Summarizing growth
Can crop development seen from above be used for yield prediction?

NPPN 2019, Båstad

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Data

- Winter barley from Sejet plant breeding
- Large plot yield trials (15 m^2)
  - 2019
    ~ 2540 plots
    ~ 730 lines
  - 2018
    ~ 1980 plots
    ~ 600 different lines
- Small plot yield trials (3 m^2)
  - 2019
    ~ 1440 plots
    ~ 1120 different lines

Sejet plant breeding

RGB data from UAS

- Flight campaigns

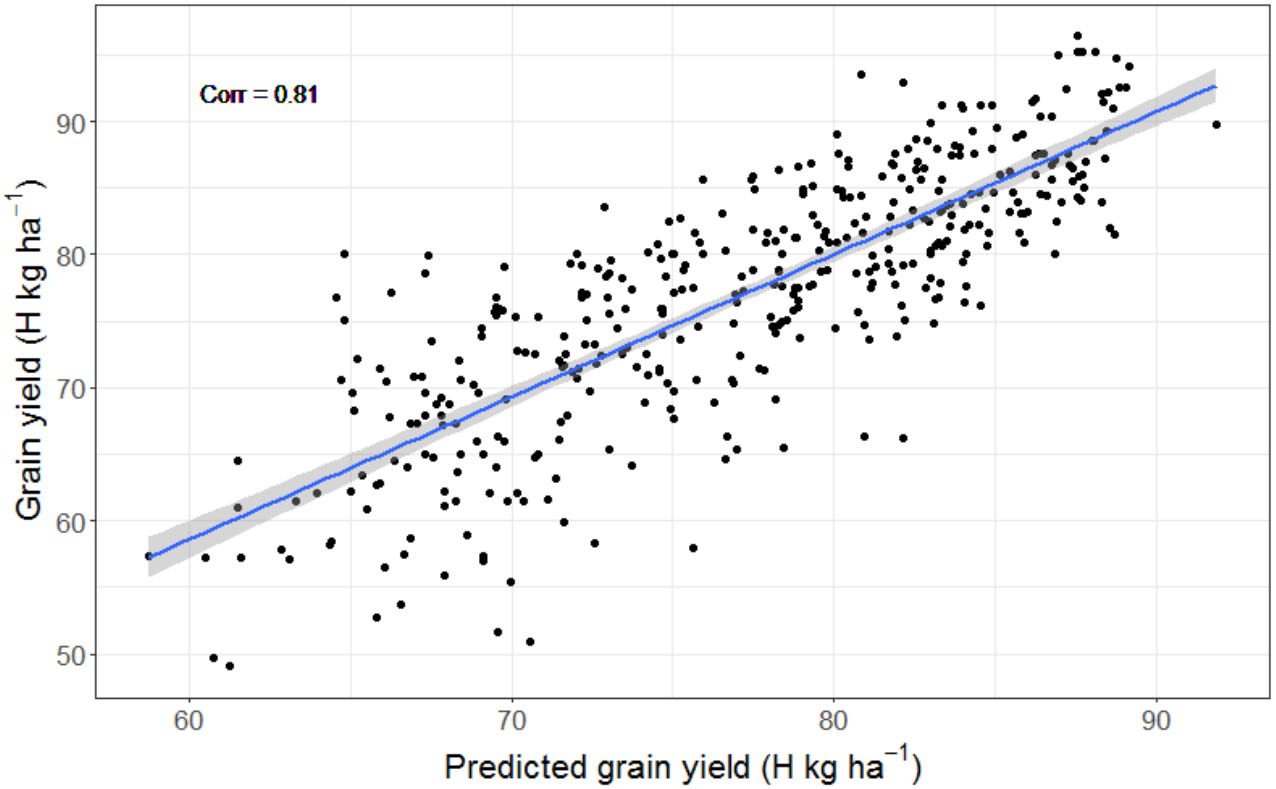
	Early vigor			Heading date	Early grain filling	Late grain filling		Maturity
Large plots, 2018		X		X	X	X	X	
Large plots, 2019	X	X	X	X				X
Small plots, 2019	X		X	X				X

