Managing Growth, Fruiting and Fruit Quality in Washington with Bioregulators

Don C. Elfving and Dwayne B. Visser

Washington State University Tree Fruit Research and Extension Center
Wenatchee, WA

Bioregulators have been used for many years to alter the behavior of fruit trees or fruit for the economic benefit of the fruit grower. Control of vegetative vigor, stimulation of flowering, regulation of crop load, reduction of fruit drop, and delay or stimulation of fruit maturity and ripening are important examples of processes in fruit trees and fruit that can be regulated with exogenous applications of bioregulators. We used to call these products "growth regulators," but that term has been replaced with the new name "bioregulator" because many of the processes we influence with these products do not necessarily involve growth, but rather other physiological processes in the tree or fruit. A bioregulator is defined as any exogenously applied chemical that can imitate or counteract one or more effects normally produced by or affected by naturally occurring hormones in the plant itself, resulting in an economic benefit for the fruit grower.

New candidate bioregulators with possible benefits for fruit growers are appearing more or less regularly now; in addition we are still finding new uses for bioregulator products that have been made available for other uses. In this discussion we will describe research we have undertaken with several bioregulator products as we seek knowledge about how to use these products beneficially in the orchard and fruit tree nursery.

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APOGEE® FOR CONTROL OF VEGETATIVE GROWTH IN APPLE

Prohexadione-calcium, the active ingredient in the product Apogee® (BASF Corp.), has been registered for use on vigorous apple trees for 3 years. This product acts by inhibiting the conversion of inactive forms of gibberellic acid (GA) into active forms in the tissues of the fruit tree. GA stimulates the elongation of cells and thus is intimately involved in the process of shoot growth. Reducing the amount of active GA reduces the stimulus for cell elongation, thereby reducing shoot extension growth. Apogee has a relatively short life in apple trees; for this reason it must be applied more than once per season to obtain control over vegetative growth. We have conducted extensive tests with Apogee over the past 5 years. We have observed that apple trees under Washington conditions often tend to maintain active shoot growth for several months, even if the trees are not exceptionally vigorous. This potential for active growth over a long period makes effective control of vegetative growth with Apogee more difficult. We have observed an interesting pattern of growth behavior in response to Apogee application that appears to be fairly consistent from year to year. When Apogee applications are begun in the spring, when new shoot growth is up to several inches in length (late April to early May), we typically observe a slowdown in shoot extension growth over the next 3 to 4 weeks that often results in cessation of shoot elongation in June. However, all too often, shoot extension growth resumes in early to mid-July. In trials we have run in the past 3 years, we have observed that the same Apogee rates and application timings that can shut shoot growth off in June are not capable of stopping a second growth flush if it starts in mid-summer. We do not know why this occurs, but it may be related to the accumulation of inactive GA forms due to the inhibition of the enzyme that converts these to active forms as well as to possible effects of environmental factors in the summer. Because Apogee is expensive, effective control strategies must necessarily seek to minimize both amounts used and the number of applications. However, even when we maintain a schedule of Apogee applications at regular intervals (every 3 weeks) starting in early May, we have seen a loss of control over shoot growth in mid-summer, although the resulting shoot growth may not be very vigorous. Unfortunately, we have not yet figured out why this occurs or how to control the second growth flush without making the cost excessive.

In making decisions about Apogee use, apple growers should also keep in mind that our research has NOT shown any positive effect of Apogee application on fruit in the season of use or on flowering the next season. In addition, we have never observed an improvement in fruit set from Apogee treatment under Washington growing conditions. Growers interested in using Apogee for shoot growth control should carefully monitor their trees throughout the growing season to be sure they are obtaining the growth control they want to achieve.

ETHEPHON® FOR STIMULATION OF FLOWERING IN SWEET CHERRY TREES ON SEEDLING ROOTSTOCKS

There has been an explosion in the planting of sweet cherry in Washington over the past 10 years. Mazzard seedling has been the standard rootstock for sweet cherries for many decades; interest is now increasing in the new, clonal, size-controlling rootstocks. However, seedling rootstocks for sweet cherry are still popular and represent a significant percentage of new trees being planted.

