# Effect of Crop Load, Fertilizer, and Leader Selection on New Tree Growth of Apple

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Managing newly planted trees for growth in the Tall Spindle Planting System is more important than ever. Growers must maximize tree growth to fill out the tree canopy and ensure maximum yield and profitability. This can be more difficult for the Tall Spindle than other planting systems because this system requires nursery trees with 10-12 side branches at planting. This results in a high shoot to root ratio which requires precise management of vegetative growth, water and fertilizers to maximize growth. Small errors in tree management and growth can result in profound differences in the time it takes an orchard to become profitable.

"The tall spindle growing system requires that the trees reach the optimum tree height of 10-11 feet by the end of the third season. The most important single management practice for leader extension growth in our experiments was to remove blossoms or newly set fruit. There was no difference between blossom removal and early fruitlet removal so timing is not as important. Total tree growth as measured by trunk cross-sectional area was improved with leader selection and fertilizer but not blossom and fruit removal."

Tree height should approach 3.04 meters by the end of the 3rd leaf through terminal extension growth (Robinson et al. 2010). The trees will not reach the required height if growth is poor in any of the 3 seasons. Poor terminal growth most likely will occur the year of planting because of the damaged root system from tree digging and the large number of side branches required by the Tall Spindle that it has to support.

## Materials and Methods

In 2010 we planted a new research and demonstration orchard at Cornell's Hudson Valley Lab in Highland NY. These trees were planted in an old orchard site that was prepared over a 2 year period by removing trees, plowing and disking, and adding spot drainage. The site was cover-cropped with "Green Grazer" Sudan grass the year prior to planting. Soil samples indicated that pH and other important nutrients were at recommended levels. After planting all live buds and shoots below 20 inches were removed the day of planting. Trees were watered with 2-3 gallons shortly after planting. Eighteen different varieties and strains were planted but 4 were selected as test subjects for these experiments; SpurRed Red Delicious (Wafler Nurseries), SnowSweet (PP# 19446=MN 1797), RisingSun Fuji (International Plant Management), and NY2 PP#12/653,612, a Braeburn X Autumn Crisp Cornell variety exclusively licensed to New York Apple Growers. Three independent experiments were planned to test commonly recommended 1st leaf tree management practices that are thought to maximize growth.

**Experiment 1 - Leader Selection**. One of the early tree management techniques recommended to maximize leader growth is to remove competitive buds shortly after bud swell below a single selected leader bud forcing all the trees resources into a single bud rather than several. Typically 3-4 buds are removed resulting in a 10mm gap immediately below the selected leader bud. There is little published research that supports this recommendation, therefore we designed an experiment to remove a) No buds b) all vegetative buds within 10mm of the leader bud, and c) all buds within 20mm of the leader bud. Cultivars were Red Delicious on G.30 rootstock and SnowSweet on B.9 rootstock. In this experiment, all blossoms were removed at full bloom and trees were fertilized with 2 applications of 113.4gms $CaNO_3$ 14 days apart.

**Experiment 2 - Fertilizer Application**. A second recommended technique is to use fertilizer applications to stimulate additional tree growth. Our experiment compared a) No fertilizer, b) 113.4gms of $CaNO_3$ shortly after planting c) 2 applications of 113.4gms $CaNO_3$, the first shortly after planting and the second 14 days after the 1st application, and d) 226.8gms $CaNO_3$ shortly after planting. Rising Sun Fuji/M.9T337 was the cultivar and rootstock. All blossoms were removed at full bloom and competitive buds (10cm) were removed below the selected leader bud shortly after growth started according to recommendations.

**Experiment 3 - Blossom and Fruitlet Removal**. Newly planted trees normally flower in the 1st leaf and observations show that flowering delays and reduces tree growth. Early flower and fruit removal is thought to stimulate tree growth helping to maximize leader extension. Therefore, treatments included a) No flowers or fruit removed, b) all flowers removed at full bloom, and c) all fruitlets removed when fruit diameter approximated 20mm. NY2 was the cultivar used in this experiment.

We measured initial trunk cross sectional area (TCA), weekly leader growth, final TCA, and recorded return bloom the second leaf in all three experiments.

