Discriminating Nitrogen Status Parameters of Maize Cultivars with High-throughput Phenotyping

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Needs

- Rising world population requires higher yield production
- Climate change is a challenge for sustainable and future-oriented agriculture

Aim

- Optimizing nitrogen management by decreasing N-inputs and environmental N losses
- Search for better performing and more efficient maize cultivars

by

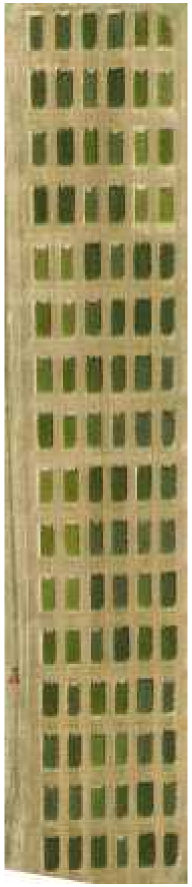
developing efficient phenotyping procedures to assess
- nitrogen uptake
- nitrogen use efficiency
and to compare different sensor systems

Methods

A) Unmanned aerial vehicle picture of the field experiment

B) Sensors mounted on a tractor measure radiation reflection

A

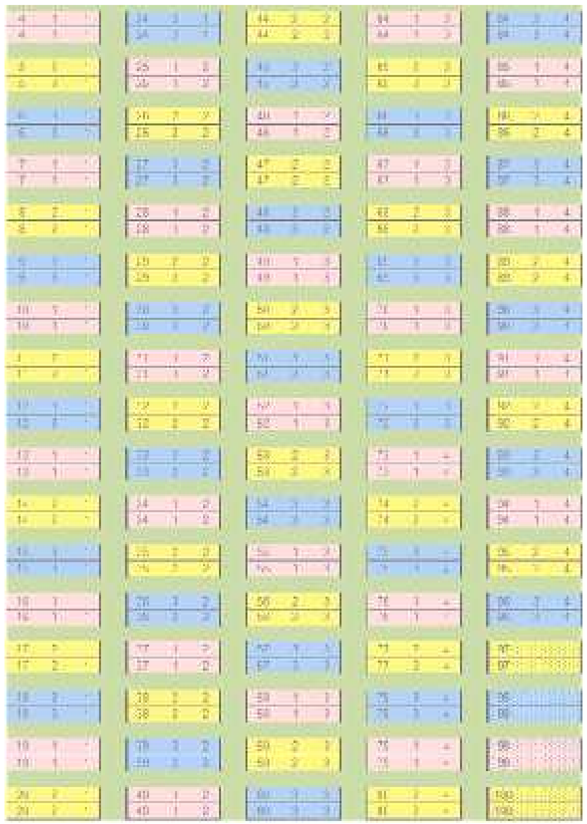


B

Methods

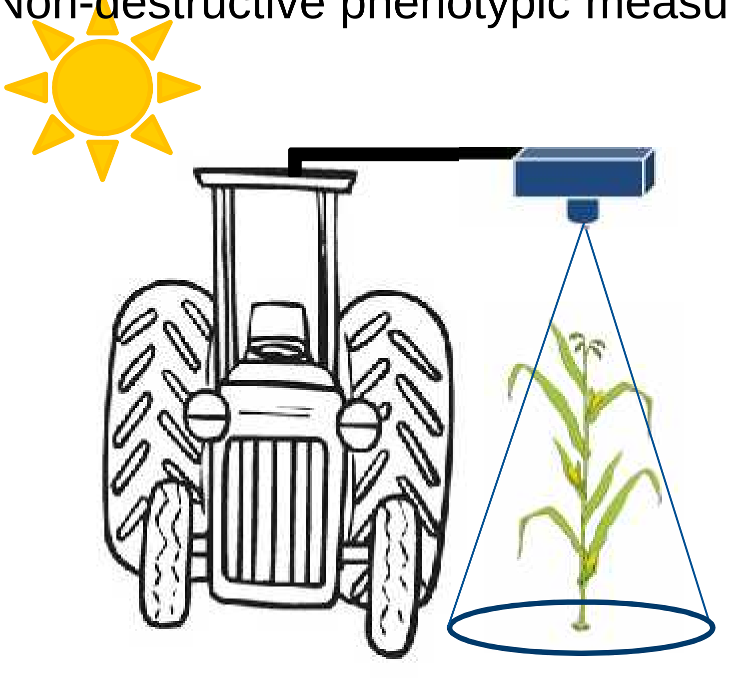
Experimental and destructive phenotypic procedures

- 8 early and late maturing cultivars
 (Lapriora, Severus, Saludo, Vitallo, Cannavaro, Barros, KWS 9361, P8105)
- Three fertilizer levels at 50, 150, 250 kg N/ha
- 4 replicates (plot size 14 m x 4 m, 6 rows, 0.66 cm between rows)
- Three biomass samplings at flowering, kernel dough stage and grain maturity
- Plants were separated into leaves, stems and cobs
- Biomass and nitrogen contents of leaves, stems and cobs were separately determined



Methods

Non-destructive phenotypic measurements



Spectral assessments

- Active sensors (Ntech GreenSeeker RT100, Holland Scientific CropCircle ACS 470, TUM ALS N-Sensor)
- Passive sensor (passive spectral spectrometer): wavelengths 300 nm - 1700 nm
- Recording 5 reflectance values per second at 4 km/h tractor speed
- Co-registration of spectral measurements with GPS data; Trimble RTK-GPS