Sejet plant breeding

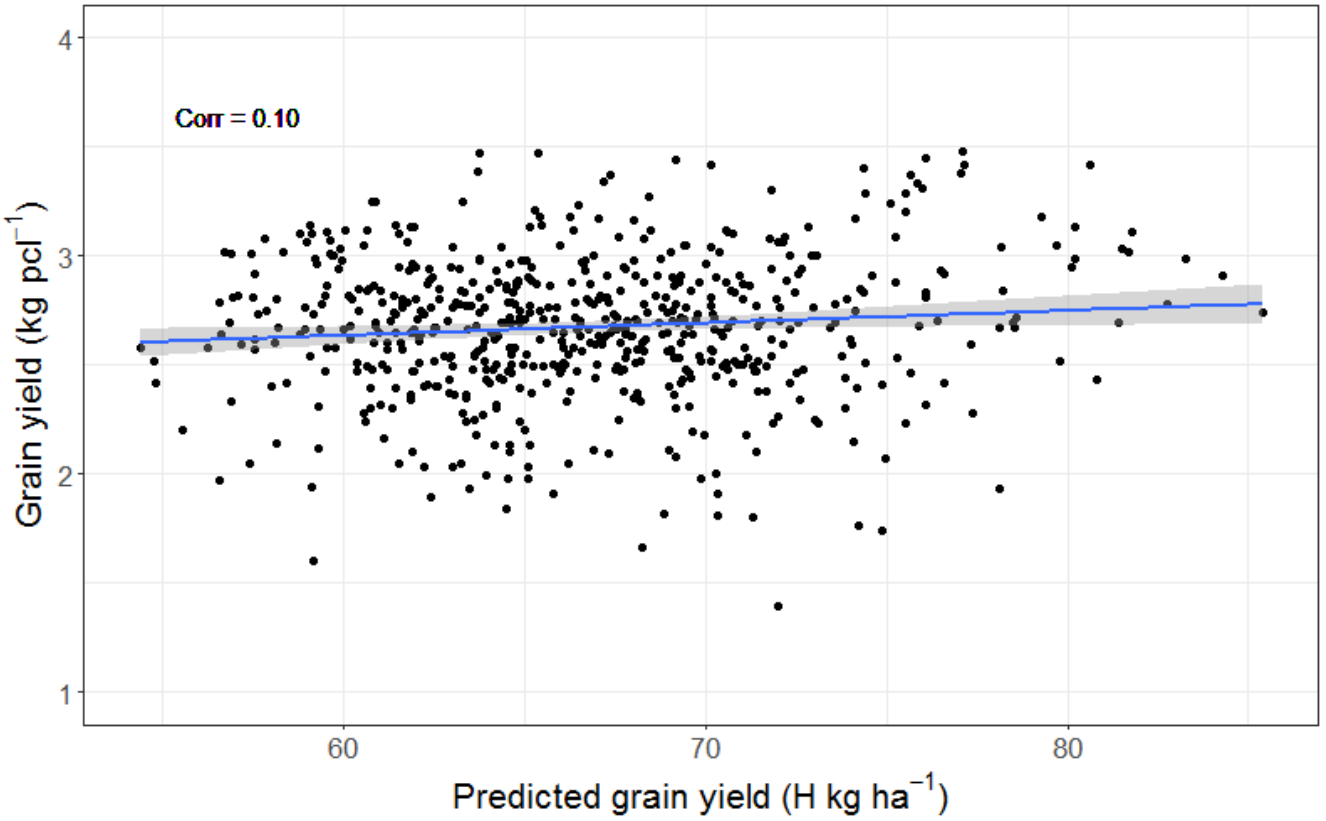
Yield prediction using machine learning

- Random forest
- Training set
  - 80% randomly chosen plots
- Test set
  - 20% remaining plots
- Data from UAS from different flight campaigns
  - Red
  - Green
  - Blue
  - ExG

