

Supplemental Table 1. Accessions in the NARO Japanese wheat core collection

| Accession ID ¹⁾ | Cultivar name | Status | Category ²⁾ | Locality | Area ³⁾ | Population ⁴⁾ | <i>Rht-D1</i> ⁵⁾ | <i>Rht-B1</i> ⁵⁾ |
|----------------------------|---------------------------|--------------------|------------------------|-----------|-----------------------|--------------------------|-----------------------------|-----------------------------|
| JWC 01 | Akagawa aka | Landrace | Classical | Hokkaido | Hokkaido | I | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 02 | Shirohada | Unknown | Classical | Hokkaido | Hokkaido | I | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 03 | Dawson 1 | Pure selected line | Classical | Hokkaido | Hokkaido | I | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 04 | Sapporo Harukomugi | Breeders line | Classical | Hokkaido | Hokkaido | I | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 05 | Soshu 2 | Pure selected line | Classical | Aomori | Tohoku | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 06 | Shisen 1 | Pure selected line | Classical | Iwate | Tohoku | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 07 | Zairai Fultz | Landrace | Classical | Iwate | Tohoku | III | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 08 | Nishimura | Breeders line | Classical | Yamagata | Tohoku | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 09 | Shirasaya | Unknown | Classical | Ibaraki | Kanto/Tosan | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 10 | Fukoku | Breeders line | Classical | Ibaraki | Kanto/Tosan | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 11 | Akagara Ibaraki 1 | Pure selected line | Classical | Ibaraki | Kanto/Tosan | I | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 12 | Shirosanjaku | Unknown | Classical | Ibaraki | Kanto/Tosan | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 13 | Akaboro 1 | Pure selected line | Classical | Tochigi | Kanto/Tosan | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 14 | Nittawase | Landrace | Classical | Gunma | Kanto/Tosan | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 15 | Sunekiri 15 | Pure selected line | Classical | Gunma | Kanto/Tosan | III | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 16 | Akabouzu | Breeders line | Classical | Saitama | Kanto/Tosan | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 17 | Hosogara | Breeders line | Classical | Chiba | Kanto/Tosan | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 18 | Shiroadaruma | Breeders line | Classical | Kanagawa | Kanto/Tosan | III | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 19 | Akadaruma | Breeders line | Classical | Kanagawa | Kanto/Tosan | III | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 20 | Wase komugi | Breeders line | Classical | Kanagawa | Kanto/Tosan | II | <i>Rht-D1a</i> | <i>Rht-B1b</i> |
| JWC 21 | Aka komugi | Landrace | Classical | Yamanashi | Kanto/Tosan | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 22 | Shibushirazu | Breeders line | Classical | Nagano | Kanto/Tosan | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 23 | Koshigun zairai shu | Landrace | Classical | Niigata | Kanto/Tosan | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 24 | Shirochabo | Unknown | Classical | Mie | Tokai/Hokuriku | III | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 25 | Sakobore | Breeders line | Classical | Shizuoka | Tokai/Hokuriku | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 26 | Shin Chunaga | Pure selected line | Classical | Hyogo | Kinki/Chugoku/Shikoku | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 27 | Hatakeda komugi | Breeders line | Classical | Okayama | Kinki/Chugoku/Shikoku | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 28 | Yushoki 347 | Unknown | Classical | Okayama | Kinki/Chugoku/Shikoku | III | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 29 | Hiroshima Shipree | Unknown | Classical | Hiroshima | Kinki/Chugoku/Shikoku | III | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 30 | Mubouchinko | Breeders line | Classical | Hiroshima | Kinki/Chugoku/Shikoku | III | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 31 | Hiraki komugi | Landrace | Classical | Tottori | Kinki/Chugoku/Shikoku | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 32 | Nakasoshu | Unknown | Classical | Kagawa | Kinki/Chugoku/Shikoku | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 33 | Homan | Unknown | Classical | Tochigi | Kanto/Tosan | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 34 | Sekichiku 1 | Pure selected line | Classical | Aichi | Tokai/Hokuriku | III | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 35 | Eshima shinriki | Breeders line | Classical | Fukuoka | Kyushu | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 36 | Igachikugo | Unknown | Classical | Saga | Kyushu | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 37 | Shiro komugi | Landrace | Classical | Saga | Kyushu | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 38 | Chikuzen | Landrace | Classical | Saga | Kyushu | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 39 | Ichigo Haya komugi | Pure selected line | Classical | Kumamoto | Kyushu | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 40 | Shirobunbu | Breeders line | Classical | Kumamoto | Kyushu | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 41 | Aso zairai (yuubou kappu) | Landrace | Classical | Kumamoto | Kyushu | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 42 | Sotome | Breeders line | Classical | Nagasaki | Kyushu | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 43 | Sadabozu | Landrace | Classical | Miyazaki | Kyushu | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 44 | Nobeokabouzu komugi | Landrace | Classical | Miyazaki | Kyushu | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 45 | Sakigake 1 | Pure selected line | Classical | Kagoshima | Kyushu | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 46 | Akasabishirazu 1 | Breeders line | Modern | Hokkaido | Hokkaido | I | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 47 | Honkei 275 | Breeders line | Modern | Hokkaido | Hokkaido | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 48 | Hokkai 240 | Breeders line | Modern | Hokkaido | Hokkaido | I | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 49 | Konosu 25 | Breeders line | Modern | Saitama | Kanto/Tosan | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 50 | Saitama 27 | Breeders line | Modern | Saitama | Kanto/Tosan | II | <i>Rht-D1a</i> | <i>Rht-B1b</i> |
| JWC 51 | Kanto 107 | Breeders line | Modern | Ibaraki | Kanto/Tosan | II | <i>Rht-D1a</i> | <i>Rht-B1b</i> |
| JWC 52 | Igachikugo Oregon | Breeders line | Modern | Nagano | Kanto/Tosan | I | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 53 | Gokuwase 4-15 | Breeders line | Modern | Hiroshima | Kinki/Chugoku/Shikoku | II | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 54 | Komugi Norin 1 | Breeders line | Modern | Iwate | Tohoku | I | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 55 | Harumakikomugi Norin 3 | Breeders line | Modern | Hokkaido | Hokkaido | I | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 56 | Komugi Norin 9 | Breeders line | Modern | Aichi | Tokai/Hokuriku | III | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 57 | Komugi Norin 10 | Breeders line | Modern | Iwate | Tohoku | I | <i>Rht-D1b</i> | <i>Rht-B1b</i> |

