

Unmanned Aerial Vehicle-based High-Throughput Phenotyping in Sugar Beet Fields

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Background:

- Germplasm trait evaluation is essential to identify genetic sources for sugarbeet breeding, but by manual scoring

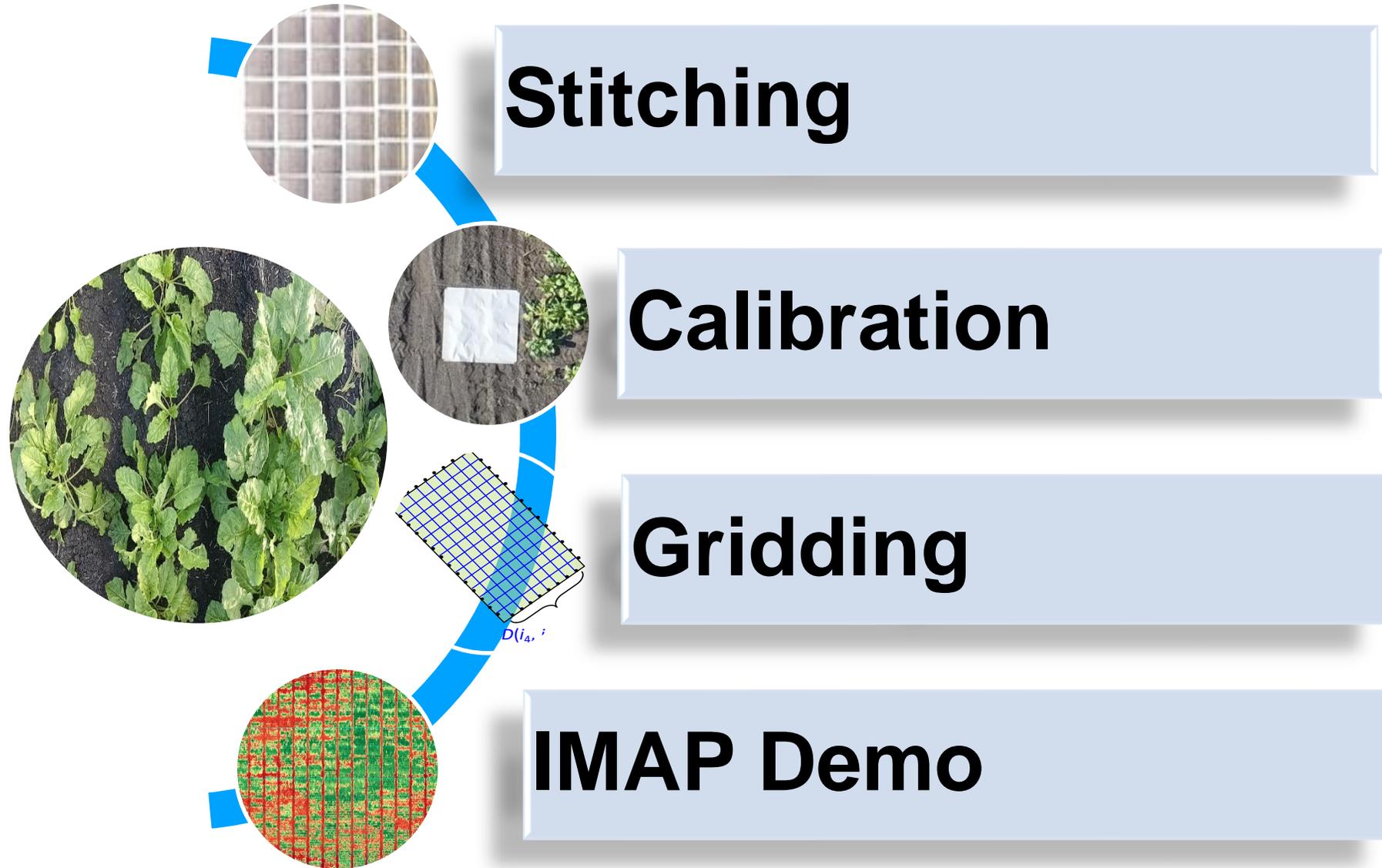
Goal: UAV-based phenotyping to expedite consistent phenotypic metrics

Methods:

- 1) UAV
- 2) Plot-level metrics
- 3) Open-source software

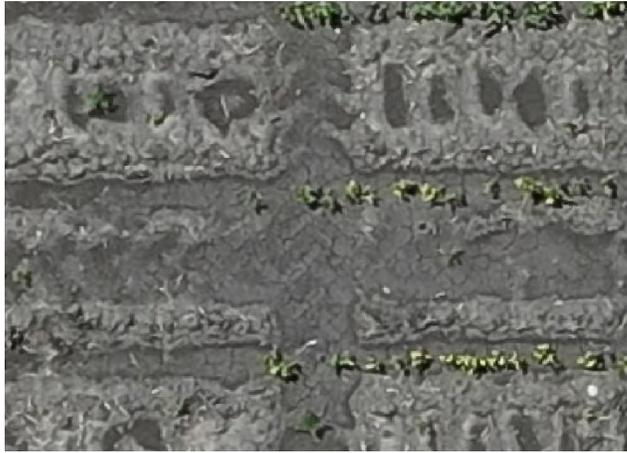
Experiment:

- Sugarbeet root maggot nurseries in St. Thomas and Reynolds ND



STITCHING

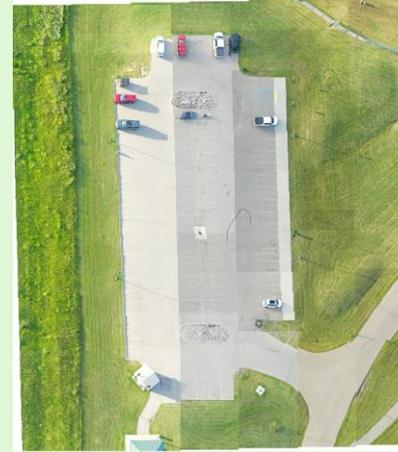
Stitched image



Tile image



DGR (18 sec)

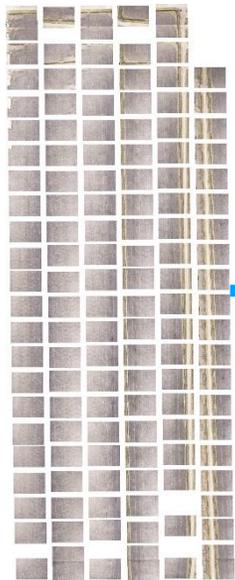


Pix4D (2hr)

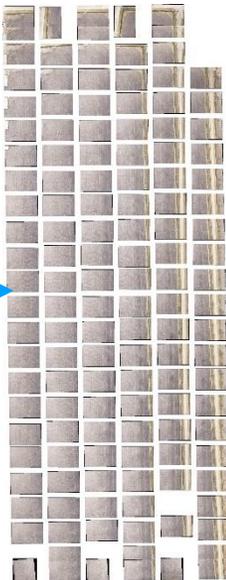


(100ft, 20MP, 162 tiles, 1.5GB)

