PROGRAMAS DE MANEJO DE PALOMILLA PARA MEJOR CONTROL Y MENOS DISRUPTION DE ENEMIGOS NATURALES –

CODLING MOTH MANAGEMENT PROGRAMS FOR BETTER CONTROL AND LESS DISRUPTION OF NATURAL ENEMIES

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As an integrated pest management consultant in the State of Washington, I have many years of experience, with success and failure, in controlling codling moth – in my region. I believe most of the information that I use, derived from research and field experience, is transferable to conditions in the apple growing regions of Chihuahua, with some modifications. In the last 15 years in Washington, adequate codling moth control could no longer be realized in many orchards using insecticides alone, due to insecticide resistance and a general increase in codling moth populations based on factors I will discuss. Based on our experience, I consider mating disruption to be an essential part of almost any codling moth control program.

LIFE HISTORY

To control codling moth effectively we must understand it, so I will review its lifecycle briefly. It overwinters as a mature larva in crevices – bark, pruning cuts, posts, and bins that are in orchard at time larvae leave fruit. Codling moth larvae weave a silken cocoon, but do not pupate until spring. Adults begin to emerge in mid March to early April in your region, but not until mid to late April in our warmest areas in Washington. The moths mate: and they do not need to fly to mate, since the pupating larvae can be aggregated. This is important where populations are high because even when it is too cold for moths to fly, emerging males can wait for nearby females to emerge and mate. The females lay eggs, singly on leaves that are near fruit and some on fruit too (up to 25% according to one study). Egg laying can be high or low in the tree – there is no preference. Larvae can start feeding on leaves, but must soon penetrate fruit to survive. Unless the small larvae die near the fruit surface due to insecticide exposure, they soon penetrate to the core of the apple.

In Washington we historically have had two codling moth generations per year, but frequently summers are warm enough that the warmer regions experience a partial third generation. In our warmest areas in 2006, third generation egg hatch began in mid August. Where codling moth population was high enough to warrant it, effective insecticide residues would need to protect the fruit until as late as the first week of September. Late season control measures can be necessary even though many mature larvae start to go into diapause much earlier in August and do not produce a third generation.

MANAGEMENT AND MONITORING

MATING DISRUPTION

Our control program for the growing season begins with the placement of mating disruption dispensers by 1st bloom. I use the Isomate C+ dispenser, at 1000 dispensers per ha. Placement of the dispensers is often initiated as early as 1/2 " green tip stage for labor management. There is very little loss of pheromone from the dispensers during this period due to cool temperatures. Proper dispenser placement is critical: uniformly through the orchard, 50 cm to 1 m below the tree tops, above the fruit, on limbs that will not bend low with the weight of the fruit. Where trees have been replaces, I prefer doubling dispensers on adjacent tall trees than putting dispensers on very short trees.

A number of factors in the orchard influence the effectiveness of the dispensers. Orchard size, shape, and topography are important. Winds that occur in the evening can reduce the pheromone concentration on the upwind portion of the orchard. The larger the contiguous orchard area treated, the better the disruption.

Although in some orchards or portions of orchards, mating disruption can be a stand-alone codling moth control program, it often must be supplemented with insecticides for codling moth. However in almost all cases, mating disruption will reduce the number of sprays needed, and consequently reduce the harmful impact on natural enemies that control mites, woolly apple aphid and other secondary pests. It is helpful to think of the effectiveness of mating disruption as a "numbers game", that is, the higher the population of codling moth, the more help will be needed from other control tactics.

MONITORING

Effective control programs for codling moth are built on the foundation of a high quality monitoring program. Knowing where your enemy – the codling moth - is in your orchard and estimating how severe it is, will always give you a much better chance at defeating it. Trapping for adults is the centerpiece of this program. It is critical for traps to be placed in the orchard before anticipated first moth flight, so, by early to full bloom. The Delta style trap is currently the best trap to use, it catches about twice as many moths as the old wing style trap. Place one trap per hectare. In some very large orchards growers use a density of one trap per 2 ha, but this should not be attempted unless the distribution of codling moth through the orchard is well known. Data suggests that the 1 per ha density is not even optimum, in a mating disrupted orchard. Use a grid to place traps, but also focus on borders and areas in orchard of historical high concentration of damage. Proper placement and maintenance essential: upper part of tree, not blocked by foliage, at least 2 m away from mating disruption dispensers. Place on a limb that won't bend. Change lures at the proper intervals and maintain sticky trap floors.

Lure types – use a standard 1X pheromone lure in conventional orchards, but use 10X lure in mating disruption orchards. In these orchards, the red lure must be changed every 3 weeks in spring and every 2 weeks in summer. If available, use a long life lure. Long life lures have more consistent attractancy than red septa lures, as well as lasting 6 – 8 weeks.

Check traps every 2 – 3 days to determine biofix. There is some argument about what event should be used to initiate the degree day model. Some entomologists insist on using the first moth captured while others wait for a consistent catch. Where populations are very low, consistent catch can be difficult to determine. We often use information from a neighboring orchard.

Check traps at least once per week after biofix date is determined. Change lures at proper intervals. Dispose of spent lures outside of orchard.
When using traps to determine the need to treat, I use treatment thresholds of 4 moths 1st generation, 2 moths 2nd and 3rd generations. Some consultants use 2 moths as the threshold for both generations. These represent accumulations of moths in a single trap over a period of 2 – 3 weeks.

