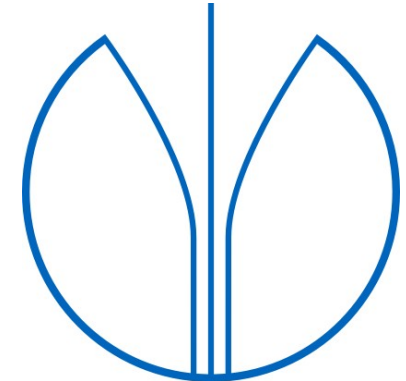


Phenotyping Wheat in Heat- and Drought-stressed Environments Using UAVs

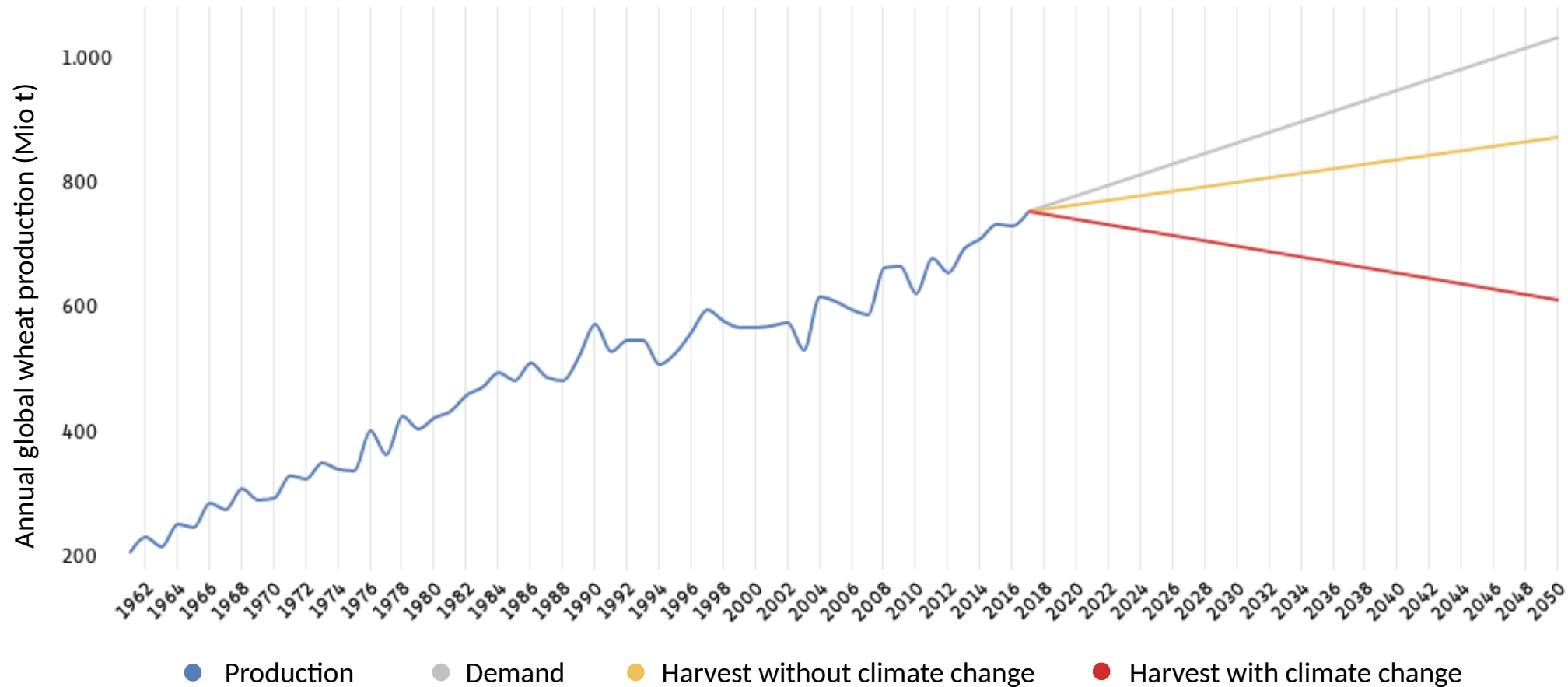


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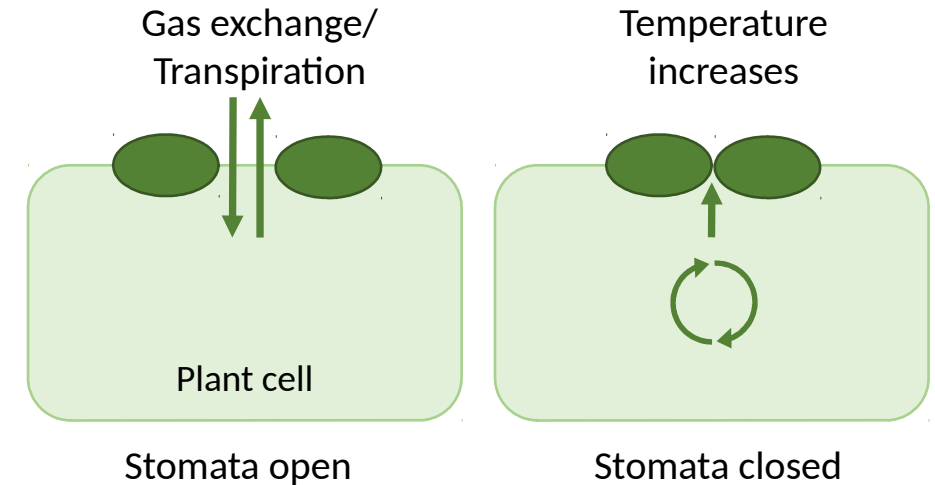
Challenges in Wheat Production

Modified from: F.A.Z / Quellen: FAO; International Wheat Genom Sequencing Consortium (IWGSC); Wheat Initiative



Effects of drought stress on wheat

- Optimum temperature 20-25°C
- Drought stress:
 - Stomata close \Rightarrow decrease in photosynthesis
 - Reduced dry matter accumulation and growth
 - Reduced number, size and weight of grains
 - Yield losses