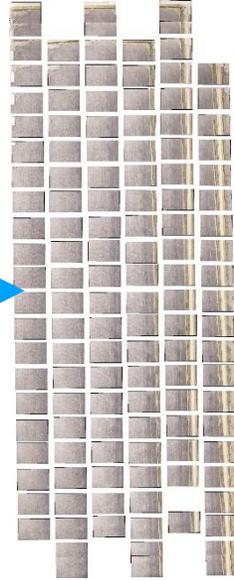
Geo-tagged



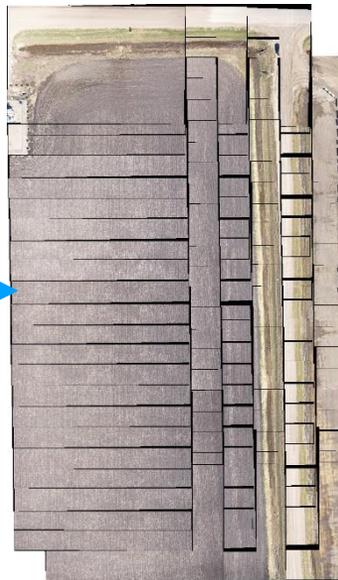
Geo-tagged + orientation



Geo-tagged + orientation-filtered



Geo-tagged + orientation-filtered + GSD



Geo-tagged + orientation-filtered + GSD + straighten



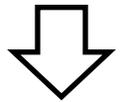
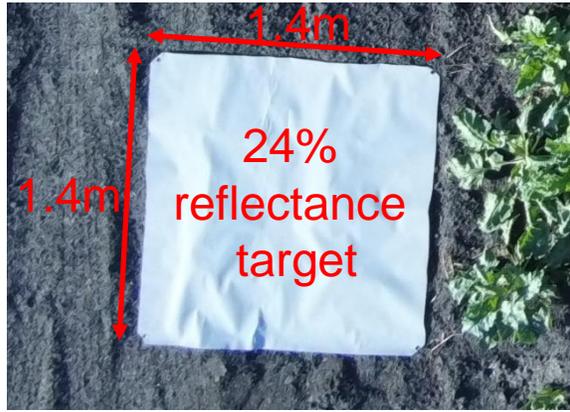
Geo-tagged + orientation-filtered + GSD + straighten + heading



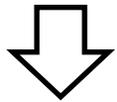
CALIBRATION

Parrot Anafi (16MP)

32ft, 0.13 in/px

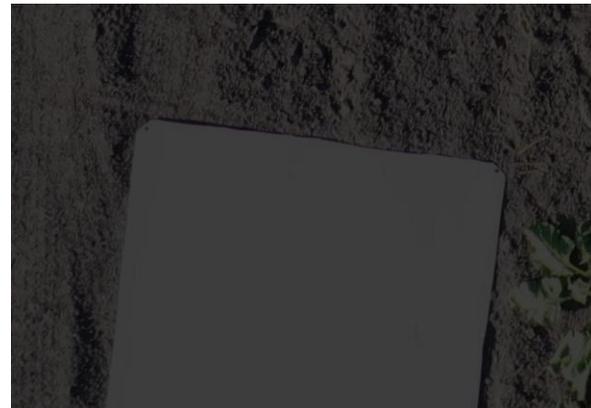
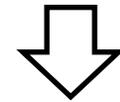


100ft, 0.4 in/px



Mavic 2 Pro (20MP)

32ft, 0.1 in/px



100ft, 0.31 in/px

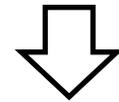
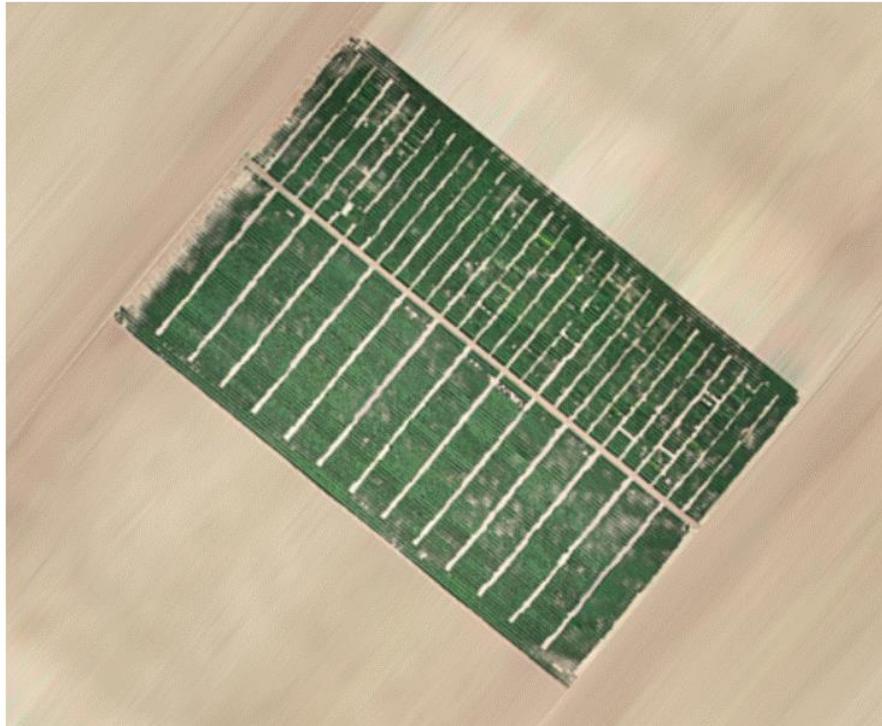