The use of the codling moth model for determining insecticide timing necessitates accurate temperature data. If you don't have a temperature monitoring station in your orchard, you should attempt to validate that whatever station's data you use is fairly similar to your site.

I supplement trap monitoring with visual searches for fruit damage beginning in earnest at about 300 DD (C) which corresponds to about 75% egg hatch of the first generation. This will give an indication of any areas of the orchard where control has been inadequate and needs to be intensified in the second generation. Damage is most likely to be found in the upper part of the trees, at orchard borders and at the top of slopes. If my traps have not caught moths in an area where I subsequently find infested fruit, then I may move a trap or add a trap in that area.

INSECTICIDE PROGRAMS TO SUPPLEMENT MATING DISRUPTION
On 90 – 95 % of the acreage under mating disruption, we still apply supplemental insecticides for codling moth, usually targeted at the first generation, in an effort to reduce populations early in the season. Effectiveness, conservation of natural enemies and management of insecticide resistance are the paramount concerns, as well as keeping costs down. If the latter is the only concern, codling moth populations will increase.

Recently, more insecticide options have become available for codling moth, both larvicides and ovicides. However, although human safety is vastly improved with the new insecticides, their effects on natural enemies are not necessarily benign. A list follows of materials and whether they are used for codling moth in our industry:

Use	Don't use	Don't use because no longer legal in U.S.A.
Horticultural Mineral Oil CM virus IGRs: pyriproxyfen methoxyfenozide novaluron* Neo-nicotinoids: acetamiprid*	Pyrethroids (too disruptive – for abandoned orchards only) Carbaryl Tebunfenozide (not very effective)	Chlorpyrifos Methyl parathion

thiacloprid (Calypso)* OP's: Azinphos-methyl Phosmet Spinosad		

* use with great caution: toxic to natural enemies

A recently developed and very effective insecticide strategy begins with an ovicide (horticultural oil, pyriproxyfen or methoxyfenozide) applied at 50 – 100 DD (C); (110 DD if applying oil). With this application, egg hatch is delayed by at least 90 DD and possibly as much as 140 DD. In most situations, as long as intense rains or hail do not wash off insecticides, waiting to make the next application at 200 DD rather than our old standard of azinphos-methyl at 140 DD is proving to be very effective. 200 DD, I believe, was the standard timing for azinphos in Chihuahua state until codling moth populations increased in the last ten years.

The action of ovicides is as follows. Eggs are laid on leaves or fruit. Oil sprayed on top of eggs (topically) prevents oxygen from reaching the developing embryo. In the case of insect growth regulators (pyriproxyfen, methoxyfenozide, novaluron, tebufenozide), they prevent the embryo from developing normally. They are effective both underneath (residual), before the egg is deposited and topically, allowing greater flexibility of use. Neonicotinyls are used against hatching larvae, but do have some ovicidal effect topically. The mechanism is not understood.

The newer larvicides for codling moth vary in effectiveness and effect on natural enemies and spider mite populations. Neonicotinyls are being used as organophosphate replacements in our industry, but they are presenting significant impacts on integrated mite management. Acetamiprid, in particular, frequently causes mite outbreaks, thiacloprid less so. Rather than killing the predatory mites, it appears to stimulate reproduction in spider mites.

Of the insect growth regulators, methoxyfenozide and novaluron have both ovicidal and larvicidal properties. Novaluron is a stronger codling moth material, but it appears to be quite lethal to many predators, and we are seeing outbreaks of green apple aphid for the first time in years, following novaluron applications. One could expect similar effects on woolly apple aphid biological control. There is little data supporting an adverse effect on predatory mites, however. For this reason, and due to its high cost, I am avoiding the use of novaluron, preferring methoxyfenozide, which has not shown obvious disruption of natural enemies in the field.

Where codling moth pressure is not excessive, codling moth granulosis virus is an excellent addition to a codling moth program. We have been able to rescue organic orchards in the last few years following the registration of these products and of an organically approved formulation of spinosad.

In very infested orchards, where azinphos-methyl has failed due to over tree impact sprinklers used for irrigation and cooling of fruit I have had excellent success with a combination of methoxyfenozide and acetamiprid timed at the period of peak egg hatch beginning at 200 DD in the first generation and 750 DD in the second generation. The two-pronged approach with an ovicide plus a larvicide – two modes of action against the pest – is highly effective, and has a long residual control period – at least 18 days. This approach, again, provides effective insecticide residues during period of highest rate of egg hatch as well as reducing the number of trips through the orchard.

CALIBRATION AND COVERAGE

Importance of coverage: proper calibration, tractor speed, penetration throughout canopy cannot be underestimated and always bears repeating. All the new post-organophosphate insecticides require that the larva crawl over or ingest them, depending on the material; I previously discussed the action of the ovicides. A tractor speed of over 1.5 – 2 miles per hour simply will not allow the spray fan to carry the spray to all parts of the canopy. I do not advocate spraying only alternate rows either. Of course, pruning the trees to allow good spray penetration is also critical. A corrective pruning job has been the only way to achieve adequate codling moth control in many an orchard.