2024

Drone Imagery For Potato Trials In Tulelake, CA

Sixten drone images taken throughout the growing season were acquired from the Southwest and Western Region potato trials at the Intermountain Research and Extension Center during 2024.

Image analysis results are summarized in this report.

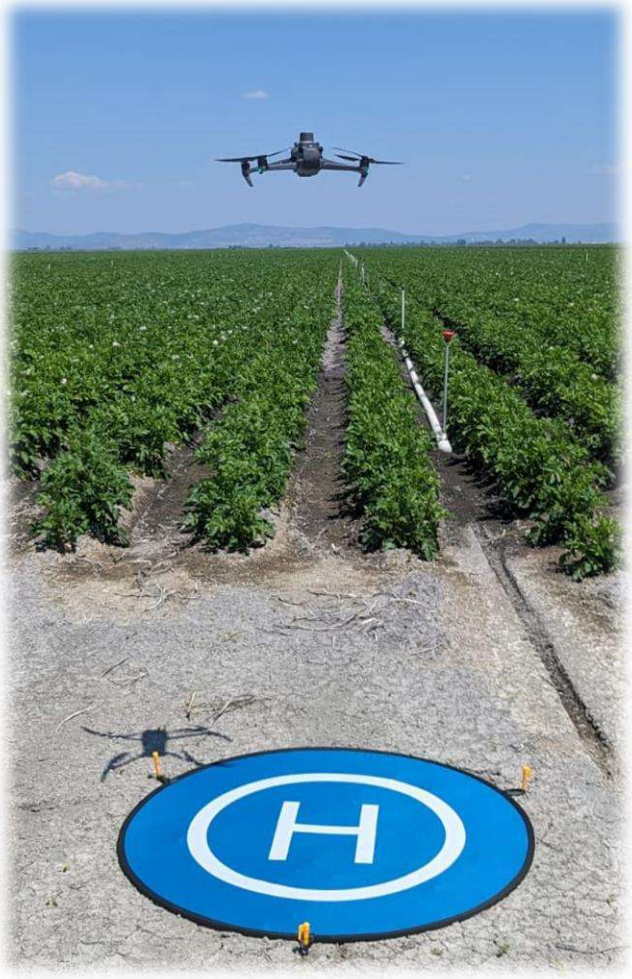

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Table of Contents

Acknowledgements 2

Introduction 2

Drone Flights Details 3

Drone Image Analysis 4

Vegetation Coverage Area 6

Vegetation Indices 9

Archived Images 10

Appendix 1: Time series for vegetation indices 11

Appendix 2: Archived Drone Images 20

University of California
Agriculture and Natural Resources
Intermountain Research & Extension Center
RESEARCH REPORT
Number 210, 2024

Drone Imagery From 2024 Southwest and Western Region Potato Trials In Tulelake, CA

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Prepared Report

A total of 16 drone multispectral images were collected using DJI Mavic 3M from the study field that contained three different potato variety trials (Russet, Red and Chip) at different crop growth stages. More details about the potato trials can be found in IREC research report number 209, 2024.

This research was funded by the USDA/NIFA Special Research Grants Program- Potato Research (Award # 2021-34141-35449)

Drone Flights Details

Location: Intermountain Research and Extension Center, Tulelake, CA

Planting Date: May 17th

Harvest Date: September 25th

Flight Altitude: 71 Feet

Frontal Overlap: 80%

Side Overlap: 70%

Forward Speed: 3 mph

Ground Sampling Distance: 1 cm/pixel

Drone images dates and days after planting (DAP):

I	Date	DAP
1	06-11-2024	25
2	06-14-2024	28
3	06-17-2024	31
4	06-18-2024	32
5	06-26-2024	40
6	07-01-2024	45
7	07-05-2024	49
8	07-08-2024	52
9	07-11-2024	55
10	07-17-2024	61
11	07-25-2024	69
12	08-03-2024	78
13	08-09-2024	84
14	08-15-2024	90
15	08-21-2024	96
16	08-27-2024	102

Drone Image Analysis

We collected drone images with RTK GPS location correction from PointOneNavigation service provider. The accuracy of this service was tested at the IREC, and the image location was accurate up to <1 inch. The use of this service allowed us to avoid the image relocation step on the analysis protocol from the previous season.

Prior to collecting drone images, we captured an image from the Sentera calibrated reflectance panel (Sentera, St. Paul, MN), as shown in Figure 1. The calibration panel provides a consistent reflectance surface, which allows the ability to precisely compensate for changes in ambient lighting conditions. All raw images were initially processed through the Pix4D Mapper software for image calibration and stitching, and then all analyses were performed through the ArcGIS Pro software.

Figure 1: Capturing a drone image from the calibration panel.

Images were analyzed using ArcGIS pro software as follows:

1- Creating rectangular polygons with 5 ft width and 15 ft length centered into each potato variety plot.

2- Extracting spectral data from each variety from all images and calculating NDVI, GNDVI, NDRE using the following equations:

GNDVI = (G-NIR) / (G+NIR)

NDVI = (R-NIR) / (R+NIR)

NDRE = (RE-NIR) / (RE+NIR)

Where G is the green, R is the red, RE is the red-edge and NIR is the near infrared reflectance values.

4- Calculating the crop coverage area from early growth stages till row closure by applying the following steps on each image:

A- Calculating NDVI and classifying pixels based on values where only NDVI>0.5 pixels were considered as vegetation. The image from July 11, 2024, had high NDVI values, and the classification criteria of NDVI > 0.8 for vegetation were more accurate in estimating the crop coverage area. I don't have a compelling reason to explain this situation.

B- Converting the classified image from raster to polygon format.

C- Clipping vegetation polygons from each variety box and calculating the total area of vegetation to calculate the crop coverage percentage. See figure 2 for example of one variety from one image.

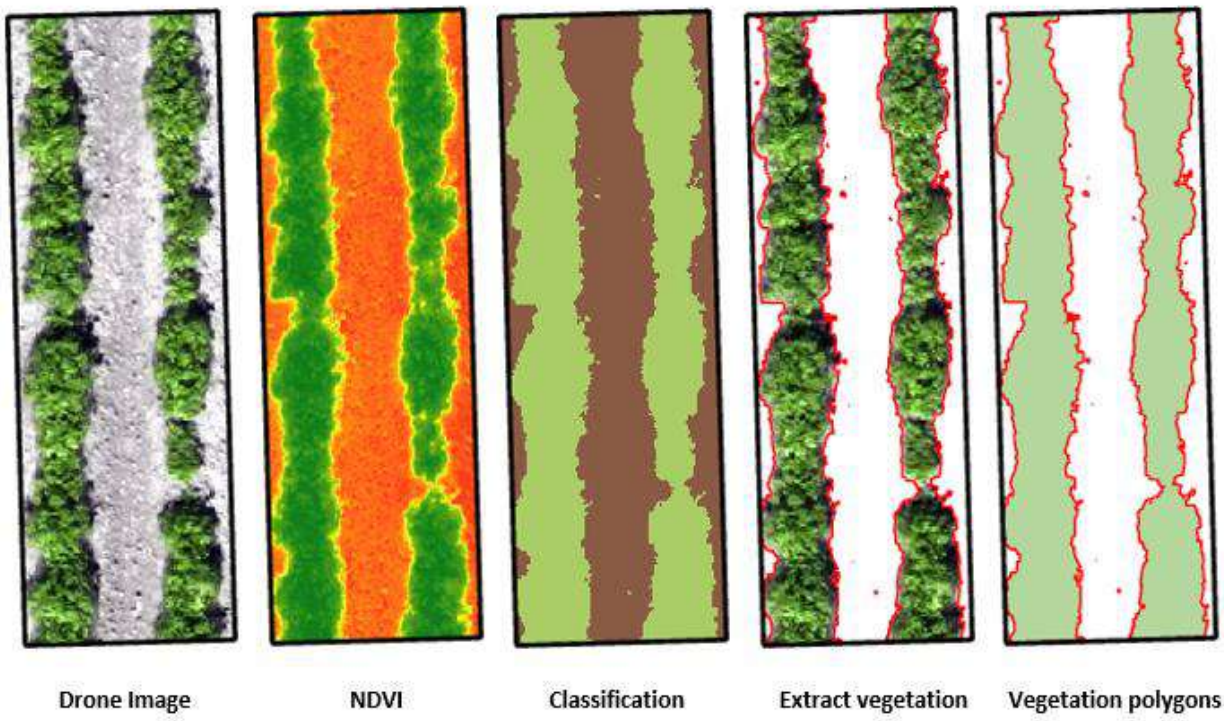


Figure 2: Example of measuring crop coverage area from a drone image acquired on 6/26/2024 for the Russet variety (CO15016-1RUsto).

Results of this analysis had three outcomes as follows:

1- Archived images for each variety at different crop stages.
2- Measurements of vegetation coverage area.
3- Time series for three vegetation indices at different crop growth stages.

Vegetation Coverage Area

Vegetation coverage area from a 5ft × 15ft box in the center of each plot was used to calculate the percentage of vegetation coverage area. Complete row closure occured when the percentage value reached 95%. Tables 2, 3 and 4 shows the percentage of vegetation coverage area for Russet, Red and Chip varieties. This information can help growers and breeders evaluate early season vigor, seed emergence problems, potential weed competition, or early season disease.

Table 2: Vegetation coverage area percentage for Russet varieties

Clone / Variety	DAP								
	25	**28**	**32**	**40**	**45**	**49**	**52**	**55**	**61**
Clearwater Russet	1	9	17	49	63	95	92	96	100
Ranger Russet	7	23	38	70	81	99	100	99	100
Russet Burbank	5	17	37	66	92	100	100	100	100
A09086-1LB	7	21	38	71	89	100	100	100	100
A12304-1sto	3	11	26	59	78	99	100	99	100
A12305-2adg	4	16	34	67	81	100	100	100	100
A13072-7	6	19	36	67	82	100	100	100	100
A13091-5	4	15	32	66	77	99	100	99	100
AFA5661-8	1	8	23	53	66	97	94	95	100
AOR11217-3	2	10	23	57	71	98	98	98	100
AOR13064-2	4	14	29	56	71	97	98	99	100
AOR15166-2	1	8	18	49	57	84	81	83	100
NWN278	7	19	36	70	81	100	100	100	100
CO13003-1RU	4	13	27	63	81	100	100	99	100
CO15016-1RUsto	1	6	16	54	76	99	100	100	100
COTX08063-2Ru	3	13	30	63	76	97	97	99	100
COTX10080-2Ru	2	9	20	51	63	90	89	93	100
CO15070-4RU	4	13	27	62	79	99	100	100	100
CO16238-4RU	1	7	15	44	58	89	83	85	100
PSS11/357/21Ru	2	10	21	56	74	98	98	98	100
PSS11/339/3Ru	4	18	31	63	78	98	96	97	100

Table 3: Vegetation coverage area percentage for Red varieties

Clone / Variety	DAP								
	25	**28**	**32**	**40**	**45**	**49**	**52**	**55**	**61**
Chieftain	7	32	44	76	87	100	100	100	100
Modoc	3	15	27	63	80	100	100	100	100
A11582-1R	4	17	34	64	82	100	100	100	100
COOR15108-1	2	12	28	58	77	99	99	100	100
A11573-5RYsto	6	23	42	78	89	100	100	100	100
Yukon Gold	4	16	34	64	74	99	100	99	100
A11576-1Ysto	15	36	59	95	100	100	100	100	100
AORTX09037-5W/Ychc	9	25	41	80	89	100	100	100	100
Purple Majesty	11	29	46	80	93	100	100	100	100
POR16PG25-2	8	23	41	73	87	100	100	100	100
TC17742-1PW/PW	2	14	25	57	61	85	85	90	100
ATX13134-3W/Y	3	22	39	69	79	98	99	98	100
CO16154-2Y	14	35	60	94	99	100	100	100	100
CO16279-5Y	8	29	52	84	98	100	100	100	100

Table 4: Vegetation coverage area percentage for Chip varieties

Clone / Variety	DAP								
	25	**28**	**32**	**40**	**45**	**49**	**52**	**55**	**61**
AC13125-5W	9	25	44	78	85	100	100	100	100
A16154-2C	2	16	36	65	74	98	95	98	100
A16153-2C	7	26	48	78	91	100	100	100	100
A16150-1C	6	27	46	83	92	100	100	100	100
A13125-3C	4	19	36	78	89	100	100	100	100
Snowden	11	29	49	74	83	99	99	100	100
Lamoka	4	22	41	74	86	100	100	100	100
Atlantic	10	35	50	83	88	100	100	100	100
AC13126-1Wadg	6	19	36	66	78	100	99	100	100

Vegetation Indices

Vegetation indices (VIs) describe vegetation properties such as photosynthetic activity and canopy structure. There are many VIs and calculation depends on the available measurements of spectral bands. For instance, NDVI is calculated from Red and NIR bands where Red light is mostly absorbed by the top of plant canopy. The NDVI saturates when the field is covered by healthy reflecting plant leaves therefore it is difficult to measure small vegetation changes with NDVI in fields with high biomass density. NDRE is calculated from Red-Edge and NIR bands where Red-Edge penetrates better through the canopy and gives better idea for canopy structure. NDRE complements NDVI as it is sensitive even with high density biomass. Furthermore, GNDVI is commonly used to determine water and nitrogen uptake into the plant canopy.

Timeseries analysis of Vis can help in assessing crop performance, drought stress or disease severity. Also, VIs are useful in growers fields for mapping field variability and correlating in season measurements with crop yield.

The complete results for time series of GNDVI, NDVI and NDRE for all potato trials are available in appendix 1.

Archived Images

Images of all varieties were compiled on one page for each drone image date to allow for convenient side by side visual comparisons. These images can easily be archived and shared with stakeholders. This could provide a better assessment approach for measuring disease severity, vine maturity, vigor, and variety tolerance to water and heat stress. A complete set of archived images for each variety and their associated VIs are included in Appendix 2.

Appendix 1: Time series for vegetation indices

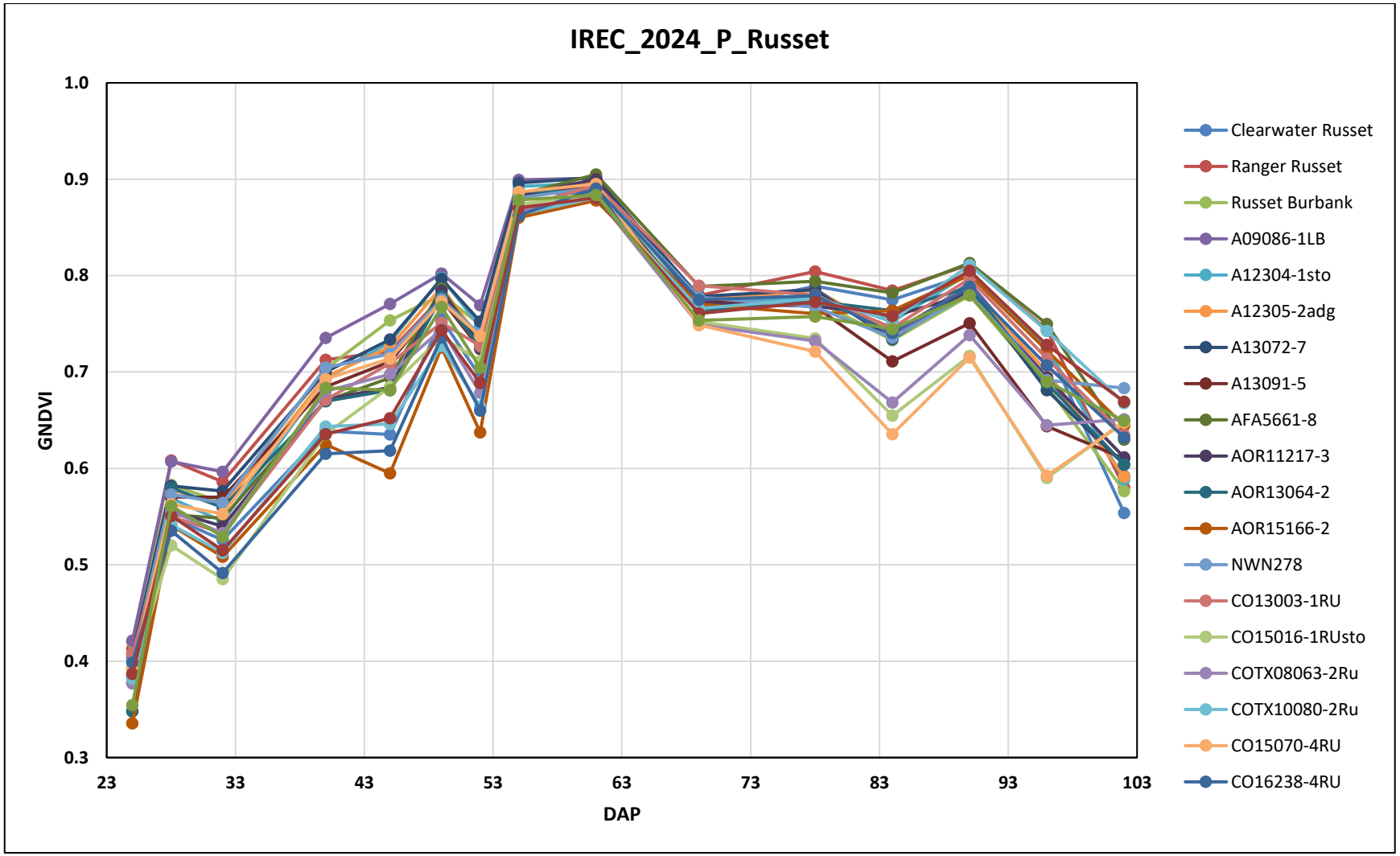


Figure 3: GNDVI time series for the Russet varieties.

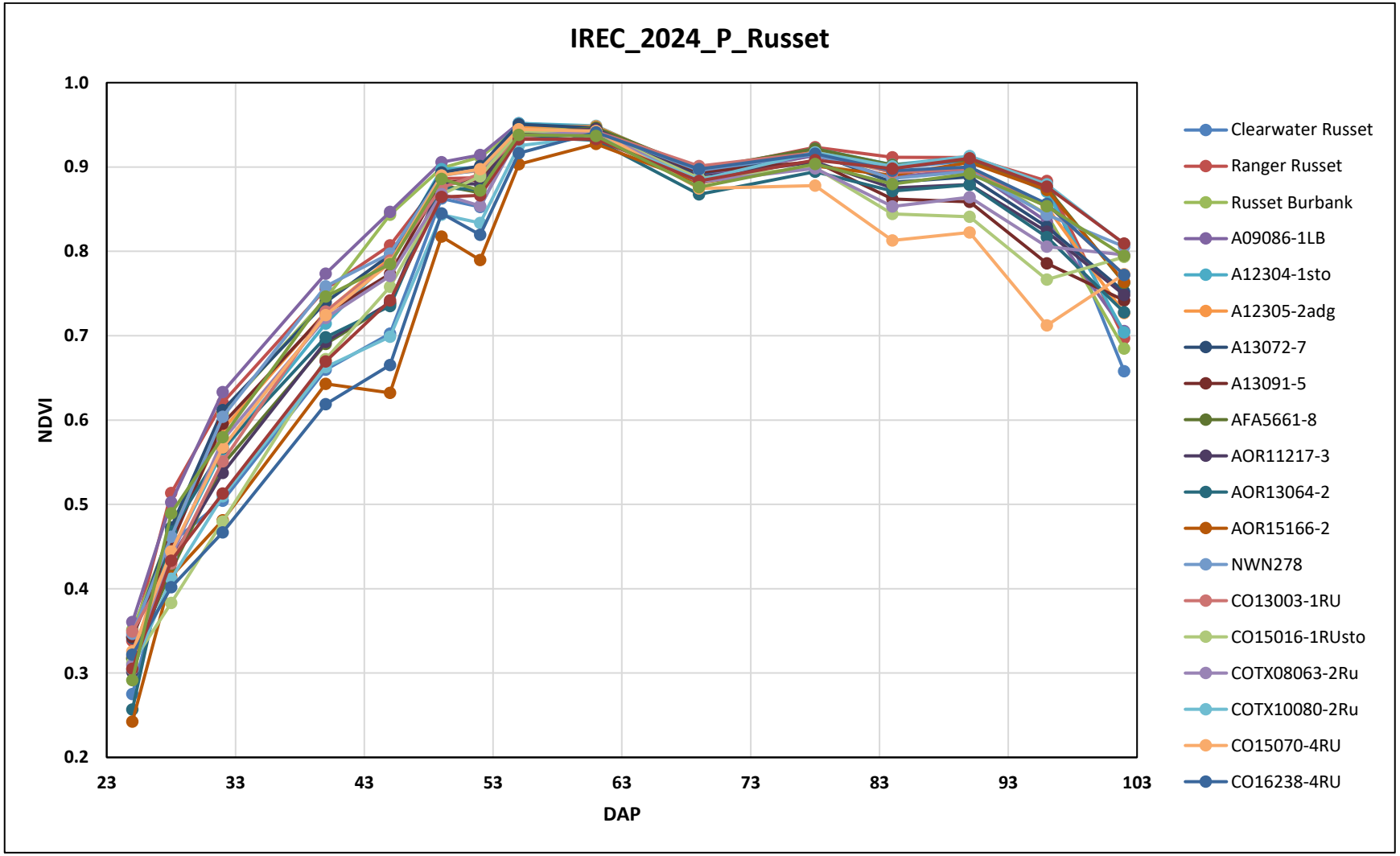


Figure 4: NDVI time series for the Russet varieties.

