Apple Chemical Thinning

Apple chemical bloom and postbloom thinning programs are intended to reduce the current season's crop load in pursuit of three fundamental goals: 1) inhibit fruit set to minimize green fruitlet hand thinning; 2) improve size and quality of surviving fruit; and 3) promote return bloom to encourage annual cropping. Successful chemical thinning usually requires comprehensive programs employing multiple chemistries during the bloom and postbloom period. Bloom thinners (applied when flowers are open and viable) reduce fruit set by damaging flower parts and/or inducing plant stress. Most postbloom thinners (applied after petal fall) typically mimic the effect of plant hormones to elicit a specific physiological response (e.g. increased ethylene evolution, which triggers fruitlet abortion) to achieve reductions in crop load.

Fertilized flowers become more difficult to thin with each passing day, making early, aggressive thinning strategies more successful than those which rely primarily on chemical applications after 15 mm fruitlet size. Research indicates that early thinning results not only in more significant reductions in fruit set, but greater improvements fruit size, fruit quality, and return bloom. Even with more aggressive chemical rates, applications of postbloom chemical thinners after 15 mm fruitlet size are usually of marginal benefit in typical Washington conditions; two exceptions to this rule are ACC and metatmitron, which have shown efficacy in applications after 20 mm fruitlet size. Spray timings based on weather and crop developmental stage (i.e. mean fruitlet diameter) are generally more reliable than those based on the calendar (i.e. days after full bloom). Most postbloom thinners reduce fruit set by temporarily inducing stress in fruit trees. Under equivalent weather conditions, apple trees tend to be most vulnerable to postbloom thinners around 10-12 mm fruitlet size, when the trees have used up most of their nutritional reserves stored through the winter, but have not yet developed enough leaf area to produce adequate fresh carbohydrates through photosynthesis.

Chemical thinning efficacy is a function of many factors, including apple cultivar and strain, rootstock, tree condition, pollen strength and density, bee activity, weather, product chemistry, rate, application method, timing, and coverage. Therefore, thinning programs should be customized to individual blocks. Select materials, timings, and rates accordingly and observe label recommendations and restrictions. Spring frosts can induce significant fruitlet abortion in lower parts of the tree, but upper parts of the canopy may still be over-cropped; in these cases, thinning sprays targeted to tree tops are often advisable to keep the trees in balance and discourage alternate bearing.

Response to chemical thinners can vary relative to weather conditions before, during, and after application, especially in the case of postbloom materials. Most postbloom chemical thinners perform better in warm temperatures, especially BA, ABA, NAA, and ethephon. Caution should be exercised when applying thinning materials in temperatures above 85°F, especially during dark, cloudy conditions, as fruitlet abortion and/or phytotoxicity may become excessive. . Thinner efficacy may diminish below 70°F, but low temperatures can also temporarily mask the symptoms of a significant thinning response; growers dissatisfied with the performance of thinning sprays during cool conditions may be well advised to wait for a few days of warm temperatures to reassess fruit set before applying additional thinners. See individual product labels for additional guidance.

Effective chemical thinning is more difficult in some apple cultivars; Fuji, Golden Delicious, and Cameo generally require more aggressive tactics (i.e. more applications and/or higher rates) than do Red Delicious, Gala, Cripps Pink (Pink Lady®), Granny Smith, Honeycrisp, Jonagold, or Braeburn to achieve comparable results. WA 38 (Cosmic Crisp®) tends to naturally thin its clusters to 1-2 fruit and chemical thinning is rarely necessary to achieve target crop loads. Ineffective thinning can result in over-cropping and induce alternate (biennial) bearing in many apple cultivars, especially Fuji, Golden Delicious, Cameo, and Honeycrisp. Unfortunately, alternate bearing cycles are easy to fall into and difficult to break and can dramatically hurt orchard profitability over time. Effective pruning and early, aggressive chemical thinning programs should be the first defenses against over-cropping, but consistent annual bearing may also be promoted with effective use of bioregulators; please refer to the section "Apple Plant Growth Regulators" for more information.

