AGRICULTURAL RESEARCH FOUNDATION
FINAL REPORT
FUNDING CYCLE 2016 – 2018

TITLE: Berms for hazelnut plantings: a potential modernization with implications for improved production

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COOPERATORS: Darin Olson, Stuart Olson Farms Inc. Salem, OR.; Ernst Irrigation, St Paul, OR.

SUMMARY:

Hazelnuts are shallow rooted relative to other orchard crops, and they are very sensitive to excessive soil moisture. In poorly drained areas, tree growth and yield are typically greatly reduced, and in severe cases, trees die. Tiling fields can be effective at lowering the water table in some orchards, however, for some soil types, tiling is ineffective. One solution is to grow trees on berms to improve drainage and aeration, which has been become standard practice for California orchard crops including citrus, almond, and avocado. Berms may provide benefits for hazelnuts that could be attractive even for optimal soil types.

Late in the growing season of 2016, we established a plot with two berm treatments (Low and High) and a flat planted treatment (Flat) with four replications of each treatment. were established on a plot at OSU's North Willamette Research and Extension Center (NWREC), and in late winter of 2017 they were planted with 3 varieties (Jefferson, McDonald, and Yamhill) (Fig. 1). Trees were drip irrigated during the growing season. The trees received one of the following mulch treatments: 1) None, 2) Sawdust, 3) Sawdust + fertilizer, and 4) Compost. Soil moisture sensors placed at 12 inches (Sawdust treatments only) showed that the berms dried down faster after an irrigation and were overall slightly drier than flatted planted trees. Soil moisture sensors placed at 24 inches showed that the High berm dried down more between irrigations relative to the other treatments. Despite differences in surface soil moisture, there was no difference in tree growth (as measured by increases in trunk diameter and canopy height). The mulches did have a significant effect on growth, with Sawdust + fertilizer having the best growth, and the highest leaf nitrogen (N) concentration. This was likely the result of added fertilizer N that reduced N immobilization from decomposing sawdust. The Compost, which contained incompletely composted dairy manure (50% of mix), caused leaf burn, likely due to high salts, and this injury likely slowed growth.

In the coming years, we will continue to monitor tree growth and, starting in 2019, yield and nut quality parameters. This study is important for the hazelnut industry because more and more farmers are planting hazelnuts on marginal soils with poor drainage. If farmers are to remain globally competetive, they will need to adopt production practices that will maintain high yields under adverse soil conditions. Currently, more than 400 acres of hazelnuts have planted on berms in the Willamette Valley (bermed and planted by Darin Olson)

OBJECTIVES:

1. Establish a hazelnut berm planting at OSU's North Willamette Research and Extension Center (NWREC).
2. Determine the effect of berming on soil moisture and tree growth/vigor.

Additional long-term objectives (beyond the scope of this ARF proposal):

3. As trees begin producing (years 3-4) and yield data can be taken, summarize data for peer reviewed publication and produce an Extension document. Use the plots for demonstration field days for growers.
4. Document economic costs of berm establishment, weigh these against benefits.
5. Evaluate long-term value of the experiment to determine practicality and feasibility of continued research. Plots may be sustainable long-term with returns from selling the hazelnuts produced in NWREC plots.

PROCEDURES:

On August 12, 2016 the berms were established at NWREC by Stuart Olson Farms, Inc. using a GPS guided tractor and an orchard berming implement from California (Iron Tree Solutions, LLC Williams, CA). The soil is mapped as a Willamette silt loam and had the following characteristics: 3.3% OM (by LOI), pH 5.7, 158 ppm Bray 1P, and 300 ppm K. Two berm sizes were created with either 2 (Low) or 4 (High) passes with the berming implement. A flat tree row (Flat) was left between the bermed tree rows in order to evaluate tree performance and soil moisture on berms compared to industry standard flat planted trees. On November 21, 2017, six height and width measurements were made for each berm, for a total of 24 measurements per berm treatment. For the Low and High berms, the average height was 8.2 and 10.4 inches, and the average width 41.4 and 43.6 inches, respectively. On the south side of the berm trial plot, standing, and sometimes flowing surface water is present during the winter and early spring, which will allow us to better evaluate berm performance for wet soil conditions.

