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RESEARCH SUMMARY

Preventing and detecting sunburn on 'Ambrosia' apples

Researchers: H. Xu, Y. Watanabe, D. Ediger, X. Yang, and D. Iritani

Production Type
- Tree fruit

Practice Benefit(s)
- Increased resilience to extreme heat

Research Location
- Okanagan Valley, BC

KEY TAKEAWAYS

- Sunburn browning on apples led to **negative fruit qualities** such as reduced weight, faster ripening, higher acidity, and faster loss of firmness and worsened weight retention after harvest.
- When water supply was sufficient, 'Ambrosia' apples on **large-dwarfing rootstock Geneva 935** had less heat damage compared to those on small and medium-dwarfing rootstocks.
- Handheld DA (delta absorbance) meters, which are usually used to monitor fruit maturation, can also **detect moderate sunburn browning** in apples.

Key Terms:
- *Sunburn browning: fruit damage, that appears as a yellow or brown spot, due to sun exposure (UV-radiation) and high fruit surface temperature.*
- *Delta absorbance: the difference in how much light is absorbed at two specific wavelengths; a measurement of the chlorophyll content in fruit peel. As apples ripen, chlorophyll content and delta absorbance decrease.*

Figure 1. Moderate sunburn browning on an 'Ambrosia' apple after extreme heat in 2021. Photo by Hao Xu.

HOW CAN THIS RESEARCH BE USED?

- Apple producers should consider **long-term climate resilience** when selecting rootstocks.
- When water supply is sufficient, large-dwarfing rootstocks such as Geneva 935 may protect 'Ambrosia' apples from sunburn damage.
- Apple producers can use a **handheld DA meter** to help detect sunburn browning in the pre-harvest stages.

WHY WAS THIS RESEARCH DONE?

To help producers adapt to the changing climate, we examined the impact of rootstock size on sunburn browning and assessed the differences in fruit quality between healthy (marketable) 'Ambrosia' apples and those affected by sunburn browning. The results of this study will help with decision making on 'Ambrosia' apple rootstock selection and post-harvest sorting.

Figure 2. Severe apple sunburn browning. Photo by Hao Xu.

Extreme weather events, such as droughts, floods, heat waves, and cold snaps, are predicted to occur more frequently and become more extreme with climate change. Regardless of the crop grown, these events can cause significant losses in crop yield and quality.

In the summer of 2021, Interior British Columbia experienced several heat waves with record-breaking temperatures, causing significant damage to apples, including 'Ambrosia'. This sparked the realization that without understanding the variety's responses to heat, it's difficult to predict or accurately assess the impacts of heat and other climate change related stress.

WHAT WAS THE OUTCOME?

Sunburn browning led to poor fruit quality. Apples with sunburn browning had lower fruit weight, reduced firmness retention, reduced weight retention (Figure 3a), were more acidic, less juicy, and ripened faster (Figure 3b). On average, normal apples weighed 188.49 g at harvest while apples with sunburn browning weighed 158.09 g. Malic acid content, which contributes to apple acidity, was 772.82 mg/100 mL for normal apples and 1092.89 mg/100 mL for apples with sunburn browning.

'Ambrosia' apples on the large-dwarfing rootstock, Geneva 935, had the fewest sun-damaged fruit, with only 5% of apples damaged. Apples on the smallest dwarfing rootstock, Budagovsky 9, had the most sun damage, with over 16% of apples damaged (Figure 3c). Geneva 935 had the highest projected yield of undamaged fruits (Figure 3d). Projected yield is the estimated yield of undamaged apples for each rootstock if the trees were to be planted at the recommended planting density (i.e. 3.1′ × 12′ spacing and 1180 trees per acre for Geneva 935). Despite having the highest ratio of damaged apples, the smallest dwarfing rootstock, Budagovsky 9, had the second highest projected yield. This is because its small tree size allows for a high planting density.

