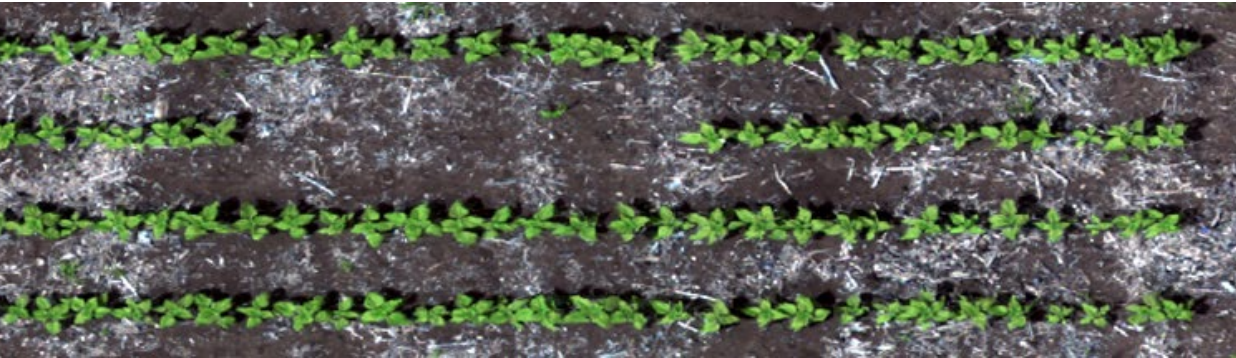
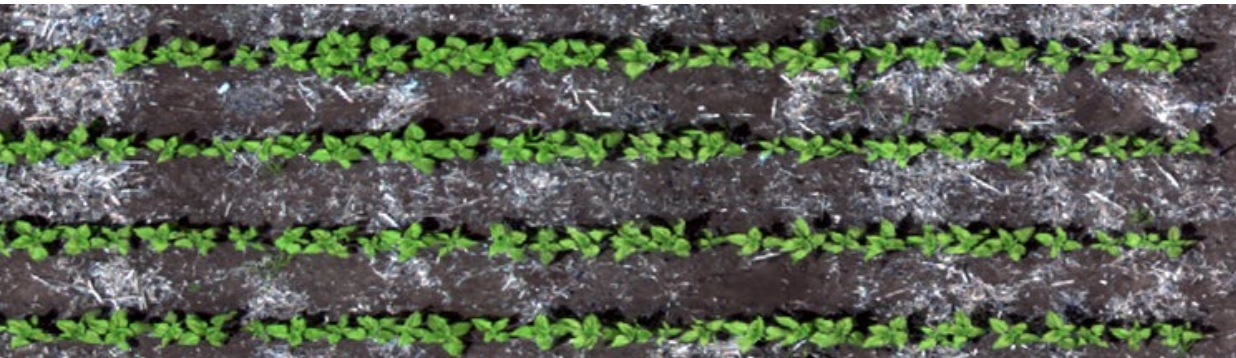


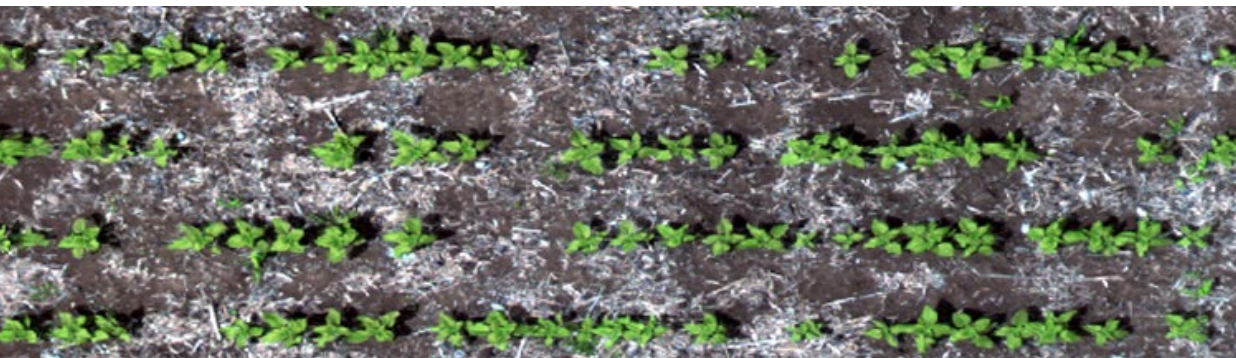
Impacts of Within-row Plant Spacing (Doubles, Skips, and Gaps) Given Consistent Population of Oilseed and Confection Sunflower (*Helianthus annuus* L.) with Phenotyping Using UAV Based Remote Sensing



