Phenotyping agriculture management effects on remote sensing assessments of maize hybrids performance

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2nd International Electronic Conference on Remote Sensing

22 March–5 April 2018

Overview

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Introduction
- **Context**
- **Conservation Agriculture**
- **Remote Sensing and Phenotyping**

Materials and Methods
- **Proximal (ground) data collection**
- **Aerial data collection**

Results and Discussion
- **Implications of growing conditions on yield**
- **Comparative performance of the vegetation indexes at determining differences in grain yield**

Conclusions

Introduction - Context

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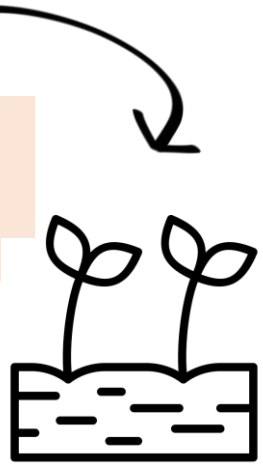
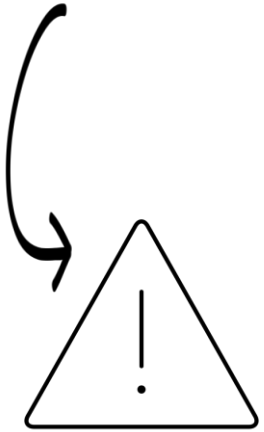
Soil tillage for land preparation



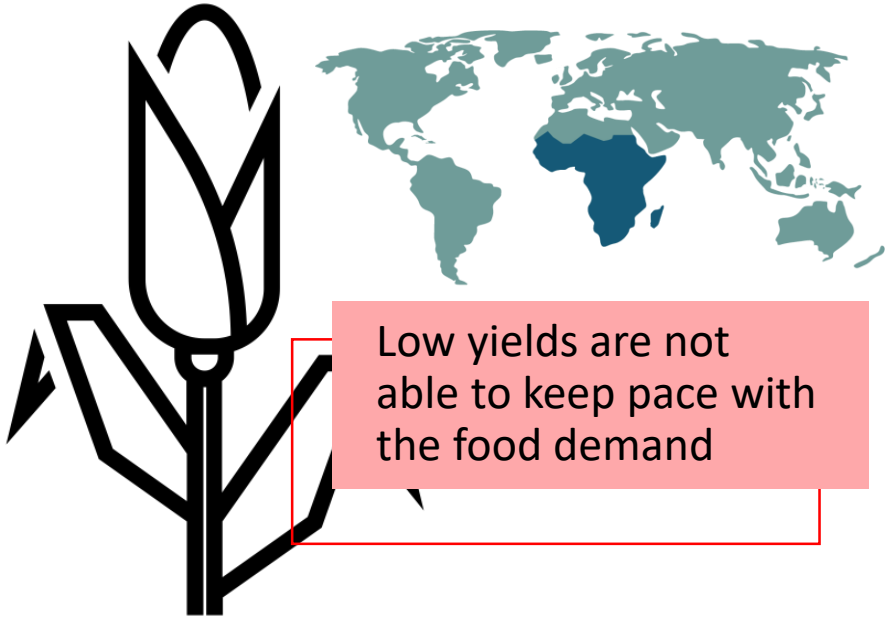
Soften the seedbed, ensure uniform germination, remove weed plants, release soil nutrients



Decline in organic matter, increase of the loss of water by runoff, soil erosion

+

Climate Change



Low yields are not able to keep pace with the food demand

Introduction – Conservation Agriculture

alternative solution…

Conservation Agriculture (CA)

Increase of yields while reducing negative effects of conventional farming practicies