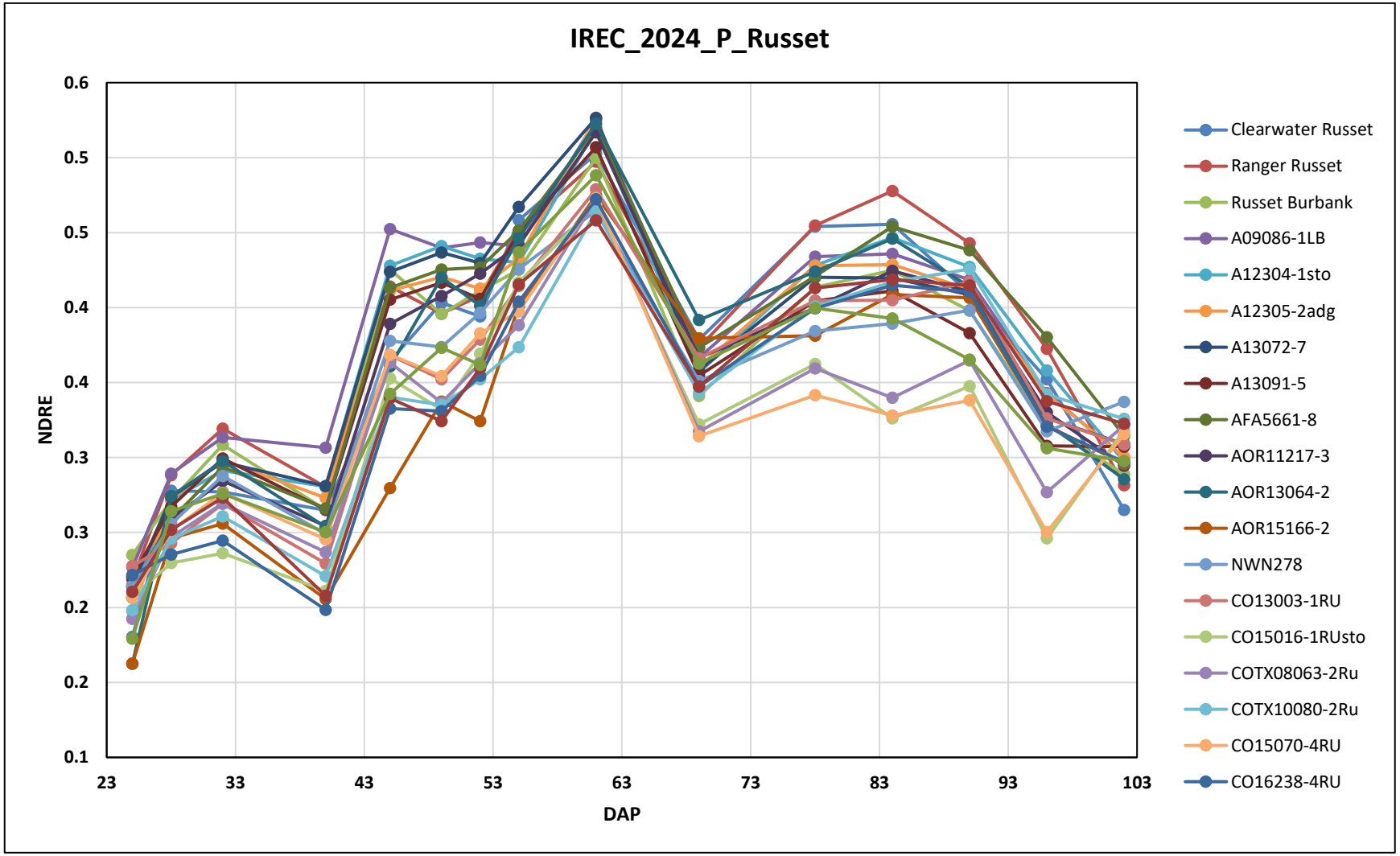


Figure 5: NDRE time series for the Russet varieties.

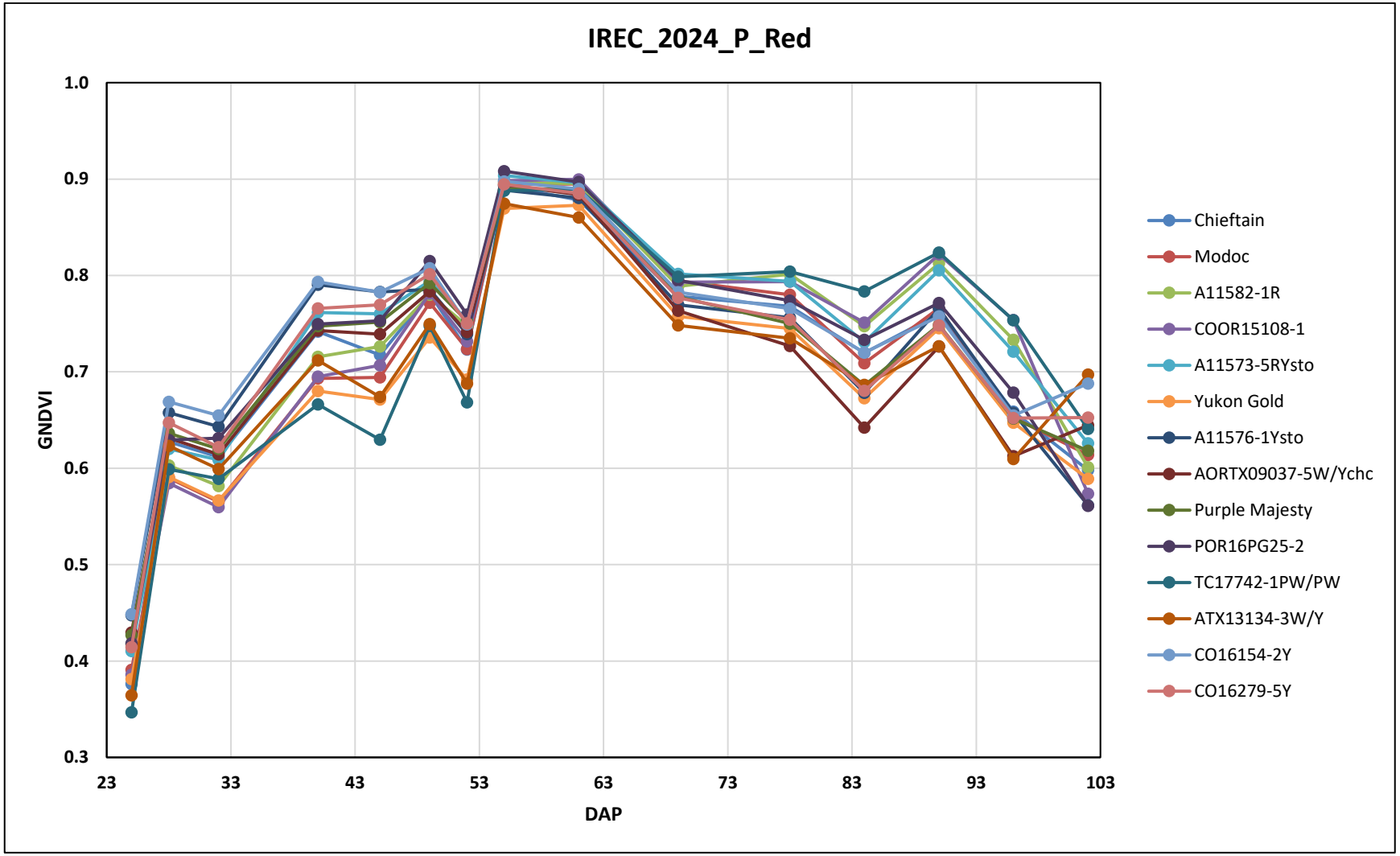


Figure 6: GNDVI time series for the Red varieties.

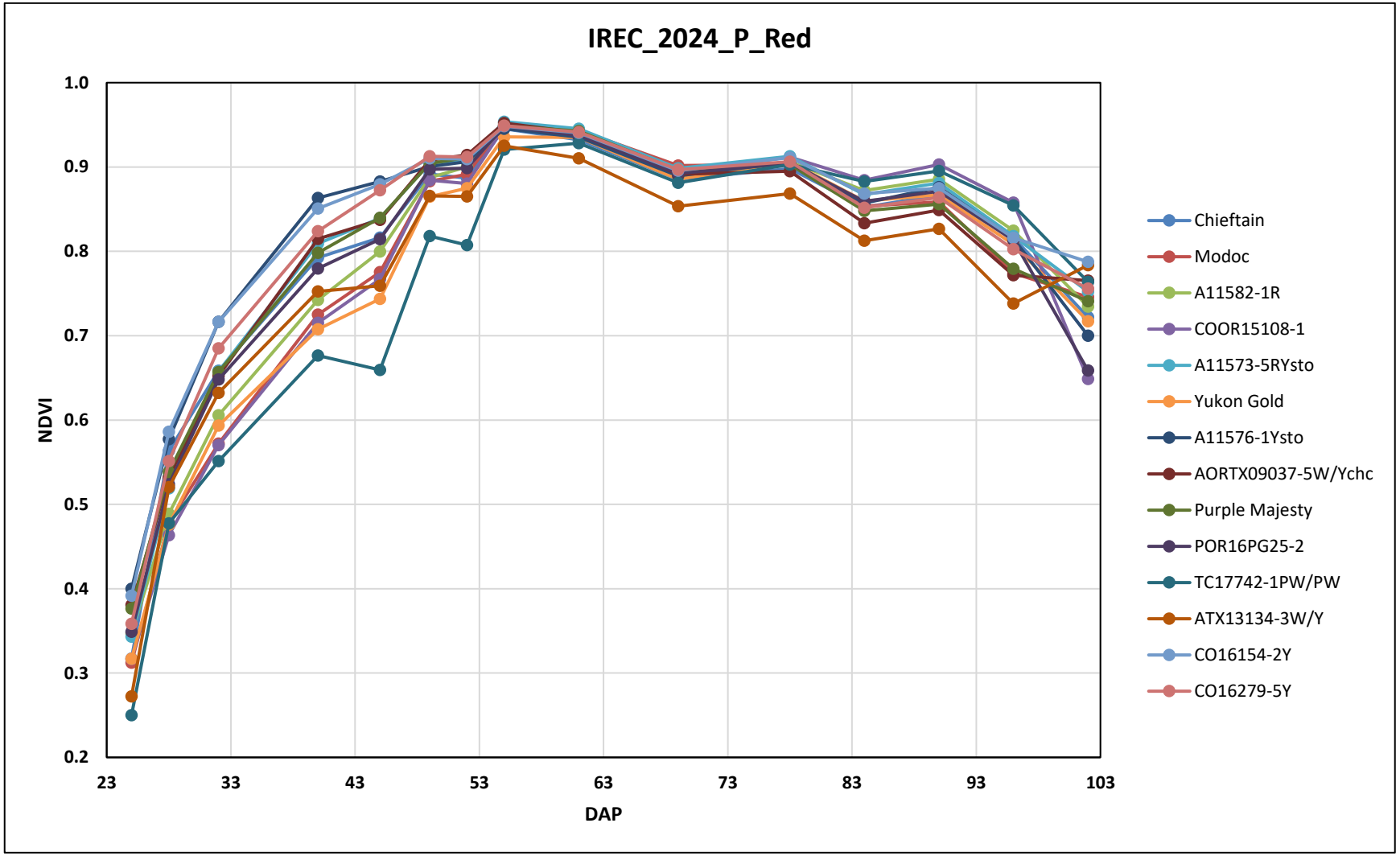


Figure 7: NDVI time series for the Red varieties.

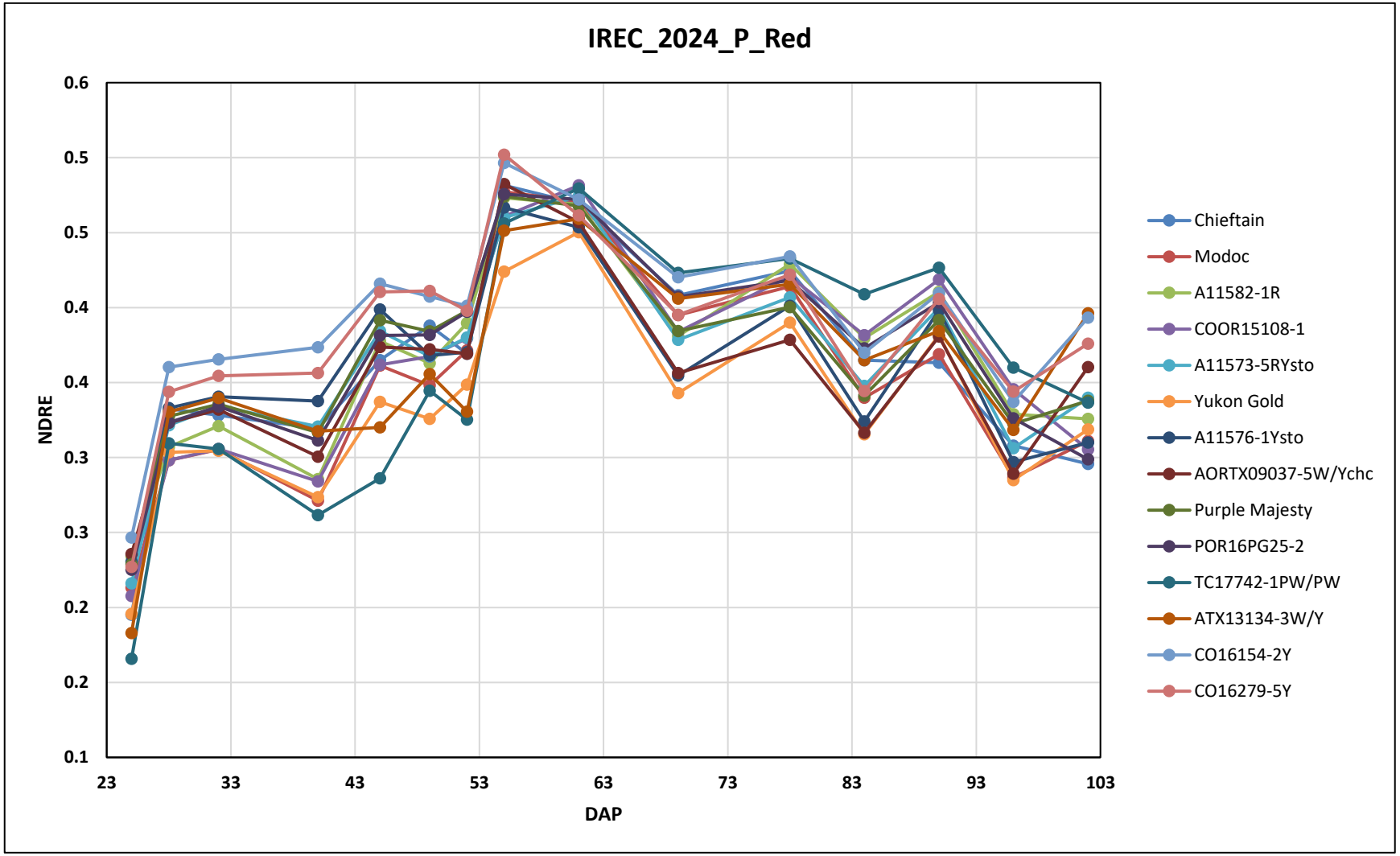


Figure 8: NDRE time series for the Red varieties.

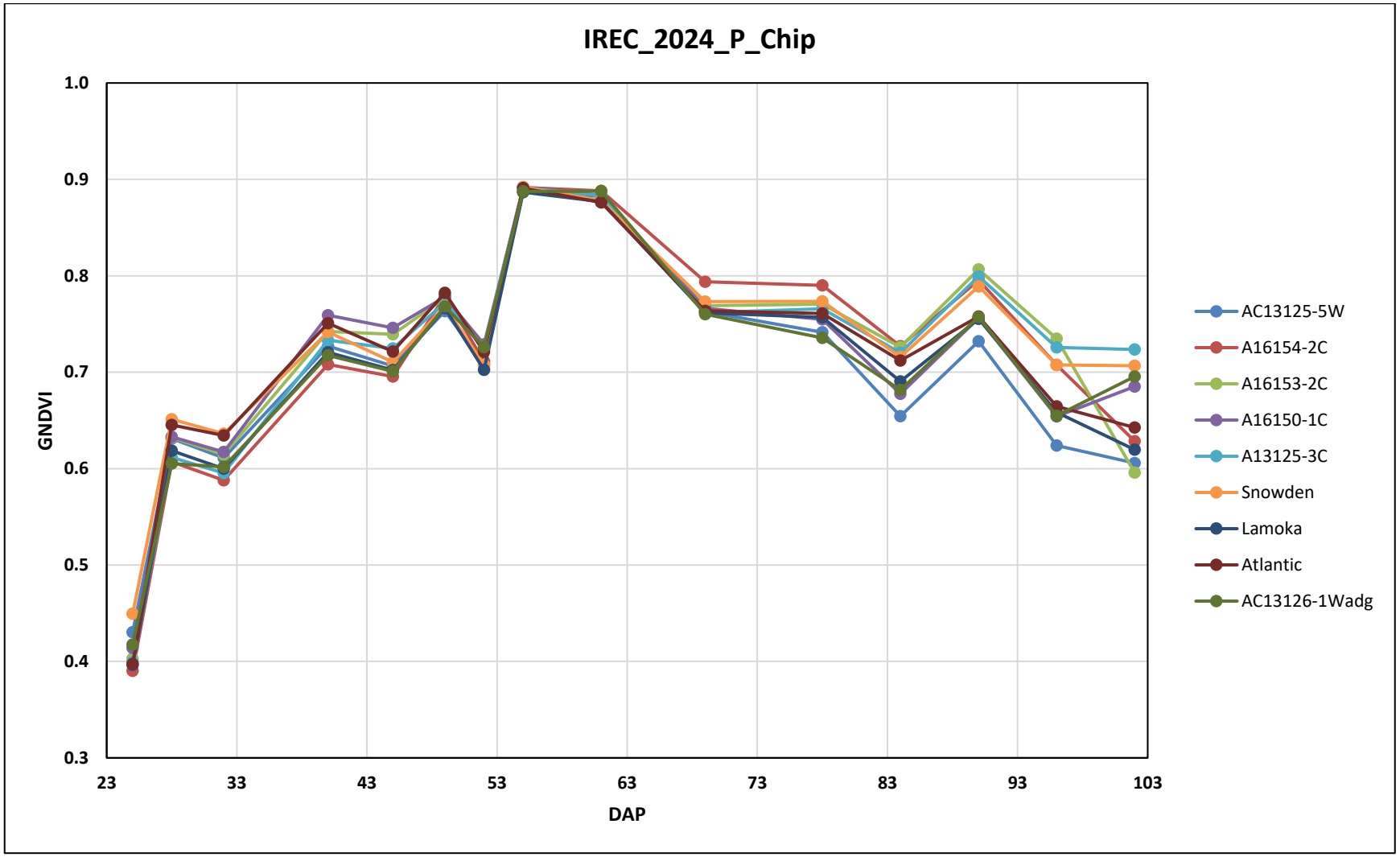


Figure 9: GNDVI time series for the Chip varieties.

