



Supplementary Materials

Table S1. ANOVA results of the origin (D, HU, UK) and cycling history effects on the F₁₃ and F₁₄ winter wheat CCPs in 2014/15 (Neu-Eichenberg, Germany), including mean squares (MS) and significance levels (*p<0.05, **p<0.01, ***p<0.001). Significant effects are marked in bold.

	Df	Yield	HI	RAUDPC	TKW	Ears_m ²
		MS	MS	MS	MS	MS
Origin	2	0.096	0.002**	0.004***	14.03***	762
Cycling	1	0.029	0.000	0.001	2.32	1774
Gen	1	0.026	0.000	0.000	5.43*	108
Origin*Cycling	2	0.238	0.001*	0.003**	1.98	1927
Origin*Gen	2	0.191	0.000	0.001	1.77	5522*
Cycling*Gen	1	0.045	0.000	0.001	1.74	9900*
Origin*Cycling*Gen	2	0.113	0.000	0.001	3.33*	4827
Rep	3	0.896***	0.001*	0.011***	0.86	12489***
Residual	73	0.099	0.000	0.000	0.99	1669

	Df	Kernel no.	Protein	Awne ears	Stem length	Ear length
		MS	MS	MS	MS	MS
Origin	2	11.30	0.087	5.76	23.75	0.048
Cycling	1	0.06	0.006	11.12	19.61	0.120
Gen	1	3.05	0.132	2.49	21.15	0.002
Origin*Cycling	2	6.49	0.488	200.44***	4.41	0.036
Origin*Gen	2	7.51	0.125	4.20	3.31	0.048
Cycling*Gen	1	10.74	0.020	1.31	3.82	0.407
Origin*Cycling*Gen	2	19.90*	0.042	3.36	13.68	0.348*
Rep	3	4.52	0.098	0.75	15.88	0.221
Residual	73	4.59	0.203	13.64	13.24	0.106

Table S2. Yield (t/ha), HI, RAUDPC, TKW (g), ear-bearing tillers/m² (Ears_m2), kernel number per ear (Kernel no.), protein content (%), percentage of ears with awns (Awned ears (%)), stem length (cm) and ear length (cm) of the F₁₃ and F₁₄ winter wheat CCP entries in the experimental years 2014/15 (Neu-Eichenberg, Germany). Differing small letters indicate significant differences between CCP entries within each year. Differing capital letters indicate significant differences between the means of the experimental years.

	Yield (t/ha)		HI		RAUDPC		TKW (g)		Ears_m ²	
	F ₁₃	F ₁₄	F ₁₃	F ₁₄	F ₁₃	F ₁₄	F ₁₃	F ₁₄	F ₁₃	F ₁₄
D13NC	4.1 ab	4.1	0.38 ab	0.37 a	0.14 ab	0.10	45.7 c	44.2	367	462
DK13	4.5 b	4.4	0.40 abc	0.39 abc	0.09 a	0.10	45.0 bc	45.9	428	388
HU13	4.1 ab	4.4	0.38 a	0.39 abc	0.12 ab	0.10	44.4 abc	45.6	412	427
TUM13	4.3 ab	4.4	0.38 ab	0.39 abc	0.11 ab	0.11	46.1 c	45.4	439	441
HU13NC	4.2 ab	4.2	0.40 abc	0.40 abc	0.17 b	0.15	43.3 ab	44.8	417	418
F13	4.3 ab	4.2	0.41 abc	0.42 c	0.12 ab	0.12	45.0 bc	44.7	434	373
UK13	4.4 ab	4.1	0.39 abc	0.39 abc	0.12 ab	0.13	44.7 bc	45.6	431	388
UK13NC	4.3 ab	4.2	0.41 bc	0.41 bc	0.09 a	0.11	44.1 abc	44.2	435	441
CH13	3.9 ab	4.2	0.39 abc	0.38 ab	0.12 ab	0.13	44.7 bc	44.6	392	407
D13	3.7 a	4.2	0.39 abc	0.37 a	0.12 ab	0.11	42.5 a	44.5	414	402
NL13	4.4 ab	4.4	0.42 c	0.40 bc	0.11 ab	0.13	42.9 ab	44.2	400	448
Mean	4.2	4.2	0.40	0.39	0.12	0.12	44.4 A	44.9 B	415	417
	Kernel no.		Protein (%)		Awned ears (%)		Stem length (cm)		Ear length (cm)	
	F ₁₃	F ₁₄	F ₁₃	F ₁₄	F ₁₃	F ₁₄	F ₁₃	F ₁₄	F ₁₃	F ₁₄
D13NC	27 ab	22 a	9.7	9.8	11 c	10 bc	89.9 ab	87.8 ab	7.68	7.08 a
DK13	27 ab	28 b	9.5	9.5	3 a	4 ab	88.4 ab	90.3 ab	7.49	7.88 b
HU13	23 a	25 ab	9.5	9.6	10 bc	10 bc	85.7 ab	89.6 ab	7.33	7.56 ab
TUM13	25 ab	25 ab	10.0	9.9	9 bc	6 abc	91.3 b	91.8 ab	7.44	7.58 ab
HU13NC	26 ab	26 ab	10.0	9.7	12 c	11 c	86.6 ab	88.0 ab	7.51	7.61 ab
F13	25 ab	28 b	9.9	9.3	2 a	4 a	83.9 a	86.7 a	7.51	7.77 ab
UK13	26 ab	26 ab	9.7	9.8	10 bc	8 abc	92.0 b	88.3 ab	7.56	7.45 ab
UK13NC	27 ab	27 b	9.7	9.4	3 a	5 ab	86.8 ab	88.3 ab	7.59	7.47 ab
CH13	25 ab	24 ab	10.1	9.8	15 c	11 c	90.7 ab	89.6 ab	7.65	7.56 ab
D13	26 ab	25 ab	10.1	10.1	10 bc	11 c	91.5 b	94.1 b	7.71	7.77 ab
NL13	29 b	26 ab	9.5	9.7	5 ab	8 abc	84.1 a	87.4 ab	7.50	7.35 ab
Mean	26	26	9.8	9.7	7	7	88.3	89.2	7.54	7.55

