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# INTRODUCTION

The use of feathered trees combined with high planting densities and minimal pruning has resulted in a significant improvement in yield of new orchards over the first five years.

The larger the initial caliper of the tree at planting, the greater the growth and yield in the first four to five years. The greater the number of feathers at planting, the greater the yield, especially in the second and third years.

Feathered nursery trees are a critical component of most high-density apple planting systems including the Tall Spindle. As the benefits of highly feathered trees were discovered, it became necessary to develop nursery management techniques to stimulate lateral branch development.

This "desired product" led to the development of the two-year branched tree, the two-year "knip" tree, leaf removal/pinching techniques, fertigation and the use of plant growth regulators such as Promalin, Maxcel, and Tiberon. As these practices and new products have been implemented by nurseries around the world, the quality (caliper, tree height, feather po-

sitioning along the trunk, crotch angles, number and length of feathers) of nursery trees has improved considerably over the last 20 years.

The number of feathers on U.S.-grown nursery trees has also improved significantly in the last decade. Most nurseries used a single spray of Promalin combined with leaf removal to obtain trees with three to five feathers. In the spring of 2009 a new branching chemical, Tiberon, was registered, and was used commercially in the Northwestern United States. Its use significantly improved the quality of apple nursery trees.





## **Figure 1**



FIGURE 1 – EFFECTS OF CYCLANILIDE (TIBERON) OR BENZYL ADENINE (MAXCEL) ON LEADER GROWTH RATE OF GALA, ACEYMAC, AND EMPIRE ON M.9 ROOTSTOCK AND MACOUN APPLE TREES ON G.11 ROOTSTOCK IN THE NURSERY OVER EIGHT WEEKS AFTER TREATMENT DURING THE 2011 GROWING SEASON AT WOLCOTT, NY.

In 2010 we evaluated the use of Tiberon in New York, and found that Tiberon sprays to Macoun trees under our climatic conditions significantly reduced tree height and caliper, and resulted in poor tree architecture. We suggested that lower rates may be needed than currently labeled for safe branching and optimal growth. It appears that there is a much more negative effect of Tiberon on tree growth in the East than in the West. For a more complete review of our 2010 findings please review Miranda Sazo and Robinson, 2011.

Currently the future use of Tiberon is in doubt since Bayer Corp., which sells the product, informed the apple nursery industry Tiberon would not be available for use on fruit tree nursery stock past this year (2012).

If Tiberon will not be available in the future, there is a great need to evaluate alternatives to ensure growers will have access to highly feathered apple trees in the coming years. Maxcel, a cytokinin plant growth regulator, is already labeled for several uses on apples, but it is not registered for chemical branching of nursery apple trees. Our results in 2010 with Maxcel have shown that three applications of 500 ppm have given very good branching with most cultivars in New York. To further study the use of Maxcel and refine the use of Tiberon in the Eastern U.S., we conducted a study in 2011 to evaluate the optimum number of sequential sprays of Maxcel to induce branching in New York using four cultivars and to determine if lower rates of Tiberon could induce branching without stopping terminal growth of Macoun trees and other similar sensitive cultivars.

### **MATERIALS AND METHODS**

An experiment was conducted in 2011 to determine the effect of Tiberon and Maxcel on branching of apple nursery trees of four apple cultivars in a nursery located in Wolcott, N.Y. The trial used a separate

### Figure 2



FIGURE 2 – EFFECTS OF CYCLANILIDE (TIBERON) OR BENZYL ADENINE (MAXCEL) ON TREE HEIGHT OF GALA, ACEYMAC, AND EMPIRE ON M.9 ROOTSTOCK AND MACOUN APPLE TREES ON G.11 ROOTSTOCK IN THE NURSERY DURING THE 2011 GROWING SEASON AT WOLCOTT, NY.

randomized complete-block design for each cultivar with four replications distributed down a row of the appropriate scion/ rootstock combination. Each experimental unit was a section of row consisting of five trees. Proprietary formulations of cyclanilide (Tiberon) and benzyl adenine (Maxcel) were used in the trials. All plant growth regulator treatments were applied with a manually operated Solo backpack sprayer with one single nozzle directed to the shoot tip of each tree. Leaf removal or leaf twisting was not conducted for all treatments.

