Use of remote sensing technology in the assessment of resistance of maize to Tar Spot Complex (TSC)

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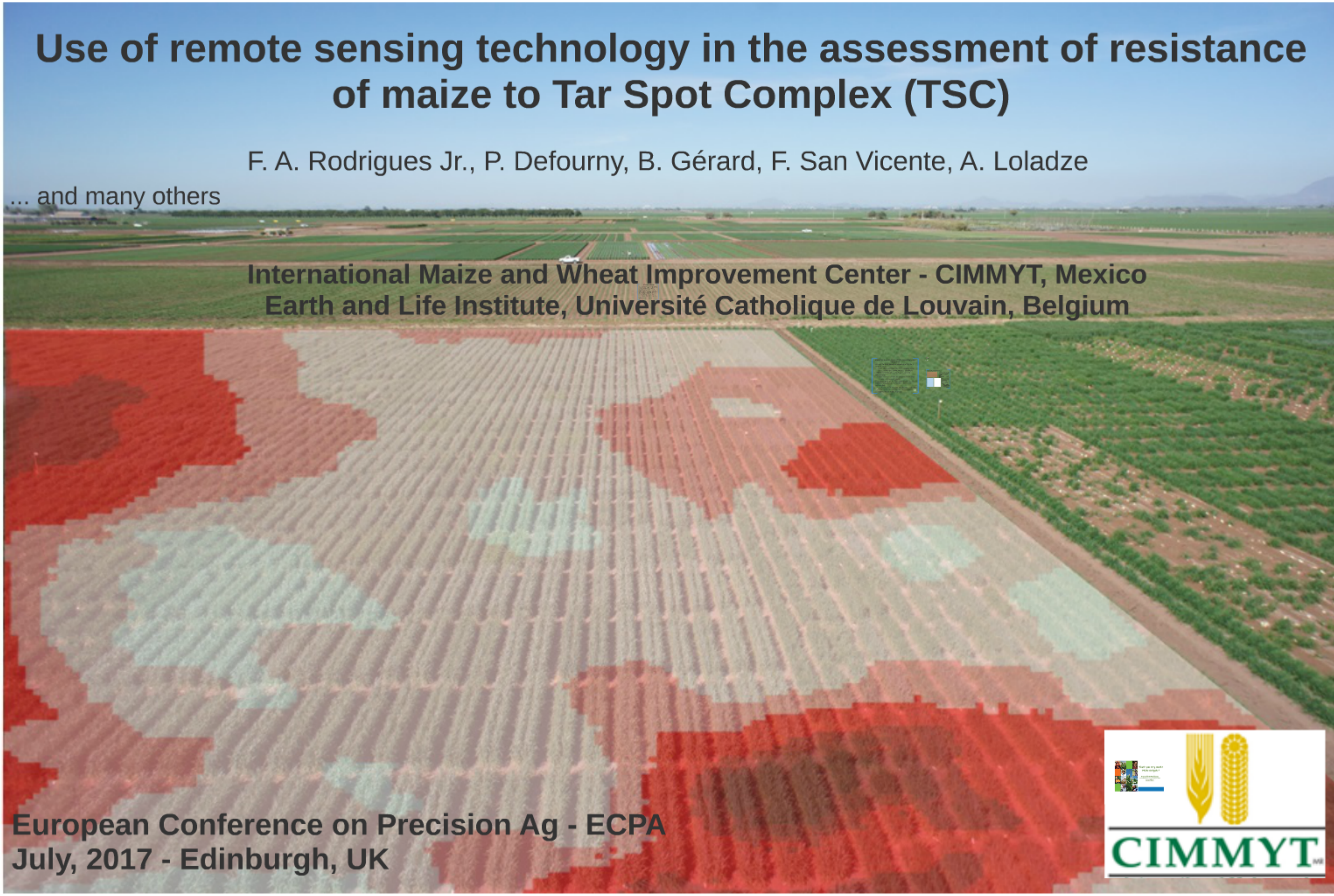
... and many others

International Maize and Wheat Improvement Center - CIMMYT, Mexico
Earth and Life Institute, Université Catholique de Louvain, Belgium

