

Title: Exploring the Unique Characteristic of Naked Barley to Manage Deoxynivalenol Accumulation Resulting from Fusarium Head Blight

Journal name: Theoretical and Applied Genetics

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Table S1 Information about the subpopulation, row type, and source of the lines in the F DIV panel

line name	subpopulation	row type	source
HINDU_KUSCH CIHO11796	1	2	GRIN
CI13453	1	6	GRIN
CI13461	1	6	GRIN
CI13507	1	6	GRIN
CIHO14362	1	6	GRIN
CIHO4358	1	6	GRIN
DH140180	1	2	OSU Doubled Haploid
MTV-COLOR-111	1	2	OSU Color Experiments
MTV-COLOR-124	1	6	OSU Color Experiments
MTV-COLOR-128	1	6	OSU Color Experiments
MTV-COLOR-158	1	6	OSU Color Experiments
MTV-COLOR-163	1	2	OSU Color Experiments
MTV-COLOR-183	1	2	OSU Color Experiments
MTV-COLOR-197	1	2	OSU Color Experiments
MTV-COLOR-2	1	6	OSU Color Experiments
MTV-COLOR-21	1	2	OSU Color Experiments
MTV-COLOR-22	1	6	OSU Color Experiments
MTV-COLOR-3	1	2	OSU Color Experiments
MTV-COLOR-52	1	6	OSU Color Experiments
MTV-COLOR-56	1	2	OSU Color Experiments
MTV-COLOR-57	1	2	OSU Color Experiments
MTV-COLOR-58	1	6	OSU Color Experiments
MTV-COLOR-8	1	6	OSU Color Experiments
MTV-COLOR-80	1	6	OSU Color Experiments
MTV-COLOR-84	1	6	OSU Color Experiments
MTV-COLOR-92	1	6	OSU Color Experiments
MTV-COLOR-94	1	6	OSU Color Experiments
MTV-COLOR-97	1	6	OSU Color Experiments
MTV-COLOR-98	1	2	OSU Color Experiments
OSCAR	1	2	North American Varieties
PI151807	1	6	GRIN
PI194990	1	6	GRIN
PI24901	1	2	GRIN
PI294734	1	2	GRIN
PI296460	1	6	GRIN
PI316815	1	2	GRIN
PI316835	1	6	GRIN
PI32042	1	6	GRIN

PI328974	1	2	GRIN
PI331981	1	6	GRIN
PI356474	1	6	GRIN
PI382486	1	2	GRIN
PI386526	1	2	GRIN
PI60689	1	6	GRIN
TIBET37	1	2	East Asian Varieties and Landraces
09WA-265.12	2	2	WSU
10.0691	2	2	OSU Other
10.0883	2	2	OSU Other
10WA-106.12	2	2	WSU
10WA-106.19	2	2	WSU
10WA-107.2	2	2	WSU
10WA-107.8	2	2	WSU
10WA-107.9	2	2	WSU
10WA-109.19	2	2	WSU
10WA-109.2	2	2	WSU
10WA-109.21	2	2	WSU
10WA-118.13	2	2	WSU
10WA-118.16	2	2	WSU
10WA-118.9	2	2	WSU
10WA-118.D	2	2	WSU
10WA-121.5	2	2	WSU
10WA-121.7	2	2	WSU
10WA-122.12	2	2	WSU
10WA-127.10	2	2	WSU
10WA-127.5	2	2	WSU
10WAN-129.6	2	2	WSU
10WA-129.7	2	2	WSU
10WA-130.4	2	2	WSU
10WA-130.5	2	2	WSU
11WA-114.5	2	2	WSU
12WA-106.2	2	2	WSU
12WA-107.2	2	2	WSU
15WA-106.2	2	2	WSU
15WA-106.21	2	2	WSU
15WA-111.4	2	2	WSU
15WA-118.33	2	2	WSU
15WA-120.10	2	2	WSU

15WA-120.14	2	2	WSU
2MS14_5315-017	2	2	UMN
2MS14_5343-024	2	2	UMN
CDC_CLEAR	2	2	University of Toronto
COLOR-F4-SSD-151	2	2	OSU Color Experiments
DH140081	2	2	OSU Doubled Haploid
DH140175	2	2	OSU Doubled Haploid
DH140176	2	2	OSU Doubled Haploid
DH140276	2	2	OSU Doubled Haploid
DH140281	2	2	OSU Doubled Haploid
DH140282	2	2	OSU Doubled Haploid
DH140285	2	2	OSU Doubled Haploid
DH140286	2	6	OSU Doubled Haploid
DH140338	2	2	OSU Doubled Haploid
DH140339	2	2	OSU Doubled Haploid
DH140418	2	2	OSU Doubled Haploid
DH140422	2	2	OSU Doubled Haploid
DH140429	2	2	OSU Doubled Haploid
DH140516	2	2	OSU Doubled Haploid
DH140641	2	2	OSU Doubled Haploid
HAVENER	2	2	WSU
HB15334	2	2	OSU Other
HB16338	2	2	OSU Other
HB16339	2	2	OSU Other
LAWINA	2	2	European Varieties
LAWINA_MC	2	2	European Varieties
MC0181-11	2	2	OSU Other
MC0181-31	2	2	OSU Other
MEGS_SONG	2	2	WSU
PI156658	2	2	GRIN
TRANSIT	2	2	North American Varieties
X07G26-T35	2	2	WSU
X07G31-T120	2	2	WSU
BB25	3	6	OSU Color Experiments
BB28	3	6	OSU Color Experiments
BB5	3	6	OSU Color Experiments
DH133915	3	6	OSU Doubled Haploid
DH140031	3	6	OSU Doubled Haploid
DH140032	3	2	OSU Doubled Haploid

DH140078	3	2	OSU Doubled Haploid
DH140079	3	2	OSU Doubled Haploid
DH140080	3	2	OSU Doubled Haploid
DH140124	3	6	OSU Doubled Haploid
DH140179	3	2	OSU Doubled Haploid
DH140210	3	6	OSU Doubled Haploid
DH140211	3	6	OSU Doubled Haploid
DH140212	3	6	OSU Doubled Haploid
DH140213	3	6	OSU Doubled Haploid
DH140215	3	6	OSU Doubled Haploid
DH140284	3	2	OSU Doubled Haploid
DH140300	3	6	OSU Doubled Haploid
DH140331	3	2	OSU Doubled Haploid
DH140337	3	2	OSU Doubled Haploid
DH140419	3	2	OSU Doubled Haploid
DH140426	3	2	OSU Doubled Haploid
DH140427	3	2	OSU Doubled Haploid
DH140450	3	6	OSU Doubled Haploid
DH140451	3	6	OSU Doubled Haploid
DH140452	3	6	OSU Doubled Haploid
DH140514	3	6	OSU Doubled Haploid
DH140515	3	2	OSU Doubled Haploid
DH140549	3	2	OSU Doubled Haploid
DH160408	3	6	OSU Doubled Haploid
DH160409	3	6	OSU Doubled Haploid
DH160410	3	6	OSU Doubled Haploid
DH160419	3	6	OSU Doubled Haploid
DH160764	3	6	OSU Doubled Haploid
DH160767	3	6	OSU Doubled Haploid
DH160779	3	6	OSU Doubled Haploid
DH160780	3	6	OSU Doubled Haploid
DH160783	3	6	OSU Doubled Haploid
DH160790	3	6	OSU Doubled Haploid
DH160792	3	6	OSU Doubled Haploid
DH160793	3	6	OSU Doubled Haploid
DH160794	3	6	OSU Doubled Haploid
DH160796	3	2	OSU Doubled Haploid
DH160797	3	6	OSU Doubled Haploid
DH160798	3	6	OSU Doubled Haploid