## Results and Discussion

**Leader Selection** –With Red Delicious, the growth rate of the leader (1.5 – 1.8 cm/week) was similar among all treatments for

the 1st 4 weeks (Fig. 1). The 0cm and10cm treatment continued to grow at this rate for an additional 6 weeks. The growth rate of the 20cm removal treatment slowed to 0.8cm/week for the next 6 weeks resulting in significant differences in leader length between the 20cm treatment and the others. From August 19 through the final measurements on September 23, the leader continued to grow slowly in the 10 and 20mm treatments at a similar rate. The 0cm treatment slowed significantly on August 20 and its growth rate dropped below that of the 10 and 20cm treatments. These results suggest that very early in the growing season competitive bud removal has no effect on leader growth but that as necessary resources become limiting, the removal of too much leaf surface will negatively impact leader growth rate. The 20cm treatment growth rate during the latter part of the season approximated the 10cm treatment but growth losses occurring during the middle part of the season were not made up resulting in shorter terminals at the end of the growing season. Maggs (1959) suggested this result when he said that debudding below the leader results in poorer leader growth.

The changes in TCA (Fig. 2) indicated that removal of any buds along the leader on Red Delicious resulted in less tree growth suggesting that maximum tree growth for this variety is attained without any bud removal but not leader extension.

For SnowSweet, growth rate approximated 5cm/week for the first 2 weeks, more than twice that of Red Delicious for all three treatments. After 3 weeks it appeared that the growth rate of the 0cm treatment began to slow and this was very evident by the 4th week after bud removal. Leader growth nearly stopped after 4 weeks. The 10cm treatment showed the same trend as the 0cm treatment but continued rapid growth for 3 week with leader growth rate slowing then stopping after 5 weeks. The 20 cm treatment continued to grow as the initial rate through the 4th week then slowed and stopped by week 6. It appears that growth rates are the same for all three treatments and only the length of time that leaders continue to grow is affected. This response is typical of that suggested by Llewlyn (1968) and Norton (unpublished).

Fig. 4 shows that the bud removal positively impacted overall growth of SnowSweet with the 20cm treatment producing 60% more growth than either the 0cm or 10cm treatments.

The differing growth responses for Delicious and SnowSweet indicate that different leader management procedures are appropriate and may depend on the variety. Slow growing weak varieties appear to do better without leader selection whereas more vigorous varieties better with bud removal.

**Fertilizer Applications** – Fertilizer application recommendations vary depending on the planting system and region. Weber (2000) recommends no nitrogen the first few years after planting yet careful fertilizer applications shortly after planting are the standard for newly planted trees in NY (Agnello et al., 2011). The standard recommendation in NY is to use one or two applications of calcium nitrate at 113.4gm per tree after a significant rain or irrigation has ensured that the soil has settled tightly around the tree roots. This protects the roots from direct exposure to the fertilizer that may burn them. This experiment compared different rates and application timings to see which promoted tree growth. The best treatment was a single application of 133.4gm $CaNO_3$ but was not significantly different from no fertilizer or 266.8gm of $CaNO_3$ (Fig. 6). The split application of 133.4gm applications 14 days apart was the poorest treatment but not significantly different than the others.

Overall growth measured by the change in TCA was best with the treatment using 2 applications of 133.4gms of $CaNO_3$ (266.8gms total), followed by a single application of 266.8gms, and then the single application of 133.4gms of fertilizer (Fig. 7). Treatment with no fertilizer showed the poorest growth. Split applications of fertilizer improved tree growth (TCA) by 38%. Although leader growth did not show it, overall tree growth as measured by the change in TCA suggests that 1st leaf tree growth is significantly improved with the careful application of additional

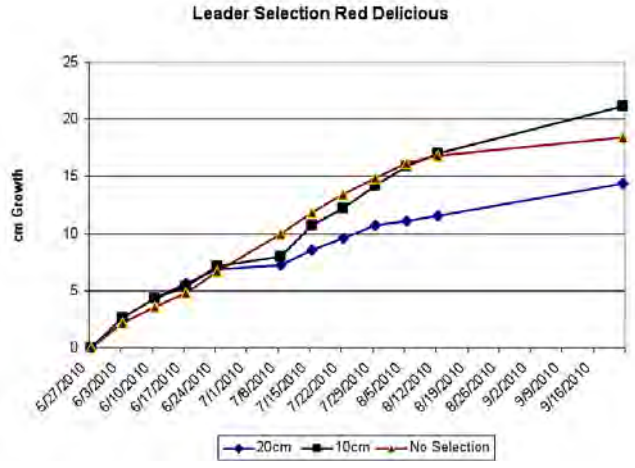


**Figure 1. Leader growth of Red Delicious after complete removal of all buds 0, 10, and 20 cm below the selected leader bud.**