European Conference on Precision Ag - ECPA
July, 2017 - Edinburgh, UK

CIMMYT



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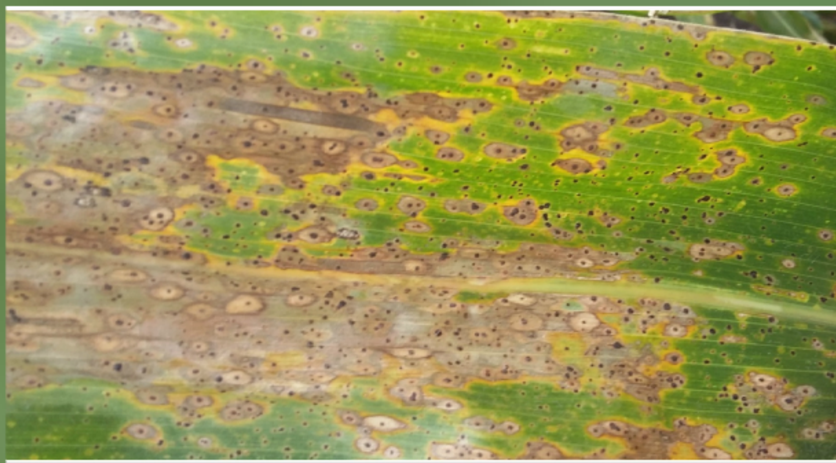
Maize Tar Spot Complex (TSC) importance and motivation

- One of the most important diseases of maize in tropical areas
  - grain loss may reach 50-75% - depending on susceptibility and environmental conditions
- Selection for TSC resistance starts at early generations
  - more advanced lines are screened in multiple locations for several years.
- Phenotyping maize for TSC resistance is mostly conducted by visual observations by breeders/ pathologists
  - A 1 to 5 scale is used for the disease evaluation
  - Depends on personal experience and results may vary due subjectiveness

TSC development...



- dark spots on the leaf surface (both lower and upper leaves)
- usually 2-3 weeks before flowering
- chlorotic circles due to the development of the second parasite

- chlorotic circles take over the entire leaves, becoming necrotic - affecting the photosynthetic activity - reducing the grain yields.
- High-throughput phenotyping through UAV may facilitate TSC resistance evaluation

