Insecticides and Miticides

Organophosphate Compounds

Azinphos-methyl, Guthion
Azinphos-methyl is formulated as a 50WP (0.5 to 0.75 pounds per 100 gallons). It is a broad-spectrum insecticide that is effective against many direct pests of apples with residual activity of 10 to 14 days. Azinphosmethyl will not control tufted apple bud moth. Azinphos-methyl provides good fruit finish when applied in combination with most fungicides. Azinphos-methyl is highly toxic and should be used with extreme care. Do not apply more than 8 pounds of product per acre per season (4 pounds active ingredient). Do not apply within 14 days of harvest, or 21 days if using rates higher than 2 pounds per acre. The re-entry interval for hand labor activities (i.e., hand thinning and harvesting) is 14 days, and 48 hours for other activities (i.e., scouting, mowing, etc.).

Chlorpyrifos, Lorsban
Chlorpyrifos is formulated as a 4EC and a 50W. Both formulations can be applied to the canopy of trees only during the prebloom period, and will control San Jose scale, climbing cutworms, and nonresistant rosy apple aphids. The 4EC can be used once per season as a dormant or delayed dormant application at 0.5 to 1.0 pint per 100 gallons. When mixed with 2 gallons oil per 100 gallons water and applied as a delayed dormant spray, it is effective against San Jose scale and cutworms. The 50WP formulation may be applied up to the pink stage at a rate of 0.5 to 0.75 pounds per 100 gallons. Do not use the 50W formulation with oil. Do not enter treated orchards for 4 days after application. A supplemental label exists for Lorsban 50W and 4EC use to control borers in apples after bloom. Under the supplemental label, applications must be directed at the trunk at a distance of no more than 4 feet using a low pressure handgun or shielded sprayer, and spray should not contact foliage or fruit. For borer control, use the 4E formulation at 1½ quarts per 100 gallons and the 50W at three pounds per 100 gallons.

Diazinon, Diazinon
Diazinon is formulated as a 50WP (1 pound per 100 gallons). It is a broad spectrum insecticide, which is particularly effective against rosy apple aphids, San Jose scale, and Comstock mealybugs. The 50WP formulation may be applied up to 21 days before harvest. Do not apply more than 4 pounds per acre per application or more than 12 pounds per acre per season. Diazinon may cause some russetting on Golden Delicious, especially when used in early cover sprays. Caution: Diazinon applied with Captan or Captec may cause phytotoxicity or russetting.

Dimethoate, Dimethoate
Dimethoate is formulated as 4EC and used at a rate of 0.5 to 1 pint per 100 gallons. It is most effective for aphid control and suppression of mites when used early in the season. Dimethoate will also control Comstock mealybugs, plant bugs, and white apple leafhoppers. Do not apply dimethoate within 28 days of harvest.

Methidathion, Supracide
Methidathion is formulated as Supracide 2E. Used at a rate of 1 to 2 pints per 100 gallons and tank-mixed with an oil as a delayed dormant application, it will control San Jose scale and rosy apple aphids. Do not apply after any blossoms have opened.

Phosmet, Imidan
Phosmet is formulated as a 70WP, and is used at a rate of 0.75 to 1 pound per 100 gallons. Phosmet is a broad spectrum insecticide that is effective against many direct pests of apples. However, it will not provide adequate control of the tufted apple bud moth or San Jose scale. It is one of the safest organophosphates to beneficial arthropods. Do not apply within 7 days of harvest.

Carbamate Compounds

Methomyl, Lannate
Methomyl is formulated as a 90SP and should be used at the rate of 0.25 to 0.5 pound per 100 gallons. Methomyl provides good control of aphids, leafminers, and many other pests of apples, and is an ovicide to leafroller eggs. However, methomyl has short residual activity. Methomyl is highly toxic to mite predators and biological mite control is less likely to occur with post-bloom use of this product. Methomyl is highly toxic and should be used with extreme care. Do not apply within 14 days of harvest.