The field was divided into 3 sections perpendicular to the tree rows, and each section was planted to either Yamhill, McDonald, or Jefferson. Trees were hand planted between March 23 and April 4 2017. Trees were planted on 9 x 18' spacing (double density) with the best bare root trees (e.g., largest root system) planted in the permanent positions in a diamond pattern, and the remaining trees in the temporary positions. A total of 184 trees of each variety were planted in each section. All the Yamhill trees were bare root, whereas in the McDonald and Jefferson planting, 40% of the trees were 1-year-old trees that had been grown in a nursery bed in 2016. The bare-root trees were topped at approximately 36 inches when possible and trunks were painted to prevent sunburn.

On May 24-25, trees received one of 4 mulch treatments: 1) None, 2) Sawdust, 3) Sawdust plus fertilizer, and 4) Compost. The compost was a mix of yard waste compost and manure. The mixture was not stable (i.e., mature), and the pile was undergoing active, hot composting when applied. Each tree received a 5-gal bucket of mulch. For the trees receiving sawdust plus fertilizer, 2 oz of granular 27-6-6 was spread around the base of the trees prior to sawdust addition.

After the mulches were applied, the drip irrigation system was installed. Each tree received a single 2 GPH Netafim pressure compensating drip emitter located at the trunk. On May 26, the trees received their first irrigation. The trees were watered 1x per week through September 5th and the irrigation rate was applied at 100% of reference evapotranspiration (ET_o) based on the Agrimet weather station located on the station (ARAO). We calculated the rate based on a wetted surface radius of 15 inches around each tree. Weeds were controlled with herbicides (glufosinate) and hand weeding. Suckers were contolled with hand pruning several times during the season.

To monitor tree growth, the trunk diameter of each tree was measured in two directions 90° from each other at 12" above the soil line at planting and again in mid-September. Total canopy height and spread (measured in two directions 90° from each other) was also taken at the end of the growing season. To assess the effect of mulch on the tissue nutrient status of the trees, leaves were collected on September 11, 2017 in the Flat treatment only and analyzed for nutrients by Fruit Grower's Laboratory (Santa Paula, CA).

SIGNIFICANT ACCOMPLISHMENTS: (detailed results and discussion can be found in Appendix A)

1. In 2016, our key cooperator (Darin Olson of Stuart Olson Farms, Inc.) purchased an orchard berming implement and created the berms at our fieldsite at NWREC (Fig. 1).
2. In the spring of 2017, after allowing the berms to settle over the winter, hazelnut trees were planted, mulch treatments were applied, and the drip irrigation installed (Fig. 2).
3. Soil moisture at 1 and 2 feet were monitored over the growing season to understand how berming affects soil moisture availability.
4. In the fall of 2017, the first growth measurements were taken to evaluate the effect of berms and mulch on tree growth.
5. We established that N fertilizer is necessary to counteract soil N immobilization by microbes as they break down the sawdust. These results will be used to modify OSU N guidelines for young trees, which currently recommend that no N fertilizer should be applied until the tree is in its 3rd growing season.
6. We identified several challenges growing on berms including irrigation management and erosion due to modifying normal drainage flow patterns. The lessons learned will be incorporated into extension outreach activities.

