



Integrating air sorting, X-ray imaging and machine learning for redwood seed selection

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Introduction



- New Zealand's forestry sector relies heavily on radiata pine (around 90%).
 - Pests and diseases take longer... but they are coming! (Need for diversification)
 - Redwood has high value timber and adapted well across the country
- ↓
- Seed lots are known for having very low germination success

Inefficiencies in nursery operations X challenge scaling up seedling production





Main objectives

- To determine the extent to which air-sorting could select viable redwood seeds
- To investigate if X-ray imaging combined with machine learning approaches could predict redwood seed viability

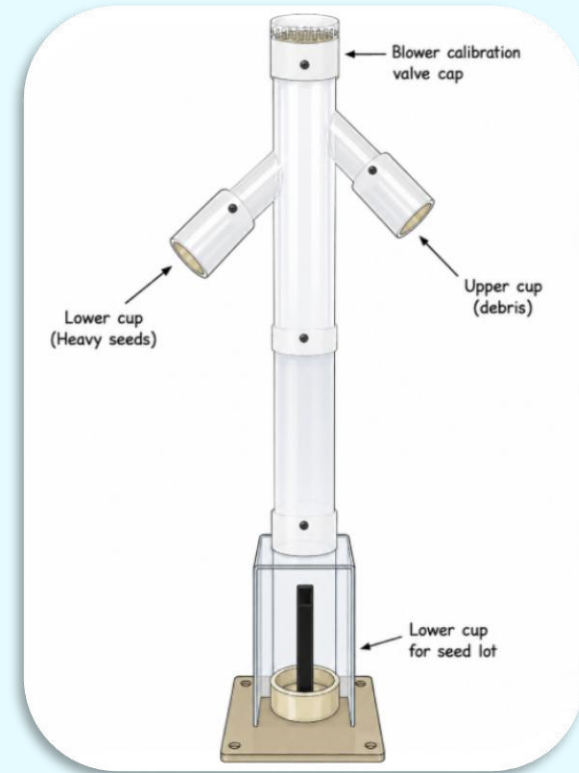
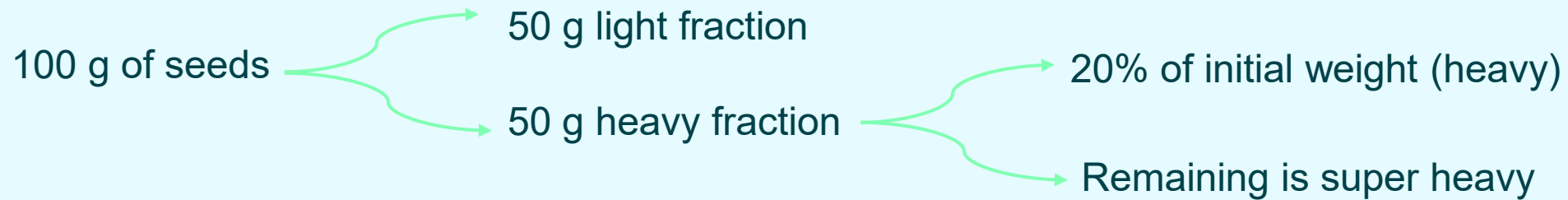