Methods

Non-destructive phenotypic measurements

Holland Scientific CropCircle ACS 470 (Cc)

TUM ALS N-Sensor

Ntech GreenSeeker RT100

Passive Sensor

Methods

Active Sensors

Holland Scientific CropCircle ACS 470 (Cc)

670, 730 and 760nm

Ntech GreenSeeker RT100

656 and 774nm

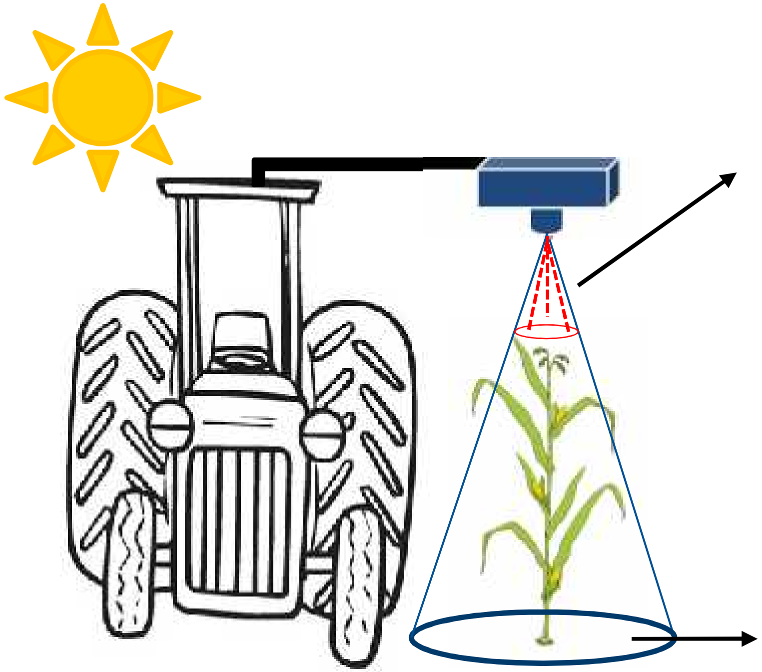
} **Light-emitting diode**

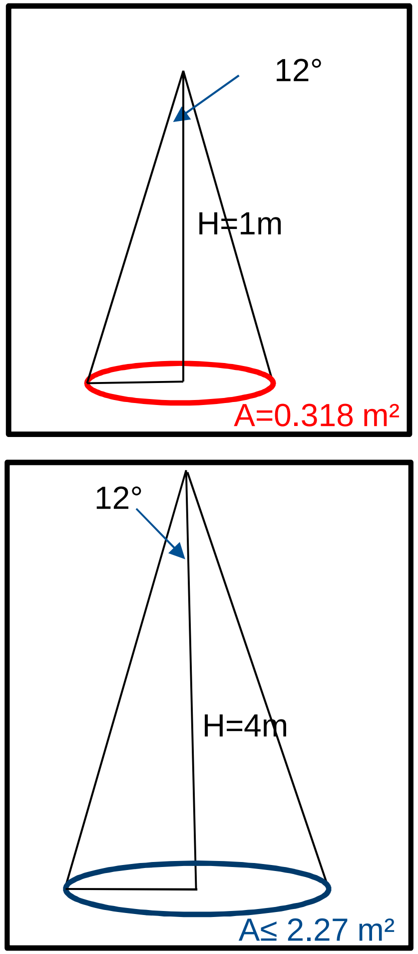
TUM ALS N-Sensor

Xenon flashlight

Methods

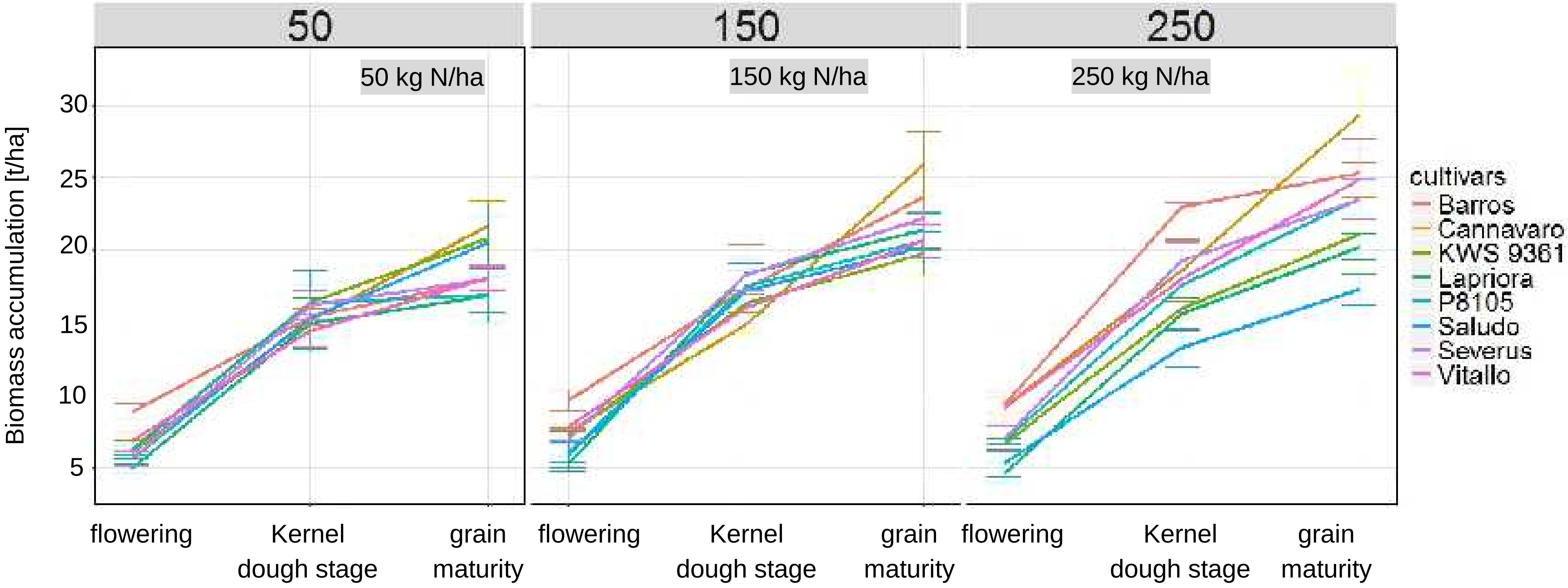
Calculation:





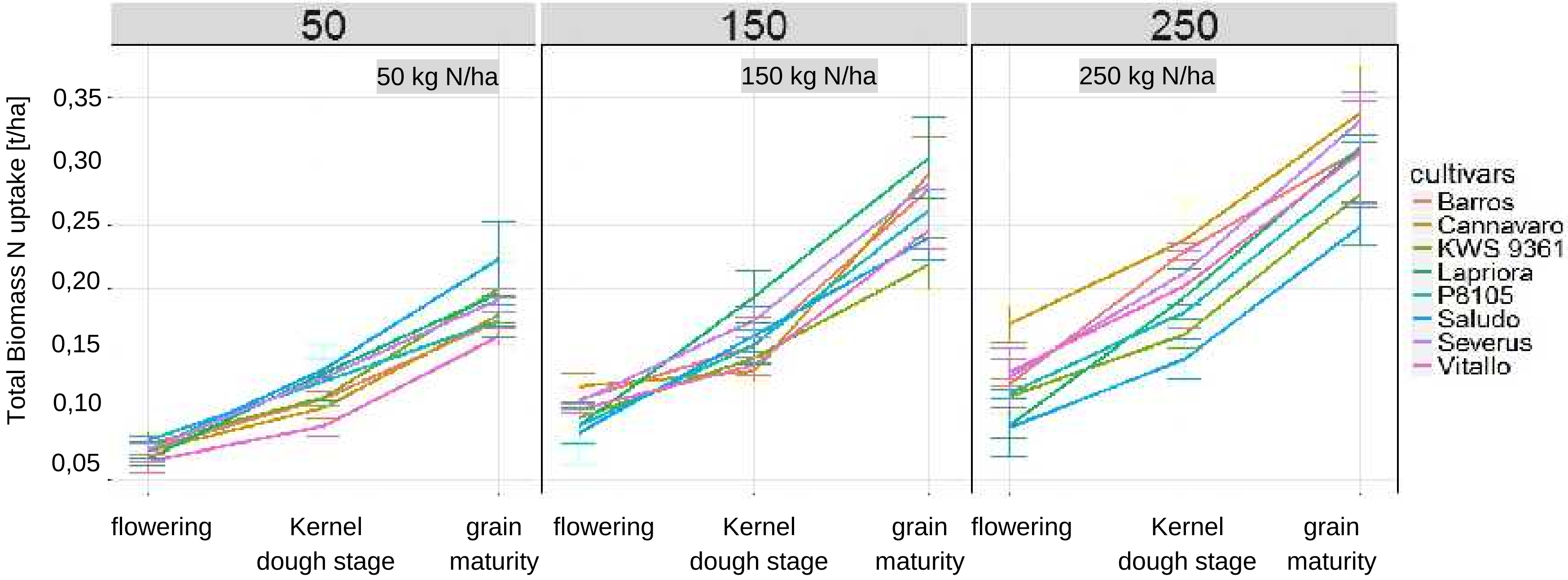
Results

Biomass accumulation at three fertilizer levels



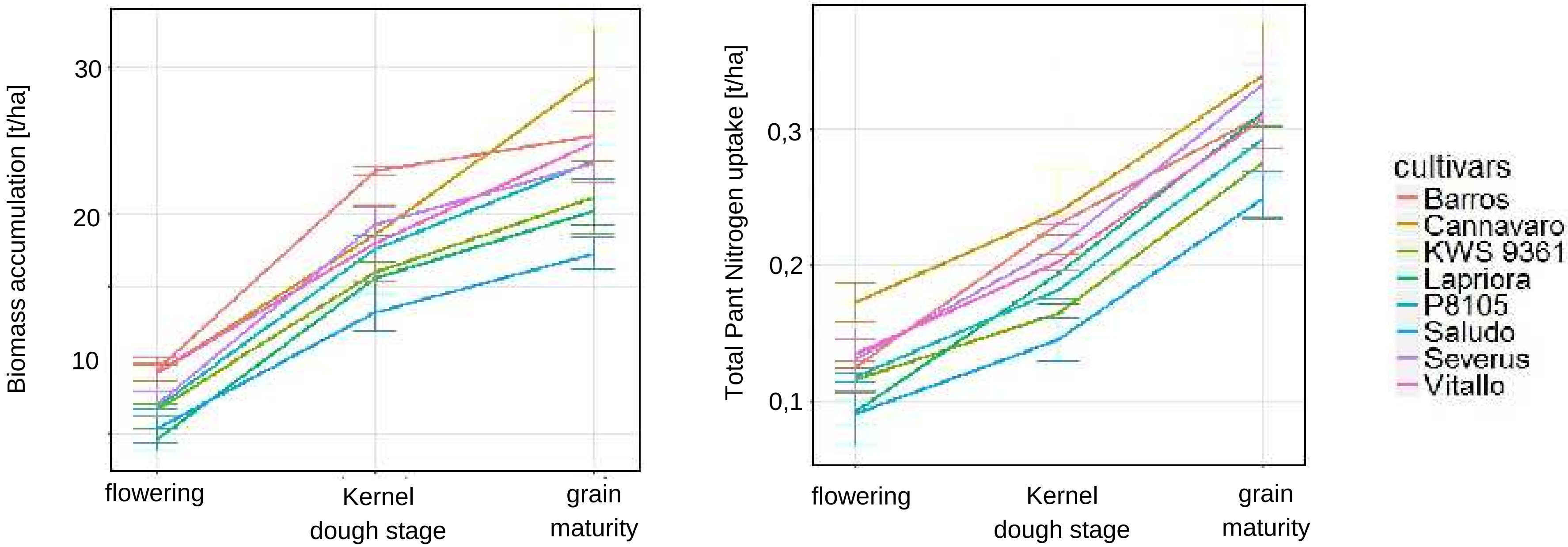
Results

Plant biomass nitrogen uptake at three fertilizer levels



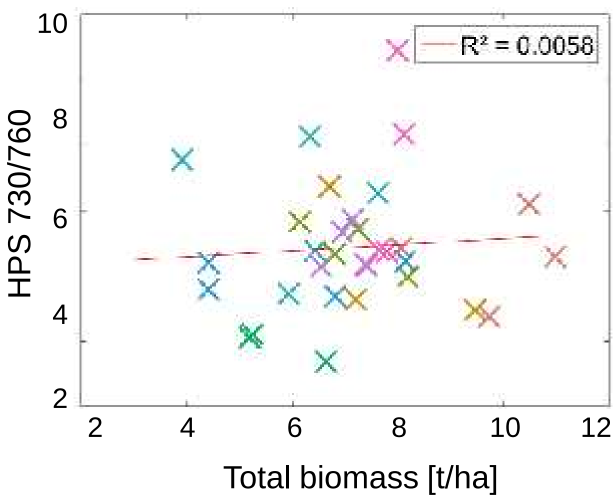
Results

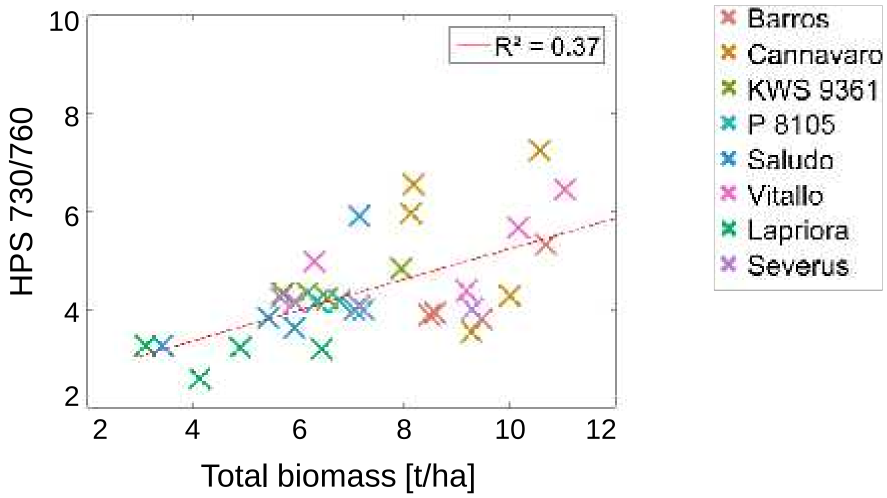