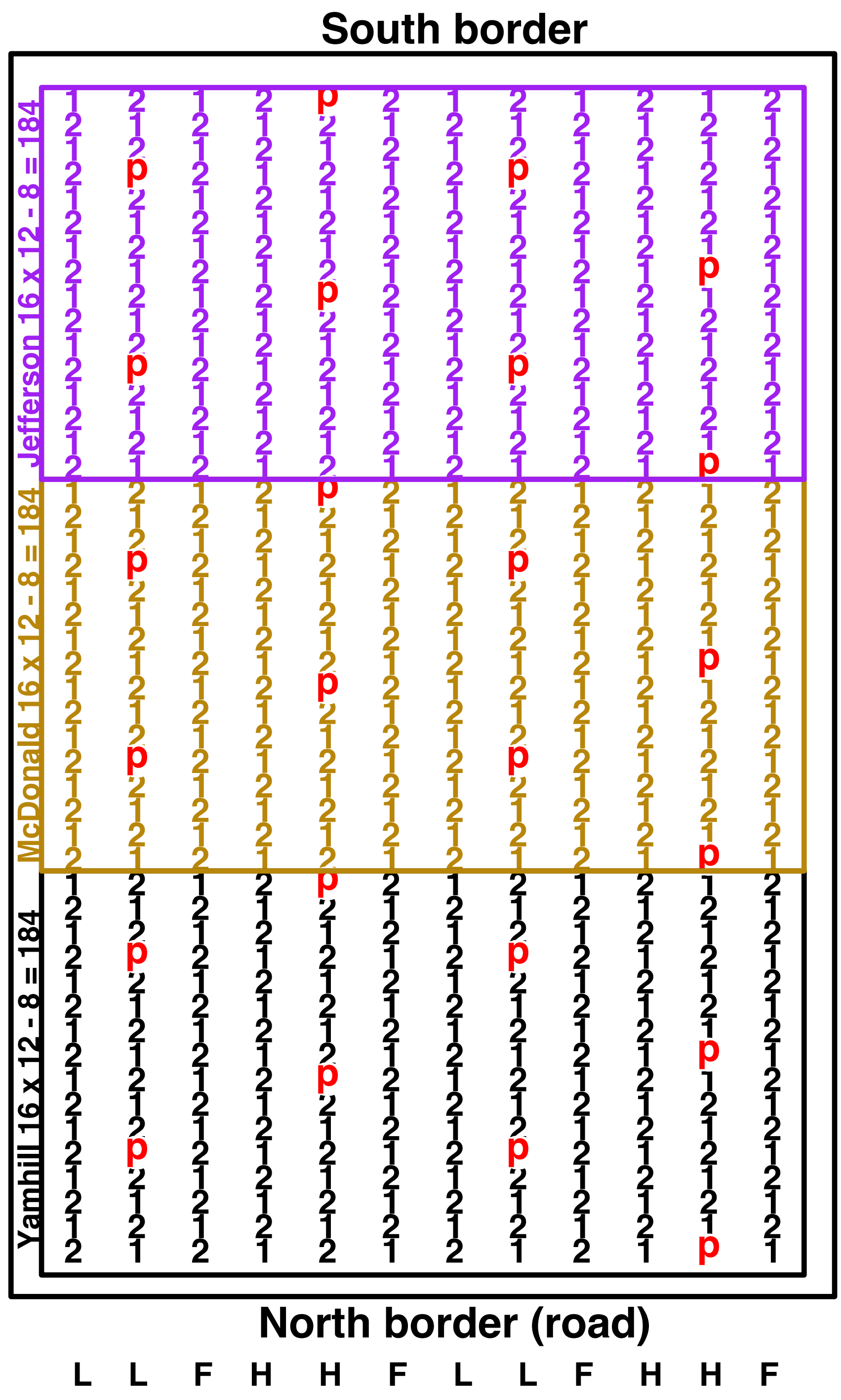


Figure 1. Berm plot layout showing permanent (No. 1), temporary (No. 2), and pollinizers (P). Treatments are Low (L), Flat (F), and High (H).

Figure 2. Formation of berms.

Figure 3. Trees planted on berms with recently applied mulch treatments.


Figure 4. Flat planted trees underwater (left) and trees on berms above the water (right).

BENEFITS & IMPACT:

From this study, we will create guidelines on how to successfully grow trees on berms. To do this will require a minimum of 3 more growing seasons, which will allow us to collect yield data. However, based on data from the first season, growing trees on berms did not negatively affect tree growth despite lower soil moisture in the berms. From this study, we have begun to revise OSU's N fertilizer practices for newly planted trees that receive sawdust or manure-based composts (see Appendix A for more information). Growing on berms has several challenges that will need to be addressed such as preventing berm erosion by installing systems to move surface water under/around/through the berms (Fig. 4). Lessons learned from this research plot will be incorporated into an Extension publication.