Methodology



Seed collection from: Mother 13, Mother 755, Mother 756 and road side

Air sorting into three fractions: light, heavy and superheavy seeds

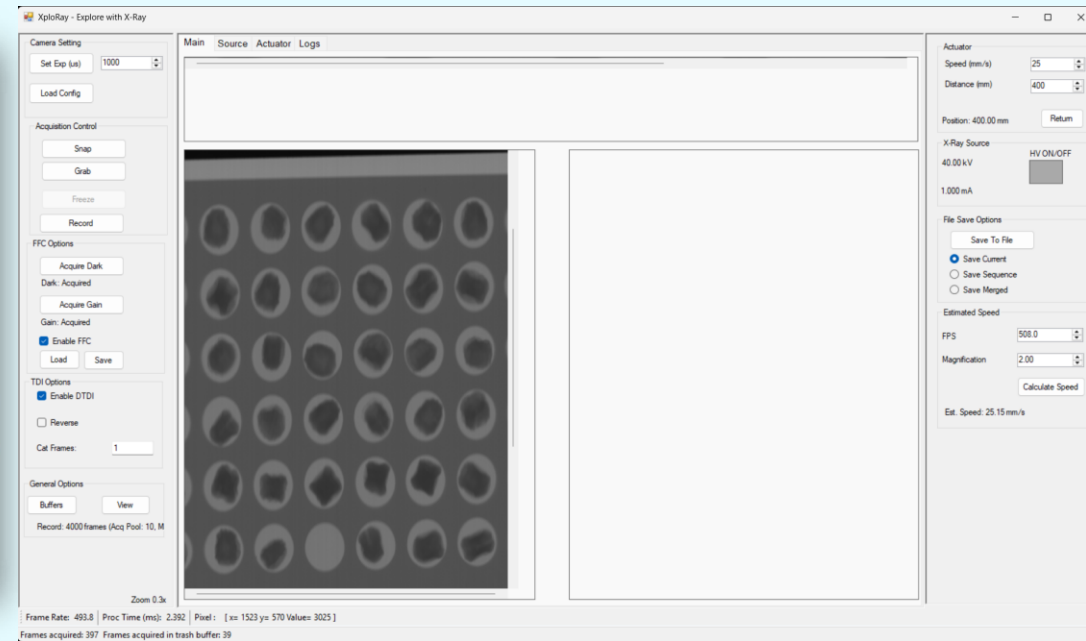
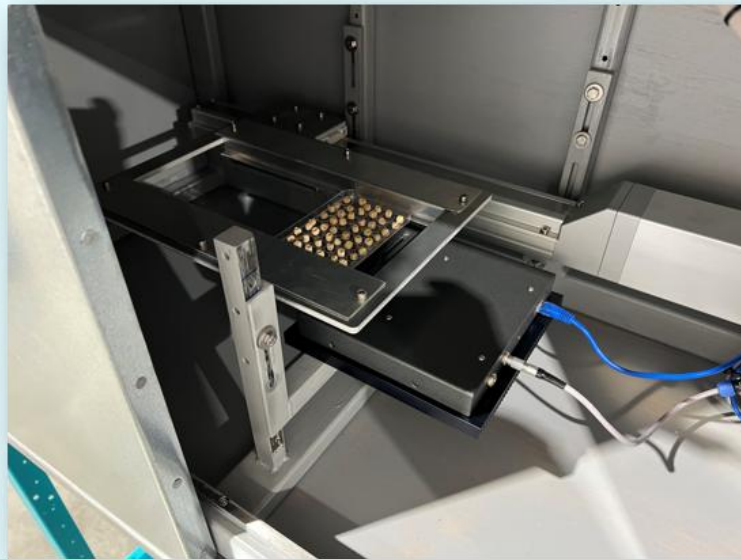


