Unmanned Aerial System for Assessment of In-season Nitrogen uptake and Yield in Corn(*Zea mays L.*) Under Various Split N Applications

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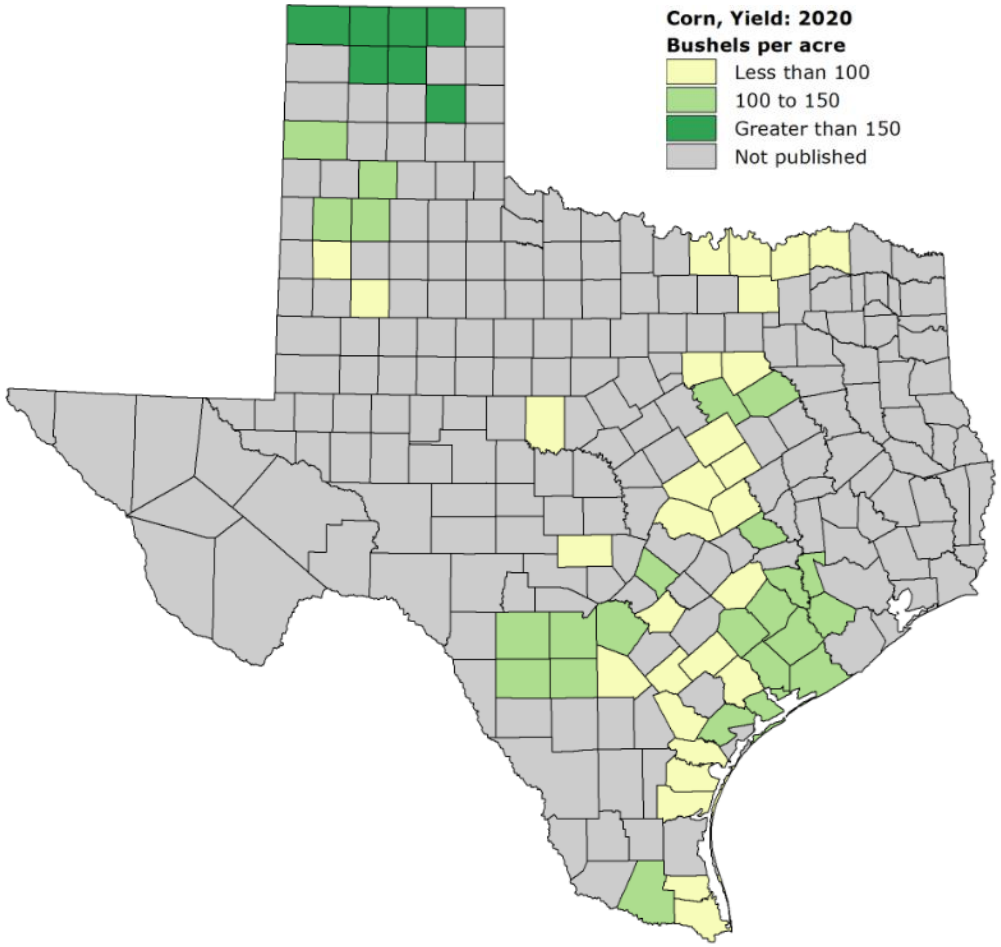
Corn and Nitrogen (N)

- Corn is a major crop in the Texas High Plains and in Central and South Texas
- More than 2 million acres planted in 2021 (NASS, 2021)
- 11.7 million metric tons harvested (www.statista.com)
- 11 thousand metric tons of Nitrogen application
- the USA is the third largest consumer of Nitrogen(N) fertilizer



Statement of Problem

- Only 30 -50 % of applied N is utilized by crops (Omara et al., 2019)
- Nitrogen management is crucial for sustainable corn production
- Split N application has the potential to reduce N losses and help in N management
- Evaluation of the Split N application is important to derive insights

Index Suggests That Half of Nitrogen Applied to Crops Is Lost

Food production is becoming less efficient at using nitrogen fertilizer, according to a review of global values. Excess nitrogen damages the environment and the climate.

By Jenessa Duncombe 23 August 2021

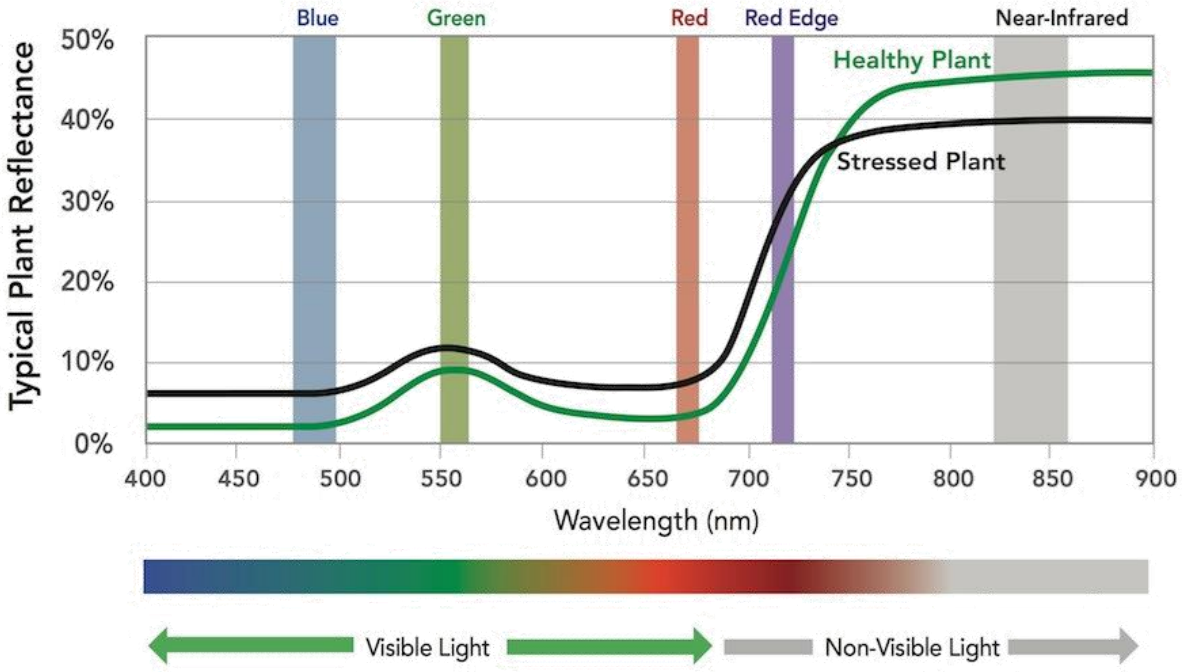
The power of nitrogen to keep crops healthy can be seen in these corn hybrids. The adult hybrid plants at left, from 2015, keep nitrogen in their leaves longer than the 1958 hybrids at right do. Credit: Tony Vyn

Statement of Problem

- Manual monitoring and assessment for large-scale production fields seems laborious and tedious
- Unmanned Aerial Vehicles (UAVs) can provide a great alternative to the manual assessment
  - Precise data and objective evaluation
  - Large scale assessment in less time

How does UAV help?