Nursery trees were not irrigated and were treated for fire blight control with streptomycin before and after the treatments were applied. The nursery was tilled as needed for weed control and pre-emergent herbicides were not used. Fourteen Tiberon treatments (10ppm, 20ppm, 30ppm, 40ppm, 50ppm, and 100ppm) and three Maxcel treatments (500ppm) were applied once, twice or three times two weeks apart to standard fall budded nursery trees of 'Gala'/ M.9T337. 'Macoun'/G.11, 'Empire'/ M.9T337, and 'AceyMac'/M.9T337, and in the second year of the nursery cycle when the budded scion was growing. On the first application date (June 28 (Gala), June 29 (Macoun and Empire) or July 1, (AceyMac), the central leader shoot tips for each cultivar were at 33.4, 37.7, 30.1, and 28.5 inches above the soil surface, respectively. Control trees were unsprayed.

At the time of treatment, a red latex paint mark was placed on a reference node located on average at 13.9, 13.9, 12.3, and 10.8 inches below the shoot tip of 'Gala', 'Macoun', 'Empire', and 'AceyMac' trees, respectively. This painted mark was used to measure weekly the length of each shoot from the tip to the painted node. From the weekly measurements we calculated shoot growth rate (inches/day) for eight weeks after treatment (June 28 until August 24, 2011).

In November 2011, trees were measured in the nursery for: (1) trunk diameter measured five inches above bud union, (2) length of central leader above ground level to tip, (3) total number of feathers (any lateral shoot longer than four inches), (4) distance from the ground level to each of the induced feathers, and (5) length of each feather.

### RESULTS

**Leader Growth Rate.** For all cultivars leader growth rate of the untreated controls was highest at the time of the



FIGURE 3 – EFFECTS OF CYCLANILIDE (TIBERON) OR BENZYL ADENINE (MAXCEL) ON NUMBER OF FEATHERS OF GALA, ACEYMAC, AND EMPIRE ON M.9 ROOTSTOCK AND MACOUN APPLE TREES ON G.11 ROOTSTOCK IN THE NURSERY DURING THE 2011 GROWING SEASON AT WOLCOTT, NY.

first application but declined each week thereafter as the season progressed and the trees were completing their sigmoidal growth curve (Fig. 1). Empire and Gala had the highest initial growth rate followed by AceyMac and Macoun. Over the course of the summer the growth rate of Gala declined more rapidly than that of the other three varieties. Treatment with Tiberon at 100ppm dramatically reduced leader growth rate within one week of treatment. The greatest reduction in shoot growth rate was with Empire and Acey-Mac. Leader growth rate of trees treated with 100ppm Tiberon began to recover in the second week after treatment for Gala and in the third week for Empire and AceyMac. However with Macoun, shoot growth rate never recovered after the application of Tiberon at 100ppm. Lower rates of Tiberon (10ppm and 30ppm) also reduced terminal shoot growth rate but to a lesser extent than 100ppm. The lower rates of Tiberon were reapplied weekly two additional times, which resulted in a further reduction of shoot growth rate in weeks two and three. By week four or five the leader growth rate of Gala, Empire and AceyMac treated with 100, 30 or 10ppm had recovered to the level of the controls but not with Macoun. Over the course of the eight weeks of measurements, Macoun appeared to be the most sensitive cultivar to higher rates or multiple sprays of low rates of Tiberon, followed by AceyMac a bit less sensitive, followed by Empire and then Gala, which was the least sensitive and had the quickest recovery in shoot growth rate following Tiberon treatment. Overall, the lower rates of 10 and 30ppm of Tiberon sprayed three times reduced shoot growth less than the high rate of 100ppm sprayed once for all cultivars.

