**FINAL PROJECT REPORT**

**Project Title**: WA 38 demonstration trial block


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**Cooperators**: **Bleyhl Farm Service, Burrow Tractor – Sunnyside, DrapeNet, G.S. Long**

**Total Project Funding**: 44,258

**Budget History:**

| Item | 2018 | 2019 |
|---|---|---|
| **WTFRC expenses** | 16,858 | 0 |
| **Salaries** | | |
| **Benefits** | | |
| **Wages** | 1,000 | 1,000 |
| **Benefits** | | |
| **Equipment** | 2,200 | 1,000 |
| **Supplies** | 1,200 | 1,200 |
| **Travel** | 2,500 | 2,500 |
| **Plot Fees** | 2,400 | 2,400 |
| **Miscellaneous** | 5,000 | 5,000 |
| **Total** | **31,158** | **13,100** |

**Footnotes: WTFRC**
Salaries/Benefits: 104 hours each for Mendoza and Hanrahan, 41% benefit rate
Wages/Benefits: 200 hours @ $11.50, 50 hours @ $16.50, 53% benefit rate
RCA room rental: 1/9$^{th}$ of one CA room for 10 months @ $6,300/year
Travel: in state travel between Yakima or Wenatchee to Prosser

**Footnotes: WSU**
Equipment: Temperature and moisture sensor + data logger.
Supplies: Materials to build Rhizotrons and stablish new irrigation system.
Miscellaneous: Soil and tissue analyses
Travel: Lewis to / from Prosser: Moses Lake

## JUSTIFICATION

The WSU WA 38 block was established at the WSU Roza Farm in 2013. The purpose of the trial was to evaluate rootstock and training systems. The 0.8-acre block was divided in 4 rows on a Spindle 3x10 using the "bending" technique, 4 rows on V trellis 1.5x10 with individual trees facing opposite sides, and 3 rows on Bi-axis on a 3x10 spacing. Within each row, G41 and M9-nic 29 rootstocks were randomized in blocks of 11 trees for Spindle and Bi-axis system and 22 trees on the V trellis. In addition, different pruning techniques were established later in a project lead by Stefano Musacchi and Karen Lewis, applying hand pruning versus mechanical pruning. The most significant findings from this project have been published and shared in detail on the WSU Tree fruit webpage – WA 38 section and in the WTFRC final report. Once the funding ended for that project in 2016, the block was not managed and was slated to be removed. In 2017 the Roza Farm was affected by a hail event during bloom accompanied by favorable conditions for fire blight development. This situation resulted in tree infections and a buildup of inoculum for 2018.

This proposal offered the opportunity to investigate and demonstrate several cultural practices specific to WA 38 under the Roza Farm growing conditions and historic circumstances. The benefit of having a mature orchard allowed us to understand challenges and demonstrate practical management techniques including but not limited to canopy and crop load management, fruit maturity and fruit quality, green spot, root growth, and more. The block also served as a gathering space to bring growers together and develop a collaborative community. Finally, this block provided fruit to PVM and WSU for marketing purposes in 2015-2018.

## OBJECTIVES

1. Provide opportunity for industry horticulturists to demonstrate/debate and teach/learn canopy management strategies for WA 38 in vertical, angled, single stem and bi-axis trees.
2. Demonstrate and field evaluate impact of spray-able and netting products for sunburn mitigation and fruit finish
3. Demonstrate the use of mechanical hedgers and platforms
4. Determine best commercial picking scenarios for optimum fruit quality and long-term storage potential
5. Evaluate the effect of drape net, spray-able sunburn protectant compound and no mitigation on nutrient status and root development
6. Demonstrate soil health and root growth across rootstocks
7. Conduct field days and document best management practices. Contribute to body of knowledge using all methods and informational platforms

## FINDINGS

1. Under the Roza Farm growing conditions, M9 rootstock was the most productive (approx. 80 bins/acre) in both V trellis and bi-axis system, with no difference between those two training system, despite having double number of trees in the V trellis.
2. Under the Roza Farm growing conditions, the spindle system trees were the most vigorous, had the most blind wood and had the lowest productivity. However, the trees trained to this system were previously managed by bending branches, and have been in transition to a traditional spindle since 2017.