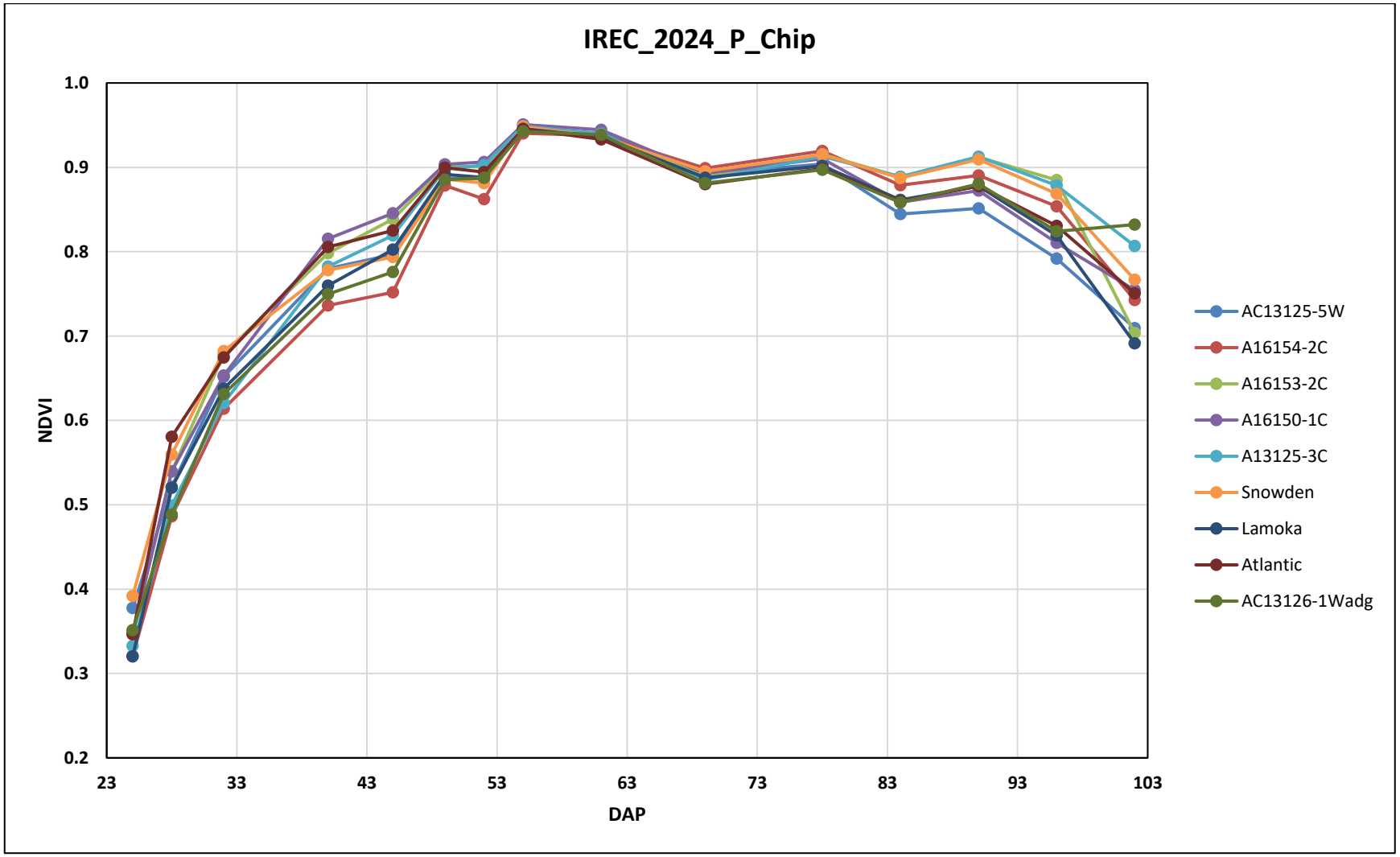


Figure 10: NDVI time series for the Chip varieties.

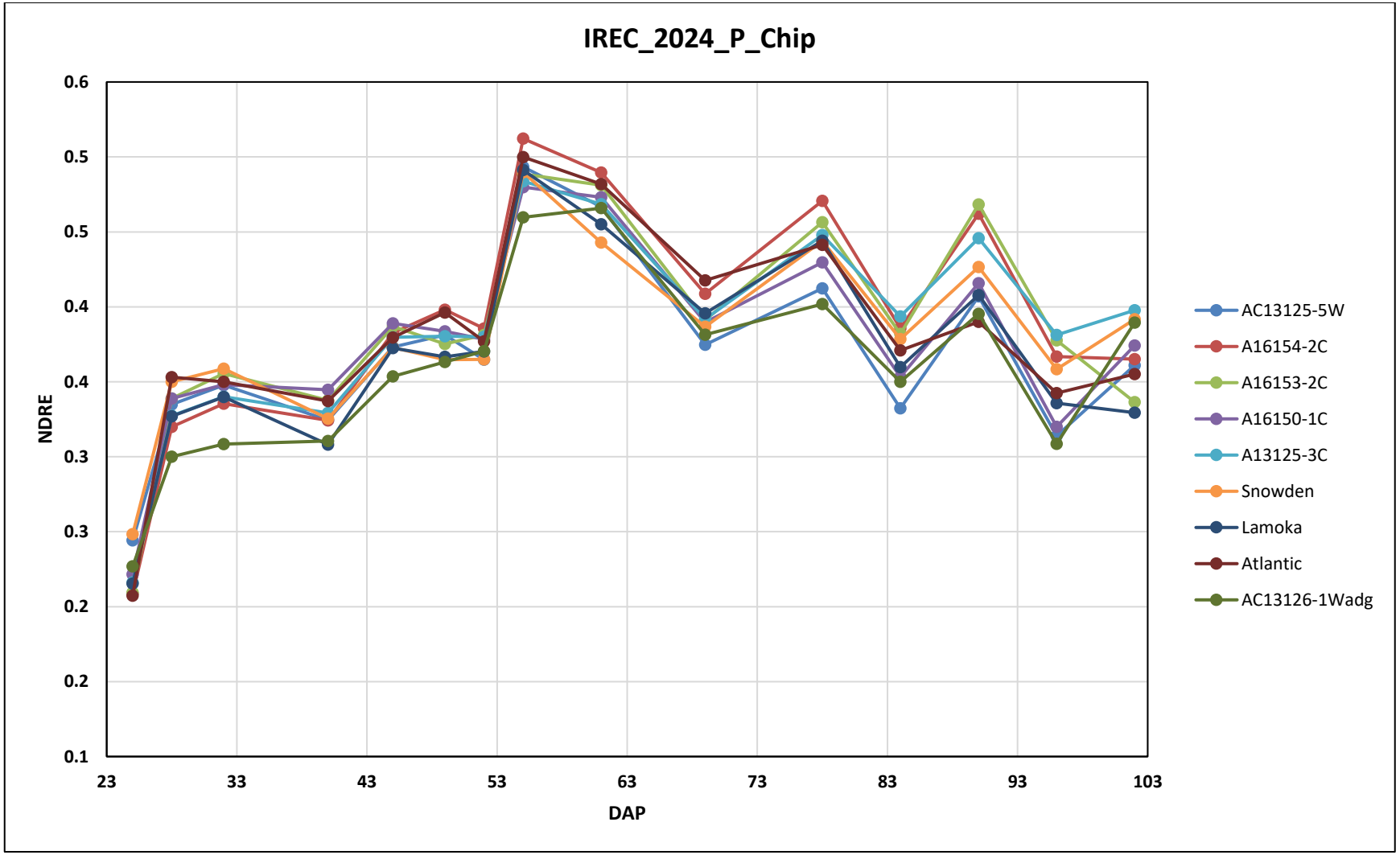


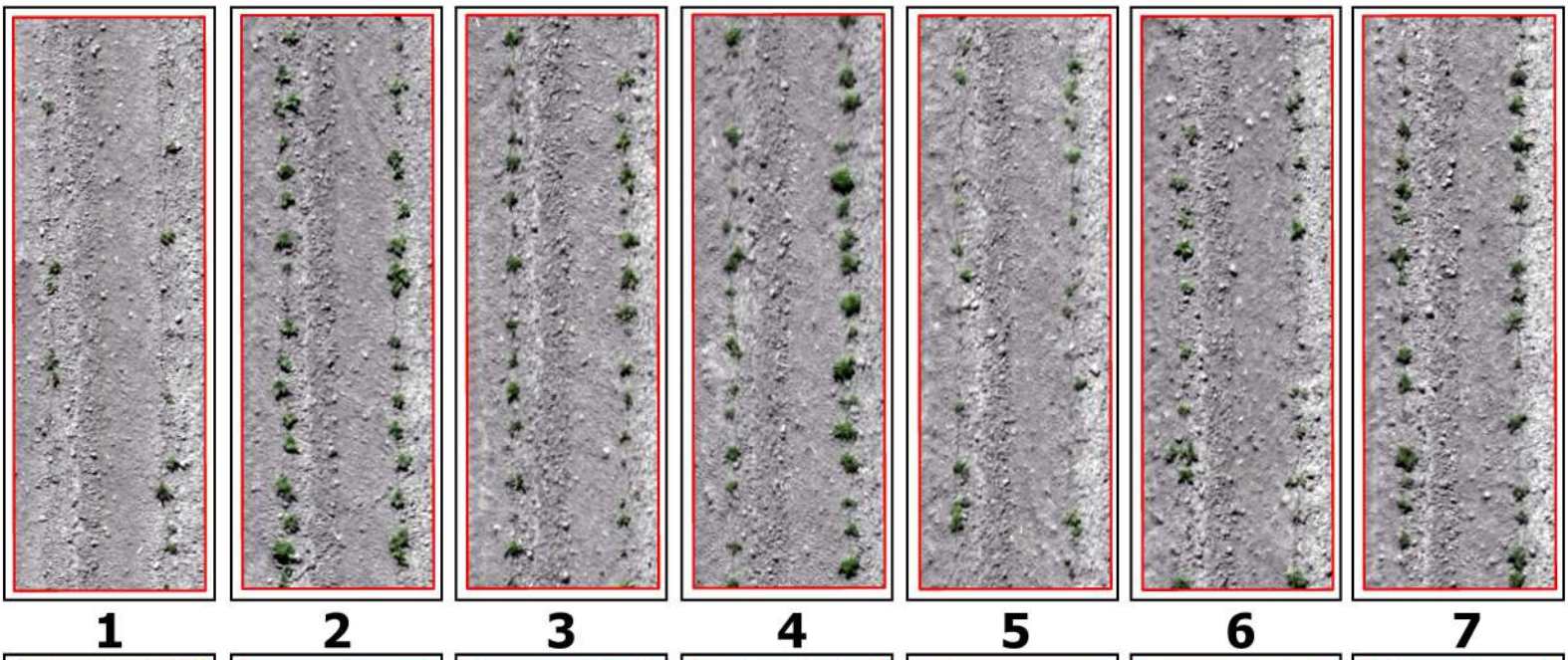
Figure 11: NDRE time series for the Chip varieties.

Appendix 2: Archived Drone Images

Russet		Red		Chip	
I	Variety	I	Variety	I	Variety
1	Clearwater Russet	1	Chieftain	1	Atlantic
2	Ranger Russet	2	Modoc	2	Lamoka
3	Russet Burbank	3	A11582-1R	3	Snowden
4	A09086-1LB	4	COOR15108-1	4	A13125-3C
5	A12304-1sto	5	A11573-5RYsto	5	A16150-1C
6	A12305-2adg	6	Yukon Gold	6	A16153-2C
7	A13072-7	7	A11576-1Ysto	7	A16154-2C
8	A13091-5	8	AORTX09037-5W/Ychc	8	AC13125-5W
9	AFA5661-8	9	Purple Majesty	9	AC13126-1Wadg
10	AOR11217-3	10	POR16PG25-2		
11	AOR13064-2	11	TC17742-1PW/PW		
12	AOR15166-2	12	ATX13134-3W/Y		
13	NWN278	13	CO16154-2Y		
14	CO13003-1RU	14	CO16279-5Y		
15	CO15016-1RUsto				
16	COTX08063-2Ru				
17	COTX10080-2Ru				
18	CO15070-4RU				
19	CO16238-4RU				
20	PSS11/357/21Ru				
21	PSS11/339/3Ru				

