Organic Methods to Promote Branching in Nursery Apple Trees

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Summary

With funding from a USDA-SARE Farmer Rancher grant, we compared several organic methods of promoting branching in nursery apple trees raised in a high tunnel. Manually removing young leaves near the growing point of the tree increased branching slightly, and spraying trees with a seaweed extract high in cytokinins reduced branching slightly. In addition, taller trees had more branches, there were strong differences between varieties in branching, and individual trees varied greatly in both height and branching. The cost in materials and labor for raising a tree in this system was approximately $11.95-$12.08, excluding overhead costs and costs of facilities and equipment; the different treatments to promote branching had minor effects on the overall cost of raising a tree.

Background and Objectives

The tall spindle training system has become a popular and successful method for growing apples in the eastern United States. Research has shown that planting well feathered trees, with 10-15 small branches along the trunk, is key to high yields in the second and third years after planting and essential to a profitable return on investment with this system.

Chemical plant growth regulators as well as manual leaf pinching have been used to produce well feathered nursery trees. Untreated nursery trees typically produce few branches because the young leaves in the growing tip of the main stem produce the growth hormone auxin which travels down the stem of the plant and inhibits lateral buds from developing into branches. Studies have shown that manually removing young leaves decreases auxin production, promotes branching, and will develop well-feathered trees in some varieties.

Researchers and commercial nurseries have also identified several effective synthetic chemical growth regulators which inhibit the effects of auxin and promote branching: Maxcel (a cytokinin), Promalin (a mixture of a cytokinin and 2 gibberellins), and Tiberon (cyclanilide). However these products are not permitted in organic production. Natural cytokinins derived from seaweed are sold commercially and are allowed in organic production

Organic apple growing is increasingly common in the midwest and eastern United States. The only common sources of feathered planting stock for the tall spindle system are commercial nurseries which raise non-organic apple trees. Although organic standards permit planting non-organic trees, many organic growers prefer to graft and raise their own trees organically to reduce reliance on synthetic products and/or to grow uncommon varieties which are well-suited to their orchard and markets but which are not readily available through commercial nurseries. We and other organic growers have been able to raise healthy trees using organic methods in on-farm nurseries, but we have found it difficult to produce well-feathered trees.

The goal of our research was to evaluate two organic methods of promoting branching in nursery trees. We compared manual leaf removal and organic cytokinin sprays to an untreated control. For each treatment, we recorded data on material cost and time required, tree growth, and feathering.

Research Methods

Our entire farm is certified organic by MOSA (mosaorganic.org) and only organic methods were used in this research. We bench grafted 60 trees each of nine varieties (Pristine, Williams Pride, CrimsonCrisp, Ashmead's Kernal, Golden Russet, Egremont Russet, Macoun, Grimes Golden, and Hudson's Golden Gem) onto G.41 rootstock from March 24-31,

2018. We collected scionwood for Pristine, Williams Pride, and CrimsonCrisp from our own orchard; we purchased scionwood of the other varieties from Maple Valley Orchards (Suamico, WI); and we purchased rootstock from Cummins Nursery (Ithaca, NY). We held trees at 65^{o} for two weeks to promote callus formation and on April 13, 2018 we planted them in an unheated 34'x102' high tunnel covered with a single layer of polyethylene. Prior to planting we applied 2 inches of finished compost (Purple Cow Organics SoilLife) over the soil surface in the entire tunnel. Because of unseasonably cold weather (outdoor daily high temperatures from 27-46°F and daily lows from 22-35°F), we covered the trees with frost cover fabric for one week after planting. After removing the frost cover we applied 4 inches of hardwood bark to the entire tunnel for weed control. Tree spacing was 10.75" within row, 3' or 8.5' between rows. As trees grew, we thinned shoots to a single shoot per scion, we manually removed all branches below 22" above the graft union, and we fastened leaders to a bamboo stake. We irrigated trees as needed with drip tape throughout the season. We ventilated the tunnel by raising rollup sides and opening end wall doors except during severe storms and cold spring weather.