Oxamyl, Vydate
Oxamyl is formulated as a 2L and should be used at 1 to 2 pints per 100 gallons. It is most effective when used for spotted tentiform leafminer and white apple leafhopper shortly after bloom, and is effective against rosy apple aphid when applied before bloom. Oxamyl is also a fruit thinner when applied within 30 days after bloom. Oxamyl is also toxic to mite predators. Do not apply more than 1 gallon of Vydate 2L per acre per season, and do not apply within 14 days of harvest.
Carbaryl, Sevin
Carbaryl is formulated as a 50 WP and XLR (4 pounds active ingredient per gallon). For insect control, the 50WP should be used at a rate of 0.5 to 1.0 pounds per 100 gallons, and the XLR formulation 0.25 to 1 quart per 100 gallons. Carbaryl gives excellent control of leafhoppers, codling moth, Oriental fruit moth, and Japanese beetle, and good control of cicada and redbanded leafroller. Carbaryl is also used as a fruit thinner on several apple varieties. Carbaryl may be applied within 1 day of harvest. Carbaryl may roughen the lenticles of fruit.

Formetanate, Carzol
Carzol is formulated as a 92SP, and is used at a rate of 0.25 pound per 100 gallons. Carzol is water soluble powder and dissolves rapidly in water. Carzol is effective against white apple leafhopper, plant bugs, and leafminers, and will suppress European red mite. A reduced rate of 2 ounces per 100 gallons will control leafhoppers. Do not apply more than 1.25 pounds per acre per season, and do not apply after petal fall. The re-entry interval after application is 16 days for hand labor activities (i.e., hand thinning, harvesting) and 10 days for other activities.

Hexythiazox, Savey
Hexythiazox is formulated as a 50WP and is recommended at the rate of 3 ounces per acre. It is labeled for a single application per season, which should provide season-long control of European red mite and twospotted spider mite. It is toxic to European red mite eggs and larval stages, and will not directly affect mite predator populations. Although it has a 28-day preharvest interval, it is most effective when applied when mite populations are low, or at petal fall or first cover if used preventively. To minimize the potential for resistance development, do not use Savey or Apollo in the same or successive years.

Carbazate Compounds

Bifenazate, Acramite
Bifenazate is a miticide formulated as Acramite 50WS, and is used at a rate of 0.75 to 1.0 pound per acre. It is effective against European red mite and twospotted spider mite, but has low toxicity to predaceous mites and other beneficial arthropods. Bifenazate has a unique mode of action with excellent knockdown activity, and acts as a mite ovicide. Do not make more than one application per season, and do not apply less than 7 days before harvest.

Neonicotinoid Compounds

Acetamiprid, Assail
Acetamiprid is formulated as Assail 70WP, and is recommended at rates of 1.1 to 3.4 ounces per acre. It is registered for use of aphids, leafhoppers, leafminers, codling moth, and oriental fruit moth, and also controls apple maggot. For control of the latter three insects, use the 3.4 ounce per acre rate. As with other neonicotinoid insecticides, it is toxic to coccinelids (lady beetles) upon contact. Do not make more than four applications per season or exceed 13.5 ounces per acre per season. Do not apply more than once every 12 days, and do not apply less than 7 days before harvest.

Imidacloprid, Provado
Imidacloprid is formulated as Provado 1.6F. It is a systemic insecticide that affects the nervous system of insects, and is recommended at rates of 1 to 2 ounces per 100 gallons. Imidacloprid is effective against aphids, leafhoppers, leafminers, and apple maggot. It is toxic to the mite predator Stethorus punctum when applied directly, but has short residual activity against this predator. Do not exceed 40 ounces per acre per season, and do not apply within 7 days of harvest.

Thiacloprid, Calypso
Thiacloprid is formulated as Calypso 4F. It has systemic activity and is recommended at 0.5 to 1.0 ounces per 100 gallons for control of aphids, leafminers, leafhoppers and mirid bugs. For control of apple maggot, codling moth, oriental fruit moth and plum curculio it should be used at 1 to 2 ounces per 100 gallons. It is toxic to coccinellid predators (lady beetles) upon contact. Do not apply closer than 30 days before harvest or more than 16 ounces per acre per year.