Table S3. ANOVA results of the origin (D, HU, UK) and cycling history effects on the F₁₃ winter wheat CCPs of 2013/14 and 2014/15 (Neu-Eichenberg), including mean squares (MS) and significance levels (*p<0.05, **p<0.01, ***p<0.001). Significant effects are marked in bold.

	Df	Yield	HI	RAUDPC	TKW	Ears_m ²
		MS	MS	MS	MS	MS
Origin	2	0.22	0.001	0.003***	19.5***	1318
Cycling	1	0.03	0.000	0.001	1.03	4517
Year	1	5.86***	0.000	0.098***	8.32*	47
Origin*Cycling	2	0.68*	0.000	0.002**	14.16***	2703
Origin*Year	2	0.16	0.000	0.000	1.11	6366*
Cycling*Year	1	0.02	0.000	0.001	0.66	96
Rep(Year)	6	0.69***	0.001***	0.003***	5.85**	9802***
Origin*Cycling*Year	2	0.15	0.000	0.001	3.39	4494
Residual	70	0.15	0.000	0.000	1.73	1509

	Df	Kernel no.	Protein	Awne ears	Stem length	Ear length
		MS	MS	MS	MS	MS
Origin	2	5.95	0.17	3.92	10.00	0.04
Cycling	1	3.04	0.00	9.72	4.78	0.04
Year	1	317.01***	0.10	0.17	723.29***	16.89***
Origin*Cycling	2	0.70	0.59*	296.91***	5.20	0.15
Origin*Year	2	5.31	0.08	5.61	8.00	0.04
Cycling*Year	1	1.65	0.01	0.86	0.08	0.01
Rep(Year)	6	9.35*	1.33***	14.57	48.03	0.27***
Origin*Cycling*Year	2	2.30	0.06	2.44	14.66	0.02
Residual	70	3.50	0.18	19.78	22.55	0.06

Table S4. Yield (t/ha), HI, RAUDPC, TKW (g), ear-bearing tillers/m² (Ears_m2), kernel number per ear (Kernel no.), protein content (%), percentage of ears with awns (Awned ears (%)), stem length (cm) and ear length (cm) of the F₁₃ winter wheat CCP entries in the experimental years 2013/14 and 2014/15 (Neu-Eichenberg, Germany). Differing small letters indicate significant differences between CCP entries within each year. Differing capital letters indicate significant differences between the means of the experimental years.

