Optimizing Nitrogen Management in Dryland Cotton Using Precision Agriculture Technologies in the Southern High Plains

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Introduction

- The Southern High Plains (SHP) - major cotton production region
- Ogallala Aquifer depletion & limited precipitation – Dryland production
- N fertilizer response varies from year to year depending on weather conditions
- Current N recommendations - on irrigated conditions.
- Therefore, research needs to investigate N application strategies under dryland conditions.

Objectives

1. Determine NUE and optimize N management options at different landscape positions with soil properties in relation to weather patterns of different growing seasons
2. Evaluate application of Unmanned Aerial Vehicle images in estimating cotton nitrogen content
3. Develop a site-specific N management strategy for dryland cotton production in fields with significant variability.

Materials and Methods

- Location: Garza and Lynn
- Experimental design: RCBD
- Fertilizer: 32-0-0
- Cultivar: FM 2334GLT
- N rates: 0, 30, and 60 lb/ac

Fig 1. Nitrogen fertilizer treatments in two dryland cotton fields in Garza County (left), and Lynn County (right), Texas, in 2021.

Materials and Methods

- UAV Platform: DJI Matrice 600 Pro
- Sensor: MicaSense RedEdge

Table 1. Plant sampling and UAV imaging, Lynn County, Texas, 2021

Date	Plant sampling	UAV Sensor
7/29/2021	√	Multispectral
8/13/2021	√	Multispectral
9/10/2020	√	Multispectral

Materials and Methods

Leaf N: LECO combustion

Plant N uptake = N concentration * Biomass

Fig 2. Preparation for soil chemical analysis at Texas A&M AgriLife Research Lab in Lubbock, Texas, 2021.

Materials and Methods

Table 2. Twelve vegetation indices that have been reported to use for crop N status estimation are used in this study

S.N.	Index	Formula
1	Normalized difference Vegetation Index (NDVI)	(NIR-R)/(NIR+R)
2	Green normalized difference vegetation index (GNDVI)	(NIR-G)/(NIR+G)
3	Normalized difference red edge index (NDRE)	(NIR-RE)/(NIR+RE)
4	Red edge chlorophyll index(CIred edge)	NIR/RE −1
5	Green chlorophyll index (CIgreen)	NIR/G-1
6	Ratio vegetation index (RVI)	NIR/R
7	MERIS terrestrial chlorophyll index (MTCI)	(NIR − RE) / (RE − R)
8	Canopy chlorophyll concentration index(CCCI)	$(NDRE - NDRE_{MIN}) / (NDRE_{MAX} - NDRE_{MIN})$
9	Transformed chlorophyll absorption in reflectance index/Optimized soil-adjusted vegetation index (TCARI/OSAVI	3*[(RE − R) − 0.2*(RE − G) (RE/R)] / [(1 + 0.16) (NIR − R) / (NIR + R + 0.16)
10	Modified chlorophyll absorption in reflectance index/Optimized soil-adjusted vegetation index (MCARI/OSAV)	{[(RE − R) − 0.2*(RE − G)] (RE/R)} / [(1 + 0.16) (NIR − R) / (NIR + R + 0.16)]
11	Red edge-based transformed chlorophyll absorption in reflectance index/Optimized soil-adjusted vegetation index (TCARI/OSAVI RE)	3*[(NIR − RE) − 0.2*(NIR − G) (NIR/RE)] / [(1 + 0.16) (NIR − RE) / (NIR + RE + 0.16)]
12	Red edge-based modified chlorophyll absorption in reflectance index/Optimized soil-adjusted vegetation index (MCARI/OSAVI RE)	{[(NIR − RE) − 0.2*(NIR − G)] (NIR/RE)} / [(1 + 0.16) (NIR − RE)/(NIR + RE + 0.16)]

