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RESEARCH ARTICLE

# RESPONSE OF WHEAT COMPOSITE CROSS POPULATIONS TO DISEASE AND CLIMATE VARIATION OVER 13 GENERATIONS

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## SUPPLEMENTARY MATERIALS

**Table S1** Estimated mean area under the disease progress curve (AUDPC) and relative AUDPC (RAUDPC) in 2009 and 2015, as well as yield (t·ha<sup>-1</sup>) and TGW (g) in 2015 for all parental cultivars and their respective grouping (Q, Y and YQ parental cvs) under organic practices

Group	Cultivar	2008/2009				2014/2015							
		AUDPC	RAUDPC	Rank	SD	AUDPC	RAUDPC	Rank	SD	Yield	SD	TGW	SD
YQ	Bezostaya	739	0.67	19	0.08	283	0.14	18	0.05	4.03		51.0	1.60
Q	Cadenza	276	0.25	8	0.05	154	0.08	13	0.02	4.20		44.8	0.50
Q	Hereward	278	0.25	9	0.07	154	0.08	14	0.03	4.34		48.1	0.30
Q	Maris Widgeon	338	0.31	12	0.15	75	0.04	5	0.00	3.65		51.2	0.60
Q	Mercia	831	0.76	20	0.13	46	0.02	2	0.00	4.79		43.2	0.80
Q	Monopol	545	0.50	17	0.17	100	0.05	9	0.01	3.52		47.7	0.10
Q	Pastiche	232	0.21	7	0.08	32	0.02	1	0.00	3.91		45.8	1.10
Q	Renan	131	0.12	2	0.06	89	0.04	7	0.00	2.39		56.2	0.20
Q	Renesansa	406	0.37	14	0.10	135	0.07	12	0.02	3.60		46.7	0.90
Q	Soissons	382	0.35	13	0.05	109	0.05	10	0.01	4.22		46.1	0.10
Q	Spark	71	0.06	1	0.05	53	0.03	3	0.00	4.26		40.8	2.00
Q	Thatcher	226	0.21	6	0.03	428	0.21	19	0.10	3.36		43.3	0.00
Y	Buchan	294	0.27	11	0.13	181	0.09	16	0.02	4.29		47.4	1.10
Y	Claire	189	0.17	4	0.11	109	0.05	11	0.00	4.73		46.9	0.40
Y	Deben	440	0.40	16	0.18	98	0.05	8	0.01	5.00		49.4	0.10
Y	High Tiller Line	416	0.38	15	0.06	54	0.03	4	0.01	4.23		47.0	0.10
Y	Norman	283	0.26	10	0.13	-	-	-	-	-		-	-
Y	Option	577	0.52	18	0.14	237	0.12	17	0.03	4.65		41.5	0.50
Y	Tanker	213	0.19	5	0.13	180	0.09	15	0.02	4.41		48.6	1.10
Y	Wembley	164	0.15	3	0.06	87	0.04	6	0.00	2.12		48.5	1.10
Mean Q		371	0.34	3	0.22	138	0.07	2	0.04	3.86	0.60	47.1	4.10
Mean Y*		368	0.33	2	0.20	154	0.08	3	0.05	4.18	0.90	47.5	2.80
Mean YQ*		352	0.32	1	0.20	137	0.07	1	0.06	3.98	0.80	47.0	3.60

Note: \*High yielding parental variety Norman not included in 2014/2015. Data are from unreplicated plots with multiple sampling replicates per plot. Ranking for both experimental seasons is based on AUDPC values and standard deviation (SD) on RAUDPC values. SD is also included for yield (t ha<sup>-1</sup>), as well as for TGW (g).

**Table S2** Combined foot disease index (DI), DI for *Oculimacula yallundae* (Oculim.), DI for *Fusarium* spp., and DI for *Ceratobasidium cereale* (Cerato.) within each experimental season for the organic and conventional CCPs and reference cultivars