| | | | | | | | | |
|--------|-------------------------|---------------|--------|-----------|-----------------------|-----|----------------|----------------|
| JWC 58 | Komugi Norin 16 | Breeders line | Modern | Gunma | Kanto/Tosan | III | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 59 | Komugi Norin 26 | Breeders line | Modern | Nara | Kinki/Chugoku/Shikoku | II | <i>Rht-D1a</i> | <i>Rht-B1b</i> |
| JWC 60 | Komugi Norin 27 | Breeders line | Modern | Iwate | Tohoku | I | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 61 | Komugi Norin 39 | Breeders line | Modern | Iwate | Tohoku | I | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 62 | Koshitsukomugi Norin 42 | Breeders line | Modern | Gunma | Kanto/Tosan | I | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 63 | Komugi Norin 50 | Breeders line | Modern | Gunma | Kanto/Tosan | III | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 64 | Komugi Norin 53 | Breeders line | Modern | Aichi | Tokai/Hokuriku | III | <i>Rht-D1a</i> | <i>Rht-B1b</i> |
| JWC 65 | Komugi Norin 55 | Breeders line | Modern | Iwate | Tohoku | I | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 66 | Komugi Norin 61 | Breeders line | Modern | Saga | Kyushu | III | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 67 | Komugi Norin 67 | Breeders line | Modern | Gunma | Kanto/Tosan | I | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 68 | Harumakikomugi Norin 75 | Breeders line | Modern | Hokkaido | Hokkaido | I | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 69 | Hokuei | Breeders line | Modern | Hokkaido | Hokkaido | I | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 70 | Muka komugi | Breeders line | Modern | Hokkaido | Hokkaido | I | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 71 | Horoshiri komugi | Breeders line | Modern | Hokkaido | Hokkaido | I | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 72 | Takune komugi | Breeders line | Modern | Hokkaido | Hokkaido | I | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 73 | Haruhikari | Breeders line | Modern | Hokkaido | Hokkaido | I | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 74 | Aoba komugi | Breeders line | Modern | Iwate | Tohoku | III | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 75 | Hitsumi komugi | Breeders line | Modern | Iwate | Tohoku | I | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 76 | Furutsu masari | Breeders line | Modern | Iwate | Tohoku | I | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 77 | Yukichabo | Breeders line | Modern | Niigata | Kanto/Tosan | I | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 78 | Hikari komugi | Breeders line | Modern | Niigata | Kanto/Tosan | I | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 79 | Fukuho komugi | Breeders line | Modern | Saitama | Kanto/Tosan | III | <i>Rht-D1a</i> | <i>Rht-B1b</i> |
| JWC 80 | Fukuwase komugi | Breeders line | Modern | Hiroshima | Kinki/Chugoku/Shikoku | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 81 | Abukumawase | Breeders line | Modern | Fukuoka | Kyushu | II | <i>Rht-D1a</i> | <i>Rht-B1b</i> |
| JWC 82 | Hokushin | Breeders line | Modern | Hokkaido | Hokkaido | I | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 83 | Chihoku komugi | Breeders line | Modern | Hokkaido | Hokkaido | I | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 84 | Haruyutaka | Breeders line | Modern | Hokkaido | Hokkaido | I | <i>Rht-D1a</i> | <i>Rht-B1b</i> |
| JWC 85 | Nanbu komugi | Breeders line | Modern | Iwate | Tohoku | I | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 86 | Kitakami komugi | Breeders line | Modern | Iwate | Tohoku | I | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 87 | Shirane komugi | Breeders line | Modern | Nagano | Kanto/Tosan | III | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 88 | Bando wase | Breeders line | Modern | Ibaraki | Kanto/Tosan | II | <i>Rht-D1a</i> | <i>Rht-B1b</i> |
| JWC 89 | Shirogane komugi | Breeders line | Modern | Fukuoka | Kyushu | II | <i>Rht-D1a</i> | <i>Rht-B1b</i> |
| JWC 90 | Chikugoizumi | Breeders line | Modern | Fukuoka | Kyushu | II | <i>Rht-D1a</i> | <i>Rht-B1b</i> |
| JWC 91 | Komugi Norin 20 | Breeders line | Modern | Saga | Kyushu | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |
| JWC 92 | Fujimi komugi | Breeders line | Modern | Saitama | Kanto/Tosan | II | <i>Rht-D1a</i> | <i>Rht-B1b</i> |
| JWC 93 | Shirasagi komugi | Breeders line | Modern | Hiroshima | Kinki/Chugoku/Shikoku | II | <i>Rht-D1a</i> | <i>Rht-B1b</i> |
| JWC 94 | Junrei komugi | Breeders line | Modern | Kagawa | Kinki/Chugoku/Shikoku | II | <i>Rht-D1a</i> | <i>Rht-B1b</i> |
| JWC 95 | Hachiman komugi | Breeders line | Modern | Iwate | Tohoku | I | <i>Rht-D1b</i> | <i>Rht-B1a</i> |
| JWC 96 | Chinese Spring | Standard line | | Sichuan | China | III | <i>Rht-D1a</i> | <i>Rht-B1a</i> |