3. G41 rootstock showed reduced productivity in spindle and V trellis systems when compared with M9.
4. Drape net improved fruit weight and size distribution. In 2019 the block had less than 1 % sunburn, thus the protective effect was not assessed.
5. G41 and M9-Nic 29 showed significant differences in root growth, length and volume. These differences did not translate to significant differences in nutrient uptake, however, green spot incidence was 56% in G41 compared to 14% on M9 with p= 0.12.

## RESULTS & DISCUSSION

**Objective # 1** Canopy Management and Crop load

In 2018 we recruited industry cooperators to prune the entire block on April 4th. Mechanical hedging was applied on July 13th when temperatures reached 100°F to reduce potential fire blight infection, leading to sunburn in the most exposed fruit. Thus, late hedging (20+ leaf stage) can lead to sunburn if temperatures are expected to be above 90 F.

Trees trained using "bending" have been pruned intensively during winter and summer to transition trees to "narrow" robot ready architectures. After two years of winter and summer pruning, tress still have high vigor and blind wood. This process has given us a good example of the importance of adequate training and pruning during the orchard establishment are fundamental for the profitability, quality and long term performance of the orchard. These rows have also served for detailed analysis of green spot and its relation to tree vigor and nutrient imbalance.

In 2018, full bloom was between April 25th to 28th, while in 2019 full bloom was recorded on May 3rd. In 2018, the pruning and crop load management strategy was to leave as much fruit as possible to control tree vigor with crop load. However, crop load was low with approximately 12 bins in the entire block, equivalent to 25 bins/acre at a 2420 trees/acre. Low production can be attributed to several factors including; lack of pollen and poor pollinator activity, unfavorable weather during bloom with 0.21 inches of rain between the 27th and 28th of April and wind speeds up to 32.5 mph.

In 2019, nine teams of industry cooperators selected post to post sections in V trellis and bi-axis rows and using varying strategies, pruned to bud count of 80-85 buds/tree. At harvest, yield/acre was estimated by harvesting 10 complete trees for each rootstock, weighing each fruit and multiplying by the trees per acre. Yield improvement from 2018 to 2019 can be attributed to; adequate pruning 2019, better conditions during bloom and overall good conditions during the growing season. (Table 1). A third year of evaluation would be required to determine the biennial potential in this block.

Table 1. Production indicators for each training system and rootstock.

| System | Spindle | | V Trellis | | Bi Axis | |
|---|---|---|---|---|---|---|
| Trees/acre | 1210 | | 2420 | | 1210 | |
| Rootstock | M9 | G41 | M9 | G41 | M9 | G41 |
| Fruit weight (g) | 290 | 298 | 221 | 240 | 240 | 328 |
| Yield/tree (lbs) | 43 | 35 | 33 | 25 | 62 | 66 |
| Yield (ton/acre) | 26 | 21 | 40 | 30 | 37 | 40 |
| Yield (bins/acre) | 56 | 45 | 86 | 65 | 81 | 86 |

Trees have gained adequate growth balance after two years of training, spring and summer pruning, and spring and dormant hedging.
Because we only have one year of evaluated pruning strategies, we cannot fully develop pruning rules that are transferable and executable by pruning crews with an acceptable level of confidence.

**Objective # 2** Sunburn / Fruit Finish
Due to the need for intensive fire blight scouting in 2018, we did not install any netting. We did deploy Drape Net in 2019. In 2018, sunburn protectants were applied during the season with five sprays between July 27 and August 29. The commercial products utilized were Parka (wax based product) and Eclipse ™ (Calcium carbonate derived Ca (25%) + B (0.1%)). The latter stays in the fruit for a long period and requires additional cleaning at harvest.
On June 20, 2019 a drape net was deployed in 4 post to post sections of G41 and M9 on the bi-axis system. There were no differences in sunburn incidence in 2019 between the netted and none netted treatments, however, fruit from netted trees weighed more than fruit from non- netted trees (Figure 1). The distribution of starch content as indicator of fruit maturity and fruit size indicated that netting can potentially delay maturity, but increase size homogeneity in the canopy (Figure 2).