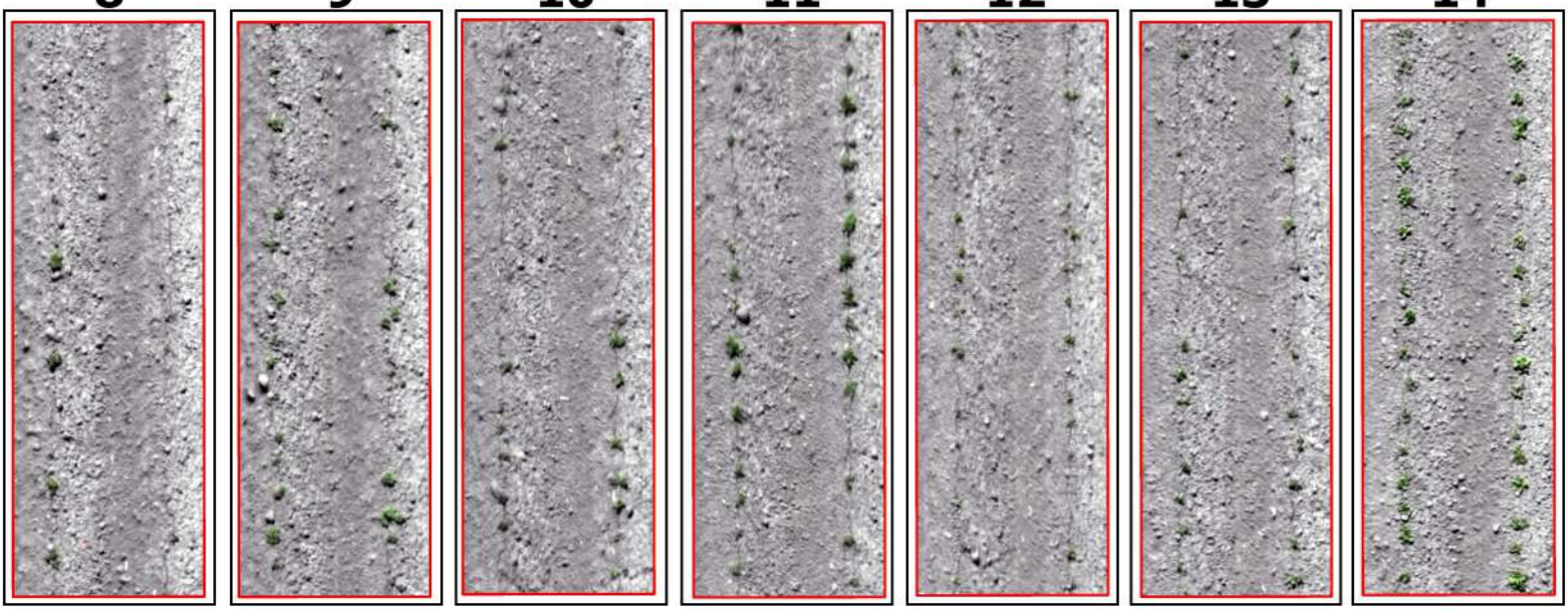
Russet 06-11-2024

0 2 4 8 Feet



1 2 3 4 5 6 7

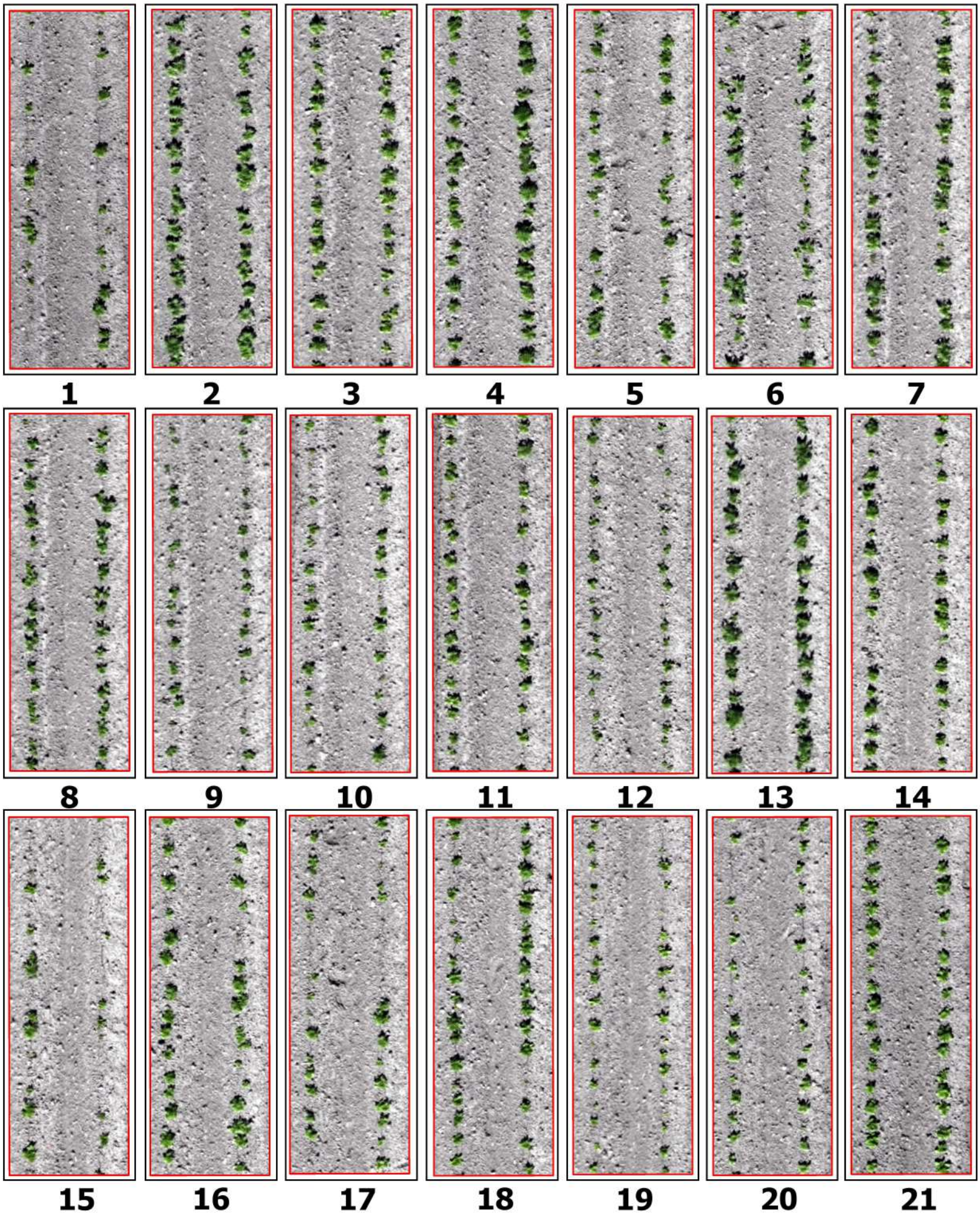
8 9 10 11 12 13 14



15 16 17 18 19 20 21

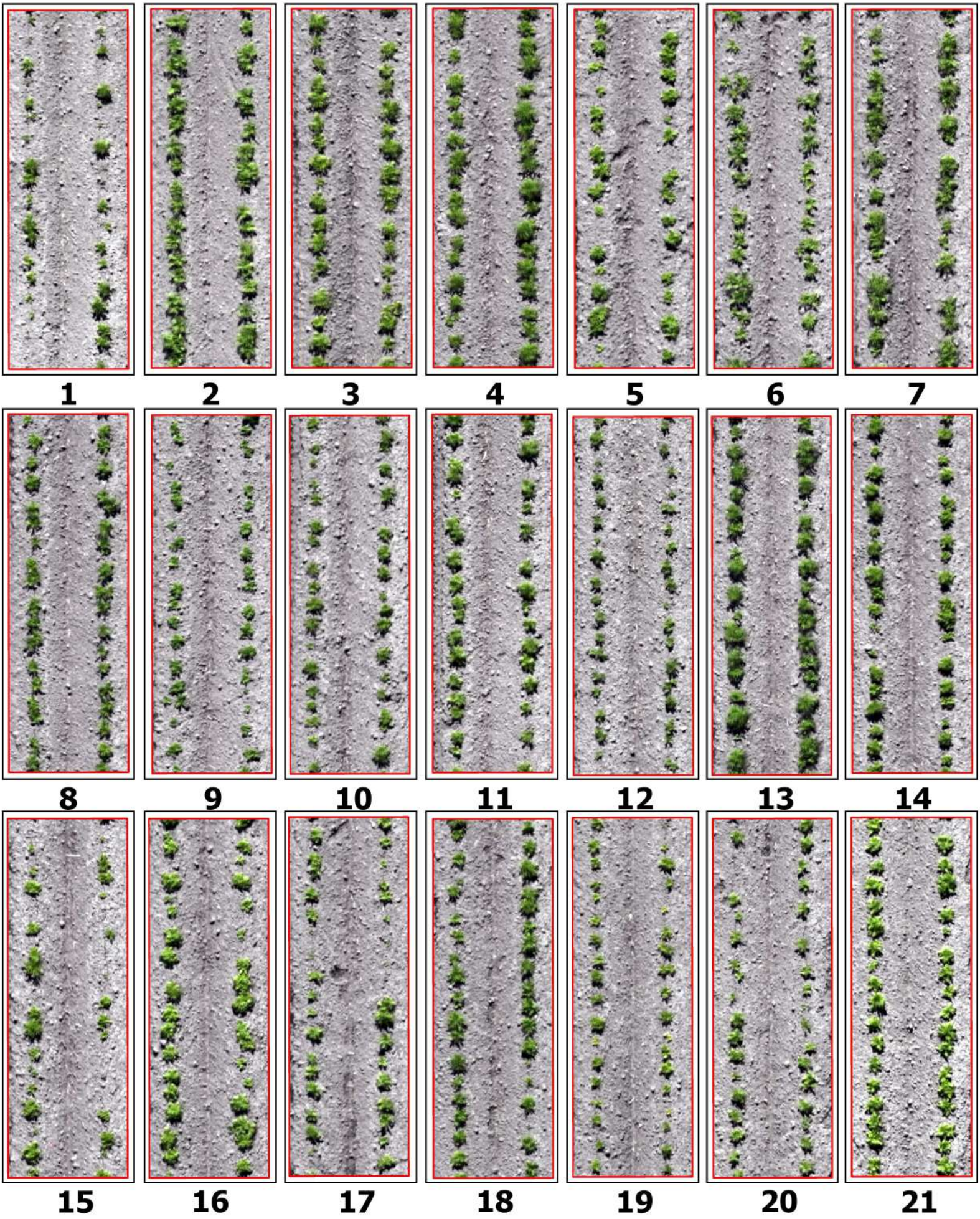
Russet 06-14-2024

0 2 4 8 Feet



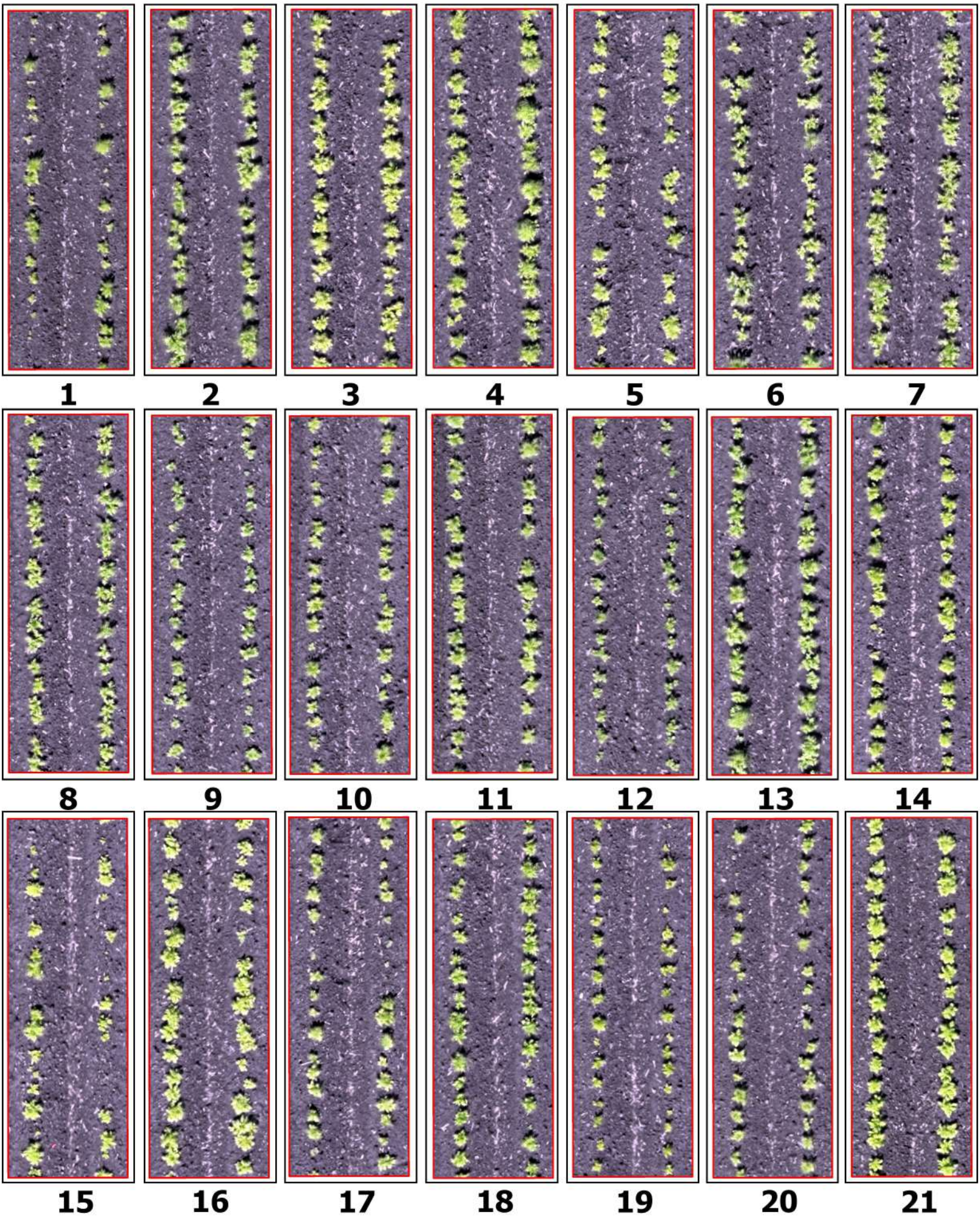
Russet 06-17-2024

0 2 4 8 Feet



Russet 06-18-2024

0 2 4 8 Feet



Russet 06-26-2024

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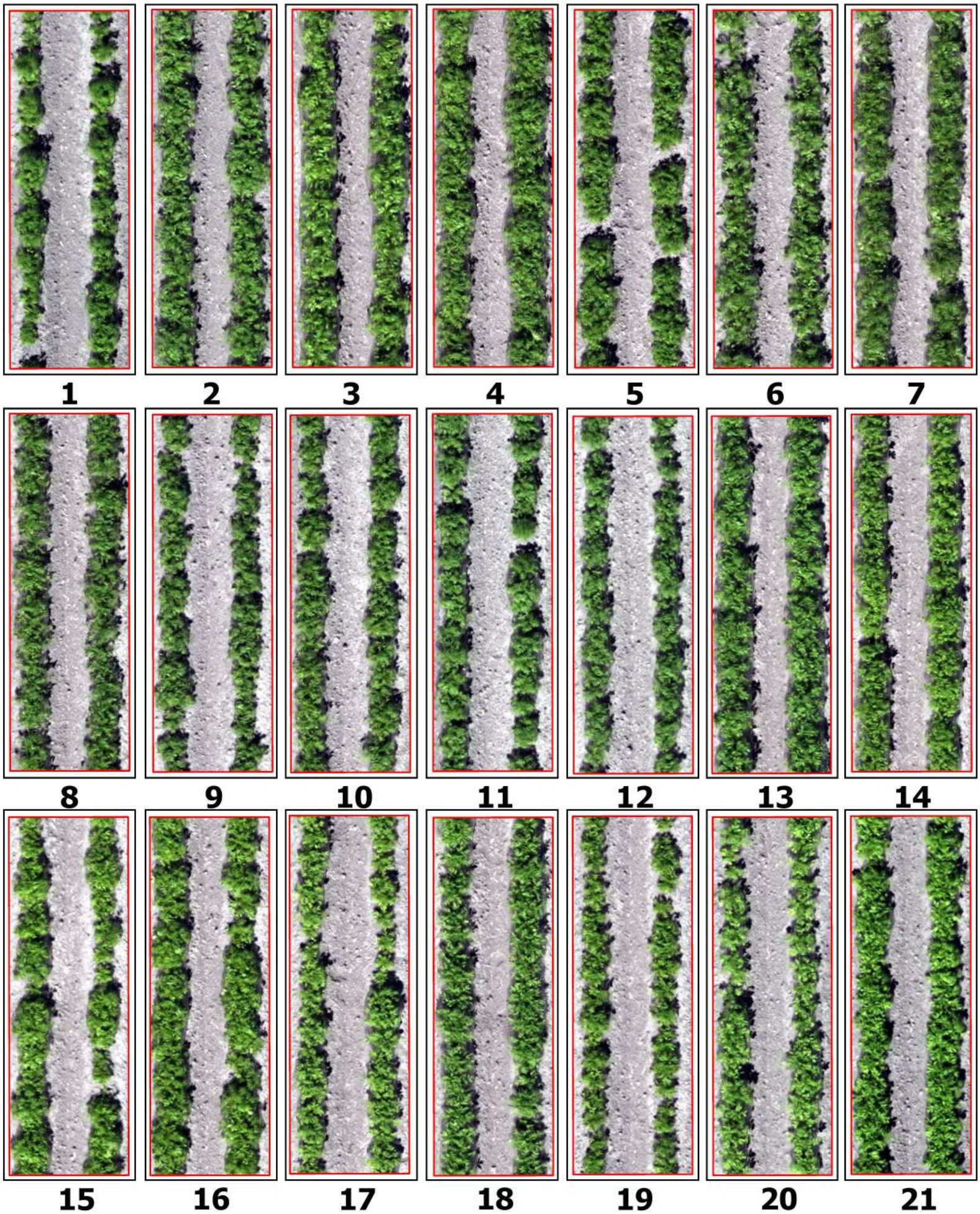

Russet 07-01-2024

0 2 4 8 Feet

Russet 07-05-2024

0 2 4 8 Feet

1 2 3 4 5 6 7

8 9 10 11 12 13 14

15 16 17 18 19 20 21

Russet 07-08-2024

0 2 4 8 Feet

1 2 3 4 5 6 7

8 9 10 11 12 13 14

15 16 17 18 19 20 21

Russet 07-11-2024

0 2 4 8 Feet

Russet 07-17-2024

0 2 4 8 Feet

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15 16 17 18 19 20 21

Russet 07-25-2024

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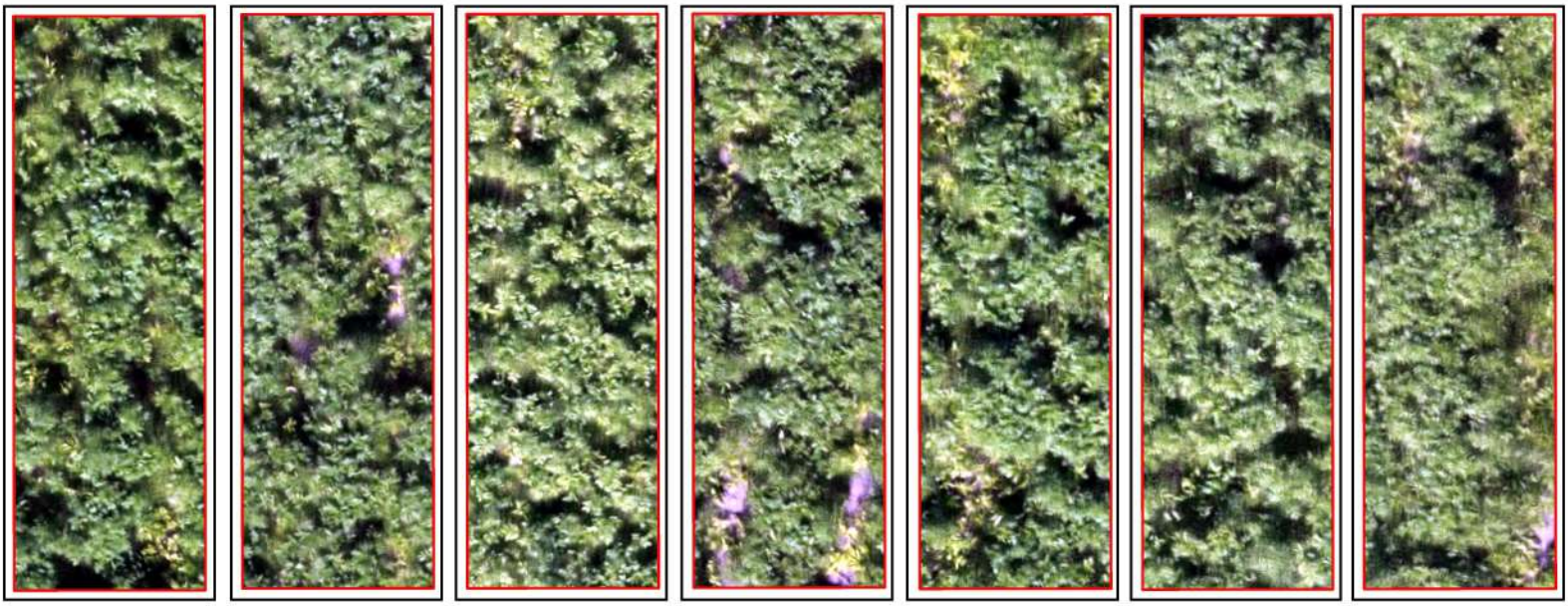

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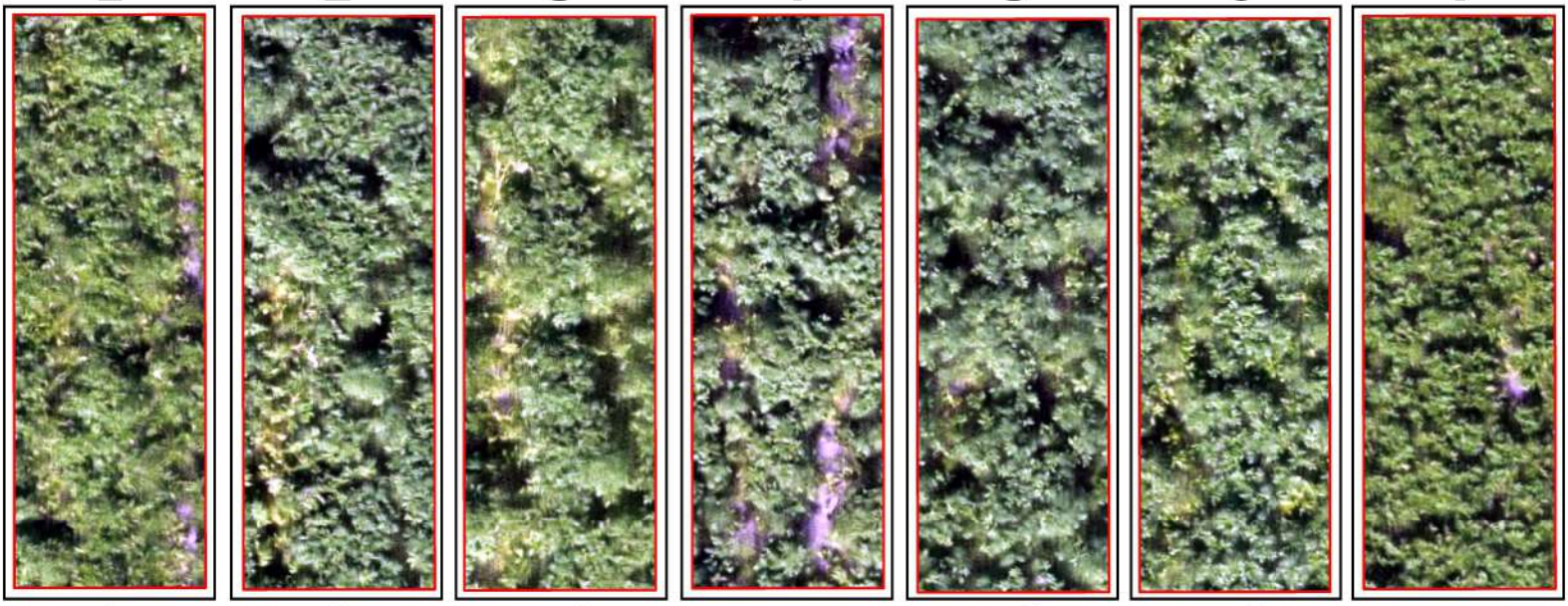

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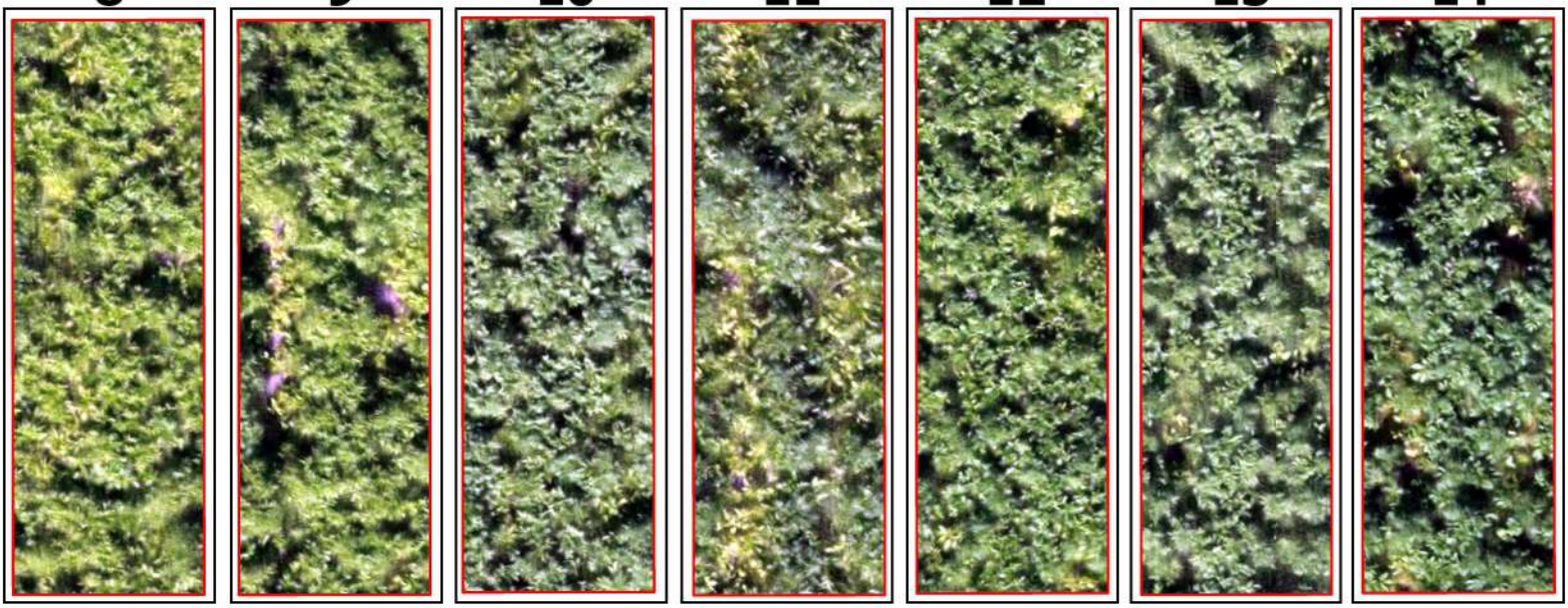
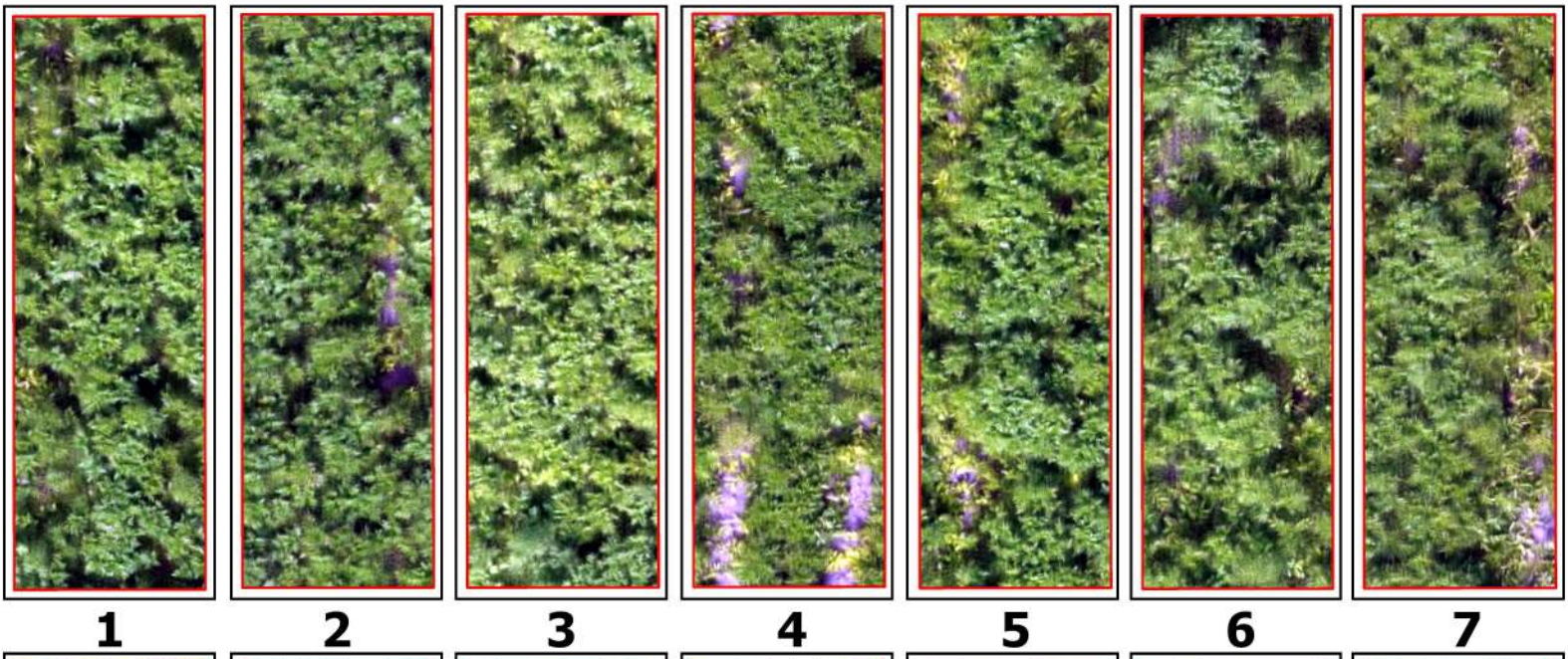