	Yield (t/ha)		HI		RAUDPC		TKW (g)		Ears_m ²	
	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15
D13NC	4.9 ab	4.1	0.39 a	0.38 ab	0.05 ab	0.14 ab	45.9 c	45.7 bc	399	367
DK13	5.0 b	4.5	0.41 ab	0.40 abc	0.04 a	0.09 a	44.9 bc	45.0 abc	442	428
HU13	4.5 ab	4.1	0.40 ab	0.38 a	0.06 ab	0.12 ab	43.3 abc	44.4 abc	396	412
TUM13	4.9 ab	4.3	0.39 a	0.38 ab	0.04 a	0.11 ab	44.1 abc	46.1 c	420	439
HU13NC	4.3 ab	4.2	0.40 ab	0.40 abc	0.07 ab	0.17 b	41.7 a	43.3 ab	389	417
F13	4.6 ab	4.3	0.40 ab	0.41 abc	0.05 ab	0.12 ab	43.3 ab	45.0 abc	379	434
UK13	4.9 ab	4.4	0.39 a	0.39 ab	0.08 b	0.12 ab	45.0 bc	44.7 abc	397	431
UK13NC	5.0 b	4.3	0.40 ab	0.41 bc	0.04 ab	0.09 a	42.7 ab	44.1 abc	407	435
CH13	4.8 ab	3.9	0.39 ab	0.39 abc	0.05 ab	0.12 ab	45.2 bc	44.7 abc	442	392
D13	4.2 a	3.7	0.38 a	0.39 abc	0.06 ab	0.12 ab	43.4 abc	42.5 a	453	414
NL13	4.7 ab	4.4	0.43 b	0.42 c	0.04 a	0.11 ab	42.0 a	42.9 a	425	400
Mean	4.7 B	4.2 A	0.39	0.40	0.05 A	0.12 B	43.8 A	44.4 B	414	415
	Kernel no.		Protein (%)		Awned ears (%)		Stem length (cm)		Ear length (cm)	
	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15	2013/14	2014/15
D13NC	29 ab	27 bc	9.6	9.7	11 cd	11 bc	92.2 abc	89.9 ab	8.56	7.68
DK13	31 ab	27 bc	9.6	9.5	1 a	3 a	93.2 abcd	88.4 ab	8.48	7.49
HU13	29 ab	23 a	9.6	9.5	7 abcd	10 bc	91.6 abc	85.7 ab	8.13	7.33
TUM13	29 ab	25 ab	9.9	10.0	11 cd	9 abc	97.1 bcd	91.3 ab	8.55	7.44
HU13NC	30 ab	26 abc	10.1	10.0	14 d	12 bc	94.5 bcd	86.6 ab	8.44	7.51
F13	32 b	25 ab	9.5	9.9	4 abc	2 a	90.0 ab	83.9 a	8.43	7.51
UK13	28 a	26 bc	9.8	9.7	9 bcd	10 bc	95.4 bcd	92.0 b	8.29	7.56
UK13NC	30 ab	27 bc	9.4	9.7	3 ab	3 a	94.1 bcd	86.8 ab	8.30	7.59
CH13	30 ab	25 ab	9.5	10.1	11 cd	15 c	99.1 cd	90.7 ab	8.51	7.65
D13	28 a	26 bc	10.2	10.1	12 cd	10 bc	100.5 d	91.5 ab	8.56	7.71
NL13	30 ab	29 c	9.5	9.5	8 bcd	5 ab	86.2 a	84.1 a	8.33	7.50
Mean	30 B	26 A	9.7	9.8	7	7	94.0 B	88.3 A	8.42 B	7.54 A

Table S5. Grain protein deviation (GPD) of the reference varieties and winter wheat CCP entries of the F₁₃ in 2013/14 and F₁₃ and F₁₄ in 2014/15 (Neu-Eichenberg, Germany). Differing small letters indicate significant differences between reference varieties and CCP entries within each year and generation.

Origin	Entry	GPD			
		2013/14		2014/15	
		F ₁₃		F ₁₃	F ₁₄
References	Achat	-0.70 a		0.41 ab	0.41 ab
	Akteur	1.99 b		1.54 b	1.54 b
	Capo	-0.58 a		-0.19 ab	-0.19 ab
D	D13NC	-0.07 a		-0.20 ab	0.03 ab
	DK13	-0.07 a		-0.50 a	-0.53 a
	HU13	-0.28 a		-0.67 a	-0.28 ab
	TUM13	0.34 ab		0.42 ab	0.23 ab
HU	HU13NC	0.65 ab		0.40 ab	-0.15 ab
	F13	-0.38 a		0.22 ab	-0.94 a
	UK13	0.24 ab		-0.25 ab	-0.01 ab
UK	UK13NC	-0.58 a		-0.21 ab	-0.76 a
	CH13	-0.29 a		0.41 ab	0.01 ab
	D13	0.79 ab		0.45 ab	0.65 ab
	NL13	-0.37 a		-0.51 a	-0.21 ab



Figure S1. Correlation coefficients (r) for various agronomic parameters for the winter wheat CCP entries over all generations and experimental years (black), of the F₁₃ in 2013/14 (red), of the F₁₃ in 2014/15 (green) and of the F₁₄ in 2014/15 (blue) (Neu-Eichenberg, Germany). Asterisks indicate significance of the correlation (*p<0.05, **p<0.01, ***p<0.001).