Results

- **Garza County**
  - ✓ Elevation : 910.6 m-915.6 m.
  - ✓ Slope: 0 to 13.4 %

- **Lynn County**
  - ✓ Elevation : 906.2 m-913.1m.
  - ✓ Slope: 0 to 16.2 %

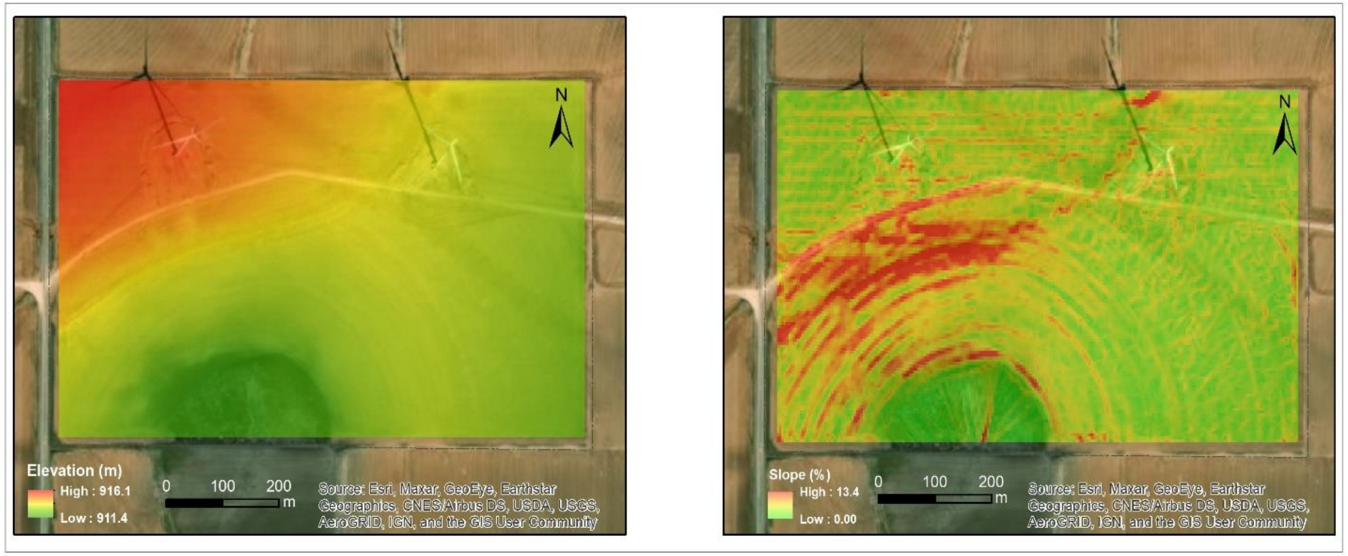

Fig 3. Elevation and Slope in a dryland field in Garza County, Texas

Results

- Cotton lint yield had substantial variability in both fields
- Cotton yield is negatively related to slope and elevation

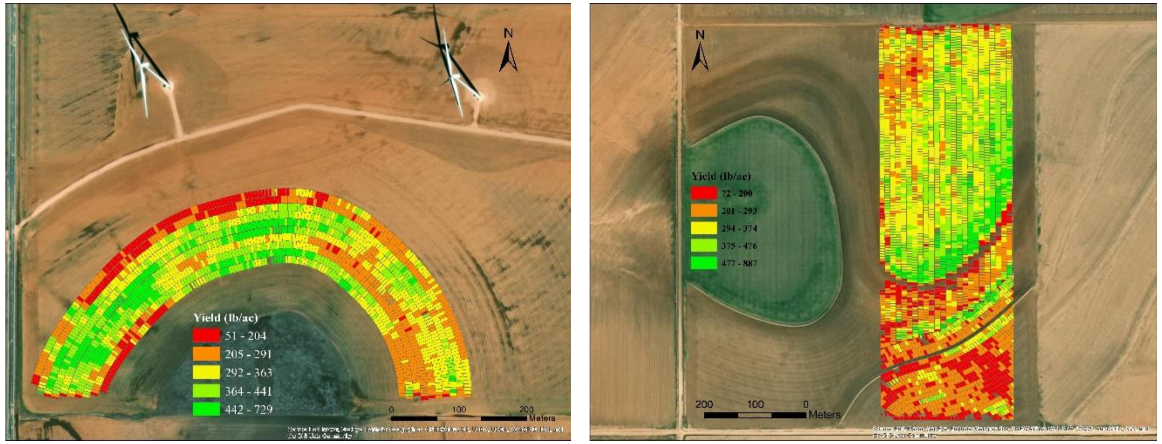

Fig 4. Cotton yield variation in two dryland fields in Garza County (left) and Lynn County (right), Texas in 2021.