1) from the NIAS Genebank (http://www.gene.affrc.go.jp/databases-core_collections_jw_en.php)

2) Classical: landraces, pure selected lines, and breeders line before and lines bred before 1920's; Modern: lines bred after 1930's

3) detailed map location for the areas in Kobayashi et al. (2016, *Breed Sci*, 66:213-225)

4) from this study

5) genotypes for *Rht* genes from Kojima et al. (2017, *Bull. NARO Crop Sci.*, 1:1-13) and this study

Supplemental Table 2. Primer sequences for detecting the alleles of *Rht-B1* and *Rht-D1* *

| Alleles | Primer sequences | |
|----------------------------|---|---|
| | Foreward | Reverse |
| <i>Rht-B1a</i> (wild type) | 5'- GGT AGG GAG GCG AGA GGC GAG -3' | 5'- CAT CCC CAT GGC CAT CTC GAG CTG -3' |
| <i>Rht-B1b</i> (dwarf) | 5'- GGT AGG GAG GCG AGA GGC GAG -3' | 5'- CAT CCC CAT GGC CAT CTC GAG CTA -3' |
| <i>Rht-D1a</i> (wild type) | 5'- GGC AAG CAA AAG CTT CGC G -3' | 5'- GGC CAT CTC GAG CTG CAC -3' |
| <i>Rht-D1b</i> (dwarf) | 5'- CGC GCA ATT ATT GGC CAG AGA TAG -3' | 5'- CCC CAT GGC CAT CTC GAG CTG CTA -3' |

*from Ellis et al. (2002)