Introduction – Phenotyping and Remote Sensing

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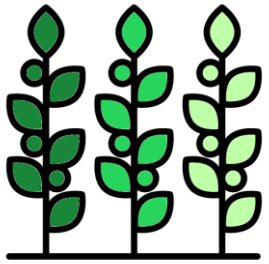
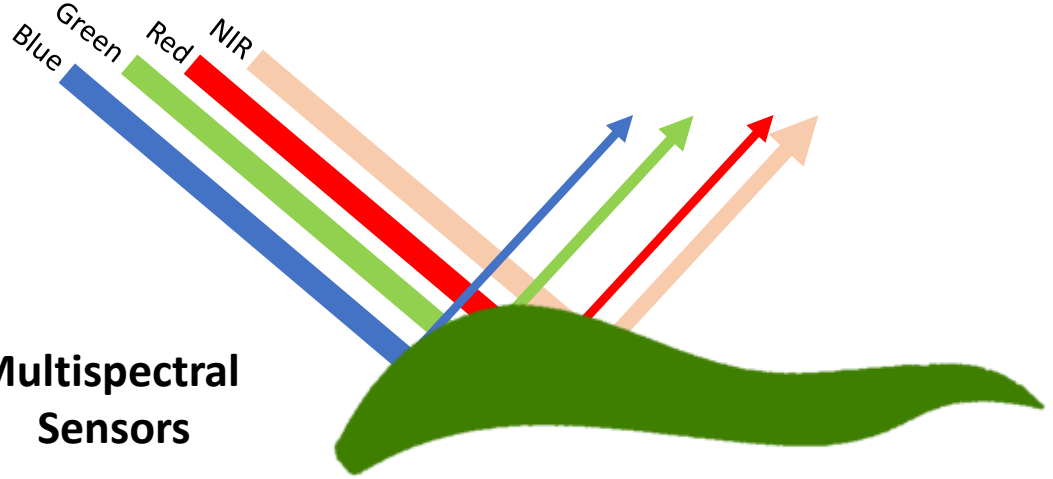
Most new cultivars have been developed under full tillage conditions



Field Phenotyping

Genotype selection for a better performance under CA



Multispectral Sensors

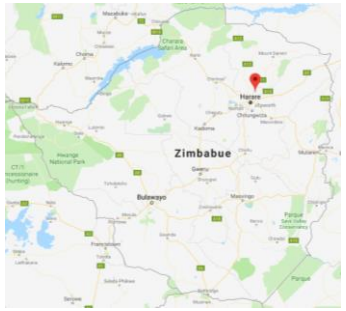
Conventional Digital Cameras

Introduction – Study case

The aim of the present study was to:

- Evaluate the efficiency of a set of remote sensing indexes in assessing the yield differences of different maize hybrids at early growth stages under conventionally ploughed (CP) and zero-tillage (CA) conditions.