We scouted trees regularly for pest issues. We applied several sprays with a backpack sprayer to control pest infestations: on 7/9, 7/16, 7/24, 8/2, and 8/10 we sprayed Pyganic EC 1.4 II (1/4 cup/gallon spray) to control potato leafhopper, Japanese beetle, and various caterpillars; and on 8/21, 8/29, and 9/5 we sprayed JMS Stylet Oil (1/4 cup/gallon spray) to control spider mites.

We planted trees in a randomized complete block design, with four blocks, and 27 plots per block; each plot had five trees of the same variety to which one of three treatments was applied: (1) untreated control; (2) manual leaf removal – tear off 3 young developing leaves near growing tip three times, two weeks apart, starting when leader reached 22" above graft union; (3) spray Sea Crop 16 three times, two weeks apart, starting when leader reached 22" above graft union, at maximum label rate (2 cups/gallon water) to 8-10" at the top of tree. (Sea Crop 16 is an OMRI-listed plant growth regulator produced by North American Kelp, Waldoboro, ME. We selected it because it had the highest cytokinin concentration of any organically-approved plant growth regulator which we are aware of. Note that this maximum label rate of Sea Crop 16 results in 50 ppm cytokinin, which is only 10-20% of the concentration of cytokinin which is typically used when Maxcel is sprayed to promote branching in conventional nurseries).

At the end of the season we collected data on the height of each tree above graft union, the height of lowest branch above the graft union, the number of branches>1" in length, and the length of all branches >1" in length.

Results

Graft Success

Graft success (measured as percent of grafts which had a live scion at the end of the growing season) was mixed. It was only 3% for Egremont Russet, presumably due to poor quality of purchased scionwood for this variety. Other varieties ranged from 60%-98%. Purchased scionwood generally performed less well than scionwood collected from our orchard. On several grafts, scions began growth in spring but then flagged and died during extremely hot weather in June. This was particularly true in the center of the tunnel (presumably the hottest area).

Branching

The appendix at the end of the report contains scatterplots which show the actual number of feathers >4" long and leader height for each successful graft in the study. Previously published guidelines state that feathers at least 4" long are desirable in the tall spindle system.

We performed multivariate regressions to examine the simultaneous effects of tree height, variety, treatment, and block on several different response variables.

There was a strong, statistically significant ($p<0.05$) correlation between height of tree and number of feathers >4" in length. Taller trees had more feathers. After accounting for differences due to variety and treatment, each increase in tree height by 6" resulted in one more feather >4" in length.

There was a strong, statistically significant ($p<0.05$) effect of variety on number of feathers>4" in length. After adjusting for effects of tree height and treatment, Macoun had the fewest branches; then Hudson's Golden Gem, Pristine, Grimes Golden, Williams Pride, Ashmead's Kernal, Golden Russet, and CrimsonCrisp. CrimsonCrisp trees had 5 more feathers>4" in length than Macoun after accounting for effects of other variables.

There was a statistically significant ($p<0.05$) effect of treatment on number of feathers>4" in length. Leaf removal promoted branching, and the Sea Crop 16 spray actually reduced branching. After adjusting for effects of other variables, leaf removal increased the number of feathers>4" in length by 0.9, and spraying decreased the number by 0.7. So the magnitude of the effect was relatively small.

Analyses of the number of feathers>1" in length showed similar trends to the analysis of feathers>4" in length.

There was no significant effect of treatment on average feather length, although there were effects of tree height (taller trees had longer feathers) and variety (Ashmead's Kernal and Pristine had significantly shorter feathers than other varieties).

There was no significant effect of treatment on the height of the first feather, although there were effects of tree height (taller trees have lower branches) and variety.