Seedling rootstocks have several advantages. Among their disadvantages is the strong tendency to delay the onset of flowering and fruiting for several years after planting. Ethephon is known to induce flowering in young apple trees, however very little research has been done to explore the potential of this product for stimulation of precocity in sweet cherry.

As an outgrowth of our research program with Apogee on apple, in 2000 we began to look at both Apogee and ethephon as possible tools for reduction of vegetative vigor and stimulation of flowering in sweet cherry. Initially we observed some very interesting effects on shoot growth reduction and stimulation of flowering in young Bing trees with Apogee, ethephon and tank mixes of the two products. However, more recent work in 2002 and 2003 has shown that

Apogee has little effect on improvement of flowering in sweet cherry. While this result is consistent with our observations of the absence of Apogee effects on flowering in apple and pear in Washington, it is unfortunate that this product seems to have no stimulative effect on flowering in sweet cherry. On the other hand, ethephon definitely has potential for stimulating precocious flower formation in sweet cherry trees on seedling rootstocks. We are now trying to determine the rates and timings that optimize this response and we are examining various sweet cherry cultivars to evaluate their responses. The variation in cherry cultivar response to ethephon may be significant. So far we have worked with 5 different cultivars and observed 5 different responses. Much more work is needed to clarify this situation, but some of our results have been promising. In one trial we increased yield the next year by more than 2 tons/acre. In two other trials in another location, ethephon treatment improved the first-time yield in those orchards the year after treatment by 38% and 115% with no loss in fruit size. We have some tantalizing evidence that ethephon treatment in one season may be able to increase flowering in young sweet cherry trees for the next two seasons.

CONTROL OF ALTERNATE CROPPING IN APPLE

Alternation in cropping from year to year has always been a problem in apple production. We know that this problem originates when apple trees set either too few or too many fruit shortly after bloom. In a low-set situation, most spurs have no fruit. As a result, most of these spurs flower the following year, establishing the alternating pattern. In a high fruit-set situation, as the seeds in the fruit develop, they release gibberellic acid into the surrounding tissues of the spurs. This GA inhibits flower initiation for the next season, thereby setting up the alternating pattern. The advent of sophisticated chemical thinning programs was very helpful in reducing alternate cropping, but many of our important apple cultivars, such as Fuji and Pink Lady®, are very susceptible to alternation of production. Even with the application of modern chemical thinning methods, it may be very difficult to overcome alternate bearing in many orchards.

A new concept that we are now testing essentially uses the tree's behavior to try to overcome alternate bearing. In the "off" year, too few spurs carry fruit, so there is a strong initiation of flowering in the huge majority of "resting" spurs (spurs with no fruit). If we apply GA to these trees at the time flower initiation is taking place, shortly after bloom, we can reduce the amount of flowering the next year. The question that requires answering is this: If we use exogenous GA in the off year, can we get enough reduction in flowering the next year (the "on" year) to help stimulate sufficient flowering so the subsequent off year is not so "off"? In our tests, we are combining this idea of GA application with various thinning programs in the on year to determine if there is an optimum combination of GA in the off year plus thinning in the on year that will allow us to either stop or greatly curtail the otherwise strong year-to-year variation in cropping we still see all too often.

At this point we are 2 years into the trial program. So far we have found that we can reduce flowering in off-year Fuji trees with a single application of GA_{4+7} (not GA_3), up to 58% reduction in one trial. We have observed that we have increased the percentage of resting spurs by up to over 100%, so we feel optimistic that we may have effectively broken the alternating cycle this time around. We still have to take more data to see if any of our treatment combinations will turn out to produce higher yields the following year, the next off year under normal circumstances. GA is expensive, so this approach has to work well to be cost effective. It is still too soon to say with any certainty that we have a new tool to combat alternate bearing, but the initial results appear favorable.

