WP 5
Prebreeding

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GeneBank 3.0

Prebreeding with genetic resources delivers promising parental lines for elite breeding in wheat

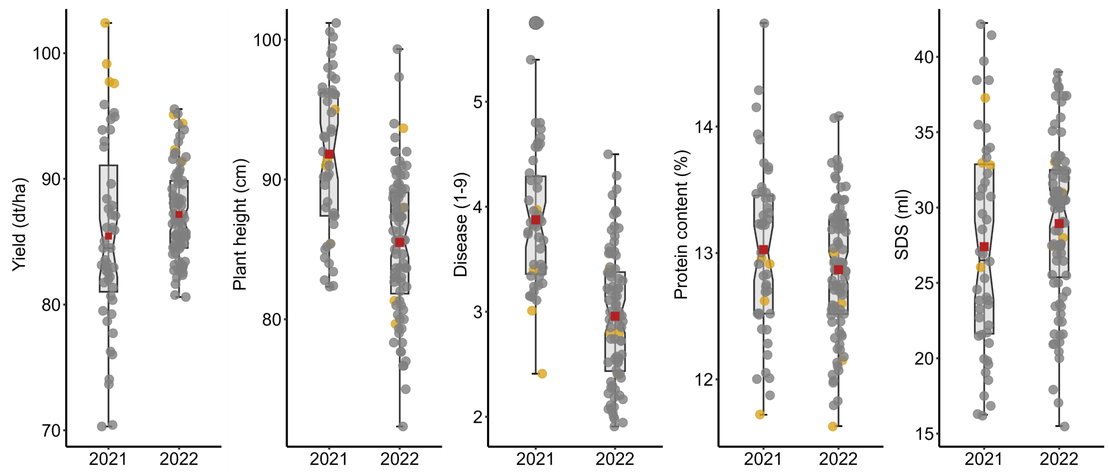
Applied breeding strategy

In the project “GeneBank”, hundreds of genetic resources are screened in the different working packages on important future traits in wheat breeding. Based on these results, most promising genetic resources are used in the prebreeding programs. As most of the genetic resources have drawbacks in several important traits, e.g. plant height or few disease resistances, we cross them to 2-3 different elite lines with differing agronomic and quality profiles (3 or 4 way cross) followed by intensive early generation selection on elite ideotype and disease resistance (Tab. 1). In F_5, first multi-location yield tests are performed coupled with multi-location observation trials and quality assessments. In parallel, molecular markers are utilized to monitor major trait markers and to estimate the amount of genetic resource still present in the prebreeding line. The aim is to finally select prebreeding lines with high genetic diversity tracking back to the genetic resource and coupled with high performance comparable to elite varieties in agronomy, disease resistance and quality. The best F_5 families are selected based on this data and 5 sub-lines per selected F_5 family are multiplied and finally tested in $F_{5:7}$.

Table 1: Applied breeding strategy (Loc = number of locations).

Time	What	Type	Loc	Traits	Markers
Year 1	A*B, C*D,…		1		
Year 2	F1 * F1		1		
Year 3	"F1"		1		
Year 4	F2	Single plant	1	height, lodging, heading, diseases	
Year 5	F3	Double row	1	height, lodging, heading, diseases	
Year 6	F4	Micro plot	1	height, lodging, heading, diseases	Major genes Rht, Ppd, Sm1, Pch1, Sbm1
Year 7	F4:5	1. yield test	5	yield, quality, diseases	Chip -> estimate % exotic in breeding line
Year 8	F5:6	Seed multi.	1	Idea: extract 5 sublines from best F4:5 families	
Year 9	F5:7	2. yield test	5	yield, quality, diseases	Chip -> estimate % exotic in breeding line

