Supplementary Material

Article

Monitoring Agronomic Parameters of Winter Wheat Crops with Low-Cost UAV Imagery

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File_S1.csv. The data of the extracted image variables and the crop parameter are given as a semicolon-separated data file.

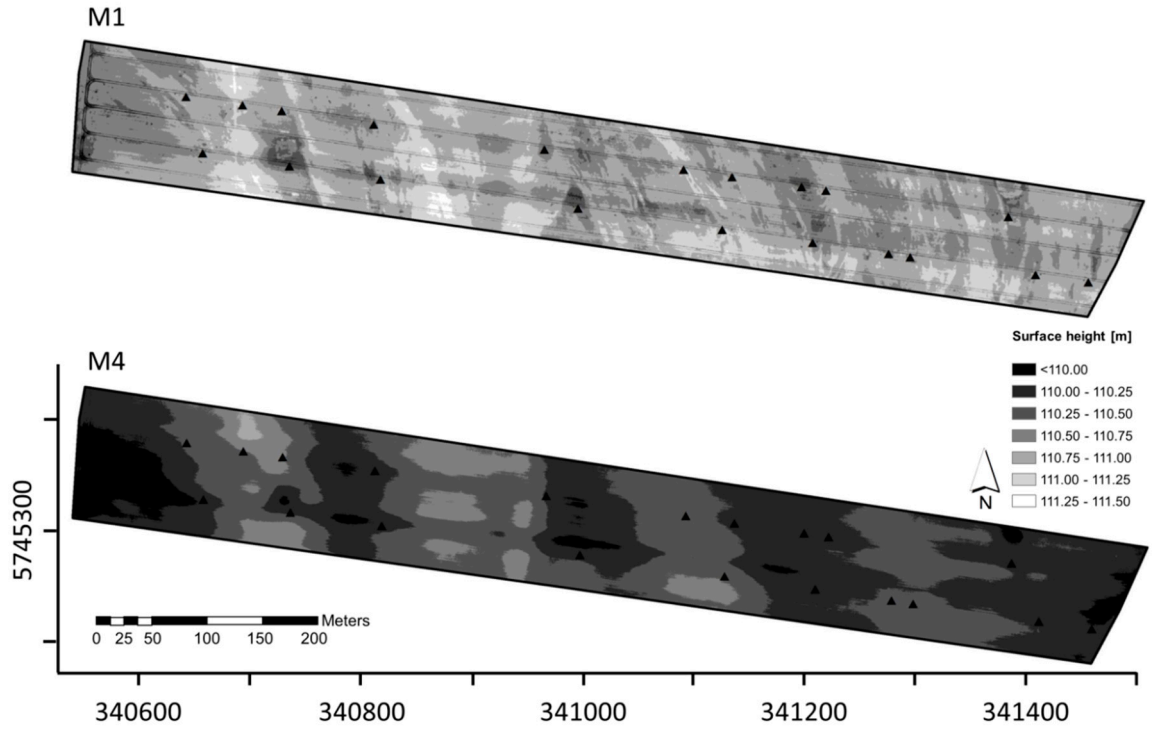

Figure S1. Surface models derived from UAV images with 60% overlap. M1 shows the wheat canopy heights at BBCH 41-47, and M4 shows the surface heights of the tilled soil.

Table S1. Results of research studies relating UAV imagery with some agronomic parameters of wheat crops.