15 16 17 18 19 20 21

Russet 08-03-2024

0 2 4 8 Feet



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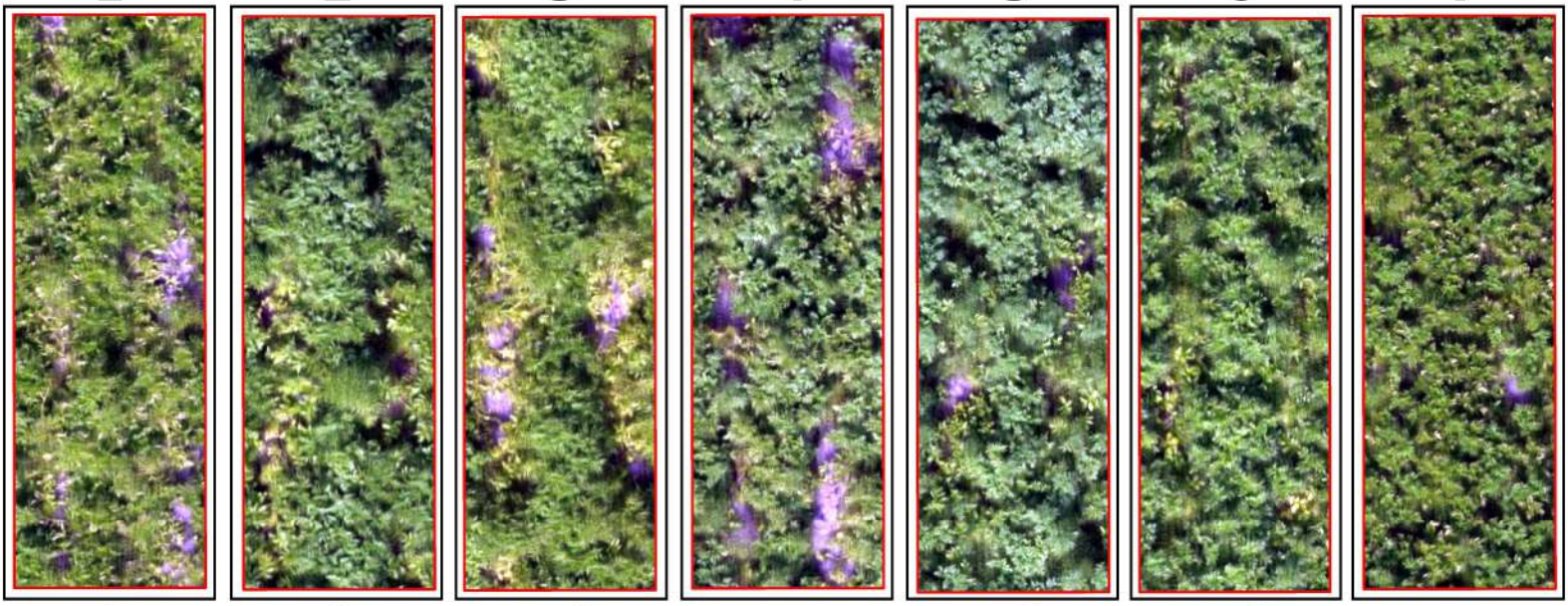


8 9 10 11 12 13 14

15 16 17 18 19 20 21

Russet 08-09-2024

0 2 4 8 Feet

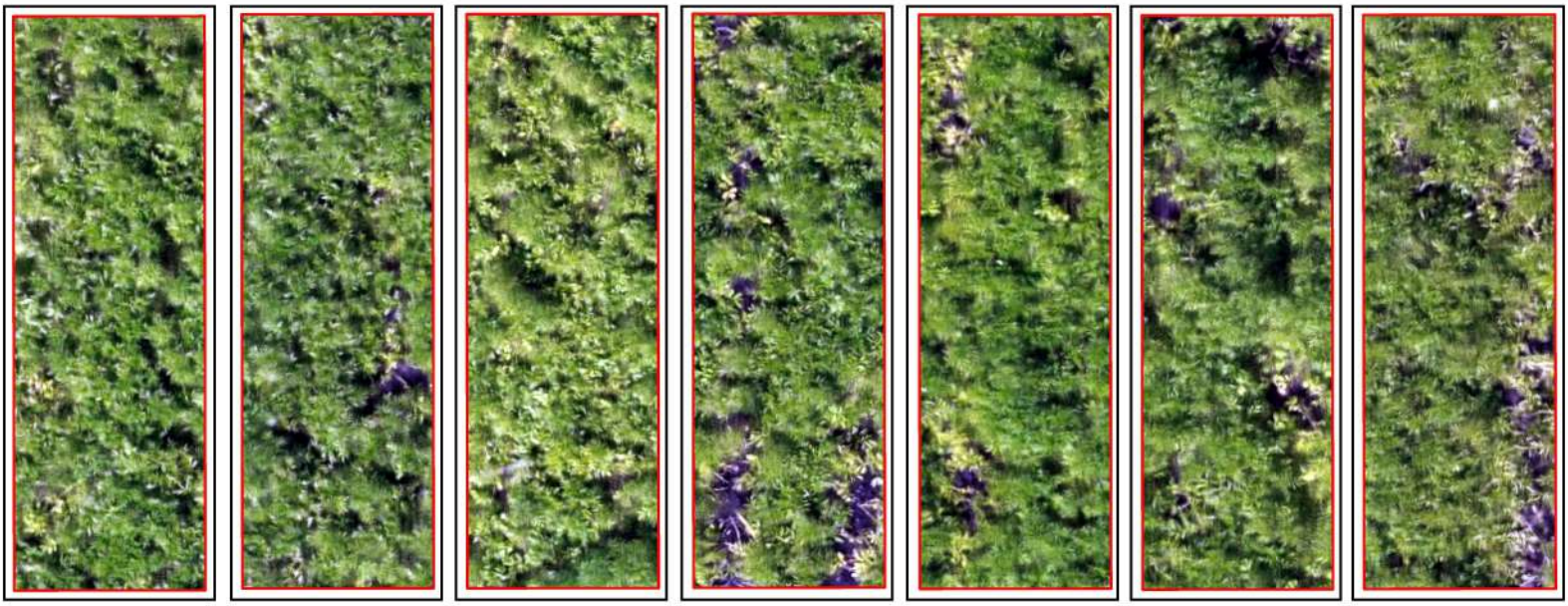
1 2 3 4 5 6 7

8 9 10 11 12 13 14

15 16 17 18 19 20 21

Russet 08-15-2024

0 2 4 8 Feet



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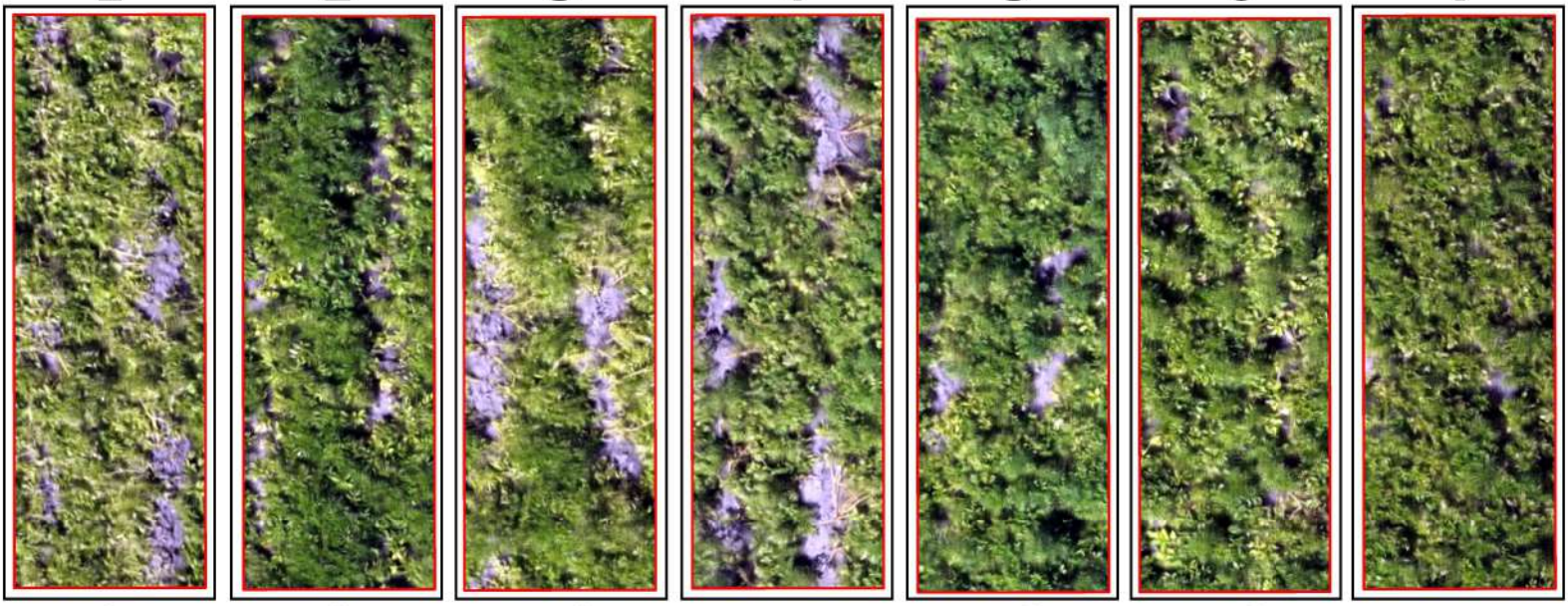
8 9 10 11 12 13 14

15 16 17 18 19 20 21

Russet 08-21-2024

0 2 4 8 Feet

1 2 3 4 5 6 7



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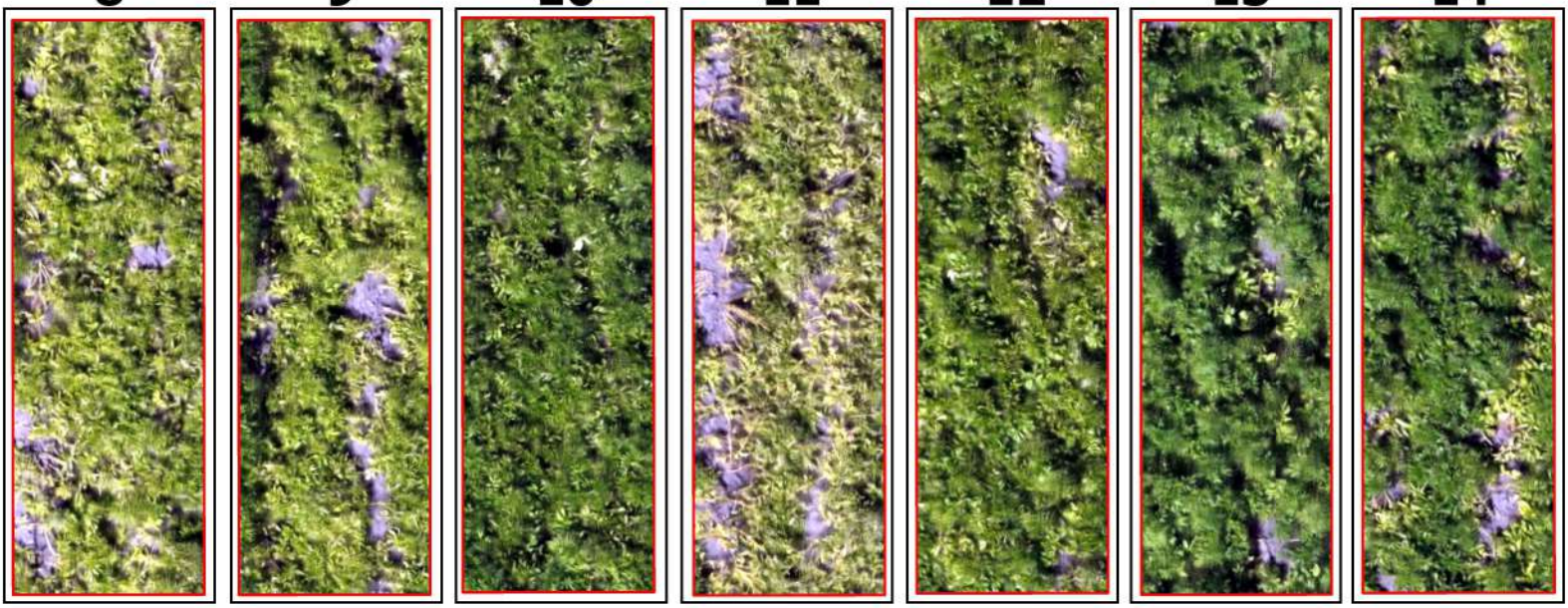
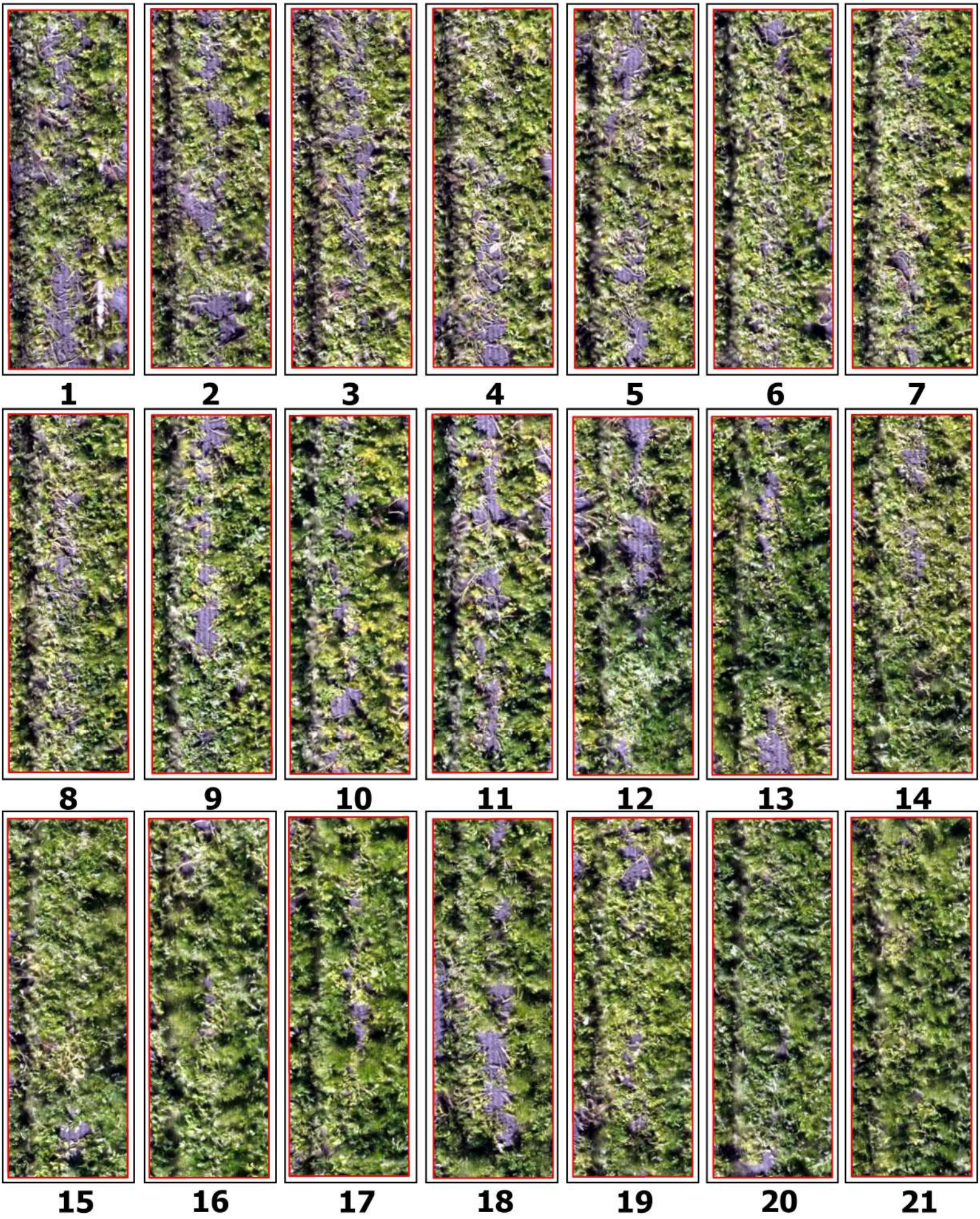