Seed air blower

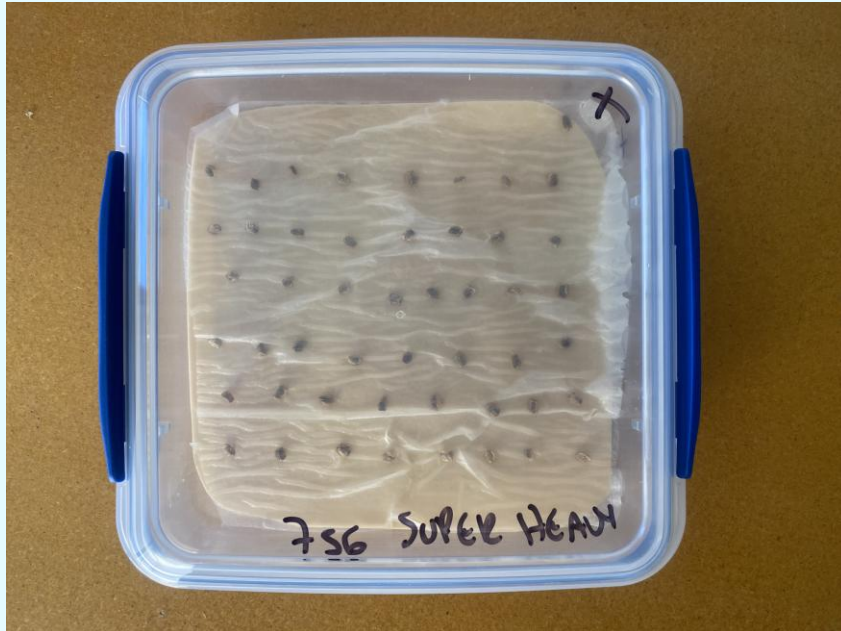
X-ray imaging



- Voltage ranging from 10kv to 50kv, designed for high resolution imaging.



Germination testing



Germination conditions:

22/20 °C day/night

12 h photoperiod

Trial layout with four replicates and 25 seeds per plot

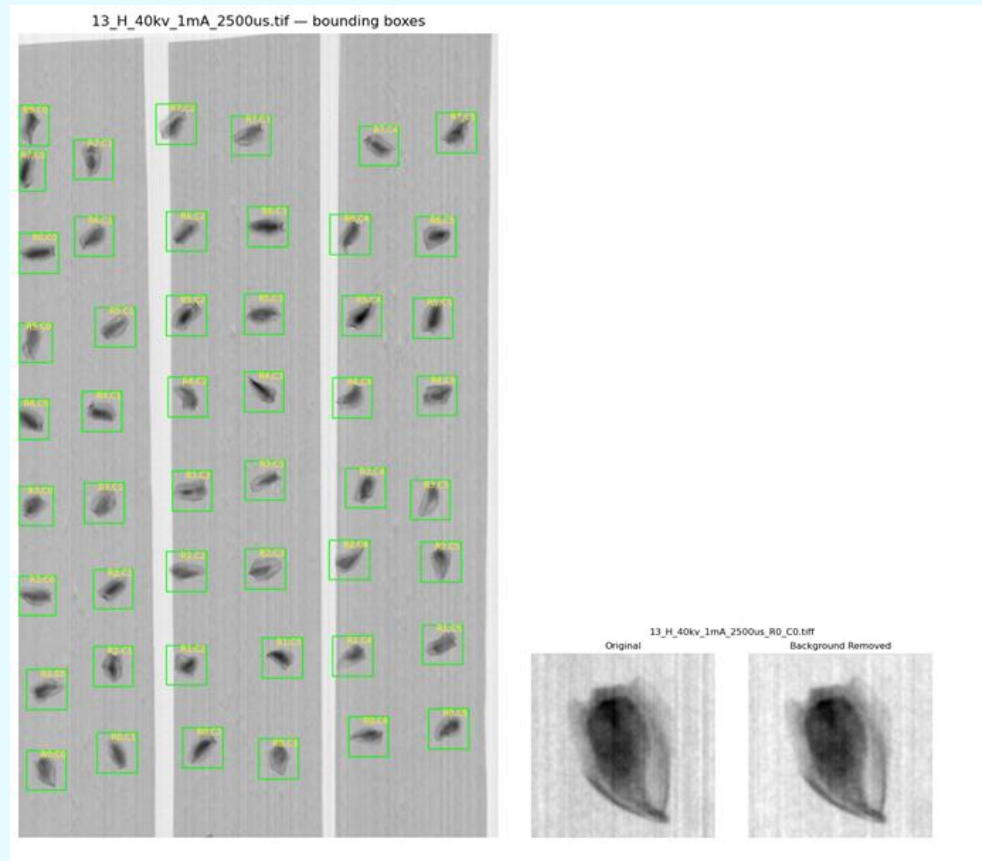
2x3 factorial scheme: Factor A - mother plants; Factor B – seed fractions

Two-way ANOVA and Tukey test ($P < 0.05$)