Target	Sensor	Total Area of Remote Sensing (ha)	VI/model	Altitude (m)	Coefficient of Determination (R^2)	Reference
biomass (t/ha)	RGB-Camera	0.073	RGBVI RGBVI (hyperspectral) Crop surface model (CSM) Plant height model (CSH)	60 60 13...16 13...16	0 0.09 up to 0.64 0.62	Possoch et al., 2016 [33]
biomass (kg/ha)	Fabry-Perot-Camera (FPI)	2.926	NDVI	140	0.59	Honkavaara et al., 2013 [32]
biomass (kg/ha)	Fabry-Perot-Camera	0.005	FVA NDVI	140*	0.81 (R) 0.63	Pölönen et al., 2013 [31]
biomass (kg/m²)	RGB-Camera	0.114	CSM	186	up to 0.72	Bendig et al., 2014 [30]
Grain yield	CropScan FieldSpec 3 HyperSpex	0.416	powered partial least squares (PPLS)	1.5 1.5 1000	0.98 0.96 0.95	Overgaard et al., 2010 [39]
total nitrogen (uptake)	RGB-Camera	0.048	NDVI	50	0.93	Caturegli et al., 2016 [40]
total nitrogen (uptake)	Greenseeker	0.00008	NDVI	1.5	0.91	
total nitrogen	Hyperspectrometer RGB-Camera	1.638	NDVI DVI R/(R+G+B)	>50	0.44 0.43 0.76	Yunxia et al., 2005 [41]
total nitrogen	Fabry-Perot-Camera	0.005 0.005	NDVI FVA	140*	0.69 (R not R^2) 0.72 (R not R^2)	Pölönen et al., 2013 [31]
total nitrogen (uptake)	RGB-Camera	0.255	(G)NDVI	20...100	0.92	Lelong et al., 2008 [35]
LAI	Hyperspectrometer/ LiCor	0.0004	difference spectral index (DSI) RSI NDSI (similar to NDVI)	1.3	0.8 0.7 0.6	Tanaka et al., 2015 [37]
LAI	NIR-GREEN-BLUE camera	10	NDVI	210	0.85	Hunt et al., 2015 [34]
LAI	RGB-Camera	0.19	SfM model	100...200	0.57	Mathews et al., 2013 [36]
LAI	RGB-Camera	not specified	GAI	150	0.98	Verger et al., 2011 [38]
LAI	RGB-Camera	0.255	NDVI	20...100	0.82	Lelong et al., 2008 [35]

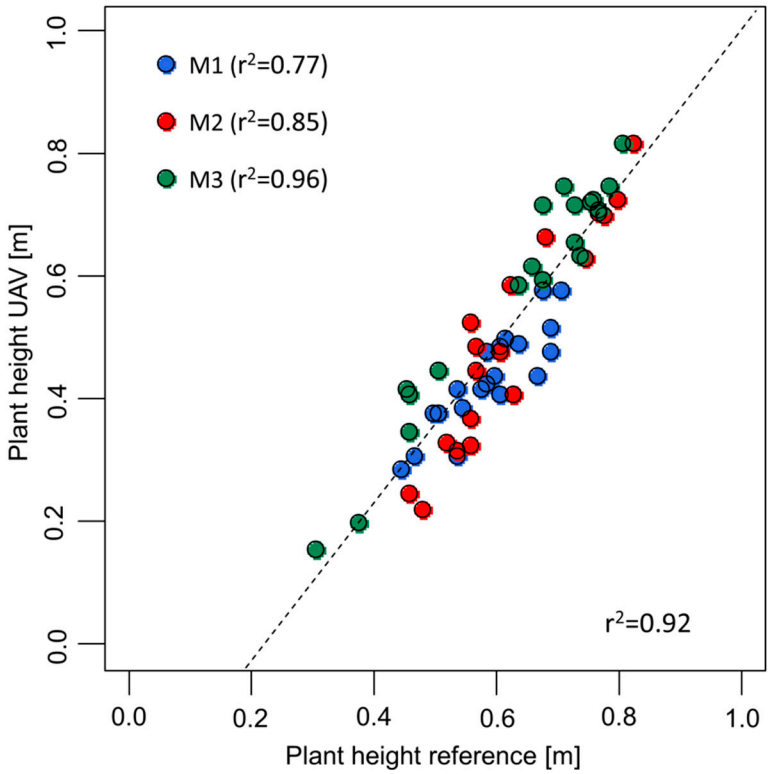

Figure S2. Scatter plot of the plant heights calculated from the surface models and the plant height measurements at the reference plots. Data were pooled from M1-3. The correlation coefficient (Pearson) was significant at $p < 0.001$.