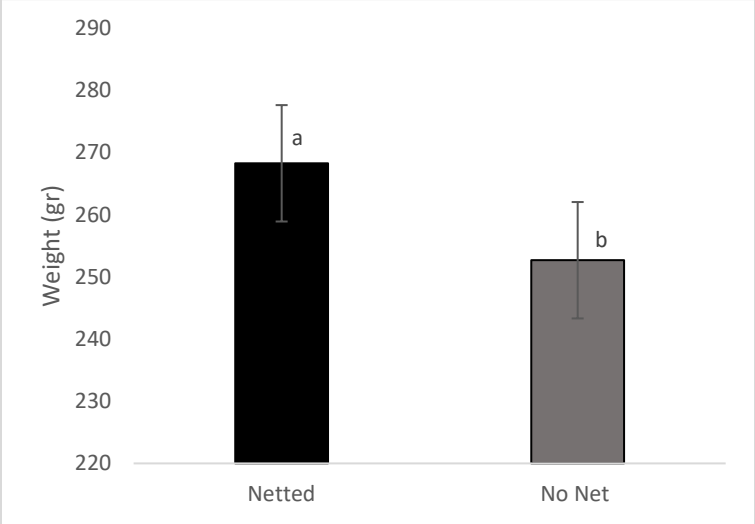


**Figure 1.** Netting effect on fruit weight. Bars indicate standard error; different letters indicate statistical significance (Tukey test p=0.06)

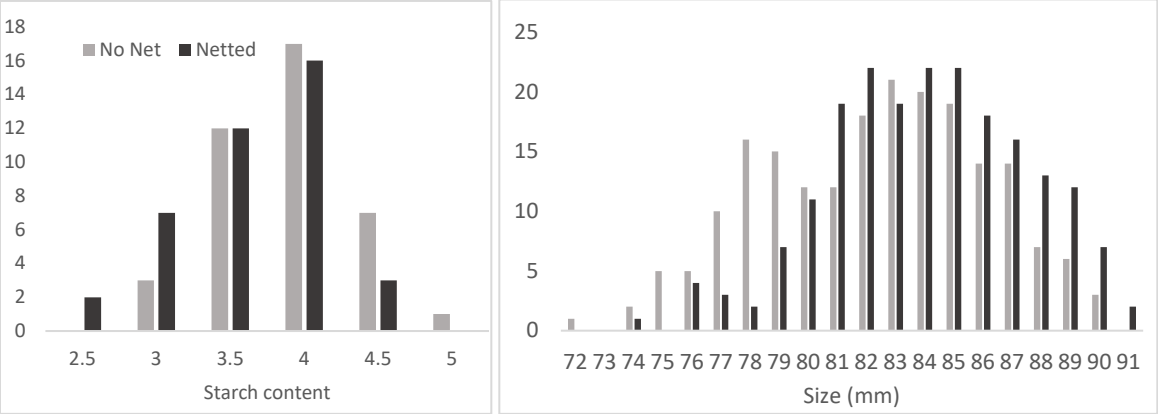


**Figure 2.** Netting effect on distribution of fruit starch content (left) and size (right).

**Objective # 3** Mechanization
In cooperation with vendors, platforms and hedging were utilized in the block for demonstration purposes. The entire block was hedged in both 2018 and 2019 at dormant and spring (12 and 20 leaf stages) . Hedging process was demonstrated and discussed at several field days and was recorded for social media. Platforms were used and demonstrated in pruning, net deployment and harvest.

**Objective # 4** Fruit Quality and Storage Potential
Mid-project, Drs. Sara Serra and Stefano Musacchi assumed leadership for this project aim. Protocols were developed to reflect industry needs expressed through the PVM Quality Standards Committee and previous experience in both WTFRC and WSU labs. The results from this objective contributed to the development of a starch scale for WA 38 distributed to the industry by WTFRC and WSU Extension. A fruit maturity field day was conducted at the Roza Farm block in both 2018 and 2019.

