

Supplementary Materials: Applying RGB- and thermal-based vegetation indices from UAVs for high-throughput field phenotyping of drought tolerance in forage grasses

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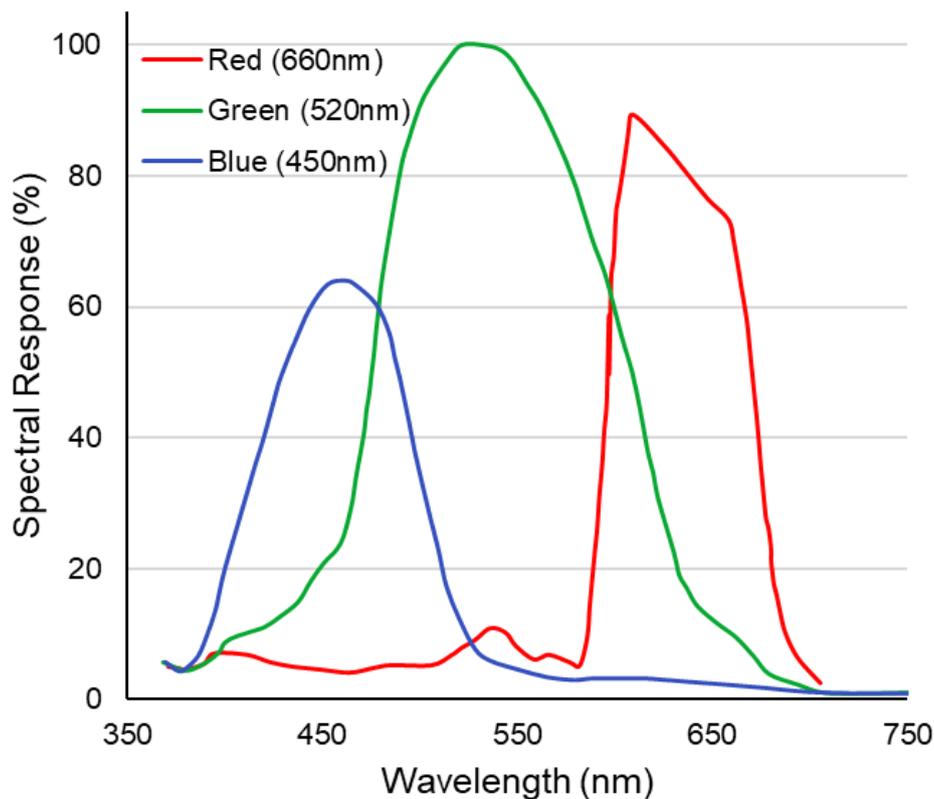


Figure S1. Spectral response of the RGB camera (Canon S110) used in this study, after [1].

1 References

1. De Kock, M.; Gallacher, D. *From drone data to decisions: Turning images into ecological answers*; 2016. doi:10.13140/RG.2.1.3587.8169.