Gap treatments have a reduced plant population



Controls and skip/double treatments have the same plant population



Yield TX Location

| Confection Yield TX 2020 | | |
|----------------------------|--------|-----|
| treat | Mean | |
| MEDG | 1999.3 | A |
| Control | 1972.7 | A |
| SDLOW | 1906.3 | AB |
| HIGHG | 1705.4 | ABC |
| MEDG2 | 1700 | ABC |
| SDHIGH | 1547.6 | BC |
| SDMED | 1545.2 | BC |
| SDMAX | 1363.1 | C |
| CV = 16.67 LSD = 420.79 | | |

Yield was significant by location in 2020

Higher skip/double treatments are at the bottom

Yield MN Location

| 2020 MN Confection Yield | | |
|---|--------|----|
| Treatment | Mean | |
| Control | 2104.4 | A |
| LOWG | 2064.7 | AB |
| SDHIGH | 2015.8 | AB |
| SDMAX | 2008.9 | AB |
| HIGHG | 2000.1 | AB |
| SDLOW | 1959.3 | AB |
| MEDG | 1956.3 | AB |
| SDMED | 1948.2 | AB |
| MEDG2 | 1844.1 | B |
| Common letters indicate that treatments are not significantly different | | |
| CV = 7.61 | | |
| LSD = 220.88 | | |

| 2020 MN Oilseed Yield | | |
|-----------------------|---------|---|
| Treatment | Mean | |
| SDMED | 2651.78 | A |
| SDLOW | 2642.01 | A |
| CONTROL | 2628.94 | A |
| MEDG | 2616.55 | A |
| SDMAX | 2597.94 | A |
| LOWG | 2583.55 | A |
| SDHIGH | 2575.71 | A |
| HIGHG | 2546.03 | A |
| MEDG2 | 2395.1 | B |
| CV = 3.469 | | |
| LSD = 130.74 | | |

MEDG2 has the lowest population due to having two 2-meter gaps in the middle rows

Unharvested plants is a combination of mostly diseased or lodged plants

| Oilseed Unharvested Plants | | | | |
|----------------------------|----------|----------------|----|---------|
| treat | Estimate | Standard Error | DF | t Value |
| SDMAX | 6.6875 | 0.5351 | 81 | 12.5 |
| SDHIGH | 5.8125 | 0.5351 | 81 | 10.86 |
| Control | 5.4375 | 0.5351 | 81 | 10.16 |
| SDMED | 5.125 | 0.5351 | 81 | 9.58 |
| MEDG | 4 | 0.5351 | 81 | 7.48 |
| HIGHG | 3.5 | 0.5351 | 81 | 6.54 |
| Treatment Pr > F = 0.0003 | | | | |

The highest occurrence of unharvested plants was in treatments with skips/doubles

| treat | treat | Estimate | Standard Error | DF | t Value | Pr > t |
|----------------|---------------|----------|----------------|----|---------|---------|
| HIGHG | SDMAX | -3.1875 | 0.7344 | 81 | -4.34 | <.0001 |
| MEDG | SDMAX | -2.6875 | 0.7344 | 81 | -3.66 | 0.0004 |
| SDMAX | SDMED | 1.5625 | 0.7344 | 81 | 2.13 | 0.0364 |
| HIGHG | SDHIGH | -2.3125 | 0.7344 | 81 | -3.15 | 0.0023 |
| MEDG | SDHIGH | -1.8125 | 0.7344 | 81 | -2.47 | 0.0157 |
| Control | HIGHG | 1.9375 | 0.7344 | 81 | 2.64 | 0.01 |
| HIGHG | SDMED | -1.625 | 0.7344 | 81 | -2.21 | 0.0297 |
| Tukey-Kramer | | | | | | |

