

What Causes Weak Wood in Apple?



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Introduction

- Apple trees consist of a scion (fruit-bearing portion) and a rootstock (root system)
- The scion and rootstock are combined during propagation
- Some scion/rootstock combinations are prone to breaking at their union
- There are many possible reasons for the failure of the union, including environmental factors, disease, or developmental differences between the scion and rootstock



Objectives

- To determine the cause of weak unions in a combination prone to union failure using light microscopy and Laser Ablation Tomography (LAT)
- To determine if these methods could be used to predict the union strength of future combinations

Significance to the Field

- Differences in tissue proportions have previously been studied using light microscopy, however they have not been sufficiently quantified and related to the development of weak unions
- LAT provides a new means for observing the growth of the union in 3-dimensions

Significance to Society

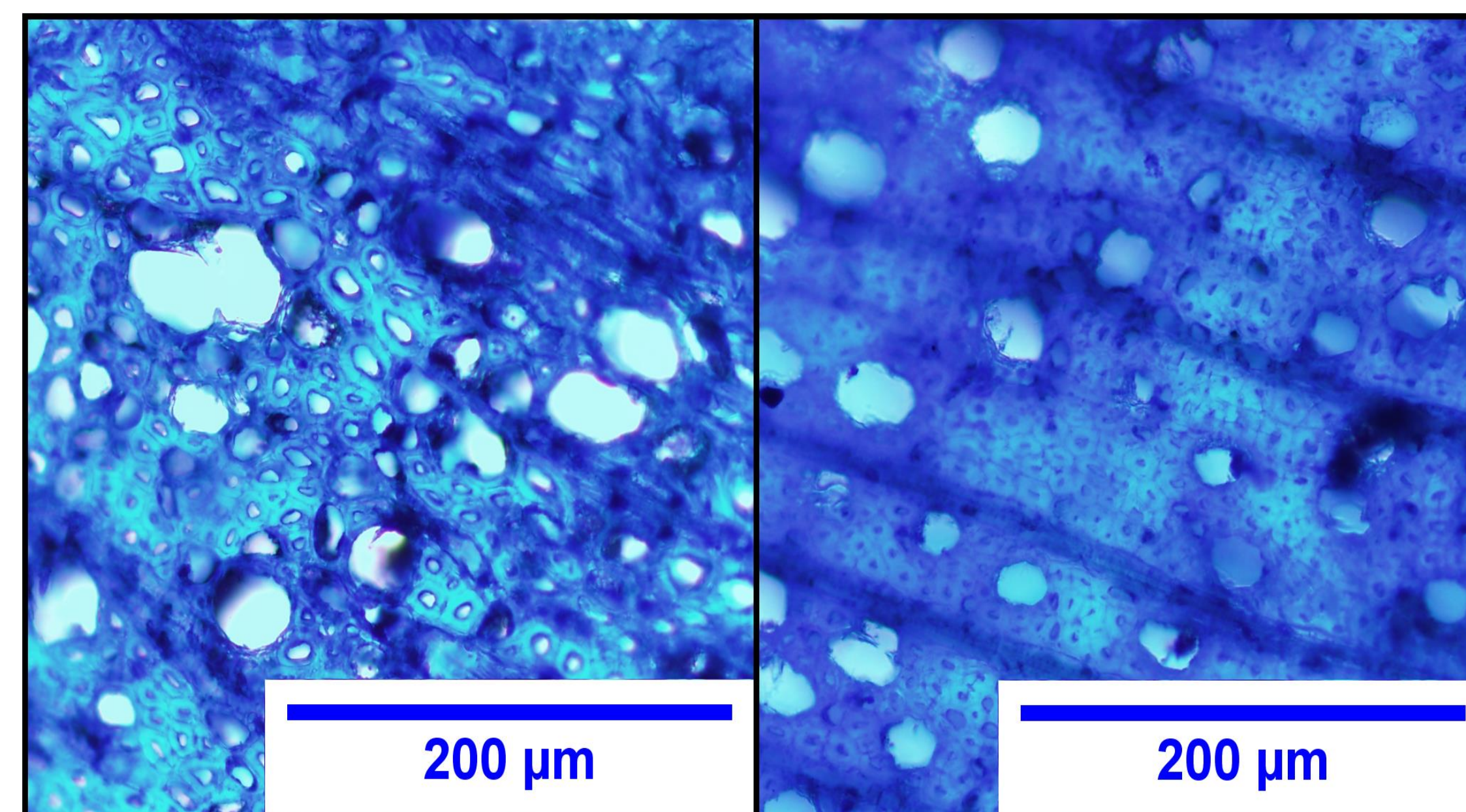
- Microscopy and LAT may allow for the detection of weak combinations, allowing us to predict them before they are planted in the field in large quantities
- These methods could save growers thousands of dollars in replanting costs caused by broken trees