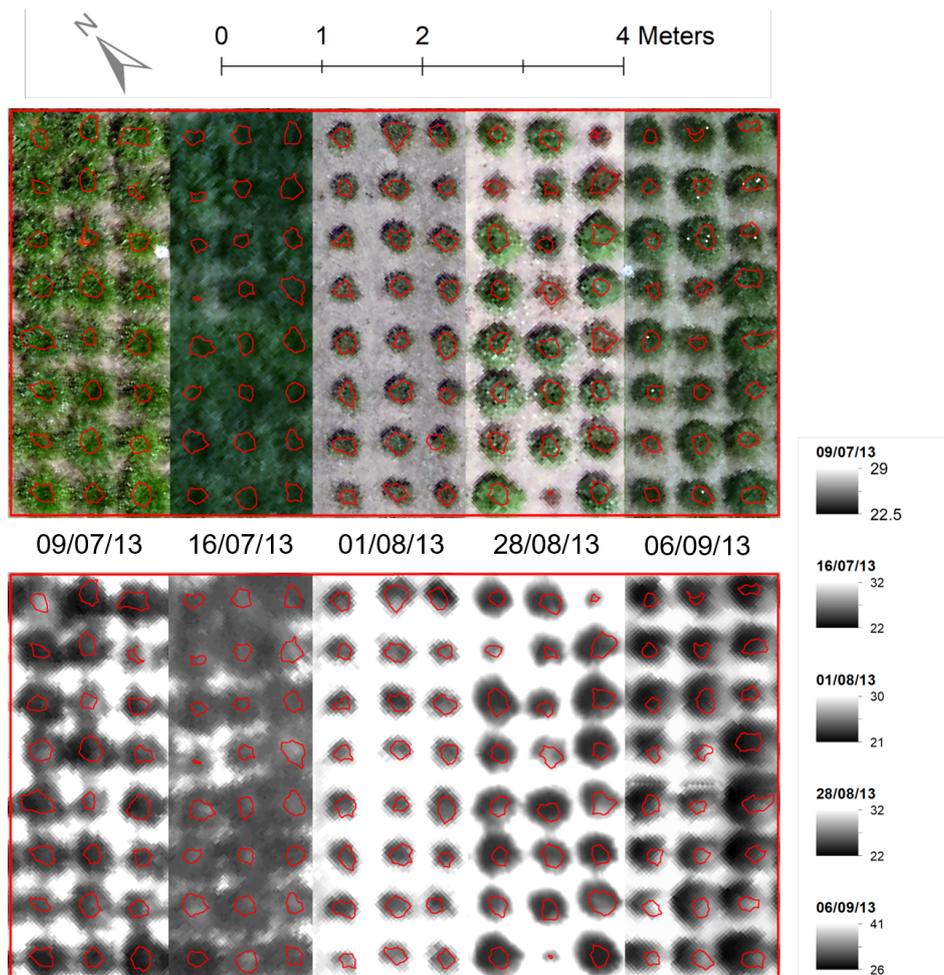


Figure S2. Detailed view of the Lp2-block (indicated by the thick, dark-red line) of the middle row (see also Figure 1, main text) for the five different time points and for the RGB orthophoto (above) and surface temperature orthophoto (below). The red polygons illustrate the plant polygons in this block used for the data analyses.

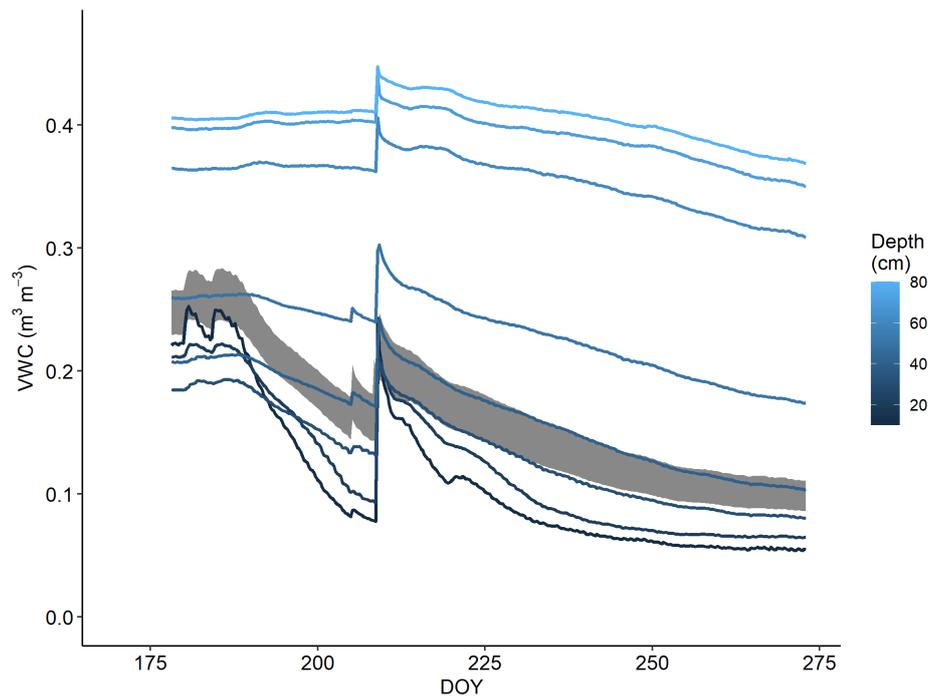


Figure S3. Volumetric Water Content (VWC) for different soil depths (from 10 to 80 cm). Blue lines are the mean of three sensors (one in each rainout shelter). The grey shaded area represents the 95% confidence interval on the VWC data of the 18 sensors monitoring the 10-40 cm soil profile (see Figure 2).