DH160799	3	6	OSU Doubled Haploid
DH160800	3	6	OSU Doubled Haploid
DH160801	3	6	OSU Doubled Haploid
DH160802	3	6	OSU Doubled Haploid
DH160803	3	6	OSU Doubled Haploid
DH160804	3	6	OSU Doubled Haploid
DH160805	3	2	OSU Doubled Haploid
DH160806	3	6	OSU Doubled Haploid
DH160807	3	6	OSU Doubled Haploid
DH160808	3	6	OSU Doubled Haploid
DH160809	3	6	OSU Doubled Haploid
DH160810	3	6	OSU Doubled Haploid
DH160811	3	6	OSU Doubled Haploid
DH160812	3	6	OSU Doubled Haploid
DH160813	3	6	OSU Doubled Haploid
DH160814	3	6	OSU Doubled Haploid
DH160815	3	2	OSU Doubled Haploid
DH160816	3	6	OSU Doubled Haploid
DH160817	3	2	OSU Doubled Haploid
DH160818	3	6	OSU Doubled Haploid
DH160819	3	6	OSU Doubled Haploid
DH160820	3	6	OSU Doubled Haploid
DH160821	3	6	OSU Doubled Haploid
DH160822	3	6	OSU Doubled Haploid
DH160823	3	6	OSU Doubled Haploid
DH160824	3	6	OSU Doubled Haploid
DH160825	3	6	OSU Doubled Haploid
DH160827	3	6	OSU Doubled Haploid
DH161444	3	6	OSU Doubled Haploid
MS10S4111-01	3	6	UMN
MS10S4115-03	3	6	UMN
PI270666	3	6	GRIN
SH98076	3	2	OSU Other
TAMALPAIS	3	6	UCD
UC1266	3	6	UCD
UC1319	3	6	UCD
UC1321	3	6	UCD
5-36-OCOLOR	4	2	OSU Color Experiments
AKANE_HADAKA	4	6	East Asian Varieties and Landraces

AKASHINRIKI	4	6	East Asian Varieties and Landraces
CHAME14	4	6	East Asian Varieties and Landraces
CHINA_HUAN_YEN	4	6	East Asian Varieties and Landraces
CIHO15270	4	6	GRIN
CIHO4182	4	6	GRIN
KAGAWA-HADAKA1	4	6	GRIN
COLOR-F4-SSD-002	4	2	OSU Color Experiments
COLOR-F4-SSD-034	4	2	OSU Color Experiments
COLOR-F4-SSD-092	4	2	OSU Color Experiments
DANGOMUGI	4	6	East Asian Varieties and Landraces
DH132614	4	2	OSU Doubled Haploid
DH132615	4	2	OSU Doubled Haploid
DH132756	4	2	OSU Doubled Haploid
DH132758	4	2	OSU Doubled Haploid
DH132841	4	2	OSU Doubled Haploid
DH132842	4	2	OSU Doubled Haploid
DH133385	4	2	OSU Doubled Haploid
HUNNAN2	4	6	East Asian Varieties and Landraces
JAPA_KITAGAWA	4	6	East Asian Varieties and Landraces
CI3202	4	6	East Asian Varieties and Landraces
KUROSHIO_HADAKA	4	6	East Asian Varieties and Landraces
MARIMO_HADAKA	4	6	East Asian Varieties and Landraces
MARUMI_16	4	6	East Asian Varieties and Landraces
MARUMI_HADAKA	4	6	East Asian Varieties and Landraces
MASAN_NAKED1	4	6	East Asian Varieties and Landraces
NEPAL92BN-1	4	6	East Asian Varieties and Landraces
PI190709	4	6	GRIN
PI270616	4	6	GRIN
PI270630	4	6	GRIN
PI281852	4	6	GRIN
PI28624	4	2	GRIN
PI330524	4	6	GRIN
PI331861	4	2	GRIN
PI41162	4	2	GRIN
PI477844	4	6	GRIN
PI506340	4	6	GRIN
PI510561	4	6	GRIN
PI573802	4	6	GRIN
PI95398	4	6	GRIN

PI97331	4	6	GRIN
PURPLE_PRINCE	4	2	North American Varieties
SETANA_HADAKA	4	6	East Asian Varieties and Landraces
SHIRAHIME_HADAKA	4	6	East Asian Varieties and Landraces
SUMIRE_MOCHI	4	6	East Asian Varieties and Landraces
TIBET_BLACK	4	6	East Asian Varieties and Landraces
TIBET_VIOLET	4	6	East Asian Varieties and Landraces
TUXSKY_NAHY	4	6	European Varieties
VIOLACEUM	4	6	OSU Other
WHITE_QUEEN	4	2	North American Varieties
YONEZAWA MOCHI	4	6	East Asian Varieties and Landraces

Table S2 Summary statistics of the marker-trait associations identified using single-SNP GWAS and the significant haplotype block (HB) into which the markers were binned

