

Loci controlling adaptation to heat stress occurring at the reproductive stage in durum wheat

Khaoula El Hassouni ^{1,2}, Bouchra Belkadi ², Abdelkarim Filali-Maltouf ², Amadou Tidiane-Sall ^{1,3}, Ayed Al-Abdallat ⁴, Miloudi Nachit ^{1,2}, Filippo M. Bassi ^{1,*}

Supplementary document

Table S1. List of durum wheat genotypes evaluated under plastic tunnel-mediated heat stress in the present study.

Accession name	Origin	Pedigree
ADYT_046	ICARDA	IcamorTA041/4/IcamorTA0469/3/Bcr/Gro1//Mgnl1/5/MIKI2
ADYT_104	ICARDA	Bcr/Lks4//Mrf1/Stj2/3/Ouasbar2
ADYT_120	ICARDA	Aghrass1/3/HFN94N8/Mrb5//Zna1/4/IcamorTA0458
Berghouata1	ICARDA	Ter1//Mrf1/Stj2
Bezaghra	ICARDA	Ossl1/Stj5/5/Bicrederaa1/4/BezaizSHF//SD19539/Waha/3/Stj/Mrb3/6/Mgnl3/Aghrass2
CaMdoH25	ICARDA	CM829/CandocrossH25
Chacan	ICARDA	Cham1/5/Cando/4/BY*2/Tace//II27655/3/Tme//ZB/W*2
DP0257	CIMMYT	1A.1D5+106/2*WB881//1A.1D5+106/3*Mojo/3/Bisu_1/Patka_3
DP0261	CIMMYT	Cndo/Primadur//Haiou_17/3/Snturkmi8384375/NIGRIS_5//TANTLO_1
DP0269	CIMMYT	Somat_3/Phax_1//Tilo_1/Lotus_4
DP062	ICARDA	Chhb88/Deraa
DWayT-0209	ICARDA	Korifla/Ae.SpeltoidesSyr//Amedakul
DWayT-0215	ICARDA	Korifla/Ae.SpeltoidesSyr//Amedakul
DWayT-0217	ICARDA	Korifla/Aeg.SpeltoidesSyr//Loukos
DWayT-0224	ICARDA	Korifla/Ae.SpeltoidesSyr//Waha
DWayT-0306	ICARDA	Korifla/Ae.SpeltoidesSyr//Heider
Faraj	ICARDA/ Morocco	F413J.S/3/Arthur71/Lahn//Blk2/Lahn/4/Quarmal
Icavice	ICARDA	IcamorTA0468/6/21563/AA//Fg/3/D68102A2A1A/4/Vitron/5/Bcr
IDON37-010	ICARDA	Marsyr3/3/Gcn//Stj/Mrb3

IDON37-033	ICARDA	Mgnl3/Ainzen1//Ammar1
IDON37-039	ICARDA	Mgnl3/Ainzen1/3/Ter1//Mrf1/Stj2
IDON37-062	ICARDA	Ter1/3/Stj3//Bcr/Lks4/4/Icajihan18
IDON37-094	ICARDA	Aghrass1//Bezai982/Bcrch1/4/IcamorTA0462/3/Quabrach3//Vitron/Bidra1/5/Stj3//Bcr/Lks4/3/Ter3
IDON37-097	ICARDA	Mgnl3/Ainzen1/3/Bcr/Gro1//Mgnl1
IDON37-129	ICARDA	CM829/CandocrossH25//Icajihan10
IDON37-141	ICARDA	IcamorTA0471//IcamorTA0459/Ammar8/4/Stj3//Dra2/Bcr/3/Ter3
IDON37-143	ICARDA	Mrb3/Mna1//Ter1/3/IcamorTA0459/Ammar7/4/Beltagy2
IDYT37-19	ICARDA	Mgnl3/Ainzen1//Maamouri3
IG:88029	Ethiopia	Landrace
Isly	Morocco	Erpel(SIB)/(SIB)Ruso
Karim	CIMMYT	Jori69(SIB)/(SIB)Anhinga/(SIB)Flamingo
Kunmiki	ICARDA	MorlF38//Bcrch1/Kund1149/3/Bicrederaa1/Miki
Louiza	Morocco	na
Margherita 2	ICARDA	Terbol975/Geruftel2
MCHCB-083	ICARDA	Cham5*4/Ae.Speltoides401294/4/IcamorTA0469/3/Bcr/Gro1//Mgnl1/5/Stj3//Bcr/Lks4/3/Ter3
MCHCB-095	ICARDA	Mck2/Tilo2//Bcrch1/Kund1149
Moulsabil2	ICARDA	H.mouline(Mor)/Sabil2
Nile	ICARDA	Snipe/Fg
Ouassara	ICARDA	Ouasloukos1/5/Azn1/4/BezaiSHF//SD19539/Waha/3/Gdr2
Ourgh	Morocco	D67gta/2/Boyero/Bit//Mexicali
Saintly	Australia	Tamaroi/WLYY9//WLYY96a1773
Secondroue	ICARDA	Stj3//Bcr/Lks4/3/Ter3/4/Bcr/Gro1//Mgnl1

