Can Unmanned Aerial System Passive Sensors Be Used To Recommend Sidedress Nitrogen For Corn? A Comparison Between Active And Passive Sensors

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Introduction

Corn alone received **46% of all nitrogen (N) fertilizer** applied in the U.S. in 2010. N use efficiency (NUE) by plants is usually low, estimated at **33% worldwide**. Low observed NUE can be attributed to asynchrony between N supply and crop N demand and spatial variability of N demand. Crop canopy sensors can be used to assess and correct in-season crop N deficiency by applying a major portion of the N fertilizer at a time crop demand is high. Many studies have compared the performance of active sensors to manage N in corn, but few have evaluated passive sensor's performance. With the rapidly-growing UAS market, there will be an increasing demand for passive sensor data to be used quantitatively in crop-related issues, including N management.

Hypothesis

Active and passive sensors perform similarly in assessing crop N status and recommending sidedress N in corn.

Objectives

(i) Assess the correlation between active and passive crop canopy sensors' vegetation indices at different corn growth stages.
(ii) Assess sidedress VR N recommendation accuracy of active and passive sensors compared to the agronomic optimum N rate (AONR).
(iii) Assess sidedress VR N rate recommendation correlation between active and passive sensors.

Material and Methods

Site Description

Site: Sandy Loam (85% sand)
OM: 1%, , pH 7.2, CEC: 7 me 100-g[-1]
Year: 2015
Passive sensor: Tetracam

Site: Silt Loam (60% silt)
OM: 3%, , pH 7, CEC: 22 me 100-g[-1]
Year: 2016
Passive sensor: RedEdge

Design

- Experimental: randomized complete-block with **4 blocks.**
- Treatment: one-way with control plus four N rates on each site, varying **from 65 to 215 kg N ha^{-1}**.

Data Acquisition

- Sensors: **RapidScan CS-45** (active, handheld), **Tetracam MCA6 Mini,** (passive, UAS-mounted) **MicaSense RedEdge** (passive, UAS-mounted).

	Blue	Green	Red	Red Edge	NIR
	---- Wavelength Center (nm) ----				
RapidScan			670	730	780
Tetracam		530	670	760	800
RedEdge	475	560	668	717	840

- Sensing time: V12-13, VT and R4.
- Vegetation Indices: **NDVI** and **NDRE.**
- Recommendation algorithm: Holland and Schepers (2010).
- Sufficiency Index: reference as highest N rate in a given site-year.