Trait	Marker	Chrom	Position	$-\log_{10}(p)$	Effect	HB
	JHI-Hv50k-2016-75226		30737781	7.13	-6.02	chr2_hap91
	JHI-Hv50k-2016-73487		25810005	6.82	-5.70	
	JHI-Hv50k-2016-73617		25944436	5.76	5.71	
	JHI-Hv50k-2016-77143		39947144	5.65	4.75	
	JHI-Hv50k-2016-77146		39947406	5.58	4.57	
	JHI-Hv50k-2016-73689		26152503	5.49	-4.54	
	JHI-Hv50k-2016-77412		40933156	5.43	-5.44	
DON in hull	SCRI_RS_141655	2H	49956455	5.19	-6.41	
DON in kernel	BOPA2_12_30924	3H	562295006	5.24	1.87	
	SCRI_RS_173164		28095804	7.82	-9.97	chr2_hap100
	JHI-Hv50k-2016-73487		25810005	7.32	-8.13	chr2_hap91
	JHI-Hv50k-2016-74351		28095204	5.84	8.33	chr2_hap100
	JHI-Hv50k-2016-75226		30737781	5.81	-7.47	
	SCRI_RS_141655		49956455	5.69	-9.23	
	JHI-Hv50k-2016-73617		25944436	5.68	7.73	chr2_hap93
	JHI-Hv50k-2016-73501		25802665	5.5	5.51	chr2_hap91
	JHI-Hv50k-2016-73689	2H	26152503	5.28	-6.19	
DON in rachis	JHI-Hv50k-2016-310062	5H	453485777	6.38	-8.31	
	JHI-Hv50k-2016-73689		26152503	19.58	-3.81	chr2_hap92
	JHI-Hv50k-2016-73617		25944436	15.71	4.03	
	JHI-Hv50k-2016-74284		28070047	12.52	-3.06	
	JHI-Hv50k-2016-73487		25810005	12.04	-3.33	
	BOPA1_2646-1277		28086868	11.1	2.78	
	SCRI_RS_239882		28095156	11.1	2.78	
	SCRI_RS_186387		27287809	10.74	-2.76	
	JHI-Hv50k-2016-73723		26372182	10.73	-3.39	
	JHI-Hv50k-2016-73673		26109061	9.98	2.68	
	JHI-Hv50k-2016-77143		39947144	9.68	2.80	
	JHI-Hv50k-2016-73422		25877853	9.66	2.59	
	SCRI_RS_115892		30007063	8.72	-2.08	
	JHI-Hv50k-2016-73712		26362729	8.65	3.17	
	JHI-Hv50k-2016-75682		33155286	8.48	2.31	
	JHI-Hv50k-2016-77146		39947406	8.3	2.50	
	SCRI_RS_143250		27286872	8.09	2.65	
	JHI-Hv50k-2016-73501		25802665	7.72	2.16	
Heading date	JHI-Hv50k-2016-73122	2H	25381159	7.55	3.34	

	JHI-Hv50k-2016-74101		27575397	7.42	2.14	
	JHI-Hv50k-2016-73545		25800459	7.4	-2.19	chr2_hap90
	BK_15		25876771	7.3	-2.07	chr2_hap92
	JHI-Hv50k-2016-77145		39947267	7.13	-2.45	
	JHI-Hv50k-2016-74210		27981626	7.07	2.30	
	JHI-Hv50k-2016-75631		33039044	6.83	1.95	
	JHI-Hv50k-2016-69414		17317857	6.81	-3.39	
	JHI-Hv50k-2016-75226		30737781	6.79	-2.66	
	JHI-Hv50k-2016-80190		53305846	6.79	-5.10	
	JHI-Hv50k-2016-77039		39484827	6.62	2.12	
	JHI-Hv50k-2016-77038		39485423	6.6	-2.08	
	JHI-Hv50k-2016-79884		50857134	6.55	-2.00	
	JHI-Hv50k-2016-72492		23829111	6.5	-2.85	chr2_hap85
	JHI-Hv50k-2016-73615		25944268	6.45	2.13	chr2_hap93
	JHI-Hv50k-2016-75638		33040970	6.36	1.83	
	JHI-Hv50k-2016-77560		41617123	6.24	2.05	
	JHI-Hv50k-2016-72946		24596462	6.19	2.16	
	SCRI_RS_115905		29995580	6.14	-2.30	
	JHI-Hv50k-2016-70484		19058647	6.13	-3.33	
	JHI-Hv50k-2016-68595		16054465	6.09	3.13	
	JHI-Hv50k-2016-72720		24187674	6.01	3.03	
	JHI-Hv50k-2016-70143		18242152	5.94	3.36	
	JHI-Hv50k-2016-72615		23984263	5.86	3.29	
	JHI-Hv50k-2016-79972		51237752	5.79	-1.69	
	SCRI_RS_186448		28546998	5.71	-2.01	
	JHI-Hv50k-2016-75048		30306863	5.69	-2.18	
	JHI-Hv50k-2016-73697		26363248	5.65	2.43	
	JHI-Hv50k-2016-78835		46305854	5.55	1.72	
	JHI-Hv50k-2016-72435		23770744	5.49	-1.69	chr2_hap85
	JHI-Hv50k-2016-75042		30307054	5.47	-2.29	
	JHI-Hv50k-2016-74407		28202988	5.46	-1.78	chr2_hap100
	JHI-Hv50k-2016-74914		29980501	5.45	1.94	
	JHI-Hv50k-2016-67704		14052712	5.41	-1.99	
	JHI-Hv50k-2016-77473		41473991	5.41	1.79	
	JHI-Hv50k-2016-73930		26674692	5.37	1.98	
	JHI-Hv50k-2016-74094		27574925	5.19	-1.77	
	JHI-Hv50k-2016-73689		26152503	7.91	-4.59	
Height	JHI-Hv50k-2016-73617	2H	25944436	6.46	4.79	chr2_hap93

	JHI-Hv50k-2016-73930		26674692	6.26	4.00	
	JHI-Hv50k-2016-66354		12391579	5.97	-5.53	
	JHI-Hv50k-2016-73712		26362729	5.93	4.87	
	JHI-Hv50k-2016-73487		25810005	5.54	-4.14	chr2_hap91
	JHI-Hv50k-2016-73422		25877853	5.45	3.57	chr2_hap92
	SCRI_RS_143250		27286872	5.43	3.98	
	JHI-Hv50k-2016-206416		569080049	6.68	-5.90	
	BOPA2_12_10188		568059624	6.62	-5.27	
	JHI-Hv50k-2016-201886		551776266	5.44	3.72	
	BOPA2_12_10205	3H	571971374	5.25	-7.73	
	JHI-Hv50k-2016-230344		11368100	5.75	-6.76	
	JHI-Hv50k-2016-234054	4H	31931512	5.31	-3.42	
	JHI-Hv50k-2016-73689		26152503	11.55	-0.07	
	JHI-Hv50k-2016-73617		25944436	7.18	0.06	chr2_hap93
	JHI-Hv50k-2016-74284		28070047	7.13	-0.05	chr2_hap100
	JHI-Hv50k-2016-73723		26372182	6.14	-0.06	
	BOPA1_2646-1277		28086868	5.93	0.04	chr2_hap100
	SCRI_RS_239882		28095156	5.93	0.04	chr2_hap100
	SCRI_RS_186387		27287809	5.6	-0.04	
	JHI-Hv50k-2016-77143		39947144	5.59	0.05	
	JHI-Hv50k-2016-73501		25802665	5.35	0.04	chr2_hap91
Hull DON proportion	JHI-Hv50k-2016-73673	2H	26109061	5.31	0.04	
	JHI-Hv50k-2016-73689		26152503	5.76	-0.28	
	JHI-Hv50k-2016-77143		39947144	5.72	0.29	
	JHI-Hv50k-2016-72492	2H	23829111	5.48	-0.36	chr2_hap85
	JHI-Hv50k-2016-451563		18130411	6.55	-0.39	
	SCRI_RS_179528		24037837	5.67	-0.28	
	JHI-Hv50k-2016-453128		24757839	5.59	-0.28	
	SCRI_RS_126944		18694936	5.36	-0.45	
	SCRI_RS_222330		18719352	5.25	0.30	
	JHI-Hv50k-2016-451807		18719772	5.25	-0.30	
Hull mass	JHI-Hv50k-2016-500781	7H	591984535	5.19	0.45	
	JHI-Hv50k-2016-73723		26372182	8.28	-0.84	
	JHI-Hv50k-2016-74284		28070047	7.91	-0.68	chr2_hap100
	JHI-Hv50k-2016-73673		26109061	7.49	0.65	
	JHI-Hv50k-2016-73617		25944436	7.42	0.77	chr2_hap93
	JHI-Hv50k-2016-74101		27575397	7.24	0.59	
Hull-kernel DON ratio	BOPA1_2646-1277	2H	28086868	7.16	0.62	chr2_hap100