Thiomethoxam, Actara
Thiomethoxam is formulated as Actara 25WDG, and is a systemic insecticide that affects the nervous system of insects. It is recommended at rates of 4.5 to 5.5 ounces per acre for most insects, but only 2.0 to 2.75 ounces per acre is recommended for leafhoppers. It may be used once before bloom at 4.5 ounces per acre for control of rosy apple aphid, leafminers and Mullein bugs, or postbloom for control of plum curculio, aphids, leafminers, and leafhoppers. It is toxic to the mite predator Stethorus punctum when applied directly, but has short residual activity against this predator. Do not exceed a total of 8.0 ounces per acre.
per season. Do not apply within 14 days of harvest at rates equal to or less than 2.75 ounces per acre, or within 35 days of harvest at rates greater than 2.75 ounces per acre.

**Organochlorine Compounds**

*Endosulfan, Thiodan, Phaser*

Endosulfan is formulated as 50WP and 3EC. Used at a rate of 1 pound or b quarts per 100 gallons, endosulfan gives good control of aphids, spotted tentiform leafminer, white apple leafhopper, and plant bugs. Endosulfan should not be applied within 21 days of harvest or with 300 feet of bodies of water.

*Dicofol, Kelthane*

Dicofol is formulated as a 50WP and used at rate of 3 to 4 pounds per acre on trees greater than 10 feet or trellised trees, and 4 to 6 pounds per acre on trees greater than 10 feet. Dicofol is an effective miticide, but does not provide long residual activity. If European red mite eggs are abundant when using dicofol, a second application within 10 days may be necessary. Dicofol is toxic to predatory mites, and should not be used at low rates to adjust predator-prey ratios. Do not apply within 7 days of harvest. To avoid plant injury, do not use glyodin fungicides with dicofol in late cover sprays.

**Organotin Compounds**

*Hexakis, Vendex*

Hexakis is formulated as a 50WP. It is registered for use on apples at a rate of 0.25 to 0.5 pound per 100 gallons to control European red mite, twospotted spider mite, and rust mites. Hexakis is of low toxicity to predaceous mites and can be used at reduced rates to adjust predator-prey ratios. Do not apply more than three times between petal fall and harvest, or within 14 days of harvest.

**Oxadiazine Compounds**

*Indoxacarb, Avaunt*

Indoxacarb is formulated as a 30WG and is recommended at a rate of 5 to 6 ounces per acre. Avaunt has relatively broad spectrum activity, and will control codling moth, Oriental fruit moth, tufted apple bud moth, plum curculio, white apple leafhopper, potato leafhopper, and low densities of apple maggot. Avaunt affects the nervous system of insects, but in a different manner than other insecticides. It has residual activity of 8 to 10 days. Do not make more than four applications per season or exceed a total of 24 ounces of Avaunt per acre per season. Do not apply within 28 days of harvest.

**Pyridazinone Compounds**

*Pyridaben, Pyramite*

Pyridaben is formulated as a 60WP and should be used at 4.4 to 6.6 ounces per acre. Pyridaben is an excellent miticide and also controls leafhoppers. Pyridaben is toxic to all motile stages of the European red mite and has residual activity of 14 to 21 days. Pyridaben is of low toxicity to predacious mites, but is toxic to Stethorus punctum. Do not make applications closer than 30 days apart, and do not apply within 25 days of harvest.

**Sulfur**

Sulfur will suppress the European red mite and twospotted spider mite when used in cover sprays on a regular basis. However, the use of sulfur after bloom may affect the fruit finish on Golden Delicious, Red Delicious, and Stayman. Also, sulfur is not safe to use above 90°F. Studies in North Carolina have shown that micronized sulfur suppressed mites better than wettable sulfur.

**Pyrethroids**

This group of insecticides is broad spectrum in activity, has good residual activity, is recommended at low dosages, and is relatively safe. However, applications of pyrethroid insecticides at any time during the season may aggravate or induce mite, woolly apple aphid, Comstock mealybug, and San Jose scale outbreaks. If these materials must be used, limit their use to a single application before bloom, preferably with an oil as a delayed dormant application.
**Esfenvalerate, Asana**
Esfenvalerate is formulated as a 0.66EC (Asana XL) and used at 2.5 to 5.8 ounces per 100 gallons. Esfenvalerate is compatible with other insecticides and fungicides. Esfenvalerate is a broad spectrum insecticide that controls many pests and is the most effective insecticide registered on apple for control of cicada. Esfenvalerate has a 21-day interval between the last application and harvest. Do not exceed 101 ounces per acre per season. Esfenvalerate is toxic to fish and may also cause skin irritation.