CIMMYT'S Experimental Station - Agua Fria, Mexico - April, 2016

Square lattice design - 25 genotypes in two main blocks

714 - fungicide

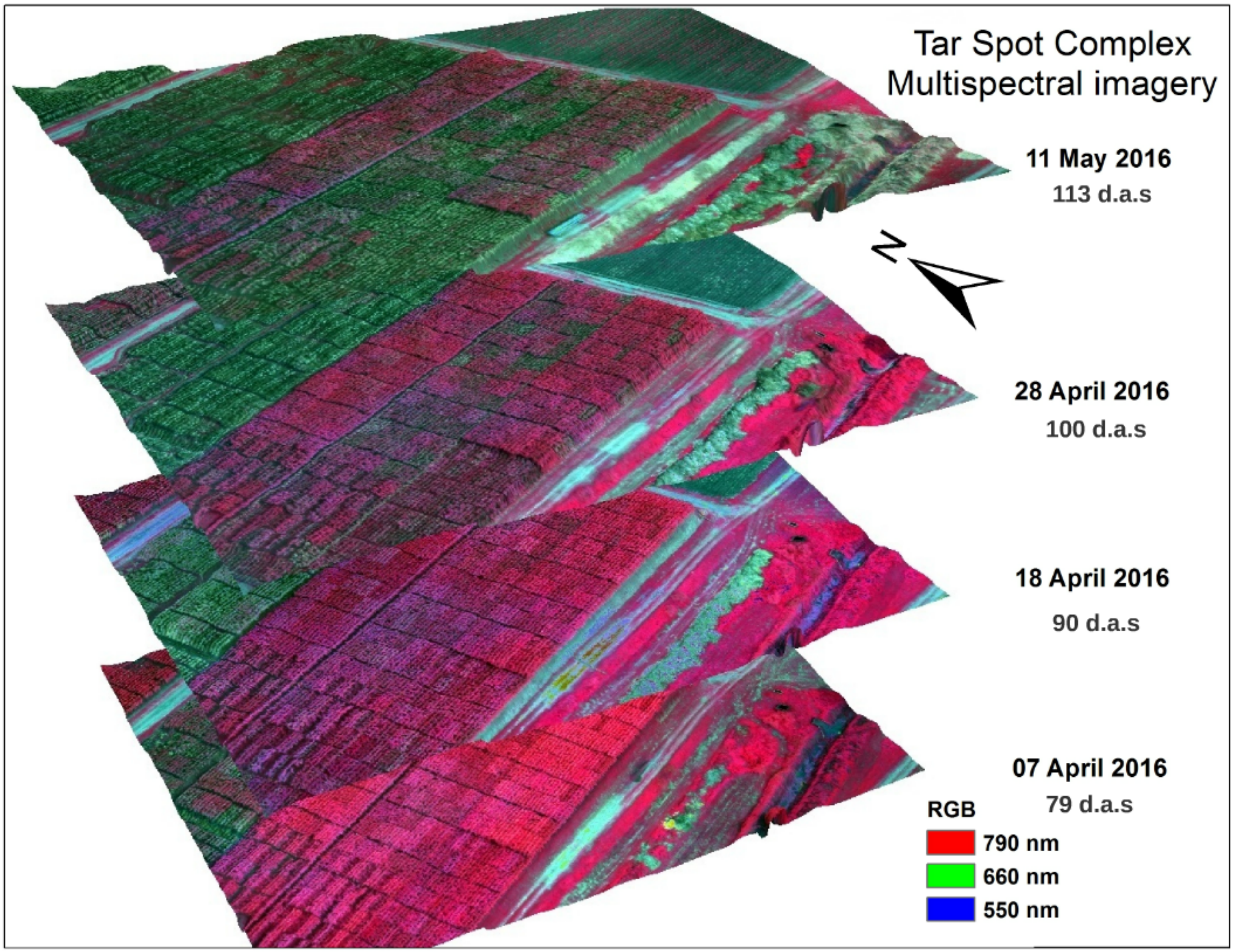
715 - without fungicide → fixed effect

three randomized replications.

plot - four rows, 4.5m x 0.75m → random effect

RML model

- MultiSpectral
  - (550, 660, 735, 790 nm) - 6 cm/px
- Thermal images – 12 cm/px



