New Insecticides and Miticides for Apple and Pear IPM

WSU-TFREC Tree Fruit IPM Workshops – February 2002

I. Chloronicotinyls

A. **Provado** (imidacloprid) – Provado is the first registered compound of a relatively new class of insecticides (*chloronicotinyls* or *neonicotinoids*) that are synthetic analogs of nicotine. Provado, and other chloronicotinyls, act in the nerve synapse like nicotine acetylcholine. In tree fruits it is generally used as a systemic insecticide and stomach poison. It does have contact insecticidal properties, however the residue is relatively short-lived in the environment. Instead, it is absorbed into leaves, where is can have a long effective residue. Provado is relatively safe for mammals.

1. Lepidopteran pests
   Codling moth – Provado has very little activity against codling moth.
   Leafrollers – We have not evaluated Provado against leafrollers but do not expect it to have any activity against this pest.
   Lacanobia fruitworm – We have had one test with Provado against lacanobia fruitworm and it provided no suppression of the larval population and no reduction in fruit damage.

2. Indirect/secondary pests
   This is primarily used as an *aphicide* in Washington, but also will provide adequate suppression of *leafminers* in some circumstances. Good toxicity to *white apple leafhopper*. Somewhat toxic to *campylomma*, but cannot be used during the critical period for prevention of damage (bloom). No apparent direct effect on *mites*, but it has been associated with an increase in mite populations (possibly by hormoligosis or mediated by effects on predatory mites). This effect is not consistent; risk of mite perturbation is low to moderate.

3. Pear pests
   The use of Provado is an important control tactic for control of both *pear psylla* and *grape mealybug* in pear (as well as grape mealybug in apple). Provado is effective against the early instars of both of these pests (first and second instars of pear psylla, 'soft-shell', and second and third instars of grape mealybug, 'crawlers'). Effectiveness against older instars of these pests is greatly reduced, and there is relatively little activity against adults. Using oil as an adjuvant to Provado has been demonstrated to increase mortality of pear psylla and grape mealybug.

   Provado is only registered for post-bloom use in both pear and apple. Thus, in order to use it effectively early in the season for both pear psylla and grape mealybug control, applications should be applied as soon after petal fall as

possible (once bees are out of the orchard). This petal fall timing has proven to be particularly effective during growing seasons with relatively mild winters, when bloom comes relatively early. In more 'normal' years, an application of Provado at petal fall can be too late to have maximum effectiveness against grape mealybug; observations of 'crawlers' should be made before the spray is applied.

The summer generation of grape mealybug, as well as summer generations of pear psylla, can be controlled using Provado as well. However, the effectiveness of the material is reduced relative to the early season applications. Additionally, Provado has a negative effect on the beneficial mirid bug campylomma (a pest in apple). Campylomma is an important pear psylla predator.

B. **Actara** (thiamethoxam) – Actara is a closely related compound to Provado. It received registration in June 2001. Its activity and use is much the same as Provado, with the same target pests and 'transtemic' activity.

1. Lepidopteran pests
   Codling moth – We have not tested Actara agaisnt codling moth. It is not expected to have activity against any Lepidoptera.
   Leafrollers – See comments under codling moth.
   Lacanobia fruitworm – See comments under codling moth.

2. Indirect/secondary pests
   Two year's tests on *campylomma* have demonstrated good efficacy against this pest, even though it cannot be used during bloom (pink would be the preferred timing). Effective against the *green aphid* complex, some suppression of *woolly apple aphid* and *rosy apple aphid* (limited data). No evidence for useful activity against *leafminer* so far. Good *leafhopper* material. Some slight increase in *mite* populations was noted, but only at rates and application frequencies higher than the label allows. No apparent direct toxicity to predatory mites, thus overall risk of mite perturbation is currently rated low.

3. Pear pests
   Actara has much the same activity against *pear psylla* and *grape mealybug* as Provado. Like Provado, Actara is effective against the early instars of both of these pests (first and second instars of pear psylla, 'soft-shell', and second and third instars of grape mealybug, 'crawlers'). Effectiveness against older instars of these pests is greatly reduced, and there is relatively little activity against adults. Using oil as an adjuvant to Actara has been demonstrated to increase mortality of pear psylla and grape mealybug.

Actara, unlike Provado, is registered for prebloom use in pear. It should not be applied later than clusterbud when used prebloom, to avoid any potential for effects on bees. The clusterbud timing is very effective in controlling both pear psylla and grape mealybug. In typical years, this period is when peak pear psylla egg hatch is occurring, and the age distribution is limited to first and second instar nymphs, as well as adults and eggs. Actara applications will cause mortality to the nymphs, and residual activity will continue to control hatching eggs. This period is also when grape mealybug have peak emergence from egg masses. Actara is very effective against the second instar crawlers that become exposed at this time.

Actara can also be effective in petal fall applications, as with Provado, provided the pear psylla and grape mealybug are of the appropriate stage. Actara is equal in efficacy to Provado when used against summer generations of both pear psylla and grape mealybug. Oil is an effective adjuvant for Actara. Summer applications of Actara have negative effects on the biocontrol agent campylomma; care should be taken to avoid impacting populations of this important beneficial.

C. **Assail** (acetimiprid) - Assail and Calypso are new insecticides in the same class as Provado (imidacloprid). Both act as nerve toxins but have a high degree of selectivity for mammals, that is, they are of low toxicity to mammals (oral LD_{50} (rat) 1,107/944 mg/kg (m/f) = toxicity category III). Assail is expected to be registered for use on apple in the first half of 2002 but there is always uncertainty associated with registration of new products. Calypso is not expected to have registration for at least two years. Both products are discussed together as they have similar action against pests.

1. Lepidopteran pests

Codling moth – Assail has performed very well against codling moth. In large replicated block tests in 2000 and 2001 Assail applied at the same timing interval as Guthion or Imidan, 2 applications per generation starting at egg hatch, provided codling moth control similar to these well-known industry standards. In the small plot test where treatments were applied by a handgun sprayer, Assail was statistically as good as Imidan or Guthion in preventing fruit injury. In a large plot test applied by an orchard air-blast sprayer Assail did not perform quite as well as Imidan. All of the tests at the research center are conducted under very high pest pressure so the minor differences in efficacy we observed between Assail and Guthion or Imidan would probably not be evident in commercial orchards where codling moth pressures are much lower. One problem we have noted with Assail is its negative impact on integrated mite management.

Leafrollers – We have not tested Assail in the field against leafrollers. We have, however, conducted laboratory bioassays to assess the relative toxicity of these products to leafroller larvae. In these tests we find that the LC_{50} of

Assail, the concentration of product that kills 50% of first instar larvae, is high relative to the proposed concentration used in the field. For example, the LC_{50} for Assail is 107 while the recommended field concentration is 44 ppm. Even the field concentration would not be expected to kill even half of the first stage larvae so the possibility that Assail would be effective against leafrollers is nil.