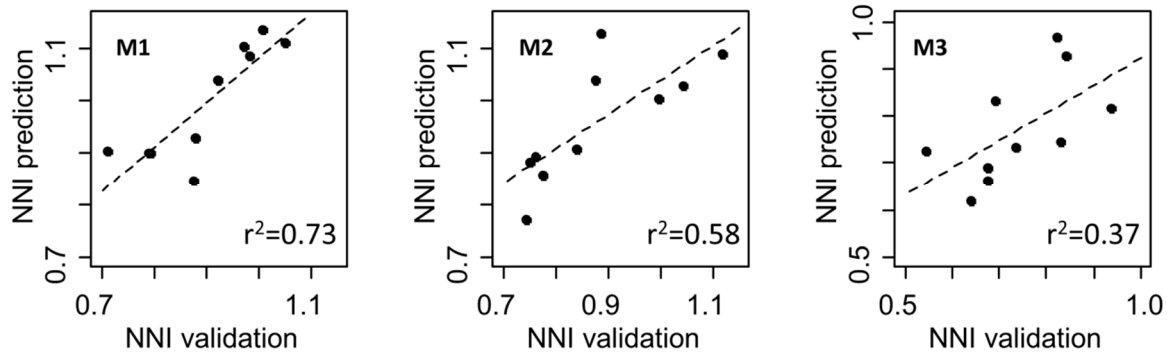

Figure S3. Scatter plots of the predictions and validations for the nitrogen nutrition index (NNI).