Temporal illustration of different parameters at 250 kg N/ha fertilizer application



Results

Correlation between reflectance index and total biomass at flowering at 150kg N/ha and 250 kg N/ha fertilizer application





➡ Better detection for 250 kg N/ha

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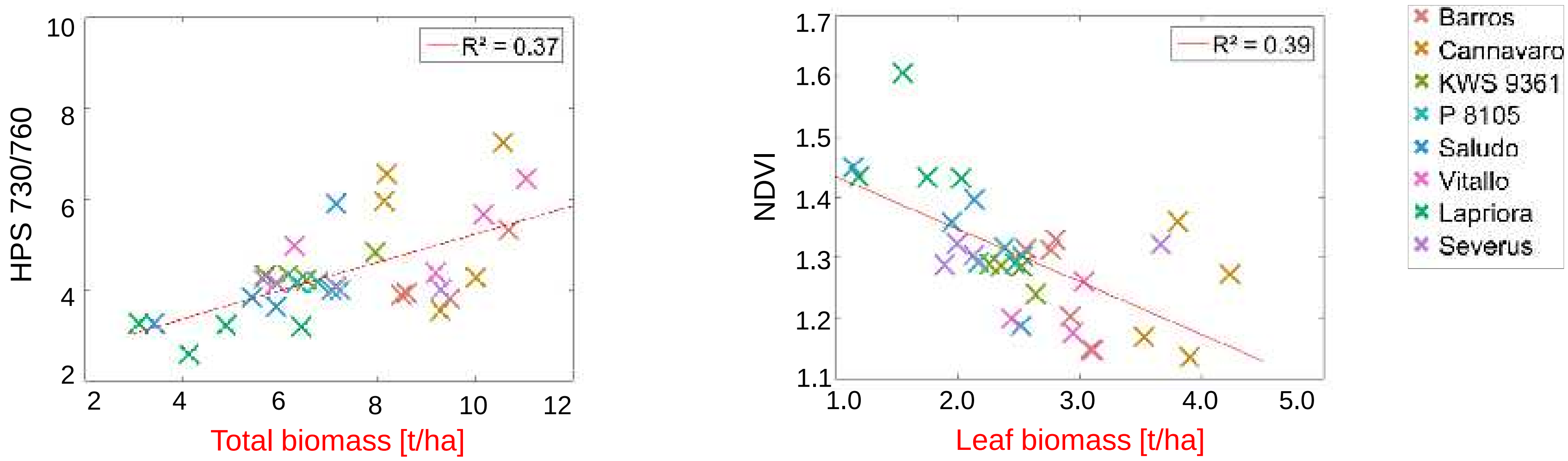
Results