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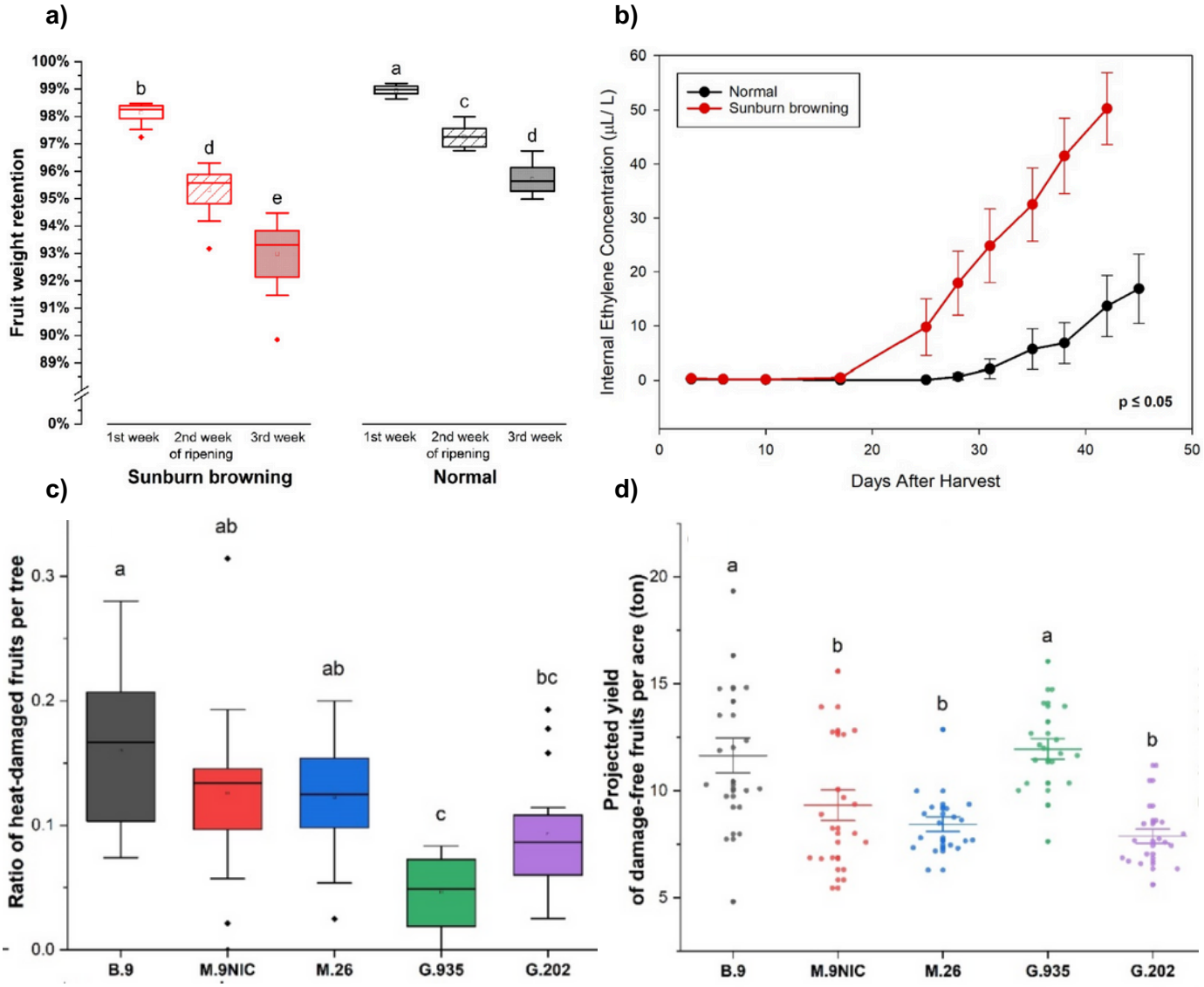

Figure 3. *(a)* Weight retention of sun-damaged and normal apples over three weeks of storage at room temperature. *(b)* Changes in internal ethylene concentration, an indicator of ripening, of normal and sun-damaged apples during storage at room temperature. *(c)* Ratio of sun-damaged apples per tree for each rootstock. *(d)* Projected yield of undamaged apples (ton/acre) based on the recommended planting density for each rootstock.

Sunburn browning can be difficult to see at harvest when the damage hasn't fully developed or for red cultivars that mask the browning. This can make it difficult for producers to sort apples accurately when harvesting. Using a DA meter, we found that delta absorbance was significantly higher on the sun-exposed side of damaged apples compared to the shaded side and both sides of a healthy apple (Figure 4a).