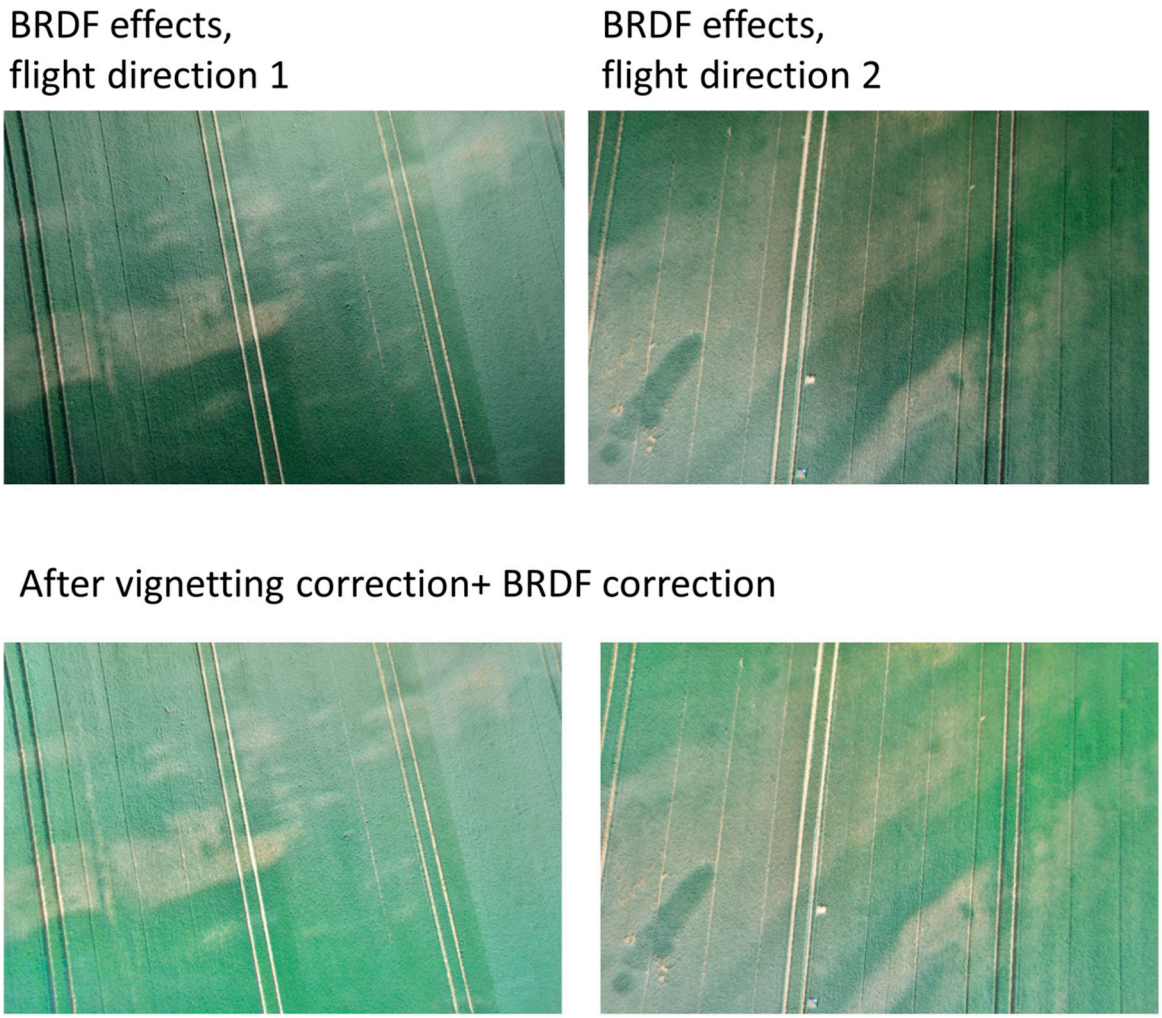

Figure S4. UAV TIFF images before (top) and after pre-processing (bottom).

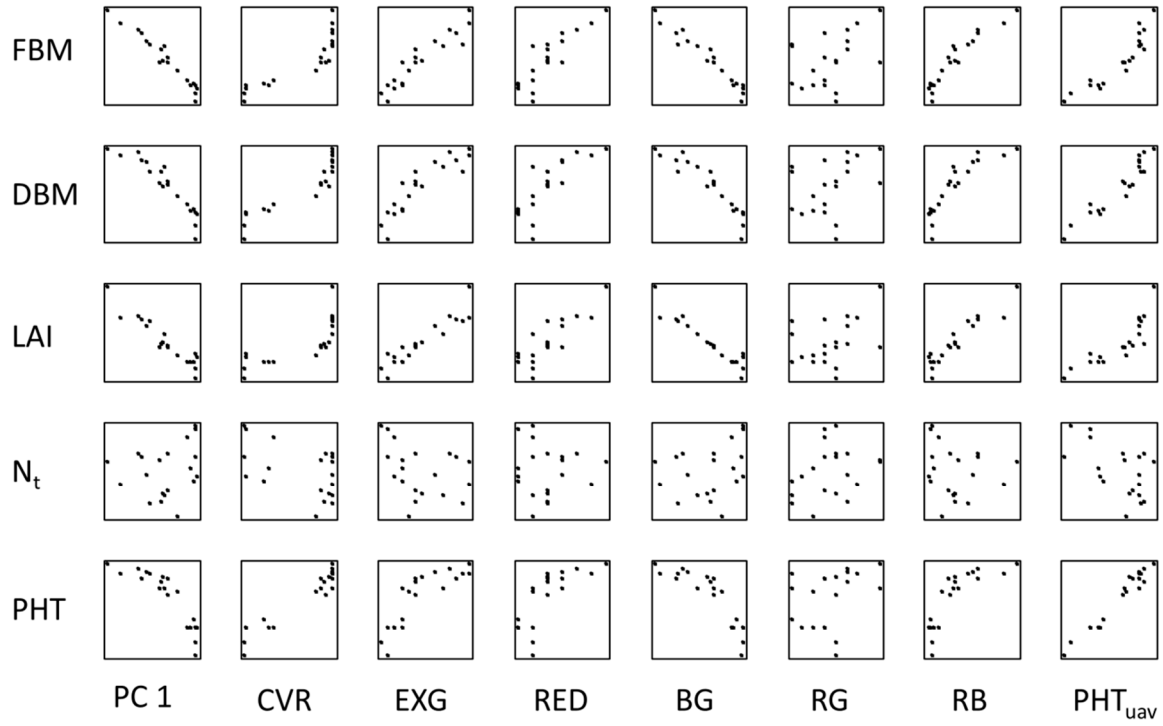

Figure S5. Scatter plot matrix showing the relationship between the image variables and PC 1 with the crop parameters.