Results

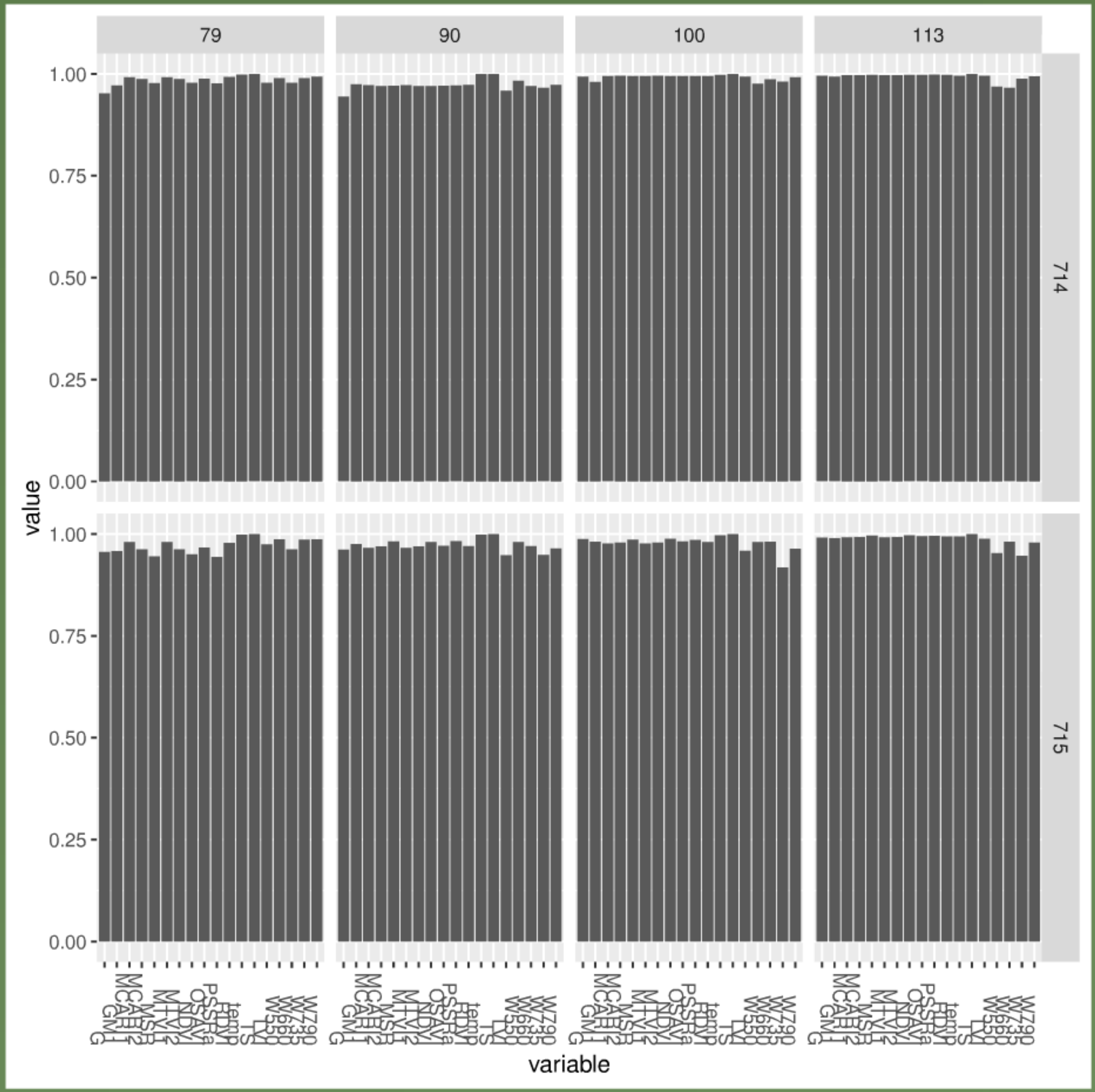


Table 1 – Phenotypic correlation between yield, image data and visual scoring (*n* = 75)

	714				715			
	79	90	100	113	79	90	100	113
NDVI	0.31*	0.31*	0.47*	0.54*	0.42*	0.51*	0.63*	0.57*
RDVI	0.28*	0.36*	0.51*	0.55*	0.55*	0.59*	0.67*	0.59*
OSAVI	0.31*	0.36*	0.50*	0.55*	0.55*	0.58*	0.66*	0.59*
MSR	0.30*	0.31*	0.49*	0.56*	0.42*	0.52*	0.68*	0.58*
MCARI1	0.22**	0.35*	0.47*	0.53*	0.51*	0.60*	0.65*	0.58*
MCARI2	0.29*	0.35*	0.48*	0.54*	0.57*	0.60*	0.66*	0.58*
TVI	-0.09	0.27*	0.25**	0.42*	0.15	0.58*	0.57*	0.53*
GM1	0.11	0.36*	0.39*	0.48*	0.23**	0.49*	0.64*	0.60*
PSSRa	0.29*	0.31*	0.50*	0.58*	0.42*	0.53*	0.72*	0.61*
G	-0.02	0.05	0.12	0.34*	0.12	0.38*	0.52*	0.51*
Thermal	-0.12	0.35*	-0.36*	0.19	-0.13	0.01	-0.46*	0.00
TS	0.08	-0.01	-0.05	-0.07	-0.30*	-0.24**	-0.39*	-0.43*

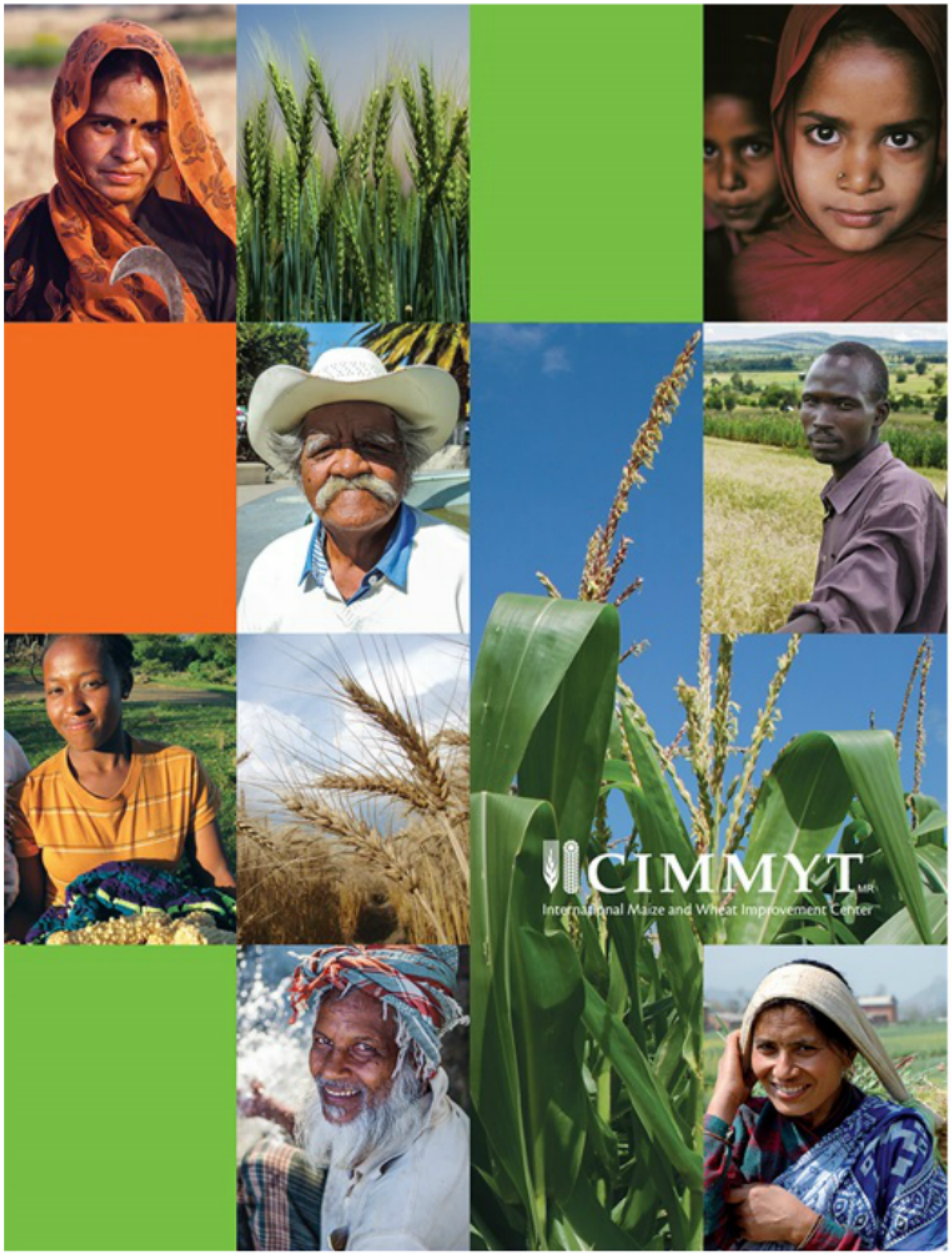
Table 2 – Genetic correlation between yield, image data and visual scoring (*n* = 25)