Field Trial

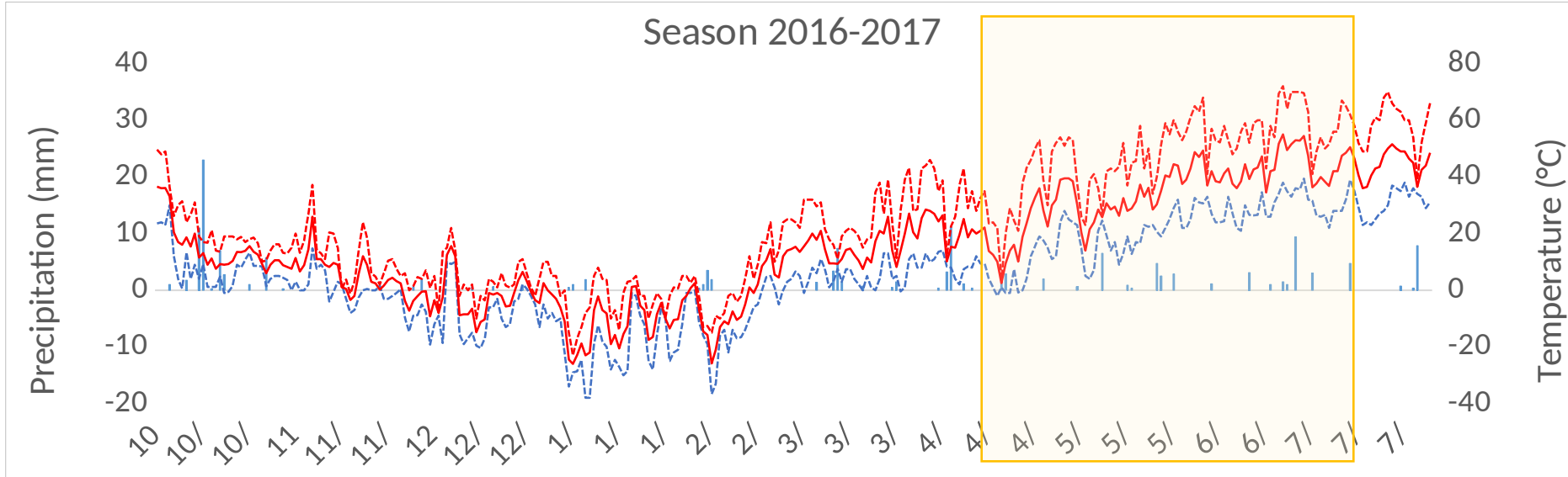


	Bălți	Freising
Latitude	47.46	48.24
Longitude	27.56	11.44
Soil texture	Clay loam	Silt loam
Ø Precipitation	530 mm	800 mm
Ø Temperature	14.1 °C	7.5 °C
Ø Precipitation in summer	200 mm	350 mm
Ø Temperature in summer	18.5 to 21 °C	13.5 °C

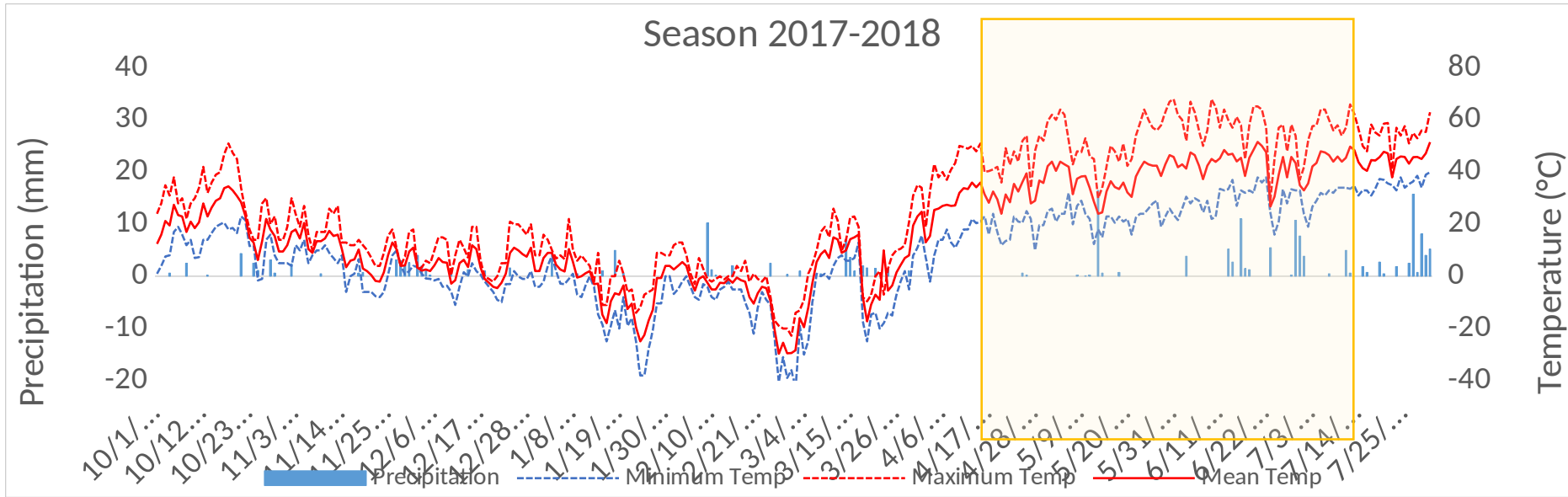
Field Trial

- Plants
 - 40 winter wheat varieties
 - 20 German: 16 lines, 4 hybrids
 - 20 Eastern European
 - 3 Replicates
- Aims
 - Find genetic resources for heat- and drought-stress resistance
 - Evaluation of the usage of drones for high-throughput phenotyping





2017	
Mean Temperature	20.4
Sum Precipitation	63.0



2018	
Mean Temperature	20.2
Sum Precipitation	143.3

Materials and Methods

Non-destructive measurements



<http://www.cetm.com.sg/mywp/wp-content/uploads/Fluke-Ti400-Thermal-Imager-CETM.jpg>