Maxcel sprayed at 500ppm three times

also had a small negative effect on shoot growth rate similar to the lowest rate of Tiberon (10ppm) (Fig. 1).

Tree Height. Final tree height of Gala was unaffected by a single Tiberon or Maxcel spray (Fig. 2). However, tree height of Empire, AceyMac and Macoun was severely reduced by a single spray of 100ppm Tiberon. Multiple sprays of Tiberon (20ppm or higher) and multiple sprays of Maxcel had a negative linear effect on tree height with three sprays affecting tree height more than two or one spray. Tree height of Empire was affected the most by multiple sprays of Tiberon or Maxcel followed by AceyMac, then Macoun, while Gala tree height was only slightly reduced by multiple sprays compared to unsprayed trees. Overall, treatment with low doses of Tiberon or Maxcel at 500ppm had a relatively minor effect on tree height while the high rate



of Tiberon had a significant negative effect on tree height.

Number of Feathers. Both Maxcel and Tiberon induced significant numbers of feathers in all cultivars while the untreated controls had few feathers (Gala 3.3 feathers/tree, AceyMac 0.3, Empire 1.6, and Macoun 0.3) (Fig. 3). With Gala the best treatments produced slightly more than eight feathers while with AceyMac the best treatments produced about six feathers and with Empire about 10 feathers and with Macoun about eight feathers. With Maxcel a single spray produced a large feathering response in Empire but almost no feathering in Macoun while Gala and AcevMac were intermediate. The greatest number of feathers with Maxcel was obtained with two sprays of 500ppm for Gala and Empire but with three sprays for AceyMac and Macoun. With Tiberon, a single spray of 100 ppm or two sprays of 50ppm or two sprays of 40ppm gave the greatest number of feathers with all cultivars. A third spray of Tiberon either at 10, 20, or 30ppm did not increase the number of feathers, indicating that only

two sprays were needed for acceptable branching.

Length of Feathers. Feather length of untreated trees was greatest for Gala, followed by Empire, Macoun and AceyMac (Fig. 4). Both Maxcel and Tiberon sprays reduced the length of feathers of all cultivars by 30 to 40 percent except Acey-Mac. The reduction of feather length was negatively related to the number of applications of both Maxcel and Tiberon. The greatest reduction in feather length for each cultivar was with three sprays of Maxcel while with Tiberon one single spray caused the greatest reduction in feather length.

### DISCUSSION

The effect of Tiberon sprays in 2011 on shoot growth rate after treatment was negative for all four cultivars we tested and was rate dependent. Maxcel sprayed at 500ppm either one, two or three times had only a small negative effect on leader growth rate. The labeled rate of Tiberon (100ppm) appears too high for New York state and quickly produced tree stunt-

ing. Daily growth rates (inches per day) of AceyMac and Macoun trees treated with Maxcel 500ppm sprayed three times were higher than Tiberon between July 7 and August 1, indicating that these cultivars were more sensitive to Tiberon than Gala and Empire four weeks after treatment. The lower rates of Tiberon gave less leader growth inhibition and resulted in similar tree heights as with Maxcel. Macoun trees were the most sensitive to Tiberon at 100ppm. These results were similar to our work in 2010 (Miranda Sazo and Robinson, 2011), but they indicate that the negative effects of high rates of Tiberon can be minimized with lower rates.

We conclude that Tiberon itself (not the humid weather conditions or the combined use of streptomycin as we previously speculated) is the major factor for the growth stunting we saw in Macoun trees. This negative effect is dose dependent and can be reduced if lower rates of 10-30ppm are used one to three times.

Both Maxcel and Tiberon were very effective in inducing branching on the four



FIGURE 4 – EFFECTS OF CYCLANILIDE (TIBERON) OR BENZYL ADENINE (MAXCEL) ON AVERAGE LENGTH OF FEATHERS (LATERAL BRANCHES) OF GALA, ACEYMAC, AND EMPIRE ON M.9 ROOTSTOCK AND MACOUN APPLE TREES ON G.11 ROOTSTOCK IN THE NURSERY DURING THE 2011 GROWING SEASON AT WOLCOTT, NY.

varieties we tested. This is similar to our earlier results (Miranda Sazo and Robinson, 2011), but in the present study good branching was obtained with lower doses of Tiberon without the severe stunting we saw in 2010.