	SCRI_RS_239882		28095156	7.16	0.62	chr2_hap100
	JHI-Hv50k-2016-73689		26152503	7.12	-0.66	
	SCRI_RS_186387		27287809	6.98	-0.62	
	BOPA2_12_10777		23770843	6.08	0.63	chr2_hap85
	JHI-Hv50k-2016-74210		27981626	5.92	0.59	
	SCRI_RS_143250		27286872	5.28	0.59	
	JHI-Hv50k-2016-74094		27574925	5.28	-0.50	
	JHI-Hv50k-2016-77145		39947267	5.25	-0.58	
	JHI-Hv50k-2016-72435		23770744	5.2	-0.47	chr2_hap85
	JHI-Hv50k-2016-206416		569080049	9.04	-2.40	
	BOPA2_12_10188		568059624	6.86	-1.83	
	JHI-Hv50k-2016-206312		568461149	6.33	1.86	
	JHI-Hv50k-2016-205649		564778986	6.28	-1.81	
	BOPA2_12_10564		597070220	5.65	-1.59	
	BOPA1_6716-823		563550753	5.6	1.51	
	SCRI_RS_146012		570730574	5.56	1.34	
	JHI-Hv50k-2016-206631		570734861	5.51	-1.33	
	JHI-Hv50k-2016-201886		551776266	5.46	1.30	
	JHI-Hv50k-2016-205369		563550753	5.38	1.49	
Kernel mass	JHI-Hv50k-2016-205861	3H	567387963	5.32	-1.79	

Chrom = Chromosome number, p = marker-trait association p-value

Table S3 The effect and $-\log_{10}(p)$ of markers associated with five traits in Crookston and Saint Paul

Traits	Markers	Chrom	Position	Crookston		Saint Paul	
				$-\log_{10}(p)$	Effect	$-\log_{10}(p)$	Effect
Heading date	JHI-Hv50k-2016-73689		26152503	17.09	-3.88	17.07	-3.60
	JHI-Hv50k-2016-73617		25944436	13.23	4.02	14.91	4.00
	JHI-Hv50k-2016-77143		39947144	6.4	2.46	11.74	3.09
	JHI-Hv50k-2016-73487		25810005	9.92	-3.27	11.68	-3.31
	JHI-Hv50k-2016-74284		28070047	11.02	-3.11	11.31	-2.95
	BOPA1_2646-1277		28086868	9.48	2.78	10.17	2.68
	SCRI_RS_239882		28095156	9.48	2.78	10.17	2.68
	JHI-Hv50k-2016-77146		39947406	5.54	2.20	10.13	2.78
	SCRI_RS_186387		27287809	9.35	-2.79	9.67	-2.64
	JHI-Hv50k-2016-73673		26109061	8.3	2.65	9.57	2.64
	JHI-Hv50k-2016-73723		26372182	9.77	-3.51	9.30	-3.17
	JHI-Hv50k-2016-75682		33155286	6.64	2.21	8.88	2.36
	JHI-Hv50k-2016-73422		25877853	8.07	2.57	8.83	2.49
	SCRI_RS_143250		27286872	5.98	2.45	8.54	2.74
	JHI-Hv50k-2016-73712		26362729	7.3	3.16	8.43	3.09
	SCRI_RS_115892		30007063	7.73	-2.13	7.98	-2.00
	JHI-Hv50k-2016-73501		25802665	6.14	2.08	7.84	2.18
	JHI-Hv50k-2016-74101		27575397	6.15	2.11	7.24	2.12
	JHI-Hv50k-2016-73545		25800459	6.41	-2.20	6.70	-2.08
	JHI-Hv50k-2016-74210		27981626	5.78	2.24	6.68	2.24
	BK_15		25876771	6.09	-2.04	6.61	-1.97
	JHI-Hv50k-2016-79884		50857134	5.21	-1.92	6.45	-2.00
	JHI-Hv50k-2016-73122		25381159	7.24	3.55	6.42	3.08
	JHI-Hv50k-2016-73615		25944268	5.36	2.10	6.10	2.07
	JHI-Hv50k-2016-69414		17317857	6.32	-3.54	5.82	-3.13
	JHI-Hv50k-2016-72720		24187674	5.2	3.04	5.44	2.88
	JHI-Hv50k-2016-70484	<u>2H</u>	19058647	5.44	-3.39	5.33	-3.08

Height	BOPA2_12_10188		568059624	6.23	-5.56	5.76	-5.22
	JHI-Hv50k-2016-206416	3H	569080049	6.68	-6.47	5.60	-5.74
Hull DON prop	JHI-Hv50k-2016-73689	2H	26152503	7.57	-0.06	9.31	-0.07
Hull-Kernel DON ratio	JHI-Hv50k-2016-73723	2H	26372182	5.29	-1.61	5.55	-0.63
Kernel mass	JHI-Hv50k-2016-206416	3H	569080049	5.71	-2.49	7.46	-2.16

The markers in bold were associated with more than one trait.