Materials and Methods

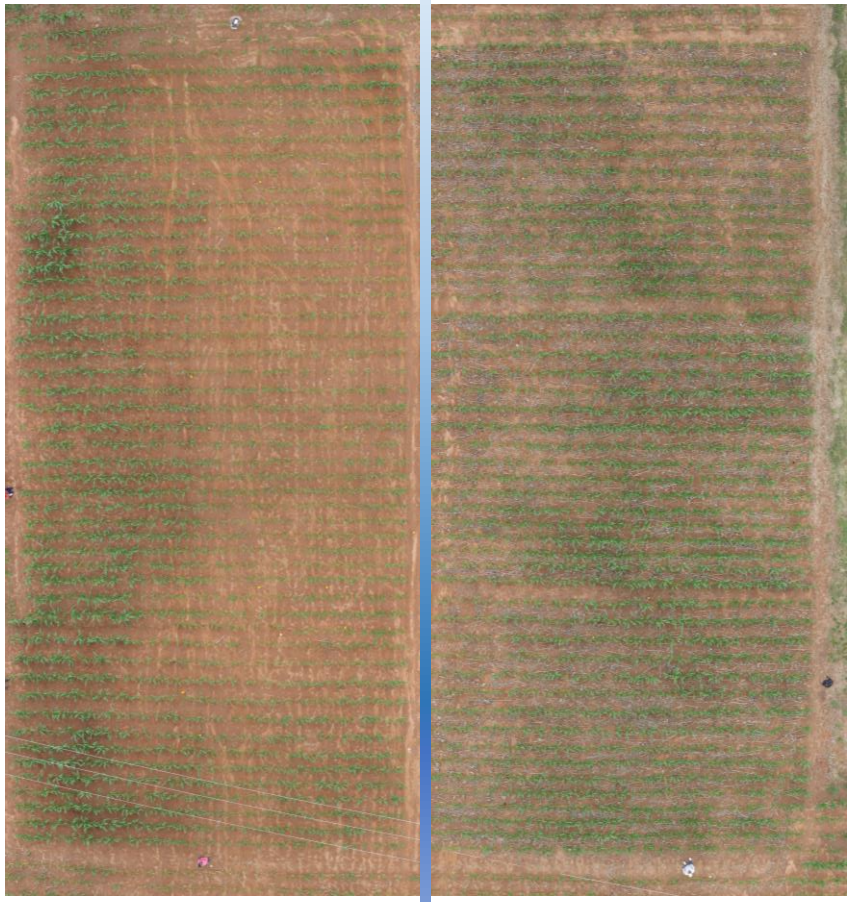


Domboshawa Training Centre (17º37'S, 31º10'E and 1560 m.a.s.l.), situated at the north-east of Harare (Zimbabwe)
2015/2016 crop season

Seven maize drought tolerant commercial hybrids (**SC621**, **Pan53**, **30G19**, **Zap55**, **Pristine601**, **PGS61** and **Zap61**) and one drought-sensitive commercial control variety (**SC513**)

Conventionally Ploughed (**CP**)

Conservation Agriculture (**CA**): No-tillage and the application of 2.5-3.0 Mg ha^{-1} of maize stover to all the plots



CP CA