Lacanobia fruitworm – We have not tested Assail in the field against lacanobia fruitworm; however, we have conducted bioassays similar to those described above for leafrollers. The LC_{50} for Assail against first instar lacanobia larvae was 44 ppm, the same concentration as the field rate would provide in a dilute spray.

2. Indirect/secondary pests

   Given the efficacy against codling moth, this material is more likely to be used in multiple application programs (label restrictions unknown); however, both a 2- and a 4-spray program have caused detectable *mite* flareups, some quite severe. At least some of this effect is attributable to a deleterious effect on predatory mites. This effect has been quite consistent, thus risk of mite perturbation is rated high. Reducing the number of applications/season, or altering the timing may be helpful. Activity against *leafhopper* is good. Limited data suggests good *green aphid* complex activity. Preliminary evidence suggests good potential as a *campylomma* material, especially if the label will allow bloom applications. No information on *leafminers*.

3. Pear pests

   Assail has much the same activity as Actara and Provado for *pear psylla* and *grape mealybug*. Like Actara, it is relatively safe for bees, and can be used before bloom at the optimal timing for controlling both pear psylla and grape mealybug. Summer activity of Assail against these pests is also comparable to Actara and Provado, with the same positive effects of adding oil as an adjuvant, and the same negative effects on campylomma.

   Assail differs from Actara and Provado in that it also is effective against codling moth. Assail controlled high populations of this pest in pear when applied at the standard codling moth timings for Guthion. Assail appears to have potential to become a viable alternative to Guthion for codling moth control in pear. However, because of resistance management concerns, it should be viewed primarily as a control for pear psylla and grape mealybug. With the current alternatives available for codling moth control (mating disruption, insect growth regulators), chloronicotinyls such as Assail should not be used when they would select for resistance in pear psylla, yet not be particularly effective in controlling codling moth.

D. **Calpyso** (thiacloprid)

1. Lepidopteran pests

   Codling moth – Calypso does not appear to have a high degree of activity against codling moth. In a trials conducted in 2000, Calypso applied 6 times (3 per generation) did not provide as good of codling moth control as Guthion that was applied 4 times (2 times per generation). Calypso provided control equal to Guthion in a test in 2001; however, to achieve this level of control, Calypso was applied twice as often as Guthion, 8 versus 4 applications per season. It is unlikely that growers will be willing to apply or pay for the number of applications of Calypso required to achieve codling moth control.

   Leafrollers – We have not tested Calypso in the field against leafrollers. As with Assail we have conducted laboratory bioassays to assess the relative toxicity of this product to leafroller larvae. In these tests we find that the LC_{50} of Calypso was 57 ppm while the recommended field concentration of Calypso is 45 ppm. Even the field concentration would not be expected to kill even half the first stage larvae so the possibility that Calypso would be effective against leafrollers is nil.

   Lacanobia fruitworm – We have not tested Calypso in the field against lacanobia fruitworm. The registrant for Calypso did not think, based on their studies in other crops, that it would be effective against an insect like lacanobia fruitworm so we did not even attempt any screening studies.

2. Indirect/secondary pests

   Good *leafhopper* material. Definite campylomma activity, but perhaps not as strong as Assail (?). Preliminary test demonstrates some perturbation of integrated *mite* control, both through effects on phytophagous and predatory mites. Risk is currently rated as moderate (depending on use pattern). No data on other indirect pests.

3. Pear pests

   Calypso is effective against *pear psylla* and *grape mealybug*, like Actara, Provado, and Assail, and also can be used for codling moth control, like Assail. Calypso will likely have a registration for prebloom use, like Assail and Actara. Calypso has been shown in field tests to control high densities of pear psylla in prebloom, petal fall, and summer applications, much the same as the other chloronicotinyls. In field tests against grape mealybug, at all appropriate timings, Calypso also significantly reduced the populations, but not to the same degree as the other three chloronicotinyls. Pest mortality was increased when oil was added to Calypso applications, and Calypso appears to have the same negative effects against campylomma as the other chloronicotinyls.

   In field trials against codling moth, Calypso successfully controlled high populations of codling moth, comparable to both Guthion and Assail. However, use of this material against codling moth in pear comes with the

same caveats as with Assail; it may be more important to direct this class of insecticides at pear psylla rather than codling moth, where there are numerous effective alternatives.

II. Insect Growth Regulators (IGRs)

A. **Intrepid** (methoxyfenozide) - Intrepid (and Confirm) acts to initiate a premature lethal molt in caterpillars. It is lethal because the insect is not able to complete the molt and dies within the old skin that it cannot shed. In some cases Intrepid will not kill the larva but the subsequent adult will not be able to reproduce. Intrepid has little or no contact activity and must be ingested by larvae to have a toxic effect. Intrepid has strong ovicidal activity that is mediated by egg contact with residues. Intrepid has the advantage over some older insecticides in having a short REI (4 hours) and PHI (14 days).

1. Lepidopteran pests

Codling moth – Experience with Intrepid as a codling moth control has primarily been to target young larvae before they can enter the apple. The Environmental Protection Agency (EPA) considers Intrepid an organophosphate replacement (OP replacement). However, this product is not a simple replacement for Guthion. It does not provide the same amount of crop protection as Guthion or Imidan under the same use pattern. To achieve control of codling moth approaching that achieved by Guthion or Imidan requires one additional application of Intrepid in each generation. In a recent test we found more damage when Intrepid was used at the more traditional "hatch" timing than when it was used at the "oviposition" timing. These data confirm our studies in the laboratory where we are examining the ovicidal activity of Intrepid. If the ovicidal timing of Intrepid is as good or better than the egg hatch timing it opens a new strategy for using this product. Because Intrepid also has good activity against leafrollers its use in the petal fall period could simultaneously control codling moth and leafroller. Intrepid should not be considered a "stand alone" control for codling moth except where very low pressures are present. It has its best fit as a component of a pheromone-based IPM program where it is integrated with the use of codling moth mating disruption. There is some concern based on experiences in California, Canada and France that Intrepid use might encounter codling moth populations that are resistant due to OP mediated cross-resistance.