- UAV-derived spectral data are sensitive to crop stress (L Zhang et., al 2019)
- UAV based remote sensing can predict yield (Haghighattalab, Atena, et al.2017)
- Spectral data can be utilized to study growth parameters



Objectives

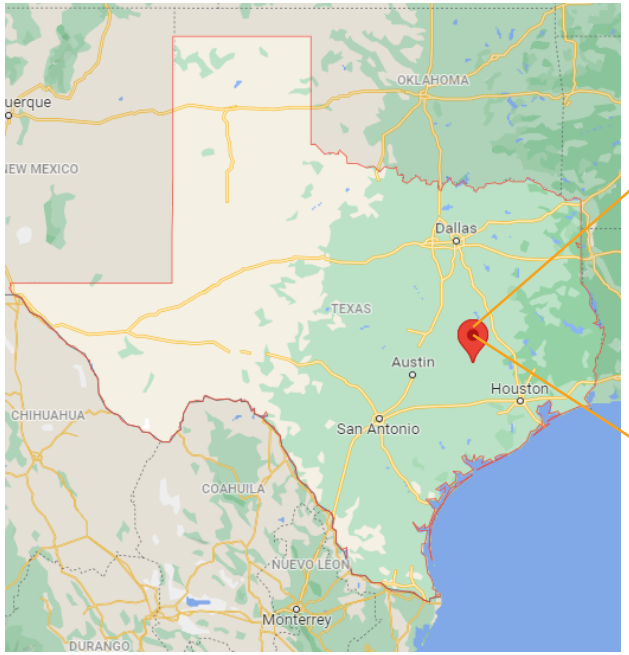
1. Determine if remote sensing variables can determine the N-uptake in split N system

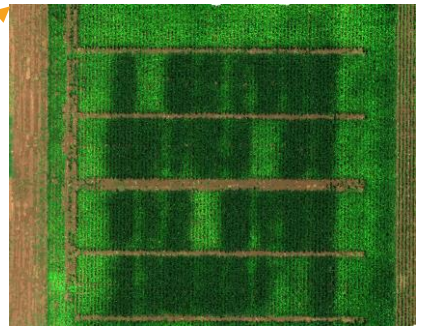
2. Evaluate the association of remote sensing variables with yield at different growth stages

Materials and Methods

Study site

- Soil Type: Clay loam(Fine, mixed, thermic, enthic, hapluderts)
- Climate: Humid subtropical climate
- Corn growing season: Early March - Late July
- Residual Soil N: 5-7 ppm NO_3-N (0-30 cm depth)
- Two years of study (2021 & 2022)



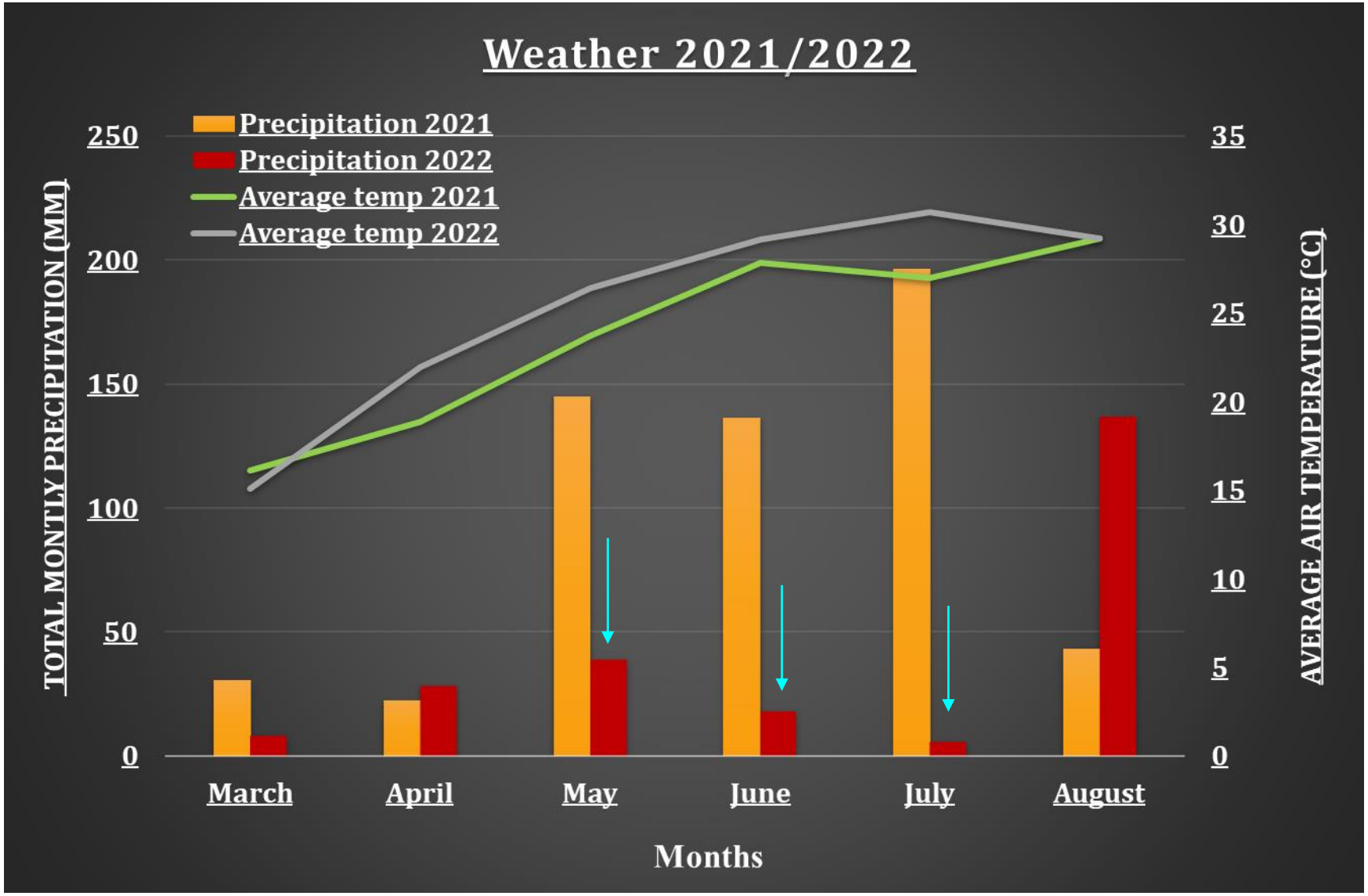


Texas A&M Agri-life Research Farm, College Station ,Texas (30°32'28.7"N 96°25'41.4"W)