Materials and Methods – Data collection

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Proximal (ground)

Aerial

Mikrokopter OktoXL 6S12

Altitude: 30 m

Materials and Methods – Data collection

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Proximal (ground)

Aerial

RGB images

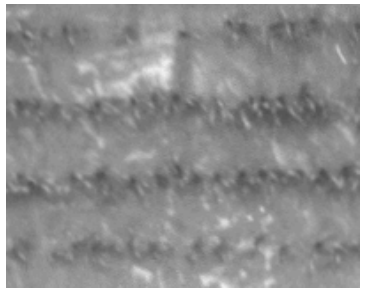
Olympus OM-D

Lumix GX7

Multispectral

GreenSeeker

micro-MCA12
Tetracam



Materials and Methods – RGB indexes

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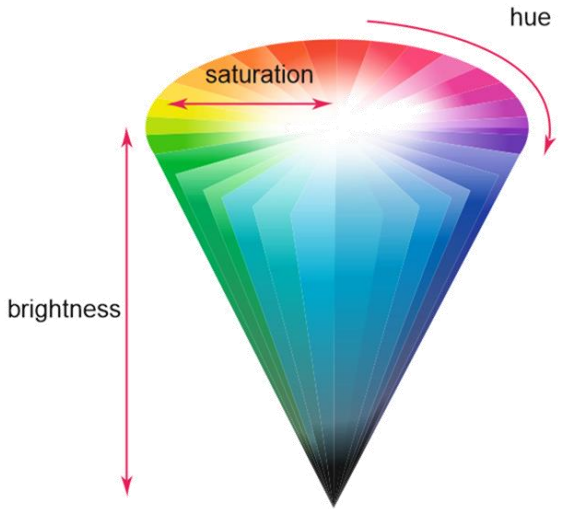
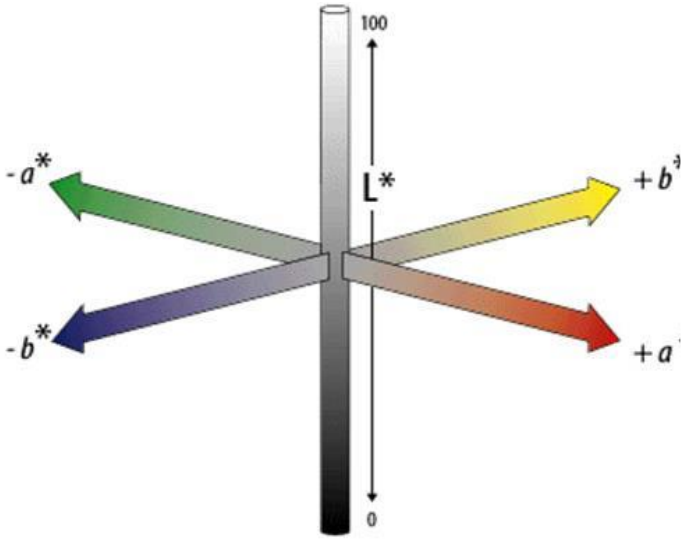
HIS color model