Quality

Pint cup samples

| Confection Testweight | | | | |
|------------------------------|-----------------|-----------------------|-----------|----------------|
| treat | Estimate | Standard Error | DF | t Value |
| SDHIGH | 23.3598 | 0.1819 | 93 | 128.41 |
| Control | 23.0202 | 0.1819 | 93 | 126.54 |
| HIGHG | 22.743 | 0.1819 | 93 | 125.02 |
| SDMAX | 22.7238 | 0.1819 | 93 | 124.91 |
| MEDG | 22.7112 | 0.1819 | 93 | 124.84 |
| Treatment Pr > F = 0.0065 | | | | |

| treat | treat | Estimate | Standard Error | DF | t Value | Pr > t |
|---------------|---------------|-----------------|-----------------------|-----------|----------------|--------------------|
| HIGHG | SDHIGH | -0.6168 | 0.2216 | 93 | -2.78 | 0.0065 |
| MEDG | SDHIGH | -0.6486 | 0.2216 | 93 | -2.93 | 0.0043 |
| SDHIGH | SDMAX | 0.636 | 0.2216 | 93 | 2.87 | 0.0051 |
| Tukey-Kramer | | | | | | |

Distribution of
seed size in a pint
cup sample

Using sieve plates

| Confection Seed Size 22/64 | | | | |
|----------------------------|----------|----------------|----|---------|
| treat | Estimate | Standard Error | DF | t Value |
| HIGHG | 0.4997 | 0.01544 | 87 | 32.37 |
| MEDG | 0.4891 | 0.01497 | 87 | 32.67 |
| SDHIGH | 0.4566 | 0.01544 | 87 | 29.58 |
| Control | 0.4509 | 0.01497 | 87 | 30.12 |
| SDMAX | 0.4501 | 0.01633 | 87 | 27.56 |
| Treatment Pr > F = 0.0024 | | | | |

| treat | treat | Estimate | Standard Error | DF | t Value | Pr > t |
|--------------|--------|----------|----------------|----|---------|---------|
| Control | HIGHG | -0.04879 | 0.02026 | 87 | -2.41 | 0.0181 |
| HIGHG | SDMAX | 0.04966 | 0.02124 | 87 | 2.34 | 0.0217 |
| HIGHG | SDHIGH | 0.04314 | 0.02063 | 87 | 2.09 | 0.0394 |
| Tukey-Kramer | | | | | | |

| Confection Seed Size 20/64 | | | | |
|----------------------------|----------|----------------|----|---------|
| treat | Estimate | Standard Error | DF | t Value |
| MEDG | 0.8177 | 0.01539 | 87 | 53.13 |
| HIGHG | 0.8126 | 0.01589 | 87 | 51.14 |
| Control | 0.7897 | 0.01539 | 87 | 51.31 |
| SDHIGH | 0.7528 | 0.01589 | 87 | 47.38 |
| SDMAX | 0.7527 | 0.01684 | 87 | 44.7 |
| Treatment Pr > F = 0.0012 | | | | |

Gap treatments have a lower population

| treat | treat | Estimate | Standard Error | DF | t Value | Pr > t |
|--------------|---------------|----------|----------------|----|---------|---------|
| MEDG | SDHIGH | 0.06489 | 0.02149 | 87 | 3.02 | 0.0033 |
| MEDG | SDMAX | 0.06505 | 0.0222 | 87 | 2.93 | 0.0043 |
| HIGHG | SDHIGH | 0.05977 | 0.02186 | 87 | 2.73 | 0.0076 |
| HIGHG | SDMAX | 0.05993 | 0.02252 | 87 | 2.66 | 0.0093 |
| Tukey-Kramer | | | | | | |

| Confection Seed Size 18/64 | | | | |
|----------------------------|----------|----------------|----|---------|
| treat | Estimate | Standard Error | DF | t Value |
| MEDG | 0.952 | 0.009059 | 87 | 105.09 |
| HIGHG | 0.9435 | 0.009355 | 87 | 100.85 |
| Control | 0.9378 | 0.009059 | 87 | 103.52 |
| SDMAX | 0.908 | 0.009922 | 87 | 91.51 |
| SDHIGH | 0.9007 | 0.009355 | 87 | 96.28 |
| Treatment Pr > F = 0.0002 | | | | |