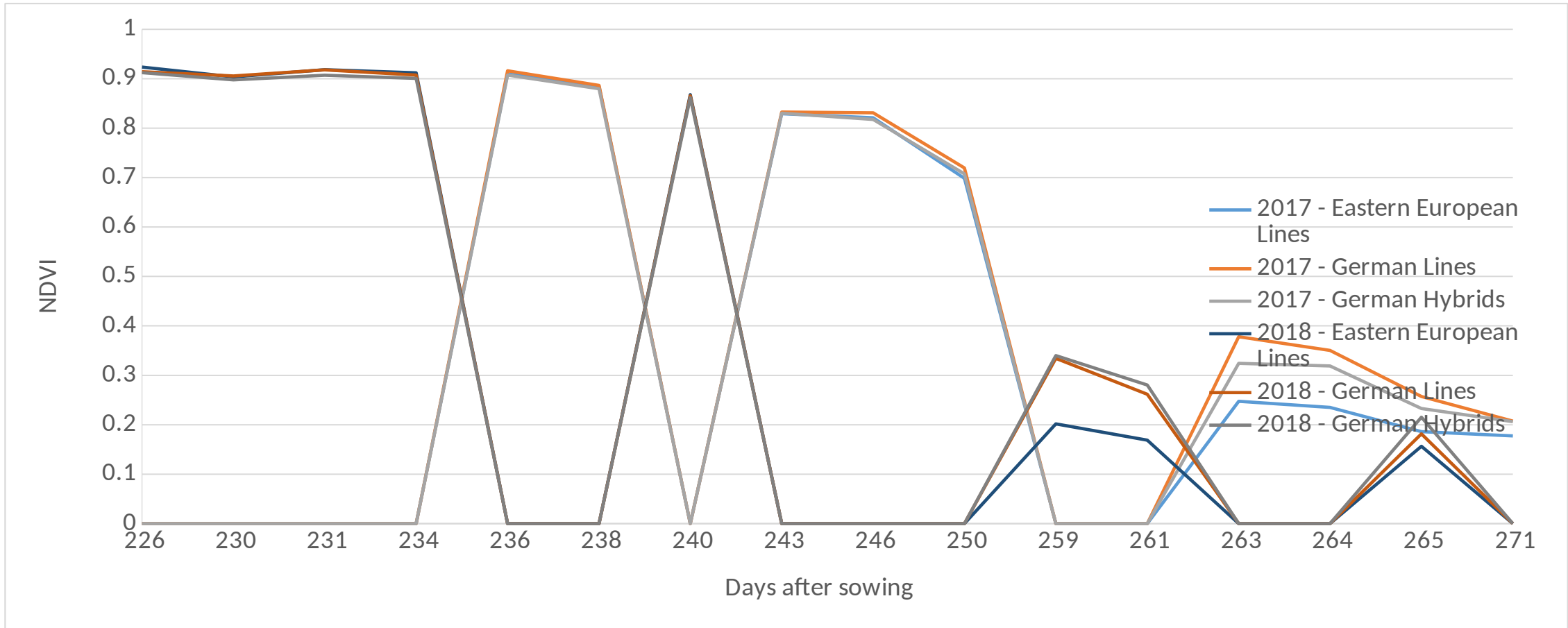


http://dronereview.com/wp-content/uploads/2016/11/810x400xBee-Plus-Left-810x400.png.pagespeed.ic.ZHqv15V6_.png

	Handheld		Drone	
	Thermal	Spectral	Thermal	Spectral
	Fluke	Handyspec	thermoMAP	Sequoia
Resolution	320 x 240 pixel		640 x 512 pixel	
Wavelength		400-1100 nm		Green (550nm), Red (660nm), Red-edge (735nm), NIR (790nm)