**Objective # 5 and 6** Evaluate and Demonstrate Nutrient Status and Root Development
Soils samples were obtained in spring 2018 and 2019 for chemical analysis following the standard methods recommended for western soils (Miller et al 2013). Mineral deficiencies of phosphorous (10 mg/kg), sulphur (8 mg/kg), zinc (0.50 mg/kg) and boron (0.12 mg/kg) were identified in 2018. All other nutrients were adequate according to the standards for WA tree fruit industry (http://treefruit.wsu.edu/orchard-management/soils-nutrition/fruit-tree-nutrition/).
To bring the soil back to adequate nutrient levels, the complete block was treated with 100 lbs of mono ammonium phosphate (MAP)/acre, 25 lbs of $ZnSO_4$/acre and 2 lbs of B/acre in 2018 and 2019. Leaf tissue analyses during the sampling season (August) showed adequate levels of all nutrients indicating adequate nutrient absorption. In 2018 Ca levels were slightly low in the V trellis, thus in 2019 additional Ca sprays were applied in spring. In 2019 tissue samples indicated adequate nutrient levels across all systems and rootstocks.

Irrigation management was done utilizing a moisture and temperature sensor located at two depths placed on G41 row (identified as the most demanding section in the block). Moisture was maintained between 0.33 and 0.19% (equivalent to 100 – 50% field capacity in a silt loam soil), which led to an average of 6 hours of irrigation per week during the growing season. Irrigation was stopped 3 weeks before harvest and we did not observe moisture levels below 0.19 during that period.

Root growth between rootstocks was evaluated by placing 3 root windows on each rootstock (replicates) in the V trellis system. A detailed explanation of how to develop the root window was shared with the Good Fruit Grower and published in April, 2019 (https://www.goodfruit.com/a-window-to-the-roots/) (Figure 3). In 2018 root growth showed no differences between rootstocks with temperatures above 59 F and at approximately 30 DAFB. In 2019, G41 initiated its root growth approximately 10 days before M9-nic 29, also with temperatures above 59 F, however in 2019, root growth happened simultaneously with the bloom period in G41 and 10 DAFB in M9-nic 29 (Figure 4).

**Figure 3.** Root windows (3 $ft^2$) built with 2x4 pine wood, plexiglass window drilled in one side of the window and placed between 5 to 7 inches from the tree trunk.