Supplemental Table 3. Summary of mapping statistics in three methods

| Accession ID* | amplicon-seq | | | | RAD-seq | | | | GBS | | | | total | |
|---------------|------------------|------------------------------|------------|-------------------|------------------|------------------------------|------------|-------------------|------------------|------------------------------|------------|-------------------|------------------|------------------------------|
| | homozygous sites | alternative homozygous sites | mean depth | % of mapped reads | homozygous sites | alternative homozygous sites | mean depth | % of mapped reads | homozygous sites | alternative homozygous sites | mean depth | % of mapped reads | homozygous sites | alternative homozygous sites |
| JWC01 | 476 | 412 | 83.60 | 88.52 | 5288 | 5399 | 7.06 | 69.01 | 10004 | 8638 | 5.83 | 71.97 | 15768 | 14449 |
| JWC02 | 453 | 435 | 79.15 | 87.10 | 5376 | 5311 | 10.63 | 65.27 | 10330 | 8312 | 5.32 | 72.01 | 16159 | 14058 |
| JWC03 | 481 | 407 | 91.88 | 89.43 | 5146 | 5541 | 8.26 | 68.90 | 10080 | 8562 | 5.29 | 70.34 | 15707 | 14510 |
| JWC04 | 485 | 403 | 92.88 | 90.20 | 5662 | 5025 | 4.13 | 65.26 | 10502 | 8140 | 4.94 | 70.23 | 16649 | 13568 |
| JWC05 | 693 | 195 | 79.60 | 90.14 | 9259 | 1428 | 12.85 | 59.62 | 15344 | 3298 | 4.79 | 73.28 | 25296 | 4921 |
| JWC06 | 666 | 222 | 89.28 | 89.98 | 8826 | 1861 | 8.62 | 62.33 | 15021 | 3621 | 4.89 | 73.54 | 24513 | 5704 |
| JWC07 | 641 | 247 | 92.58 | 90.14 | 8723 | 1964 | 10.97 | 60.24 | 14541 | 4101 | 4.81 | 72.20 | 23905 | 6312 |
| JWC08 | 665 | 223 | 82.43 | 88.99 | 8602 | 2085 | 11.03 | 60.86 | 14665 | 3977 | 4.93 | 73.10 | 23932 | 6285 |
| JWC09 | 686 | 202 | 99.54 | 90.84 | 8572 | 2115 | 10.77 | 61.21 | 14708 | 3934 | 5.05 | 73.29 | 23966 | 6251 |
| JWC10 | 687 | 201 | 101.20 | 90.75 | 9347 | 1340 | 14.71 | 60.66 | 15284 | 3358 | 4.74 | 72.31 | 25318 | 4899 |
| JWC11 | 591 | 297 | 85.76 | 89.52 | 7338 | 3349 | 14.43 | 60.44 | 12952 | 5690 | 4.53 | 70.69 | 20881 | 9336 |
| JWC12 | 654 | 234 | 88.40 | 89.96 | 8255 | 2432 | 3.39 | 63.75 | 14325 | 4317 | 4.90 | 71.93 | 23234 | 6983 |
| JWC13 | 681 | 207 | 99.31 | 90.66 | 8915 | 1772 | 11.99 | 60.65 | 15120 | 3522 | 4.67 | 73.26 | 24716 | 5501 |
| JWC14 | 659 | 229 | 85.55 | 90.32 | 8387 | 2300 | 11.67 | 61.20 | 14395 | 4247 | 4.71 | 71.66 | 23441 | 6776 |
| JWC15 | 665 | 223 | 97.62 | 90.93 | 8519 | 2168 | 12.11 | 61.17 | 14525 | 4117 | 3.07 | 71.77 | 23709 | 6508 |
| JWC16 | 707 | 181 | 95.57 | 91.46 | 8527 | 2160 | 4.25 | 64.48 | 14595 | 4047 | 4.60 | 73.30 | 23829 | 6388 |
| JWC17 | 635 | 253 | 96.19 | 90.41 | 7925 | 2762 | 10.82 | 62.77 | 13723 | 4919 | 4.47 | 72.57 | 22283 | 7934 |
| JWC18 | 664 | 224 | 98.69 | 90.58 | 8514 | 2173 | 8.53 | 65.11 | 14507 | 4135 | 4.51 | 72.43 | 23685 | 6532 |
| JWC19 | 676 | 212 | 88.73 | 90.60 | 8413 | 2274 | 8.91 | 66.39 | 14528 | 4114 | 4.57 | 71.67 | 23617 | 6600 |
| JWC20 | 542 | 346 | 96.01 | 90.16 | 7818 | 2869 | 12.77 | 61.40 | 13705 | 4937 | 4.51 | 71.71 | 22065 | 8152 |
| JWC21 | 676 | 212 | 93.27 | 90.50 | 8979 | 1708 | 12.31 | 60.37 | 14979 | 3663 | 4.68 | 72.75 | 24634 | 5583 |
| JWC22 | 634 | 254 | 85.66 | 89.88 | 8253 | 2434 | 13.49 | 59.83 | 13960 | 4682 | 4.88 | 71.17 | 22847 | 7370 |
| JWC23 | 678 | 210 | 89.00 | 90.10 | 8622 | 2065 | 11.47 | 61.85 | 14780 | 3862 | 4.51 | 71.95 | 24080 | 6137 |
| JWC24 | 680 | 208 | 66.51 | 86.11 | 8940 | 1747 | 12.62 | 58.81 | 14954 | 3688 | 3.02 | 71.68 | 24574 | 5643 |
| JWC25 | 688 | 200 | 62.02 | 84.79 | 8589 | 2098 | 10.79 | 61.19 | 14668 | 3974 | 3.11 | 71.56 | 23945 | 6272 |
| JWC26 | 632 | 256 | 51.85 | 81.80 | 8468 | 2219 | 14.57 | 58.96 | 14519 | 4123 | 2.47 | 71.45 | 23619 | 6598 |
| JWC27 | 675 | 213 | 93.35 | 89.13 | 8994 | 1693 | 12.38 | 61.70 | 14979 | 3663 | 5.34 | 72.59 | 24648 | 5569 |
| JWC28 | 664 | 224 | 96.09 | 90.50 | 8513 | 2174 | 16.47 | 59.85 | 14509 | 4133 | 4.90 | 72.36 | 23686 | 6531 |
| JWC29 | 690 | 198 | 92.78 | 89.81 | 8620 | 2067 | 13.35 | 60.37 | 14643 | 3999 | 4.38 | 69.22 | 23953 | 6264 |
| JWC30 | 694 | 194 | 88.40 | 90.27 | 8842 | 1845 | 3.56 | 63.06 | 14925 | 3717 | 5.00 | 72.82 | 24461 | 5756 |
| JWC31 | 677 | 211 | 79.25 | 90.17 | 8642 | 2045 | 4.65 | 63.43 | 15016 | 3626 | 4.83 | 73.62 | 24335 | 5882 |
| JWC32 | 676 | 212 | 106.82 | 90.27 | 8786 | 1901 | 12.58 | 60.28 | 14854 | 3788 | 5.00 | 71.90 | 24316 | 5901 |

