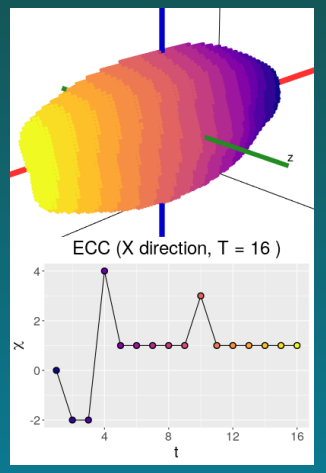
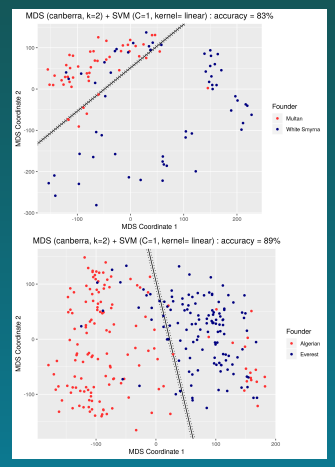
# Using **topology** to **analyze** the **shape** of barley

## ↓ **Animated** version! ↓

bit.ly/eccb21_tda




## Preprint [QR below]

doi.org/10.1101/2021.03.27.437348

# Euler meets plant science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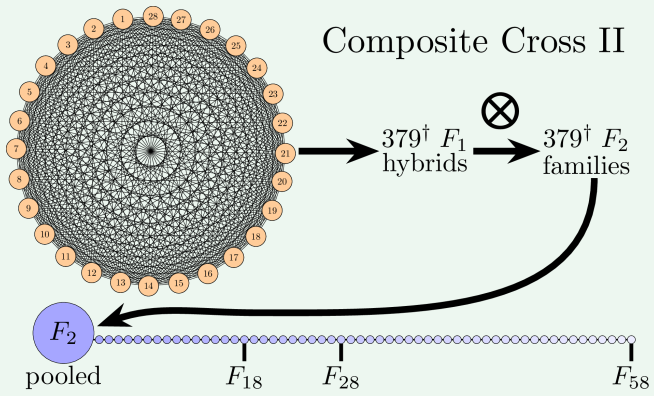
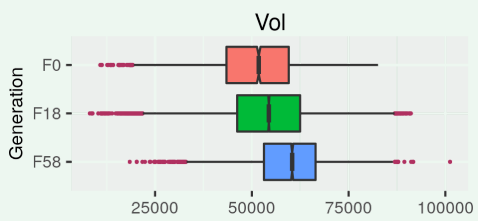
## Barley Experimental Design




- 28 founders (land races). 58 generations.

## Image processing to measure seeds




- 3D X-ray CT scan data: 875 barley spikes.
- 38,000 seeds: generations F0, F18, and F58.
- Distribution of length, height, width, volume, etc.

## SVM Classification Results

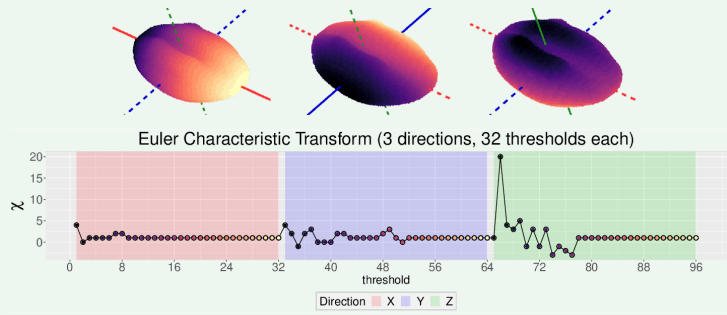
| Shape descriptors | # descr | F1 Score |
|---|---|---|
| Traditional | 11 | 0.55 ± 0.019 |
| Topological (ECT + UMAP) | 12 | 0.74 ± 0.016 |
| Combined (Trad + Topo) | 23 | 0.86 ± 0.010 |

- SVM to classify 3,000 seeds from the 28 founders
- (75% training vs 25% testing) × 50 times
- **Up to 84% classification accuracy**

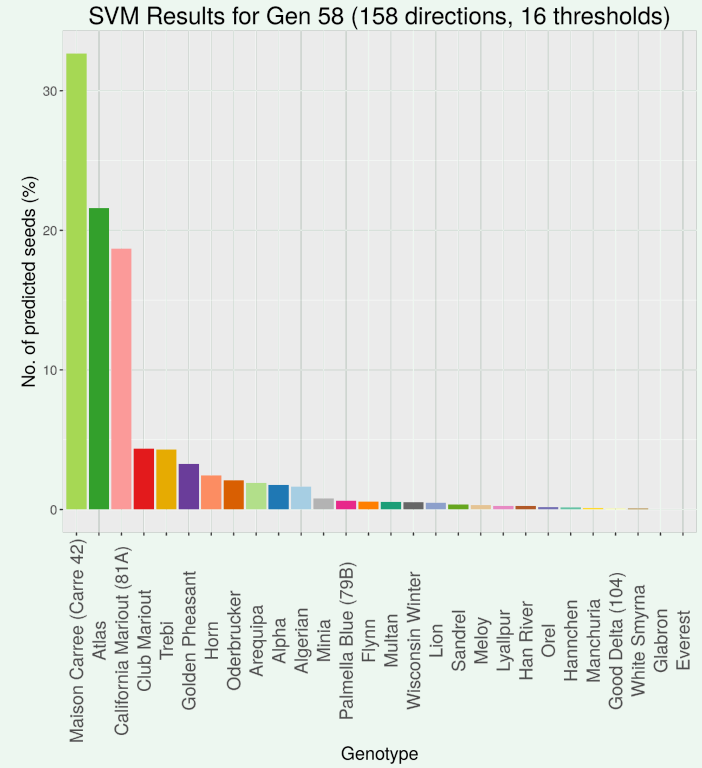
## Euler characteristic transform (ECT)

$$\chi = \#(\text{Vertices}) - \#(\text{Edges}) + \#(\text{Faces})$$

- ECT is the record of how the EC changes as we reconstruct a given object in all possible directions.
- The ECT summarizes all shape information [1].




## Semi-supervised learning




- Train with 100% of the founder seeds
- Classify 6000 unlabeled seeds from F58
- Three morphologies are enriched through time.
- Similar conclusion with genomic analysis!


### Acknowledgements

This work is supported in part by Michigan State University and the National Science Foundation Research Traineeship Program (DGE-1828149).


### References


[1] K. Turner, S. Mukherjee, and D. M. Boyer, "Persistent homology transform for modeling shapes and surfaces," *Information and Inference*, vol. 3, no. 4, pp. 310–344, Dec. 2014.