There was a wide variation in tree growth above the graft union, from 2.5' to 8'. In general, grafts grew much more than is typical for outdoor nurseries in our experience. Treatment did not affect tree height, although variety did affect height. Pristine trees were tallest, followed by Macoun, Williams Pride, Golden Russet, CrimsonCrisp, Hudsons Golden Gem, Grimes Golden, and Ashmead's Kernal.

Reports state that 10-15 feathers >4" in length are desirable for the tall spindle system. Only 18 of 379 live trees in our study achieved this. However, many leading commercial nurseries do not produce trees that meet these standards: Schlabach's and Adams County Nursery both consider 4 branches at least 8" in length enough for a tree to be sold as "feathered". 23% of our trees met that standard; ranging from 40% of trees of varieties that branch readily (Williams Pride, Golden Russet, CrimsonCrisp) down to <5% for Macoun and Hudson's Golden Gem. (Cummins and Stark Brothers do not offer a feathered grade. Wafler Nursery does not specify their standard for feathered trees on their website.)

Time and Cost For Raising Nursery Trees

The tables below show costs and time required to raise nursery trees in this experiment. In general, the costs of applying the leaf removal and seaweed extract treatments were small relative to other costs of raising the trees. Much more time was required for grafting, planting, deleafing and digging the trees. Major materials costs were for rootstocks, mulch, and compost. We divided costs into those required for all grafts regardless of whether the graft was successful (e.g., purchasing rootstock, grafting) and those required only for successful grafts (e.g., spraying trees in summer, digging trees in autumn). With this division we could calculate the cost per successful graft based on treatment and grafting success rate (Table 5). Again, treatment has a small effect on cost ($0.13 per tree). Grafting success rate has a large effect on cost – with a success rate of 60%, the cost per final tree is almost $5 greater than with a success rate of 100%. Other growers may have different costs, particularly if their labor costs, cost of rootstocks, and growing methods differ. Our figures assume a labor cost of $20/hour. Also, note that the calculations here underestimate true costs because they exclude overhead costs and costs of facilities and equipment. Also our calculations only consider costs for materials used, whereas in reality growers must often purchase more than they

need, and this factor is particularly important in small scale plantings. In addition, successful grafts varied greatly in size at the end of the season, and some were not truly large enough for planting in the orchard the following spring; the grower would need to discard those trees or raise them for another year in the nursery, thus incurring further costs.

Table 1. Time to Raise Nursery Trees: Tasks Performed For All Trees Grafted (Regardless of whether graft was successful)

Task	Minutes per tree
Graft	3.6
Spread compost	0.8
Spread bark mulch	0.9
Plant trees, stake, and cover	1.5
Remove frost cover	0.2
Weed	0.6
Early season pruning: singulate scion shoots, remove root suckers, remove flowers	0.8
Total	8.3

Table 2. Time to Raise Nursery Trees: Tasks Performed Only For Successful Grafts

Task	Minutes per tree
Remove branches below 22” above graft union	0.3
Tie trees to stake	0.1
Spray pesticide	0.5
Perform leaf removal three times (treated trees only)	0.2
Spray seaweed extract, three times (treated trees only)	0.3
Manually deleaf trees before digging	1.2
Dig trees in autumn	2.1
Total for untreated trees	2.2
Total for trees in leaf removal treatment	2.3
Total for tree in seaweed extract treatment	2.3

Table 3. Cost to Raise Nursery Trees: Costs Incurred For All Trees Grafted (Regardless of whether graft was successful)

Bamboo stake	$0.21
Rootstock	$2.63
Hardwood bark mulch	$0.60
Compost	$1.12
Labor @$20/hour (from Table 1 above)	$2.78
Total	$7.34