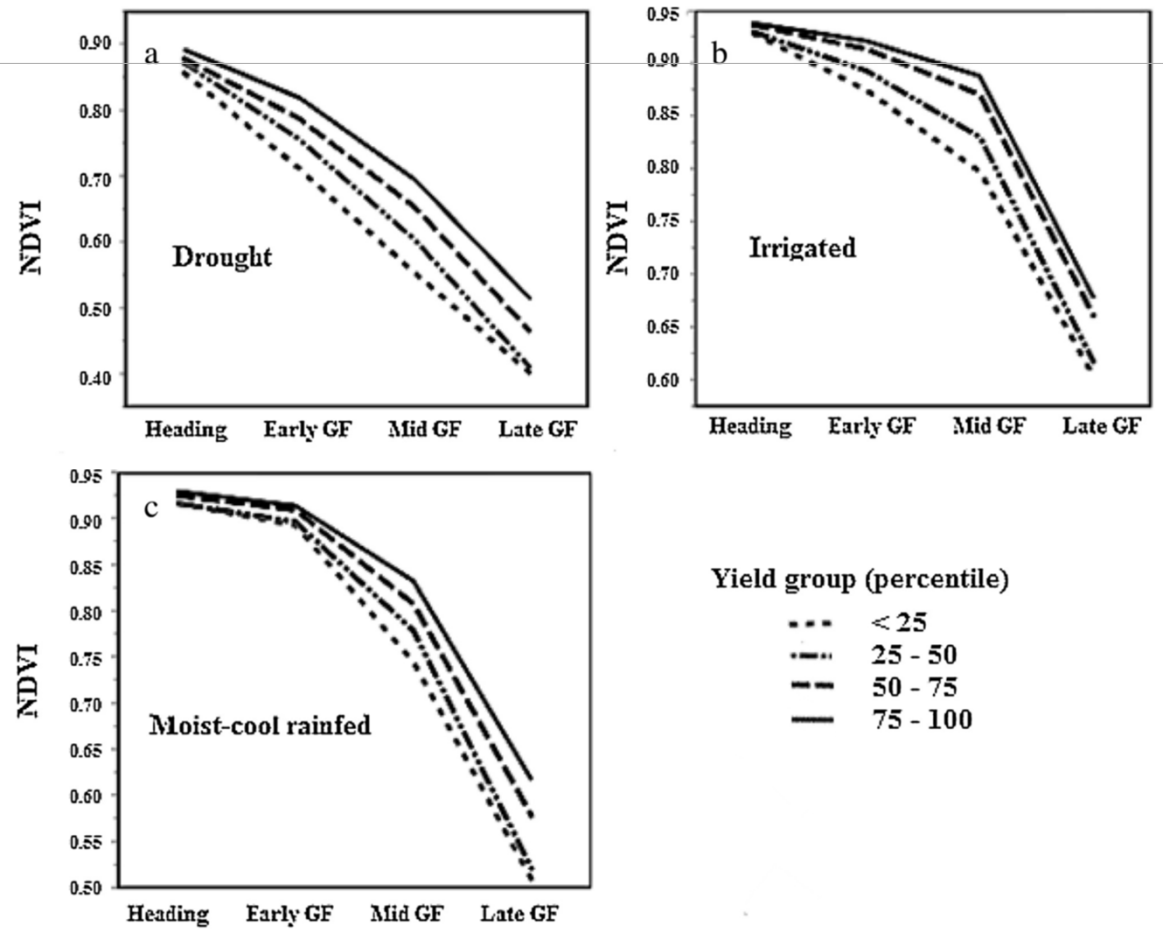
Yield prediction with ML, large plot trial