| | | | | | | | | | | | | | | |
|-------|-----|-----|--------|-------|------|------|-------|-------|-------|------|-------|-------|-------|-------|
| JWC33 | 673 | 215 | 76.02 | 86.75 | 9356 | 1331 | 6.97 | 67.01 | 15147 | 3495 | 10.98 | 66.36 | 25176 | 5041 |
| JWC34 | 702 | 186 | 89.59 | 87.87 | 8919 | 1768 | 11.59 | 60.95 | 14887 | 3755 | 13.97 | 66.66 | 24508 | 5709 |
| JWC35 | 652 | 236 | 90.52 | 87.61 | 8639 | 2048 | 2.84 | 60.64 | 14112 | 4530 | 15.60 | 65.62 | 23403 | 6814 |
| JWC36 | 675 | 213 | 90.29 | 87.81 | 9005 | 1682 | 11.00 | 61.91 | 14971 | 3671 | 15.37 | 66.50 | 24651 | 5566 |
| JWC37 | 679 | 209 | 92.23 | 89.73 | 9092 | 1595 | 12.53 | 60.58 | 15039 | 3603 | 4.87 | 71.87 | 24810 | 5407 |
| JWC38 | 672 | 216 | 78.59 | 91.25 | 9365 | 1322 | 11.17 | 61.74 | 15146 | 3496 | 4.74 | 72.37 | 25183 | 5034 |
| JWC39 | 626 | 262 | 93.71 | 90.20 | 8144 | 2543 | 10.56 | 61.43 | 13818 | 4824 | 4.30 | 69.92 | 22588 | 7629 |
| JWC40 | 698 | 190 | 95.39 | 90.15 | 9366 | 1321 | 12.08 | 60.08 | 15414 | 3228 | 4.40 | 72.95 | 25478 | 4739 |
| JWC41 | 665 | 223 | 106.93 | 91.10 | 8139 | 2548 | 9.22 | 65.74 | 14265 | 4377 | 4.35 | 72.72 | 23069 | 7148 |
| JWC42 | 657 | 231 | 104.12 | 90.73 | 8989 | 1698 | 13.12 | 59.47 | 14773 | 3869 | 4.47 | 72.29 | 24419 | 5798 |
| JWC43 | 678 | 210 | 90.98 | 88.20 | 9219 | 1468 | 14.82 | 60.89 | 15374 | 3268 | 4.69 | 72.40 | 25271 | 4946 |
| JWC44 | 701 | 187 | 95.67 | 89.51 | 8816 | 1871 | 11.12 | 61.31 | 14860 | 3782 | 4.81 | 72.66 | 24377 | 5840 |
| JWC45 | 691 | 197 | 89.69 | 89.09 | 8569 | 2118 | 5.85 | 58.05 | 14642 | 4000 | 4.57 | 72.65 | 23902 | 6315 |
| JWC46 | 426 | 462 | 92.57 | 89.33 | 5004 | 5683 | 12.13 | 61.98 | 9624 | 9018 | 4.52 | 69.55 | 15054 | 15163 |
| JWC47 | 568 | 320 | 99.25 | 90.08 | 7748 | 2939 | 10.34 | 62.27 | 13136 | 5506 | 4.65 | 66.42 | 21452 | 8765 |
| JWC48 | 528 | 360 | 108.51 | 90.78 | 6242 | 4445 | 12.56 | 61.49 | 11808 | 6834 | 4.86 | 70.85 | 18578 | 11639 |
| JWC49 | 549 | 339 | 105.96 | 90.52 | 7606 | 3081 | 8.18 | 65.18 | 13153 | 5489 | 4.23 | 69.91 | 21308 | 8909 |
| JWC50 | 546 | 342 | 96.96 | 90.06 | 7536 | 3151 | 7.42 | 63.49 | 13377 | 5265 | 3.94 | 70.32 | 21459 | 8758 |