15 16 17 18 19 20 21

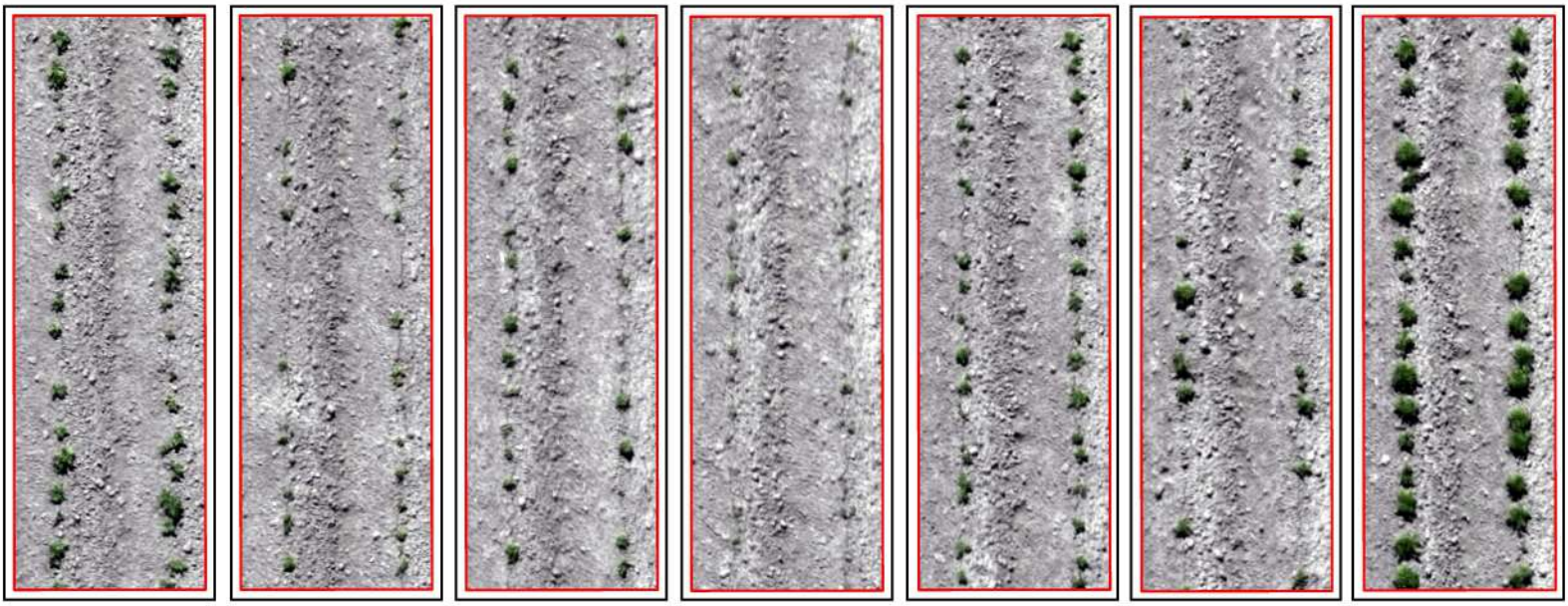
Russet 08-27-2024

0 2 4 8 Feet



Red 06-11-2024

0 2 4 8 Feet



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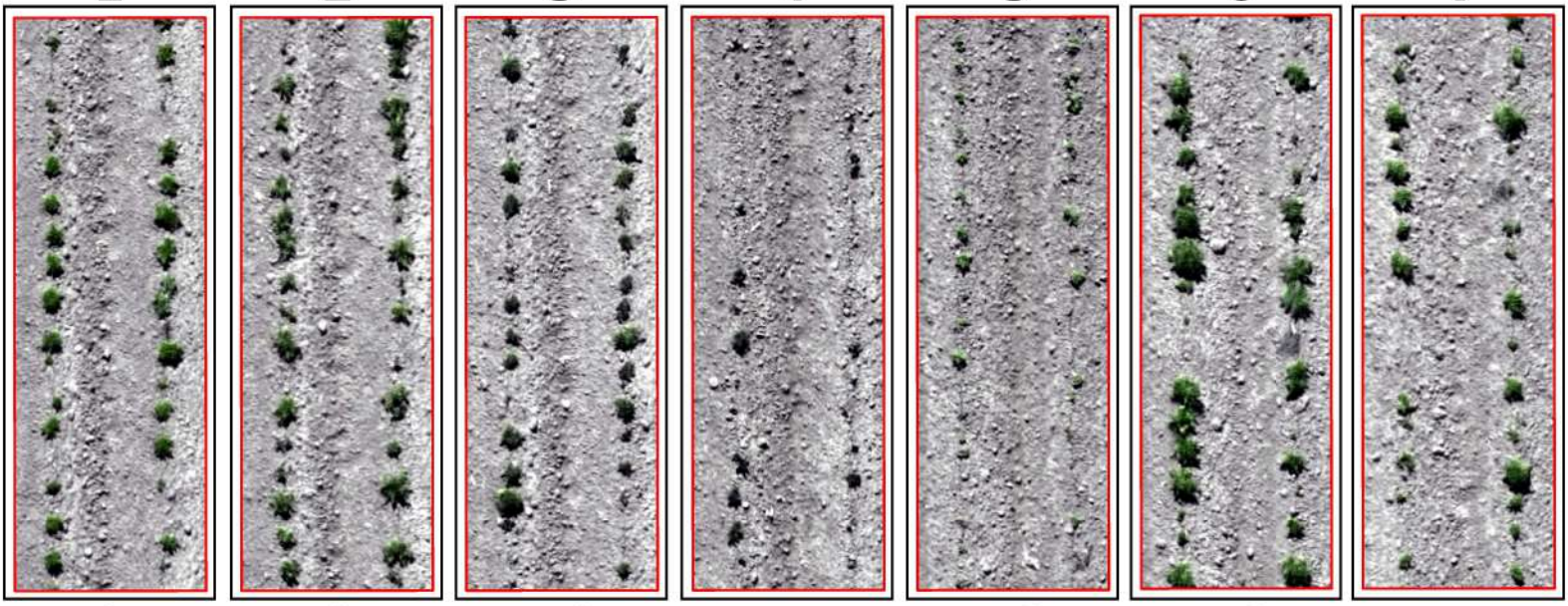
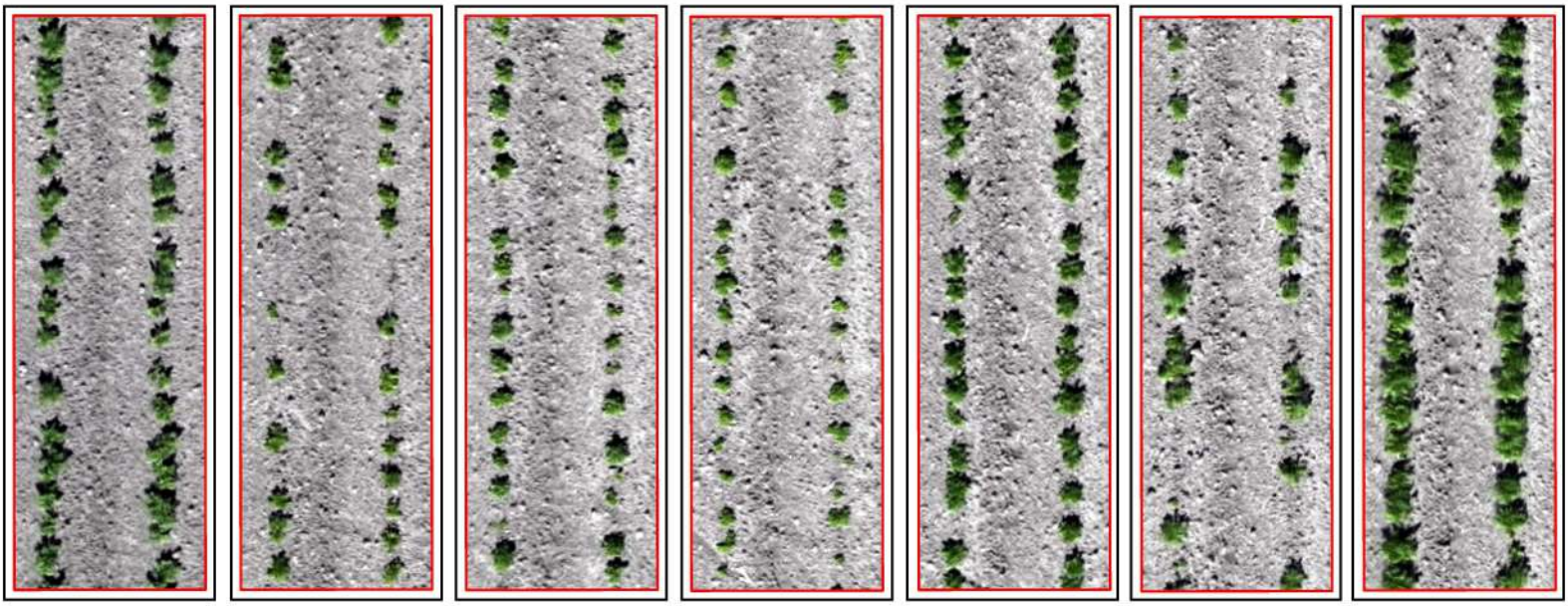


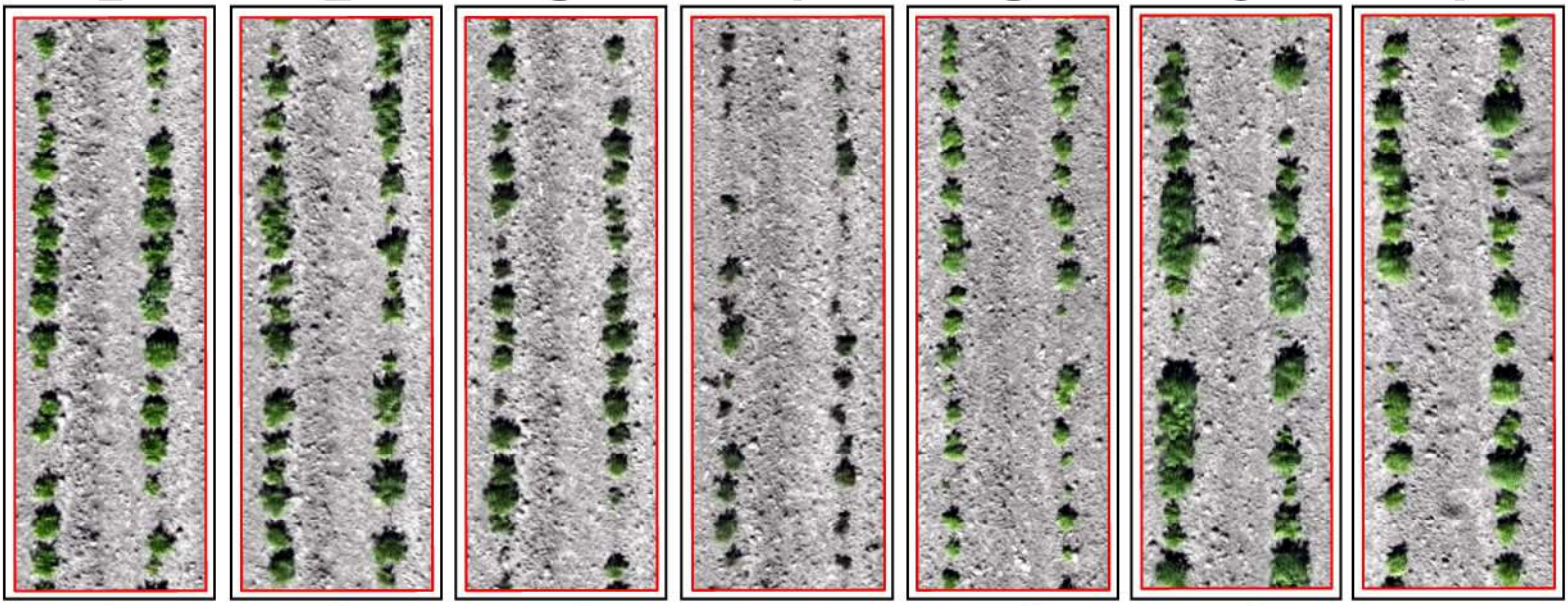
8 9 10 11 12 13 14

Red 06-14-2024

0 2 4 8 Feet



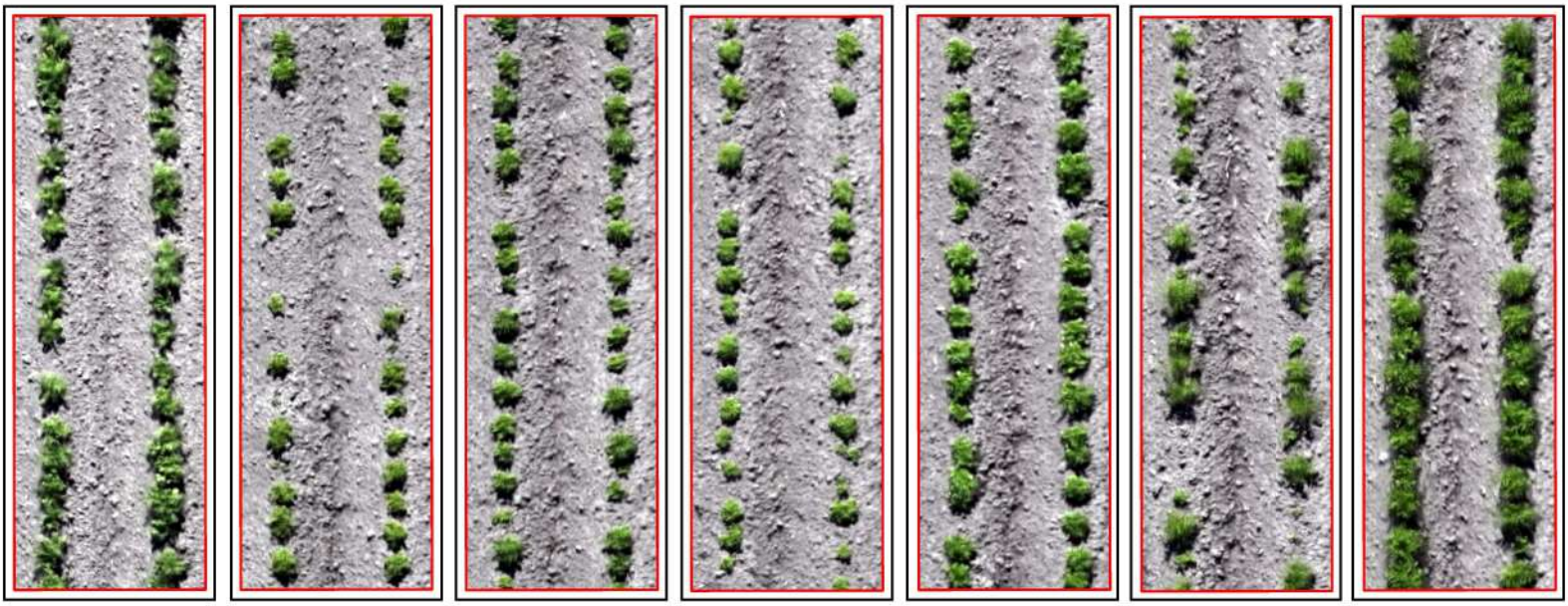
1 2 3 4 5 6 7



8 9 10 11 12 13 14

Red 06-17-2024

0 2 4 8 Feet

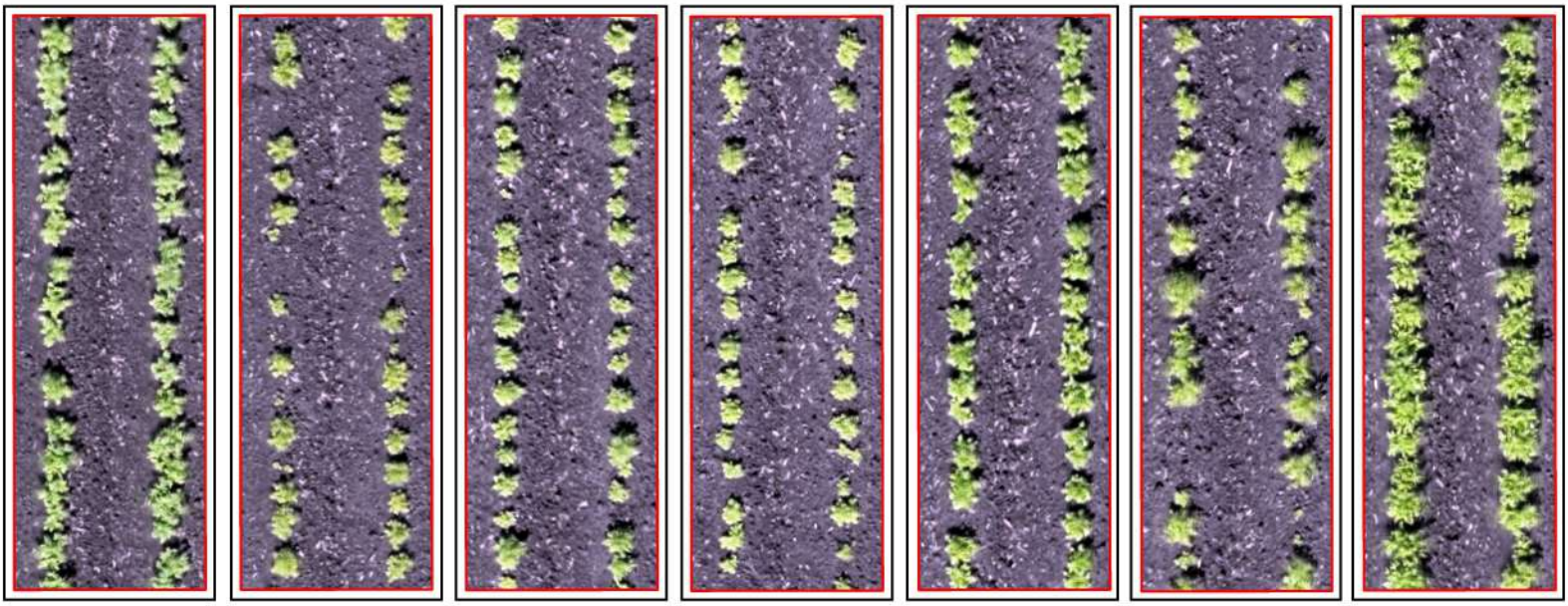


1 2 3 4 5 6 7

8 9 10 11 12 13 14

Red 06-18-2024

0 2 4 8 Feet



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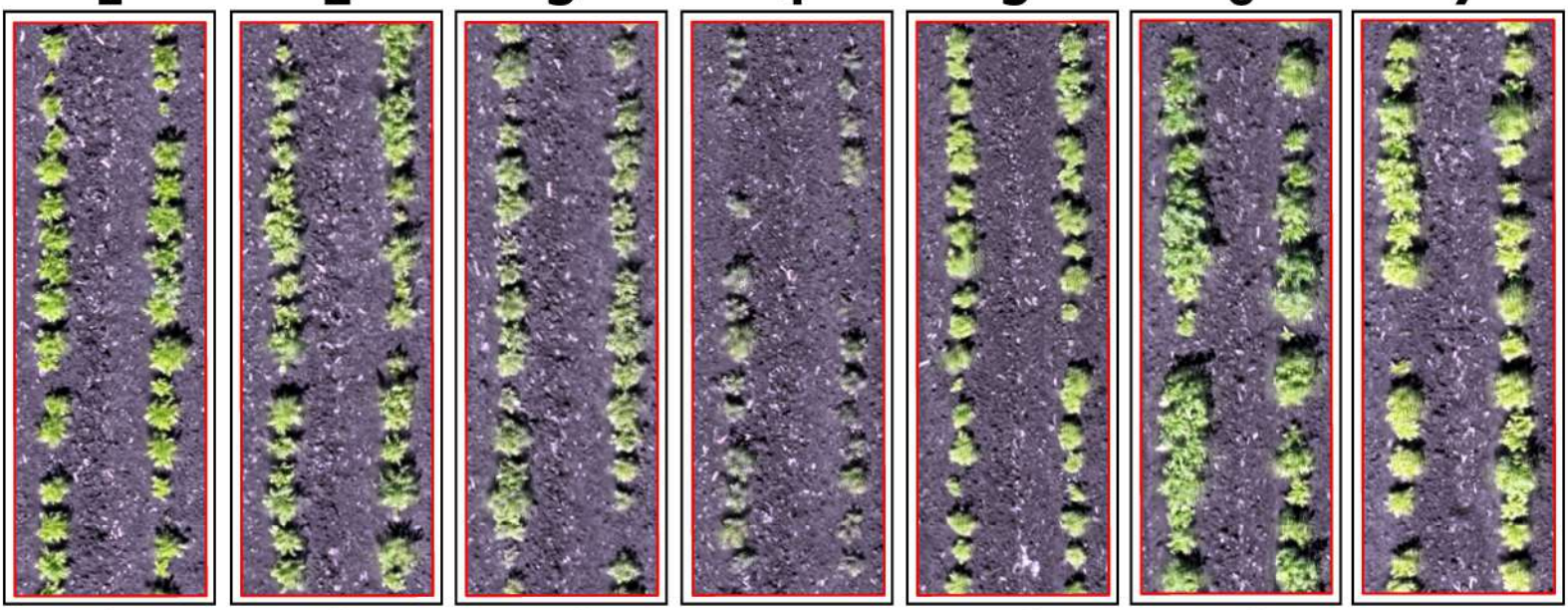
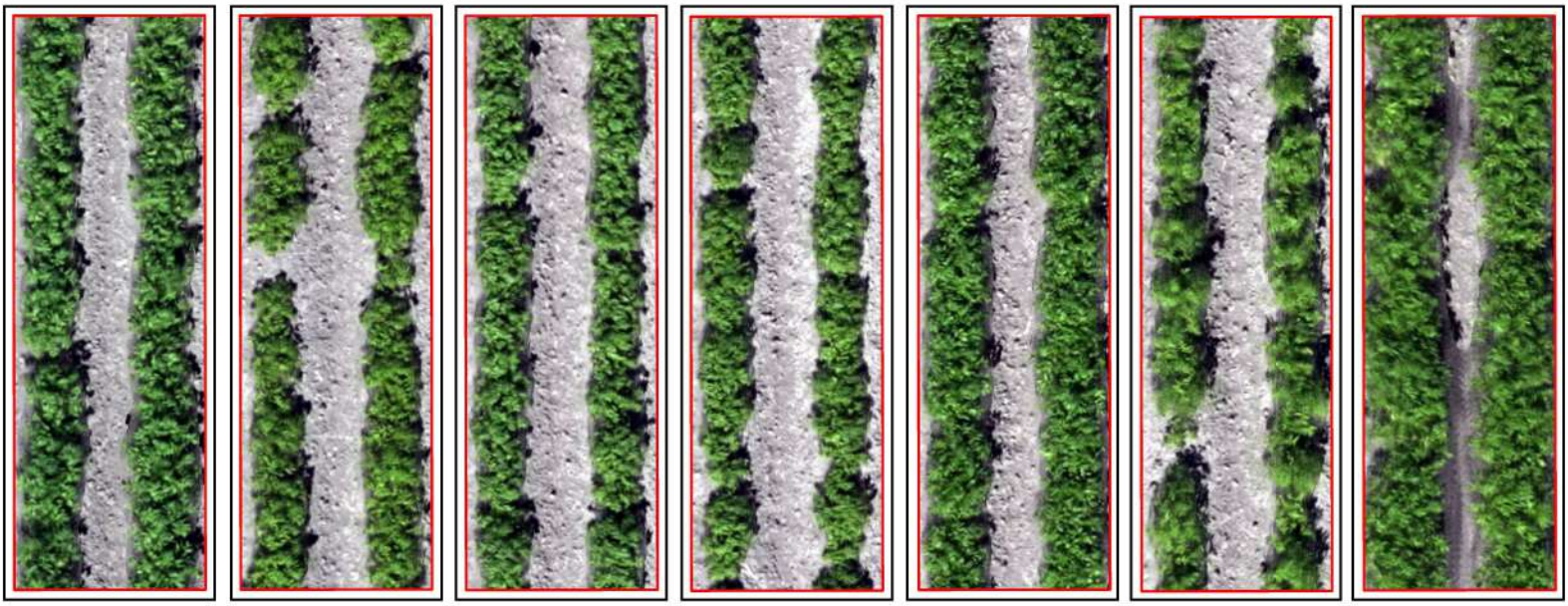