Ultimately, we expect this research to benefit the hazelnut industry by providing farmers with the resources necessary to be able to grow trees on poorly drained, marginal land, thus expanding hazelnut acreage and maintaining Oregon's place in the global hazelnut market.

Figure 4. Berms may block the natural flow of surface water, resulting in berm erosion. To prevent this from occurring, at pipe was installed to divert water through the berm. In this case we were not aware of the surface water problem. In some sites, berms could be used to convey surface area to drained areas, or to hold prevent soil loss on slopes.

ADDITIONAL FUNDING RECEIVED DURING PROJECT TERM:
Grower donations have been leveraged for some equipment purchases including drip irrigation equipment.

FUTURE FUNDING POSSIBILITIES:
In year 3 we will begin to collect yield data. The nuts collected will be sold to a hazelnut processor, and the nut sales will help offset research costs. The Oregon Hazelnut Commission is a potential source to continue this project until 2 years of yield data can be collected.

Appendix A. Results and discussion

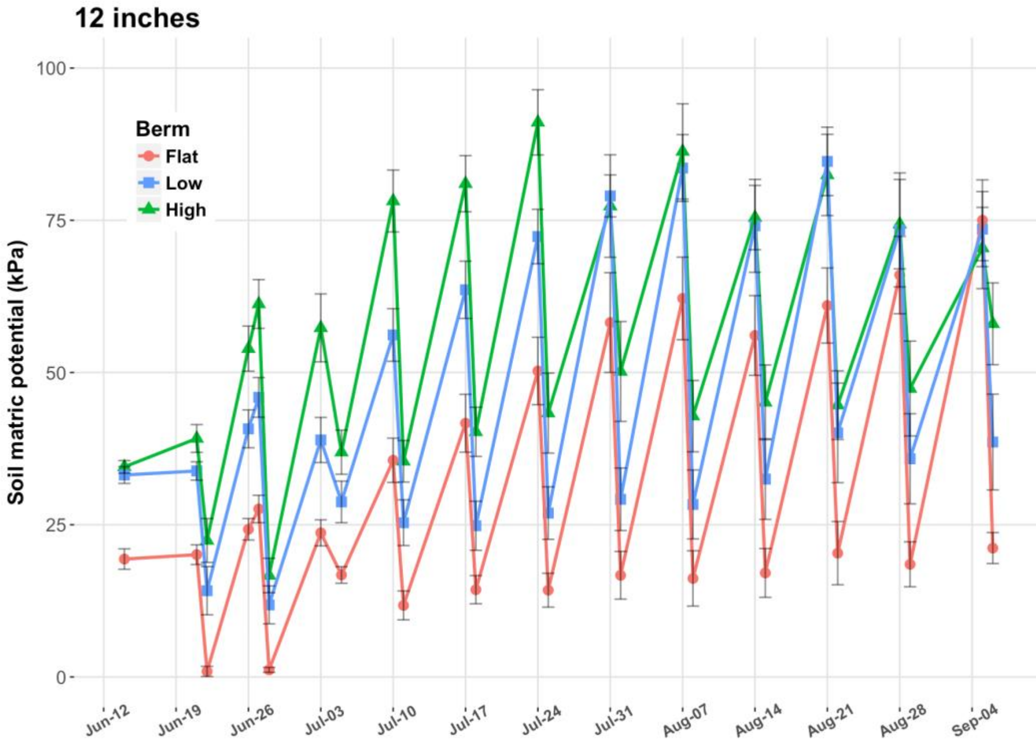
Soil moisture at 12 and 24 inches is given in Fig. 1A. The berm plots were generally drier and dried down faster after an irrigation compared to the industry standard flat planted trees (Flat). At 24 inches, there was no difference in soil moisture following an irrigation among treatments, but the High berm dried down faster. For almonds and walnuts, irrigation is recommended when the matric potential is between 60 to 80 kPa. Based on this recommendation, the weekly irrigation schedule was adequate to minimize water stress.