Chrom = Chromosome number, p = marker-trait association p-value

Table S4 Summary of the 12 haplotype-trait associations identified in this study

Trait	Haplotype block	Markers in block	Chrom	Interval First and Last SNP (distance in bp)	Distance apart (kbp)	Haplotype alleles	$-\log_{10}(p)$	Allelic effects	R ²
DON in hull	chr2_hap90	JHI-Hv50k-2016-73247, JHI-Hv50k-2016-73335, JHI-Hv50k-2016-73361, JHI-Hv50k-2016-73545		25439410 - 25800459	361.05	BBBBBAABB, AABBBBBBB, BBABAABB, BBBBAAAA, BBAAAAABBAA, BBBBAAAABB, BBAAAABBBB, AABBBBAABB	4.91	0.00 - 14.13	8.17
	chr2_hap92	BK_15, BK_13, JHI-Hv50k-2016-73422, JHI-Hv50k-2016-73570, JHI-Hv50k-2016-73584	2H	25876771 - 25938729	61.96	AABBBBAABB	5.05	0.00 - 16.51	10.53
DON in rachis	chr2_hap90	JHI-Hv50k-2016-73247, JHI-Hv50k-2016-73335, JHI-Hv50k-2016-73361, JHI-Hv50k-2016-73545		25439410 - 25800459	361.05	BBBBBAABB, AABBBBBBB, BBABAABB, BBBBAAAA, BBAAAAABBAA, BBBBAAAABB, BBAAAABBBB, AABBBBAABB	5.41	0.00 - 20.05	4.82
	chr2_hap92	BK_15, BK_13, JHI-Hv50k-2016-73422, JHI-Hv50k-2016-73570, JHI-Hv50k-2016-73584		25876771 - 25938729	61.96	AABBBBAABB	5.82	0.00 - 25.18	4.42
	chr2_hap175	SCRI_RS_175300, JHI-Hv50k-2016-92852	2H	355527110 - 355537286	10.18	BBAA, AAAA, AABB	6.41	-59.07 - 45.71	11.30
	chr2_hap85	JHI-Hv50k-2016-72460, JHI-Hv50k-2016-72435 , BOPA2_12_10777, JHI-Hv50k-2016-72492 , JHI-Hv50k-2016-72531, JHI-Hv50k-2016-72545		23764524 - 23831955	67.43	AAAAAABBAAAA, AABBAABBBBBB, AAAAAAAAAABB, AAAABBBBBBBB, BBBBAABBBBBB	4.84	-8.33 - 0.00	6.44
	chr2_hap91	JHI-Hv50k-2016-73501 , JHI-Hv50k-2016-73489, JHI-Hv50k-2016-73487 , JHI-Hv50k-2016-73480		25802665 - 25871485	68.82	AAAAAABB, AAAAAAAAA, AABBBBBB, BBBBAABB, BBAAAAABBAA, BBBBAAAABB, BBAAAABBBB, AABBBBAABB	5.24	-0.39 - -6.43	18.17
	chr2_hap92	BK_15 , BK_13, JHI-Hv50k-2016-73422 , JHI-Hv50k-2016-73570, JHI-Hv50k-2016-73584		25876771 - 25938729	61.96	AABBBBAABB	7.70	0.00 - 8.34	28.57
Heading date	chr2_hap93	JHI-Hv50k-2016-73615 , JHI-Hv50k-2016-73617	2H	25944268 - 25944436	0.17	AABB, AAAA, BBBB	7.43	0.00 - 9.98	26.50

						AABBBBBBBAABBBB AA, AAAABBBBAABBA ABB, AABBBBBBBBAABB BB, BBBBAAAAAABBBB BB , AAAABBBBAABBBB AA			
	chr2_hap100	JHI-Hv50k-2016-74284 , JHI-Hv50k-2016-74327, BOPA1_2646-1277 , SCRI_RS_239882 , JHI-Hv50k-2016-74351, SCRI_RS_173164, JHI-Hv50k-2016-74372, JHI-Hv50k-2016-74407		28070047 - 28202988	132.94		5.48	-6.53 - 0.00	16.43
	chr2_hap95	SCRI_RS_188893, JHI-Hv50k-2016-73755, JHI-Hv50k-2016-73780	2H	26375085 - 26380311	5.23	BBAABB, AABBA, BBBBBB	5.28	0.00 - 9.85	9.96
		JHI-Hv50k-2016-230275, JHI-Hv50k-2016-230276, JHI-Hv50k-2016-230295, JHI-Hv50k-2016-230302, JHI-Hv50k-2016-230319		11067631 - 11161747		AAAABBAAAA, AABBAAAAAA, BBBBAAAAAA, BBBBAAAABB, BBBBBAABBBB			
Height	chr4_hap41		4H		94.12		5.47	-1.45 - 16.17	28.24

Chrom = Chromosome number, p = marker-trait association p-value, R² = percentage variation explained

Markers in bold were identified by single-SNP GWAS

Table S5 Effects and percentage variation explained (R^2) by the two haplotype blocks associated with heading date in Crookston and Saint Paul

Haplotype blocks	Crookston		Saint Paul	
	Effects	R^2 (%)	Effects	R^2 (%)
chr2 hap92	0.00 - 9.03	29.15	0.00 - 8.08	23.46
chr2 hap93	0.00 - 10.70	30.83	0.00 - 9.63	18.27