Entry	Combined foot DI									DI for Oculim.									DI for <i>Fusarium</i>									DI for Cerato.										
	2008/2009	2009/2010	2010/2011	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018	Mean	2008/2009	2009/2010	2010/2011	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018	Mean	2008/2009	2009/2010	2010/2011	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018	Mean	2008/2009	2009/2010	2010/2011	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018	Mean		
<b>Organic</b>																																						
Achat	29.1	33.7	26.8	20.7	14.6	29.1	37.1	41.7	29.1	21.5	19.8	10.1	8.7	4.3	27.1	26.3	39.3	19.6	6.9	13.8	16.7	11.3	9.6	1.3	10.3	2.3	9.0	0.8	0.0	0.0	0.8	0.7	0.7	0.5	0.0	0.4		
Akteur	-	-	-	22.6	9.0	-	-	-	-	-	-	-	8.5	2.1	-	-	-	-	-	-	-	13.5	6.2	-	-	-	-	-	-	-	0.6	0.7	-	-	-	-		
Astaro	-	36.6	25.8	-	-	-	-	-	-	-	29.0	9.2	-	-	-	-	-	-	-	7.6	15.8	-	-	-	-	-	-	-	0.0	0.8	-	-	-	-	-	-		
Batis	28.4	30.5	21.3	-	-	-	-	-	-	18.2	14.0	6.9	-	-	-	-	-	-	9.8	16.6	14.4	-	-	-	-	-	-	0.4	0.0	0.0	-	-	-	-	-	-		
Bussard	22.0	-	-	-	-	-	-	-	-	15.4	-	-	-	-	-	-	-	-	6.0	-	-	-	-	-	-	-	-	0.6	-	-	-	-	-	-	-	-		
Butaro	-	-	-	17.7	11.4	31.6	-	29.6	-	-	-	-	5.7	3.0	27.1	-	25.3	-	-	-	-	11.8	8.0	4.2	-	3.1	-	-	-	-	0.2	0.4	0.3	-	1.1	-		
Capo	20.4	21.7	20.6	21.2	18.6	42.6	46.9	32.9	28.1	15.5	12.4	9.0	8.6	11.5	36.3	42.1	29.6	20.7	4.8	9.1	11.6	12.3	6.8	5.9	2.1	3.3	6.9	0.0	0.2	0.0	0.3	0.3	0.4	1.7	0.0	0.4		
Naturastar	-	-	-	21.7	12.9	-	-	-	-	-	-	-	5.7	2.4	-	-	-	-	-	-	-	15.6	7.7	-	-	-	-	-	-	-	0.5	2.8	-	-	-	-		
Poesie	-	-	-	-	-	-	35.8	-	-	-	-	-	-	-	-	21.6	-	-	-	-	-	-	-	-	13.8	-	-	-	-	-	-	-	-	0.2	-	-		
Scaro	-	-	-	24.7	12.9	-	-	-	-	-	-	-	13.6	2.3	-	-	-	-	-	-	-	10.3	8.6	-	-	-	-	-	-	-	0.8	1.9	-	-	-	-		
Skagen	-	23.6	23.8	-	-	-	-	-	-	-	9.9	7.9	-	-	-	-	-	-	-	13.6	15.9	-	-	-	-	-	-	-	0.2	0.0	-	-	-	-	-	-		
Tamaro	16.7	29.5	19.2	-	-	-	-	-	-	7.3	16.9	8.4	-	-	-	-	-	-	8.9	12.0	10.8	-	-	-	-	-	-	0.6	0.6	0.0	-	-	-	-	-	-		
Tobias	-	-	-	-	-	-	40.7	-	-	-	-	-	-	-	-	33.9	-	-	-	-	-	-	-	-	6.9	-	-	-	-	-	-	-	-	0.0	-	-		
Wiwa	-	-	-	-	21.1	28.1	45.6	36.8	-	-	-	-	-	3.5	17.4	34.6	29.9	-	-	-	-	-	17.6	9.5	10.2	5.8	-	-	-	-	-	0.0	1.3	0.8	1.1	-		
OQI	36.9	28.7	31.6	21.8	24.2	29.1	50.9	41.7	33.1	26.1	16.5	11.8	10.9	8.9	12.1	41.8	33.8	20.2	8.0	11.2	18.4	10.9	15.3	17.0	9.1	6.4	12.0	2.8	1.1	1.5	0.0	0.0	0.0	0.0	1.5	0.9		
OQII	21.6	15.0	22.9	12.5	31.5	24.7	44.1	44.4	27.1	11.4	3.6	4.2	1.7	17.7	13.1	34.7	35.1	15.1	9.7	11.4	18.8	10.8	12.9	10.8	7.1	9.3	11.4	0.6	0.0	0.0	0.0	0.8	0.8	2.3	0.0	0.6		
OYI	37.0	15.6	35.4	11.1	37.9	21.7	48.1	38.5	30.7	24.5	0.6	10.4	0.0	19.7	8.8	37.5	23.7	15.6	11.5	14.4	25.0	11.1	18.2	12.8	10.0	14.1	14.6	1.0	0.6	0.0	0.0	0.0	0.0	0.5	0.7	0.3		
OYII	53.6	19.9	21.8	16.7	20.2	41.3	48.3	35.4	32.1	40.6	10.2	7.3	2.5	7.3	22.4	32.7	25.5	18.5	11.5	9.1	14.5	14.2	12.1	18.9	15.5	9.9	13.2	1.6	0.6	0.0	0.0	0.8	0.0	0.0	0.0	0.4		
OYQ I	42.9	22.3	26.5	22.1	19.2	41.8	48.0	44.3	33.4	27.2	15.2	7.6	11.0	5.8	25.7	42.0	39.4	21.7	13.0	7.0	18.9	11.0	13.3	16.0	5.9	4.8	11.3	2.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3		
OYQ II	19.4	16.2	24.3	22.9	30.0	38.9	49.2	41.2	29.1	10.6	9.6	9.0	9.7	0.8	25.4	39.9	36.3	17.7	8.8	5.9	11.8	13.2	16.1	13.5	7.7	4.8	10.2	0.0	0.7	3.5	0.0	4.0	0.0	1.5	0.0	1.2		
<b>Conventional</b>																																						
Achat	-	-	-	30.9	18.6	28.0	19.3	33.8	-	-	-	-	24.4	8.2	17.5	14.3	27.2	-	-	-	-	6.5	9.3	10.4	4.1	6.5	-	-	-	-	0.0	1.1	0.0	0.7	0.0	-		
Akteur	-	-	-	25.4	14.5	-	-	-	-	-	-	-	18.0	0.8	-	-	-	-	-	-	-	7.4	11.0	-	-	-	-	-	-	-	0.0	3.2	-	-	-	-		
Batis	-	19.4	17.4	-	-	-	-	-	-	-	12.9	9.8	-	-	-	-	-	-	-	6.5	5.2	-	-	-	-	-	-	-	0.0	2.4	-	-	-	-	-	-		
Butaro	-	-	-	44.7	9.3	41.1	18.2	34.2	-	-	-	-	41.3	1.2	20.3	15.2	30.1	-	-	-	-	3.3	6.5	19.2	2.3	4.0	-	-	-	-	0.0	1.6	1.6	0.7	0.0	-		
Capo	45.9	30.7	19.2	42.6	12.0	54.7	26.9	31.3	32.9	43.2	27.6	8.2	40.2	4.3	36.9	24.2	27.9	26.5	2.7	3.1	9.9	1.6	5.4	17.8	2.2	3.3	5.7	0.0	0.0	1.0	0.8	2.3	0.0	0.3	0.0	0.6		