Despite lower soil moisture (Fig. 1A and Table 1A), there was no difference in tree growth among the berm treatments for any variety or tree age (1yr-old vs. bare-root trees) (Figs. 2A-5A). This indicates that berms do not have a negative impact on growth for young trees receiving irrigation. In 2018, we will withhold irrigation from some trees to see how the berms affect growth when grown dryland. We suspect that irrigation may be necessary when growing on berms.

Mulch treatment did have a significant effect on tree growth (Figs. 2A-5A). The best growth was observed with the sawdust + fertilizer treatments. Approximately 15 g N per tree was applied with the fertilizer, which translates to approximately 470 lb/acre in the application area (~1 ft radius around the trunk). This N likely counteracted soil N immobilization by microbes as they broke down the high C:N sawdust. As a result, trees that received just sawdust were pale green, indicating an N deficiency, and reduced leaf N concentrations relative to those receiving fertilizer (Fig. 6A). In general, trees receiving no mulch (None) had the lowest growth, likely due to drier soil. The mulches are applied to conserve water as well as prevent weed growth.

The trees receiving compost performed as well as the Sawdust treatment. This is surprising as approximately 90 g of total N was applied with the compost, and soil N immobilization is unlikely as the compost had a C:N ratio is 20. Much of the N in the compost is organically bound and not in a plant available form. As a result, the leaf N concentration was higher than Sawdust but lower than the Sawdust + fertilizer. For Compost, 50% was comprised of dairy manure compost, which was not mature (still actively composting and hot when sitting in a pile at the fieldsite). As a result of a high salt concentration in the compost, approximately 25% of the trees experienced fertilizer burn (Fig. 7A). This injury may have initially stressed trees and reduced growth, but leaves that emerged later in the season did not exhibit fertilizer damage. To avoid this issue, we recommend avoiding mulches derived from manures.

We will continue to monitor tree growth, and yield in years 3 and 4. We will also monitor tree blow-over as the trees grown in the berms may be more susceptible to wind damage than flat planted trees. The initial results indicate that trees planted on berms perform as well as flat planted trees in their first growing season.



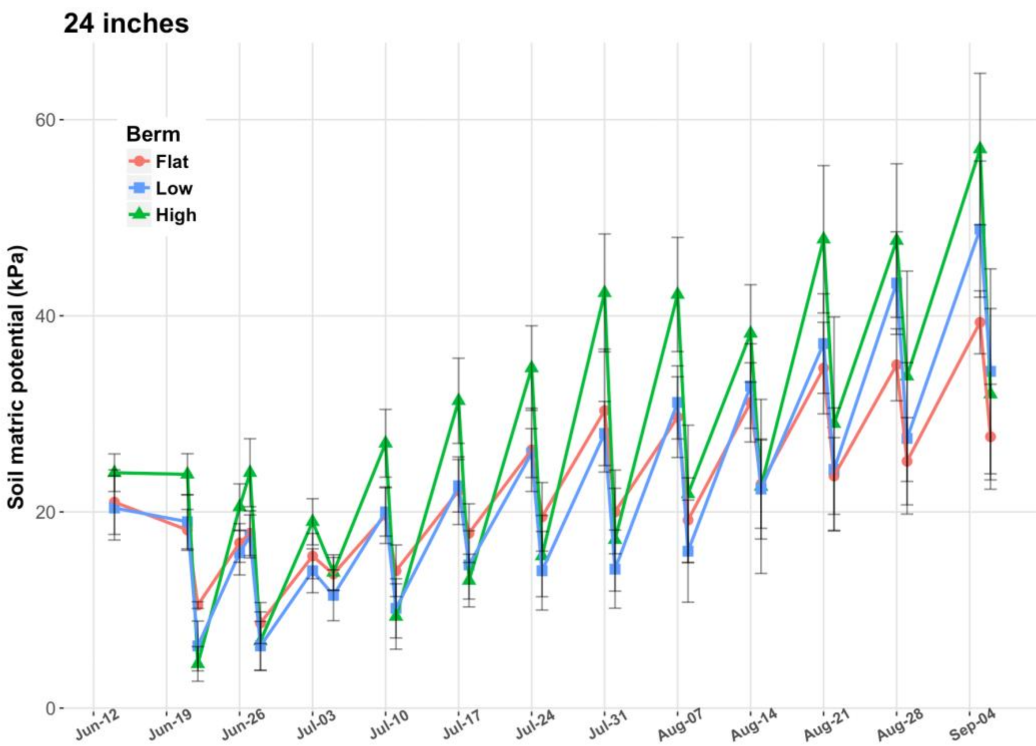


Figure 1A. Soil moisture measured before and after a weekly irrigation event at 12 and 24 inches. Error bars represent the SE (n=6).