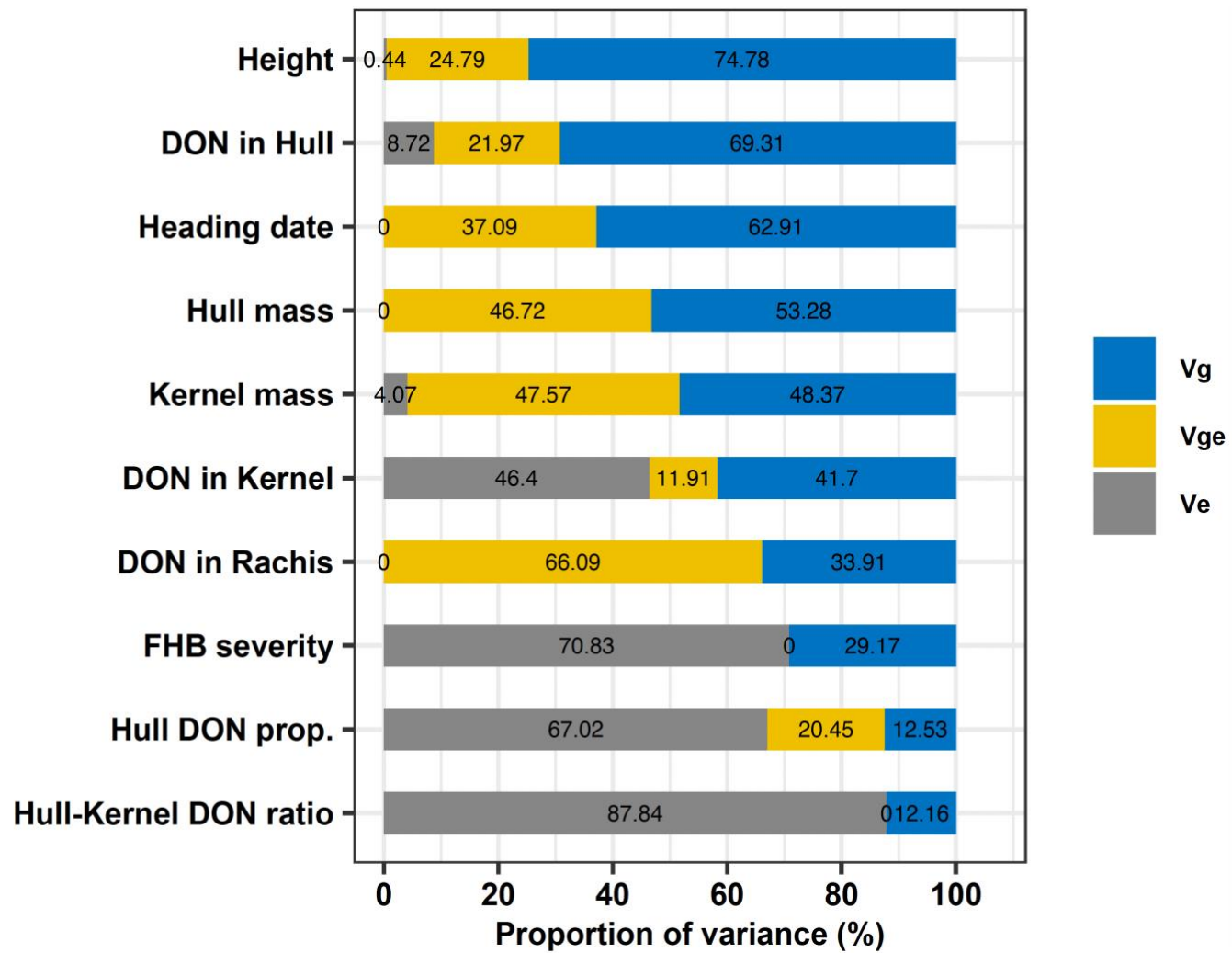


Fig. S1 Variance components of the ten traits measured in the F_DIV panel

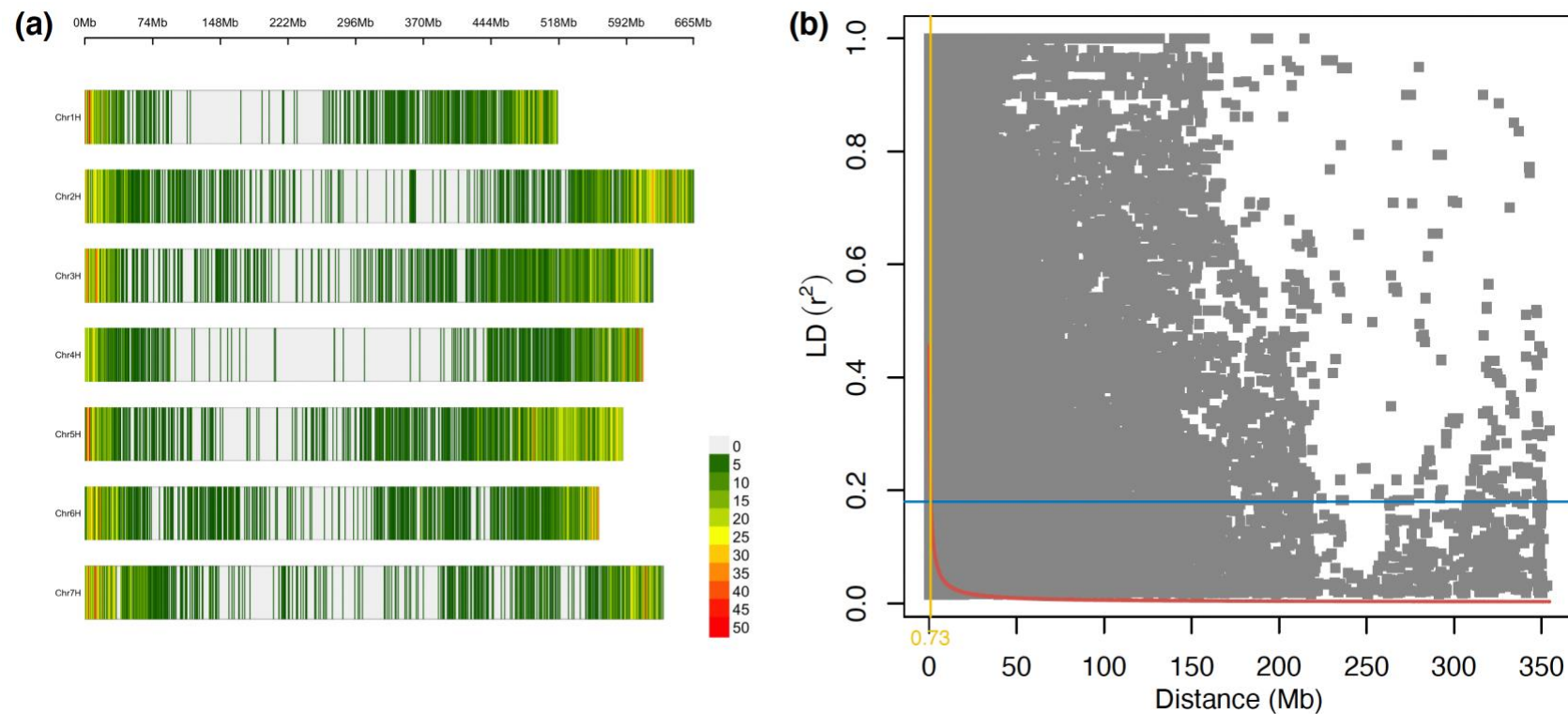


Fig. S2 (a) Distribution of 15,042 SNP markers among seven chromosomes of barley within 1Mb size. The color bar represents the density of the SNPs; green and yellow colors signify low and high, respectively, and (b) Linkage disequilibrium decay across chromosomes in the F_DIV panel. The red curve is the smoothing spline regression model fitted to LD decay. The blue line represents the average linkage disequilibrium value across the genome. The yellow line indicates the physical distance (0.73 Mb) at which the LD half-decay ($r^2 = 0.23$) intersects with the LD decay curve