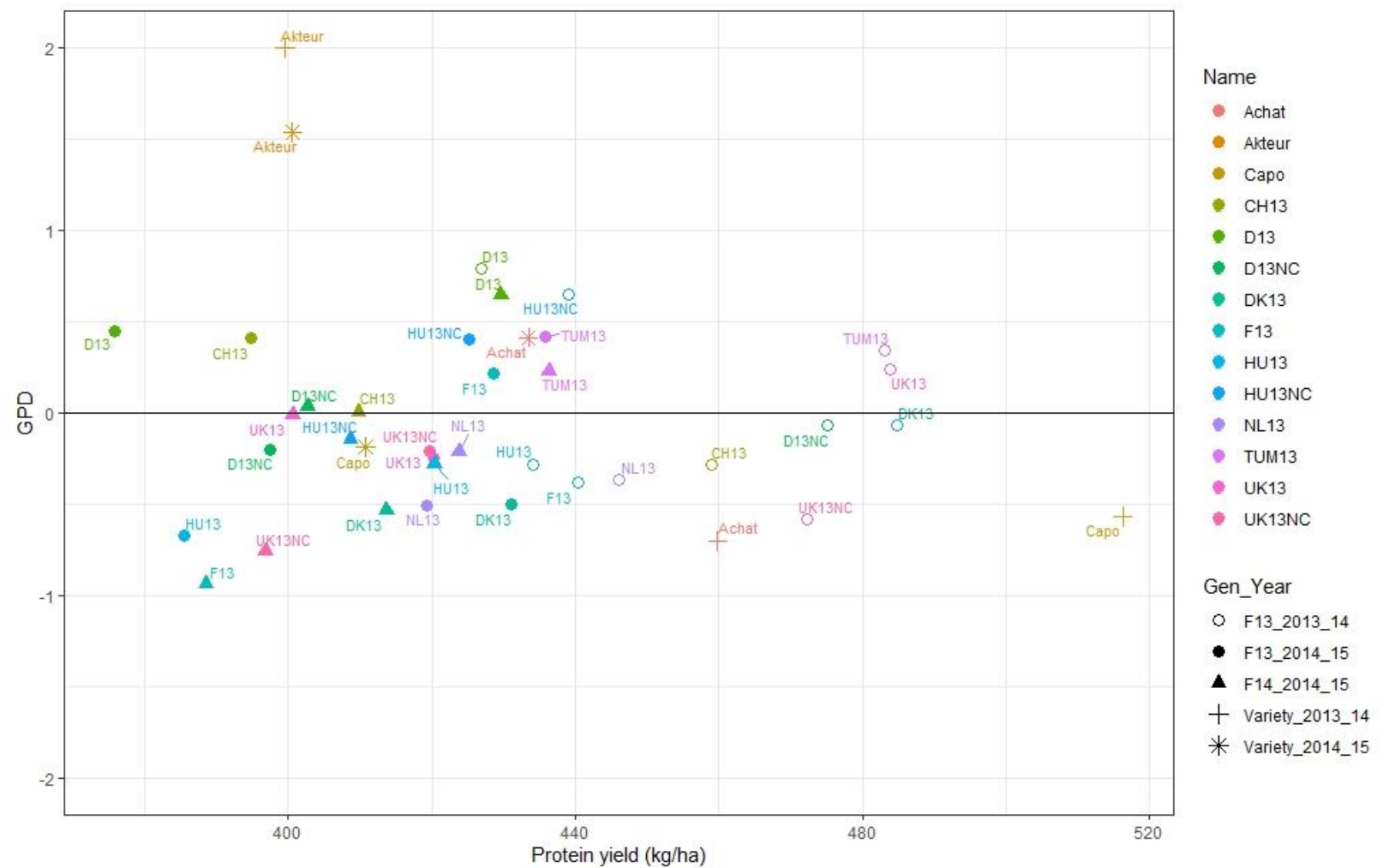


Figure S2. Grain protein deviation (GPD) and protein yield (kg/ha) of the experimental entries (winter wheat CCPs and reference varieties) in the A) F₁₃ of 2013/14 and 2014/15 and B) F₁₄ of 2014/15 (Neu-Eichenberg, Göttingen).