Results

Table 3. Mixed model regression analysis of cotton lint yield response to N treatments, soil physical properties, and topography in a field in Garza County, TX in 2021

Variable	Coefficient	Standard error	T value	P> |t|
N Treatment	2.177	0.63	3.481	0.003
Elevation	-9.963	26.00	-0.383	0.706
Slope	-3.262	12.97	-0.252	0.804
Sand	428.564	407.93	1.051	0.307
Clay	109.057	284.27	0.384	0.706

Results

Table 4. Mixed model regression analysis of cotton lint yield response to N treatments, soil physical properties, and topography in a field in Lynn County, TX in 2021

variables	Coefficients	Standard error	T value	P> |t|
N Treatment	-0.22	0.433	-0.516	0.609
Elevation	48.60	28.941	1.679	0.101
Slope	-44.08	15.966	-2.761	0.009
Sand	0.14	9.273	0.016	0.988
Clay	7.01	12.33	0.569	0.573

Results

Table 5. Best fitting models between VIs derived from UAV images and leaf N concentration and plant N uptake at three growth stages

VI at different stages	Leaf N concentration (%)		Plant N uptake (Kg ha^{-1})	
	Model	r^2	Model	r^2
48 DAP				
CIrededge	Polynomial	0.30	Linear	0.36
RVI	Power	0.41	Polynomial	0.20
MTCI	Polynomial	0.45	Polynomial	0.23
CCCI	Polynomial	0.54	Polynomial	0.31
TCARI/OSAVI_RE	Polynomial	0.20	Polynomial	0.28
MCARI/OSAVI_RE	Polynomial	0.22	Polynomial	0.30
62 DAP				
NDVI	Polynomial	0.30	Polynomial	0.42
NDRE	Linear	0.47	Linear	0.17
CIred edge	Polynomial	0.32	Polynomial	0.59
MTCI	Polynomial	0.32	Polynomial	0.27
CCCI	Power	0.57	Polynomial	0.69
TCARI/OSAVI_RE	Polynomial	0.28	Polynomial	0.31
90 DAP				
NDRE	Polynomial	0.37	Power	0.18
CIred edge	Polynomial	0.47	Power	0.20
RVI	Linear	0.42	Power	0.49
MTCI	Polynomial	0.49	Power	0.66
CCCI	Polynomial	0.65	Polynomial	0.47
MCARI/OSAVI_RE	Polynomial	0.45	Polynomial	0.42

