BC FoodWeb

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RESEARCH SUMMARY

Large-dwarfing rootstocks can protect apples from sunburn

Researchers: H. Xu, S. Blatt, and D. Ediger

Production Type
- Tree fruit

Practice Benefit(s)

Increased resilience to extreme heat

Research Location
- Okanagan Valley, BC

KEY TAKEAWAYS

- The **vigor** of a rootstock impacts an apple tree's ability to **tolerate extreme heat**.
- When water supply was sufficient, **large-dwarfing rootstock varieties Geneva 935 and Geneva 4814** created larger tree canopies and reduced heat stress on the trees, which led to **fewer sun-damaged 'Buckeye Gala' apples**.

Key Terms:
- *Vigor: how big and fast a plant grows.*
- *Stem water potential: the potential for water movement from one part of the plant to another, often used as an indicator for water stress in fruit trees.*

Figure 1. Sunburn-damaged apples after multiple heat waves in 2021. Photo by Hao Xu.

HOW CAN THIS RESEARCH BE USED?

- Apple producers should consider **long-term climate resilience** when selecting rootstocks.
- Large-dwarfing rootstocks can protect 'Buckeye Gala' apple trees from heat stress, leading to fewer sunburn-damaged apples when there is **sufficient water** (i.e. through irrigation). However, **small-dwarfing** rootstocks might be more resistant to extreme **drought** conditions or prolonged water shortage because they use less water.

WHY WAS THIS RESEARCH DONE?

In this study, we investigated if rootstock size selection can contribute to extreme heat resilience in 'Buckeye Gala' apple trees, measured through fruit sunburn damage. This research is a step towards developing a comprehensive apple rootstock evaluation that will help tree fruit growers adapt to climate change.

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Small-dwarfing rootstocks, such as Budagovsky 9 and Malling 9, are commonly used in tree fruit production because their small tree size allows for a higher planting density and a higher fruit yield per hectare. However, as climate change worsens and extreme weather events become more frequent, the shallow root system, small trunk, and small canopy of small-dwarfing rootstocks may put them at a disadvantage in the long-term.

WHAT WAS THE OUTCOME?

Overall, apple trees on large-dwarfing rootstocks handled the heat better.

Trees on the large rootstocks (G.4814, G.935, and G.969) and a few of the medium-dwarfing rootstocks (G.41 and G.11) had the largest canopies (Figure 2a). There were fewer sunburn-damaged apples on the large-dwarfing rootstocks (G.4814, G.935, and G.969) compared to the medium-dwarfing rootstocks (Bud 10, G.11, G.41, M.26, and NZ#2) (Figure 2b), which had damage on over 25% of apples.