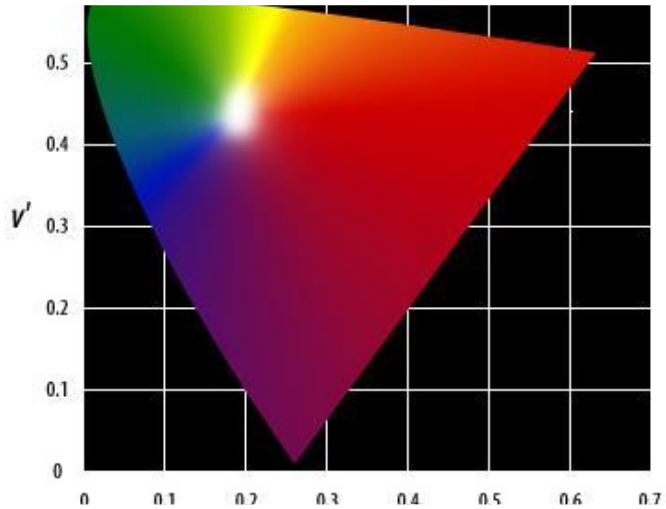
Green Area (**GA**)
(% pixels con 60º < Hue < 120º)
Greener Area (**GGA**)
(% pixels con 80º < Hue < 120º)

CIElab color model



a* and **u***
The more negative,
the more greenness.

CIEluv color model



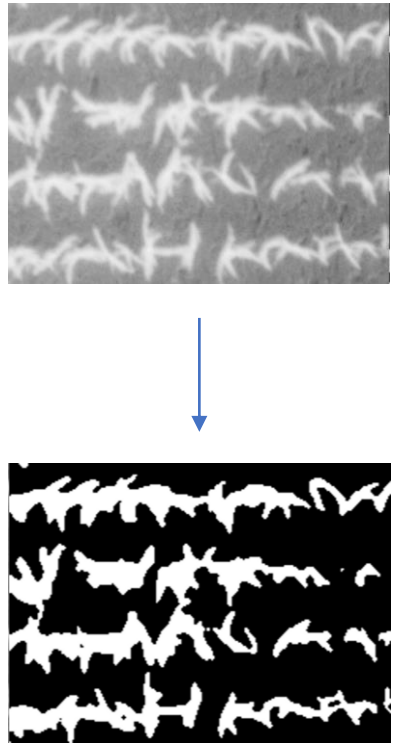
CIMMYT Maize Scanner
(FIJI Research Plugin)

https://github.com/george-haddad/CIMMYT

Materials and Methods – Multispectral indexes

Table 1. Indexes derived from the multispectral visible and near infrared bands.

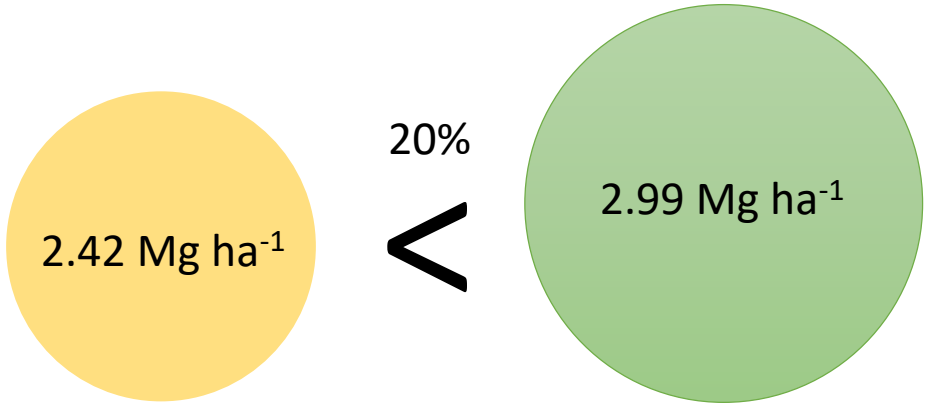
Group	Index	Equation	Wavelengths	References
Broadband Greenness	Normalized Difference Vegetation Index (NDVI)	$\frac{(B840 - B670)}{(B840 + B670)}$	Red, NIR	(Rouse et al., 1973)
	Soil Adjusted Vegetation Index (SAVI)	$\frac{(B840 - B670)}{(B840 + B670 + L)}$ Low vegetation, L=1, intermediate, 0.5, and high 0.25	Red, NIR	(Huete, 1988)
	Optimized soil-adjusted vegetation index (OSAVI)	$\frac{(1 + 0.16) \cdot (B780 - B670)}{(B780 + B670 + 0.16)}$	Red, NIR	(Rondeaux et al., 1996)
	Renormalized Difference Vegetation Index (RDVI)	$\frac{(B840 - B670)}{\sqrt{(B840 + B670)}}$	Red, NIR	(Roujean and Breon, 1995)
	Enhanced Vegetation Index (EVI)	$\frac{2.5 \cdot (B840 - B670)}{(B840 + (6 \cdot B670) - (7.5 \cdot R450) + 1)}$	Blue, Red, NIR	(Huete et al., 2002)
Light Use Efficiency	Photochemical Reflectance Index (PRI)	$\frac{(B550 - B570)}{(B550 + B570)}$	Green	(Gamon et al., 1997)
Leaf Pigments	Modified Chlorophyll Absorption Ratio Index (MCARI)	$(R700 - R670) - 0.2 \cdot (R700 - R550) \cdot \left(\frac{R700}{R670}\right)$	Green, Red, NIR	(Daughtry, 2000)
	Chlorophyll Content Index (CCI)	$\frac{(B550 - B670)}{(550 + B670)}$	Green, NIR	(Gamon et al., 2016)