Table 4. Cost to Raise Nursery Trees: Costs Incurred Only For Successful Grafts

Task	Cost
Tieing tape and staples	$0.04
Pesticide	$0.04
Seaweed extract (treated trees only)	$0.05
Labor @$20/hour for untreated trees (from Table 2 above)	$1.38
Labor @$20/hour for trees in leaf removal treatment (from Table 2 above)	$1.45
Labor @$20/hour for trees in seaweed extract treatment (from Table 2 above)	$1.46
Total for untreated trees	$1.47
Total for trees in leaf removal treatment	$1.54
Total for trees in seaweed extract treatment	$1.60

Table 5. Cost To Raise a Successfully Grafted Tree as Determined by Grafting Success Rate and Branch Promoting Treatment. Does not include overhead costs or costs of equipment and facilities (including high tunnel). Graft success rate was 72% in our research.

Percentage of Grafts Successful:	No treatment	Leaf Removal	Seaweed Extract Spray
60%	$ 13.70	$ 13.76	$ 13.83
70%	$ 11.95	$ 12.02	$ 12.08
80%	$ 10.64	$ 10.71	$ 10.77
90%	$ 9.62	$ 9.69	$ 9.75
100%	$ 8.81	$ 8.87	$ 8.94

Other Observations

We saw symptoms of iron chlorosis in May-June, possibly due to overwatering and slow evaporation from the soil under the bark mulch. Our soil is high in pH (~7.0), which also contributes to iron chlorosis. Trees outgrew this condition later in the summer.

Almost none of the nursery trees set terminal buds on the leader (we have observed this in young trees grown outdoors as well). Vegetative growth continued until early-mid October. Failure to set terminal buds may be a significant problem in the following year because the young tree in the orchard will not have apical dominance and will behave as if it had been headed.

Some nursery trees formed many short axillary branches along the leader which did not elongate beyond 1" in length and therefore were not counted as branches in this study.

When practicing leaf removal, be careful not to accidentally break off the growing tip by trying to remove overly small leaves. We learned to only remove leaves which are large enough to be clearly distinguishable.

Although we don't have specific data on this, it was evident that the first leaf removal treatment encouraged branch growth, but that subsequent leaf removal treatments often resulted in no branch development or branches which remained very short.

Major pest problems were potato leafhoppers and spider mites. Both were controlled well by sprays (Pyganic for potato leafhopper, oil for spider mites). Other pests were Japanese Beetle and various caterpillars (including a number that we do not observe outdoors on apples). No disease was observed.

Conclusions

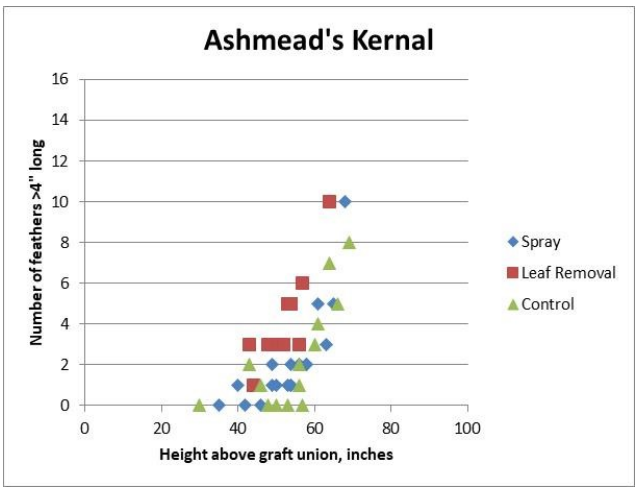
To promote branching in nursery trees, we recommend manual leaf removal because it increased branching slightly and is inexpensive to perform. Taller trees had more feathers and are generally more desirable for planting, so we recommend measures to encourage vegetative growth and vigor (e.g., a high tunnel or other crop protection/season extension, fertile soil, weed control, irrigation, and control of vegetative pests). The cost of raising trees on-farm is considerable, and we recommend careful consideration of costs and benefits. In particular, grafting success rate can have a large effect on the cost of raising a nursery tree.