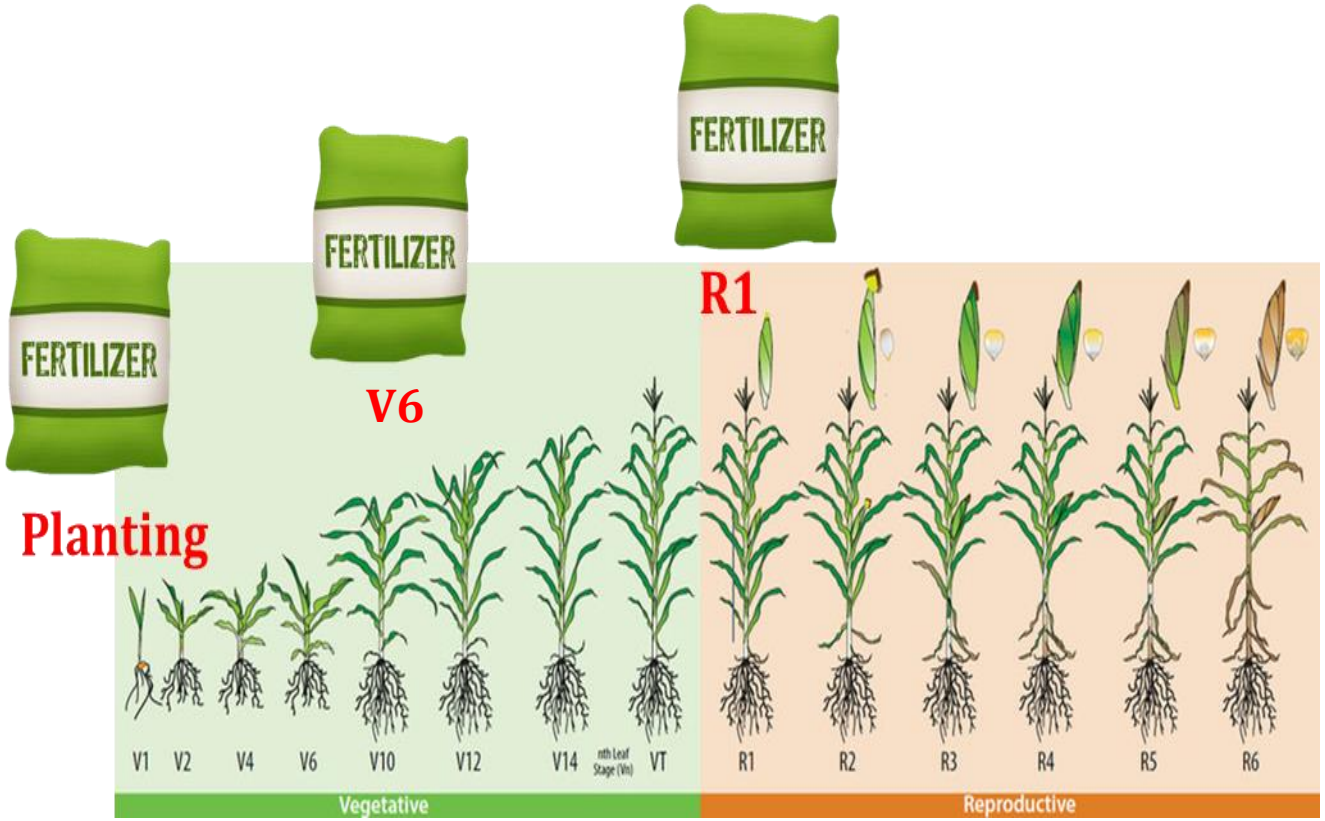
Materials and Methods: Experimental Setup

- Each plot: 13m x 6.5m
- RCBD design
- 8 treatments (7 treatments + 1 control) in 2021
- 10 treatments (2 treatments added in 2022)
- 4 replications
- Pioneer 1847 VHYR variety
- Rainfed irrigation management

Materials and Methods: Experimental Setup



Materials and Methods: Experimental Setup



Split-treatment

	First application	Second application
T1-	0	0
T2-	20% (planting)	80% (V6)
T3:	100% (planting)	-----
T4:	90% (planting)	10% (R1)
T5:	80% (planting)	20% (R1)
T6:	70% (planting)	30% (R1)
T7:	60% (planting)	40% (R1)
T8:	50% (planting)	50% (R1)
T9:	**50% (planting)**	-----
T10:	**25% (planting)**	-----

Added treatments for 2022

N application rate - 240 kg/hectare

Unmanned Aerial Vehicle and Sensor

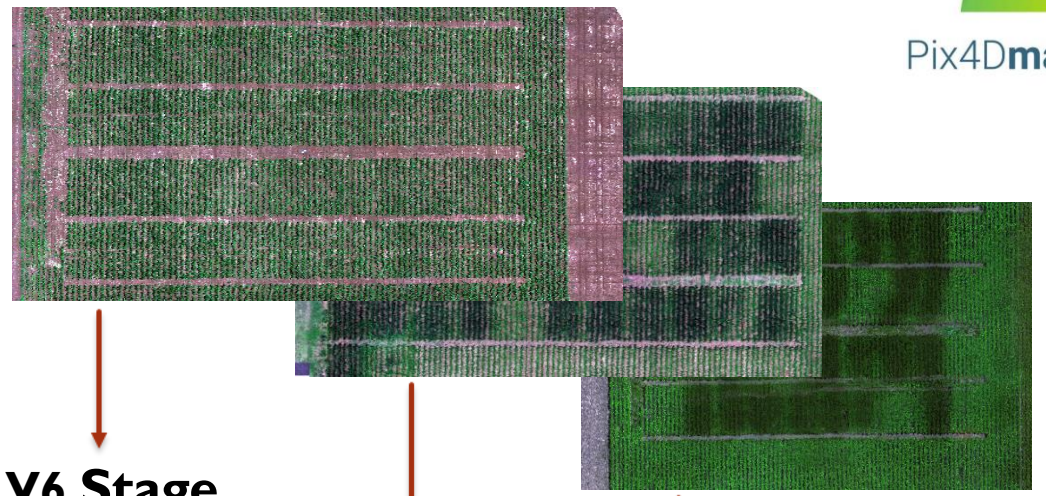
Data collection: UAV imagery

Hylio attached with Sentera 6X camera

- Five bands (Blue, Green, Red, NIR, Red-Edge)
- Altitude 15 m
- Image overlap: 80 %
- Image resolution: 0.8 cm/pixel