Soil mask

Pixels NDVI <0.4-1

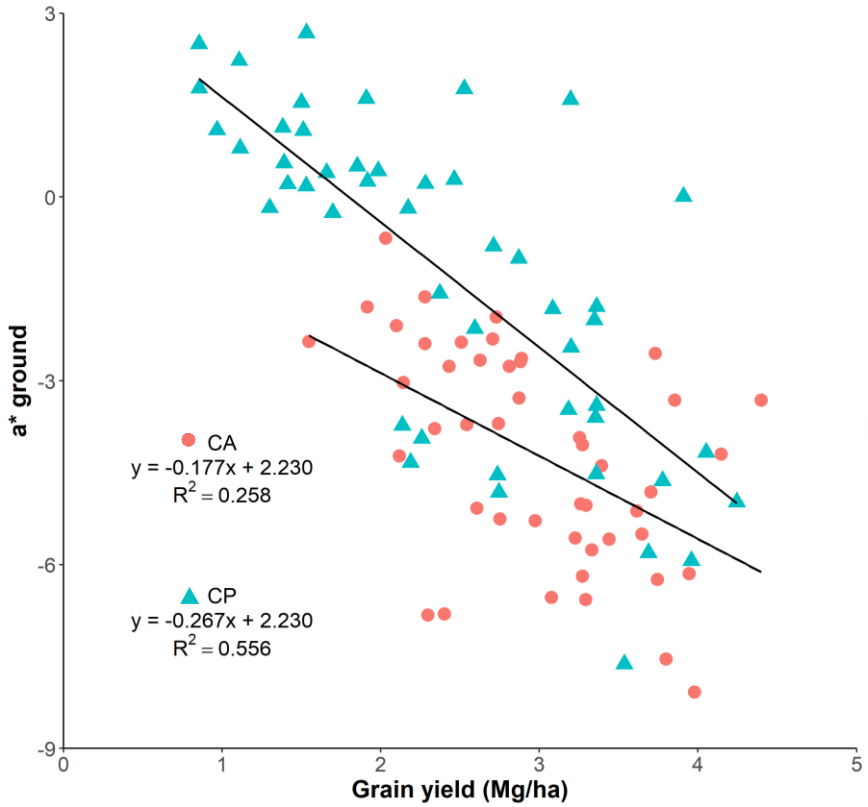
Results and Discussion: Grain Yield



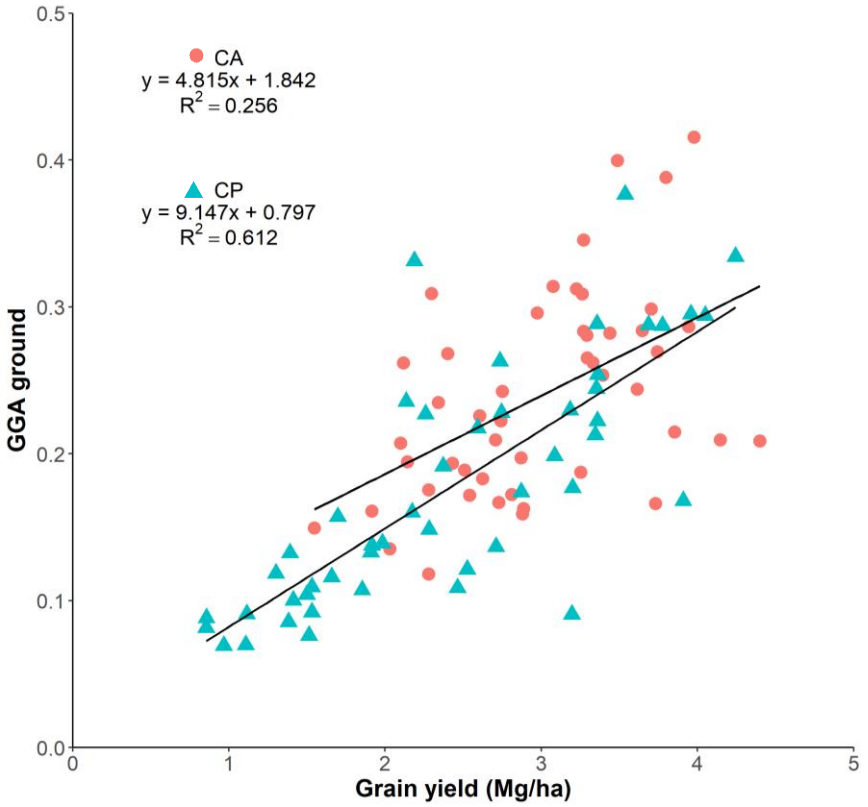
Since crop management has led to a considerable increase in yield, **changes in genotype** may be an option **to make use of the enhanced yield potential** provided by this environmental factor.