Table S2. Correlation (*r*), linear regression estimated via ordinary least squares (OLS) and flexible regression estimated via regression additive model. a; under heat stress. b; under normal conditions.

a) Plastic tunnel-mediated heat stress

Trait	<i>r</i>	OLS regression			GAM		Deviance (%)	L-R test
		<i>B</i>	<i>t</i>	Deviance	E.D.F.	<i>F</i>		
Biomass	0.61**	0.18	4.85**	37.10	1.00	23.54**	37.10	**
HI	0.73**	6702.90	6.65**	52.50	2.69	19.75**	64.00	**
Spkm ²	0.18 ^{ns}	1.24	1.16 ^{ns}	3.29	1.00	1.35 ^{ns}	3.29	*
GN _{spk}	0.81**	179.95	8.72**	65.50	2.64	30.37**	72.80	*
TKW	0.49**	51.72	3.58**	24.30	1.16	10.48**	25.00	^{ns}

b) Normal conditions

Trait	<i>r</i>	OLS regression			GAM		Deviance (%)	L-R test
		<i>b</i>	<i>t</i>	Deviance	E.D.F.	<i>F</i>		
Biomass	0.67**	0.24	5.71**	44.90	2.52	12.45**	51.80	^{ns}
HI	0.55**	7203.30	4.12**	29.80	1.14	14.24**	30.40	^{ns}
Spkm ²	0.45**	4.64	3.19**	20.20	1.00	10.14**	20.20	**
GN _{spk}	0.66**	139.90	5.54**	43.40	1.00	30.76**	43.50	**
TKW	0.56**	151.62	4.32**	31.90	2.76	7.43**	42.00	^{ns}