Leafrollers – Intrepid has good efficacy against leafrollers. In our laboratory bioassays that compare relative toxicity of products Intrepid is 10 to 20 times more active than Confirm against leafrollers. Intrepid has primarily been evaluated at its full field rate against leafrollers; however, it is likely that reduced rates will also be effective and future research will focus on determining the efficacy of lower rates. Intrepid is effective against leafrollers in the spring from bloom to about 14 days after petal fall. One application of Intrepid can be effective against low leafroller densities but a second application might prove necessary against high populations. In the spring

Intrepid should be used when weather forecasts for warm conditions, 65°F or better for 3 days at least, in order to insure active feeding by larvae. Intrepid has a long residual activity so is not as subject to the vagaries of weather on efficacy as are Bt products. Intrepid is also effective against leafroller larvae in the summer and the best timing is when larvae are young. When applied at 20% egg hatch of leafroller Intrepid provided excellent control, comparable to Success in most tests. Intrepid has a long residual activity but has no contact activity. Therefore, Intrepid must be applied with good coverage but it is not necessary to use dilute sprays. We have some concern that leafroller populations show a high degree of variability of susceptibility to Intrepid and this variability seems directly related to the OP resistance in the same populations. This could mean that the genetic basis for resistance to Intrepid exists in some leafroller populations in WA. Good product stewardship should be used including switching between products with different modes-of-action as part of a resistance management program.
Lacanobia fruitworm – Intrepid is very effective against the lacanobia fruitworm. This insect is a fairly new pest in WA. It has two generations per year and can cause severe fruit damage when the grower is not aware of its presence. We have developed a degree-day model that should be very useful for timing sprays against the lacanobia fruitworm. The best timing of Intrepid against this insect is when about 80% of eggs have hatched, prior to the presence of large larvae. A single application seems adequate to control this pest and it is very likely reduced rates will be as effective as the full field rate. Our research in 2002 will focus on this possibility. Experience in the Areawide II project in 2001 showed that lacanobia fruitworm densities were suppressed in orchards that used Intrepid in multiple applications against codling moth. These timings overlapped with the optimal timing for lacanobia fruitworm providing control of both pests at the same time.

2. Indirect/secondary pests
   No known effect on *campylomma, leafhoppers, aphids, mites* (either phytophagous or predatory), none expected. Suppression to control of *leafminer* depending on timing; better success has been achieved where it has been used in codling moth programs than in single-application leafminer timings (although suppression may be sufficient in some cases)

3. Pear pests
   Intrepid has been tested against *codling moth* in pear, and appears to work effectively against moderate to low populations. At low densities, Intrepid was comparable with Guthion treatments. However, when challenged with very high codling moth populations, Intrepid treatments sustained significant damage. Intrepid does not affect pear psylla or grape mealybug. We do not have enough research data on Intrepid effects on *leafrollers* in pear to reach any conclusions on its effectiveness.

B. **Confirm** (tebufenozide) – See discussion under Intrepid (methoxyfenozide). Confirm has a much lower ovicidal activity compared to Intrepid. It is likely that Confirm will be withdrawn from the fruit market leaving only Intrepid available.

1. Lepidopteran pests

   Codling moth – We have had several years of experience with Confirm as a codling moth control. It was the first insecticide identified by the EPA as a "safer pesticide" and targeted for expedited registration as a potential OP replacement. Confirm does not provide nearly the same level of crop protection as Guthion or Imidan, even when applied at more frequent intervals. Our experience has shown little difference in efficacy in the timing or even rates of Confirm used against codling moth. Coverage, especially dilute sprays, seemed to be a key to achieving best control. Confirm has only a weak ovicidal activity on codling moth. Confirm should never be considered a "stand alone" control for codling moth. It has its best fit as a component of a pheromone-based IPM program where it is integrated with the use of codling moth mating disruption.

   Leafrollers – Conifrm has efficacy against leafrollers but not as good as Intrepid. Confirm is effective against leafrollers in the spring from bloom to about 14 days after petal fall. One application of Confirm can be effective against low leafroller densities but two applications are necessary against moderate to high populations. Confirm is also effective against leafroller larvae in the summer and the best timing is when larvae are young. When applied at 20% egg hatch of leafroller Intrepid provided good control. Like Intrepid, Confirm has a long residual activity but has no contact activity. Therefore Confirm must be applied with good coverage but it is not necessary to use dilute sprays.

   Lacanobia fruitworm – Confirm is very effective against the lacanobia fruitworm. Comments above for Intrepid apply equally well to Confirm.

2. Indirect/secondary pests

   No known effect on *campylomma, leafhoppers, aphids, mites* (either phytophagous or predatory), none expected. Probable suppression of *leafminer* similar to Intrepid but probably not as strong.

3. Pear pests

   Confirm has been tested against *codling moth* in pear, and appears to work effectively only against low populations. Even at low codling moth densities, however, Confirm treatments sustained significant injury. Confirm may provide acceptable control of low to moderate codling moth densities in pear when used in conjunction with other control tactics, such as mating disruption. Confirm does not effect pear psylla or grape mealybug. We do not have enough research data on Confirm effects on *leafrollers* in pear to reach any conclusions on its effectiveness.

C. **Esteem** (pyriproxyfen) - This insect growth regulator functions as a juvenile hormone mimic. It can be a highly selective insecticide providing control of leafroller and codling moth (not lacanobia fruitworm) without disrupting activities of biological control agents. Esteem has low toxicity to mammals and has a short worker reentry period (REI), 12 hours, but a long pre-harvest period (PHI), 45 days. Esteem is limited to two applications per season and the total amount of active ingredient per acre is also limited to 98 grams (3.45 ounces).

1. Lepidopteran pests

   Codling moth – Esteem has activity against the codling moth egg, acting as an ovicide. We have limited experience with Esteem as a codling moth control material in WA. It has activity when the codling moth egg is deposited on the Esteem residue. Therefore, applications made against the first codling moth generation should be applied as soon as possible after moths start flying. In most situations a second application of Esteem should be made 14 to 21 days following the first. This approach provides active Esteem residues during most of the egg laying period of codling moth. Esteem is not considered to be a strong codling moth control tool. It should be used in a pest management program that includes codling moth mating disruption. It can be a very useful tool in this kind of program because applications made against codling moth will also provide suppression of leafrollers.

   Leafrollers – Esteem seems to work equally well against the pandemis or obliquebanded leafroller; however, experience against the latter species in WA is limited. Esteem is thought to act primarily against the last larval stage of leafrollers, though it could have activity against leafroller eggs. The effect against the leafroller egg stage has not been evaluated in WA. Both pandemis and obliquebanded leafroller larvae reach the last larval stage shortly after petal fall which makes this the best time to apply Esteem. Esteem must be consumed by the leafroller larva to have any effect, therefore good coverage is very important. Once consumed by the leafroller larvae Esteem acts to disrupt the normal transition from larva to pupa or, in some cases, pupa to adult. Esteem efficacy against leafrollers is difficult to assess because the larvae do not immediately die and deformed larval-pupal intermediates or pupae that do not produce adults are difficult to locate. It is necessary to monitor the leafroller generation following the one treated to see the effect of the Esteem treatment. When we applied Esteem against the overwintering generation of leafroller we found no leafroller larvae in the treated areas in July while the untreated area had a relatively high leafroller larval population. The conclusion was that the Esteem treatment had prevented the successful development of leafrollers resulting in no larvae present the following generation.

   Lacanobia fruitworm – We have no information on the efficacy of Esteem against lacanobia fruitworm. Because use of this product is probably going to be limited to the early season it probably does not have a fit for lacanobia fruitworm control. It is possible that applications made against codling moth

or leafroller in early June could have a negative impact on young larvae that appear in mid-June but there is currently no evidence to support this.

2. Indirect/secondary pests
   Appears to be an effective *San Jose scale* material; untested against other indirect pests.