Results and Discussion – RGB indexes performance

a*



GGA

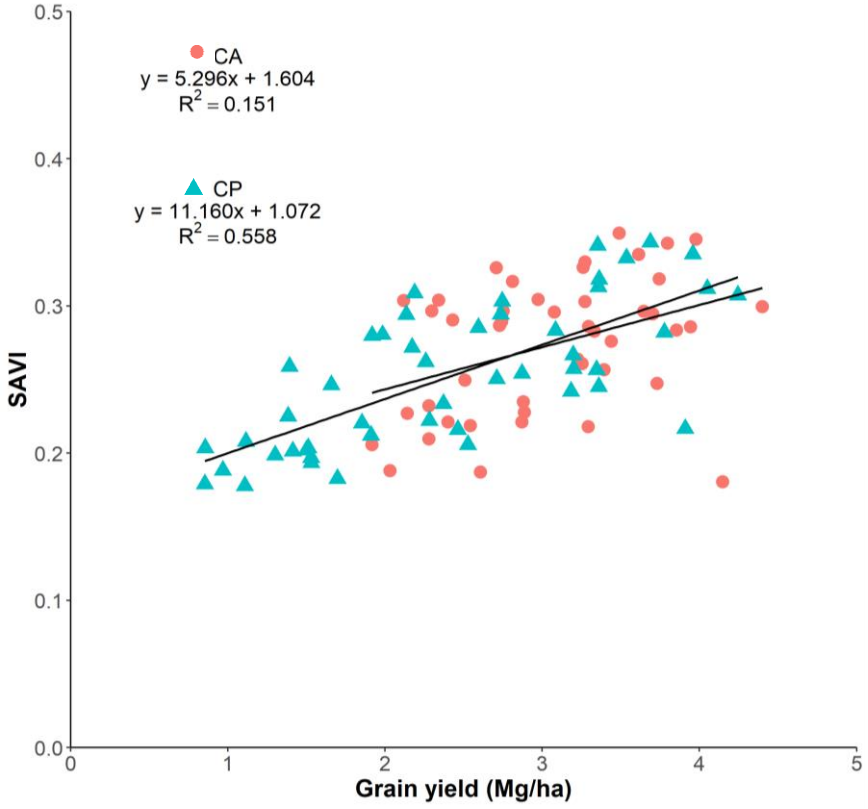


Indexes related to **canopy greenness**

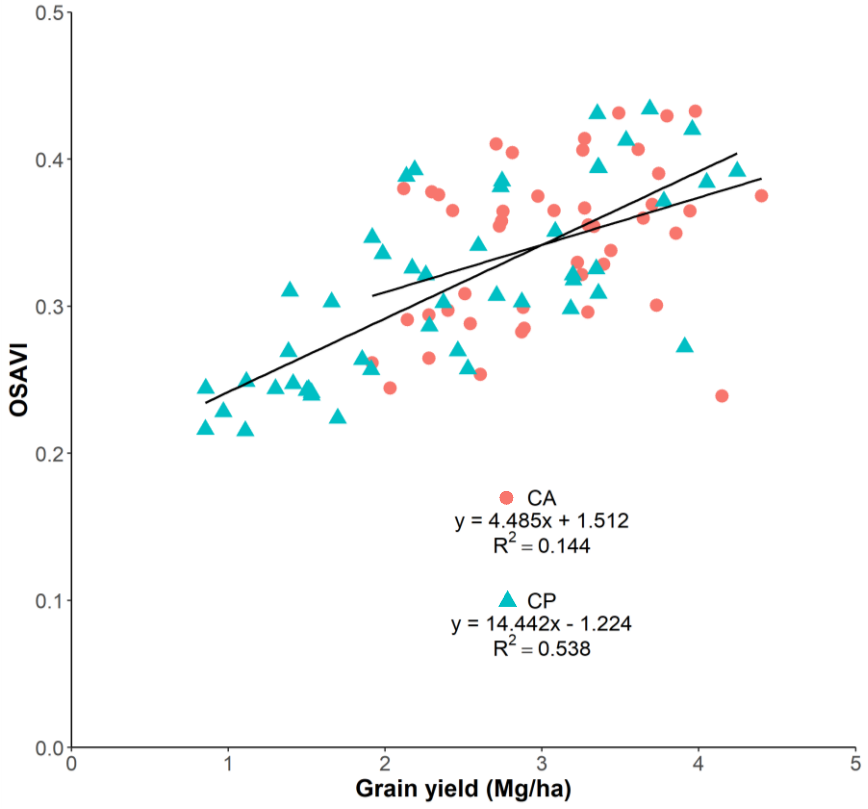
Elevated values of these indexes, driven by higher biomass levels, **help to anticipate higher yields** even at early growing stages.

Results and Discussion – Multispectral indexes perf.

SAVI



OSAVI



Indexes related to **canopy greenness**

Those indexes contain information from the red reflectance region, which increases with a reduction of the biomass density.

NIR

$$SAVI = \frac{(B840 - B670)}{(B840 + B670 + L)}$$

Results and Discussion – Multispectral indexes perf.