Image Analysis

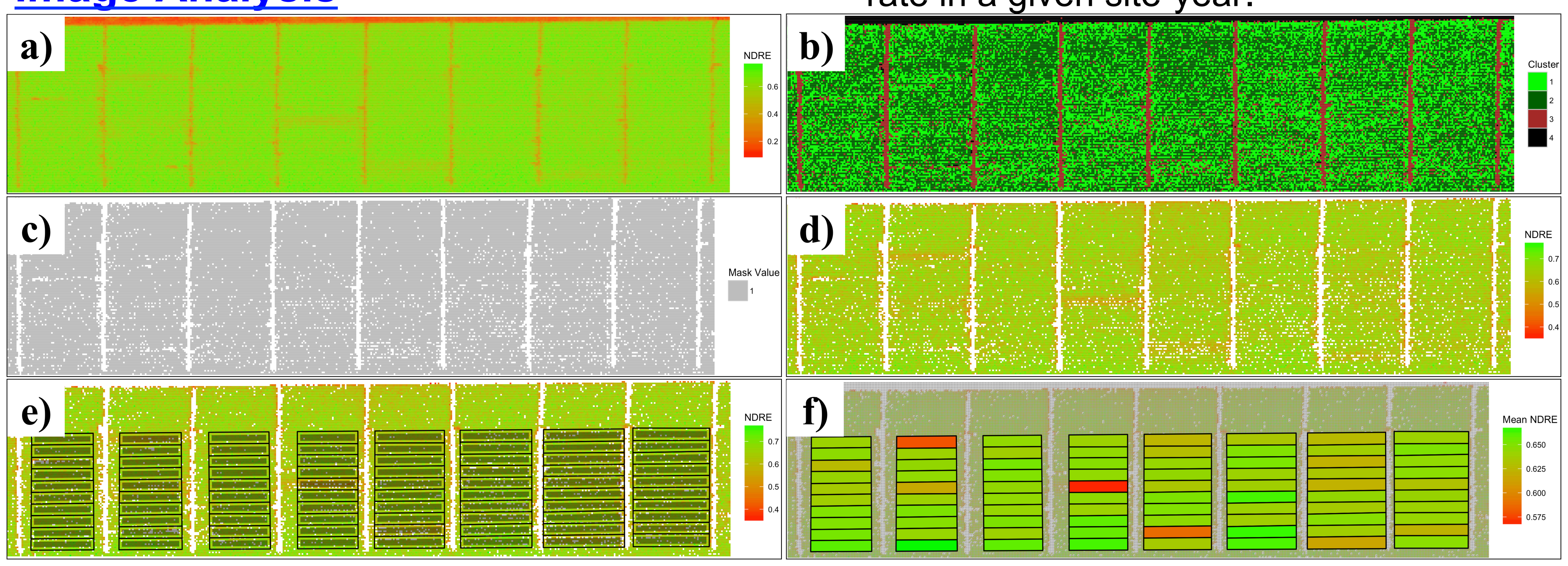

Fig. 1. Image processing analysis with a) vegetation index (VI) calculation, b) unsupervised classification (k-means) to separate plant from non-plant pixels, c) mask creation, d) VI file with non-plant pixels masked out, e) plot boundaries and buffered area and f) zonal statistics to obtain plot buffered area mean VI.

Results

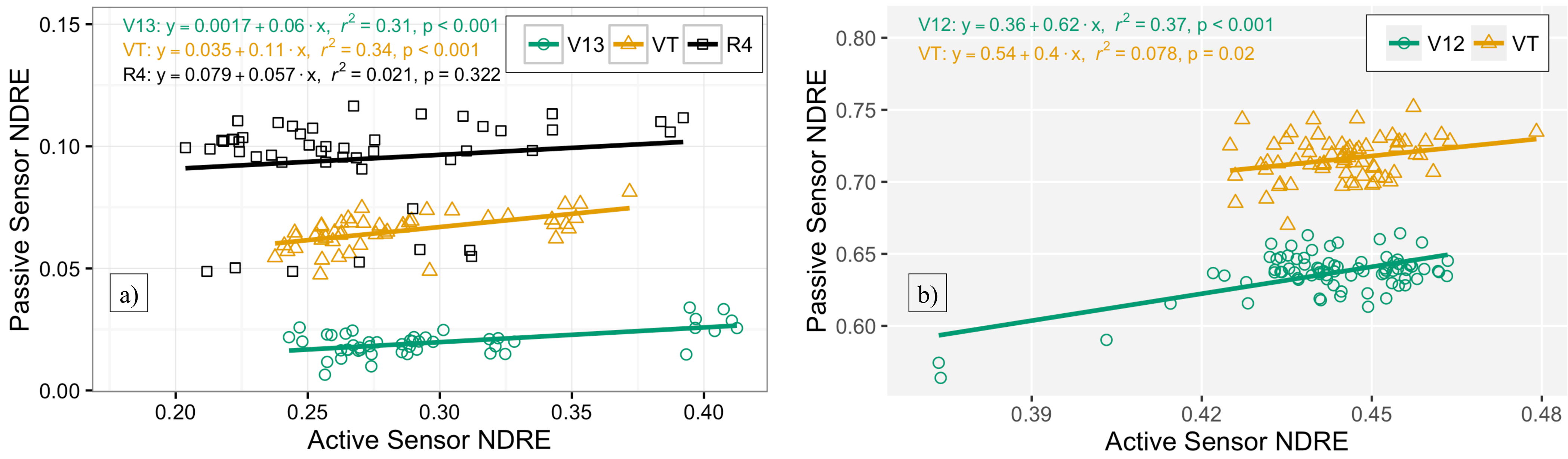

Fig 2. Passive and active sensor NDRE correlation at different growth stages for a) Sandy Loam and b) Silt Loam.