**Table S3** Numerical degrees of freedom (DF), denominator degrees of freedom (DenDF), mean squares (MS), and F and *P* values from the analysis of variance for yield (t ha<sup>-1</sup>) and TGW (g) in the three wheat composite cross populations (CCP) types under organic and conventional management depending on the site

Site	Item	CCP type (yield)					CCP type (TGW)				
		DF	DenDF	MS	F value	<i>P</i> value	DF	DenDF	MS	F value	<i>P</i> value
Saurasen and Teilanger	CCP type	2	62.4	1.5	15.8	< 0.001	2	85.3	13.4	5.5	< 0.01
	Year	4	63.3	28.0	285.9	< 0.001	6	71.1	531.6	219.4	< 0.001
	System	1	62.4	24.8	253.5	< 0.001	1	85.3	292.2	120.6	< 0.001
	CCP type × Year	8	62.4	0.2	2.3	0.03	12	85.3	2.7	1.1	0.37
	CCP type × System	2	62.4	0.2	2.3	0.10	2	85.3	2.4	1.0	0.37
	Year × System	4	62.4	4.6	47.0	< 0.001	6	85.3	12.9	5.3	< 0.001
Teilanger	CCP type × Year × System	8	62.4	0.3	3.0	< 0.01	12	85.3	4.6	1.9	0.05
	CCP type	2	8.2	0.3	2.9	0.11	2	114	1.9	0.8	0.43
	Year	4	69.9	15.6	156.0	< 0.001	4	114	137.7	59.9	< 0.001
	System	1	68.5	17.2	172.1	< 0.001	1	114	102.1	44.4	< 0.001
	CCP type × Year	8	69.9	0.3	2.5	0.02	8	114	8.8	3.8	< 0.001
	CCP type × System	2	68.5	0.1	0.8	0.46	2	114	0.2	0.1	0.92
	Year × System	4	68.5	2.0	20.1	< 0.001	4	114	61.5	26.8	< 0.001
CCP Type × Year × System	8	68.5	0.1	1.3	0.25	8	114	4.8	2.1	0.05	

Note: Year represents the experimental seasons, system represents management system (organic or conventional) and CCP type represents Q\_CCP, Y\_CCP and YQ\_CCP, excluding management history.