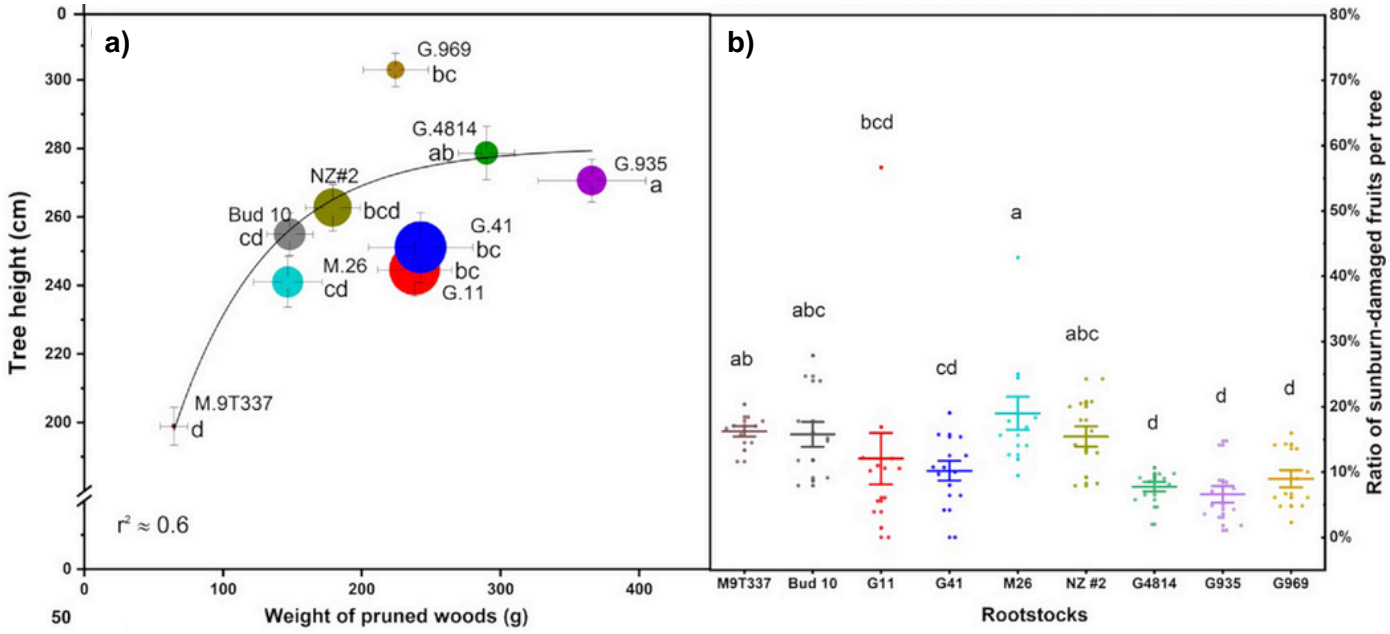

Figure 2. *(a)* Tree canopy size, determined by the weight of pruned wood and tree height at the end of the growing season in 2021. *(b)* Ratio of sunburn-damaged fruits per tree. The average value is indicated by the middle horizontal line of each rootstock.

Large-dwarfing rootstocks G.935 and G.4814 had the lowest water stress, with an average stem water potential of -1.10 and -1.12 MPa, respectively. The small-dwarfing rootstock (M.9T337) and two medium-dwarfing rootstocks (Bud 10 and G.11) had the most water stress, with average stem water potentials of -1.30, -1.33, and -1.37 MPa, respectively.

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Higher stem water potential and larger canopy volumes were associated with significantly fewer sunburn-damaged apples. This is likely due to shading and cooling effects. The higher stem water potential means that the trees can release water vapour into the air (transpire), creating a cooling effect within the canopy. Meanwhile, the larger canopies block the sun, lowering fruit surface temperatures and reducing UV-radiation exposure.

Projected yield was the highest for the large rootstocks and the lowest for the smallest rootstocks (Figure 3). Projected yield is a calculated number that estimates the yield of damage-free apples for each rootstock if the trees were to be planted at the recommended planting density (Table 1) and with 3" by 11" spacing. Usually, small-dwarfing rootstocks have a high projected yield because of their high planting density. However, after the heat wave, the small rootstocks had many damaged apples and a low yield of sunburn-free apples per tree.

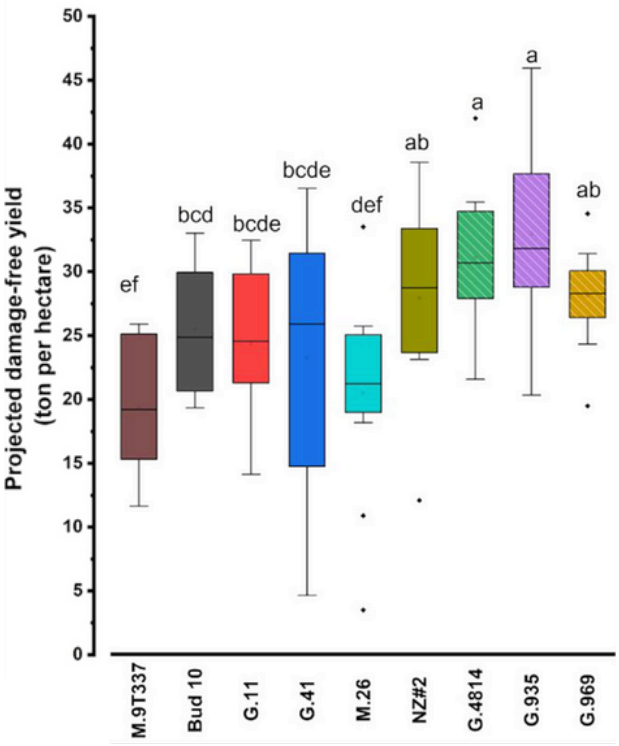

Figure 3. Projected damage-free yield per hectare of each rootstock based on recommended planting densities. © His Majesty the King 2023, licensed to the Canadian Journal of Plant Science under CC-BY 4.0.