This is the smallest sieve plate size used

The gap treatments and control measured a significantly higher distribution of large seeds compared to the skip/double treatments

| treat | treat | Estimate | Standard Error | DF | t Value | Pr > t |
|----------------|---------------|----------|----------------|----|---------|---------|
| MEDG | SDHIGH | 0.05131 | 0.0129 | 87 | 3.98 | 0.0001 |
| MEDG | SDMAX | 0.04407 | 0.01331 | 87 | 3.31 | 0.0014 |
| HIGHG | SDHIGH | 0.04274 | 0.01311 | 87 | 3.26 | 0.0016 |
| Control | SDHIGH | 0.03709 | 0.0129 | 87 | 2.88 | 0.0051 |
| HIGHG | SDMAX | 0.0355 | 0.01351 | 87 | 2.63 | 0.0102 |
| Control | SDMAX | 0.02985 | 0.01331 | 87 | 2.24 | 0.0275 |
| Tukey-Kramer | | | | | | |

The SDHIGH treatment had the highest testweight

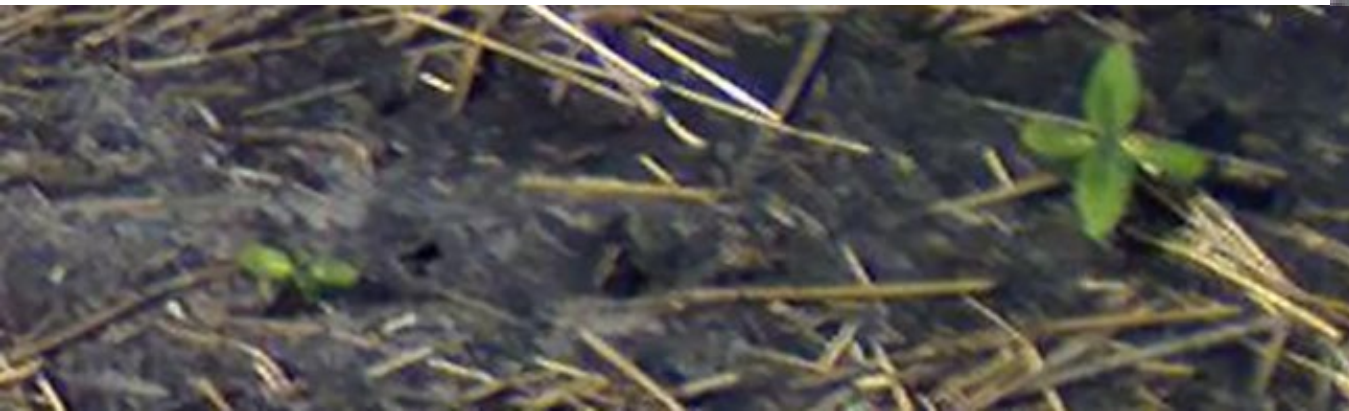
Emergence

Timelapse images

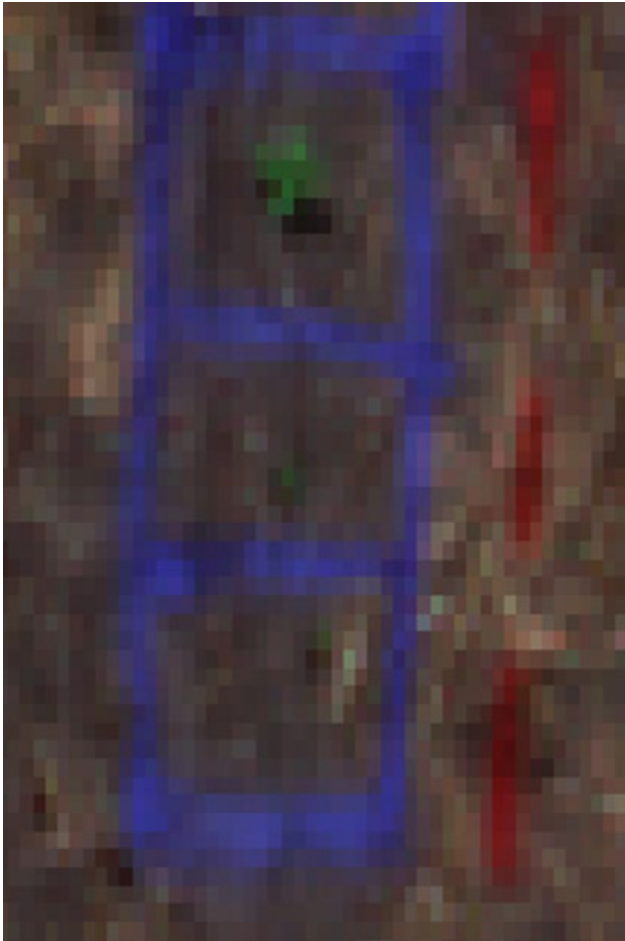
First emergence June 17th (right)