Machine learning training

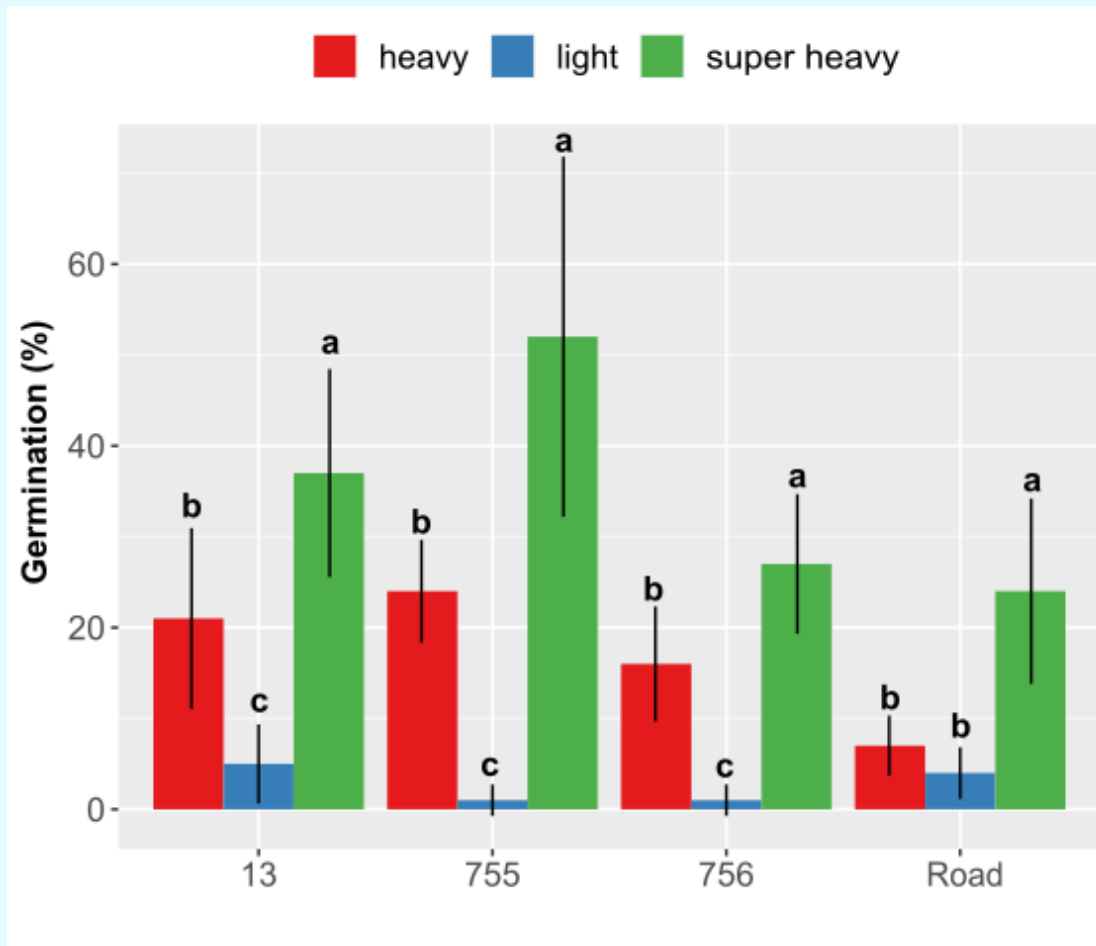


- Free space and endosperm+embryo (seed weight) in relation to the total seeds area