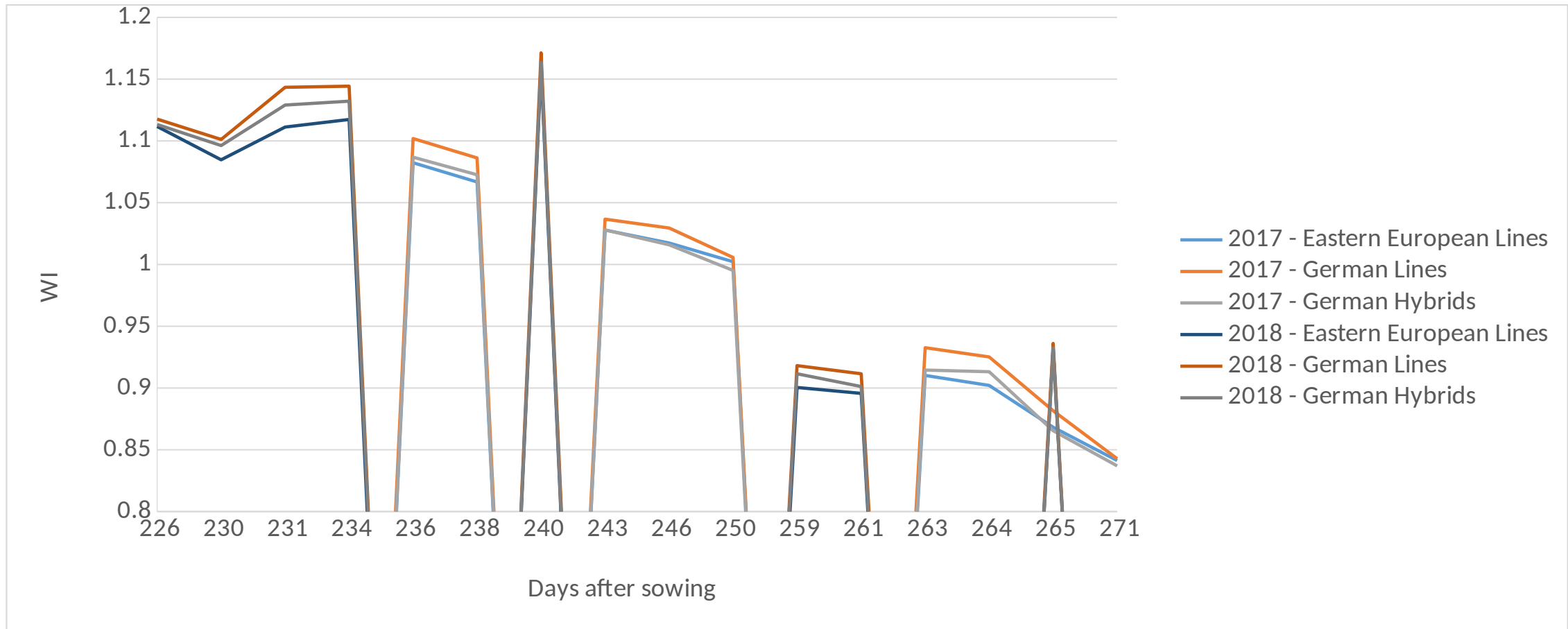
Normalized Differenced Vegetation Index

$$NDVI = \frac{NIR - Red}{NIR + Red}$$

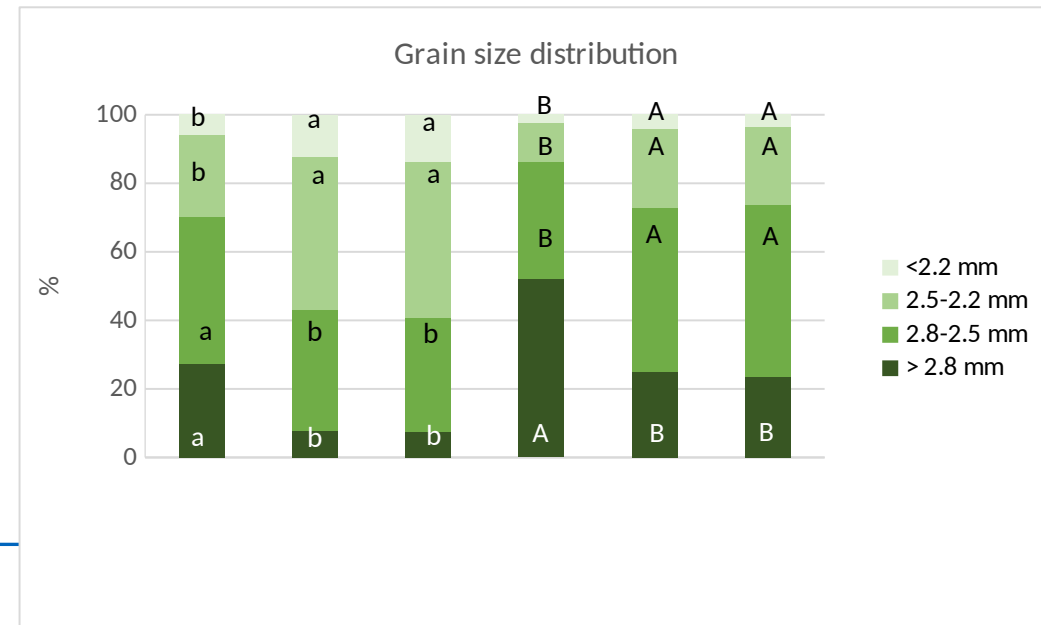
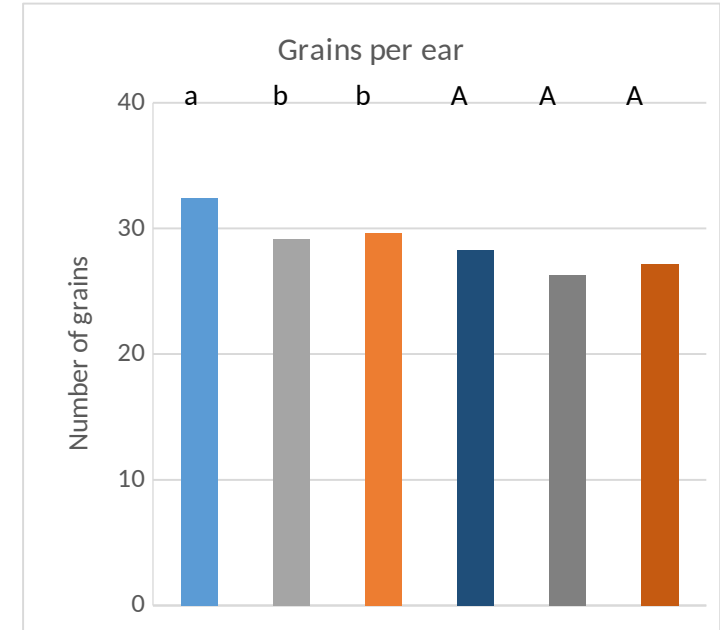
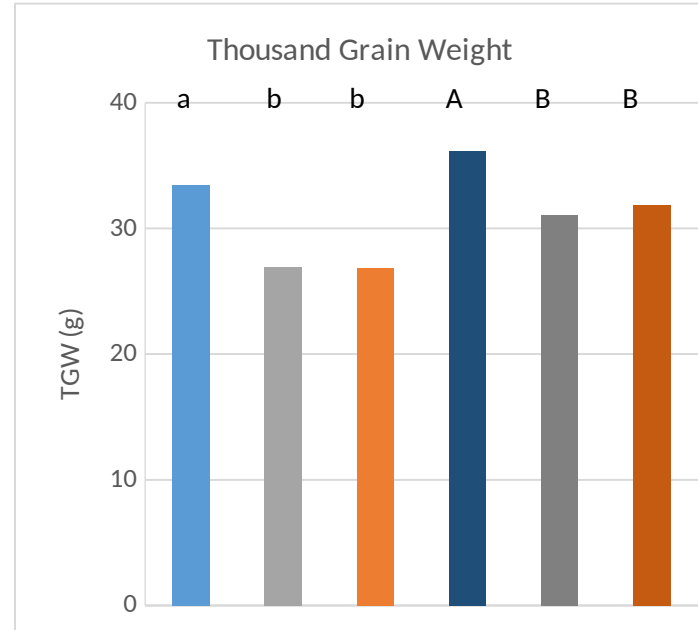
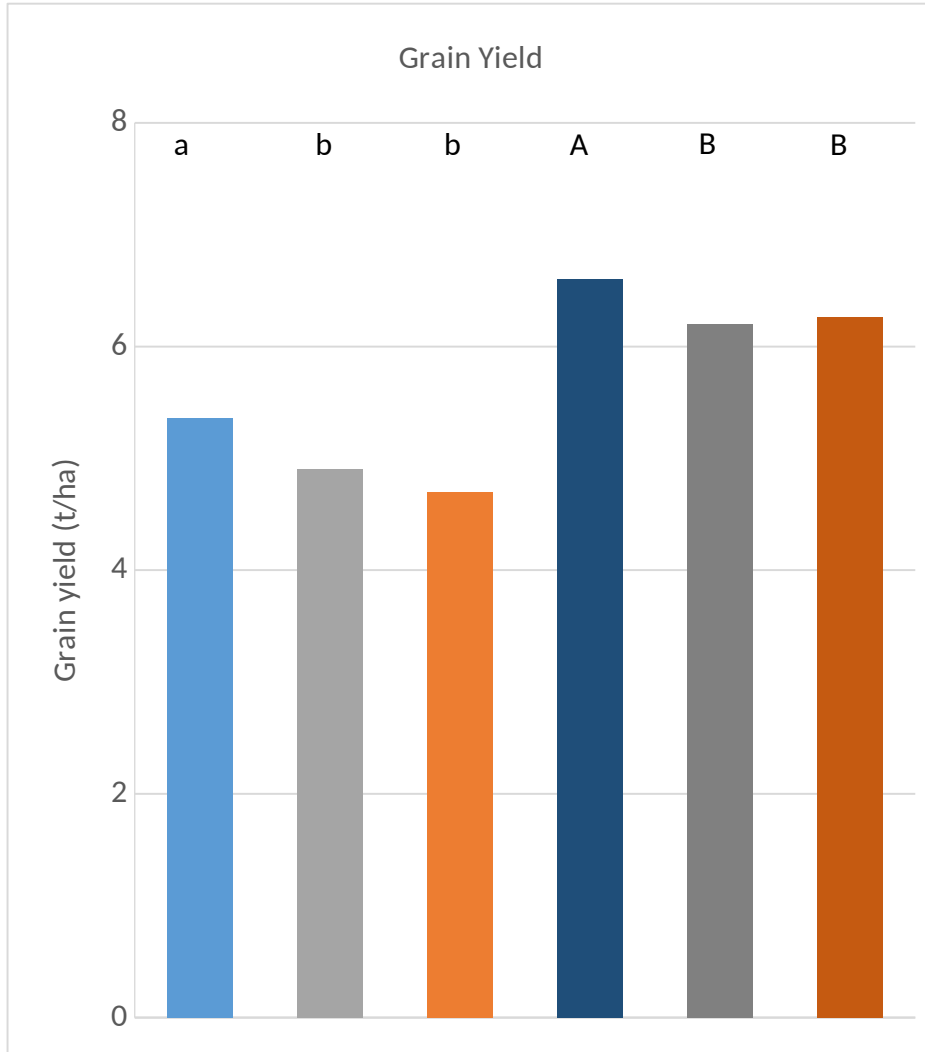


Water Index

$$WVI = \frac{R_{900}}{R_{970}}$$



Harvest parameters



Correlation of grain yield and spectral/thermal measurements

2017

Days after sowing	236	243	250	261	264	271
NDVI	0.10	0.08	-0.19*		-0.68*	-0.53*
WI	-0.18	-0.08	0.01		-0.47*	-0.16
Fluke		-0.16	0.04	-0.11		0.06

2018

Days after sowing	230	234	240	254	259	265
NDVI	0.25*	0.28*	0.17		-0.38*	-0.05
WI	0.10	0.03	0.23*		-0.34*	-0.26
Fluke	-0.09	-0.12	0.05	0.10	0.02	
NDVI eBee			0.32*	-0.30*		
Temperature eBee			-0.05	-0.05		

Conclusions

- Drones to support phenotypical measurements
- Eastern European varieties have advantages
- Hybrids suffer less than German lines in droughty conditions
- Rainfall at anthesis is advantageous for German lines
 - Drought has higher impact than heat
- Phenotyping under realistic conditions helps to identify tolerant varieties for future breeding



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