Methods

- Light Microscopy
 - Transverse sections were taken from the union of weak and strong scion/rootstock combinations of apple
 - Cells were split into categories based on their function, including parenchymatous (nutrient storage and wound repair), fibrous (mechanical support), and conductive (conduct water throughout the tree) cells
 - Quantified proportions of cell types at the union using ImageJ image analysis software
- LAT
 - A laser beam vaporized union sections 3cmx2.5cmx4mm in size
 - Pictures were taken in 100µm intervals, and a 3-dimensional model was created using AVIZO imaging software
 - Images were qualitatively analyzed for the presence of irregular tissue that may lead to a weak union

Results and Conclusions

Light Microscopy

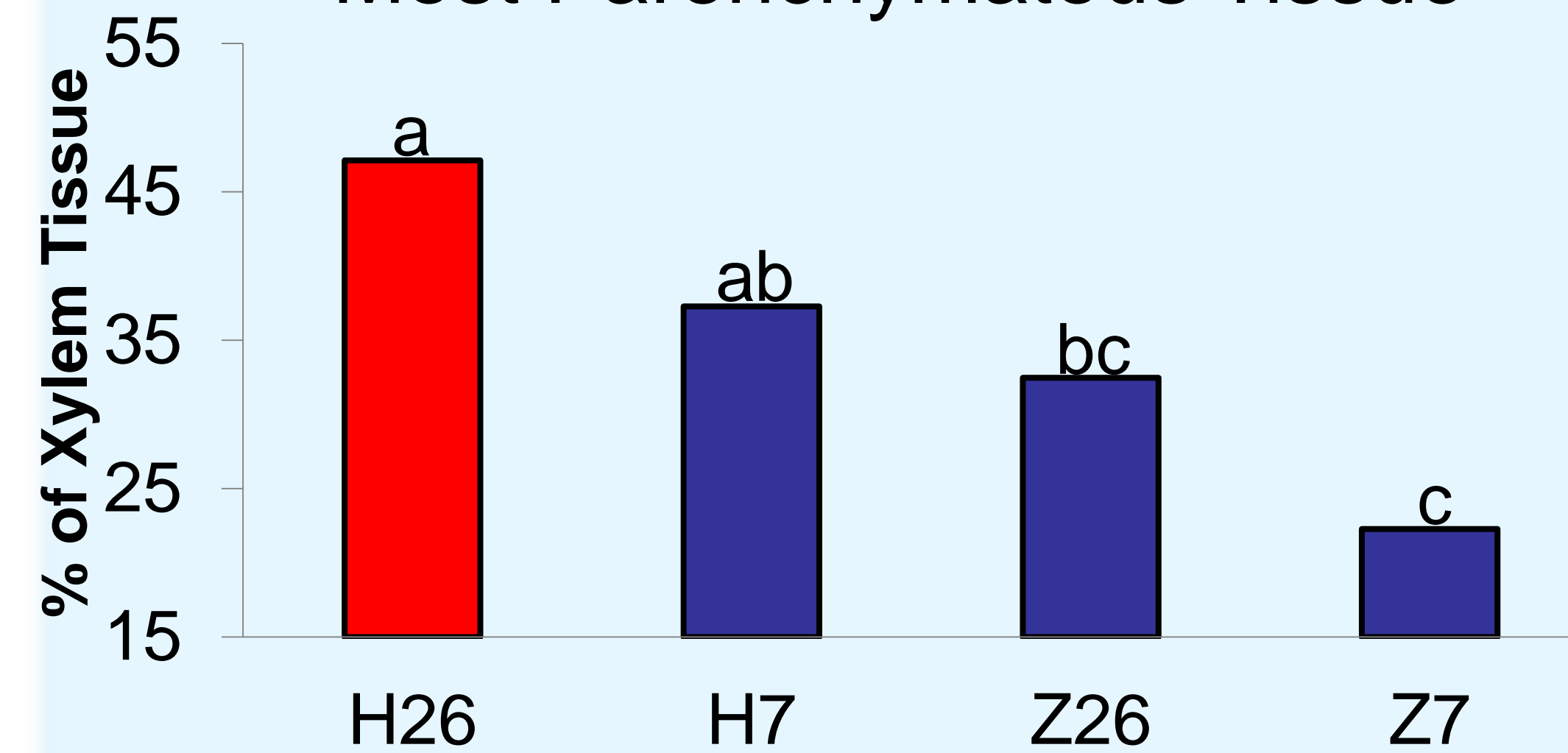


Weak

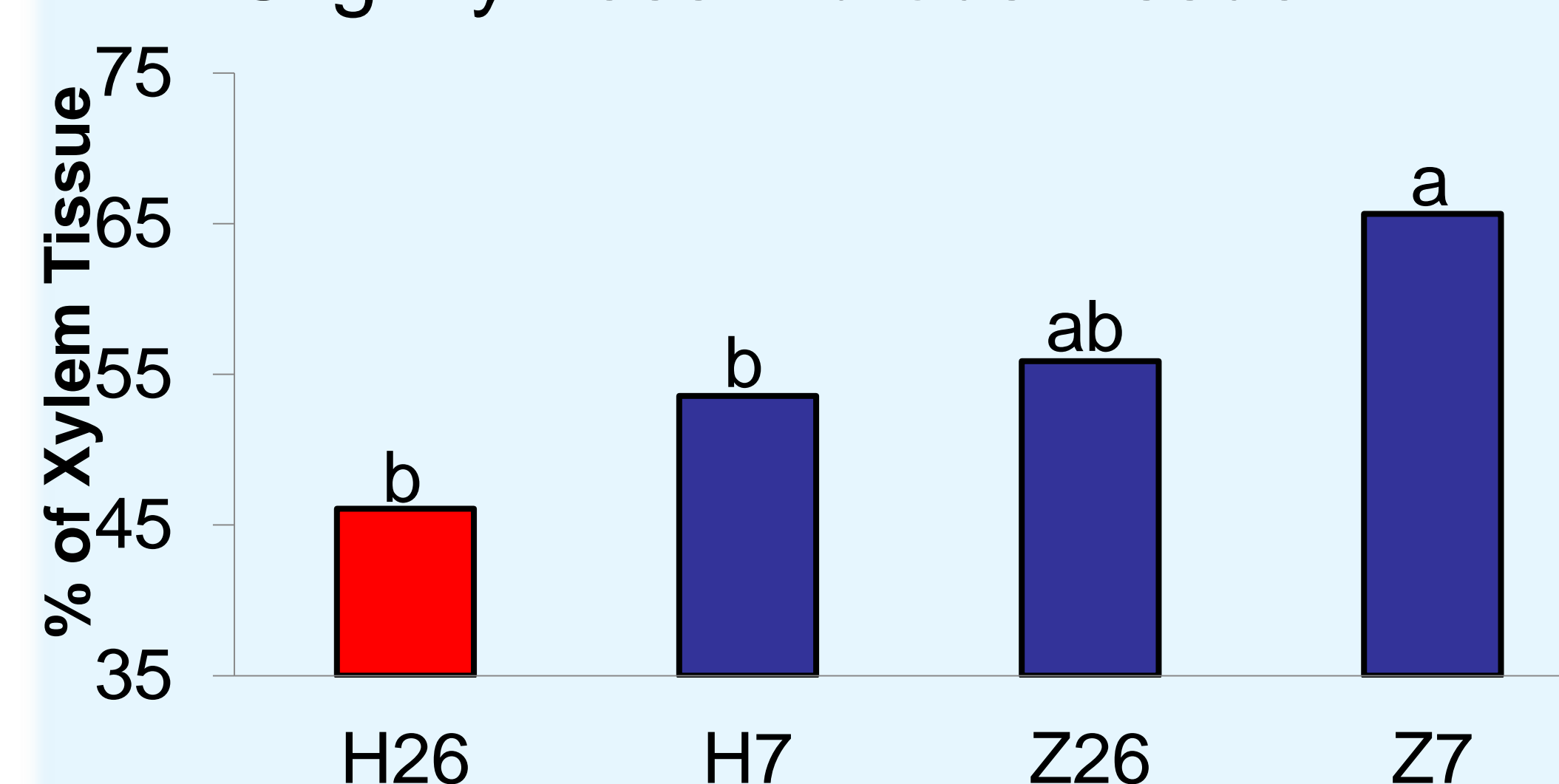
Strong

- Parenchyma tissue (purple-blue) was most abundant in the weak union 'Honeycrisp'/'M.26 EMLA'
- Tissues appeared poorly organized in the weak combination
- These anatomical differences were quantifiable, and the weak combination contained significantly more parenchymatous tissue than two of the three strong combinations
- The weak combination had the least amount of fiber cells, and contained significantly less fiber cells than one of the strong combinations
- These anatomical differences may be caused by a lack of recognition between the scion and the rootstock in the weak combination