Both Tiberon and Maxcel reduced the length of the feathers with multiple applications having a greater negative effect on feather length than a single application. Multiple Maxcel sprays seem to have a greater effect on reducing feather length than Tiberon. The reduced feather length is a positive effect for trees planted in the Tall Spindle system since shorter feathers are easier to manage in the close in-row spacing of the Tall Spindle (approximately three feet). We suggest that the ideal tree for high-density plantings should have 10-12 well-positioned feathers with a maximum length of 16 inches and starting at a minimum height of 30 inches from the soil. In the present study we achieved this with Empire when sprayed with Tiberon 30-40ppm two to three times. The best treatment with the other three varieties had six to eight feathers, which is close to the 10 feathers we seek.

Our 2010 results with Tiberon (Miranda Sazo and Robinson, 2011), and our 2011 results provide evidence that Tiberon sprays to Macoun trees under New York climatic conditions can significantly affect normal leader growth, reduce tree height, reduce final caliper, and result in poor tree architecture. A similar negative result was observed in 2010 by Duane Greene (personal communication) on young bench grafted Topaz apple trees. In his study, bench grafts of Pinova, Fuji, Topaz, and Creston on M.9 were planted in the orchard in July 2009 and sprayed with Tiberon at 100 ppm in the spring of 2010 when terminal shoot growth was about 10 inches. Terminal growth at the end of the season was not affected on Fuji, Creston, and Pinova, but the terminal shoot growth on Topaz was reduced by about 25 percent.

In another study in Massachusetts (Jon Clements, personal communication), oneyear Macoun trees in the orchard treated with Tiberon at 100ppm had less leader growth than untreated controls. In our trials, the lower rate of Tiberon (50ppm) applied twice in 2010 and the rate of Tiberon 100ppm applied once in 2011 similarly affected Macoun trees. It appears that to achieve more acceptable chemical branching of Macoun (or other potentially more sensitive apple cultivars), lower rates of 20-30ppm applied two to three times are needed.



FIGURE 5 – OUR RESULTS FROM 2010 AND 2011 HAVE SHOWN THAT 2-3 APPLICATIONS OF 500PPM (96.4ML PRODUCT/ 1 GALLON WATER) HAVE GIVEN VERY GOOD BRANCHING WITH MOST APPLE CULTIVARS UNDER NY NURSERY GROWING CONDITIONS.

Our results with multiple applications of Maxcel in 2010 and 2011 have been very promising. For the coming years, it appears that the potential use of Maxcel if applied multiple times (three to four sprays of 500ppm) will help U.S. nurserymen to continue producing highly feathered apple trees similar to the ones produced in the last three years with Tiberon (Fig. 5).

In Europe, Italian nurserymen use Maxcel for chemical branching of 'knip-boom' trees. Depending on cultivar, Italian nurserymen apply from three to four Maxcel treatments with spray intervals of five to seven days depending on temperatures after application.

A Maxcel spray "works better" for them when it is followed by a three hour period of at least 18°C (65°F). They prefer the use of Promalin to Maxcel only for branching of Red Delicious types. Maxcel has also been shown to be a useful tool if planting whips or poorly feathered trees in New York orchards when the leader is not headed and a Maxcel spray of 500ppm is applied to the leader from the tip down to 24 inches above the soil at 10-14 days after bud break (Miranda Sazo and Robinson, unpublished).

The importance of having highly branched trees with good height and caliper is of such critical importance to the success of newly planted high density orchards that continued research of Maxcel rates and timings under different growing conditions (in the west and east in the United States) is very important. It will result in improved techniques for chemical branching of nursery apple trees. If Tiberon will not be available in the future, there is an opportunity for Maxcel to become a good alternative for chemical branching in the U.S.

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