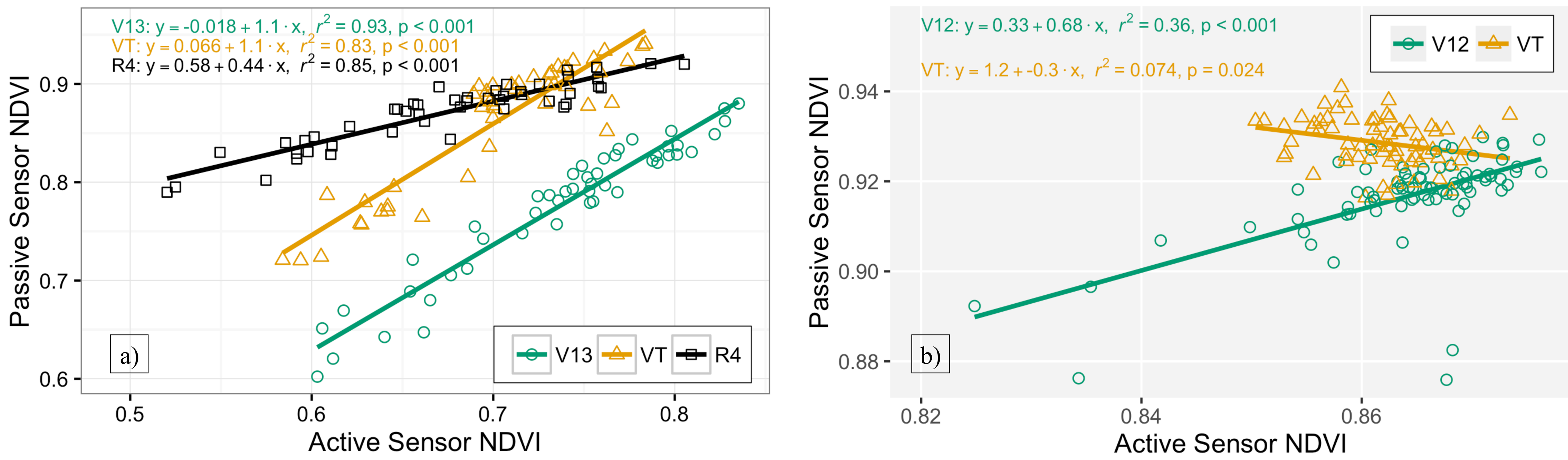

Fig 3. Passive and active sensor NDVI correlation at different growth stages for a) Sandy Loam and b) Silt Loam.