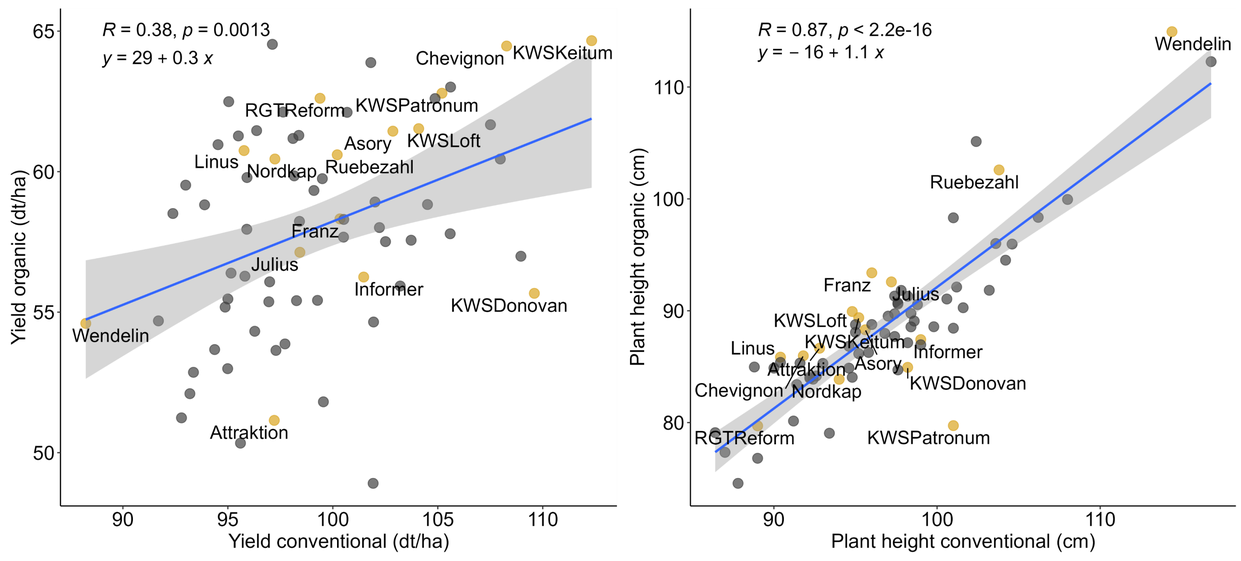
Fig. 1: Mean of the tested prebreeding lines in 2021 and 2022 for different traits. Commercial varieties are marked in golden color.



Results confirm success of applied strategy across years

The challenge in wheat breeding is to improve numerous traits from agronomy and quality in parallel. Furthermore, we have to prove that prebreeding using genetic resources can continuously deliver promising new parental lines for elite crossings. Therefore we show results of our program from 2021 – 2023 (Fig. 1 and Tab. 2). In all three years we were able to select finally few prebreeding lines using different genetic resources and elite parents, which were at the level of important commercial wheat varieties regarding yield, disease resistance, plant height and quality. Interestingly, the best prebreeding lines were derived with different old varieties from 1980s or even a landrace from 1920 (Tab. 2). And few of these resources were present in best prebreeding lines using different elite parents indicating a promising breeding value of them.

Fig. 2: Mean values of the same prebreeding lines tested in five conventional and four organic yield trials in 2023. Commercial varieties are shown by their names.



Breeding for different farming systems

An additional funding by the “Ministerium für ländlichen Raum und Verbraucherschutz Baden-Württemberg” enabled to perform a yield test additionally at four organic yield locations in 2023. In Fig. 2 we show the mean values from organic and conventional yield trial series for the traits yield and plant height. While for grain yield the ranking of the different prebreeding lines differed considerably in the two farming systems, it was very similar for plant height, which confirms results from other cereals like spelt. That might suggest to run prebreeding programs for organic and conventional farming using the same initial crosses and early generation selection environments, but differing the expected ideotypes (plant height, quality) and finally evaluate yield in respective farming systems separately. However, further breeding cycles and test years are necessary to draw general conclusions.

Table 2: Results from multi-location field trials of prebreeding lines 2023; Yield = grain yield (dt/ha), HD = flowering time in days of an year, PH = plant height (cm), Lod = lodging, and disease susceptibility against yellow rust (YR), Septoria (ST), leaf rust (LR), Fusarium head blight (FH) and powdery mildew (PM) on a scale of 1 = no – 9 = high susceptibility); conv = conventional cultivation, org = organic cultivation, GBR = United Kingdom.