Most emergence occurred by June 19th

Last emergence on timelapse cameras was
June 24th (June 22nd below)



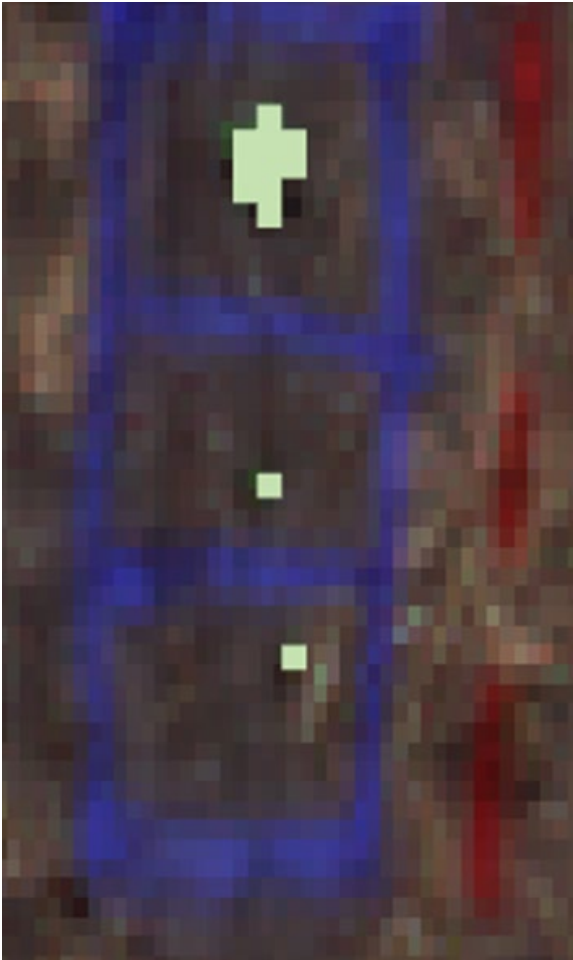
Spray paint was used to
ground truth areas with
different plant stages