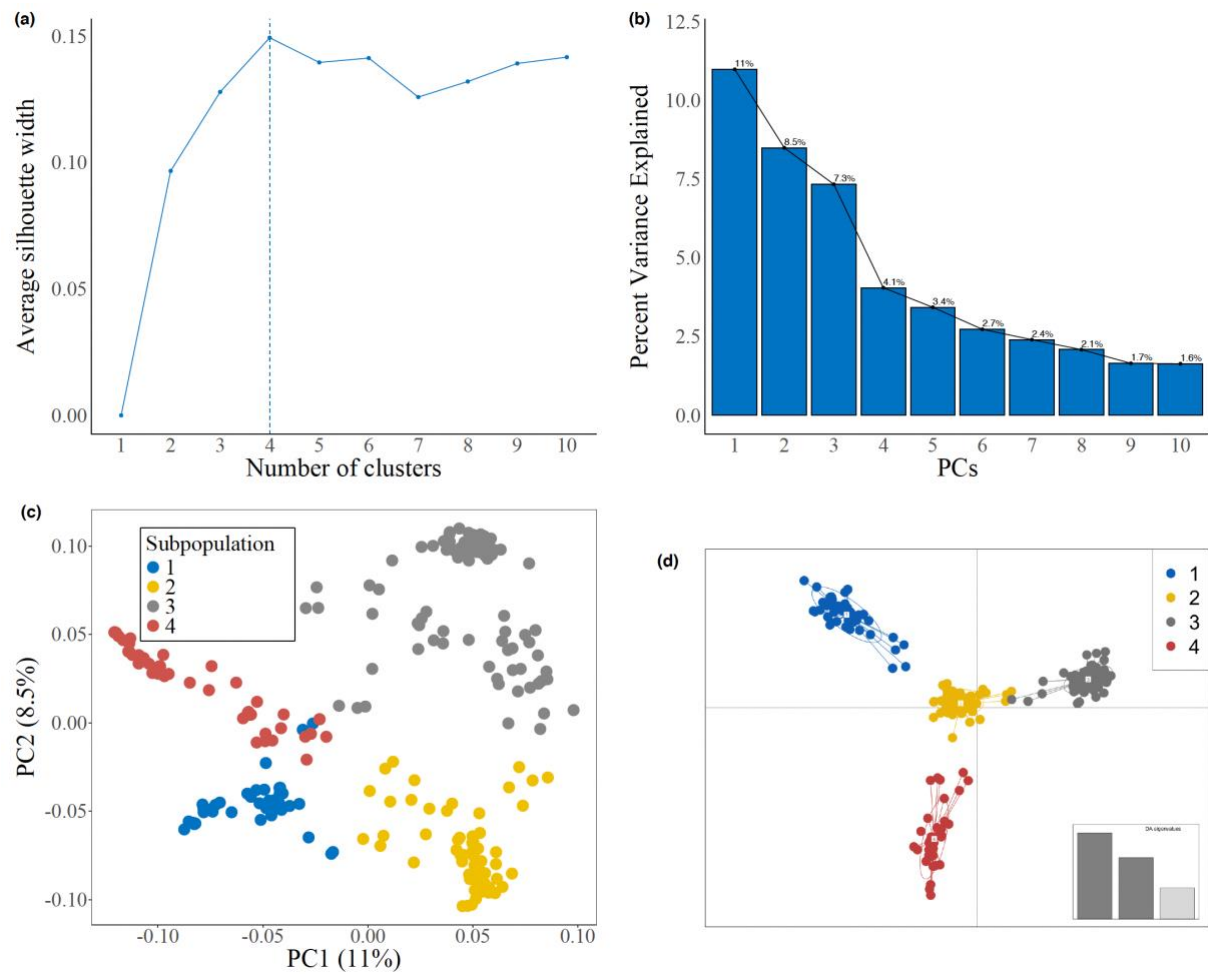


Fig. S3 (a) The average silhouette width for $K = 1$ to 10 based on 15042 SNPs for the lines in the F_DIV panel. The algorithm revealed that the optimal number of clusters or subpopulations is four, (b) The proportion of genetic variation explained by the first 10 PCs, (c) Scatter plot of first and second principal components of 244 lines in the F_DIV panel based on 15042 SNPs, and (d) Discriminant analysis of principal components for 244 lines in the F_DIV panel. The axes represent the first two Linear Discriminants (LD). Circles with different colors represent subpopulations, and each solid circle represents a line. The bar plots in the figure's lower right corner are the eigenvalues of the LD retained for analysis

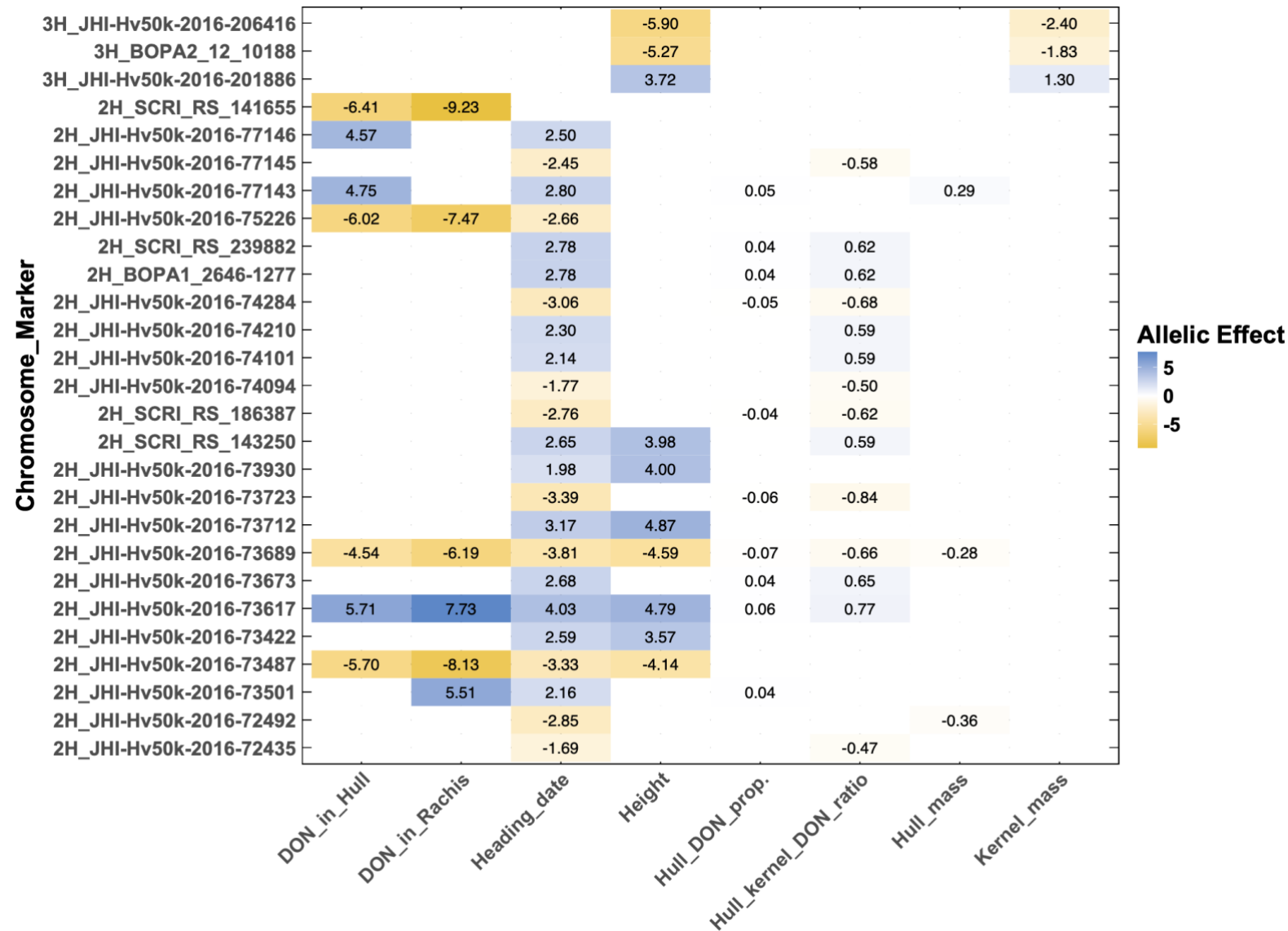


Fig S4 Effect sizes of SNP markers that are associated with more than one trait in the F_DIV panel. Markers are arranged in increasing order of chromosome numbers and physical positions

