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

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**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 |
| Bezaghras | 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 |
| Icavicre | 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//Bezaiz982/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.

1. Plastic tunnel-mediated heat stress

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Trait | *r* | OLS regression | | | GAM | | | L-R test |
| *B* | *t* | Deviance | E.D.F. | *F* | Deviance (%) |
| 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 | \*\* |
| Spkm² | 0.18ns | 1.24 | 1.16ns | 3.29 | 1.00 | 1.35ns | 3.29 | \* |
| GNspk | 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 |

1. Normal conditions

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Trait | *r* | OLS regression | | | GAM | | | L-R test |
| *b* | *t* | Deviance | E.D.F. | *F* | Deviance (%) |
| 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 |
| Spkm² | 0.45\*\* | 4.64 | 3.19\*\* | 20.20 | 1.00 | 10.14\*\* | 20.20 | \*\* |
| GNspk | 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 r² | 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 | Spkm² | 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 |
| Spkm² | 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