3. Pear pests
   In addition to being an effective management tool for control of *codling moth* in pear (as in apple), Esteem works well against *pear psylla*. Its juvenile hormone mimic activity affects the insect much the same as Comply did (fenoxycarb, used under Section 18 Petition for Emergency Exemption from Registration for pear psylla control from 1994-1997). Esteem has been shown to act on eggs and first through third instar nymphs, and may have sublethal effects on later instars ('hardshells') and adults as well. The first generation of pear psylla is the best target for Esteem applications, as the life stage distribution is the most synchronized at this time. The use of delayed dormant oils, sulfurs, Thiodan, and Surround greatly enhance this synchrony, further increasing the effectiveness of Esteem. Applications against the first generation can be made from delayed dormant (targeting early eggs) through 2 weeks post-petal fall (targeting third instar nymphs). The optimal timing, however, is from clusterbud to petal fall, when there is peak egg hatch. Results with Esteem have been variable, in some cases being able to control high populations while in others not controlling low populations. This may be a result of a predisposition of some orchards to resistance. Orchards with some degree of developing resistance to Comply may have reduced control effectiveness with Esteem. The spacial distribution and degree of this resistance trait has not yet been determined. Esteem does not appear to have significant effects against *grape mealybug*, and is soft on beneficials.

D. **Dimilin** (diflubenzuron) – This insecticide is being proposed for control of pests on pear only and will likely not have a label on apple. Therefore results obtained from apple that might apply to control of the pest on pear are not provided as a recommendation for this products use on apple.

1. Lepidopteran pests
   Codling moth – Dimilin does have activity against the codling moth egg. When Dimilin is applied at the beginning of the egg-laying period it will disrupt normal egg development. To obtain adequate control two applications of Dimilin will be required. In apple Dimilin has not provided the same degree of control as products like Guthion or Imidan but in pear Dimilin seems to work better, in part because young pear fruit have a natural resistance to codling moth. The limitations on Dimilin will likely mean it will only be used against the first generation.

Leafrollers – Dimilin has not been evaluated as a possible control for leafrollers.
Lacanobia fruitworm – We have not tested Dimilin against lacanobia fruitworm.

2. Indirect/secondary pests
No known effect on *mites, aphids, campylomma, scale, or leafhopper*; when originally tested it was quite effective on *leafminer*, but this diminished over the course of a few years (not really an issue on pears, and no projected registration on apple)

3. Pear pests
Dimilin has been tested extensively in pear for *pear psylla* and *codling moth* control for over two decades, but is still not registered. However, the tolerance was posted for comment in the Federal Register in December, so perhaps the registration is imminent. Dimilin is another selective insect growth regulator, with activity like Esteem but with a different mode of action (Dimilin inhibits chitin synthesis whereas Esteem acts as a juvenile hormone analog).

Dimilin has been shown to have moderate activity against *pear psylla*; it will control a low to moderate population. Like Esteem, Dimilin affects the eggs and early instars of pear psylla, although there are likely sublethal effects on later instars and adults. Dimilin has been found to be most effective when applied to the first generation of pear psylla, from delayed dormant through petal fall. The optimal timing to target pear psylla in a typical year is at clusterbud, where maximum effects against eggs and early nymphs would occur. When using Dimilin in a pear psylla program it is important that Thiodan, sulfurs, and oil are used at delayed dormant to help reduce the pest pressure and better synchronize the generation. Applications in the summer also can provide some degree of control; however, the level of effectiveness is decreased as more and larger instars become present in the developing populations. High rates of Dimilin (2-3 lbs/acre) are necessary to provide adequate control.

Codling moth is another target pest for Dimilin applications in pear. Dimilin has been shown to be effective against codling moth, but the level of control is lower than other available products. Dimilin should be used only against low populations of codling moth, except in situations where other control tactics such as mating disruption are being used.

Preliminary tests have also found that Dimilin causes mortality to *pear rust mite*. Future studies will be conducted to examine this when Dimilin becomes registered.

III. Miticides

A. **Acramite** (bifenazate): a hydrazine compound, recently registered for use on tree fruits, including apple, pear, peach, nectarine, plums, prunes; primarily used against motile stages, may have some ovicidal activity.

1. Apple - PHI 7 days, REI 12 hours. Acramite appears to be a specific, selective miticide, with good activity against spider mites. No rust mite activity.
2. Pear - Acramite has proven to be a very effective miticide in pear. Acramite was used in Washington and Oregon in 2001 under a Section 18 Petition for Emergency Exemption from Registration, and received Section 3 Registration in 2002. Acramite can control low to moderate populations of two-spotted spider mites, and will suppress heavy infestations. Heavy infestations, where much leaf damage and defoliation has already occurred, will require another miticide to be used with Acramite. This material is limited to one application per year in pear. This limitation will hopefully slow the first development of resistance to this compound, and maintain its usefulness in pear for the future.

B**. Secure** (extoxazole) -- primarily an ovicide, another new class of chemistry.

1. Apple - preliminary tests look good
2. Pear - Secure has proven in field tests to be a very effective material in controlling two-spotted spider mites on pear. Its activity is primarily ovicidal (like Savey and Apollo, though with a different mode of action). As such its effects in controlling mite populations are relatively slower than other compounds, and it likely will not prove to be a 'rescue' material.

C. **Envidor** (spirodiclofen) -- new class of chemistry with IGR-like activity (endocrine system disruption). Like most IGRs, expect slow activity (vs. quick knock down). Not acutely toxic to adults. Some systemic/translaminar activity, but not much. May affect some insect pests, but probably not at a useful level (not well studied in tree fruits yet). No apparent direct toxicity to leafhopper nymphs.

1. Apple - Results to date have shown promising activity; one test to a rising population indicated the slow activity (still 10-16 mites/leaf 5 days after treatment, but fine the rest of the season).
2. Pear - Envidor have been demonstrated in field tests to be an effective miticide. Its activity is much like that of Acramite and Secure, in that they all work very well, control moderate populations and suppress high populations, and will not provide 'rescue' treatments due to their relatively slow activity. Envidor will fit well with Acramite and Secure in an acaricide resistance management program, in that all three have different modes of action (and all are effective, a truly rare occurrence).

D. **Mesa** (milbemectin) - this material is similar to abamectin (Agri-Mek), with a similar spectrum of activity (mites, leafminer). Residual activity appears shorter than Agri-Mek's; cross-resistance should be a consideration.

1. Apple - tests to date have shown reasonable mite activity; motile forms are primary targets.
2. Pear - Mesa's similarity in mode of action to Agri-Mek provides it with activity against both spider mites and pear psylla. However, Mesa is only effective against spider mites at the labeled rates, and pear psylla control should not be attempted with Mesa at these rates. Mesa provides effective spider mite control. However, spider mite populations with developing resistance to Agri-Mek may not be controlled by applications of Mesa. Fortunately, Agri-Mek resistance in pear orchards is fairly limited in distribution in Washington.