| JWC51 | 518 | 370 | 98.70 | 90.02 | 7679 | 3008 | 13.81 | 60.58 | 13155 | 5487 | 3.91 | 69.78 | 21352 | 8865 |
| JWC52 | 515 | 373 | 96.84 | 89.96 | 6913 | 3774 | 14.23 | 61.93 | 12201 | 6441 | 4.01 | 70.75 | 19629 | 10588 |
| JWC53 | 507 | 381 | 97.59 | 89.22 | 7530 | 3157 | 14.59 | 59.73 | 12972 | 5670 | 3.85 | 69.68 | 21009 | 9208 |
| JWC54 | 565 | 323 | 81.42 | 88.73 | 7022 | 3665 | 13.24 | 60.70 | 12700 | 5942 | 4.22 | 72.01 | 20287 | 9930 |
| JWC55 | 514 | 374 | 101.75 | 89.90 | 5597 | 5090 | 3.04 | 67.31 | 10802 | 7840 | 4.69 | 68.34 | 16913 | 13304 |
| JWC56 | 642 | 246 | 87.95 | 89.07 | 8666 | 2021 | 9.32 | 61.37 | 14275 | 4367 | 4.98 | 70.98 | 23583 | 6634 |
| JWC57 | 564 | 324 | 108.00 | 90.54 | 7215 | 3472 | 4.50 | 62.20 | 12734 | 5908 | 4.41 | 71.94 | 20513 | 9704 |
| JWC58 | 560 | 328 | 107.83 | 90.16 | 7444 | 3243 | 14.47 | 60.00 | 12655 | 5987 | 4.03 | 71.16 | 20659 | 9558 |
| JWC59 | 542 | 346 | 91.18 | 89.15 | 7810 | 2877 | 13.05 | 61.10 | 13713 | 4929 | 4.20 | 71.24 | 22065 | 8152 |
| JWC60 | 468 | 420 | 100.74 | 90.12 | 6579 | 4108 | 15.27 | 62.51 | 11410 | 7232 | 4.63 | 70.25 | 18457 | 11760 |
| JWC61 | 529 | 359 | 81.24 | 88.95 | 6138 | 4549 | 15.04 | 61.57 | 11602 | 7040 | 4.61 | 71.85 | 18269 | 11948 |
| JWC62 | 541 | 347 | 88.87 | 88.78 | 6802 | 3885 | 10.51 | 61.42 | 12100 | 6542 | 3.91 | 68.49 | 19443 | 10774 |
| JWC63 | 620 | 268 | 95.85 | 89.80 | 8588 | 2099 | 3.67 | 64.15 | 14386 | 4256 | 2.90 | 70.79 | 23594 | 6623 |
| JWC64 | 598 | 290 | 93.70 | 90.19 | 8232 | 2455 | 11.34 | 61.22 | 14093 | 4549 | 3.22 | 40.12 | 22923 | 7294 |
| JWC65 | 536 | 352 | 105.68 | 89.31 | 7147 | 3540 | 11.61 | 63.54 | 12099 | 6543 | 3.59 | 55.20 | 19782 | 10435 |
| JWC66 | 627 | 261 | 86.36 | 90.06 | 8222 | 2465 | 12.14 | 60.13 | 14185 | 4457 | 3.24 | 43.69 | 23034 | 7183 |
| JWC67 | 534 | 354 | 83.69 | 88.09 | 6380 | 4307 | 14.00 | 61.62 | 11718 | 6924 | 3.89 | 68.69 | 18632 | 11585 |
| JWC68 | 497 | 391 | 84.64 | 89.01 | 5541 | 5146 | 4.08 | 67.88 | 10882 | 7760 | 4.35 | 70.34 | 16920 | 13297 |
| JWC69 | 457 | 431 | 83.95 | 88.19 | 5480 | 5207 | 15.95 | 61.51 | 10078 | 8564 | 4.01 | 69.55 | 16015 | 14202 |