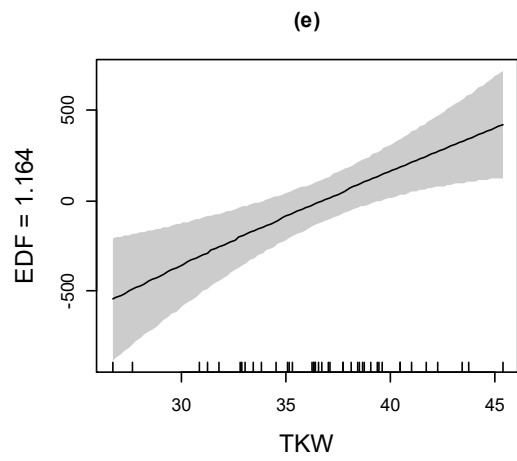
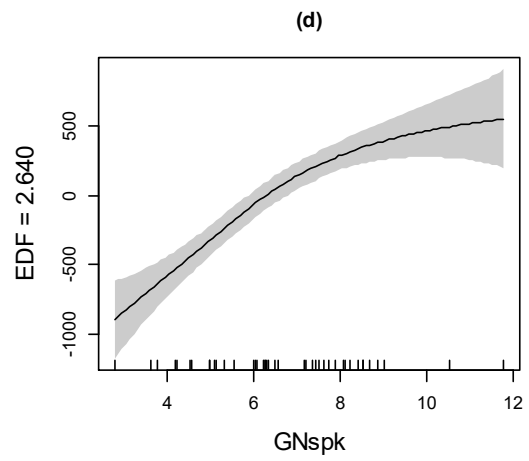
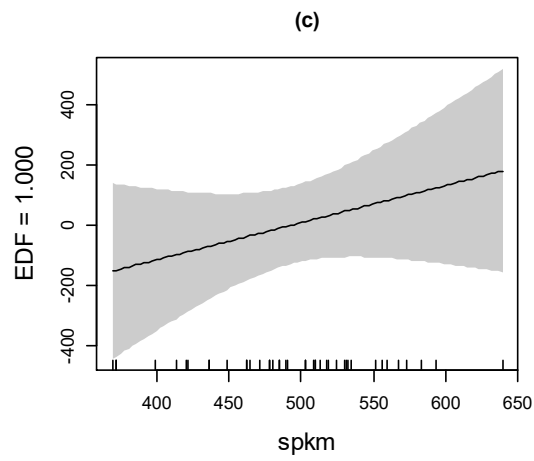
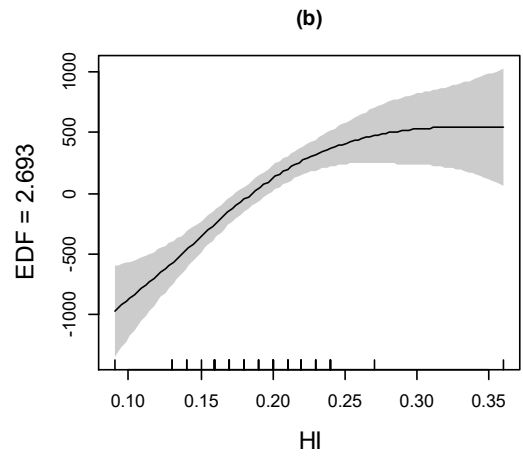
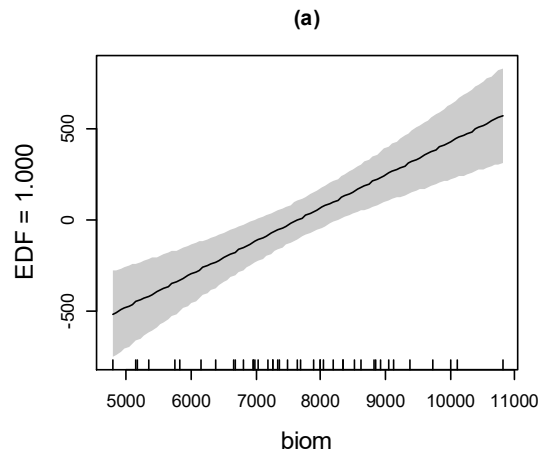
Table S3. Markers associated with days to heading (DTH) under heat stress and normal conditions.

Locus	Chr.	Main marker	Position	Max LOD	Max <i>r</i> ²	Heat stress	Normal conditions
MTA.DTH.01	4A	AX-94954115	135455654	3.1	0.29	*	*
MTA.DTH.02	4B	AX-95082485	417259719	3.1	0.29	*	*
MTA.DTH.03	4B	AX-94397040	418863736	3.1	0.29	*	*
MTA.DTH.04	6A	AX-94732269	65926884	3.1	0.27		*

Table S4. Pearson correlation matrix between all the measured traits under heat conditions (upper part) and normal (lower part) conditions. GY – Grain yield; Biom – Biomass; HI – Harvest index; Spkm² - Spikes per square meter; GNspk - Grain number per spike; TKW – Thousand kernel weight; DTH – Days to heading. *, ** Significant at the 0.05 and 0.01 probability levels, respectively.

	GY	Biom	HI	Spkm ²	GNspk	TKW	DTH
GY		0.61**	0.73**	0.18 ^{ns}	0.81**	0.49**	0.09 ^{ns}
Biom	0.67**		-0.02 ^{ns}	0.36*	0.30*	0.44**	0.07 ^{ns}
HI	0.54**	-0.18 ^{ns}		-0.09 ^{ns}	0.78**	0.28 ^{ns}	0.01 ^{ns}
Spkm ²	0.45**	0.53**	0.02 ^{ns}		-0.12 ^{ns}	-0.04 ^{ns}	0.03 ^{ns}
GNspk	0.67**	0.27 ^{ns}	0.51**	-0.27 ^{ns}		0.16 ^{ns}	-0.18 ^{ns}
TKW	0.56**	0.44**	0.35*	0.28 ^{ns}	0.06 ^{ns}		0.17 ^{ns}
DTH	-0.18 ^{ns}	0.19 ^{ns}	-0.44**	-0.06 ^{ns}	-0.17 ^{ns}	-0.09 ^{ns}	