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IV. Other Pesticides

A. **Success** (spinosad) - Success is a relatively new insecticide, having been registered for use on apple in 1998. The active ingredients of Success, spinosyns, are produced through a fermentation process of a microorganism, *Actinomycetes spinosa*. Success has low mammalian toxicity as reflected in its short REI, 4 hours. As with many new insecticides Success has little contact activity and must be ingested before expressing it toxicity.

1. Lepidopteran pests
   Codling moth – Success has activity against codling moth larvae. In field trials 3 applications of Success per generation provided suppression of codling moth but never to the same level as Guthion. The lack of strong activity of Success against codling moth is likely due to its shorter residual activity. We do not recommend Success as a codling moth control for two reasons. First, there are products that work better with fewer numbers of applications and would therefore be less expensive for the grower to use. Second, and more important, Success is a very good insecticide for leafroller control and we want to conserve its use in apple primarily for this purpose. Good product stewardship is important in reducing risks of resistance development in pests.
   Leafrollers – Success is a very effective insecticide for the control of leafrollers. It works well as a single spray in the spring at petal fall to control the overwintering larvae. It also works well as a summer treatment timed to coincide with the presence of early stage larvae. If populations are high it might require two applications in summer to suppress leafroller densities below damaging levels. We have had three years of use of Success in WA orchards and conducted a survey of several leafroller populations in 2001 to assess resistance. The good news was that there was no change in susceptibility in any of the populations we evaluated. However, it is important to adopt a good resistance management program and use other leafroller control products in rotation with Success as a way to retain its efficacy as long as possible.
   Lacanobia fruitworm – Success is effective against lacanobia fruitworm larvae but only against the young, first through third instar, larvae. If the

timing is late control will not be as good as could be achieved with other products. In high populations 2 applications are required to achieve adequate control.

2. Indirect/secondary pests
   Success is a good leafminer material. Slightly earlier timings than the standard one (10% tissue feeders) give best control. Control is improved by the use of an adjuvant (oil or organosilicone). Never tested on leafhopper, campylomma, scale, aphids or mites, no reason to suspect activity. No effect on Typhs.

3. Pear pests
   There has been some limited work with Success against *leafrollers* in pear, and while the studies were not conclusive, they suggested that Success would provide control. There have been no studies on codling moth in pear. Success was tested against pear psylla in the field, and a low level of activity was observed. Success was registered for use on pear late in 2001; 2002 will be the first year of commercial use.

B. **Avaunt** (indoxacarb) - Avaunt was registered for use late in 2000 so last year was the first full year we could use this product. We have had several years of experience testing Avaunt back to when it was a numbered experimental insecticide. Avaunt is a unique chemistry with a novel mode of action. It is a nerve poison to insects but has very low toxicity to mammals and is thus safe. Its safety is reflected by the EPA's allowance for an REI of 12 hours for workers conducting intensive activities. The PHI is 28 days so it is not an option for use close to harvest. Avaunt is limited to a maximum of 4 applications per year.

1. Lepidopteran pests
   Codling moth – Avaunt does not seem to be a good product for codling moth management in WA. In several tests it has not provided adequate suppression of codling moth even with up to 10 applications per season. In laboratory bioassays against codling moth Avaunt also appears weak when compared to Guthion, Imidan or Assail.
   Leafrollers – We have had less experience in testing Avaunt against leafrollers. It appears to have good efficacy against larvae of the pandemis leafroller but not against larvae of the obliquebanded leafroller. In laboratory bioassays larvae of both leafrollers from our colonies are highly susceptible to Avaunt. However, one field population of obliquebanded leafroller larvae showed high levels of resistance to Avaunt while two field populations of pandemis leafroller were only slightly less susceptible than our laboratory colony. It seems likely that Avaunt may suffer from cross-resistance effects with organophosphate insecticides in leafrollers. Additional research is needed to confirm this suspicion.

Lacanobia fruitworm – Avaunt is very effective against the lacanobia fruitworm. In several field tests Avaunt has controlled larvae of the lacanobia fruitworm with only a single, well-timed application. Even when Avaunt was used at reduced rates there has been little difference in the efficacy of this product against lacanobia fruitworm.

2. Indirect/secondary pests
   Reasonable leafhopper material, may have some effect on leafminer (insufficient data). No campylomma activity. Not tested on other secondary pests (no reason to suspect activity).

3. Pear pests
   We do not have any data for the effectiveness of Avaunt on pests of pear.

C. **Surround** (kaolin) - Surround is a particle film technology developed by USDA researchers. The active ingredient is kaolin clay that is specially processed to maximize its pesticidal and horticultural activity. Surround has no known toxicity to mammals and the REI is short (4 hours) as is the PHI (1 day). Research on Surround in WA has been conducted over the last 3 years and it has a fit in IPM programs but carries some potential negative impacts on natural enemies.

1. Lepidopteran pests
   Codling moth – Surround does have an impact on codling moth larvae. The exact mechanism of action is not completely understood but codling moth larvae have been shown to avoid Surround treated areas on apple. However, they will also search an apple coated with Surround, find an uncovered area, and bore into the apple. Thus the main effect of Surround appears to be as a barrier to prevent larvae from entering the fruit. In several tests we have shown that 3 applications of Surround per generation (50 pound per acre rate) will suppress codling moth damage 50-60%. It is possible that lower rates of Surround would be equally as effective but those studies have not been conducted.
   Leafrollers – Surround residue on leaves is avoided by leafroller larvae. The impact is greatest on young larvae so residues (applications) should be in place prior to egg hatch. If leafroller larvae do not have a choice to avoid Surround residues then some larval mortality has been observed. Spring applications of Surround suppress leafrollers evidently by interfering with their ability to move from overwintering hibernacula and establish feeding sites in opening buds. Summer applications of Surround have been shown to suppress leafroller densities.
   Lacanobia fruitworm – Surround has a strong negative effect on lacanobia fruitworm populations. In the laboratory newly hatched lacanobia fruitworm larvae suffer high mortality if they are provided only Surround treated foliage and show a very strong preference to colonize foliage not treated with Surround. In the field Surround has shown good efficacy in reducing

lacanobia fruitworm densities. Experience in recent years indicates that only two applications prior to egg hatch can reduce most lacanobia fruitworm populations below economically important levels.

2. Indirect/secondary pests
   Has some effect on a broad range of species. No apparent (direct) effect on *aphids* or *campylomma*; has some suppressive effect on *mites*, but also has been associated with causing mite flareups (possibly through predator repellency). Also suppresses *leafminers*, but deleterious effect on the leafminer parasitoid *Pnigalio flavipes* may outweigh any benefit. Evidence from a Wapato study indicated *scale* and leafminer outbreaks occured in kaolin half season or full season kaolin programs, and generalist predators are reduced, possibly provoking an increase in aphid populations. White apple *leafhopper* is suppressed by one or two applications/generation to the nymphs.