Table 1A. Average soil moisture matric potential (kPa) over the growing season before (Pre) and after (Post) an irrigation. Values with the same letter in a column are not statistically different using TukeyHSD (p<0.05).

Berm	------ 12 inch ------		------ 24 inch ------	
	Pre	Post	Pre	Post
	--------------------- kPa (cbar) ----------------------			
Flat	50a	16a	27a	19
Low	67b	31b	29ab	18
High	75c	43c	37c	20

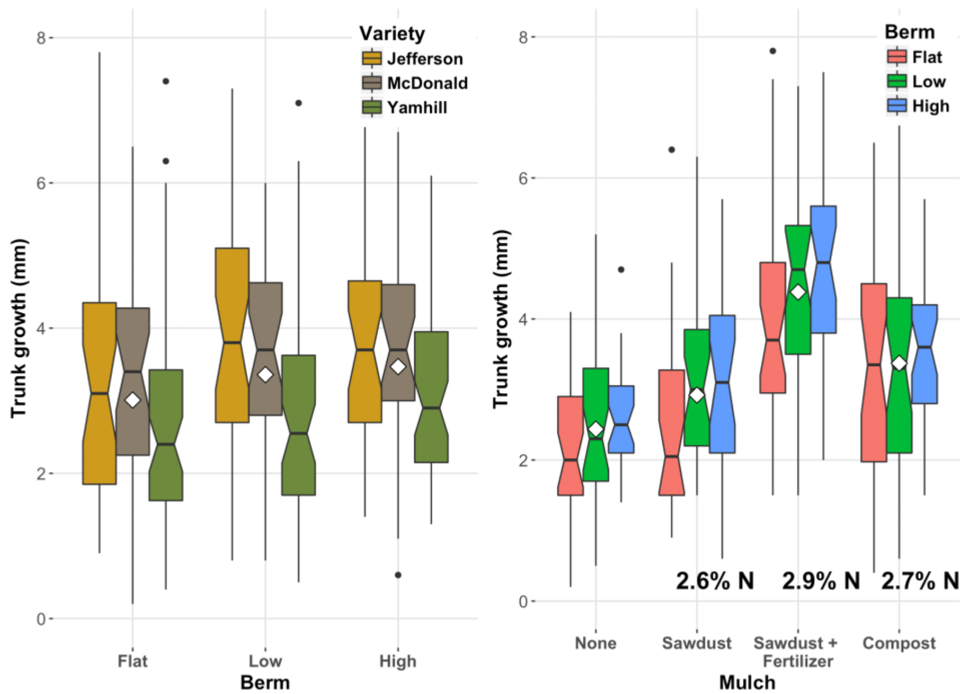


Figure 2A. Change in trunk growth at the end of the first growing season for bare-root "whips". The white diamonds are the average growth for each berm (left) or mulch treatment (right). Leaf tissue N concentration collected September 8, 2017 for the different mulch treatments (leaves collected from the Flat berm treatment only) is given below the boxplots (right). Trees receiving sawdust plus fertilizer were more vigorous and leaves were darker green.

