering cocoons over 3-4 months; maximum emergence of the 1st generation occurs in November and December in Hawke's Bay.
- The BIOFIX is the date of first sustained flight activity each season and this varies for each region: Hawke's Bay - October 7th; Nelson - October 21st; Otago - November 1st.
- Few moths from the over-wintered generation emerge after mid-January. Most mid or late summer moth activity in Hawke's Bay is associated with the second generation.

Seasonal development of codling moth

- Seasonal development of codling moth is dependent on spring and summer temperatures because it affects all stages of population development including:
  - the time of the emergence of moths from over-wintered cocoons
  - the length of time for eggs to hatch
  - the rate of development of each generation
- Moth activity occurs in most regions between mid-late October and mid-late March. In South Island regions there is typically one generation per year while in the North Island a small proportion of the population completes a second generation.



In Hawke's Bay

- there is a partial second generation of codling moth
- perhaps 10-20% of the first generation may complete a second generation
- second generation larvae are small larvae and difficult to detect during grading
- targeting the 1st generation in Hawke's Bay reduces second generation larvae

Some of the key events in the development of codling moth e.g. first egg hatch, first larvae to complete development and the first moths of the second generation, are expressed in terms of GDD (Growing Degree Days) above the development threshold temperature (10°C) from the BIOFIX date and are given in Table 1.

Table 1. Key GDD stages in the seasonal development of codling moth populations.

Development stage	GDD	Range	Activity and timeframe
Egg development (1st larvae)	88	69 - 111	1st insecticide at 70-110 GDD
Larval development	263	200 - 345	1st larvae exiting fruit at 350 GDD
Pupation to emergence	230	133 - 325	1st adults generation II at 580 GDD
Egg – Adult	580	-	Total GDD taken to complete development
One generation (egg-egg)	610	-	Gen II egg laying starts from 610 GDD

Timing your first insecticide

- Codling moth has lower and upper development thresholds of 10°C and 31°C respectively, outside this range of temperature the immature stages do not develop.
- If the daily temperatures are known, we can estimate the amount of time when the temperature is within the range for codling moth to develop and can predict when events such as egg hatch will occur.
- Your first insecticide must be applied within the 80-110 GDD window following the BIOFIX date for your region to avoid the first potential opportunity for larvae to penetrate fruit.
- Do not push the envelop for the first application, it is much better to apply this first insecticide early closer to 80GDD rather than later.
- For Taiwan we recommend that the first insecticide is applied in the green zone but must be applied no later than the yellow zone shown in the phenology model for your area. In the red zone appears it is too late, and larval entries will occur if codling moth activity is present.