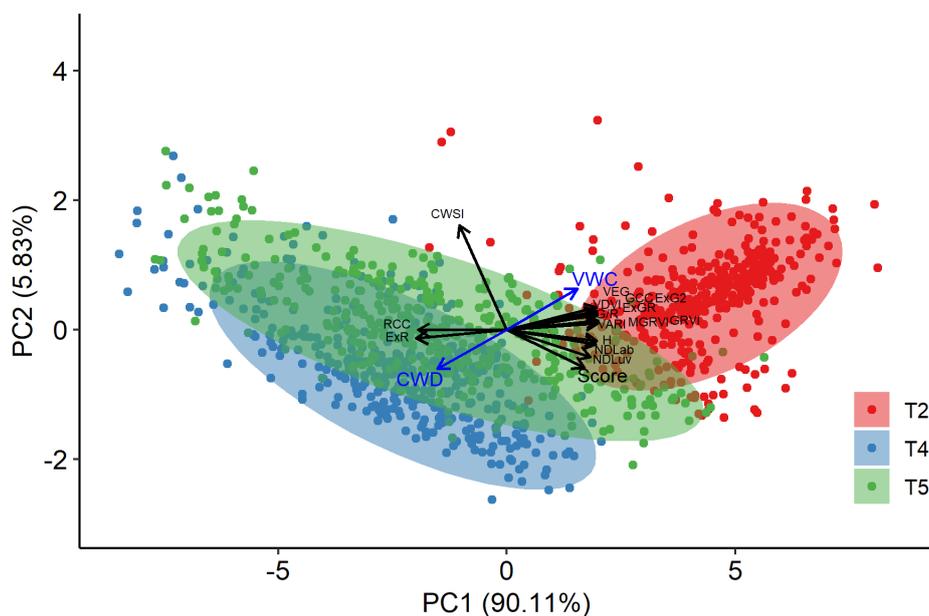


Figure S4. Two first principal component axes of the Principal Component Analysis (PCA) performed on the individual genotype values per day for the breeder scores and the indices *RCC*, *ExR*, *GCC*, *ExG2*, *G/R*, *GRVI*, *MGRVI*, *VARI*, *VDVI*, *VEG*, *H*, *NDLab*, and *CWSI*. Dots display the projected mean values per genotype and per time point (T2, T4 and T5). The Cumulative Water Deficit (CWD) and Volumetric Water Content (VWC) data are presented as a quantitative supplementary variable, but were not used for the PCA.