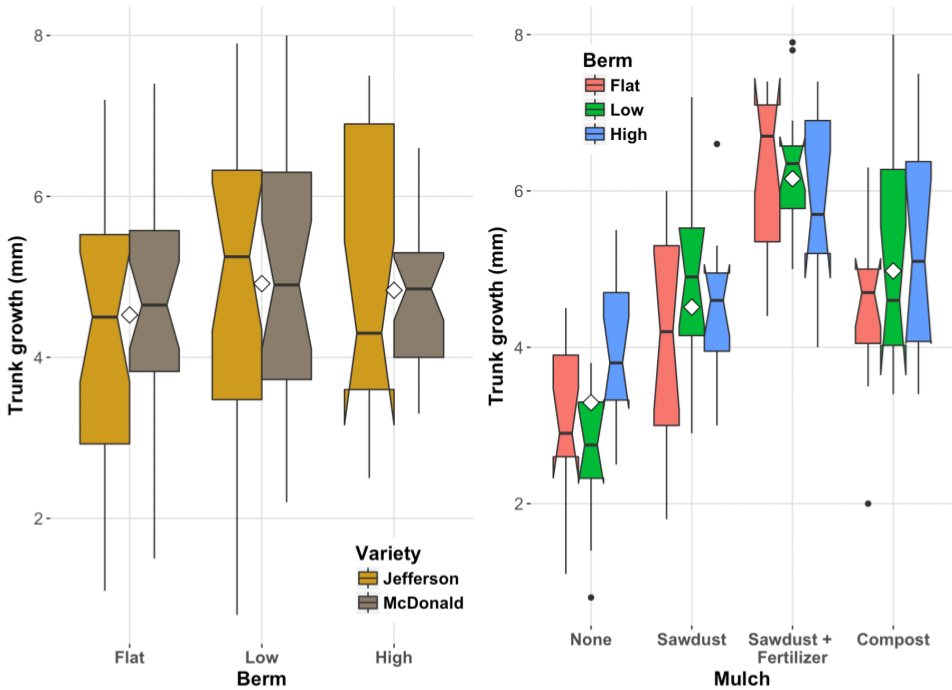


Figure 3A. Change in trunk growth at the end of the first growing season for 1-year-old trees. The white diamonds are the average growth for each berm (left) or mulch treatment (right). Leaf tissue N concentration collected September 8, 2017 for the different mulch treatments (leaves collected from the Flat berm treatment only) is given below the boxplots (right). Trees receiving sawdust plus fertilizer were more vigorous and leaves were darker green.

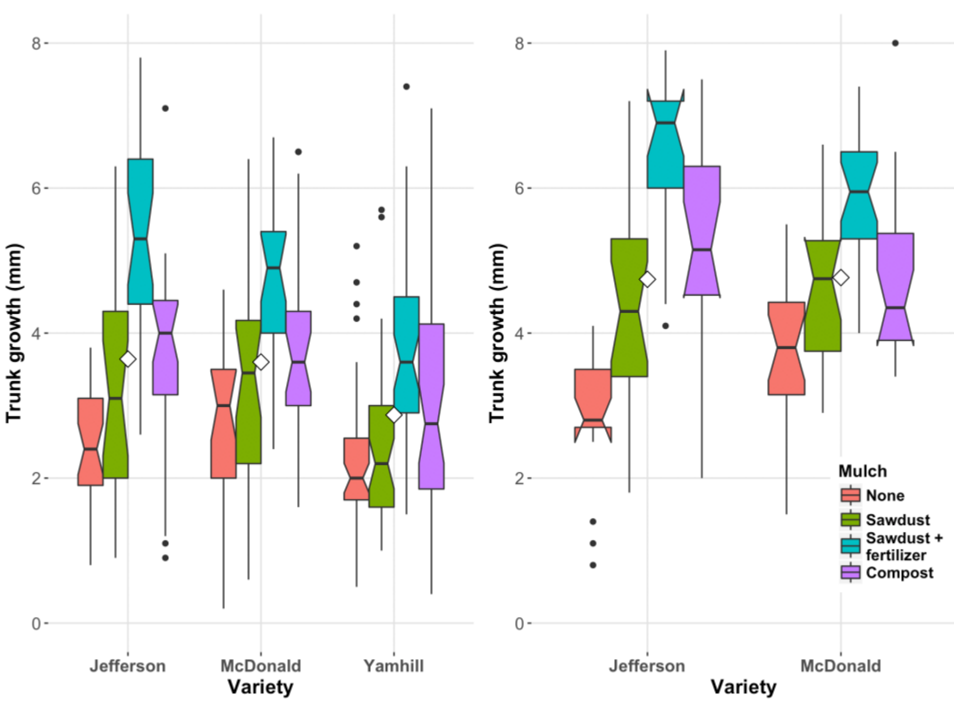


Figure 4A. Change in trunk growth at the end of the first growing season for bare-root "whips" (left) and 1-year-old trees (right). The white diamonds are the average growth for each variety.