| | | | | | | | | | | | | | | |
|-------|-----|-----|-------|-------|-------|------|-------|-------|-------|------|------|-------|-------|-------|
| JWC70 | 465 | 423 | 84.18 | 88.57 | 5795 | 4892 | 11.72 | 63.07 | 10722 | 7920 | 4.05 | 69.24 | 16982 | 13235 |
| JWC71 | 493 | 395 | 71.49 | 86.99 | 6039 | 4648 | 11.78 | 62.43 | 11315 | 7327 | 4.13 | 70.48 | 17847 | 12370 |
| JWC72 | 458 | 430 | 91.52 | 88.94 | 5738 | 4949 | 11.57 | 62.91 | 10956 | 7686 | 3.68 | 69.19 | 17152 | 13065 |
| JWC73 | 515 | 373 | 96.30 | 89.47 | 5907 | 4780 | 14.15 | 61.93 | 11118 | 7524 | 4.39 | 69.64 | 17540 | 12677 |
| JWC74 | 564 | 324 | 80.40 | 87.66 | 7901 | 2786 | 5.61 | 63.33 | 13252 | 5390 | 3.51 | 69.91 | 21717 | 8500 |
| JWC75 | 525 | 363 | 88.32 | 89.87 | 6589 | 4098 | 12.16 | 65.31 | 11669 | 6973 | 4.49 | 70.92 | 18783 | 11434 |
| JWC76 | 529 | 359 | 80.94 | 90.04 | 6910 | 3777 | 9.87 | 64.12 | 12522 | 6120 | 4.60 | 71.45 | 19961 | 10256 |
| JWC77 | 527 | 361 | 76.44 | 87.48 | 5961 | 4726 | 13.12 | 62.63 | 11199 | 7443 | 4.14 | 70.81 | 17687 | 12530 |
| JWC78 | 482 | 406 | 80.64 | 87.81 | 6175 | 4512 | 14.77 | 62.76 | 11057 | 7585 | 4.31 | 68.55 | 17714 | 12503 |
| JWC79 | 578 | 310 | 86.14 | 89.94 | 7664 | 3023 | 11.70 | 62.33 | 13709 | 4933 | 4.35 | 70.20 | 21951 | 8266 |
| JWC80 | 598 | 290 | 85.30 | 89.06 | 7678 | 3009 | 9.91 | 62.33 | 13265 | 5377 | 3.76 | 68.87 | 21541 | 8676 |
| JWC81 | 588 | 300 | 90.94 | 88.85 | 8140 | 2547 | 14.37 | 60.10 | 13972 | 4670 | 4.02 | 71.00 | 22700 | 7517 |
| JWC82 | 448 | 440 | 89.83 | 88.94 | 5436 | 5251 | 12.00 | 61.94 | 10767 | 7875 | 4.12 | 69.16 | 16651 | 13566 |
| JWC83 | 471 | 417 | 91.26 | 89.51 | 5602 | 5085 | 12.99 | 63.10 | 10989 | 7653 | 4.45 | 71.17 | 17062 | 13155 |
| JWC84 | 527 | 361 | 87.92 | 90.09 | 6594 | 4093 | 11.95 | 64.07 | 12052 | 6590 | 4.48 | 71.18 | 19173 | 11044 |
| JWC85 | 440 | 448 | 85.29 | 88.08 | 5958 | 4729 | 15.85 | 63.82 | 10936 | 7706 | 4.30 | 70.11 | 17334 | 12883 |
| JWC86 | 499 | 389 | 80.00 | 89.46 | 6463 | 4224 | 4.66 | 65.14 | 11782 | 6860 | 4.65 | 70.45 | 18744 | 11473 |
| JWC87 | 582 | 306 | 82.66 | 89.53 | 7473 | 3214 | 11.87 | 62.10 | 12941 | 5701 | 4.20 | 70.56 | 20996 | 9221 |
| JWC88 | 553 | 335 | 76.06 | 89.72 | 7704 | 2983 | 9.53 | 62.31 | 13645 | 4997 | 3.92 | 70.39 | 21902 | 8315 |
| JWC89 | 589 | 299 | 96.17 | 89.67 | 8276 | 2411 | 11.88 | 61.29 | 13969 | 4673 | 4.25 | 71.88 | 22834 | 7383 |
| JWC90 | 536 | 352 | 98.01 | 89.98 | 7760 | 2927 | 11.63 | 62.47 | 13477 | 5165 | 3.98 | 70.11 | 21773 | 8444 |
| JWC91 | 625 | 263 | 91.86 | 89.85 | 8131 | 2556 | 7.82 | 66.10 | 13814 | 4828 | 4.82 | 66.36 | 22570 | 7647 |
| JWC92 | 524 | 364 | 88.58 | 88.97 | 7642 | 3045 | 12.04 | 61.12 | 13174 | 5468 | 4.56 | 68.37 | 21340 | 8877 |
| JWC93 | 542 | 346 | 90.02 | 89.15 | 7814 | 2873 | 11.88 | 61.36 | 13707 | 4935 | 3.78 | 70.91 | 22063 | 8154 |
| JWC94 | 560 | 328 | 82.46 | 87.88 | 8423 | 2264 | 9.65 | 61.92 | 14180 | 4462 | 4.16 | 70.69 | 23163 | 7054 |
| JWC95 | 529 | 359 | 79.53 | 88.04 | 7708 | 2979 | 11.14 | 63.02 | 18427 | 215 | 4.13 | 73.04 | 26664 | 3553 |
| JWC96 | 882 | 6 | 79.13 | 89.17 | 10196 | 491 | 5.32 | 64.01 | 12039 | 6603 | 4.77 | 71.24 | 23117 | 7100 |