Same model applied to the small plot trial same year



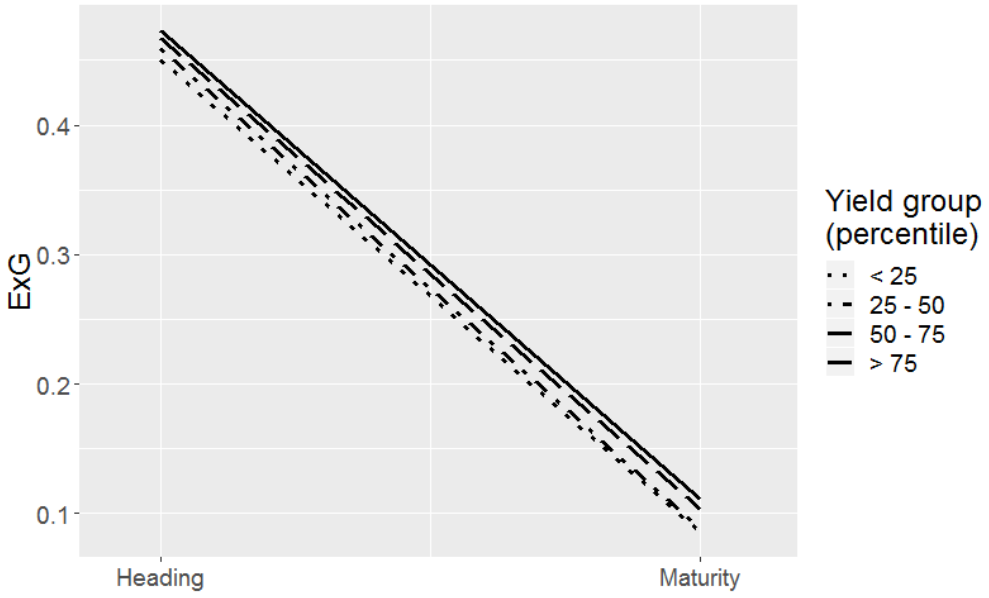
Yield and VI in winter wheat



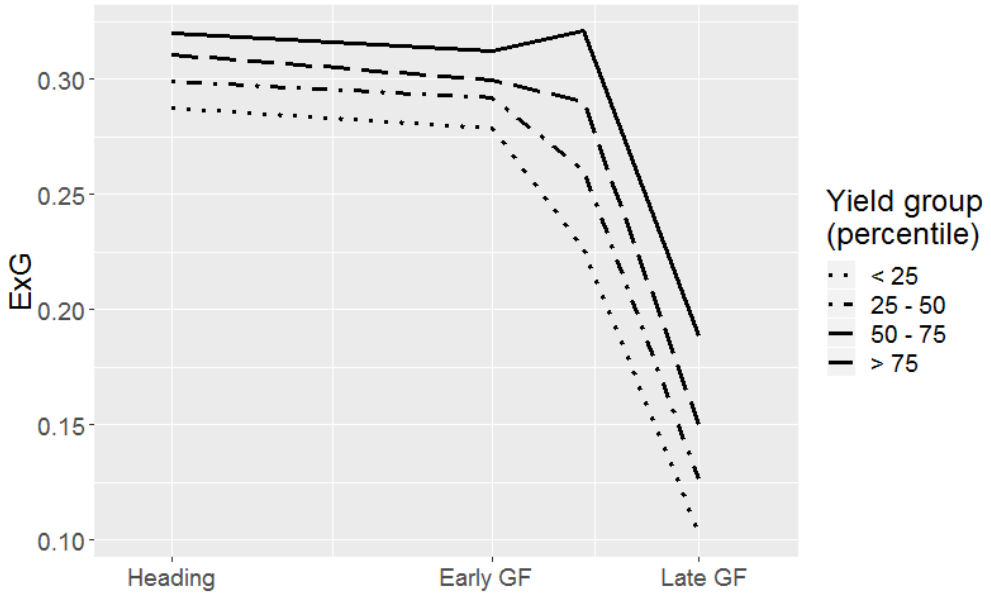
Gizaw et al. 2016

Yield and VI in winter barley

2019



2018

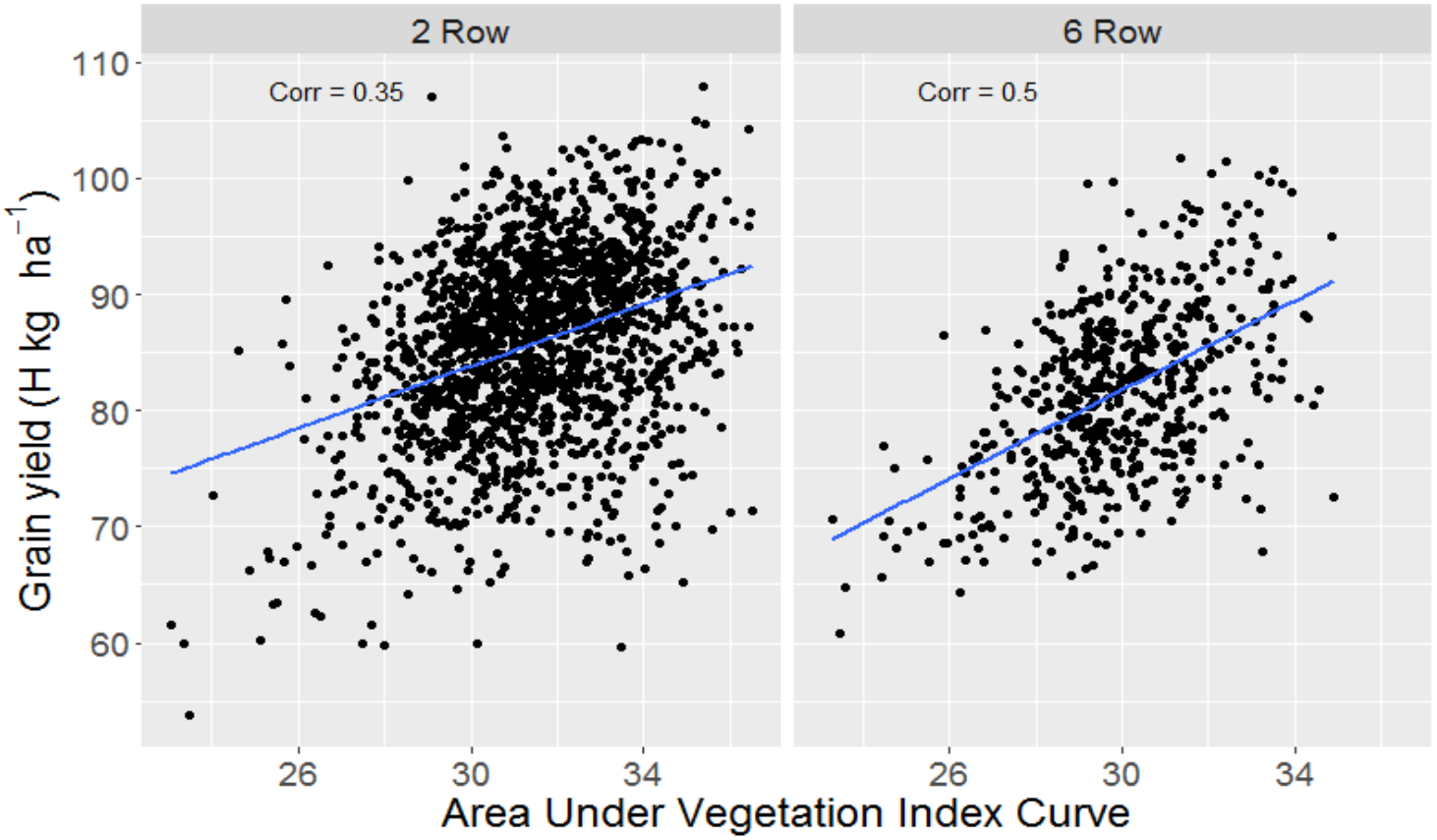


VI and derived indices for predicting yield in winter wheat

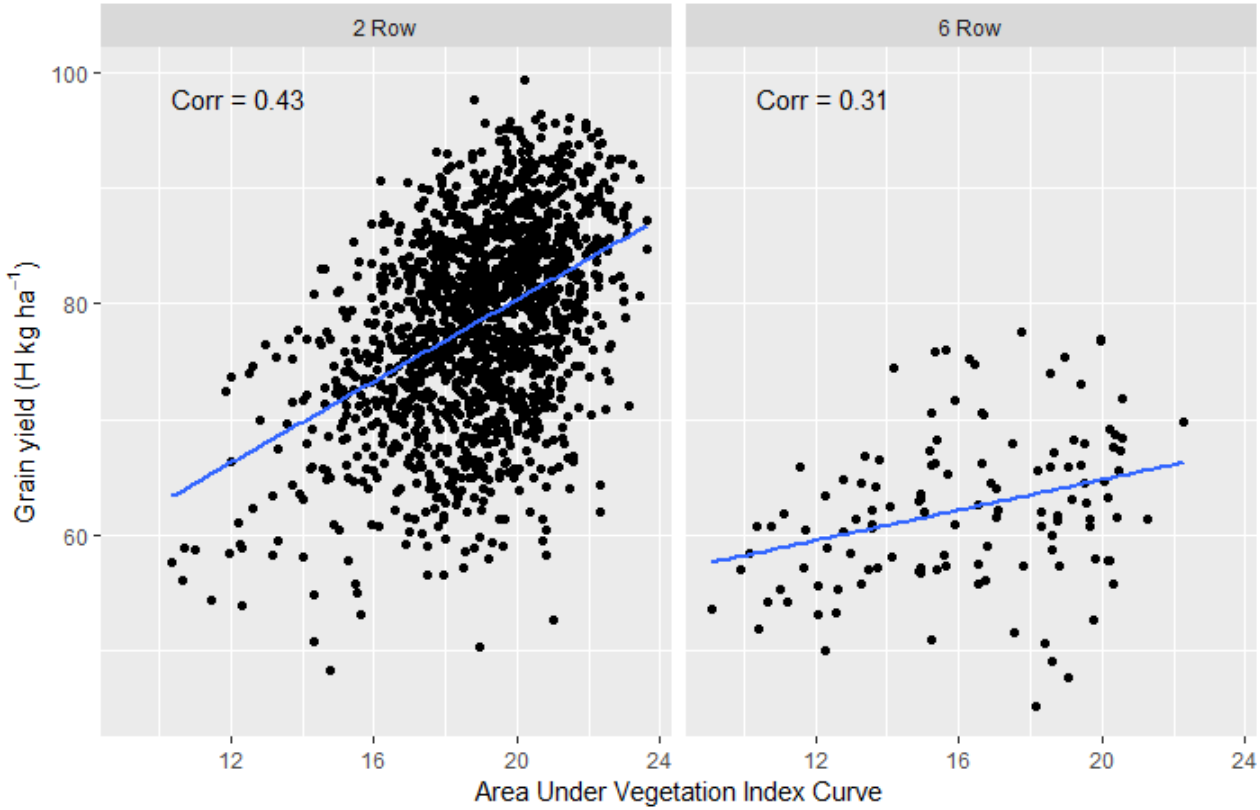
Subgroup	Parameter	Trials						
		I	II	III	IV	V	VI	VII
Hard	AUVIC	0.65	0.42	0.48	0.50	0.69	0.50	0.57