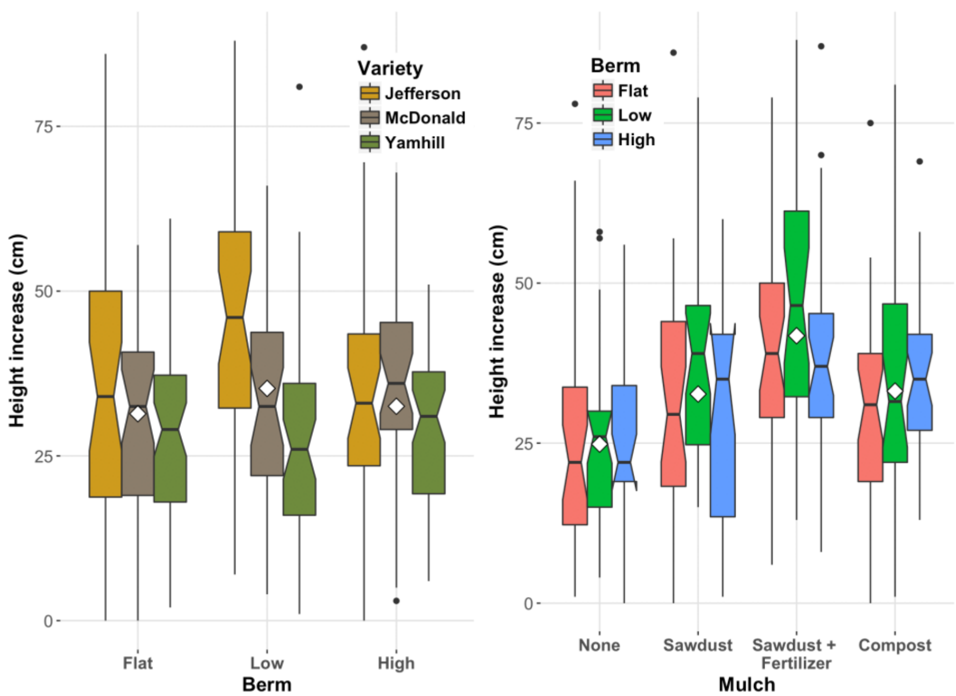


Figure 5A. Change in canopy height at the end of the first growing season for bare-root "whips". The white diamonds are the average growth for each berm (left) or mulch treatment (right).

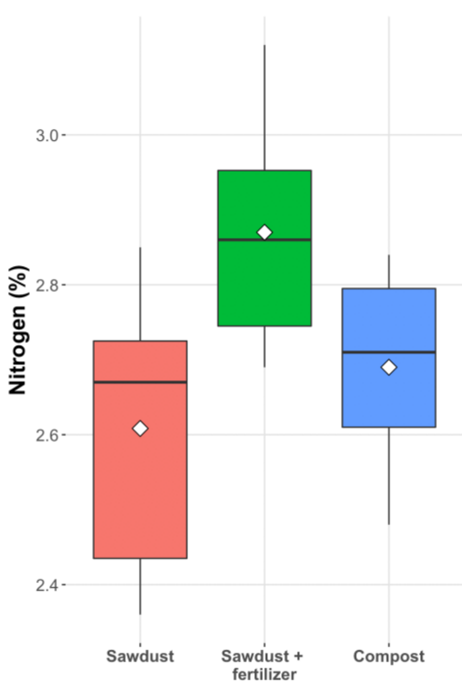


Figure 6A. Leaf nitrogen concentration for each mulch treatment for the flat planted trees (Flat).

Figure 7A. Fertilizer burn on trees receiving a yardwaste compost mixed with a young dairy manure compost. The burn caused by salts/nutrients reduced tree growth relative to trees receiving sawdust plus fertilizer.