	Yield		Agronomy			Disease susceptibility					Information about parents	
Genotype	conv	org	HD	PH	Lod	YR	ST	LR	FH	PM	Pedigree	Exotic source
KWSDonovan	109.6	55.67	151.00	98.20	1.33	1.33	2.17	7.00	6.5	NA	Beyond most multiplied German wheat cultivars, A-quality	
WW-17051-353-708	109.0	56.99	151.40	101.20	1.83	1.00	1.83	5.67	6.0	6	(Tri14280 * Reform)* Franz	Landrace Austria ~1920
Chevignon	108.3	64.47	148.00	91.80	1.33	1.33	3.00	2.83	5.0	4.5	Most widely spread recent wheat cultivar in EU, B-quality	
WW-15101-POP-F2-349-PL1-685	108.0	60.45	151.00	98.80	1.67	2.83	2.33	2.67	5.0	2.3	Multi parent pop	Diversity EU from ~1990-2005
WW-17084-347-648	107.5	61.67	146.40	103.60	2.83	4.50	3.50	4.67	5.0	4.5	(KWSLoft*Avalon)* Chevignon	Avalon: GBR 1980
WW-17080-343-601	105.6	63.01	151.20	97.40	1.33	4.33	3.17	3.67	4.0	1.8	(Avalon*Attraktion)* Sheriff	Avalon: GBR 1980
WW-15101-POP-F2-349-PL1-660	105.6	57.79	151.60	103.20	2.17	1.33	2.67	6.00	6.5	6	Multi parent pop	Diversity EU from ~1990-2000
KWSPatronum	105.0	62.79	149.60	101.00	1.83	3.50	2.50	3.67	3.0	NA	New German wheat cultivar with A-quality	
WW-17077-340-580	104.9	62.60	150.80	101.00	1.67	2.00	2.00	2.83	7.0	3.8	(RGTReform*Norman)* KWSLOft	Norman: GBR 1981
WW-17052-354-499	104.5	58.83	152.80	99.00	1.33	1.00	2.17	6.00	2.5	3.8	(Tri14280 * Reform)*(Sumo_x_SUR99820SUR186)	Landrace Austria ~1920
KWSLoft	104.1	61.53	150.60	94.80	2.00	6.33	3.50	4.67	4.5	NA		
WW-15101-POP-F2-349-PL1-673	103.7	57.56	151.40	104.60	5.00	4.00	3.17	4.00	5.5	1.8	Multi parent pop	Diversity EU from ~1990-2002
WW-17067-330-515	103.2	55.93	150.40	98.40	4.33	3.50	3.33	5.17	6.0	4.3	(Alexander*Rinaldo) * (RGTReform*Norman)	Norman: GBR 1981, Rinaldo 1984
Asory	102.9	61.44	151.80	95.60	3.33	3.67	3.17	5.00	4.0	NA	Beyond most multiplied German wheat cultivars, A-quality	
WW-15101-POP-F2-349-PL1-680	102.5	57.51	153.00	93.40	2.67	5.17	3.33	2.67	3.5	2.8	Multi parent pop	Diversity EU from ~1990-2004
WW-15101-POP-F2-349-PL1-672	102.2	58.01	151.60	92.60	1.67	2.00	4.50	2.50	7.0	3	Multi parent pop	Diversity EU from ~1990-2006
WW-17082-345-622	102.0	58.92	147.00	91.60	2.33	1.00	3.33	4.17	7.0	3	(Norman*Attraktion)* Chevignon	Norman: GBR 1981
WW-17012-310-30/1-833	101.9	54.65	154.00	87.00	1.00	1.83	2.17	4.33	4.5	1.8	Dolomit* Mentor	D 1984
WW-15017-207-306-33/2-543/1/2-5103	101.9	48.91	149.60	108.00	2.83	5.17	3.00	4.67	2.0	4.3	Mulan * KWS Triton	Mulan: D 2006 * KWSFerrum-S