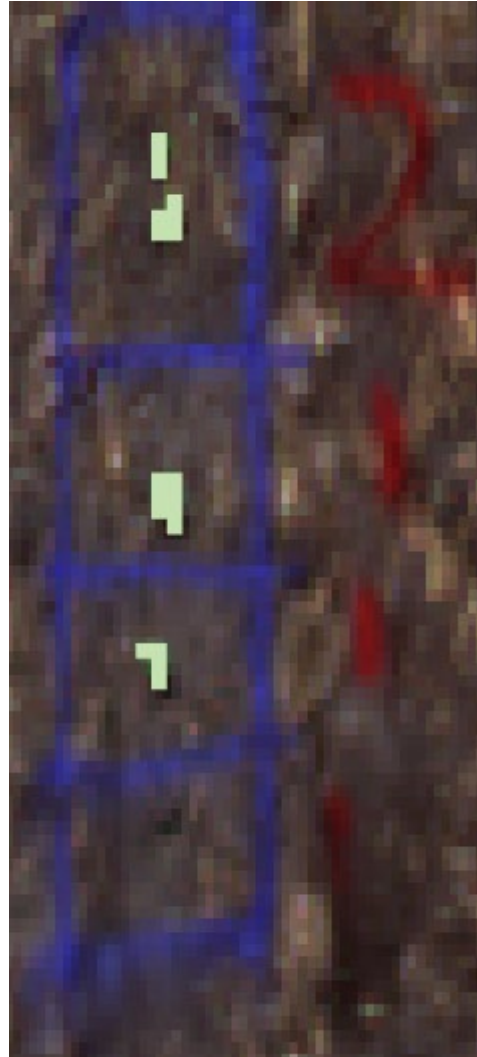
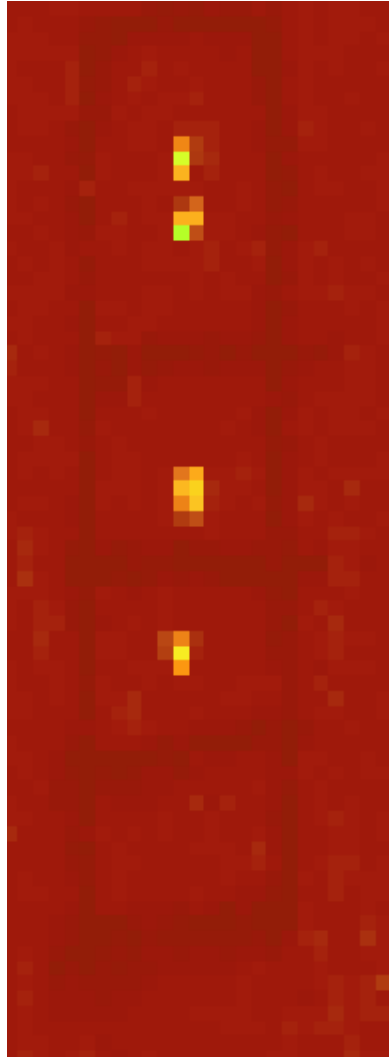
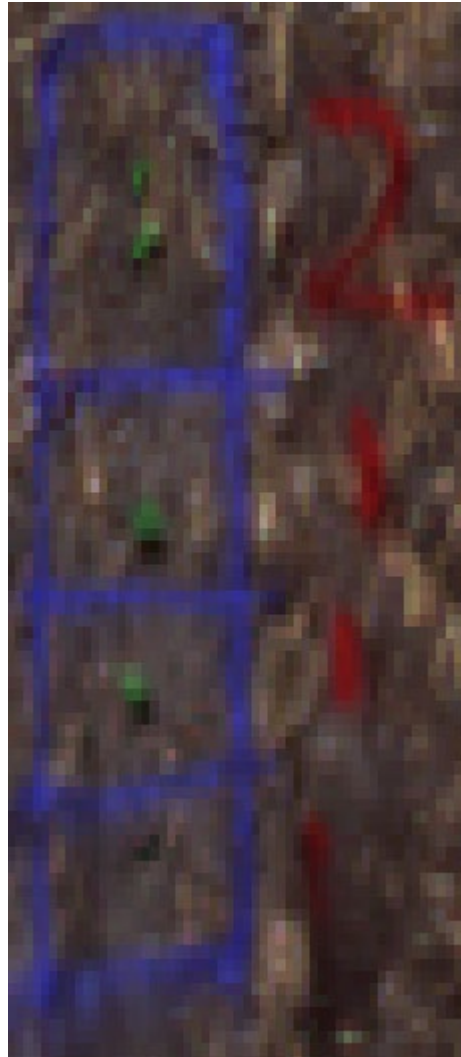


Combination of vegetation
indexes increase contrast
between vegetative material
and soil



Classify the pixels in the
high contrast raster that
are plants





Precision for blocks with known singles was 85%

Reflects the percent of known plants that are correctly classified.

Blocks that had doubles were underestimated 63% of the time to just a single plant.

The false negative rate (for the classification to fail to detect a plant in a block) was 10.2%

Thank you!

National Sunflower Association

Brent Hulke

Calvin Trostle

Ron Meyer

Brady Koehler

Mike Grove

Brian Smart

Andre Gossweiler

Mike DeGreef

Cameron Poyd

Jaime Paterson

Adam Wronski

Cassidy Voeltz

Kali-Jo Olson

Maya Gatz