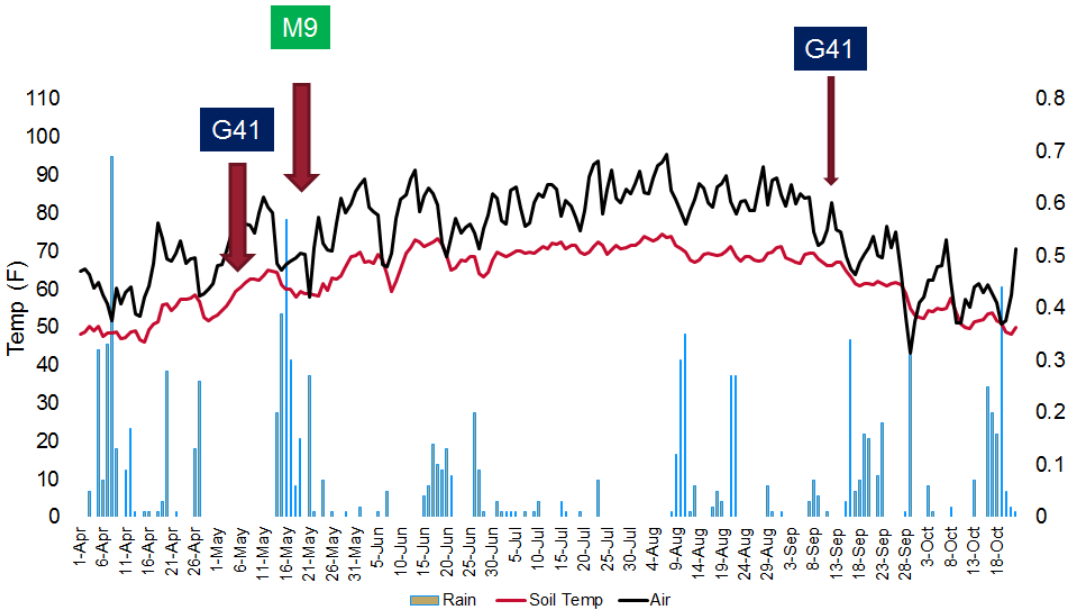


**Figure 4.** Root growth start date for G41 and M9 during 2019 and its relation with soil and air temperature (principal axis) and rain (inches secondary access) during the growing season.

Root growth in G41 started earlier in the season than root growth in M9 (May 3 and May 16 respectively). Both roots had the greatest rate of growth between start date and 40 DAFB, coinciding with the period of cell division in apples. While M9 stop growing after June 7, G41 continue growing until June 27. The volume of roots was also significantly different between rootstocks. G41 had 3X the volume of roots when compared to M9 (Figure 5). This root growth differences can explain the vigor differences observed in both rootstocks and the potential to develop Ca deficiency disorders.

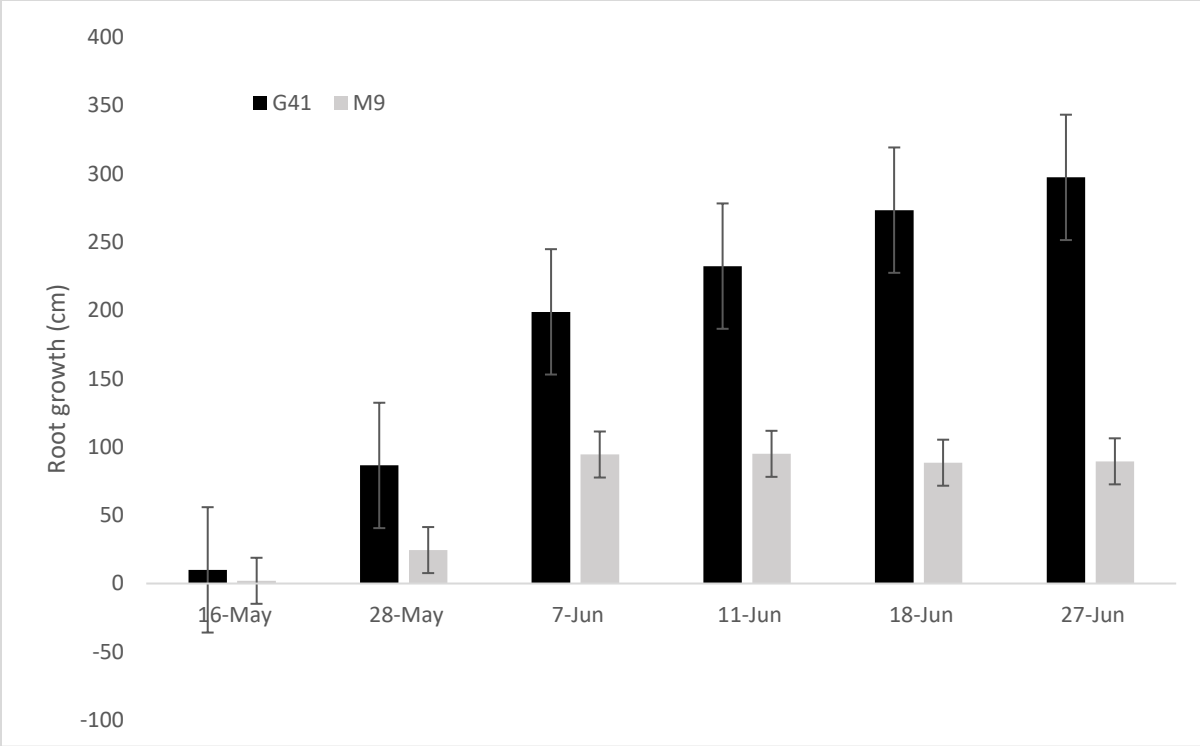


**Figure 5.** Root growth length for G41 and M9 in 2019.

Despite the differences in root growth pattern, nutrient content in fruit showed no differences between rootstocks. The incidence of green spot was significantly different between the M9 and G41 rootstock (Table 1). However, internal variability within the tree could be masking the effect of root growth on nutrient uptake and its relation with green spot incidence.