**Fenpropathrin, Danitol**
Fenpropathrin is formulated as a 2.4EC (Danitol 2.4EC) and is used at a rate of 10 to 21 ounces per acre. Danitol is a broad spectrum insecticide that can be used before bloom for control of rosy apple aphid, or postbloom for control of beetles, lepidopterous pests, and mites. For delayed dormant or pre-pink applications, the lower rate can be used, but for postbloom applications a minimum rate of 16 ounces per acre should be used. Although Danitol is a pyrethriod and toxic to mite predators, it is also controls European red mite. However, multiple applications per season should be avoided to prevent the development of resistance. Danitol has a 14 day preharvest interval. Do not apply more than 42 ounces per acre per season.

**Permethrin, Ambush, Pounce**
Permethrin is formulated as a 2E (Ambush) and 3.2EC (Pounce). Ambush is used in the range from 6.4 to 12.8 fluid ounces per acre, and Pounce may be used in the range from 4 to 8 fluid ounces per acre. Both products are also formulated as 25WP and should be used in the range from 6.4 to 12.8 ounces per acre. Do not exceed three applications of either Ambush or Pounce per season, and do not apply either after petal fall.

**Tetrazine Compounds**

**Clofentezine, Apollo**
Clofentezine is formulated as a SC and is recommended at a rate of 4 ounces per acre. Although it has a 45-day preharvest interval, the most effective timing is usually at petal fall or first cover. It is toxic to European red mite eggs and larval stages, and will not directly affect mite predator populations. To minimize the potential for resistance development, do not use Apollo or Savey in successive years.

**Biologically Based Insecticides**

**Bacillus thuringiensis, Dipel, Xentari, CryMax**
These products contain crystal proteins and spores produced by the bacterium *B. thuringiensis* subsp. *kurstaki* or *aizawai*. When ingested by lepidopterous larvae, the protein crystals dissolve and rupture the gut wall. They do not have contact activity, and larvae may require up to 3 days to die; however, larvae will stop feeding shortly after ingestion of the product. In apples, they are most effective against leafrollers (i.e., tufted apple bud moth, redheaded leafroller, and variegated leafroller). They have relatively short persistence, so thorough coverage is important for effective control. Dipel DF (1 pound per acre), Xentari (1 pound per acre), and CryMax (1 pound per acre) are all registered for use on apples. In larger trees (greater than 350 gpa tree-row volume) the rates should be increased to 1.5 pounds per acre.

**Abamectin, Agri-Mek**
Abamectin is a naturally derived substance produced by a soil microorganism; Agri-Mek is synthetic abamectin. It provides long residual control of European red mite, twospotted spider mite, spotted tentiform leafminer, and white apple leafhopper when used at 2.5 to 5.0 ounces per 100 gallons. Excellent results have been obtained at a rate of 10 ounces per acre on a variety of tree sizes. It is labeled for use from the petal fall stage to 6 weeks after bloom; however, best results are obtained when applied at petal fall. Agri-Mek is a locally systemic insecticide per miticide (translaminar activity) and must be tank mixed with a paraffinic spray oil at 0.25 percent or 1 gallons per acre, or a penetrating adjuvant, to enable movement of the chemical into the leaf. The efficacy of this product is dependent on movement into the leaf, and it may not adequately move into leaves damaged by either insects or frost. When Agri-Mek is used with oil, do not spray captan 2 weeks before or after applying Agri-Mek and oil.

**Spinosad, SpinTor**
Spinosad is naturally produced by the antinomycete *Saccharopolyspora spinosa* under aerobic fermentation conditions. It is active via ingestion and contact activity, and affects the nervous system of insects in a different manner than other insecticides. It is formulated as a 2SC, recommended at rates of 5 to 8 ounces per acre, and is effective against leafrollers (including the tufted apple bud moth) and spotted tentiform leafminer. Because of its short residual activity (ca. 5 days), it should not be relied upon to control codling moth, Oriental fruit moth, or apple maggot if applications are extended beyond 10-day intervals. Do not exceed 45 ounces of SpinTor per season, and do not apply closer than 7 days before harvest.
Insect Growth Regulators

Etoxazol, Zeal
Etoxazol is formulated as Zeal 72WDG and is recommended at 2 to 3 ounces per acre. It is an insect growth regulator that is specific to plant-feeding mites and is safe to mite predators. Etoxazol will kill European red mite and twospotted spider mite eggs and nymphs, and sterilizes adults. It has translaminar activity, and should be applied when mite populations are low, generally within one month of bloom. Do not make more than one application per season, and do not apply with 28 within days of harvest.