	714				715			
	79	90	100	113	79	90	100	113
NDVI	0.29	0.21	0.40**	0.45**	0.09	0.26	0.58*	0.54*
RDVI	0.56*	0.38***	0.44**	0.45**	0.53*	0.48*	0.60*	0.55*
OSAVI	0.50*	0.34***	0.43**	0.45**	0.52*	0.45**	0.60*	0.55*
MSR	0.26	0.22	0.39***	0.46**	0.09	0.30	0.62*	0.54*
MCARI1	0.56*	0.46**	0.43**	0.43**	0.51*	0.52*	0.60*	0.54*
MCARI2	0.55*	0.39**	0.43**	0.43**	0.57*	0.51*	0.61*	0.55*
TVI	0.36***	0.44**	0.36***	0.39**	0.42**	0.54*	0.57*	0.54*
GM1	0.00	0.19	0.23	0.38***	-0.25	0.13	0.52*	0.53*
PSSRa	0.24	0.22	0.38***	0.46**	0.09	0.32	0.65*	0.55*
G	0.24	0.24	0.32	0.37***	0.26	0.38***	0.60*	0.54*
Thermal	-0.36***	0.56*	-0.50*	-0.27	-0.17	-0.1	-0.57*	-0.33*
TS	-0.19	-0.1	-0.11	-0.14	-0.61*	-0.51*	-0.62*	-0.60*

Where: NDVI, RDVI, OSAVI, MSR, MCARI1 and MCARI2 – structural indices; TVI, GM1, PSSRa - chlorophyll indices; G – RGB ratio; thermal – canopy temperature; TS – visual disease scoring; 714 – fungicide treatment; 715 – Non-fungicide treatment. 79, 90, 100 and 113 days after sowing. * Coefficients of correlation statistically significant at 1% probability; ** coefficients of correlation statistically significant at 5% probability; *** coefficients of correlation statistically significant at 10% probability.

Conclusions

- VIs (structural and chlorophyll) proved to be a promising tool for the estimation of yield losses caused by TSC and offering new opportunities for high throughput phenotyping for resistance of maize to this highly important foliar disease;
- High r2 (<0.8) between visual scores and wavelengths
- 2017 maize growing cycle was carried out to account for possible environmental variability and to ensure the repeatability of the methodology.
  - Room for improvements = different approaches for image data extraction
    - multivariate analysis are the next steps - squeeze data!
- Challenges
  - Early detection.. before eyes can see it!
  - Upscale it!



Thank you very much !
Muito obrigado !

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CGIAR RESEARCH PROGRAM ON Wheat

CGIAR RESEARCH PROGRAM Maize