Generated ortho-mosaicked imagery

Pix4Dmapper

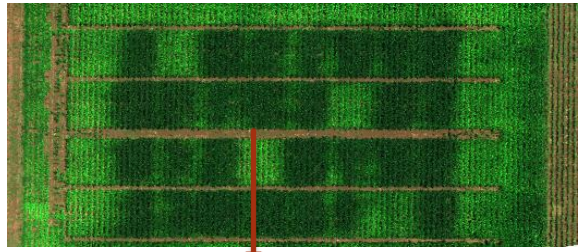


V6 Stage

R1 Stage

R4 Stage

2021



V14 Stage

Added in2022

Remote Sensing Data: Vegetation Indices

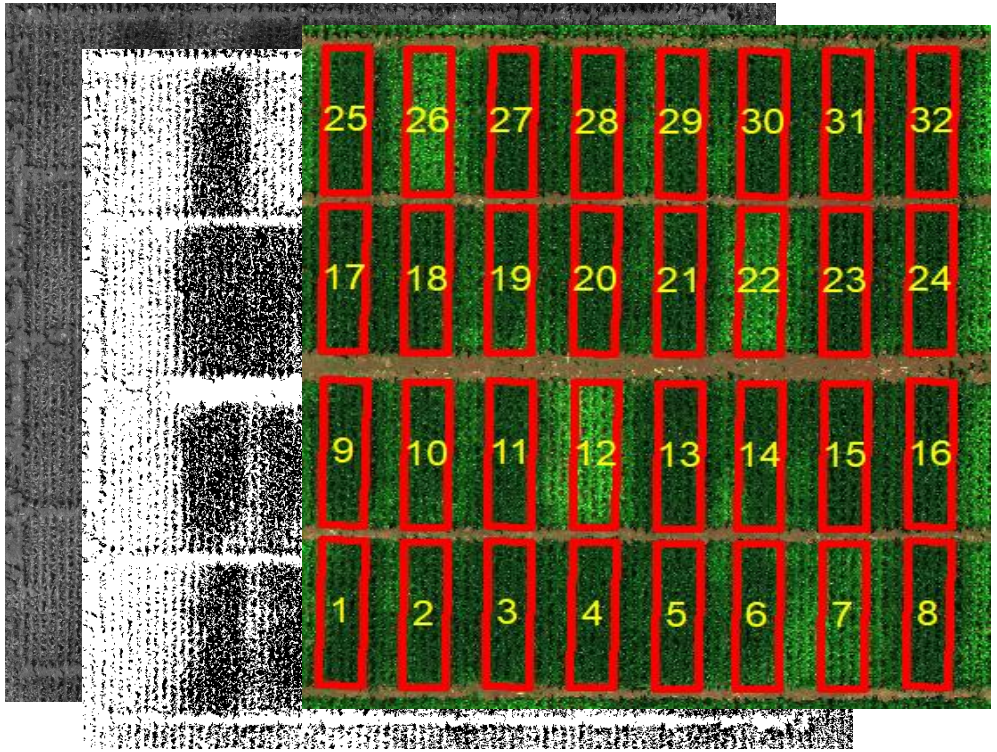
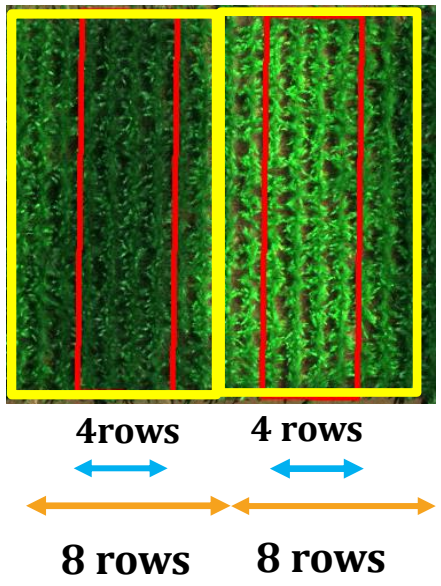


Image masking and NDVI & NDRE



To reduce boarder effect

Table

ZonalSt_NDRE_VG

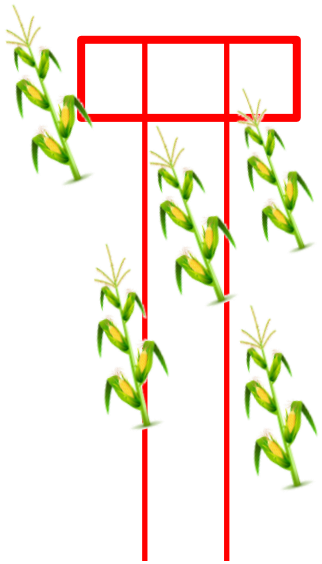
OBJECTID *	Id	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
1	1	33638	15.956804	0.270661	0.660765	0.390105	0.474835	0.068703	15972.493561
2	2	33065	15.684991	0.270019	0.631054	0.361035	0.445017	0.07793	14714.502263
3	3	32669	15.497141	0.270047	0.628772	0.358725	0.442522	0.074959	14456.736019
4	4	33077	15.690684	0.27002	0.63098	0.360961	0.436642	0.072073	14442.793723
5	5	33529	15.905098	0.270029	0.637089	0.367059	0.469639	0.075827	15746.516334
6	6	33435	15.860507	0.270032	0.604638	0.334606	0.429837	0.06929	14371.606126
7	7	19446	9.224568	0.270002	0.490798	0.220796	0.339382	0.044706	6599.620406
8	8	19427	9.215555	0.270022	0.477076	0.207054	0.332926	0.043672	6467.759449

VI extraction

NDVI: (NIR- Red) / (NIR + Red)
NDRE: (NIR – RedEdge) / (NIR + RedEdge)

Materials and Methods

Data collection : Leaf, Stem and Grain tissue for N analysis



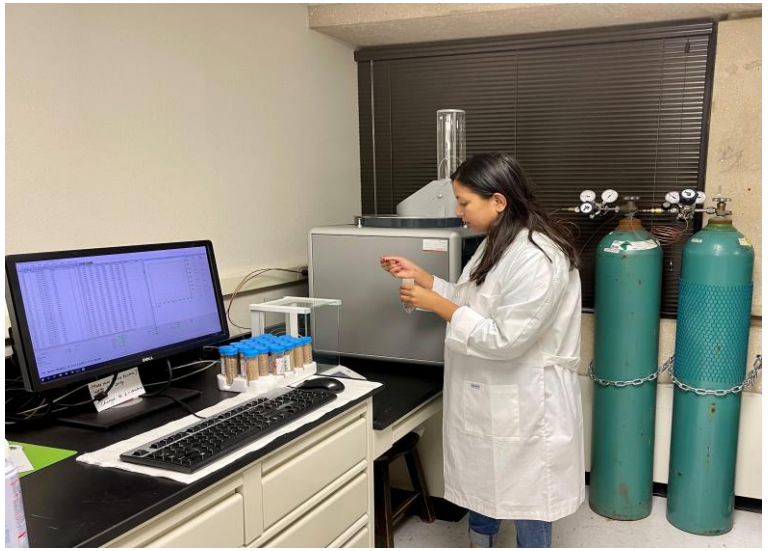
5 representative plants were cut and separated