The Weak Combination Had the Most Parenchymatous Tissue

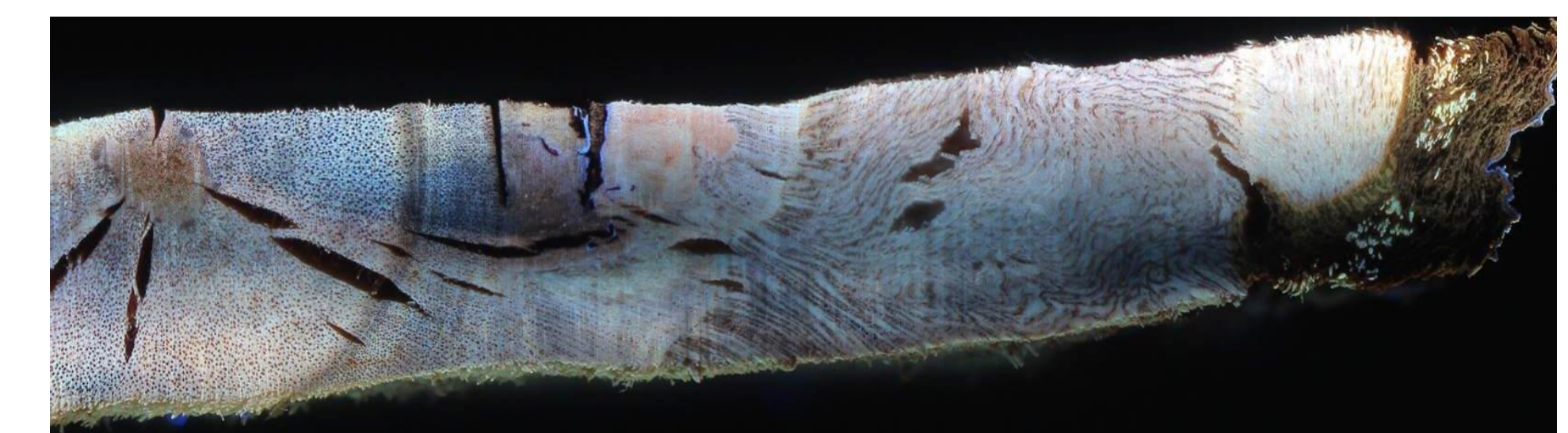


The Weak Combination Had Slightly Less Fibrous Tissue

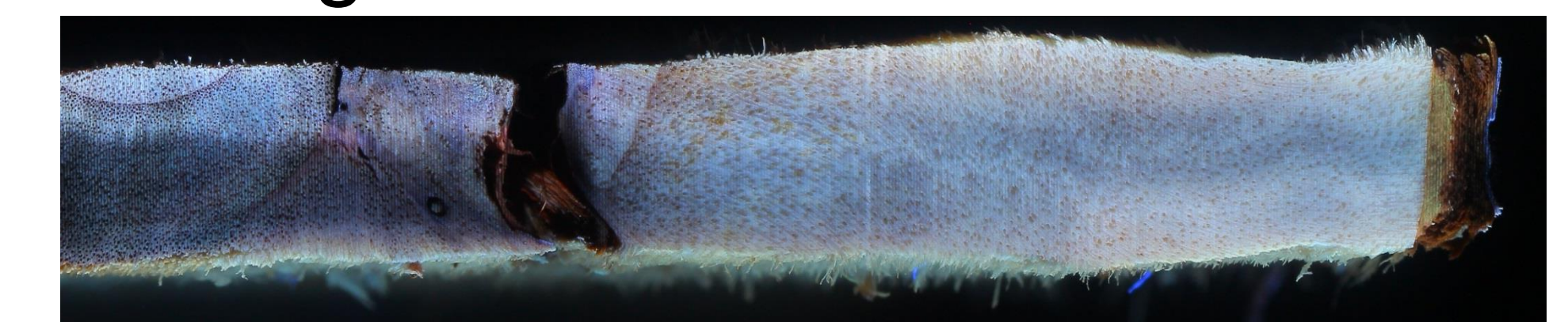


Laser Ablation

Weak



Strong



- The weak combination tended to have larger areas of disorganized tissue, and lacked proper vessel orientation
- Areas of swirling xylem tissue were evident throughout the following season of growth in the weak combination
- Irregularities were also present in strong combinations, including areas of necrosis and vascular discontinuity
- This method did not allow us to view the entire union, or to observe differences at the cellular level

Interpretation

- Differences were observed between the weak and strong combinations using microscopy
- The overproduction of parenchyma has previously been described as a sign of a lack of recognition between the scion and rootstock, and may cause the weakness in the failure-prone combination
- The variability of these tissues may make it difficult to predict future weak unions based entirely from a 2-dimensional study
- Differences were observed between the weak and strong combinations using LAT, and the swirling xylem observed in the weak combination may help explain its weakness
- Anomalies were observed in strong combinations as well, which may make it difficult to use LAT as a prediction method for weak unions in future scion/rootstock combinations

Future Studies

- Continue microscopy studies to further assess its validity and to determine the variability of the tissues at the union
- Use a higher magnification in LAT to achieve cellular resolution
- Use LAT to observe anatomical differences in younger trees shortly after propagation to determine if differences are detectable early in cell differentiation
- Biochemical and genetic studies of traits unique to weak combinations

Acknowledgements

- International Fruit Tree Association
- Penn State University College of Agricultural Sciences

References

<http://www.omafra.gov.on.ca/english/crops/facts/05-04716.jpg>