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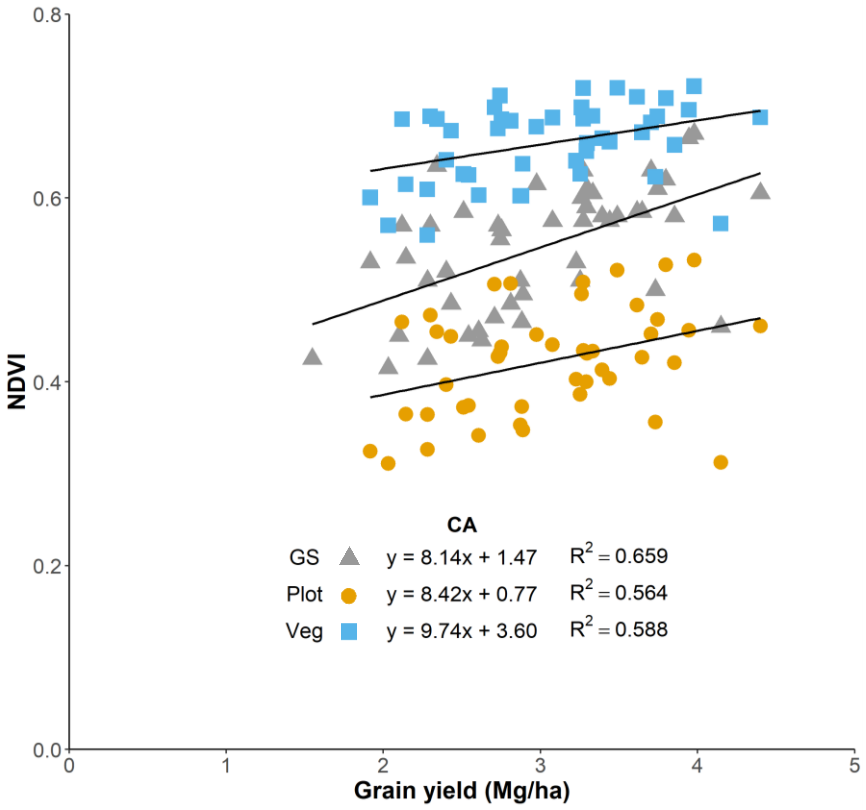
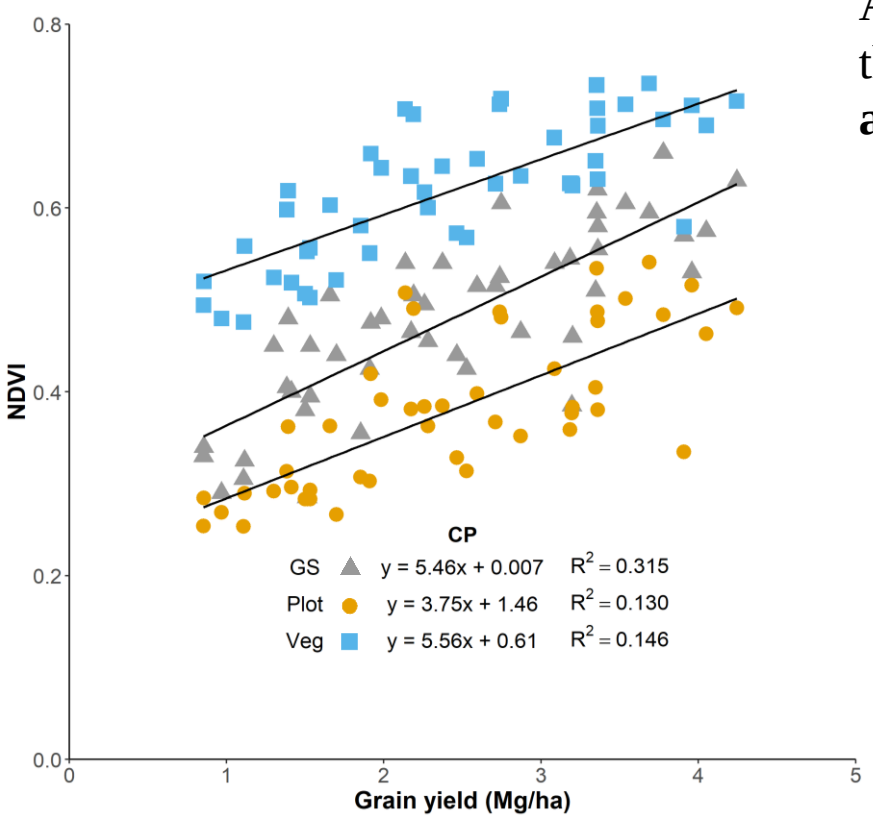
CA



CP



According to the FAO definition, the **soil surface has to be covered at least by 30%** to qualify as CA.

Influence on remote sensing measurements.

Conclusions

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CA management practices had a positive effect on increasing yields as compared to CP system. These results may help support the adoption of CA to combat declining yields that affect SSA agriculture.

Future efforts should be focus on the study of the impact of the genotype selection for a particular management system and dissect that traits associated with a better performance under CA

Even at early crop growth stages, the different RGB and multispectral indexes effectively assess yield differences under CA conditions, even if their performance is lower than under CP conditions.

The platform proximity effect on the image resolution did not have a negative impact on the performance of the indexes, reinforcing the usefulness of UAV and its associated image processing for high throughput plant phenotyping studies under field conditions.

Many thanks for your attention!
Muchas gracias por vuestra atención!
Moltes gràcies per la vostra atenció!

Phenotyping agriculture management effects on remote sensing assessments of maize hybrids performance

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