Sample oven dried: 60° C

Ground sample for N analysis

250 mg of sample of N analysis

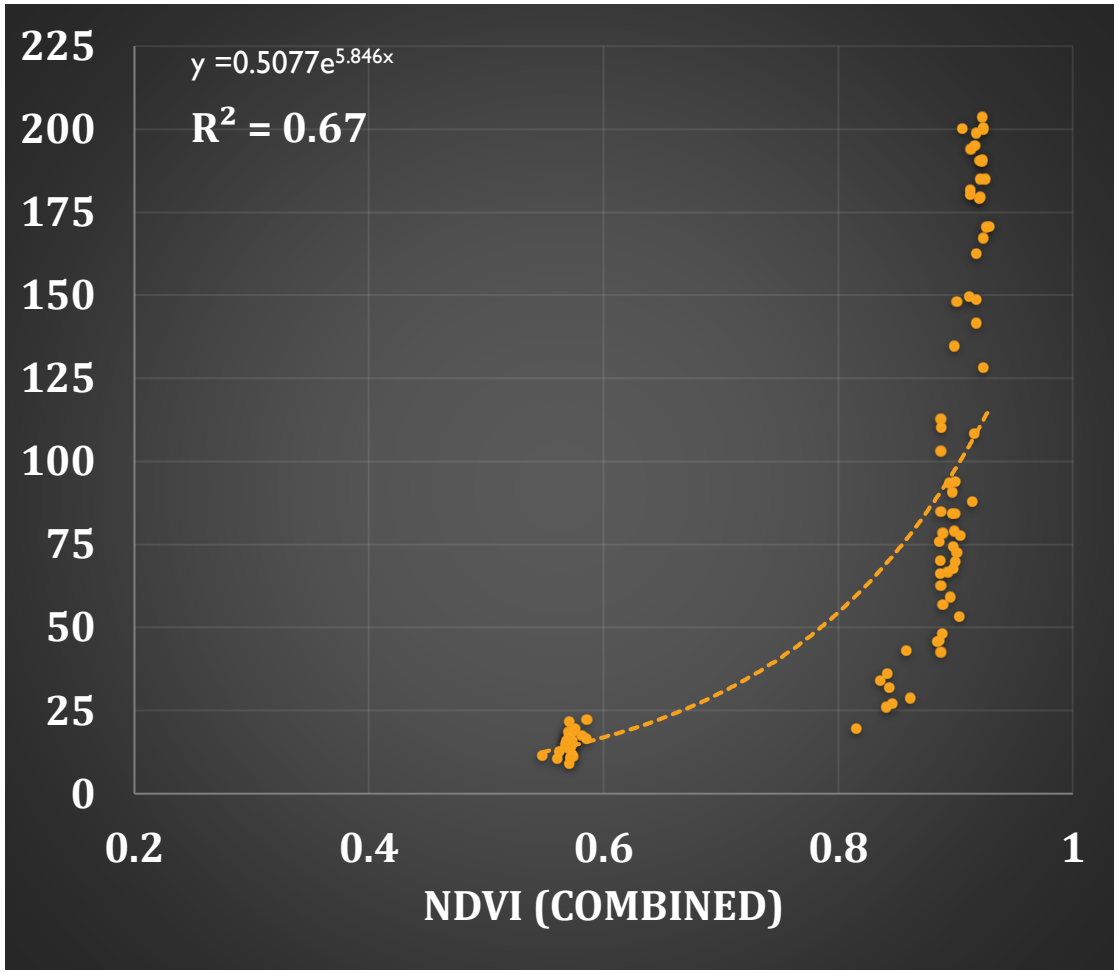
Total above-ground N uptake (kg per ha)



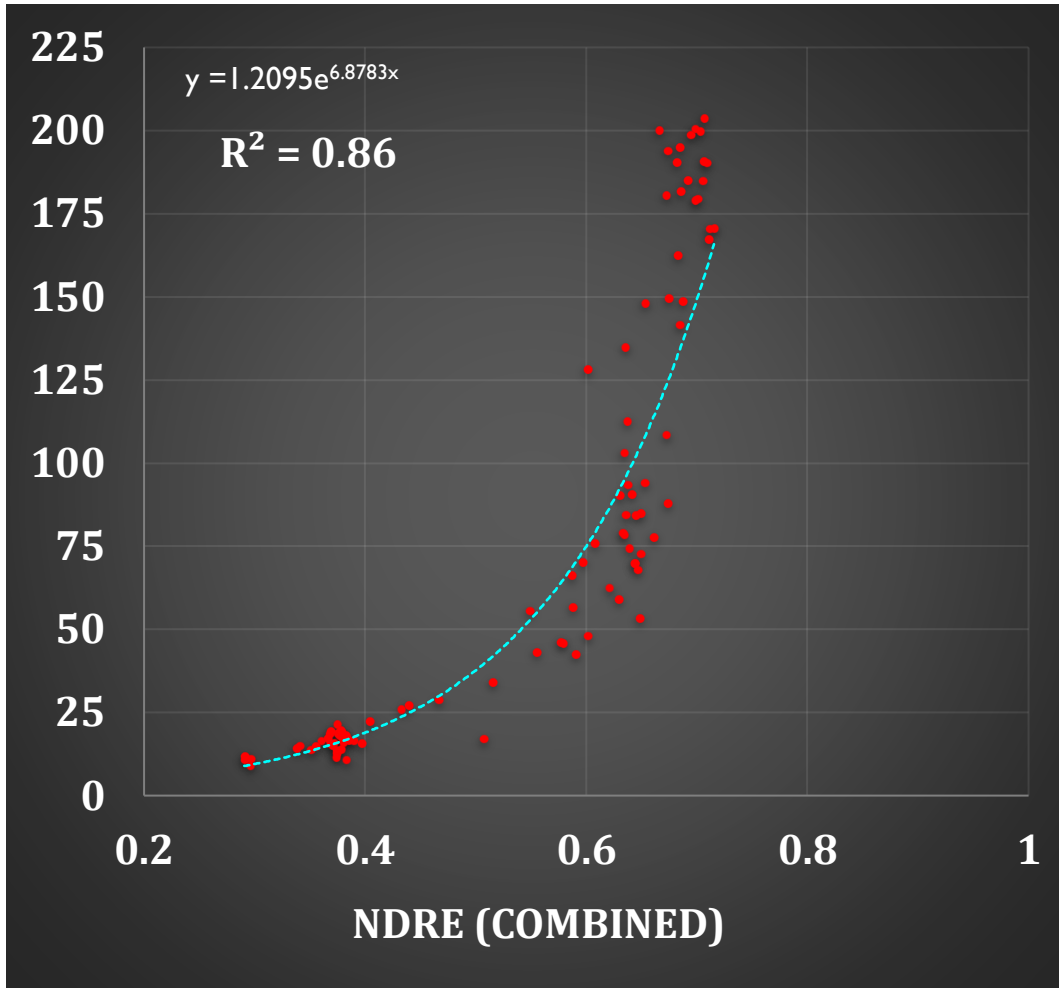
Nitrogen analysis - VARIO MAX CUBE ELEMENTAR