- Model training
- Tracking seeds for the germination tests

Results – germination testing



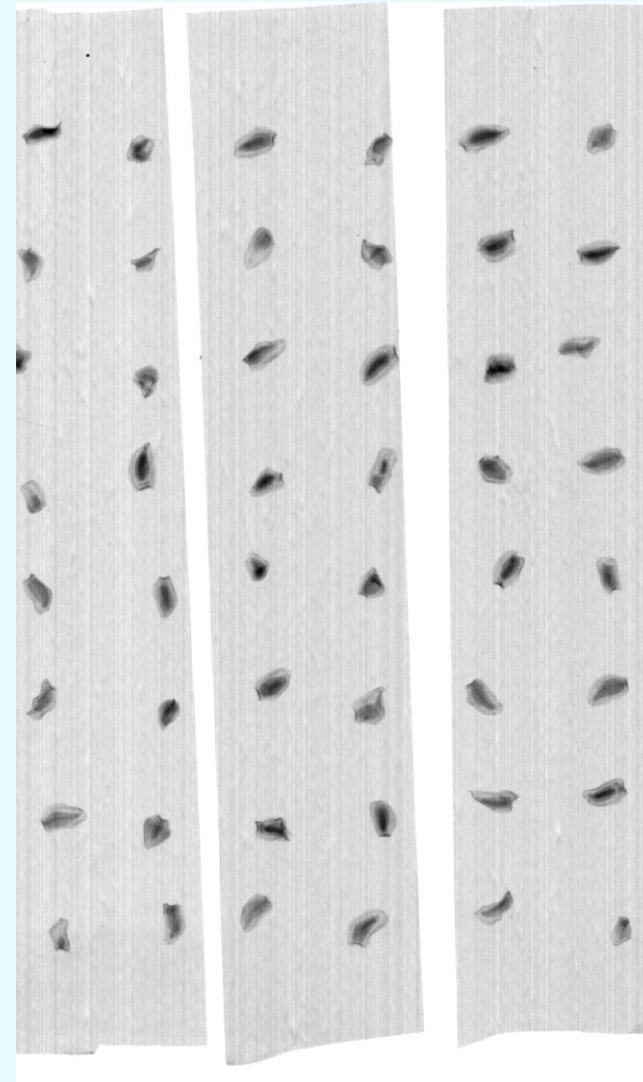
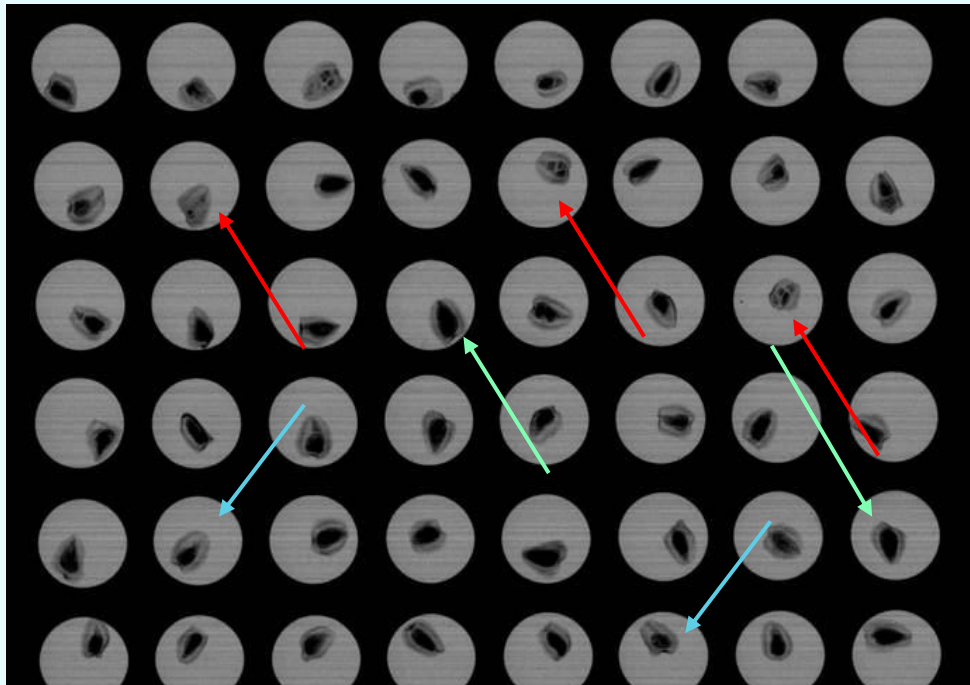
- Gains in germination rate were dependant on mother plant
- Mother 755 achieved 50% increase (highest)

Different lowercase letters indicate statistically significant differences between superheavy, heavy and light seeds within each mother plant factor ($P < 0.05$) by Tukey's test.