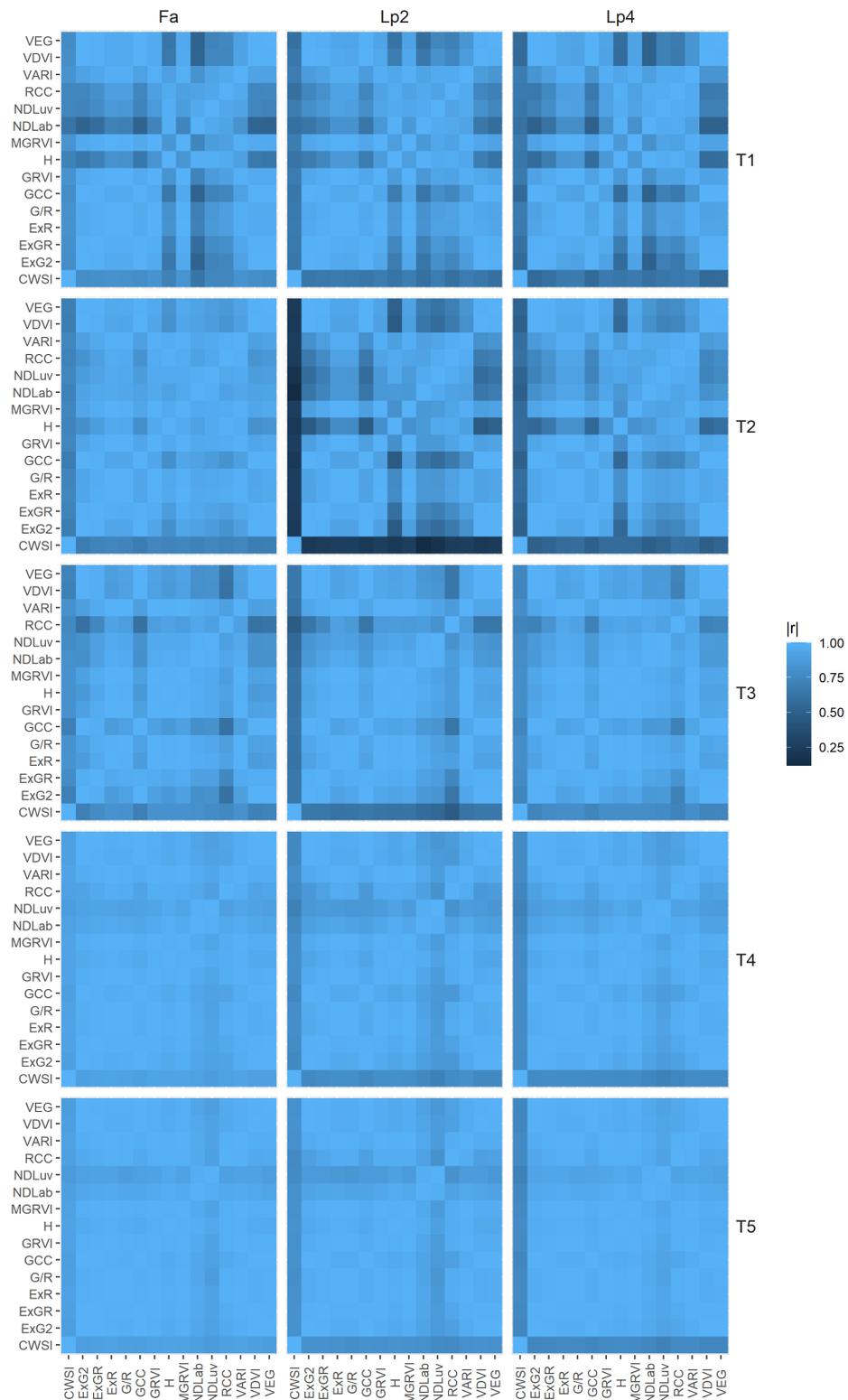


Figure S5. Absolute values of Pearson correlations ($|r|$) between selected vegetation indices for five time points (T1 - T5) and for all species (Fa: *Festuca arundinacea*, Lp2: diploid *Lolium perenne*, Lp4: tetraploid *Lolium perenne*).

Table S1. Pearson correlations between all 37 indices and the breeder score for the individual species (Fa: *Festuca arundinacea*; Lp2: diploid *Lolium perenne*; Lp4: tetraploid *Lolium perenne*), and all species pooled together (All), and for the individual time points (T2, T4, T5) and all time points pooled together (All).