Methoxyfenozide, Intrepid
Methoxyfenozide is formulated as a 2F and is recommended at 6 to 16 ounces per acres. Methoxyfenozide is an analog of tebufenozide with the same mode of action and spectrum of activity, except that methoxyfenozide is more active at lower rates and greater activity against Oriental fruit moth compared to tebufenozide. Because these two insecticides have the same mode of action, they should be considered the same insecticide for resistance management practices. Intrepid is generally more active than Confirm against codling moth and Oriental fruit moth. For tufted apple bud moth, Intrepid should be used a 6 to 10 ounces per acre, and for codling moth and Oriental fruit moth use at 10 to 16 oz per acre. Do not apply more than 64 ounces per acre per season, or closer than 14 days before harvest.

Pyriproxyfen, Esteem
Pyriproxyfen is formulated as a 35WP (Esteem) and is registered for use at 4 to 5 ounces per acre. Esteem interrupts normal development of eggs and immatures so that individuals do not complete development. It is effective against San Jose scale, codling moth, rosy apple aphid (if applied no later than ½ inch green tip), and spotted tentiform leafminer. For San Jose scale, apply as either a delayed-dormant with oil, or against crawlers in cover sprays. For codling moth, it must be applied prior to egg laying, or about 100 degree days after biofix, and a second application should be made 14 days later. Do not apply within 45 days of harvest or more than 32 ounces per acre per season.

Oils

Superior Oil
A superior-type oil in the green-tip spray as a 2 percent solution (2 gallons per 100 gallons) controls overwintering European red mite eggs and San Jose scale. If application is delayed until the tight-cluster to pink stage of tree development, reduce the oil concentration to ½ to 1 percent (0.5 to 1 gallon per 100 gallons). The petroleum oil should be highly refined to eliminate toxicity to leaf tissue. For plant safety and maximum insect control, use a superior-type oil with a minimum viscosity of 68 to 78 seconds (at 100°F), minimum unsulfonated residue of 92 percent, a minimum pourpoint (°F) of 20, and distillation at 10 mm Hg (°F 50% point) of 412 + 8.

A superior-type spray oil is an effective miticide if coverage is thorough. Mites have not developed resistance to oil, and this spray is very effective for early season control of the European red mite. It is suggested that you: 1) apply oil only in a dilute spray; 2) spray only on days when weather conditions favor good coverage and when temperatures near freezing or frost will not occur within 24 hours; and 3) apply enough liquid to thoroughly wet all surfaces on the tree.

Highly Refined Oils
Highly refined oils are those with a molecular weight that exhibit minimal phytotoxicity so that they can be applied after bloom for suppression of mites and scales. There are numerous brands (e.g., Ultra-Fine Spray, Biocover), and most are used at concentrations of 0.5 to 2 percent solution for control of the European red mite. They should not be used in combination with or within 14 days of applying dinitro compounds or fungicides containing sulfur (e.g., Captan). It is important that these oils be used according to the label to avoid compatibility and phytotoxicity problems. They are most effective when applied at first and second cover sprays or when mites are just beginning.

Pheromones for Mating Disruption
Codling moth and oriental fruit moth pheromones are both registered for mating disruption on apples. Diverse products are available in both hand-applied and sprayable formulations. Sex pheromones are species specific, and usually consist of multiple chemical components. Most products for mating disruption consist of the major components rather than the full blend of chemicals emitted by female moths.
**Codling Moth Pheromone**

**Isomate-C Plus** (EPA Reg. No. 53575-6). Each dispenser consists of two brown-red colored polymer tubes, one filled with the three-component blend of codling moth pheromone and the other containing a wire so the dispenser can be twisted around the branch of a tree. Each dispenser contains 183.2 mg of pheromone, and it is recommended that they be applied at 400 dispensers per acre. Dispensers remain active for a minimum of 150 days, and usually continue to emit pheromone for much longer periods of time (e.g., 200 days).