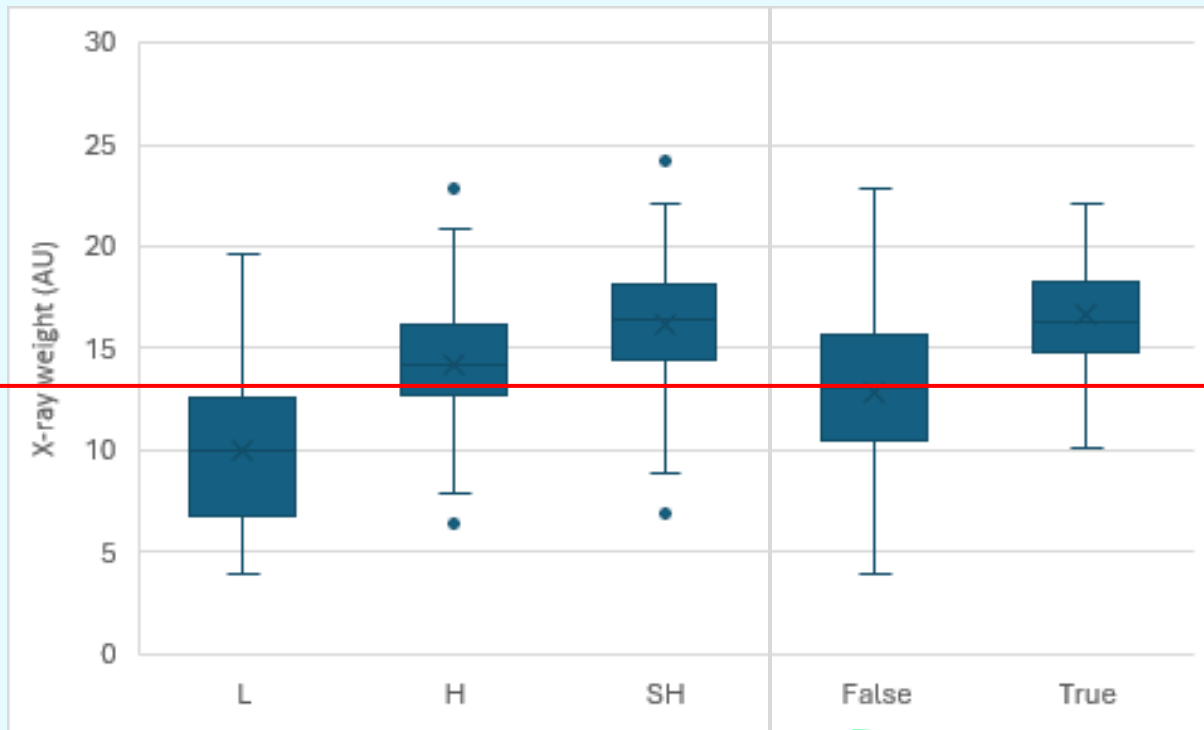
X-ray imaging



- Adjust contrast, exposition...
- Sound and unsound seeds

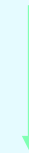


X-ray – seed weight distribution vs fractions



Light Heavy Superheavy

- Overlap between heavy and super heavy
- Cut off point for germination around 13.5AU