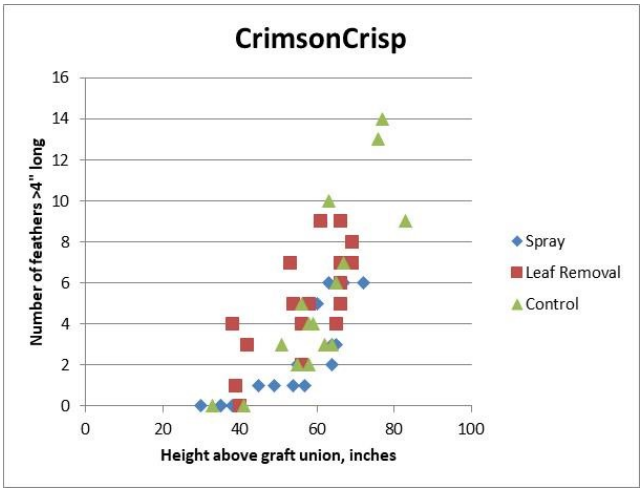
Figure 1. Tip of a leader four days after leaf removal treatment was applied. Notice the petiole stubs where leaves were removed.

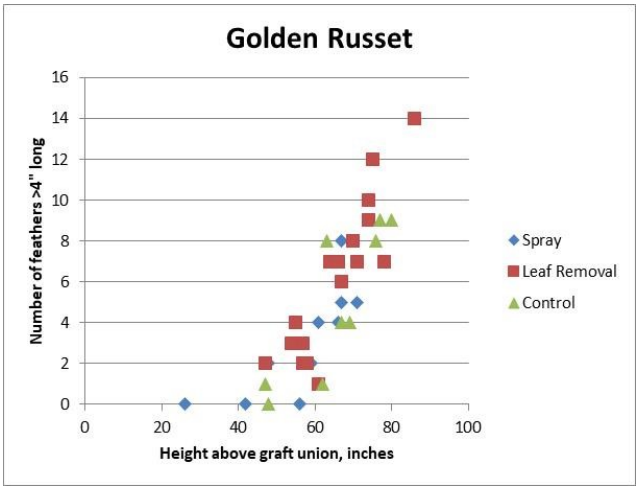
Figure 2. Trees growing in the nursery

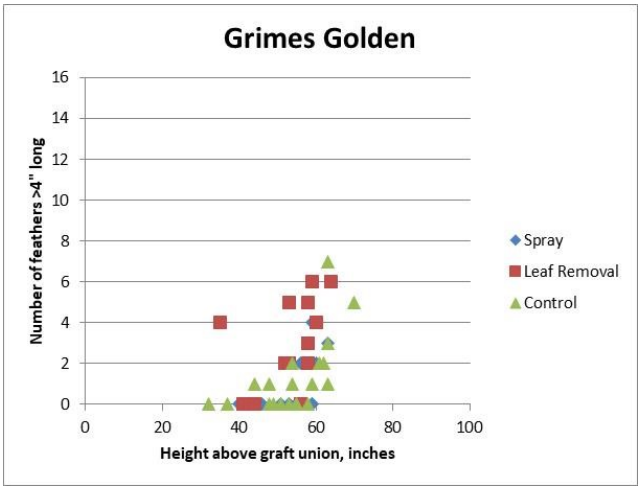
Figure 3. Two newly dug Grimes Golden Trees in December