**Isomate-C TT** (EPA Reg. No. 53575-25). dispensers are similar to Isomate-C Plus, except that both tubes are filled with pheromone and there is no wire in one of the tubes. The two parallel tubes are joined at the ends so that the dispenser is separated in the middle and can slip over the end of a branch. Each dispenser contains 382.4 mg of pheromone, and it is recommended that they be applied at 200 dispensers per acre. Pheromone is released at a slightly higher rate from Isomate-C TT dispensers compared with Isomate-C Plus, but both dispensers release pheromone for a similar length of time.

**Disrupt CM-Xtra** (EPA Reg. No. 8730-63). Pheromone is dispensed from a plastic matrix, and dispensers are attached to the limbs of trees by a bread clip. Each dispenser contains 180 mg of codling moth pheromone, and it is recommended that they be applied at 200 dispensers per acre. Dispensers will release pheromone for a period of about 180 days.

**CheckMate CM-XL 1000** (EPA Reg. No. 56336-12). Pheromone is dispensed through a membrane system, and dispensers are attached to the limbs of trees by a bread clip. Each dispenser contains 270 mg of codling moth pheromone, and it is recommended that they be applied at 120 to 200 dispensers per acre. Dispensers will release pheromone for a minimum of 160 days.

**Oriental Fruit Moth Pheromone**

**Isomate-M 100** (EPA Reg. No. 53575-19). Dispensers consist of a reddish-colored polymer filled with oriental fruit moth pheromone, which are twisted around the limbs of trees. Each dispenser contains 232.1 mg of oriental fruit moth pheromone. It is recommended that they be applied at 100 dispensers per acre, and they will emit pheromone for about 100 days.

**Isomate-M Rosso** (EPA Reg. No. 53575-26). Dispensers are similar to Isomate-M 100 dispensers except that they are fill with more pheromone and are designed to emit pheromone for a longer time. Each Isomate-M Rosso dispenser is filled with 250 mg of oriental fruit moth pheromone, and dispensers will emit pheromone for about up to 150 days. It is recommended that they be applied at 160 to 200 dispensers per acre.

**Disrupt OFM** (EPA Reg. No. 8730-61). Pheromone is dispensed from a plastic matrix, and dispensers are attached to the limbs of trees by a bread clip. Each dispenser contains 250 mg of oriental fruit moth pheromone, and it is recommended that they be applied at 108 dispenser per acre. Dispensers will release pheromone for a period of about 90 days.

**CheckMate OFM** (EPA Reg. No.56336-36 ). Pheromone is dispensed through a membrane system, and dispensers are attached to the limbs of trees by a bread clip. Each dispenser contains 250 mg of oriental fruit moth pheromone, and an application at 100 to 200 dispensers per acre. Dispensers will release pheromone for a minimum of 90 days.

**3M MEC-OFM Sprayable** (EPA Reg. No. 10350-51). A microencapsulated formulation of OFM pheromone that is applied with an airblast sprayer. Each ounce of product contains 6 gm of oriental fruit moth pheromone, and the application rate is 1.7 to 2.5 ounces per acre. Pheromone will be emitted for a 4 to 5 week period after application, so the product must be reapplied for extended control.

**CheckMate OFM-F** (EPA Reg. No. 56336-54). Is a sprayable formulation of oriental fruit moth pheromone that is applied with an airblast sprayer. Each ounce of product contains 6.8 gm of oriental fruit moth pheromone, and the application rate is 1.3 to 2.9 ounces per acre. Pheromone will be emitted for about 4 weeks after application, so the product must be reapplied for extended control.

**Other Products**

**Kaolin, Surround 95WP**

Surround is finely ground kaolin that is formulated to form a white particular film on the surface of sprayed surfaces. In addition to controlling and suppressing certain insect pests, it is also used as a protectant against sunburn and heat stress. Surround is labeled at 25 to 50 pounds per acre, with higher rates used on larger trees. Surround is highly susceptible to wash-off by rain events.