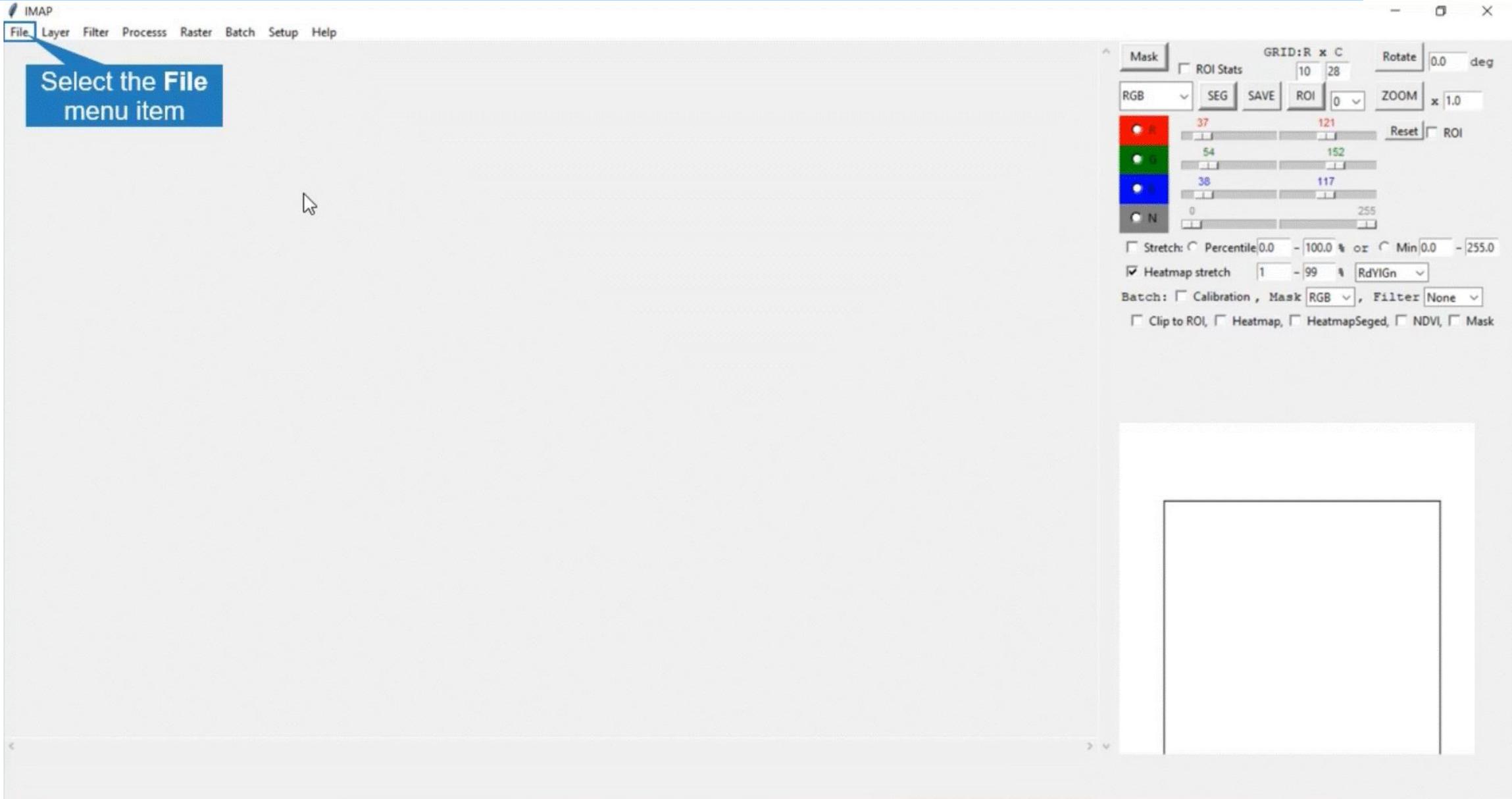
Image rotation



Adaptive Gridding
by ROI rotation

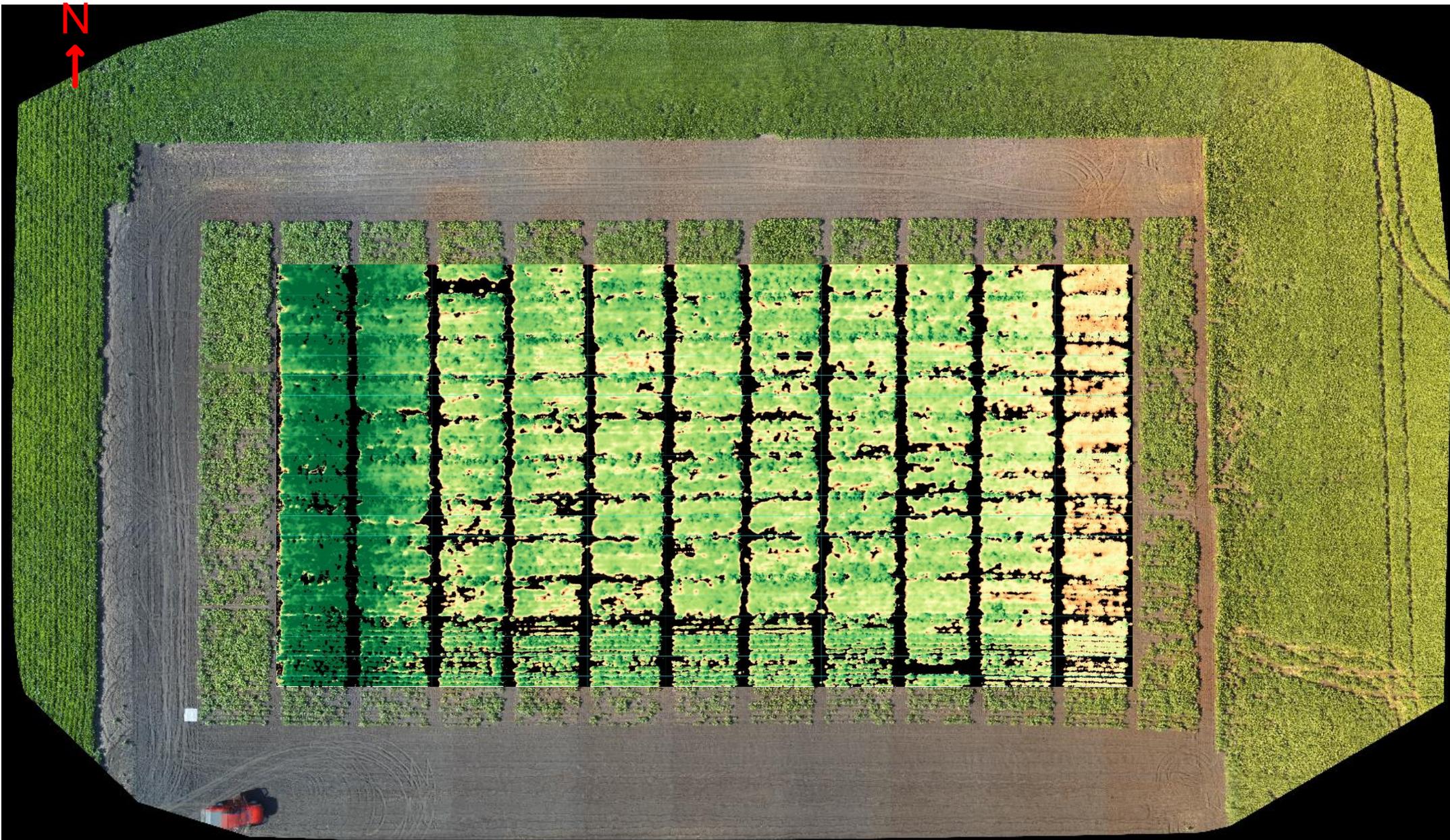


IMAP DEMO



The screenshot displays the IMAP software interface. At the top left, a menu bar includes 'File', 'Layer', 'Filter', 'Process', 'Raster', 'Batch', 'Setup', and 'Help'. A blue callout box with a white arrow points to the 'File' menu item, containing the text 'Select the File menu item'. The main workspace is a large, empty gray area. On the right side, there is a control panel with various settings. At the top of the panel, it says 'Mask' and 'GRID: R x C' with values '10' and '28'. Below this are 'Rotate' (0.0 deg), 'RGB' (selected), 'SEG', 'SAVE', 'ROI' (0), and 'ZOOM' (x 1.0). There are four color-coded sliders: Red (37 to 121), Green (54 to 152), Blue (38 to 117), and N (0 to 255). Below the sliders are options for 'Stretch' (Percentile 0.0 - 100.0 % or Min 0.0 - 255.0) and 'Heatmap stretch' (checked, 1 - 99 % RdYIGn). At the bottom of the panel, there are 'Batch' options: 'Calibration', 'Mask' (RGB), 'Filter' (None), and checkboxes for 'Clip to ROI', 'Heatmap', 'HeatmapSeged', 'NDVI', and 'Mask'. A white rectangular box is visible in the bottom right corner of the main workspace.