Correlation between reflectance index and leaf biomass and total biomass at flowering at 250 kg N/ha fertilizer application



➡ Hardly no difference between total biomass and leaf biomass correlatic

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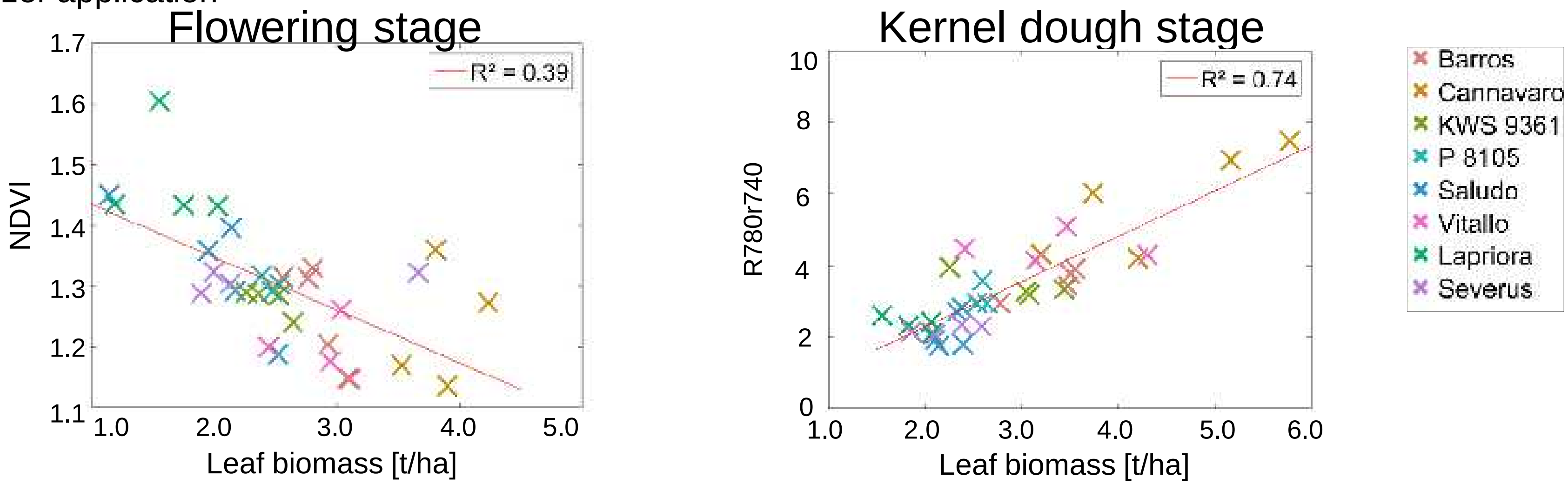
Results

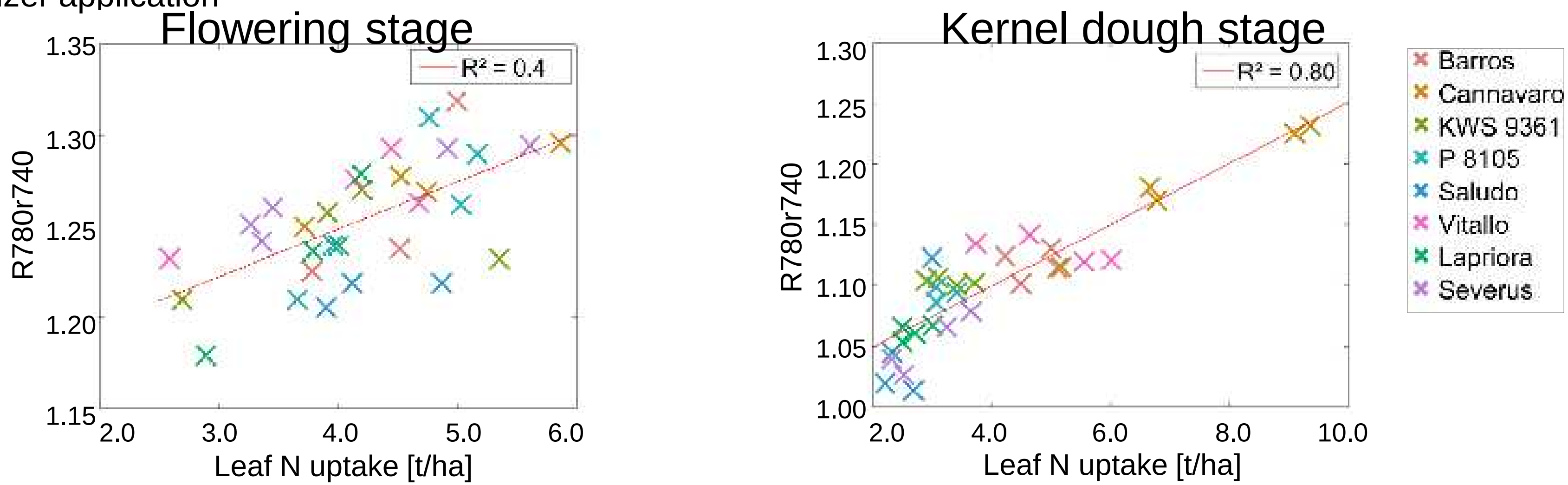
Correlation between reflectance index and leaf biomass at flowering and kernel dough stage with 250 kg N/ha fertilizer application