3. Pear pests
   The use of Surround is becoming a standard part of the pear pest management program. Surround is effective for *pear psylla* control, likely through a combination of repellency or host masking rather than direct mortality. It appears that Surround is most effective when targeted against adult pear psylla, applied to limit oviposition. The optimal time for this tactic is the prebloom period. Two to three applications of Surround, applied from dormant-delayed dormant through bloom, has been demonstrated to be the most effective way to reduce pear psylla adult densities in orchards, and consequently reduce their oviposition. Surround has been used in combination with oil during the prebloom period without significant detrimental effects.

   Postbloom applications of Surround are also effective for pear psylla control, but diligence is required in maintaining coverage and residue. Surround needs to entirely coat the foliage, as the material is not intoxicating the psylla; tree growth produces new foliage that needs to be covered by repeated Surround applications. Once psylla have survived into later instars, Surround does not appear to be effective and other tactics must be applied. Additionally, Surround can be disruptive to biological control; applications in the prebloom period minimize this effect, while summer applications directly impact predator populations. Thus, summer use of Surround is often not reliable and can be costly. Postharvest applications, made after the trees defoliate, can provide residue that deters pear psylla immigration into treated orchards through the beginning of the following season. This tactic may prove useful for psylla management in orchards that have difficulty making applications early in the season because of snow, mud, etc.

   Grape mealybug is not effectively managed by Surround. *Two-spotted spider* mites are also not managed by Surround. However, damage from spider mites appears to be mitigated by Surround by some unknown mechanism. Pear leaves treated with Surround can tolerate much higher than normal densities of

spider mites without suffering from 'transpiration burn.' While there is potential to use Surround to thus increase the damage threshold of spider mites, the negative impacts on natural enemies prevents biological control from becoming established, as in apple.

D. **Horticultural Mineral Oil** - Horticultural mineral oils have been used in orchard pest management for many decades. They were among the first pesticides used to control pests but these products have in recent years become more refined and quality controls tightened to reduce the potential for phytotoxicity. Pre-bloom use of oil is an important component of an apple IPM program. This use provides control of San Jose scale and European red mite (eggs) as well as suppression of aphids, all without negative impact on natural enemies. Summer use of horticultural mineral oils has increased as they have become safer. Typical concentrations of oil for summer use are 1 to 2%, though the higher concentrations have a greater risk of phytoxicity. The advantage of using oils is short REI and PHI and relative safety to natural enemies. There remain questions about the long-term negative impact of summer oil use on fruit tree vigor and fruit size. This is probably more of a concern for pear than apple but careful observation of any decline in tree vigor should be a part of any program using summer oil treatments.

1. <u>Lepidopteran pests</u>
   Codling moth – Horticultural mineral oils act against codling moth by suffocating the egg. The best timing strategy is therefore to allow many eggs to be laid prior to making an application and then repeat the application again after more eggs have been laid but before they hatch. A timing that has worked well is to apply the first application 200, 400 and 600°D after BIOFIX of the first generation and 1200, 1400 and 1600°D of the second generation. Where high codling moth populations are present the interval of re-treatment should be shortened to 150°D intervals. Use of oil in summer is a good supplemental control for codling moth in a mating disruption approach where conservation of natural enemies is a high priority. Oils are one of the only effective controls for codling moth in organic production.
   Leafrollers – Oil has no effect on overwintering larvae. Oil used in combination with Lorsban in the delayed-dormant period is effective against leafrollers but it is the Lorsban that provides control. We have observed in seasonal oil programs directed at codling moth that leafroller densities are also suppressed but do not know what stage is affected. Oil can result in mortality of leafroller eggs and may deter egg laying by females. Oil in combination with several insecticides acts as a good surfactant improving uniformity of coverage.
   Lacanobia fruitworm – We have no information on the effect of oil on this insect.

2. <u>Indirect/secondary pests</u>
   This material is a toxicant to a broad range of secondary and indirect pests, and often has an effect on soft-bodied insects. It suppresses *mites* fairly effectively, although repeat applications may be necessary. It can cause a

reduction in predatory mite populations, but usually this does not provoke later flareups, thus there is a net benefit. One to two applications per generation applied against the nymphs of *white apple leafhopper* are effective in reducing nymph populations; it is also an ovipositional repellent to the adult leafhopper females, but the effect is transitory. *Woolly apple aphids* are also suppressed by oil applications. Oil in the delayed dormant has been a standard recommendation for eight decades or more, and is still effective in long term control of the overwintering stages of European red mite and San Jose scale.

3. Pear pests

Horticultural mineral oils are important tools in pear pest management. At the very least they should be used for delayed dormant applications and as adjuvants, and in some cases they can be useful as stand-alone applications. Application of oil early in the season, in the dormant and delayed dormant periods, is important in starting the *pear psylla* control program. Additionally, these applications help control *San Jose scale* and European red mites, if present. The early oil sprays inhibit pear psylla oviposition; the mechanism of this activity is not known. Nevertheless, this inhibition helps push peak oviposition back by one to two weeks and helps synchronize the population development (there is also some degree of ovicidal activity).

Using oils as adjuvants helps increase the level of control obtained from virtually every psyllicide it has been tested with. In some cases this is simply from the mortality induced by the oil, while in others there is synergism in activity. In our tests, we include 0.25% oil and find that it helps the chloronicotinyls, Agri-Mek, Neem compounds, and Applaud. This is also true of the new miticides. Caution should be taken when using oils with some materials, particularly emulsifiable concentrates, to reduce the possibility of fruit marking and other phytotoxic effects.

We have tested using oils alone for control of *pear psylla, spider mites*, and *codling moth*, and these studies have met with some success. It appears that repeated applications are capable of suppressing the pests; however, if damaging levels are present, the oils do not reduce the populations below damage thresholds. There are anecdotal concerns in the industry regarding the long term use of frequent oil applications. Some have hypothesized that there could be significant reductions in yield and/or fruit size following several years of 'intensive' oil use. A preliminary two-year study in Bartlett did not find any negative effects; however future long-term studies need to be conducted to properly address this issue.

E. **Bt** (*Bacillus thuringiensis*) - There are several products that contain the active ingredients produced by the bacteria *Bacillus thuringiensis* (Bt). All Bt products must be consumed to have activity against insects. This is why Bt products do not affect most

natural enemies of insect pests. Bt products are very safe. Their REI is 4 hours and the PHI is only 1 day. Bt products have short residual activity and are degraded by sunlight and high temperatures.