Result and Discussion

Regression Analysis – Plant N uptake & vegetation Indices -2021



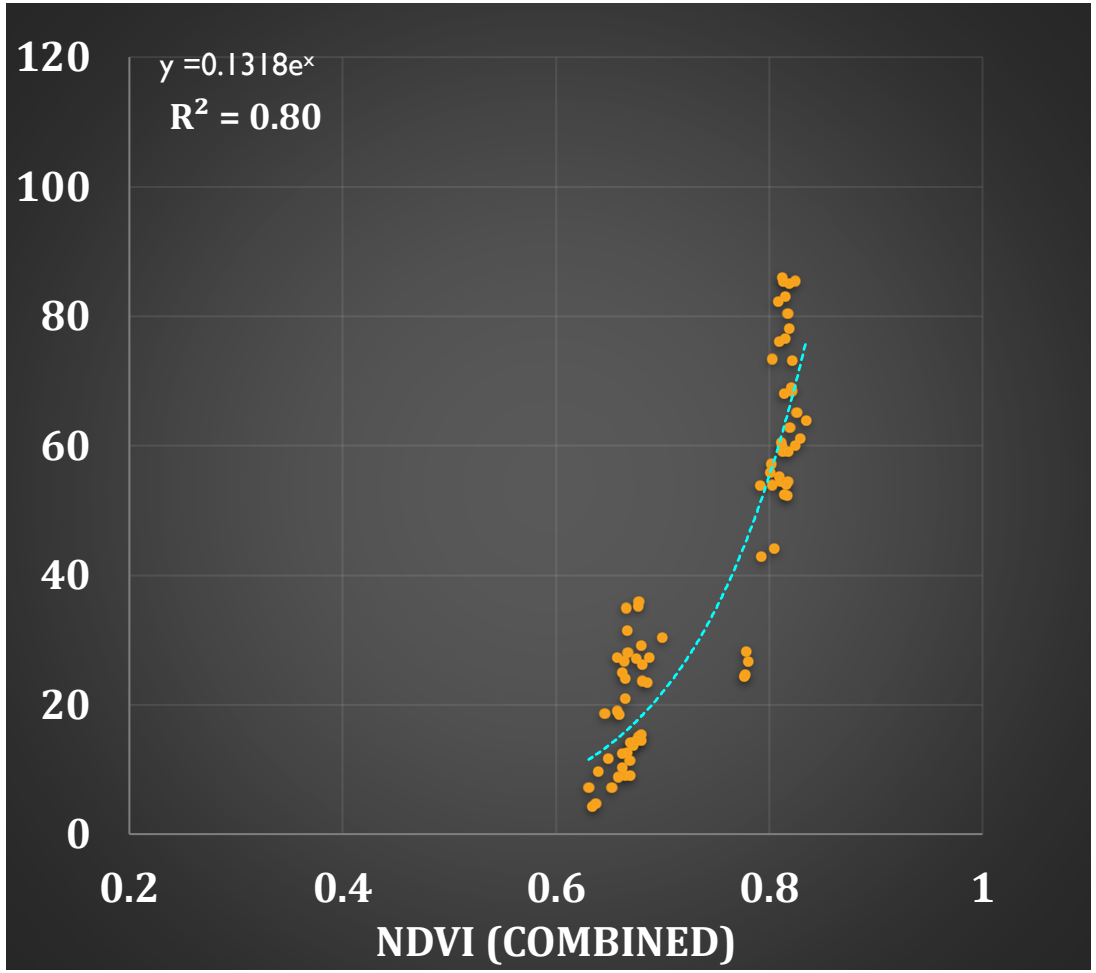
V6 + R2 +R5



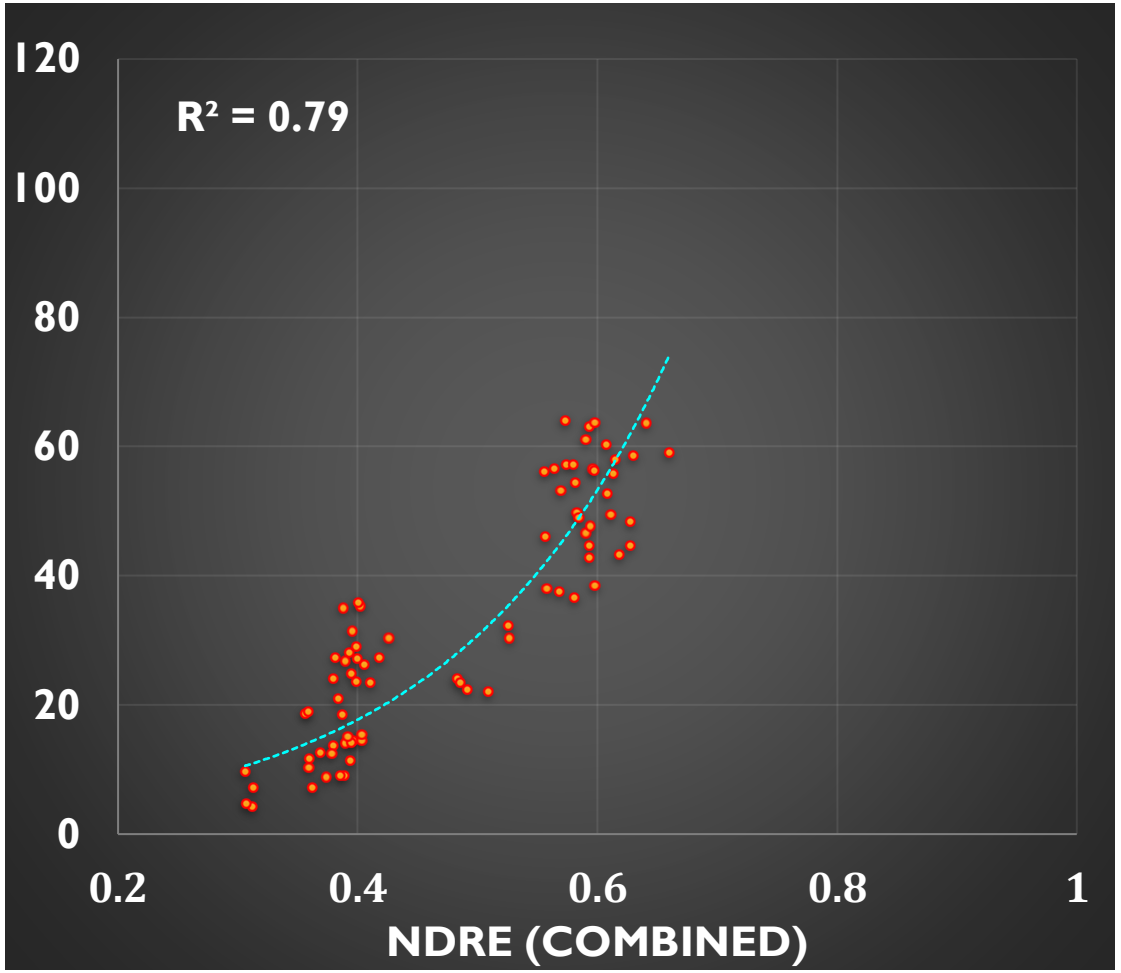
V6 + R2 +R5

Result and Discussion

Regression – Plant N uptake & vegetation Indices -2022

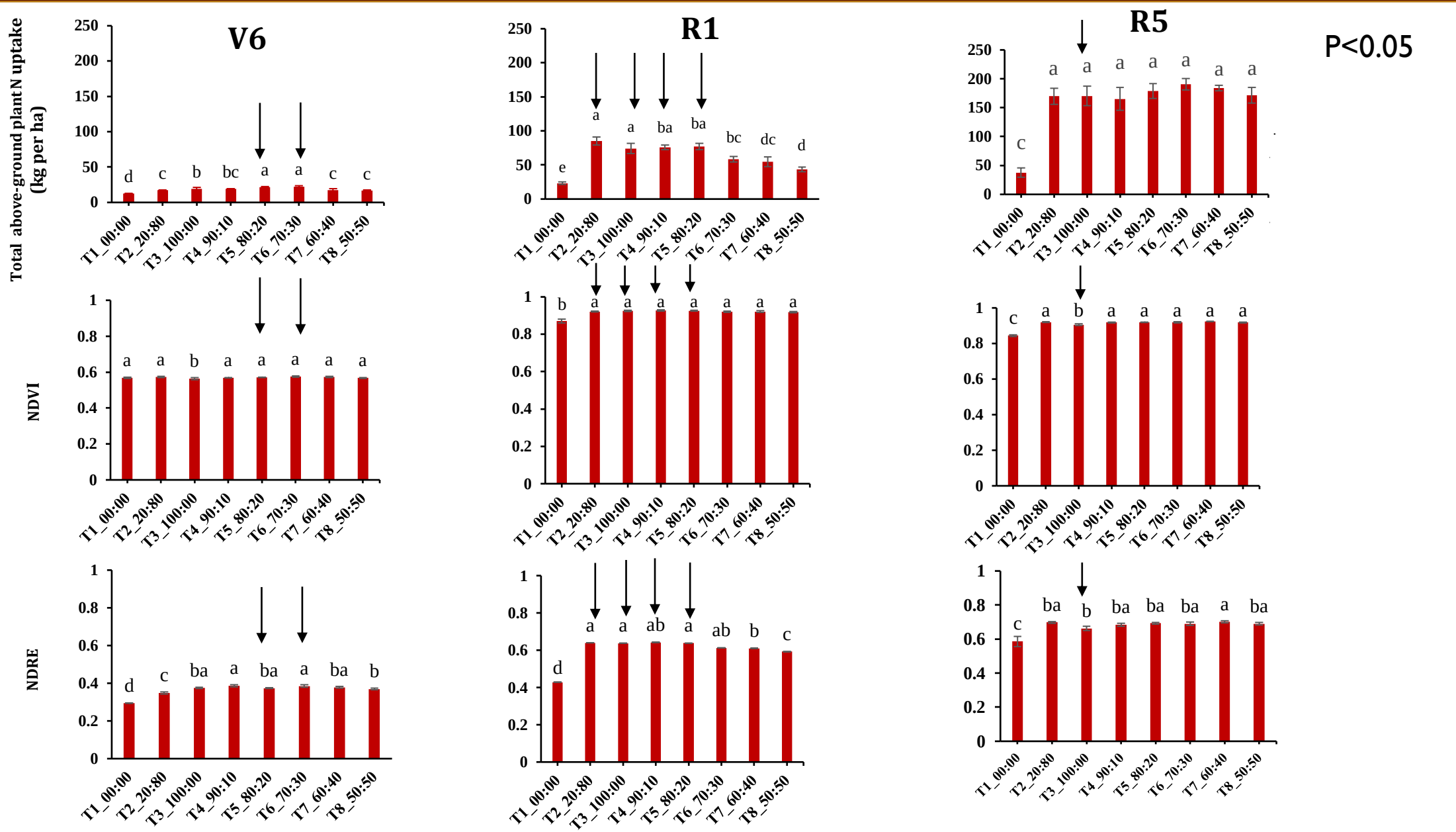


V6+V14

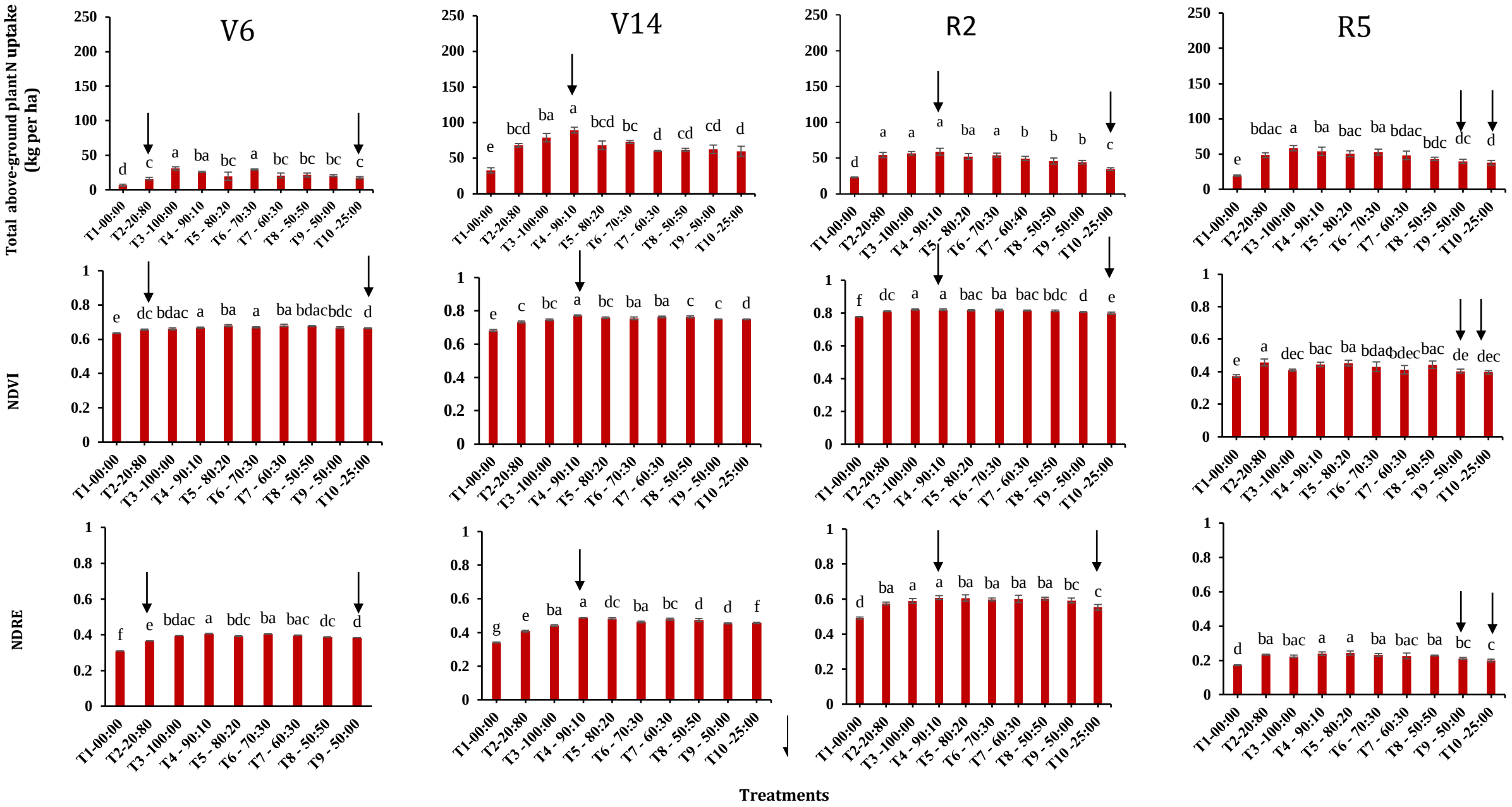


V6+V14

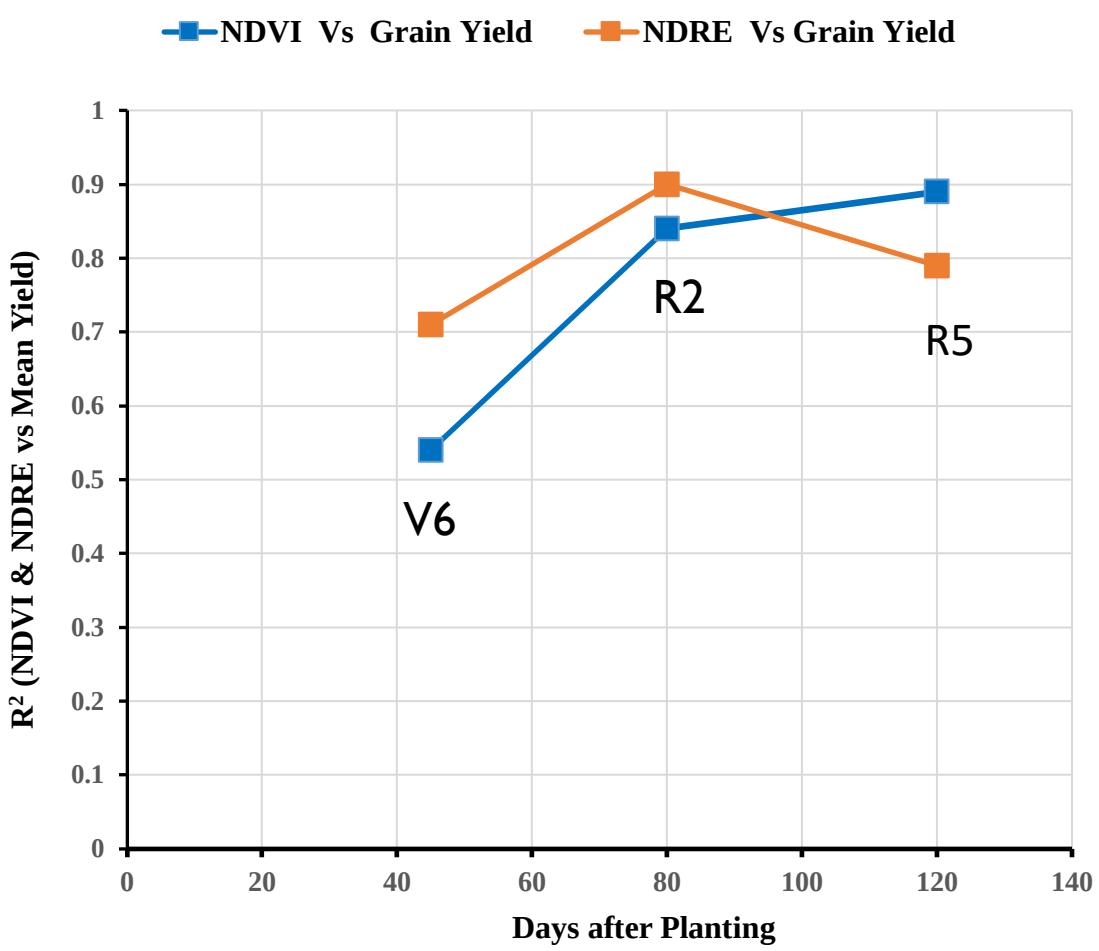