Results: CCCI

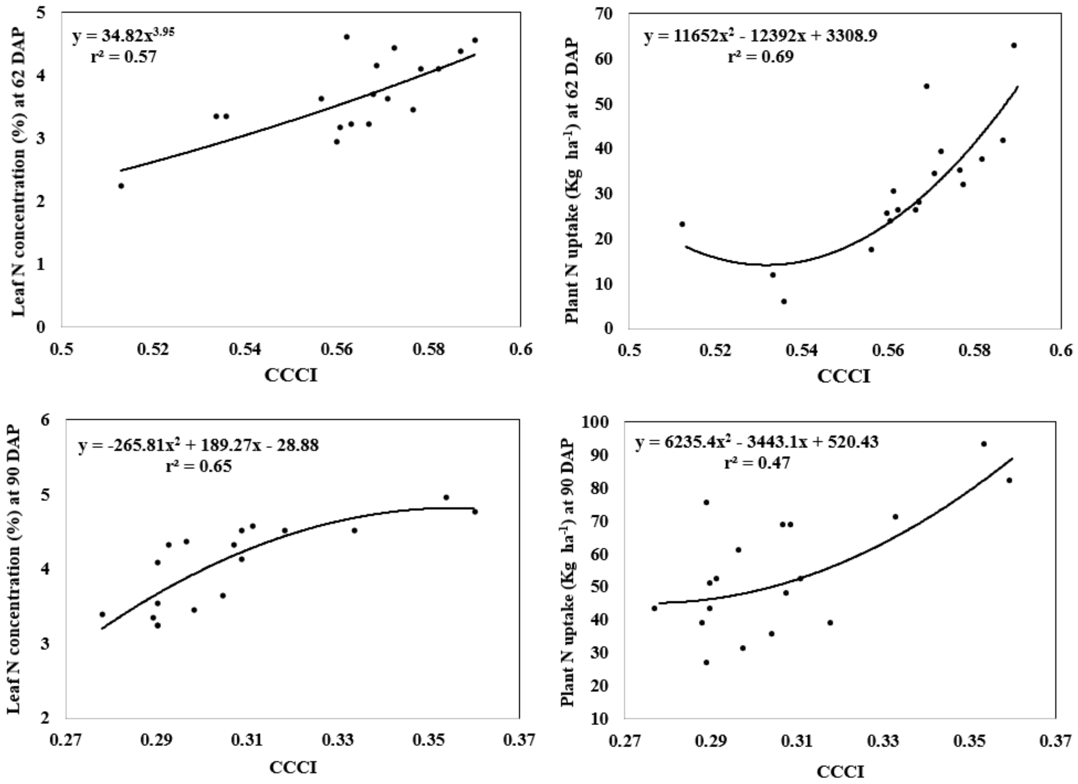

Fig 5. Relationship between CCCI and leaf N concentration, and plant N uptake at two growth stages in 2021

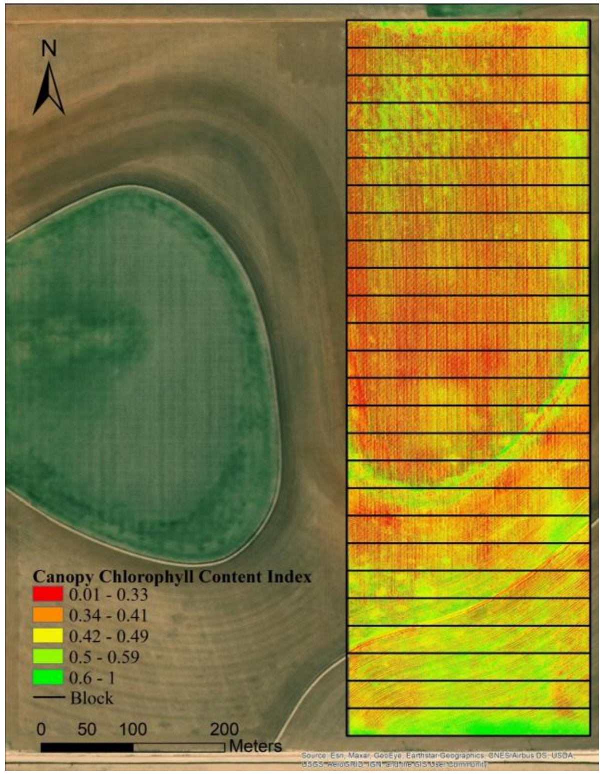

Fig 6. CCCI at 62 DAP

Conclusion

- N fertilizer response varied with different landscape positions and weather patterns which indicates that there is the potential to perform site-specific nitrogen management based on landscape positions.
- Preliminary results show that UAV images have a great potential in monitoring crop N status, with CCCI performing consistently better at three growth stages.

Next steps

- ✓ Determining NUE at different landscape positions with soil and weather patterns of different growing seasons
- ✓ Develop a site-specific N management strategy for dryland cotton production in fields with significant variability.

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Thank you

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