8 9 10 11 12 13 14

Red 06-26-2024

0 2 4 8 Feet



1 2 3 4 5 6 7

8 9 10 11 12 13 14

Red 07-01-2024

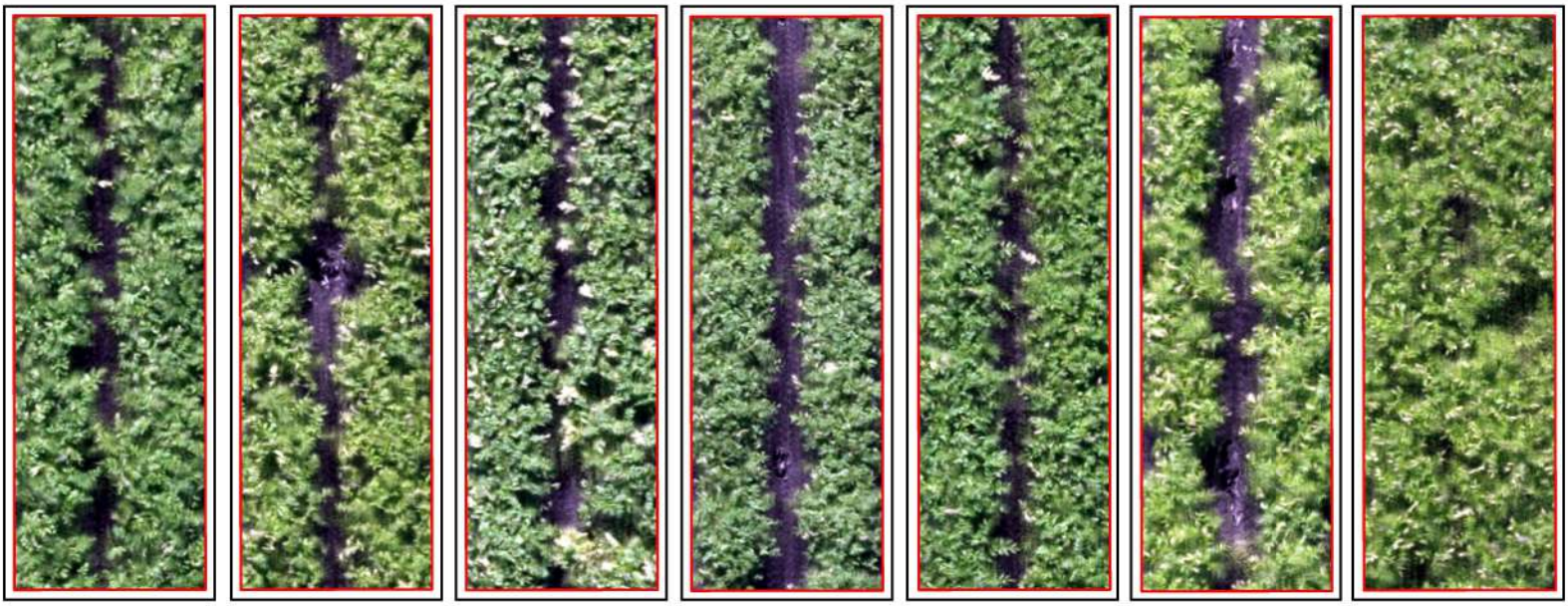
0 2 4 8 Feet

1 2 3 4 5 6 7

8 9 10 11 12 13 14

Red 07-05-2024

0 2 4 8 Feet



1 2 3 4 5 6 7

8 9 10 11 12 13 14

Red 07-08-2024

0 2 4 8 Feet

1 2 3 4 5 6 7

8 9 10 11 12 13 14

Red 07-11-2024

0 2 4 8 Feet

1 2 3 4 5 6 7

8 9 10 11 12 13 14

Red 07-17-2024

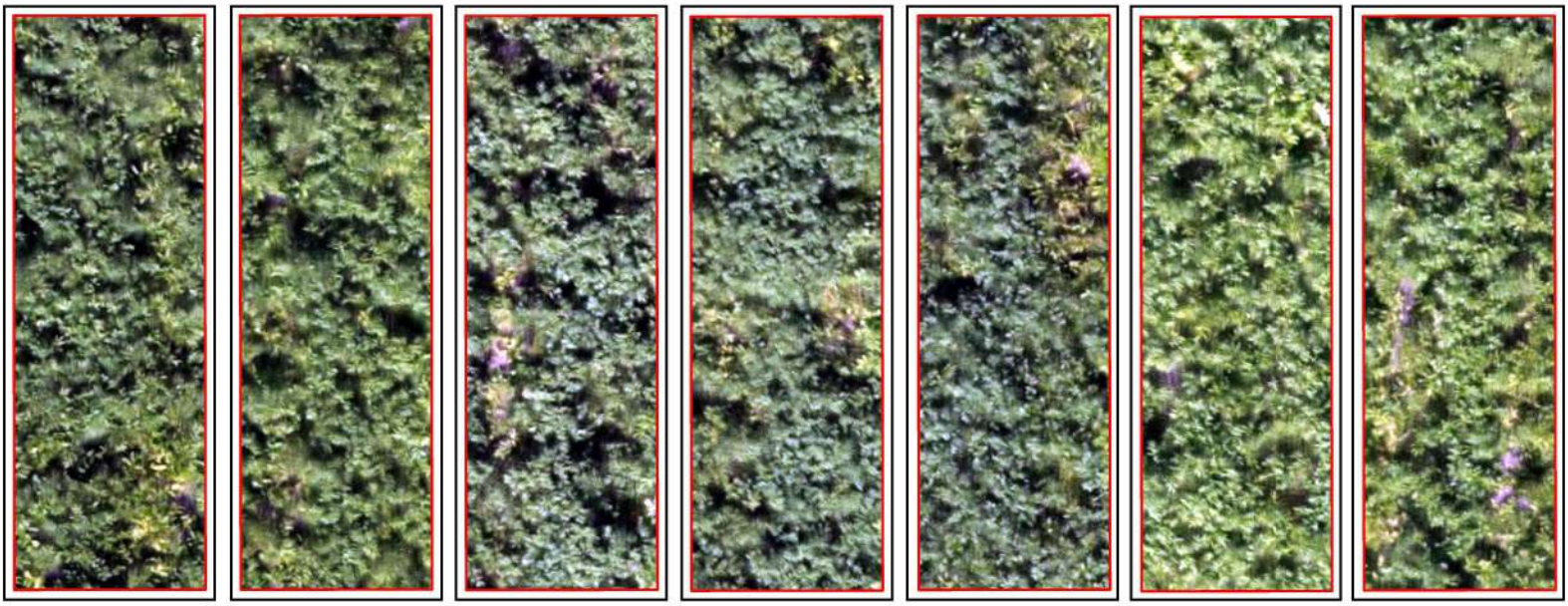
0 2 4 8 Feet

1 2 3 4 5 6 7

8 9 10 11 12 13 14

Red 07-25-2024

0 2 4 8 Feet



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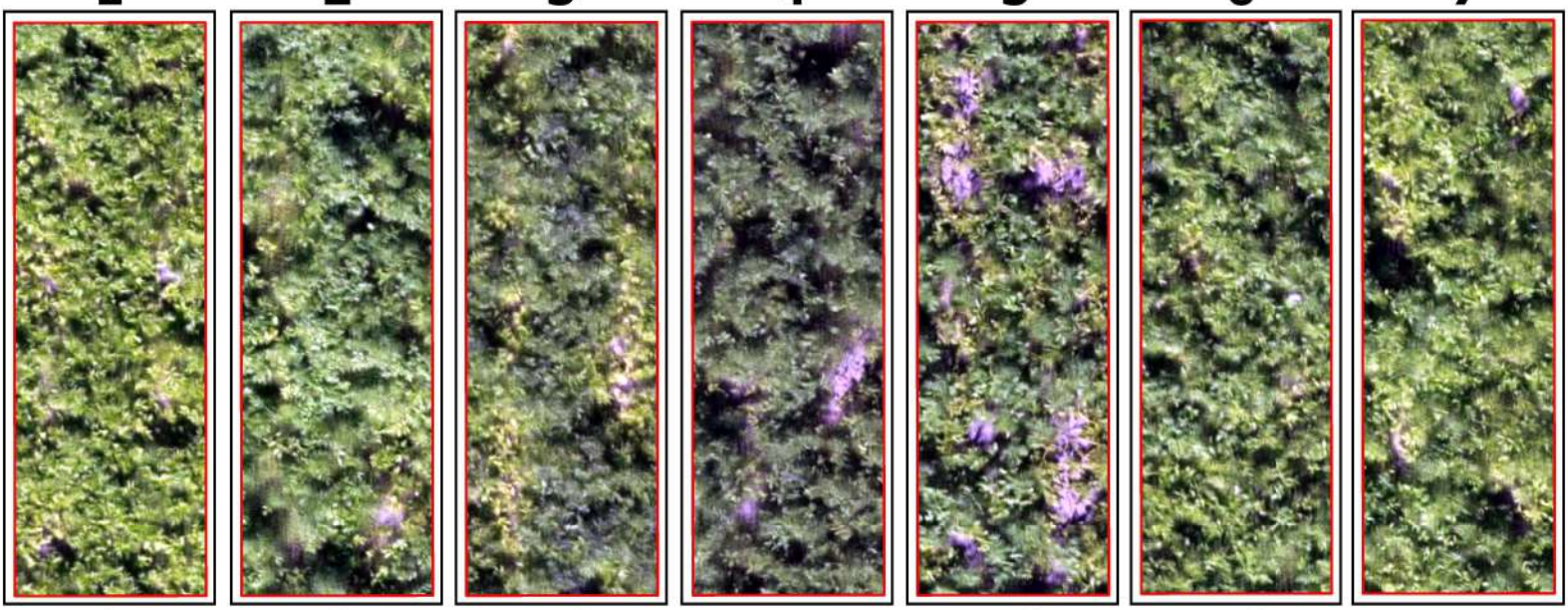
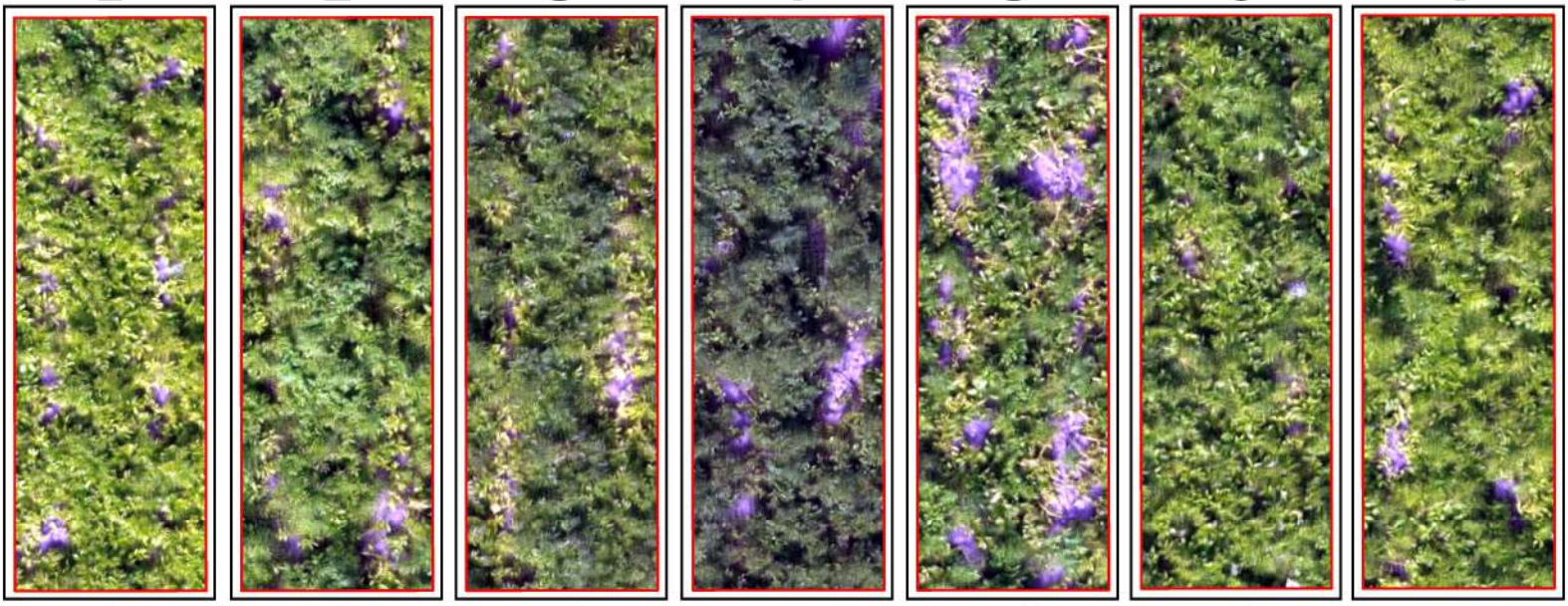