	Slope	0.06	0.48	0.43	0.38	0.66	0.49	0.25
	Mean	0.66	0.50	0.50	0.45	0.67	0.70	0.55
	Heading	0.55	0.39	0.13	0.22	0.11	0.47	0.30
	Early GF	0.67	0.44	0.54	0.52	0.09	0.69	0.46
	Mid GF	0.60	0.52	0.47	0.50	0.73	0.70	0.58
	Late GF	0.41	0.47	0.40	0.35	0.62	0.68	0.37
Soft	AUVIC	0.71	0.64	0.36	0.28	0.64	0.65	0.50
	Slope	0.31	0.47	0.25	0.10	0.53	0.66	0.30
	Mean	0.72	0.50	0.37	0.28	0.64	0.67	0.50
	Heading	0.56	0.02	0.10	0.33	0.56	0.41	0.29
	Early GF	0.58	0.49	0.42	0.32	0.39	0.64	0.47
	Mid GF	0.71	0.54	0.43	0.29	0.63	0.64	0.45
	Late GF	0.55	0.42	0.11	0.06	0.56	0.67	0.43

Gizaw et al. 2016

AUVIC as a predictor for yield in winter barley, 2019 data



AUVIC as a predictor for yield in winter barley, 2018 data



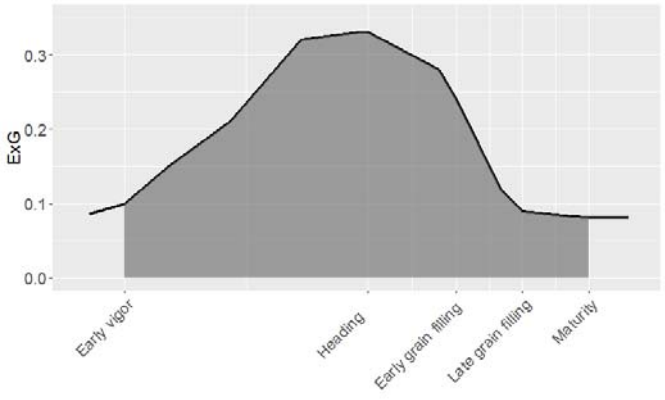
AUVIC or VI at a single time point

		Large plots		Small plots
2 Row	Parameter	2018	2019	2019
	AUVIC	0.43	**0.35**	**0.27**
	Early vigor	0.21	0.23	0.21
	Heading	0.36	0.30	0.22
	Early grain filling	0.21	-	-
	Late grain filling	**0.67**	-	-
	Maturity	-	0.21	0.17