Research has shown that bloom thinning materials which damage sensitive flower parts (stigmas, styles, pollen) and/or induce whole-tree stress can reduce fruit set. Lime sulfur programs not only damage floral anatomy but can kill growing pollen tubes in pollinated flowers, as well as temporarily depress plant photosynthesis, inducing apple trees to abort some fruitlets which may have already been fertilized. Because their success is not solely reliant on damaging recently exposed organs in unpollinated flowers, lime sulfur-based thinning programs have shown more of a “kickback” effect than caustic salts in research studies. Sequential applications of lime sulfur or oil + lime sulfur can have a cumulative effect on plant stress and typically increase levels of thinning, especially in warm, cloudy weather. Growers might improve the precision of their chemical bloom thinning programs with the use of pollen tube growth models to time their bloom thinning applications; these models may be accessed on WSU's AgWeatherNet system (weather.wsu.edu).

Bloom thinning on apples

Symptom/Behaviour	Chemical	Rate per Acre	REI	PHI	Notes
Difficult to thin varieties including Golden Delicious, Fuji, Cameo, Pacific Rose	**lime sulfur/calcium polysulfide + fish oil** lime sulfur/calcium polysulfide + fish oil	1-3 % v/v 2 % v/v	48 h	none listed	Organic
	lime sulfur/calcium polysulfide + petroleum oil, summer lime sulfur/calcium polysulfide + petroleum oil, summer	1-3 % v/v 1-1.5 % v/v	48 h	0 d	Organic
	lime sulfur/calcium polysulfide + petroleum oil- dormant lime sulfur/calcium polysulfide + petroleum oil- dormant	1-3 % v/v 0.5-1 % v/v	48 h	none listed	Organic
	lime sulfur/calcium polysulfide lime sulfur/calcium polysulfide	6-12 % v/v	48 h	none listed	Organic

Symptom/Behaviour	Chemical	Rate per Acre	REI	PHI	Notes
Easy to thin varieties including Red Delicious, Gala, Braeburn, Cripps Pink, Jonagold, Granny Smith, Honeycrisp	**lime sulfur/calcium polysulfide + fish oil** lime sulfur/calcium polysulfide + fish oil	1-2 % v/v 2 % v/v	48 h	none listed	Organic
	lime sulfur/calcium polysulfide + petroleum oil, summer lime sulfur/calcium polysulfide + petroleum oil, summer	1-2 % v/v 1-1.5 % v/v	48 h	0 d	Organic
	lime sulfur/calcium polysulfide lime sulfur/calcium polysulfide	4-10 % v/v	48 h	none listed	Organic
	lime sulfur/calcium polysulfide + petroleum oil- dormant lime sulfur/calcium polysulfide + petroleum oil- dormant	1-2 % v/v 0.5-1 % v/v	48 h	none listed	Organic
	Notes: Lime sulfur is registered for use as a bloom thinner either alone or in combination with horticultural oil products on Red Delicious, Golden Delicious, Gala, Fuji, Honeycrisp, Braeburn, Cameo, Cripps Pink (Pink Lady®), Granny Smith, Jonagold, or Pacific Rose. Oils tend to increase the penetration and efficacy of lime sulfur, requiring lower concentrations of lime sulfur when combined with oils to achieve desirable results. If using oil with lime sulfur, consult the oil label for specific use guidelines. A maximum of three applications can be made during bloom according to the needs of the individual block.				

Postbloom thinning on apples

Symptom/Behaviour	Chemical	Rate per Acre	REI	PHI	Notes
Postbloom thinning all varieties	**ACC** Accede	23 - 46 fl oz	12 hours	none listed	Accede is labeled for application at timings as early as king bloom, but is more effective when sprayed at 15-20 mm fruitlet size. Use of a non-ionic surfactant may increase efficacy. See the product label for more guidance.
	Naphthaleneacetamide Amid-Thin W	2.4-8 oz	48 h	2 d	Naphthaleneacetamide (NAD) is chemically similar to NAA and can be used on varieties other than Red Delicious, where it may cause abnormally small (pygmy) fruit. Apply from petal fall to 14 days past full bloom. When the weather is cool after bloom, delay applications until the largest fruit are 2-3 mm in diameter and forecasted temperatures after spraying are above 50°F, and preferably above 65°F. Use higher concentrations of NAD if applied without a surfactant; see product label for more guidance. To increase thinning, tank mix NAD with carbaryl (see section on carbaryl).
	metamitron Brevis SC	16 - 48 fl oz	12 hours	72 days	Apply Brevis SC between late petal fall and 20 mm fruitlet size. Use a non-ionic surfactant with Brevis SC in applications west of the Rocky Mountains. Consult the product label for more information.