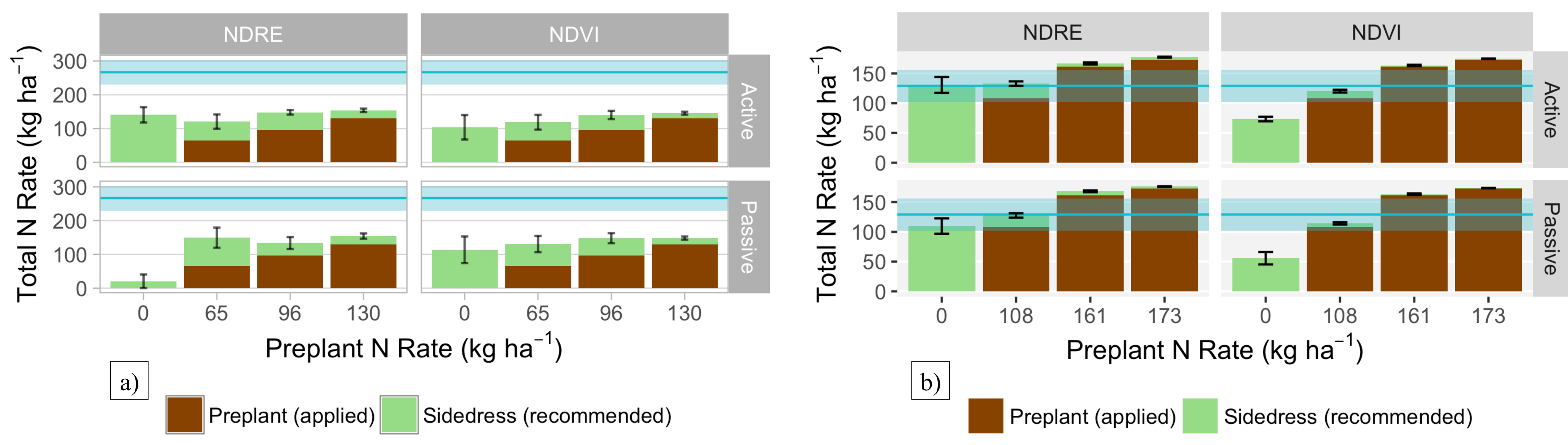

Fig 4. Sidedress variable N rate recommendation calculated using NDRE or NDVI derived from active or passive crop canopy sensor at V12-13 growth stage for a) Sandy Loam and b) Silt Loam using the Holland and Schepers (2010) algorithm. Black bars represent standard error of the mean of the sidedress variable rate. Light blue horizontal line represents AONR for Sandy Loam (267 kg N ha^{-1}, 238 lbs N ac^{-1}) and Silt Loam (129 kg N ha^{-1}, 115 lbs N ac^{-1}), with shaded light blue band representing AONR standard error.

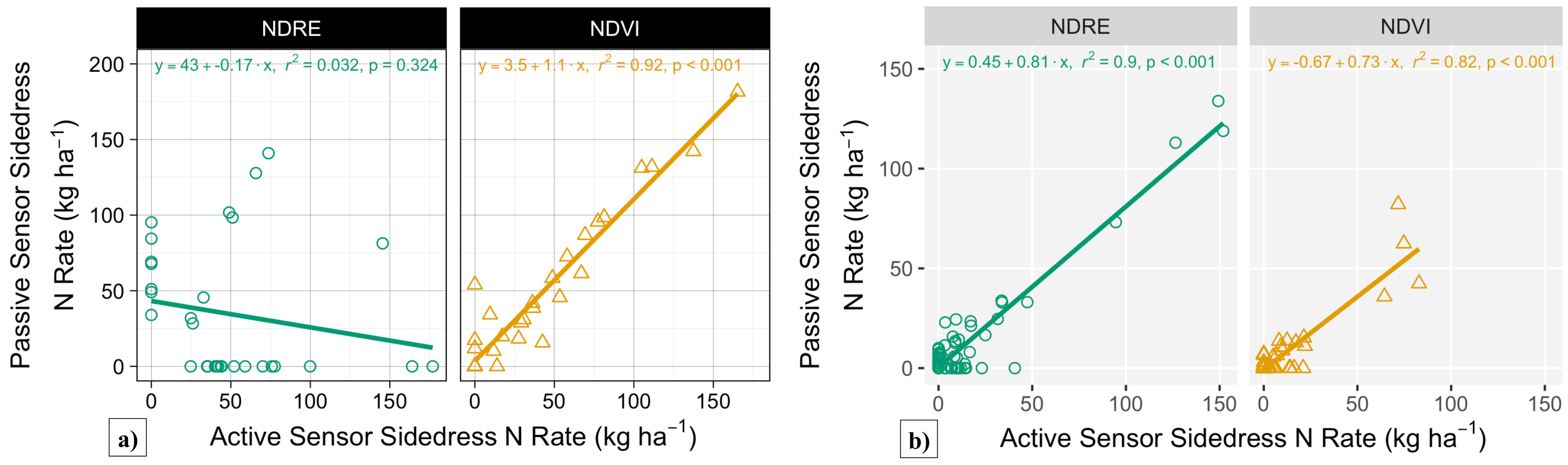

Fig 5. Correlation between active and passive sensors recommended sidedress N rate using NDRE and NDVI at V13 growth stage on a) Sandy Loam and b) Silt Loam.

Conclusions

- **NDRE** values from passive and active sensors were weakly correlated at different crop stages regardless of passive sensor type. In the case of Tetracam, this was due to RE center being too close to NIR.
- **NDVI** values from passive and active sensors were strongly correlated at crop stages V9 and V13 when Tetracam was the passive sensor used, but poorly correlated when MicasSense RedEdge was the passive sensor.
- Using **different VIs from either sensor** did not produce a sidedress N rate that accurately approached AONR at any crop stage for the Sandy Loam study. This was due to high nitrate leaching loss, causing N-stressed reference.
- **Sidedress N rate recommendation** derived from both sensors were correlated when NDVI was used at V13 for the Sandy Loam study and both NDRE- and NDVI-based sidedress N rate recommendation were correlated at V12 for the Silt Loam study.

Acknowledgements

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