Vegetation Indices response to plant N uptake -2021



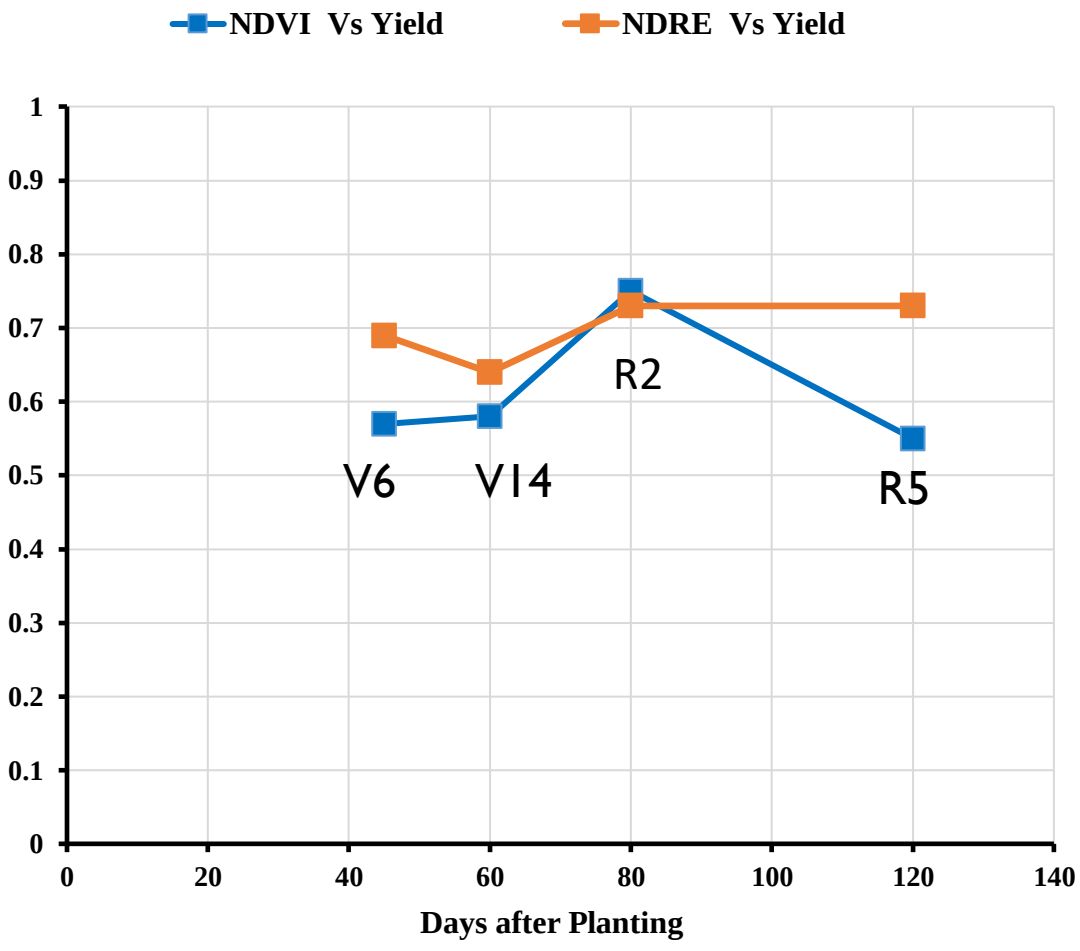
Vegetation Indices response to plant N uptake -2022



Result and Discussion



2021



2022

Conclusions

Non-drought

- **NDRE correlated better than NDVI to yield before 80 DAP**

Drought

- **NDVI correlated slightly better compared to NDRE**
- **NDRE correlated better than NDVI to yield before 80 DAP**

Main Takeaway:

- **UAV-based remote sensing can be an alternative means of Split N assessment, especially under non-drought conditions**

Future Direction

- **Validate the vegetation index – N uptake estimation model at the field level**
- **Multiple remote sensing variables can be used combinedly via Machine Learning Regression techniques for better N-uptake estimation**

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Thank you!!

Questions?