➡ Better detection of fully expanded leaves at kernel dough stage

Results

Correlation between reflectance index and leaf N uptake at flowering and kernel dough stage with 250 kg N/ha fertilizer application



- Plants better distinguished
- Fully expanded leaves

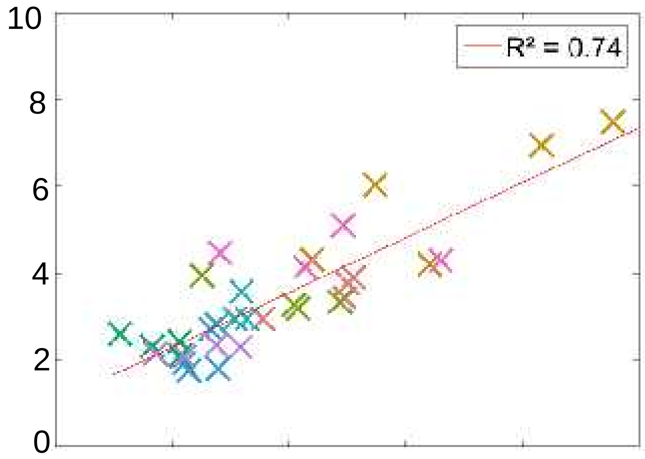
} Better nitrogen uptake detection

Conclusions

- Differences in biomass and nitrogen uptake of different cultivars were observed
- Passive sensing outperformed active sensing
- Optimized Indices were growth stage specific

- Overall, spectral information was more closely related to leaf biomass and leaf nitrogen uptake at kernel dough stage than at flowering
- Discrimination of biomass and nitrogen uptake of individual cultivars seems to be possible

Thank you for your attention!



Response: TM.Blatt..kg.ha.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Sorte	7	15057961	2151137	8.3685	**6.659e-05 *** **
Wdh	3	283872	94624	0.3681	0.7768
Residuals	21	5398074	257051		

$groups

	trt	means	M
1	**Cannavaro**	**4076.085**	**a**
2	Barros	3328.119	ab
3	Vitallo	3327.433	ab
4	KWS 9361	2954.057	abc
5	P8105	2538.058	bc
6	Saludo	2238.682	bc
7	Severus	2230.835	bc
8	Lapriora	1877.359	c

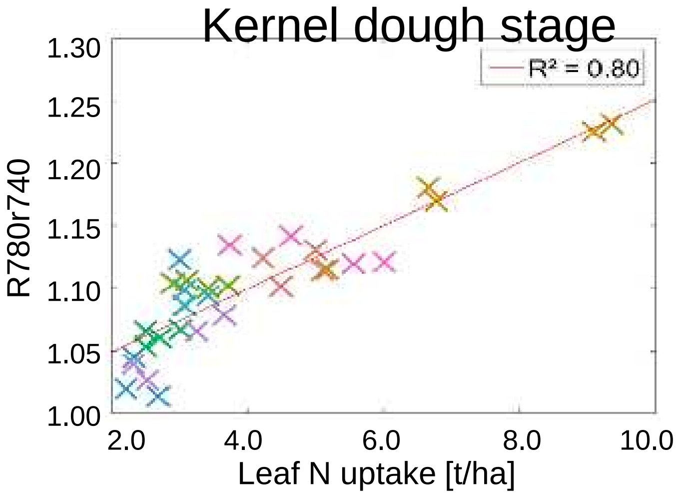
Response: R780.r740

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Sorte	7	0.050202	0.0071717	4.6275	**0.00289 ** **
Wdh	3	0.005575	0.0018583	1.1991	0.33440
Residuals	21	0.032546	0.0015498		

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

$groups

	trt	means	M
1	**Cannavaro**	**1.278743**	**a**
2	Vitallo	1.220152	ab
3	P8105	1.203623	ab
4	Lapriora	1.181541	b
5	Barros	1.170379	b
6	Severus	1.168927	b
7	KWS 9361	1.163578	b
8	Saludo	1.145274	b



Response: Nup.Blatt

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Sorte	7	6428.6	918.38	17.0194	**2.411e-07 *****
Wdh	3	225.5	75.16	1.3929	0.2726
Residuals	21	1133.2	53.96		

$groups

	trt	means	M
1	**Cannavaro**	**69.23851**	**a**
2	Vitallo	49.86995	b
3	Barros	47.08224	bc
4	KWS 9361	32.86096	bcd
5	P8105	31.58246	cd
6	Severus	29.45820	d
7	Lapriora	26.86340	d
8	Saludo	25.64669	d