	Fa				Lp2				Lp4				All			
R	-0.42	-0.75	-0.75	-0.47	-0.14	-0.6	-0.62	-0.43	-0.33	-0.69	-0.62	-0.31	-0.33	-0.67	-0.65	-0.42
G	-0.22	-0.42	-0.51	-0.34	0.02	0.07	-0.05	-0.3	-0.22	-0.02	-0.15	-0.19	-0.15	-0.21	-0.29	-0.29
B	-0.24	-0.62	-0.64	-0.4	-0.01	-0.39	-0.47	-0.37	-0.26	-0.47	-0.4	-0.25	-0.2	-0.5	-0.52	-0.35
RCC	-0.61	-0.87	-0.86	-0.83	-0.43	-0.87	-0.85	-0.74	-0.45	-0.84	-0.84	-0.78	-0.49	-0.86	-0.82	-0.78
GCC	0.48	0.85	0.84	0.78	0.25	0.8	0.85	0.73	0.42	0.79	0.8	0.73	0.35	0.79	0.8	0.74
BCC	0.14	-0.31	-0.16	-0.14	0.1	-0.27	-0.34	-0.32	-0.01	-0.23	-0.09	-0.14	0.05	-0.26	-0.23	-0.21
ExG	0.21	0.77	0.66	0.03	0.24	0.83	0.83	0.06	0.07	0.79	0.85	0.16	0.2	0.77	0.75	0.08
ExG2	0.48	0.85	0.84	0.78	0.25	0.8	0.85	0.73	0.42	0.79	0.8	0.73	0.35	0.79	0.8	0.74
ExR	-0.58	-0.88	-0.87	-0.83	-0.37	-0.87	-0.87	-0.75	-0.46	-0.85	-0.85	-0.78	-0.44	-0.86	-0.83	-0.78
ExGR	0.53	0.87	0.86	0.81	0.3	0.84	0.86	0.74	0.44	0.82	0.83	0.76	0.39	0.83	0.82	0.76
GRVI	0.58	0.88	0.87	0.83	0.38	0.87	0.87	0.75	0.46	0.85	0.85	0.78	0.45	0.85	0.83	0.78
GBVI	0.17	0.69	0.68	0.57	0.04	0.61	0.69	0.62	0.23	0.59	0.59	0.55	0.15	0.61	0.64	0.58
BRVI	0.49	0.53	0.65	0.59	0.33	0.45	0.39	0.44	0.3	0.44	0.6	0.57	0.37	0.47	0.52	0.52
G/R	0.56	0.87	0.85	0.81	0.36	0.87	0.86	0.71	0.46	0.84	0.83	0.74	0.43	0.85	0.81	0.75
G-R	0.53	0.88	0.87	0.57	0.51	0.88	0.89	0.55	0.33	0.85	0.87	0.65	0.43	0.86	0.86	0.59
B-G	-0.15	0.31	-0.12	-0.23	0.06	0.64	0.53	-0.17	-0.12	0.56	0.47	-0.08	-0.05	0.46	0.22	-0.17
VDVI	0.48	0.85	0.85	0.79	0.26	0.81	0.85	0.74	0.42	0.79	0.81	0.74	0.36	0.8	0.81	0.75
VARI	0.59	0.88	0.87	0.84	0.42	0.87	0.88	0.76	0.46	0.85	0.85	0.78	0.47	0.86	0.83	0.79
MGRVI	0.58	0.88	0.87	0.84	0.39	0.87	0.87	0.76	0.46	0.85	0.85	0.78	0.46	0.85	0.83	0.79
CIVE	-0.17	-0.73	-0.6	0.03	-0.23	-0.83	-0.81	-0.01	-0.04	-0.78	-0.84	-0.1	-0.17	-0.75	-0.72	-0.02
VEG	0.49	0.85	0.83	0.77	0.26	0.81	0.84	0.7	0.42	0.8	0.8	0.72	0.36	0.8	0.79	0.73
WI	0.59	-0.01	-0.03	0	0.44	0.01	-0.05	-0.02	0.31	-0.01	-0.01	0.01	0.46	0	-0.03	0
H	0.62	0.89	0.88	0.87	0.46	0.87	0.89	0.82	0.43	0.86	0.86	0.83	0.51	0.87	0.86	0.84
S	0.18	0.63	0.58	0.51	0.05	0.54	0.57	0.57	0.24	0.51	0.45	0.48	0.16	0.53	0.53	0.52
V	-0.22	-0.5	-0.57	-0.36	0.02	-0.1	-0.24	-0.32	-0.22	-0.18	-0.29	-0.21	-0.15	-0.32	-0.39	-0.31
I	-0.29	-0.58	-0.62	-0.39	-0.03	-0.23	-0.3	-0.34	-0.26	-0.35	-0.37	-0.23	-0.21	-0.43	-0.45	-0.33
L	-0.25	-0.53	-0.58	-0.37	0	-0.14	-0.23	-0.33	-0.24	-0.25	-0.3	-0.22	-0.18	-0.36	-0.4	-0.32
a*	-0.4	-0.85	-0.82	-0.34	-0.34	-0.87	-0.88	-0.34	-0.16	-0.84	-0.87	-0.44	-0.31	-0.84	-0.84	-0.37
b*	-0.21	0.02	-0.37	-0.32	0.01	0.46	0.29	-0.26	-0.2	0.36	0.08	-0.17	-0.12	0.24	-0.07	-0.26
ab	-0.1	-0.77	-0.63	-0.07	-0.15	-0.82	-0.8	-0.06	0.05	-0.76	-0.84	-0.17	-0.1	-0.76	-0.73	-0.09
NDLab	0.56	0.86	0.86	0.84	0.27	0.81	0.87	0.81	0.4	0.84	0.84	0.82	0.44	0.84	0.84	0.82
u*	-0.41	-0.88	-0.84	-0.55	-0.33	-0.88	-0.89	-0.51	-0.14	-0.86	-0.86	-0.61	-0.32	-0.86	-0.85	-0.56
v*	-0.22	0.03	-0.41	-0.3	0.02	0.54	0.23	-0.25	-0.19	0.45	0.06	-0.15	-0.13	0.28	-0.11	-0.24
uv	-0.16	-0.85	-0.77	-0.33	-0.18	-0.87	-0.85	-0.24	0.01	-0.84	-0.85	-0.38	-0.15	-0.84	-0.81	-0.32
NDLuv	0.6	0.82	0.83	0.82	0.37	0.73	0.81	0.78	0.39	0.8	0.81	0.81	0.48	0.78	0.8	0.8
dT	-0.56	-0.76	-0.71	-0.65	-0.25	-0.58	-0.67	-0.59	-0.38	-0.32	-0.56	-0.5	-0.41	-0.55	-0.6	-0.57
CWSI	-0.56	-0.77	-0.71	-0.64	-0.25	-0.59	-0.67	-0.59	-0.36	-0.31	-0.56	-0.32	-0.4	-0.55	-0.6	-0.52
	T2	T4	T5	All												