



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 10 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. Timings based on weather and crop developmental stage (i.e. mean fruitlet diameter) are generally more reliable and accurate than those based on the calendar (i.e. days after full bloom). Application timing for chemical bloom thinners may be improved with the guidance of pollen tube growth models available on WSU's AgWeatherNet system (weather.wsu.edu); these models can be used to predict when apple flowers are effectively fertilized, which can be helpful information when making chemical thinning decisions.

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. Caution should be exercised when applying thinning materials in temperatures above 80°F, especially during dark, cloudy conditions, as fruitlet abortion and/or phytotoxicity may become excessive in some cases. Thinner efficacy may be diminished below 60°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. Spur-type Red Delicious are often more difficult to thin than non-spur Red Delicious. 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 establish and difficult to break and can dramatically hurt orchard profitability over time. Early, aggressive chemical thinning programs should be the first defense 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 materials which damage sensitive flower parts (stigmas, styles, pollen) and/or induce whole-tree stress can reduce fruit set. Programs which have shown promise in experimental settings include caustic salts, weak acids, lime sulfur, and combinations of spray oils and lime sulfur. 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. Growers might improve their chances of hitting chemical thinning objectives 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	none listed	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
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	none listed	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.
	NAD 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).
	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	See NAA comments for Fruitone N.
	NAA Fruitone N	1.2-8 oz	48 h	2 d	NAA (K-Salt Fruit Fix, 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.

Symptom/Behaviour	Chemical	Rate per Acre	REI	PHI	Notes
	NAA K-Salt Fruit Fix 200	0.48-4.8 fl oz	48 h	2 d	See NAA comments for Fruitone N.
	6-BA MaxCel	48-128 fl oz	12 h	86 d	See notes for Exilis 9.5SC.
	ethephon Motivate	1.5-6 pt	48/72 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.
	NAA PoMaxa	0.5-4 fl oz	48 h	2 d	See NAA comments for Fruitone N.
	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 N.
	Notes: Carbaryl is a carbamate-class insecticide that also 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. Other factors to consider include potential toxicity to bees in or near the orchard and possible impacts on mite management. Please check the product label for additional guidance. 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 3-10 mm fruit diameter. Excessive thinning may occur if daytime temperatures are above 80°F. Caution: Many formulations of carbaryl are highly toxic to bees; use 4F or 4L formulations, which are less hazardous. If open bloom is present, apply when bees are not foraging. Before using any carbaryl formulation, it is advisable to eliminate flowers in the cover crop (i.e. by mowing) to minimize bee kill. Carbaryl can also be highly toxic to predatory mites and the rust mites on which they feed. The hazard is greatest in orchards where carbaryl has not been used extensively and little resistance has developed. Reduce the hazard of injury to mites by directing sprays towards tree tops, applying early in the season, and limiting the total number of applications.				

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