Response: R780.r740

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Sorte	7	0.050202	0.0071717	4.6275	0.00289 **
Wdh	3	0.005575	0.0018583	1.1991	0.33440
Residuals	21	0.032546	0.0015498		

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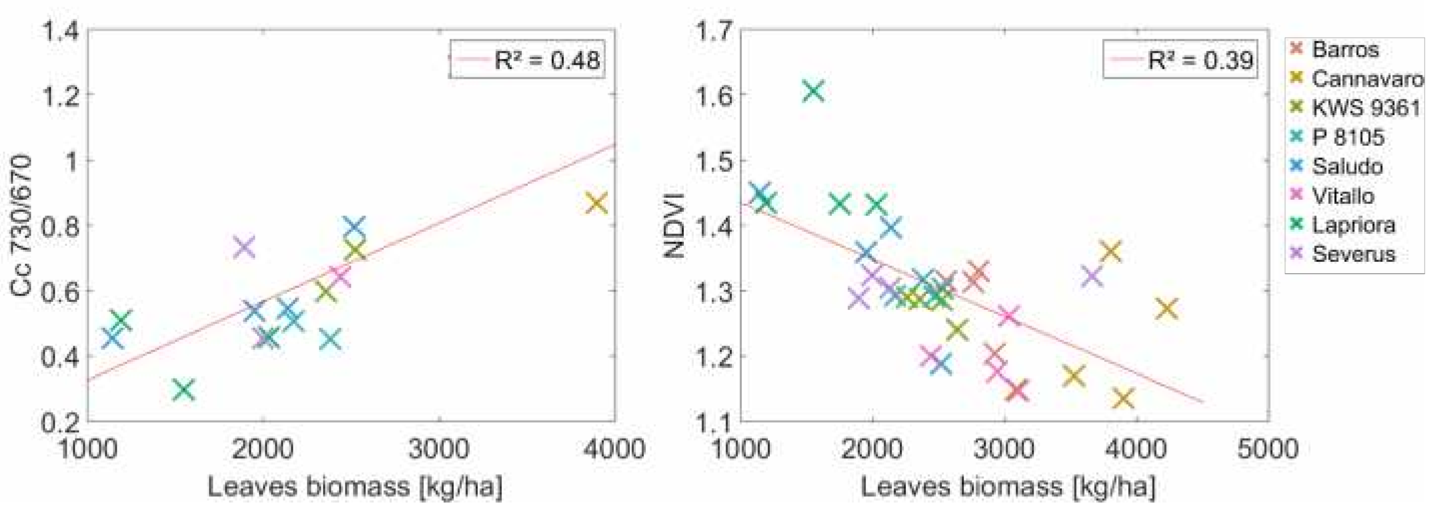
Results

Relationship between reflectance index and leaf biomass at flowering with 250 kg N/ha fertilizer application



Backup information

Cultivars	**Usage**	**Maturity**	**Silo-/Körnerreifezahl**
Cannavaro	Biogas	Very late	S:310
Lapriora	Silage	Early	K:190
Saludo	Silage, grain	Early	S:210, K:210
Severus	Silage	Early	S: ca. 190, K: ca. 190
Vitallo	Silage	Late	S: 270

Tabelle 1: Nutzungszwecke und Reifegruppen der untersuchten Maissorten

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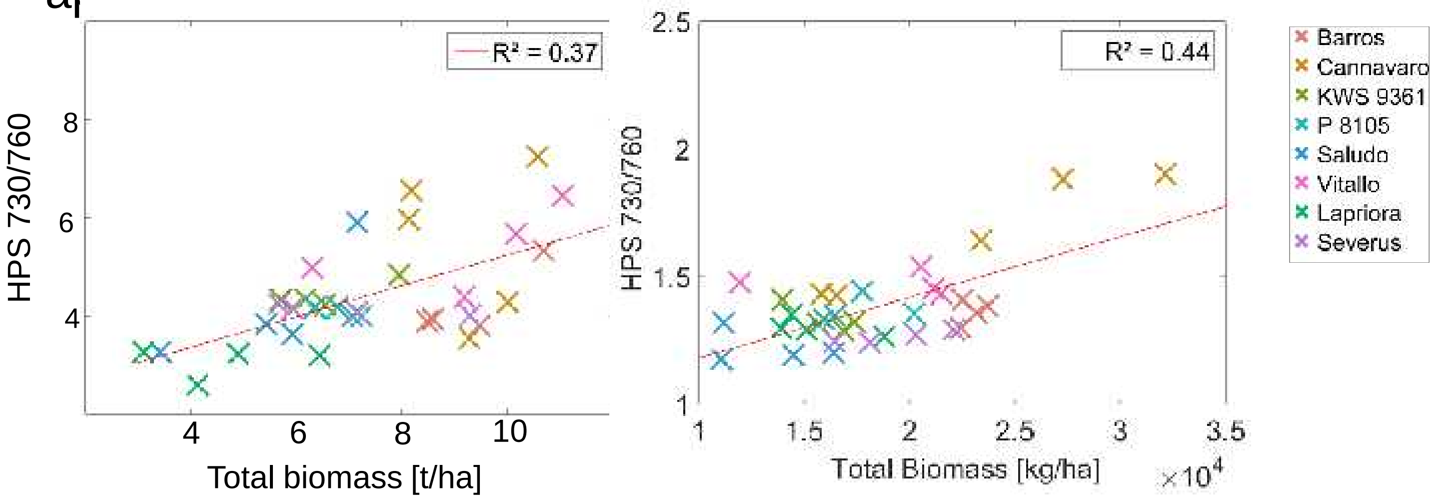
Results