Symptom/Behaviour	Chemical	Rate per Acre	REI	PHI	Notes
	carbaryl Carbaryl 4L Insecticide	32 - 96 fl oz	12 h	3 d	Carbaryl mimics the action of auxins and can be applied to apple as a chemical thinner any time from 80% petal fall to 16 mm fruit size. Results from carbaryl depend on temperature, chemical rates, variety, and pollination. Carbaryl may be applied with NAA or NAD; their use in combination is more effective than when used separately. For optimal response, apply the combination of carbaryl + NAD or NAA at 8-12 mm fruit diameter. Excessive thinning may occur if daytime temperatures are above 80°F. Caution: Carbaryl is a carbamate-class broad spectrum insecticide that is toxic to many arthropod species including honeybees, native pollinators, and beneficial insects and mites important to Integrated Pest Management (IPM) programs. Even though newer formulations of carbaryl (4F, 4L) are safer for honeybees than older versions, care should still be taken to minimize the exposure of bees and other pollinators as they forage on late flowers in blocks to be sprayed or in neighboring blocks or orchards with late-blooming crops or varieties; early spray timings such as petal fall or 5 mm fruitlet size are particularly risky to pollinator health. If open bloom is present, consider other thinning chemistries (e.g. lime sulfur or NAA) or delaying carbaryl application until bloom is complete. Before using any carbaryl formulation, it is advisable to eliminate flowers in the cover crop (i.e. by mowing) to minimize bee kill. To reduce the hazard of injury to beneficial mites, direct sprays towards tree tops and limit the total number of applications. Please consult the product label or a crop advisor for additional guidance and discuss application plans with neighboring growers/beekeepers who have placed hives in/near blocks to be sprayed.
	ethephon Ethephon 2SL	1.5-6 pt	72 h	7 d	Ethephon is a synthetic precursor of ethylene and may be applied with carbaryl, NAA, and/or NAD to increase fruit thinning and promote return bloom. Applications for thinning are most effective 10-20 days after full bloom. Caution: high rates of ethephon may reduce fruit size; Red Delicious fruit shape may also be affected by inhibiting calyx-end development when applied earlier than 3 weeks after bloom. Please refer to the product label for more guidance and section “Apple Plant Growth Regulators” for more information on other uses of ethephon.

Symptom/Behaviour	Chemical	Rate per Acre	REI	PHI	Notes
	6-BA Exilis 9.5 SC	9.6-25.6 fl oz	12 h	86 d	6-benzyladenine (BA) is a cytokinin analog which has the ability to thin fruitlets as well as enhancing cell division in developing fruit, ultimately resulting in larger fruit size. For thinning, use one to two applications of BA when king-bloom fruit are 5–10 mm fruit diameter according to specific recommendations of the product label. Best results are obtained when BA is combined with carbaryl or NAA and temperatures greater than 65°F occur during and for a period of several days following application. If increased fruit size is desired without reducing fruit set, BA may be used by itself at lower concentrations than the maximum allowed by the label (see section on promotion of fruit size). Use a well-calibrated sprayer for BA applications to ensure uniform and complete coverage. Spray volumes of 100 to 200 gallons per acre should be adequate for most orchard spacings and tree row volumes.
	NAA Fruitone L	0.5 - 4 fl oz	48 h	2 d	NAA (Fruitone, PoMaxa, Refine). Naphthaleneacetic acid (NAA) is an auxin analog which can be applied from petal fall to 30 days past full bloom, with best results occurring from applications between 5 – 15 mm. The thinning effects of NAA increase dramatically when apple trees are under photosynthetic stress, so exercise caution if applying shortly before or during hot and/or cloudy conditions. Use higher concentrations of NAA if applying without a surfactant; see product label for more guidance. To increase thinning, tank mix NAA with other thinning agents such as carbaryl or 6-BA.
	6-BA MaxCel	48-128 fl oz	12 h	86 d	See notes for Exilis 9.5SC.
	NAA PoMaxa Plant Growth Regulator	0.5-4 fl oz	48 h	2 d	See NAA comments for Fruitone L.
	ABA ProTone SG	6.6 - 33.1 oz	4 h	none listed	Target upper portions of tree canopy and apply during slow-drying conditions for better results. ABA may cause significant leaf yellowing and/or abscission. **Organic**
	NAA Refine 3.5 WSG	5 - 20 ppm	48 h	2 d	See NAA comments for Fruitone L.

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