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The DA meter is a handheld device that is typically used by producers to determine fruit maturation. However, because delta absorbance also changes when an apple has sun damage, the DA meter may prove useful in detecting sunburn damage pre- and post-harvest

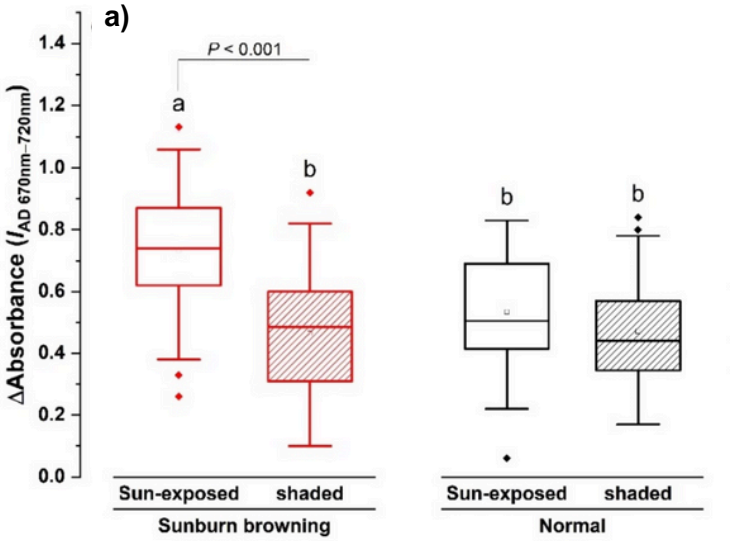

Figure 4. *(a)* Delta absorbance, an indicator of chlorophyll content, of the sun-exposed and shaded sides of damaged and normal apples. Values were measured two weeks before harvest. © Her Majesty the Queen 2022, licensed to the Canadian Journal of Plant Science under CC-BY 4.0. *(b)* Checking the delta absorbance value of an apple with a DA meter. Photo by Hao Xu.

WHAT'S NEXT?

Sunburn browning from prolonged heat stress led to the deterioration of several fruit quality traits in 'Ambrosia' apples including lower fruit weight, worsened weight retention, quicker loss of firmness, and faster ripening. Future research should evaluate other fruit qualities such as the progression of red-colour development in the skin, fruit maturation, and post-harvest issues such as internal browning. The DA meter proved useful for detecting moderate sunburn browning in 'Ambrosia' apples. However, its effectiveness awaits testing across a broader range of sunburn severities and apple varieties.

After a summer of unprecedented heat, the large-dwarfing rootstock Geneva 935 demonstrated the best heat resilience, having the fewest sun-damaged fruits. To confirm these findings beyond the one-year study, further research on Geneva 935 should span multiple years and test its performance under concurrent extreme weather events, such as drought and prolonged heat.

HOW WAS THE RESEARCH DONE?

This study took place at an experimental farm at Agriculture and Agri-Food Canada's Summerland Research and Development Centre in 2021. The farm contains 'Ambrosia' trees grafted onto one of five dwarfing rootstocks:

- **Small-dwarfing:** Budagovsky 9 (B.9)
- **Medium-dwarfing:** Malling 26 (M.26) and Malling 9NIC29 (M.9)
- **Large-dwarfing:** Geneva 935 (G.935) and Geneva 202 (G.202)

In mid-August, we tagged 100 fruits with moderate sunburn browning and 100 healthy, undamaged fruits. Between September 20-23 we harvested the tagged fruits and an additional 100 per type.

We measured fruit qualities with various equipment. Prior to harvest, we measured delta absorbance and skin surface temperature. At harvest, we measured fruit weight, soluble solids content, acidity, dry matter content, and tissue water potential. To monitor weight retention, we recorded fruit weight after one, two, and three weeks of ripening at 20°C. Similarly, to see changes in fruit firmness over time, we recorded fruit firmness at harvest, after two months of storage at 4°C, and then after an additional three weeks of ripening at 20°C.

For rootstock evaluation, we recorded fruit yield per tree and the ratio of damaged apples to the total apple count.

ABOUT THIS BRIEF

This brief is based on the following scientific journal article:

Xu, H., Watanabe, Y., Ediger, D., Yang, X., & Iritani, D. (2022). Characteristics of sunburn browning fruit and rootstock-dependent damage-free yield of ambrosia™ apple after sustained summer heat events. *Plants, 11*(9), 1201. https://doi.org/10.3390/plants11091201

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: "Large-dwarfing rootstocks can protect apples from sunburn" at bcfoodweb.ca

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