Correlation between reflection index of total plant biomass at flowering and kernel dough stage with 250 kg N/ha fertilizer application



Index ist eigentlich der R760r730

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Backup information

biomass

50			150			250		
flowering	kernel dough stage	grain maturity	flowering	kernel dough stage	grain maturity	flowering	kernel dough stage	grain maturity
Lapriora	Vitallo	Lapriora	Lapriora	Cannavaro	KWS 9361	Saludo	Saludo	Saludo
Saludo	Lapriora	P8105	Saludo	Vitallo	Saludo	Lapriora	Lapriora	Lapriora
Severus	Cannavaro	Barros	P8105	KWS 9361	Vitallo	KWS 9361	KWS 9361	KWS 9361
Cannavaro	Saludo	Severus	Severus	Saludo	P8105	P8105	P8105	Severus
P8105	Barros	Vitallo	KWS 9361	Barros	Lapriora	Barros	Vitallo	P8105
KWS 9361	Severus	Saludo	Cannavaro	P8105	Severus	Severus	Cannavaro	Vitallo
Vitallo	P8105	KWS 9361	Vitallo	Severus	Barros	Vitallo	Severus	Barros
Barros	KWS 9361	Cannavaro	Barros	Lapriora	Cannavaro	Cannavaro	Barros	Cannavaro

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Backup information

Nitrogen Uptake

50			150			250		
flowering	**kernel dough stage**	**grain maturity**	**flowering**	**kernel dough stage**	**grain maturity**	**flowering**	**kernel dough stage**	**grain maturity**
Vitallo	Vitallo	Vitallo	Saludo	Cannavaro	KWS 9361	KWS 9361	Saludo	Saludo
Lapriora	Cannavaro	Barros	Lapriora	Vitallo	Saludo	Saludo	KWS 9361	KWS 9361
Cannavaro	Barros	P8105	P8105	KWS 9361	Vitallo	Vitallo	P8105	P8105
Saludo	KWS 9361	Cannavaro	KWS 9361	Barros	P8105	P8105	Lapriora	Vitallo
Severus	P8105	Severus	Vitallo	P8105	Barros	Severus	Vitallo	Barros
Barros	Severus	Lapriora	Severus	Saludo	Severus	Lapriora	Severus	Lapriora
KWS 9361	Lapriora	KWS 9361	Barros	Severus	Cannavaro	Barros	Barros	Severus
P8105	Saludo	Saludo	Cannavaro	Lapriora	Lapriora	Cannavaro	Cannavaro	Cannavaro

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Backup information

Nitrogen Nutrition Index

50 kg N/ha			150 kg N/ha			250 kg N/ha		
flowering	**kernel dough stage**	**grain maturity**	**flowering**	**kernel dough stage**	**grain maturity**	**flowering**	**kernel dough stage**	**grain maturity**
Cannavaro	Saludo	Severus	KWS 9361	P8105	P8105	KWS 9361	Saludo	Severus
Vitallo	KWS 9361	P8105	P8105	KWS 9361	Saludo	Saludo	P8105	Saludo
Barros	Vitallo	Vitallo	Vitallo	Severus	Vitallo	P8105	KWS 9361	Barros
KWS 9361	Severus	Barros	Barros	Saludo	KWS 9361	Barros	Severus	P8105
Saludo	P8105	Cannavaro	Cannavaro	Barros	Severus	Lapriora	Lapriora	KWS 9361
P8105	Barros	KWS 9361	Saludo	Cannavaro	Barros	Vitallo	Barros	Lapriora
Lapriora	Cannavaro	Lapriora	Severus	Vitallo	Lapriora	Severus	Vitallo	Vitallo
Severus	Lapriora	Saludo	Lapriora	Lapriora	Cannavaro	Cannavaro	Cannavaro	Cannavaro

Correlations between non-destructively and destructively assessed parameters leaf and biomass dry weight (LDW and BDW), leaf and biomass nitrogen uptake at flowering and kernel dough stage (LNU and BNU)

	Flowering					Kernel dough stage				
Sensor	LDW	BDW	LNU	BNU	NNI	LDW	BDW	LNU	BNU	NNI
Cc730_670	0.13	0.09	0.03	0.03	0.00	0.06	0.11	0.04	0.10	0.01
Cc760_670	0.04	0.02	0.00	0.00	0.04	0.12	0.22	0.39	0.33	0.36
Cc760_730	0.15	0.13	0.09	0.09	0.03	0.00	0.02	0.23	0.10	0.45
HPS NDVI	0.29	0.31	0.21	0.17	0.05	0.51	0.04	0.51	0.20	0.52
HPS 730_670	**0.30**	0.27	0.28	0.22	0.07	**0.55**	0.00	0.37	0.06	0.32
HPS 760_670	0.25	**0.32**	0.17	0.13	0.01	**0.53**	0.03	0.53	0.18	0.52
HPS 760_730	0.18	**0.37**	0.44	0.41	**0.48**	0.21	0.11	**0.66**	0.40	0.53
HPS 780_740	0.16	0.18	0.45	0.41	**0.50**	0.08	0.08	**0.62**	0.37	0.53
HPS 742_764	0.18	0.19	**0.46**	**0.42**	**0.50**	0.10	0.11	**0.67**	**0.41**	**0.63**
HPS REIP	0.13	0.14	0.42	0.39	0.09	0.11	0.10	**0.63**	0.39	**0.60**