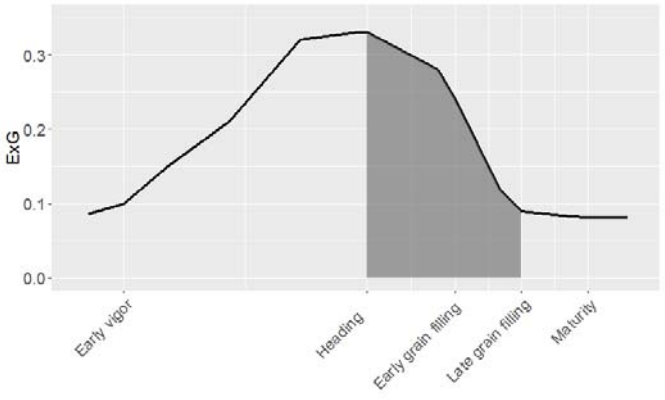
6 Row	Parameter	2018	2019	2019
	AUVIC	0.31	**0.50**	NS
	Early vigor	0.19	0.38	NS
	Heading	**0.45**	0.35	NS
	Early grain filling	0.19	-	-
	Late grain filling	0.28	-	-
	Maturity	-	0.43	NS

What period should be covered

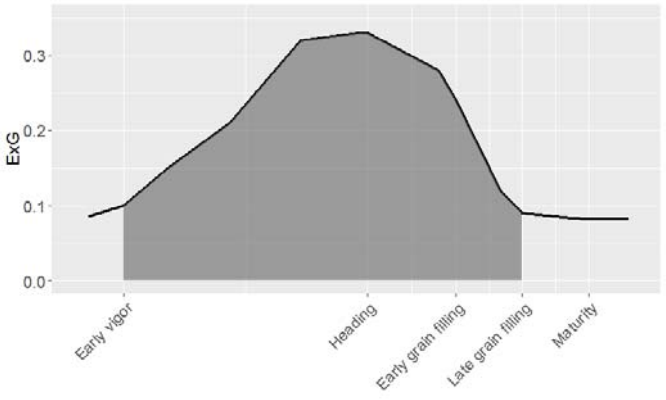
Early vigor – Maturity



Grain filling

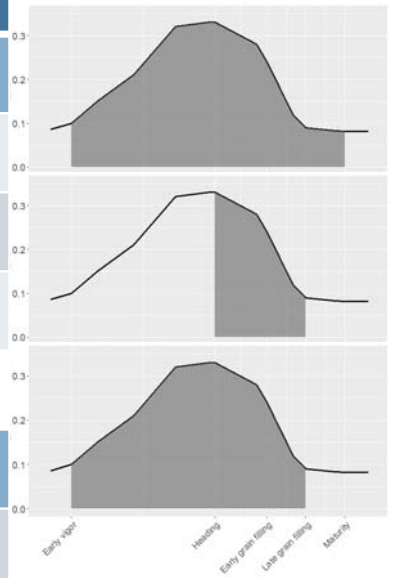


Early vigor – Grain filling



Correlations for different AUVIC

		Large plots		Small plots
2 Row	Growth period	2018	2019	2019
	Early vigor – maturity	0.43	**0.35**	**0.27**
	Grain filling	**0.44**	0.33	0.25
	Early vigor - grain filling	0.35	0.28	0.22
6 Row	Growth period	2018	2019	2019
	Early vigor – maturity	0.31	**0.50**	NS
	Grain filling	**0.32**	0.47	NS
	Early vigor - grain filling	0.29	0.43	NS