1. Lepidopteran pests
   Codling moth – We have evaluated Bt products against codling moth and they have very little activity. The main problem is associated with the short residual activity and the inability to uniformly cover the surface of the fruit, thus allowing codling moth larvae to enter without becoming intoxicated.
   Leafrollers – Bt products have their best fit in apple IPM as leafroller controls. Several Bt products have been tested over the last decade and few differences have been detected in their relative efficacy assuming that appropriate rates are used. In the spring Bt products are best used between bloom and 10-14 days after petal fall. Because the leafroller larva must consume the Bt it is important to have good coverage of foliage and to apply sprays when temperatures are predicted to be 65°F or higher for 3 or more days. Leafroller larvae are not active feeders when temperatures are below 65°F and long periods of cool wet weather following a Bt application will greatly reduce the efficacy of the treatment. It is usually necessary to apply more than one Bt treatment to obtain adequate leafroller suppression. We have consistently observed 50-60% control with one application and 80-95% control with two applications 7 to 10 days apart. In the summer Bt treatments last only 5 to 7 days; however, with good coverage, it is possible to obtain good control. When dealing with a high leafroller population three applications may be necessary to achieve adequate control.
   Lacanobia fruitworm – Bt products have been evaluated against lacanobia fruitworm but have not proven effective.

2. Indirect/secondary pests – no activity against secondary pests.

3. Pear pests - Bt is used in pears for leafrollers as described for apples.

F. **Azadirachtin** (neem products) - There are several neem-based insecticides available for tree fruit, and nearly all have azadirachtin as the active ingredient. Azadirachtin is derived from many parts of the Indian neem tree. The insecticidal activity is rather complex; azadirachtin may act as an ovipositional deterrent, feeding deterrent, and insect growth regulator. The IGR activity itself is complex relative to other IGRs, in that azadirachtin interferes with neuroendocrinal control of metamorphosis, affecting both ecdosteroidal and juvenile hormone titers. Neem products in general are very safe to applicators.

1. Lepidopteran pests
   Codling moth – We have evaluated Neem products against codling moth and even when multiple applications were made at different rates control was not achieved.

Leafrollers – We have tested products containing azadirachtin against leafrollers. In general they have not been active in laboratory bioassays even when development was followed through most of the larval stages. Neem products can act slowly, similar to IGRs. If Neem products have any potential efficacy against leafrollers it is likely that multiple applications will be required to provide adequate suppression of populations.
Lacanobia fruitworm – We conducted a laboratory bioassay of a Neem product against lacanobia fruitworm. There was some promise of activity against young larvae. No field tests have been conducted.

2. Indirect/secondary pests
Although *green aphids* are often listed as a target, there does not appear to be much mortality. There does appear to be a useful level of activity against *leafminer*, but this has been variable depending on material and timing; also, the activity is slow in comparison to other products. There is some suppression of *woolly apple aphid* (Ecozin). Some suppression has been observed of *leafhopper* and *campylomma* (Neemix).

3. Pear pests
There has been limited testing of the neem products against *grape mealybug* and *codling moth* in pear, and extensive testing against *pear psylla*. The neem products have complex modes of action against the pests, but the primary method of activity is as an insect growth regulator. There appears to be little activity against grape mealybug. Codling moth is also not controlled by the neem compounds, although there appears to be some activity. Pear psylla, on the other hand, can be managed using neem products. However, because of the IGR activity, the population response to azadirachtin is slow. This, combined with the short residual activity, makes frequent reapplications necessary. Additionally, it is difficult to control high populations of pear psylla with these materials. Applications beginning at clusterbud or petal fall, and followed with four to six applications every seven to ten days, have been successful in managing pear psylla. Using oil as an adjuvant has also been shown to increase the mortality in pear psylla.

G. **Virosoft** (CM granulosis virus) - The codling moth granulosis virus has been known for many years and different companies have attempted to formulate it as a biological pesticide. Most formulations have not provided consistent control. The virus is subject to rapid degradation by UV light and high temperatures. The virus has the potential if effective to cause mortality of codling moth larva but this usually does not occur fast enough to prevent its entry into the fruit. The advantages of the codling moth granulosis virus is that it only affects codling moth and thus does not interfere with activities of natural enemies.

1. Lepidopteran pests
   Codling moth – Virosoft is a newly registered codling moth granulosis virus. We have had only one year's experience with this product. We applied Virosoft against both codling moth generations at intervals of 7, 10 and 14 days. After the first generation there was some suppression of damage by the most frequent re-treatment interval but by harvest high levels of fruit injury were noted in all treatments. We are not recommending this product for codling moth control at this time.
   Leafrollers – Has no activity against leafrollers.
   Lacanobia fruitworm – Has no activity against lacanobia fruitworm.

2. Indirect/secondary pests - no data, no reason to suspect activity
3. Pear pests – same as for apple pests

H. **Applaud** (buprofezin) - Buprofezin is a unique chemistry, a thiadiazine compound. Its activity is also unique, in that it can be used as a contact insecticide, stomach poison, or insect growth regulator. It is currently being investigated for registration in pear only.

1. Lepidopteran pests
   Codling moth – We have not tested Applaud against codling moth.
   Leafrollers – We have not tested Applaud against leafroller.
   Lacanobia fruitworm – We have not tested Applaud against lacanobia fruitworm.

2. Indirect/secondary pests - no Washington data

3. Pear pests
   Applaud is very active against *grape mealybug* and *pear psylla*, and, if registered, should become an important component of pear IPM programs. Applaud is currently being supported by the pear industry and WSU for IR-4 Minor Crop registration. Applaud has a unique mode of action, acting primarily as an insect growth regulator on the chitin synthesis pathway on these pests, but it also has a low level of neurotoxic effects. Because of its activity against the same primary pests as the chloronicotinyls, Applaud is an excellent rotation candidate in a resistance management program.

   Field tests of Applaud against pear psylla have been conducted at numerous timings, all with good success. Applaud has activity that is comparable to the chloronicotinyls against pear psylla, although the residual activity appears shorter (less than 2 weeks). Nevertheless, it appears to be the most active compound available against grape mealybug, particularly in summer applications. Effects of Applaud against campylomma or other biocontrol agents in pear are not known at this time.

Relative efficacy table for insecticides on Lepidoptera pests of apple.

Insecticide	**Codling moth**	**Leafrollers**	**Lacanobia fruitworm**
Provado	None	None	Not tested
Actara	Not tested	Not tested	Not tested
Assail	High	Low	Low
Calypso	Low	Low	Low
Intrepid	Moderate	High	High
Confirm	Low	Moderate	High
Esteem	Moderate	High	Not tested
Success	Moderate	High	Moderate
Avaunt	Low	High (PLR only) Low (for OBLR)	High
Surround	Moderate	Moderate	Moderate
Horticultural Oil	Moderate	Low	Not tested
Bacillus thuringiensis	Low	Moderate	Low
Virosoft CP4	Low	None	None
Applaud	Not tested	Not tested	Not tested
Azadirachtin	None	Low	Not tested

Relative efficacy table for insecticides on pests of pear.

Insecticide	**Pear psylla**	**Grape mealybug**	**Codling moth**
Provado	High	High	None
Actara	High	High	Not tested
Assail	High	High	High
Calypso	High	High	High
Intrepid	None	None	Moderate
Confirm	None	None	Low
Esteem	Moderate	None	Moderate
Dimilin	Moderate	None	Moderate
Success	Low	None	Not tested
Avaunt	Not tested	Not tested	Not tested
Surround	Moderate	Very low	Moderate
Horticultural Oil	Moderate	Low	Moderate
Bacillus thuringiensis	None	None	Low
Virosoft CP4	None	None	Not tested
Applaud	High	High	Not tested
Azadirachtin	Moderate	Very low	Very low

Information on limitations on uses of insecticides on apple.