WW-17077-340-582	101.8	63.88	151.60	95.00	2.00	4.17	3.00	3.83	5.5	4.5	(RGTReform*Norman)* KWSLOft	Norman: GBR 1981
Informer	101.5	56.25	154.00	99.00	1.67	1.00	2.50	4.33	4.5	3.5	Beyond most multiplied German wheat cultivars, B-quality	
WW-17050-352-352	100.7	62.11	150.20	98.40	1.83	1.50	3.00	5.33	7.0	5	(Tri14280 * Reform)*(Tri21165 * Glaucus)	Landrace Austria ~1920
WW-17026-317-447	100.5	58.30	151.80	96.80	1.50	1.50	3.17	5.17	7.0	1.8	Promentin* Nordkap	Old French variety 1983
WW-17051-353-715	100.5	57.67	153.60	97.40	1.67	3.83	3.67	3.67	4.0	1.5	(Tri14280 * Reform)* Franz	Landrace Austria ~1920
Franz	100.3	58.32	153.60	96.00	1.67	3.67	3.17	4.33	6.0	2		
Rübezahl	100.2	60.60	149.20	103.80	3.67	4.00	2.67	3.33	4.0	NA	Recent German wheat cultivar for organic farming	
WW-17069-332-521	99.6	51.81	150.60	104.20	1.67	2.67	2.83	3.83	5.0	4	(Alexander*Donski-93) * (Bonanza*Duellant)	Donksi: RUS, Duellant: D 1975
WW-17026-317-461	99.5	59.75	151.60	98.20	1.33	1.50	2.67	5.00	7.0	1.5	Promentin* Nordkap	Old French variety 1983
RGTReform	99.4	62.61	152.20	89.00	1.33	4.17	3.17	4.00	6.0	3.5	Beyond most multiplied German wheat cultivars, A-quality	
WW-17029-318-463	99.3	55.42	150.60	95.80	1.67	5.67	3.50	4.83	5.0	1.8	(WW*Durum-F4)* Franz	Durum
WW-17201-361-826	99.1	59.33	153.60	91.20	1.33	1.67	2.33	4.50	4.5	2.8	TRI_14280 * Reform	Landrace Austria ~1920
Julius	98.4	57.13	153.20	97.20	1.67	4.00	3.67	4.83	6.0	NA		
WW-17012-310-1/1-829	98.4	58.23	153.80	86.40	1.00	1.67	2.33	4.50	4.0	2.3	Dolomit* Mentor	D 1984
WW-17082-345-614	98.4	61.29	149.00	90.40	1.83	1.50	4.50	3.17	7.5	3.5	(Norman*Attraktion)* Chevignon	Norman: GBR 1981
520150338-372-788	98.3	55.41	154.40	97.80	3.33	5.00	3.17	4.00	2.5	3.8	IPKF1_Glaucus_TRI_19594	TRI: Gene bank Gatersleben, Germany
WW-17026-317-451	98.2	59.85	152.20	100.60	1.33	1.17	2.83	4.33	7.5	1.5	Promentin* Nordkap	Old French variety 1983
WW-17051-353-695	98.1	61.18	153.80	97.60	2.00	5.00	2.83	4.67	4.5	1.3	(Tri14280 * Reform)* Franz	TRI: Gene bank Gatersleben, Germany
WW-17030-319-480	97.7	53.87	152.60	97.60	1.67	4.17	3.17	5.00	5.0	2.8	(LangeAehre WW*Durum-F4)* Impression	Durum
WW-17082-345-613	97.6	62.12	148.40	97.40	1.83	1.00	3.50	4.17	7.0	4.3	(Norman*Attraktion)* Chevignon	Norman: GBR 1981
WW-17070-333-524	97.3	53.64	153.00	106.20	3.67	3.83	3.17	4.83	3.5	3.5	(Benchmark*Banderola) * (Linus*Multweiss)	Banderola: Pol2010, Multweiss: AUT 1965

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