8 9 10 11 12 13 14

Red 08-03-2024

0 2 4 8 Feet

1 2 3 4 5 6 7



8 9 10 11 12 13 14

Red 08-09-2024

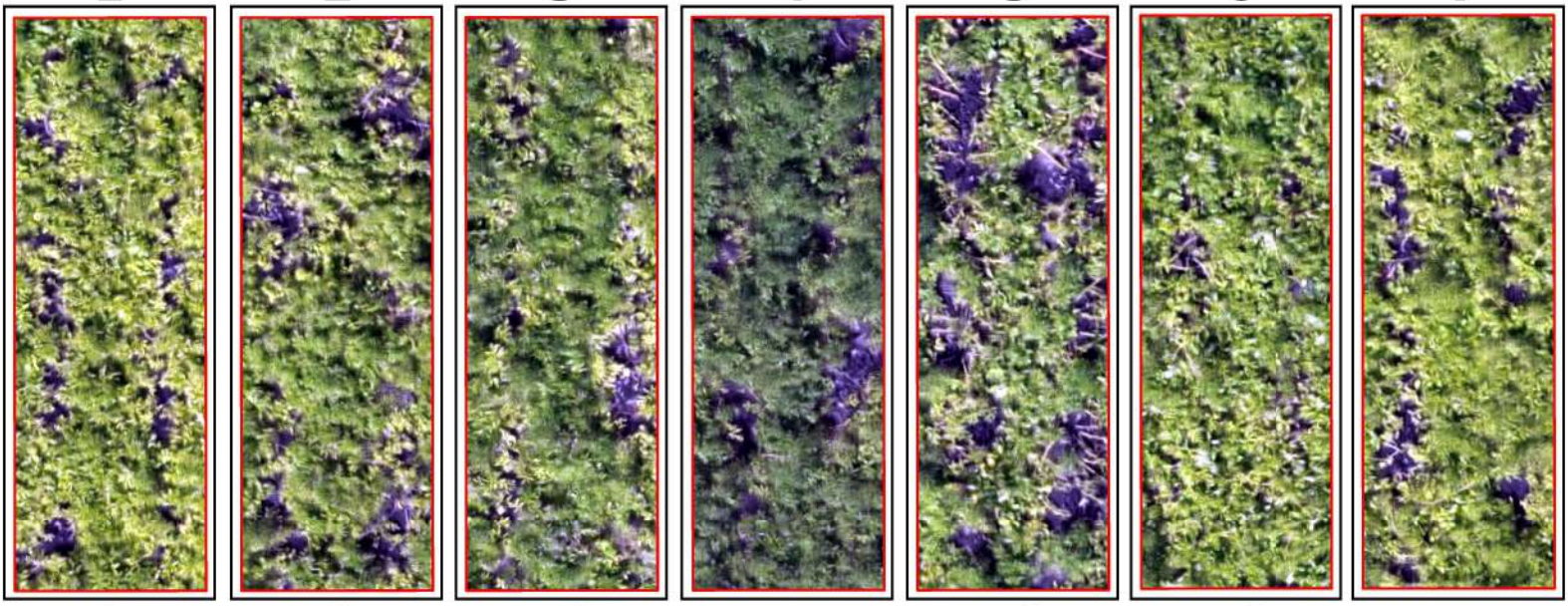
0 2 4 8 Feet

1 2 3 4 5 6 7

8 9 10 11 12 13 14

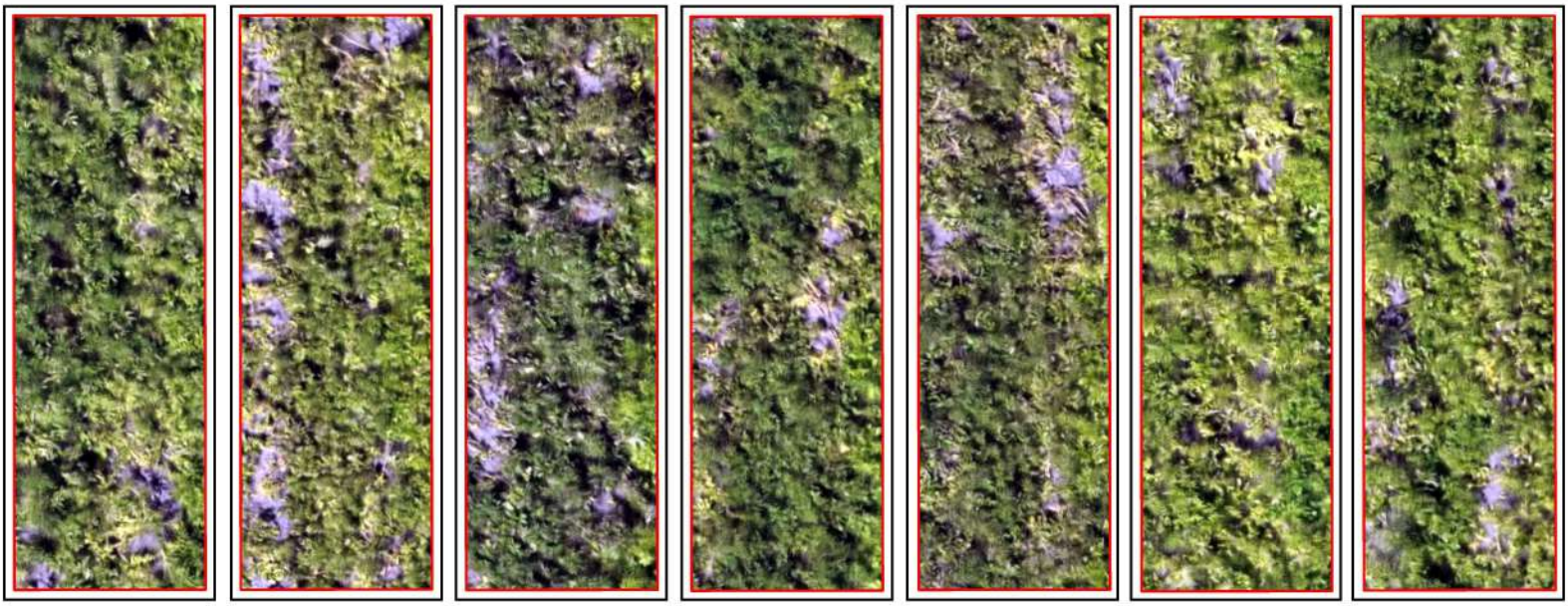
Red 08-15-2024

0 2 4 8 Feet



Red 08-21-2024

0 2 4 8 Feet



1 2 3 4 5 6 7

8 9 10 11 12 13 14

Red 08-27-2024

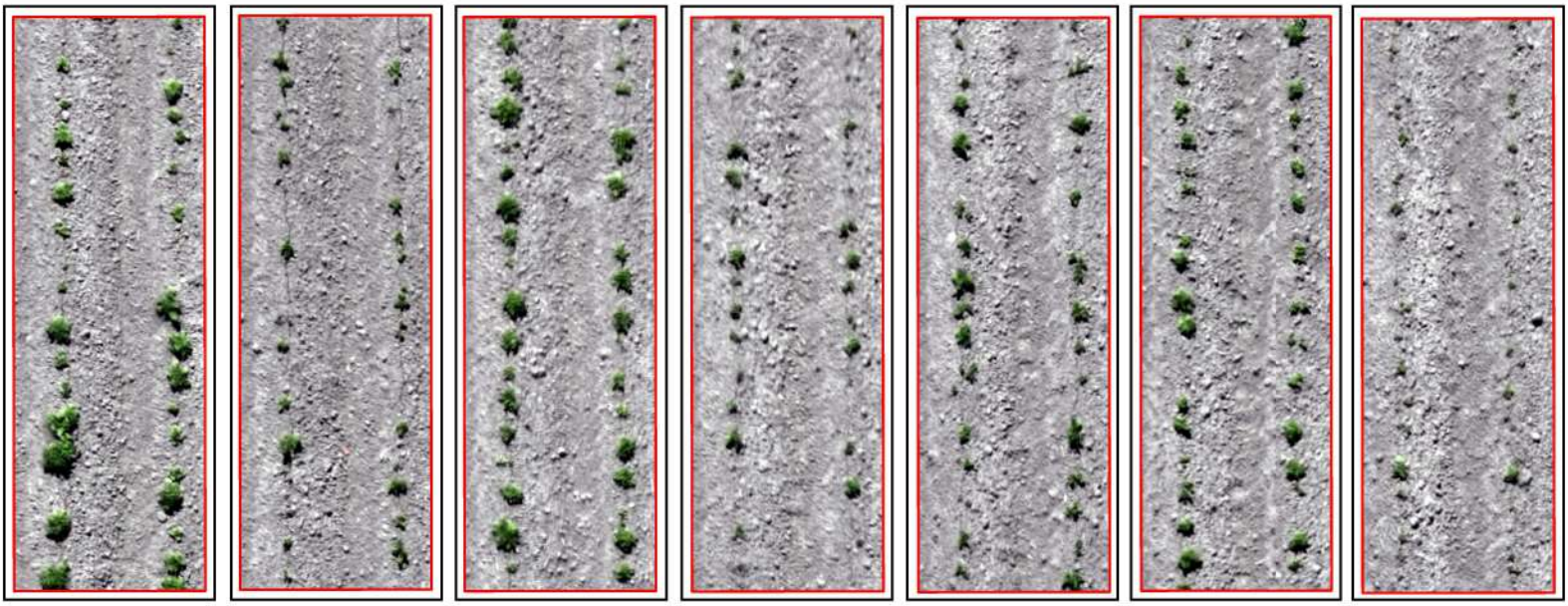
0 2 4 8 Feet

1 2 3 4 5 6 7

8 9 10 11 12 13 14

Chip 06-11-2024

0 2 4 8 Feet



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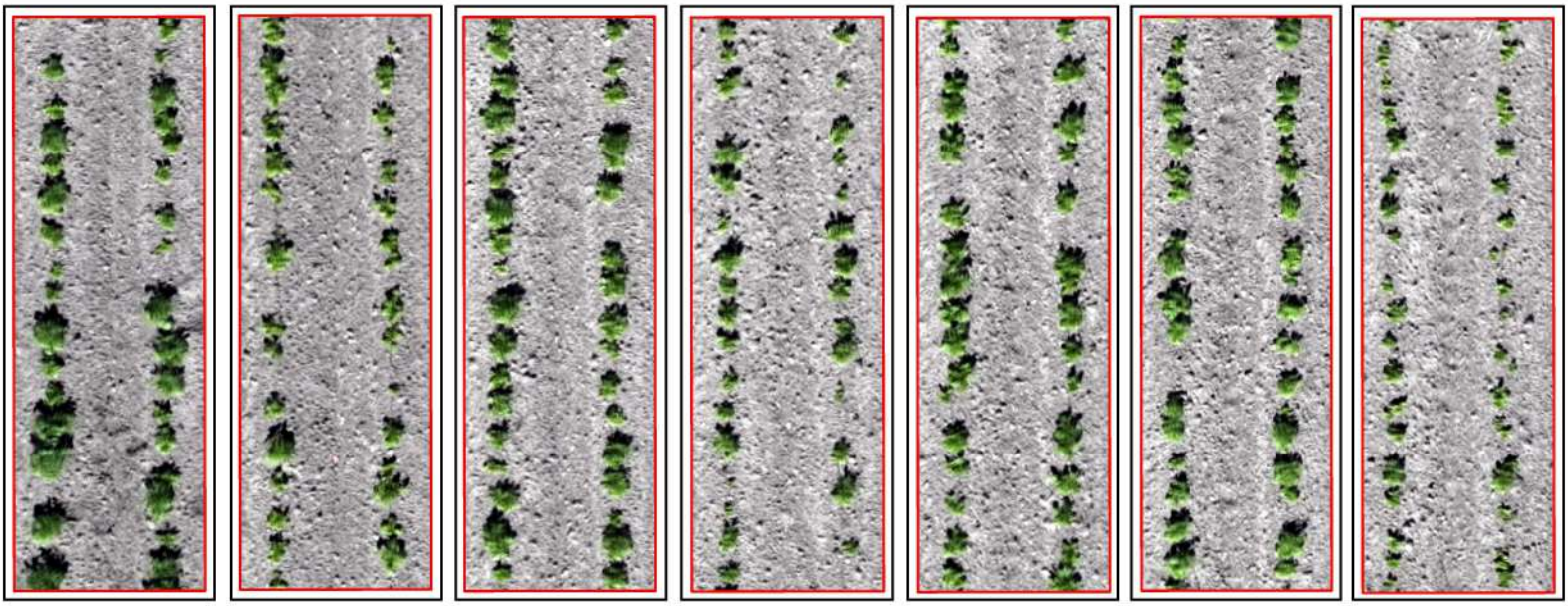
8 9

Chip 06-14-2024

0 2 4 8 Feet



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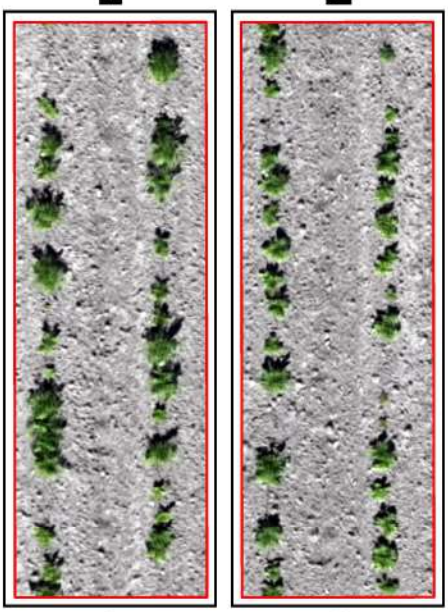
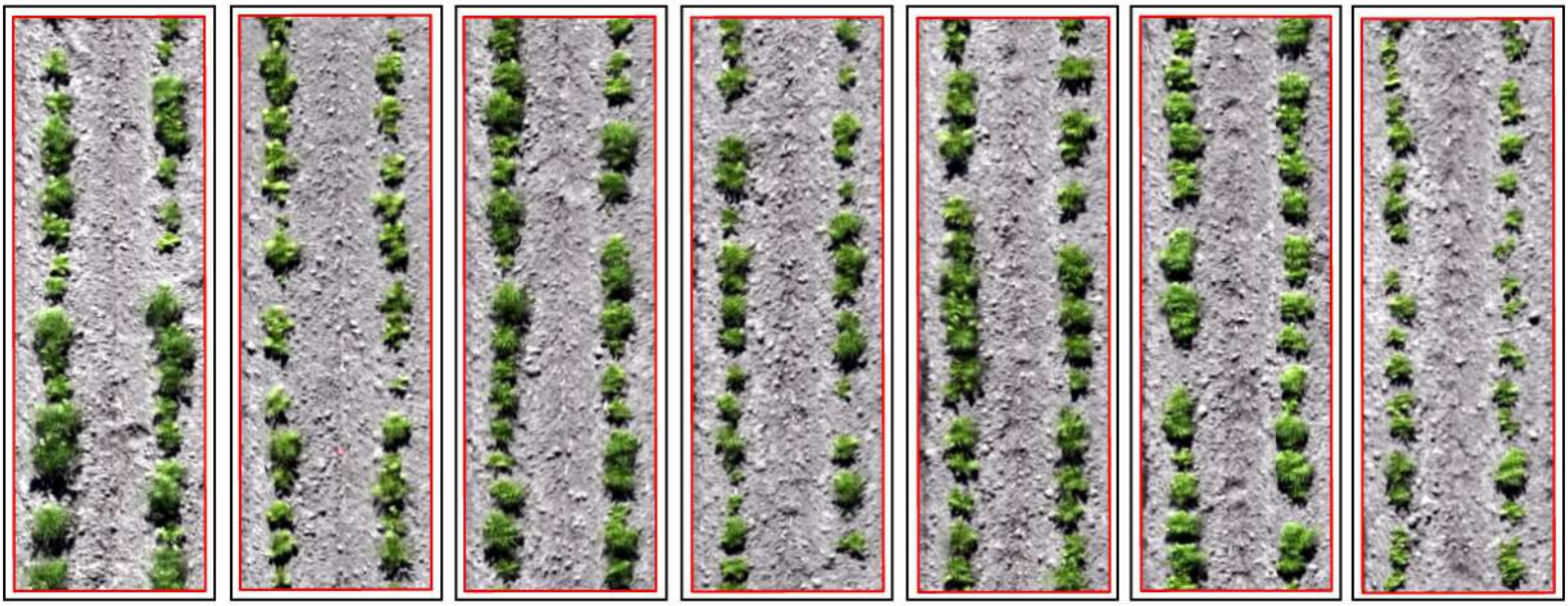


8 9

Chip 06-17-2024

0 2 4 8 Feet



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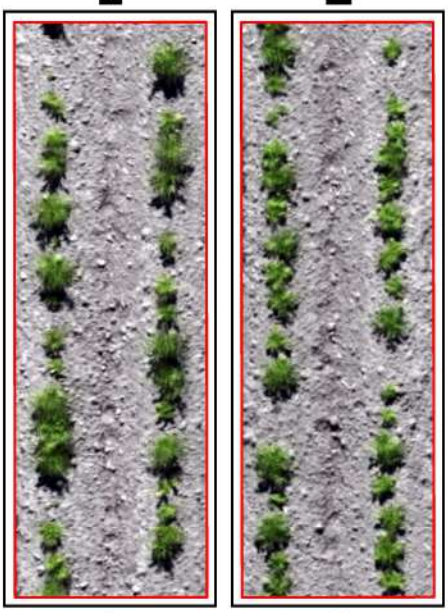

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Chip 06-18-2024

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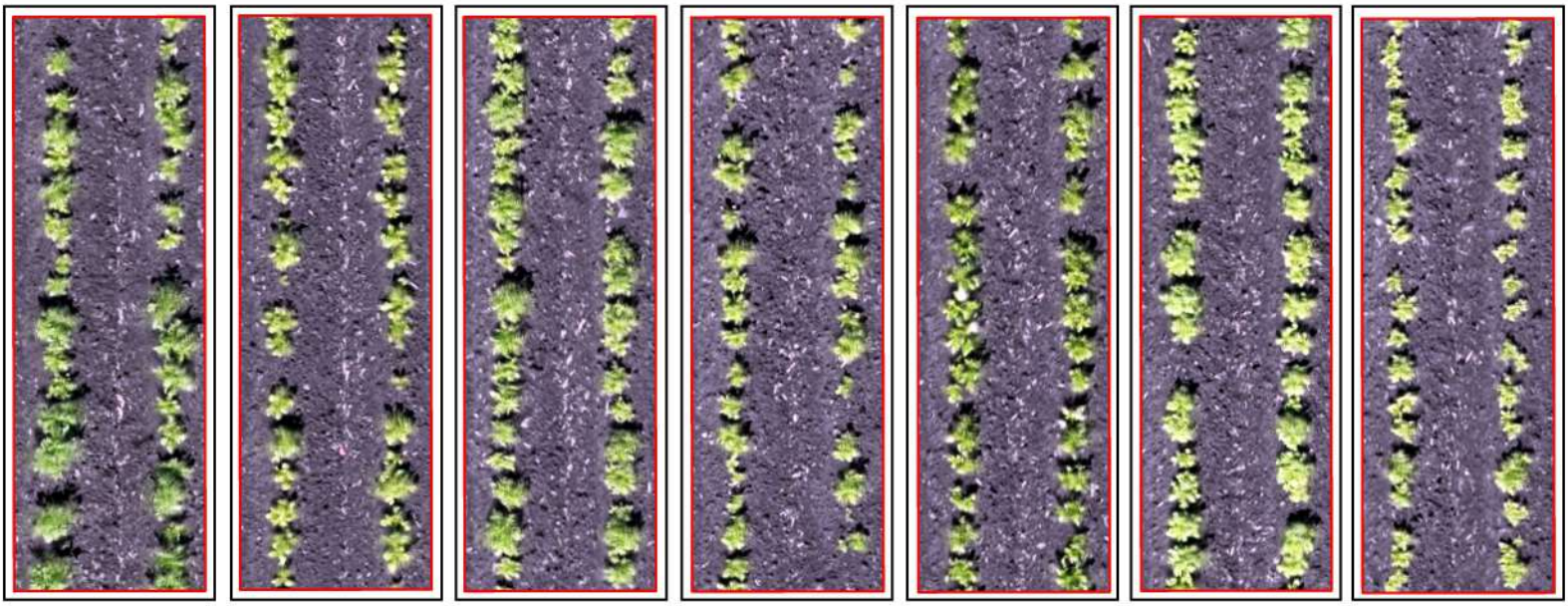
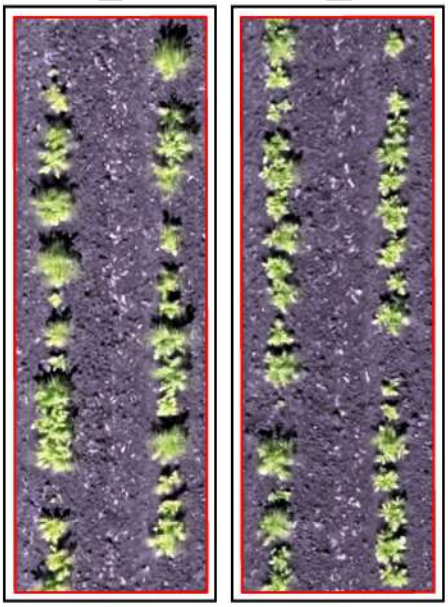


1 2 3 4 5 6 7



8 9

Chip 06-26-2024

0 2 4 8 Feet

1 2 3 4 5 6 7

8 9

Chip 07-01-2024

0 2 4 8 Feet

1 2 3 4 5 6 7

8 9

Chip 07-05-2024

0 2 4 8 Feet

1 2 3 4 5 6 7

8 9

Chip 07-08-2024

0 2 4 8 Feet

1 2 3 4 5 6 7

8 9

Chip 07-11-2024

0 2 4 8 Feet

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Chip 07-17-2024

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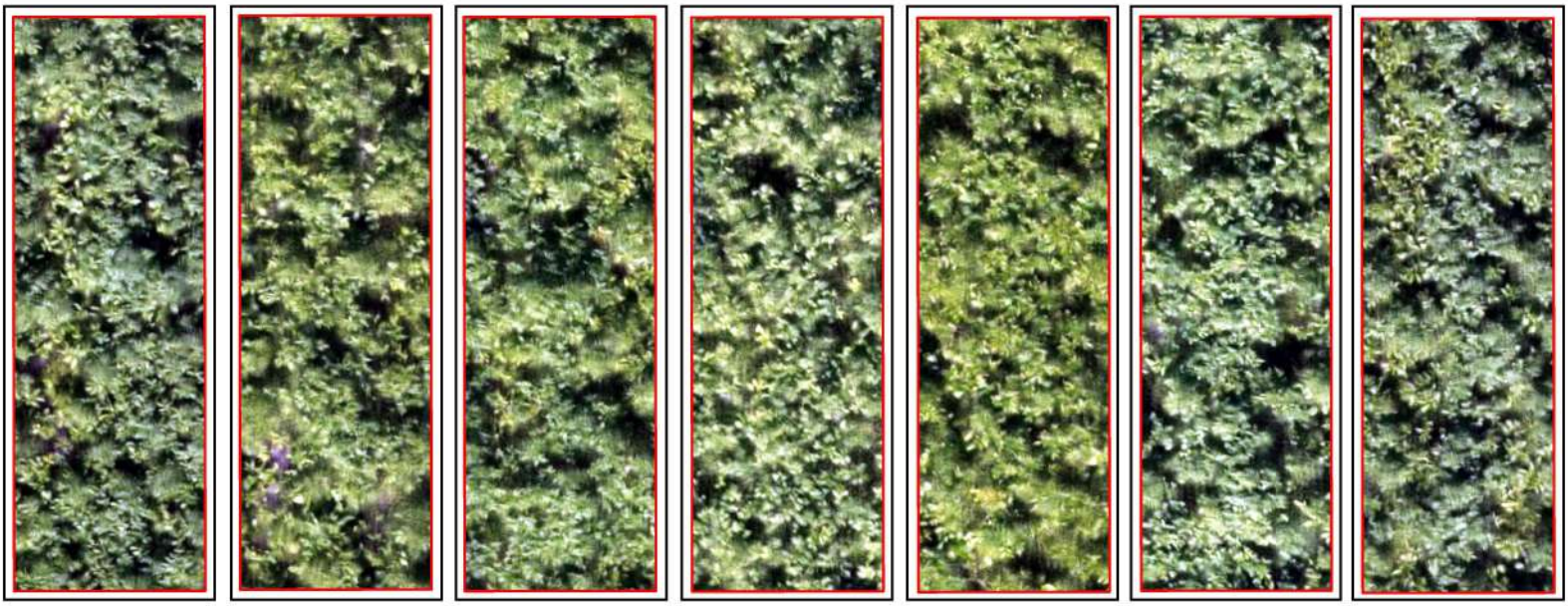
1 2 3 4 5 6 7

8 9

Chip 07-25-2024

0 2 4 8 Feet



1 2 3 4 5 6 7

8 9

Chip 08-03-2024

0 2 4 8 Feet

1 2 3 4 5 6 7

8 9

Chip 08-09-2024

0 2 4 8 Feet

1 2 3 4 5 6 7

8 9

Chip 08-15-2024

0 2 4 8 Feet

1 2 3 4 5 6 7

8 9

Chip 08-21-2024

0 2 4 8 Feet

1 2 3 4 5 6 7

8 9

Chip 08-27-2024

0 2 4 8 Feet

1 2 3 4 5 6 7

8 9