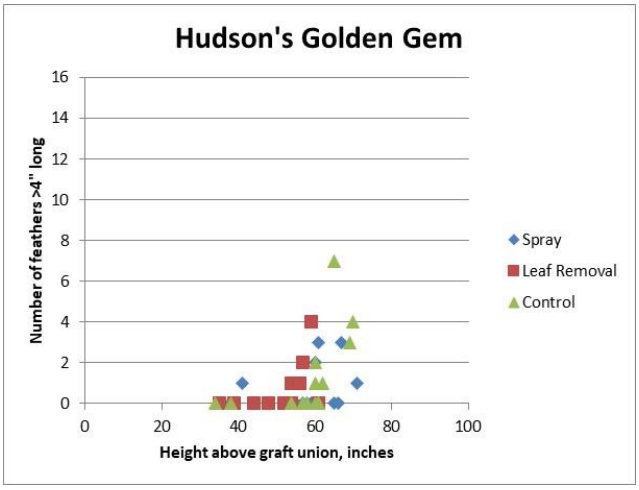
Appendix. Scatterplots showing the number of feathers and tree height of each tree for each variety. The scatterplots show the variability between trees, obvious differences between varieties in tree height and branching, and the weak but significant effect of treatment on branching.

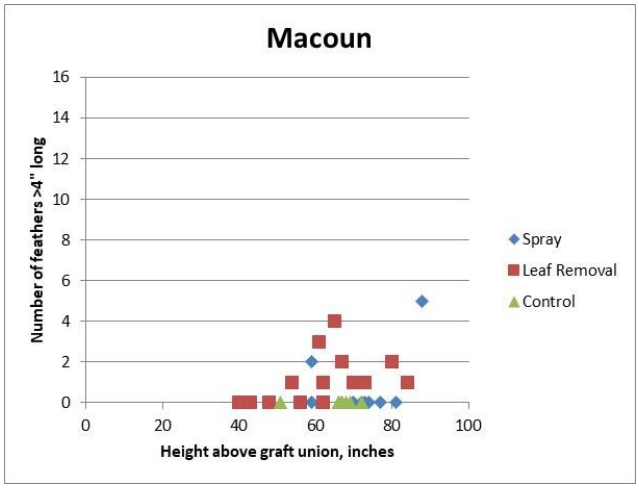


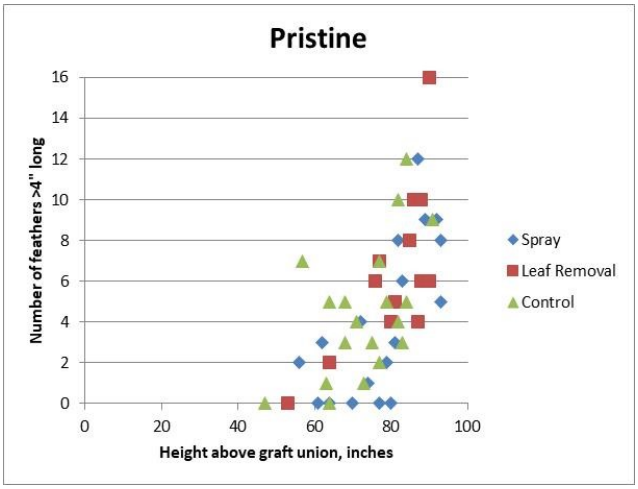


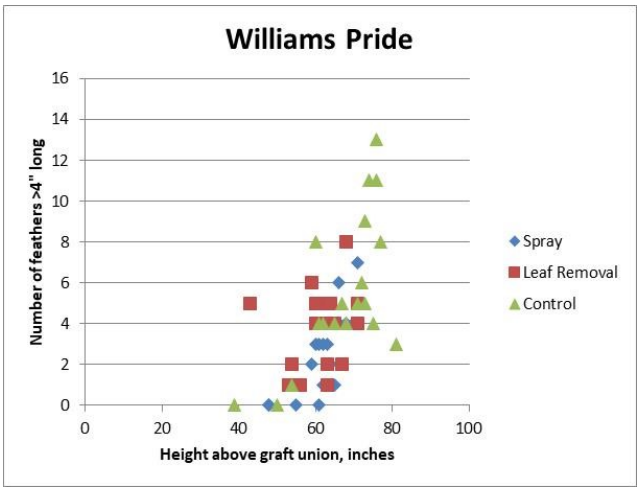












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