STIMULATION OF LATERAL BRANCHING IN YOUNG TREES

We began work with a new bioregulator, cyclanilide®, two years ago. This product has no registered uses in tree fruit at the present time. Cyclanilide appears to act as an anti-auxin in the plant. Auxin is one of the two groups of plant hormones involved in "apical dominance," the physiological phenomenon that controls the way that buds break when growth takes place. On vigorous new shoots, the shoot tip and the newest leaves produce auxin, which moves down the shoot. This auxin inhibits the lateral buds in the axils of the leaves from breaking and growing, even though they are capable of doing so under the right conditions. When cyclanilide is applied to growing shoots, it appears to temporarily interfere in some way with auxin behavior, resulting in a burst of lateral buds breaking and growing into lateral shoots. This kind of response can be beneficially applied to the formation of the canopy in young trees of highly apically dominant species such as sweet cherry and may also be very useful in the nursery for stimulation of feathering (lateral branch formation) in nursery trees. Cyclanilide appears to be very effective on apple, pear and sweet cherry. One very nice characteristic that enhances its potential as a branching agent is the fact that cyclanilide does not damage the active shoot tip in any way. Treated shoots form laterals, but the terminal shoot tip on each shoot continues to develop normally, permitting the normal formation of that shoot. For nursery trees this is especially important because nursery trees are formed as central leaders, with a dominant leader shoot and lateral shoots growing out at wide angles to the leader shoot. Cyclanilide promotes strong lateral branch development with wide crotch angles while permitting the central leader to continue development. We are intensively studying how cyclanilide acts under both orchard and nursery conditions. We think this product has a useful role to play in the structural development of fruit trees. We hope that registration can be obtained once we have confirmed the potential of this product in fruit tree growth and development.

MECHANICAL HARVESTING OF SWEET CHERRY

Mechanical harvesting is routine in many processed crops but has not been widely adopted for fresh market production of tree fruit. Recently interest has grown in Washington in the possible application of mechanical harvesting methods for sweet cherry. Preliminary trials with mechanically harvested cherries have shown that an acceptable product can be obtained and that consumers will readily accept mechanically harvested sweet cherries in good condition. The key to successful mechanical harvest of sweet cherries is the capacity to loosen the fruit sufficiently to permit their removal by shaking limbs. Loosening of sweet cherries has been accomplished by applying ethephon a week or two before harvest. Ethephon stimulates an abscission zone to form between the cherry fruit and the pedicel (the stem-like structure that attaches the fruit to the tree). Thus mechanically harvested sweet cherries are "stemless," i.e., they lack the pedicel that is characteristically present in hand-harvested fruit. The absence of pedicels has not proven a barrier to consumer acceptance. Many factors appear to influence the ethephon-mediated fruit loosening process, and ethephon produces other side effects that are not desirable. We have been investigating ethephon effects on Bing cherry loosening, fruit quality and side effects for the past few years.

When ethephon is applied to sweet cherry trees, several things happen. The fruit begin the process of separating from the pedicels. This process is slow, normally taking as long as two or more weeks for fruit to loosen sufficiently to be harvestable mechanically by shake-and-catch methods. We have found that the ethephon-induced loosening is also accompanied by ethephon-induced loss in flesh firmness in the fruit, an undesirable side effect. We have also observed that ReTain application prior to or with ethephon has little or no effect on either the loosening process, flesh firmness loss, or any other fruit quality parameter. We doubt that ReTain will have a useful role to play in maintaining fruit firmness or other quality factors in ethephon-treated sweet cherries.

Ethephon causes gummosis in sweet cherry trees. The amount of gummosis appears to be related to the amount of ethephon applied per acre, but we have not been able to demonstrate a convincing relationship between gummosis severity and actual concentration of ethephon in the spray solution. The gummosis reaction appears to represent some sort of injury response to treatment, but we do not yet know what implications the appearance of gummosis might have on tree productivity the subsequent year. Even more importantly, we simply have no data on what might occur if ethephon were to be used annually over several years. Only further research can determine whether long-term exposure to ethephon is harmful to sweet cherry trees under Washington conditions.

Unfortunately, at this time no other product is known besides ethephon that can loosen sweet cherries for mechanical harvest. Other products are used in other crops. In preliminary research with three such products, none showed a beneficial effect on loosening sweet cherries. The ideal would be to find an effective abscission agent for cherry that did not degrade fruit quality. At this point such a product remains unavailable.

Bioregulators are widely used in tree fruit production. They produce many beneficial effects on both trees and fruit. Our research program seeks to expand the range of useful responses of fruit trees and fruits themselves to bioregulators by conducting trials of new products as well as new research directions for bioregulators already available for use in the tree fruit industry.