RESULT - REYNOLDS, ND



Calibration



NDVI



Segmentation

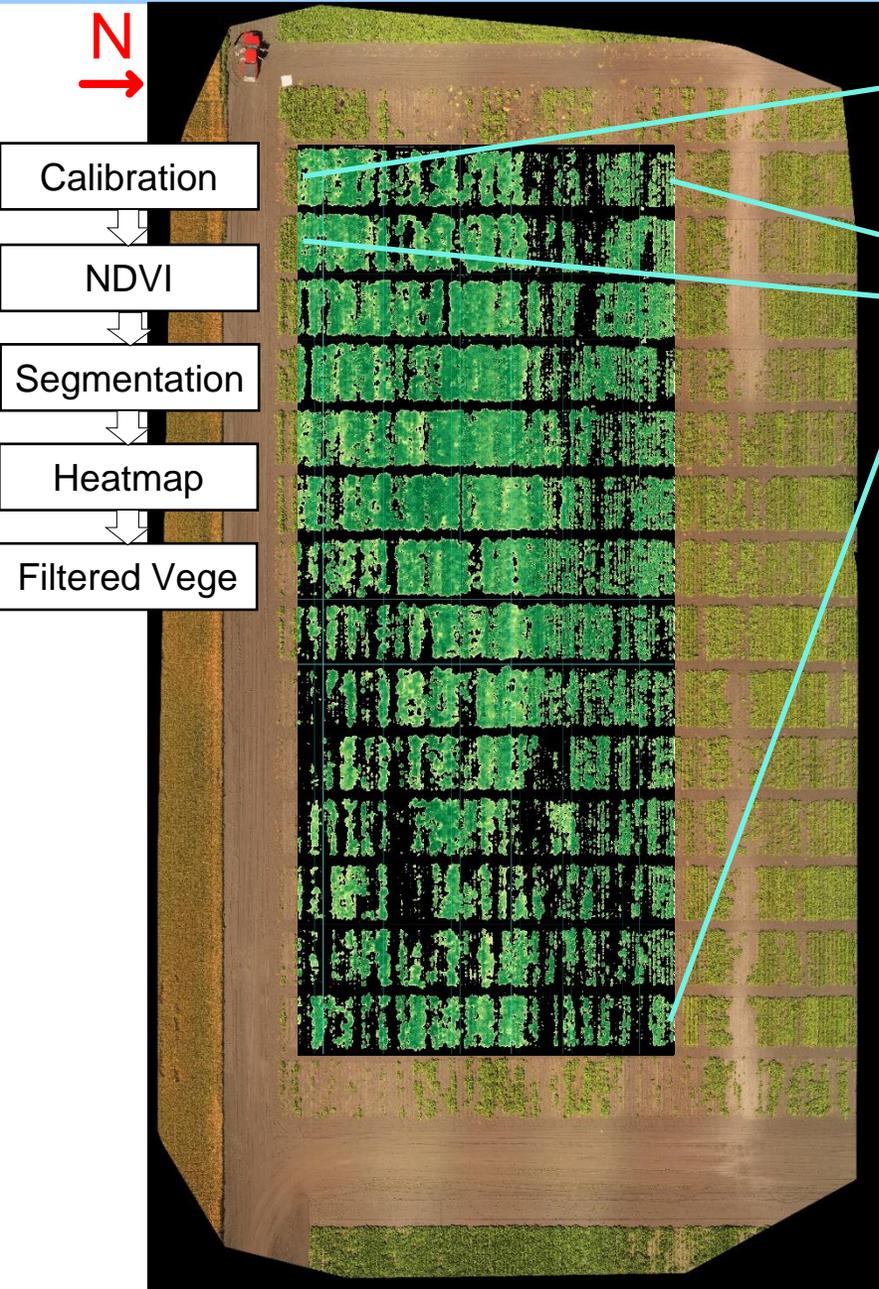


Heatmap

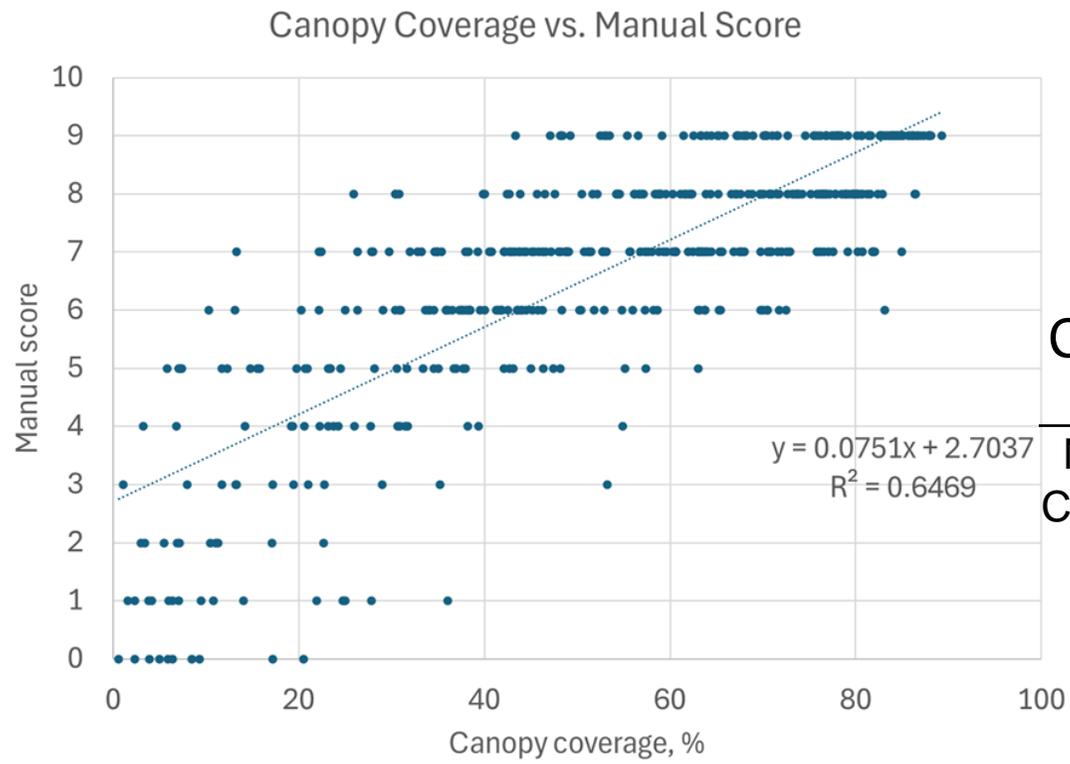


Filtered Vege

RESULT - ST. THOMAS, ND



| Iter | Row | Col | cnt_Fgnd | cnt_ROI | %Canopy | R [%] | G [%] | B [%] | NDVI |
|------|-----|-----|----------|---------|---------|-------|-------|-------|-------|
| 1 | 1 | 1 | 61588 | 87847 | 70.11 | 12.73 | 12.74 | 5.44 | 0.712 |
| 2 | 1 | 2 | 76374 | 88668 | 86.13 | 12.29 | 12.68 | 4.95 | 0.744 |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 44 | 1 | 44 | 50167 | 87847 | 57.11 | 14.04 | 13.91 | 5.61 | 0.697 |
| 45 | 2 | 1 | 69406 | 87847 | 79.01 | 12.58 | 13.03 | 4.85 | 0.746 |
| ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ | ⋮ |
| 616 | 14 | 44 | 26461 | 87847 | 30.12 | 14.03 | 14.09 | 6.2 | 0.712 |



Correlation, R=

| | Reynolds St. Thomas | |
|--------|---------------------|------|
| NDVI | 0.46 | 0.63 |
| Canopy | 0.10 | 0.80 |

- UAV-based plant phenotyping to facilitate the breeding pipeline
- Deployed adaptive gridding successfully
- Published open-source analytic software, IMAP

Future Work:

- Deploy Auto-Trac planter for field alignment
- Expand UAV and IMAP for other stress identification (CLS, weed, etc.)
- Enhance direct geo-referencing of UAV images