Table 1. Macronutrient levels and green spot incidence in G41 and M9 on V trellis.

| Root | N | P | K | Ca | Green Spot % |
|---|---|---|---|---|---|
| G41 | 2.16 a | 0.35 a | 2.25 a | 1.6 a | **56** |
| M9 | 2.30 a | 0.32 a | 1.99 a | 1.5 a | **14** |
| Pr > F(Model) | 0.30 | 0.69 | 0.28 | 0.43 | **0.12** |

**Objective #7** Conduct field days and document best management practices. Contribute to body of knowledge using all methods and informational platforms.

Field days and Orchard Tours – Over 200 people toured or attended a field day at Roza Farm block in both 2018 and 2019. Information / lessons learned were shared in presentations, in WSU Fruit Matters, on social media and in the Good Fruit Grower Magazine.

**Reference**

Miller, R.O, R. Gavlak, D. Horneck. 2013. Soil, Plant and Water Reference Methods for the Western Region. WREP 125

**Project Title:** WA 38 Demonstration Trial Block

**Key words:** WA38, Cosmic Crisp®, Root growth, Netting

**Abstract:**
Approximately 400 people toured the block, attended field days and / or collaborated in pruning events. G41 and M9-Nic 29 showed significant differences in root growth, length and volume. M9 rootstock was the most productive in V trellis and bi-axis systems, with no difference between training systems.

## EXECUTIVE SUMMARY

The WSU WA 38 block was established at the Roza Farm in 2013. The purpose of the trial was to evaluate rootstock and training systems. The 1-acre block was established with 4 rows on a spindle 3x10 using the "bending" technique, 4 rows on V trellis 1.5x10 with individual trees facing opposite sides, and 3 rows on bi-axis on a 3x10 spacing.
After a few seasons of minimum management in the block plus fire blight outbreaks and a hail event the PI's of this project developed a plan to rehabilitate the block by replacing fire blight infected trees, replacing and increasing diversity of pollinizers, transitioning trees trained using the bending technique to the click technique and improving the uniformity of the irrigation system. Moisture sensors were deployed that allowed for data driven irrigation strategies to be executed and a scheme for soil and plant nutrient testing was developed. The process opened up the opportunity to investigate and demonstrate several cultural practices specific to WA 38 under the Roza Farm growing conditions and historic circumstances. The benefit of having a mature orchard allowed us to understand challenges and demonstrate practical management techniques including but not limited to canopy and crop load management, fruit maturity and fruit quality, green spot, root growth, and more. The block also served as a gathering space to bring growers together and develop a collaborative community. Finally, this block provided fruit to PVM and WSU for marketing purposes in 2015-2018.
Significant finds include:

1. Under the Roza Farm growing conditions, M9 rootstock was the most productive (approx. 80 bins/acre) in both V trellis and bi-axis system, with no difference between those two training system, despite having double number of trees in the V trellis.
2. Under the Roza Farm growing conditions, the spindle system trees were the most vigorous, had the most blind wood and had the lowest productivity. However, the trees trained to this system were previously managed by bending branches, and have been in transition to a traditional spindle since 2017.
3. G41 rootstock showed reduced productivity in spindle and V trellis systems when compared with M9.
4. Drape net improved fruit weight and size distribution. In 2019 the block had less than 1 % sunburn, thus the protective effect was not assessed.
5. G41 and M9-Nic 29 showed significant differences in root growth, length and volume. These differences did not translate to significant differences in nutrient uptake, however, green spot incidence was 56% in G41 compared to 14% on M9 with p= 0.12.

Approximately 400 people toured the block, attended field days and / or collaborated in pruning events over the 2-year period. This mature block of apples is a valuable asset for WSU Extension and specifically for our programming efforts in WA 38 production, management and fruit handling.