a-



b-

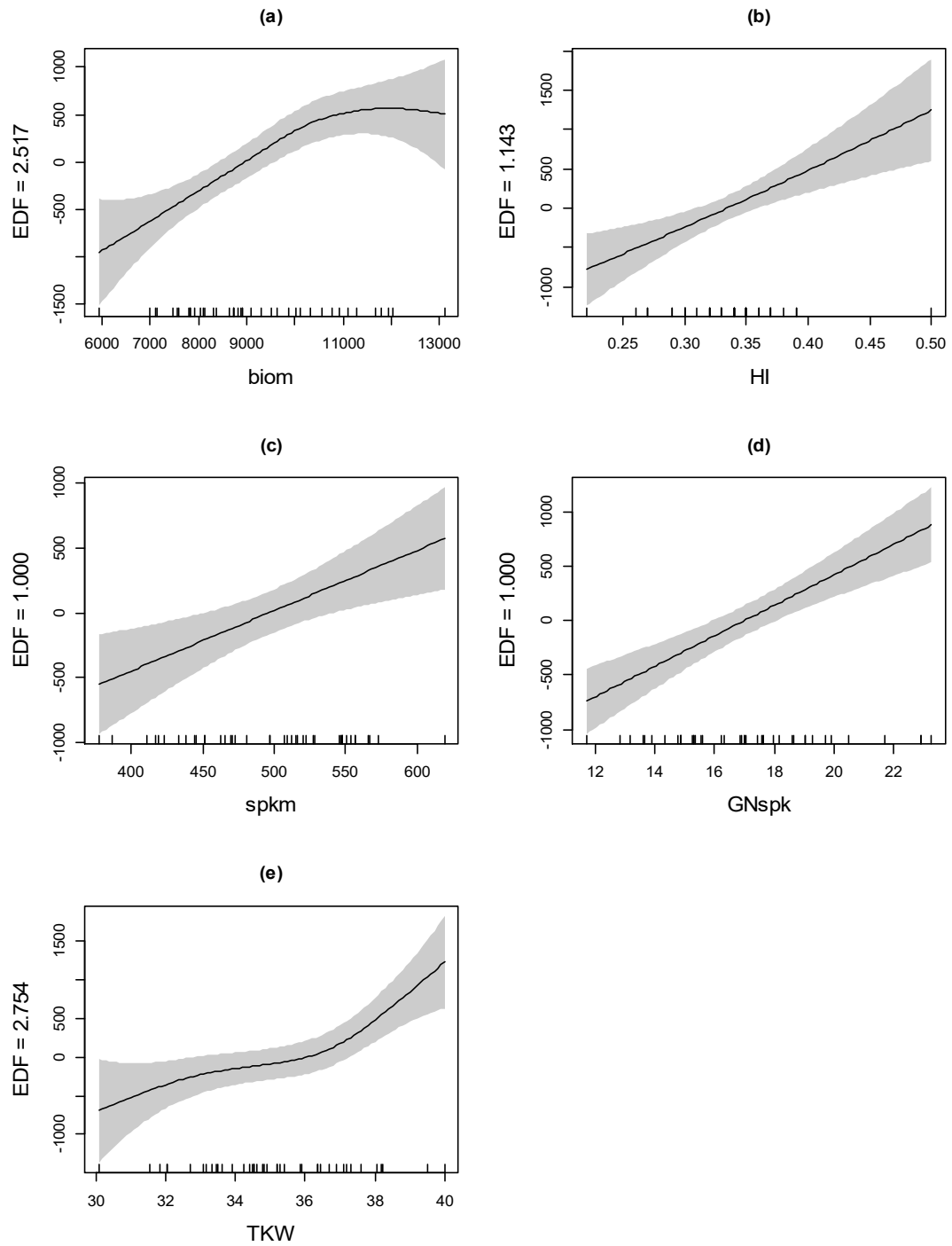


Figure S1. Plots of the additive regression model showing GNspk, biom, TKW, spkm² and HI as the spline function of the target trait grain yield (GY). a; under heat stress. b; under normal conditions