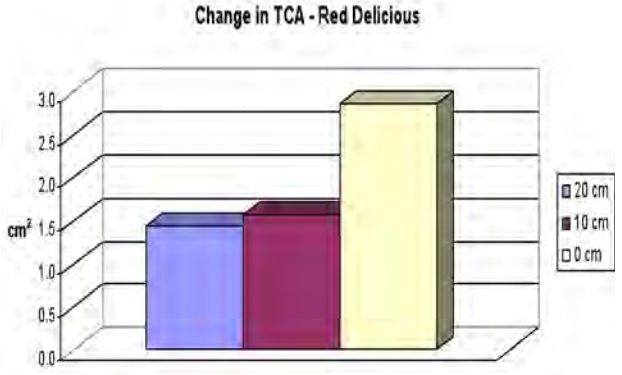


**Figure 2. Change in Trunk Cross Sectional Area(TCA) of Red Delicious after complete removal of all buds 0, 10, and 20 cm below the selected leader bud.**

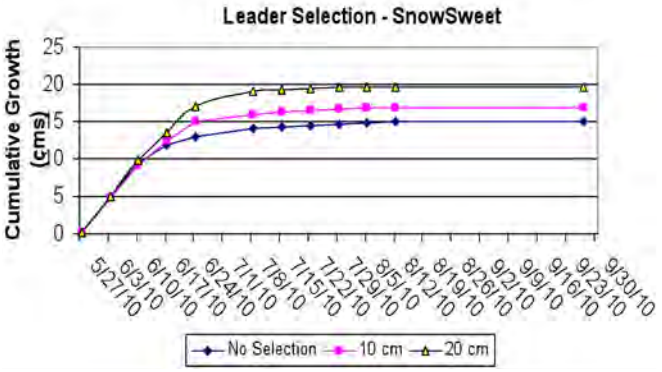


**Figure 3. Leader growth of SnowSweet after complete removal of all buds 0, 10, and 20 cm below the selected leader bud.**

nitrogen. This additional growth would likely reflect in better 2nd year growth. Poorer nursery trees would also likely benefit from aggressive fertilizer application.

**Blossom and fruitlet removal** - A third management practice thought to influence tree growth is blossom and early fruit removal on newly planted trees (Maggs, 1963). Nursery practices, the use of dwarfing rootstocks and minimally pruned planting systems typically induce 1st leaf trees to bloom shortly after planting (Fig. 8). Depending on tree vigor, pollinators available and environmental conditions these flowers can set and develop into normal fruit (Fig. 9). Pomologists have long observed that trees that flower shortly after planting in the orchard have reduced early shoot growth particularly when the terminal leader bud is a fruit bud. It is also apparent that these trees often set fruit which further restrict growth. In this trial, both blossom removal and removal of fruitlets (at 18.9 mm fruit diameter) allowed the leader to put on 20% more growth the year of planting (Fig 10). There was no difference between blossom and small fruit removal suggesting that the window between blossoming and early fruit set is suitable for removing potential fruit that could interfere with tree growth. The treatment where blossoms and fruit were not removed set an average of 5.2 fruit per tree (2-10 fruit). It is evident from the data (not shown) that the more fruit that set, the more growth restriction occurs.

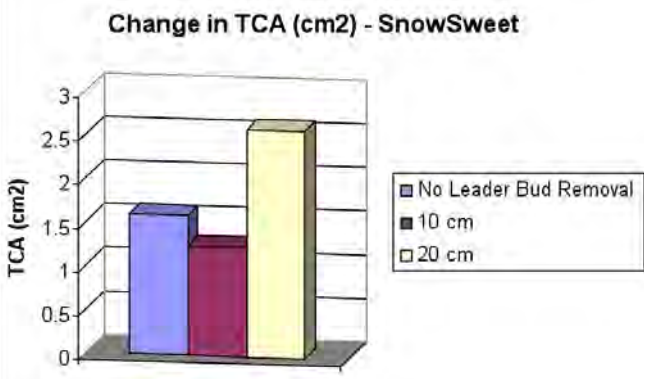


**Figure 4. Change in Trunk Cross Sectional Area(TCA) of SnowSweet after complete removal of all buds 0, 10, and 20cm below the selected leader bud.**

**Figure 5. Calcium nitrate was spread around the tree within the root zone making sure no fertilizer contacted the trunk.**