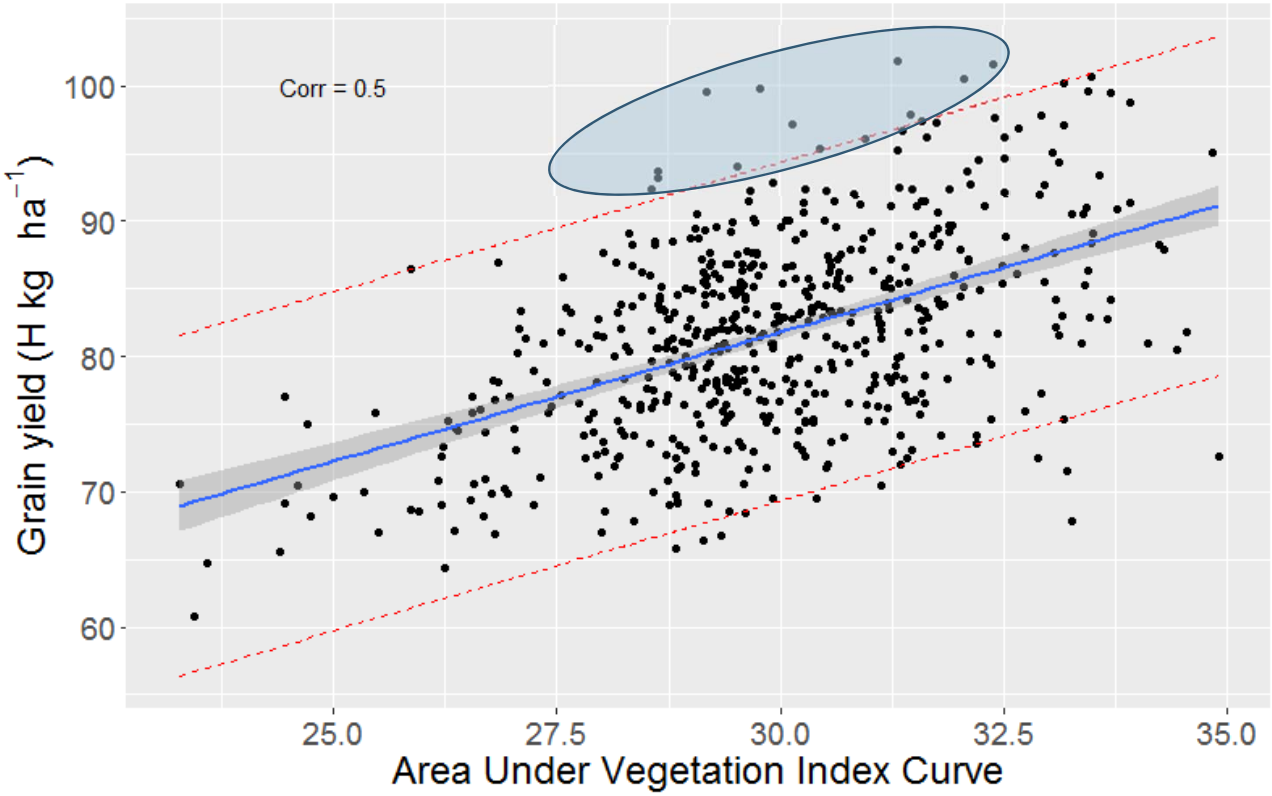
Heritability

Broad sense heritability:

$$H^2 = \frac{V_G}{V_G + V_E + V_R}$$

	Large plots		Small plots
	2018	2019	2019
Yield	0.15	0.28	0.24
AUVIC	0.26	0.32	0.15

The "outliers"



Conclusion

- Advantages of the AUVIC
  - Biological interpretation
    - Stay green
    - Accumulated biomass
  - Less dependent on time to collect data
  - Consistent correlations
  - Prediction accuracy competing with genomic prediction
- AUVIC based on other indices
  - NDVI
  - ExGR
- Is calibration necessary for AUVIC?

References

- Gizaw, Shiferaw A., Kimberly Garland-Campbell, and Arron H. Carter. "Evaluation of agronomic traits and spectral reflectance in Pacific Northwest winter wheat under rain-fed and irrigated conditions." *Field Crops Research* 196 (2016): 168-179.

- Kross, Angela, et al. "Assessment of RapidEye vegetation indices for estimation of leaf area index and biomass in corn and soybean crops." *International Journal of Applied Earth Observation and Geoinformation* 34 (2015): 235-248.