Insecticide	Maximum Formulated Rate/acre	Active ingredient per year	Number of applications per year	Worker reentry interval	Pre-harvest interval
Provado					
Actara					
Assail 70 WDG*	***0.21 lbs.***		***4 (?)***	***NR***	***NR***
Calypso 480 EC*			***(?)***	***NR***	***NR***
Esteem 35WP	5 ounces	98 grams	2	12 hours	45 days
Intrepid 2F	16 fl. ozs		4	4 hours	14 days
Confirm 2F	21 fl. ozs		4	4 hours	14 days
Success 2 SC	10 fl. ozs.	0.45 lbs	none	4 hours	7 days
Avaunt 30 WDG	6 ounces	0.44 lbs	4	12 hours	28 days
Surround WP	50 pounds	Not limited	Not limited	4 hours	1 day
Mineral Oil	Variable	Not limited	Not limited	4 hours	1 day
Bacillus thuringiensis	Variable	Not limited	Not limited	4 hours	1 day
Virosoft CP4	4.4 fl. ounces			4 hours	1 day
Applaud					
Azadirachtin products					
Acramite					
Secure					
Envidor					
Mesa					

- product is not yet registered for use by EPA.

Summary table of pesticides, timing and targets for pest management on apple.

	Delayed dormant	Pink-Bloom	Petal fall	10-14 days post-petal fall	Early summer	Mid- to late summer
Provado						
Actara						
Assail					***codling moth***	***codling moth***
Intrepid			leafroller + codling moth	leafroller + codling moth	codling moth + lacanobia	codling moth + lacanobia + leafroller
Confirm			leafroller + codling moth	leafroller + codling moth	codling moth + lacanobia	codling moth + lacanobia
Esteem	San Jose scale		leafroller + codling moth	leafroller + codling moth		
Success			leafroller	leafroller		leafroller
Avaunt					lacanobia	lacanobia
Surround	Leafroller (?)				lacanobia	
Horticultural Oil	San Jose scale + aphids + mites			codling moth	codling moth	codling moth
Bacillus thuringiensis		leafroller	leafroller	leafroller	leafroller	leafroller
Virosoft CP4						
Applaud						
Azadirachtin products						
Acramite						
Secure						
Envidor						
Mesa						

Information on limitations on uses of insecticides on pear.

Insecticide	Maximum Formulated Rate/acre	Active ingredient per year	Number of applications per year	Worker reentry interval	Pre-harvest interval
Provado	20 oz	40 oz formulated	2	12 hrs	7 days
Actara	5.5 oz	8 oz formulated	2 @ 4oz	12 hrs	35>2.75oz/a 14 < 2.75oz
Assail 70 WDG*	***0.21 lbs. (?)***	***(?)***	***4 (?)***	***NR***	***NR***
Calypso 480 EC*	***(?)***	***(?)***	***(?)***	***NR***	***NR***
Esteem 35WP	5 oz	10 oz	2	12 hours	45 days
Intrepid 2F	16 oz	64 oz	4	4 hours	14 days
Confirm 2F	20 oz	120 oz	6	4 hours	14 days
Dimilin 50WP*	***3 lbs(?)***	***(?)***	***(?)***	***NR***	***NR***
Success 2 SC	10 fl.oz.	0.45 lbs.	No limit	4 hours	7 days
Avaunt 30 WDG	6 ounces	0.44 lbs	4	12 hours	28 days
Surround WP	50 pounds	Not limited	Not limited	4 hours	1 day
Mineral Oil	Variable	Not limited	Not limited	4 hours	1 day
Bacillus thuringiensis	Variable	Not limited	Not limited	4 hours	1 day
Virosoft CP4	4.4 fl. ounces			4 hours	1 day
Applaud*	***(?)***	***(?)***	***(?)***	***NR***	***NR***
Azadirachtin products	Variable	Not limited	Not limited	4-12 hrs	1 day
Acramite	1.0 lb	1.0 lb	1	12 hr	7 days
Secure*	***(?)***	***(?)***	***(?)***	***NR***	***NR***
Envidor*	***(?)***	***(?)***	***(?)***	***NR***	***NR***
Mesa*	***(?)***	***(?)***	***(?)***	***NR***	***NR***

- product is not yet registered for use by EPA.

Summary table of pesticides, timing and targets for pest management on pear.

	Dormant	**Delayed dormant**	**Clusterbud (Pink)**	**Petal fall**	**10-14 days post-petal fall**	**Early summer**	**Mid- to late summer**	**Post Harvest**
Provado				Pear psylla + Grape mealybug		Pear psylla	Pear psylla + Grape mealybug	
Actara			Pear psylla + Grape mealybug	Pear psylla + Grape mealybug		Pear psylla	Pear psylla + Grape mealybug	
Assail			***Pear psylla + Grape mealybug***	***Pear psylla + Grape mealybug***		***Pear psylla + codling moth***	***Pear psylla + grape mealybug + codling moth***	
Intrepid				codling moth + leafroller	codling moth + leafroller	codling moth + lacanobia	codling moth + lacanobia + leafroller	
Confirm				leafroller	codling moth + leafroller	codling moth + lacanobia	codling moth + lacanobia	
Esteem		Pear psylla + San Jose scale	Pear psylla	Pear psylla + leafroller	Pear psylla + codling moth + leafroller			
Dimilin		Pear psylla	Pear psylla	Pear psylla	Pear psylla + codling moth			
Success				leafroller	leafroller		leafroller	
Avaunt						lacanobia	lacanobia	
Surround	Pear psylla	Pear psylla	Pear psylla			lacanobia		Pear psylla
Horticultural Oil		Pear psylla + San Jose scale + mites	Pear psylla	Pear psylla	Pear psylla + codling moth	Pear psylla + codling moth	Pear psylla + codling moth	
Bacillus thuringiensis			leafroller	leafroller	leafroller	leafroller	leafroller	
Virosoft CP4								

	Dormant	**Delayed dormant**	**Clusterbud (Pink)**	**Petal fall**	**10-14 days post-petal fall**	**Early summer**	**Mid- to late summer**	**Post Harvest**
Applaud			***Pear psylla + Grape mealybug***	***Pear psylla + Grape mealybug***			***Pear psylla + Grape mealybug***	
Azadirachtin products			Pear psylla	Pear psylla	Pear psylla	Pear psylla	Pear psylla	
Acramite						Two-spotted spider mites	Two-spotted spider mites	
Secure						Two-spotted spider mites	Two-spotted spider mites	
Envidor						Two-spotted spider mites	Two-spotted spider mites	
Mesa						Two-spotted spider mites	Two-spotted spider mites	