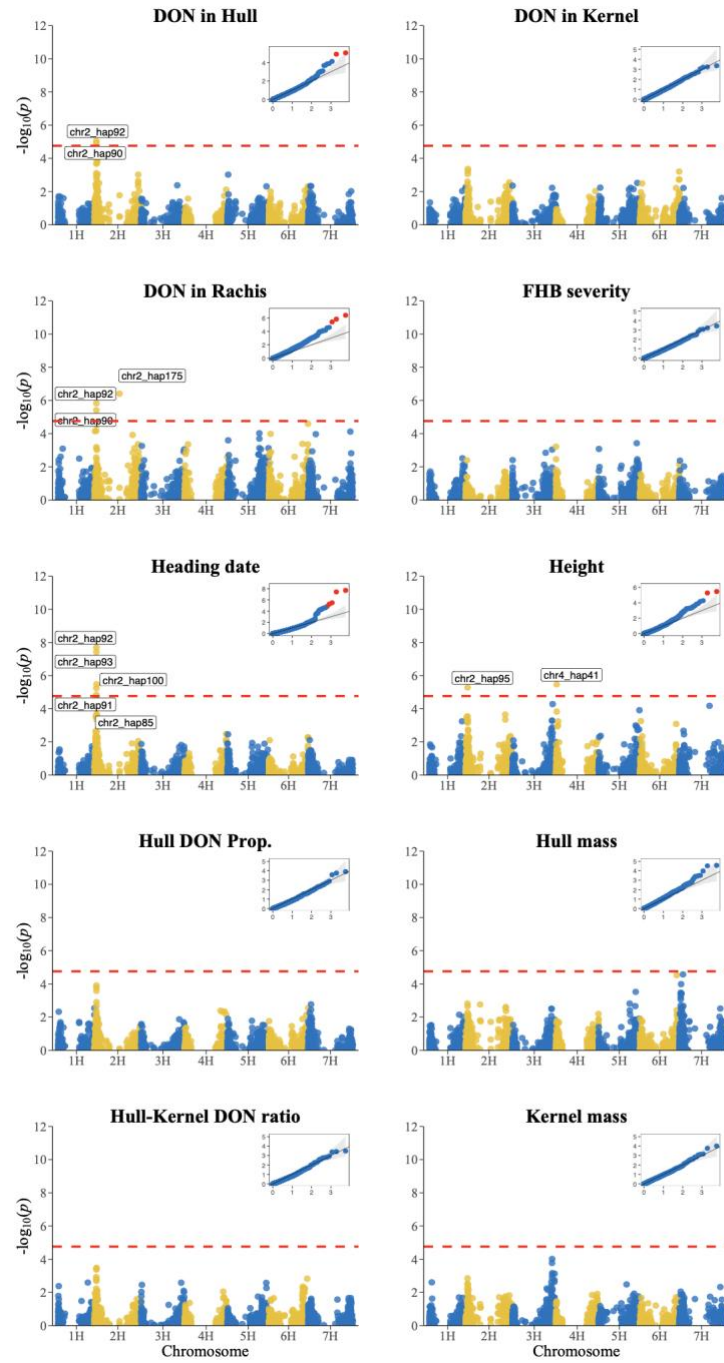


Fig. S5 Manhattan plots for haplotype-based GWAS for ten traits in the F_DIV panel evaluated in four environments using the compressed MLM. The inset on the Manhattan plot is the QQ plot with expected p-values on the x-axis and observed p-values on the y-axis. The red line represents the GWAS Bonferroni threshold of 4.76 ($p < 0.05$). Haplotype blocks associated with trait variations are annotated in boxes

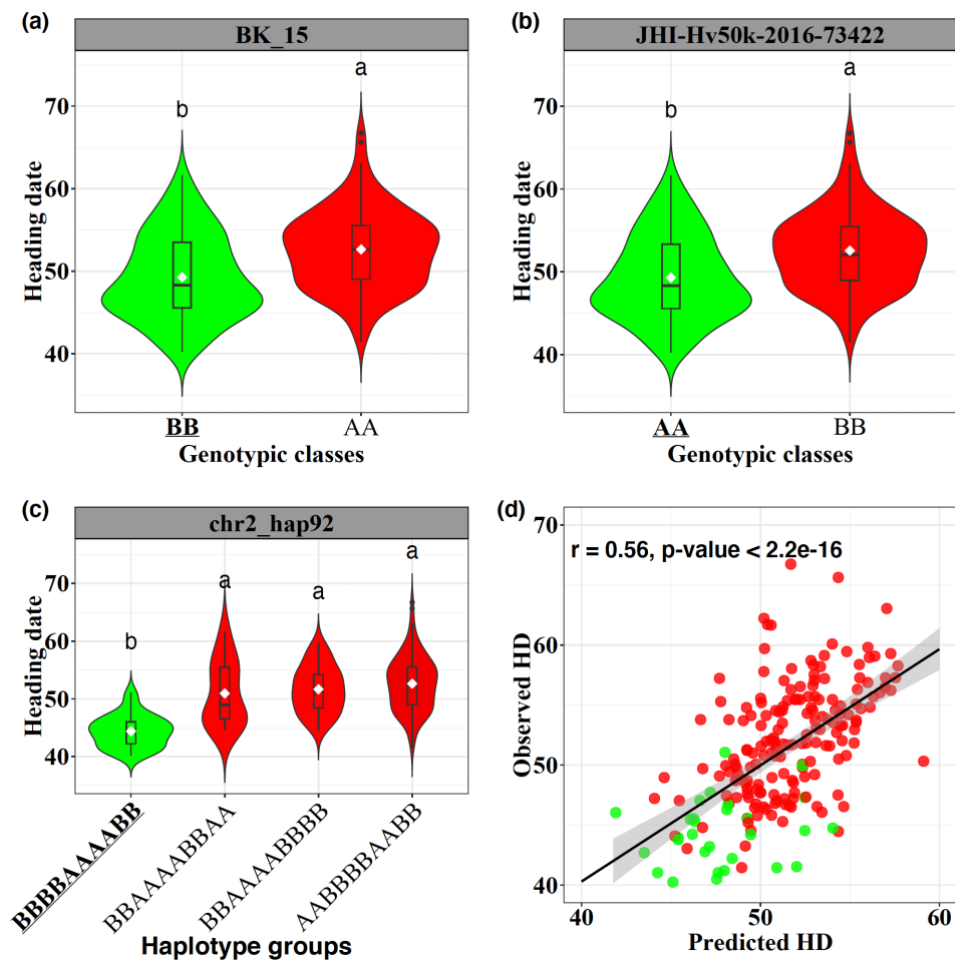


Fig. S6 The distribution of lines at markers (a) BK_15, (b) JHI-Hv50k-2016-73422 for heading date, (c) The distribution of haplotypes at block “chr2_hap92” for heading date, and (d) Scatterplot showing the relationship between the observed and RRBLUP-predicted heading date. The haplotype block “chr2_hap92” consisted of five markers; only BK_15 and JHI-Hv50k-2016-73422 were declared significant using single-SNP GWAS. The white-filled diamond shape represents the mean of each genotype class or haplotype group, and those with the lowest mean were in bold and underlined. The green-filled circles represent the haplotype with the lowest heading date, while the red-filled circles represent the other groups