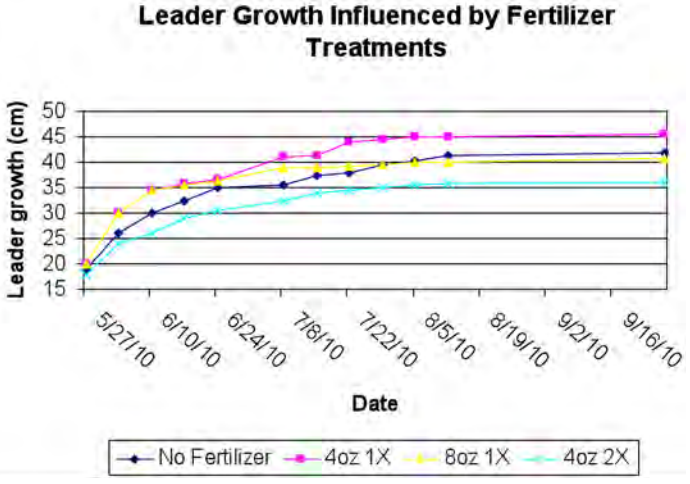


**Figure 6. Seasonal leader growth for 4 fertilizer treatments on Rising Sun Fuji; 1) None 2) 4oz $CaNO_3$ 3) 8oz CaNO3 4) 2 applications of 4 oz $CaNO_3$ 14 days apart.**

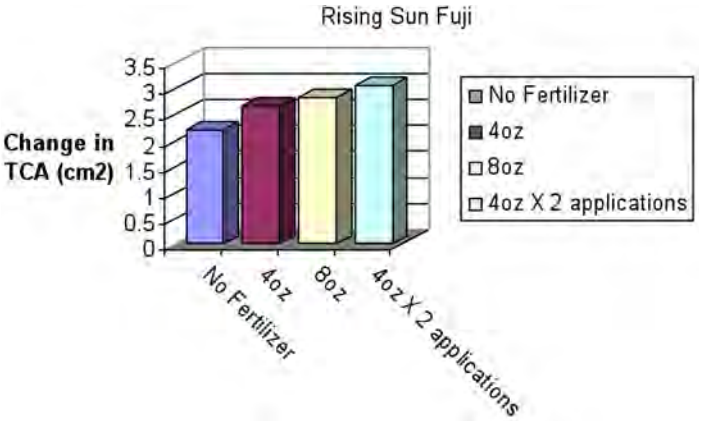


**Figure 7. Change in Trunk cross-sectional area (TCA) influenced by different 1st year fertilizer treatments.**

**Figure 8. Leader growth with 10cm removal. All bloom removed at this stage in blossom removal treatment.**

**Figure 9. Fruit set stage. All fruit removed at this stage in the fruit removal treatment.**

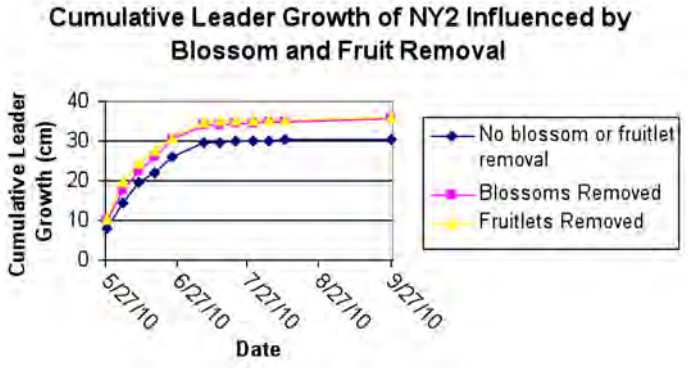


**Figure 10. Influence on leader growth of NY2 with blossoms removed, fruit removed, and no blossom or fruit removed.**

## Conclusions

Leader growth can be influenced by leader selection, fertilizer, and blossom and fruit removal. The effect is not as great as expected when the other important management practices studied were combined with each of them. This experiment did not include a treatment where none of the three management practices were followed but this scenario likely would have resulted in more significant growth reductions resulting in reduced profitability of the Tall Spindle planting system. The most important single management practice for leader extension growth in this experiment was to remove blossoms or newly set fruit. There was no difference between blossom removal and early fruitlet removal so timing is not as important. Total tree growth as measured by trunk cross-sectional area was improved with leader selection and fertilizer but not blossom and fruit removal.

There are many other known factors that are important in new tree growth including the effect of weed competition and irrigation.

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