WHAT'S NEXT?

The large-dwarfing rootstocks G.935 and G.4814 performed the best in producing sunburn-free 'Buckeye Gala' apples and maintaining good tree water levels under sustained summer heat.

Future research should evaluate the effects of rootstock size in different sites and over multiple years to evaluate the long-term ability of these large-dwarfing rootstocks to mitigate heat stress. Rootstock selection based on multi-site and multi-year data may be key to building climate resilience in apple production across British Columbia.

Figure 4. 'Buckeye Gala' planting in Summerland, May 2022. Photo by Hao Xu.

HOW WAS THE RESEARCH DONE?

A 'Buckeye Gala' rootstock trial was planted in Summerland, British Columbia in 2019. The trial contained nine rootstocks (Table 1), with 15 trees per rootstock. We used these trees for our study in 2021. The trees received an adequate supply of water, through drip line, from May to early October.

We looked at three traits to determine whether the severity of apple sunburn was impacted by rootstocks: tree vigor (represented by trunk diameter and canopy dimension), fruit production, and stem water potential. Stem water potential is a measure of the water activity in the stem where a higher value means that there is more water in the stem and less water stress on the tree.

Table 1. Dwarfing rootstocks used in this study and recommended planting densities of each size (vigor) class, based on sources listed on page 5.

	Small-dwarfing	**Medium-dwarfing**	**Large-dwarfing**
Rootstock(s)	• Malling 9T337 (M.9T337)	• Budagovsky 10 (Bud 10) • Geneva 11 (G.11) • Geneva 41 (G.41) • Malling 26 (M.26) • New Zealand #2 (NZ#2)	• Geneva 4814 (G.4814) • Geneva 935 (G.935) • Geneva 969 (G.969)
Recommended planting density (trees/hectare)	• 3260	• 2715	• 2345

We measured stem water potential on two sunny days in mid-late July, using a pressure chamber instrument. At the end of the growing season, we measured trunk diameter 30 cm above the graft union. To determine canopy dimension, we recorded tree height and the weight of pruned woods after winter pruning.

Fruit yield was measured at harvest. For each tree, we recorded the ratio of sunburn-damaged apples to the tree's total apple count.

Projected damage-free yield was calculated for each rootstock by multiplying the average yield per tree by the ratio of undamaged apples and by the recommended planting density for each size class.

ABOUT THIS BRIEF

This brief is based on the following scientific journal article:

Xu, Hao., Blatt, S., & Ediger, D. (2023). Tools for climate resilience in tree fruit I: large-dwarfing rootstocks can alleviate sunburn damage in "Buckeye Gala" apple. *Canadian Journal of Plant Science, 103*(1), 128-132. https://doi.org/10.1139/cjps-2022-0080

Recommended tree planting densities were based on the following sources:

- Lordan J., Francescatto P., Dominguez L.I., Robinson T.L. 2018. Long-term effects of tree density and tree shape on apple orchard performance, a 20 year study—part 1, agronomic analysis. Sci. Hortic. 238: 303–317.
- Robinson T. 2022. Apple rootstock performance—an eastern perspective. In SCRI Apple Root to Fruit Webinar on Rootstock and Nutrition. Available from https://youtube.com/playlist?list=PLYLbxsK4pTXXoyNLVkWZjKprOVOkkoQCL [accessed 20 March 2022].

Want to learn more?

- For questions regarding this research, contact Hao Xu at hao.xu@agr.gc.ca
- Check out another BC Food Web research brief on apple rootstock selection: "Preventing and detecting sunburn on 'Ambrosia' apples" at bcfoodweb.ca

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