Low chances or success below this point

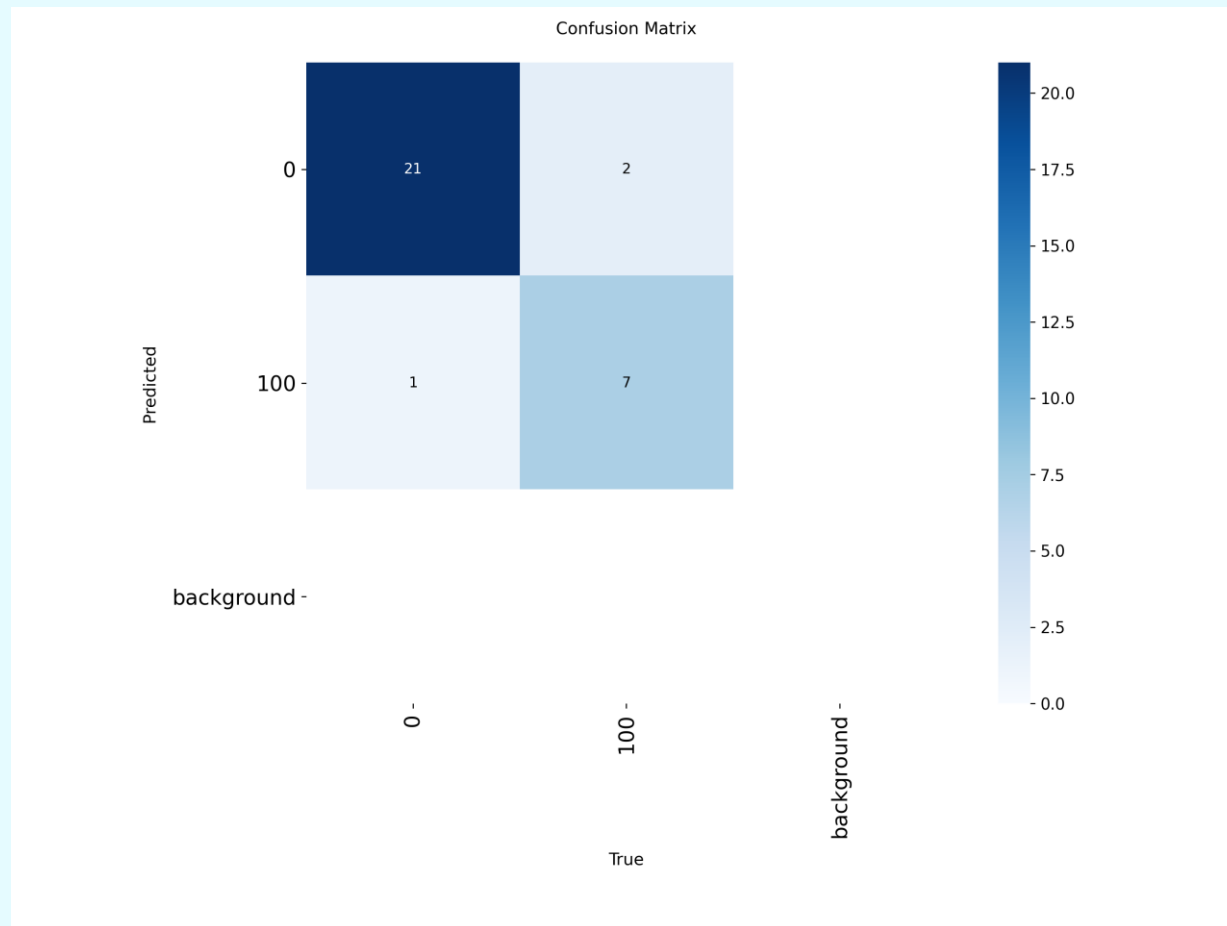
Germinated

Non germinated

Confusion matrix of the trained model



Prediction of seed viability *versus* true germination (100) using filtered data



- Model incorrectly “accepted” two seeds
- Model prediction 8 germ seeds with 1 false positive
- 87% accuracy for germination prediction

Seed weight vs germination success



None of them germinated...

Mother 756	Mother 756	Mother 756
Light	Heavy	Superheavy
2%	6.25%	12.5%

- Chemical compounds, such as tannins, limiting germination even in undamaged full seeds

→ Possibly a confounding factor for model prediction



Final considerations

- Air-sorting was (to some extent) an effective method to improve selection of viable seeds.
- AI model (using x-ray imaging) achieved around 87% accuracy for germination prediction

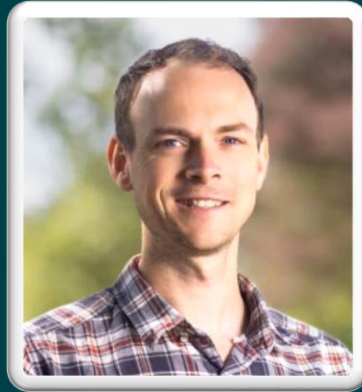
Next steps

- Increase sample sizes for more training and validation of the results – test using unseen samples
- Evaluate the results per mother plant (confounding factors limiting germination?)

Mos Sharifi



Sam Hitchman



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Thank you