*: from the NIAS Genebank (http://www.gene.affrc.go.jp/databases-core_collections_jw_en.php)

Supplemental Table 4. SNP marker distribution in the A, B, D and whole genomes

| Chr. | No. of SNP markers | | | | SNP marker density (Mb/marker)* | | | |
|----------------|--------------------|-------|------|-------|---------------------------------|-------|-------|-------|
| | A | B | D | Total | A | B | D | Total |
| 1 | 1906 | 2070 | 350 | 4326 | 0.314 | 0.338 | 1.425 | 0.416 |
| 2 | 1978 | 2728 | 651 | 5357 | 0.398 | 0.298 | 1.009 | 0.421 |
| 3 | 1282 | 3362 | 295 | 4939 | 0.588 | 0.253 | 2.100 | 0.451 |
| 4 | 1787 | 748 | 131 | 2666 | 0.422 | 0.901 | 3.957 | 0.730 |
| 5 | 1460 | 2086 | 213 | 3759 | 0.489 | 0.343 | 2.676 | 0.532 |
| 6 | 1479 | 2756 | 278 | 4513 | 0.421 | 0.265 | 1.782 | 0.410 |
| 7 | 2028 | 2206 | 364 | 4598 | 0.367 | 0.346 | 1.766 | 0.468 |
| unknown | | | | 59 | | | | 5.959 |
| All | 11920 | 15956 | 2282 | 30217 | 0.417 | 0.329 | 1.753 | 0.482 |

Chr., chromosome

*The length of each chromosome was referred to Zhu et al. (2021)

**Supplemental Table 5. Pairwise mean Fst values
(Weir and Cockerham) between three populations
calculated SNPs between populations**

| Population | Population | Weir and Cockerham mean Fst |
|------------|------------|-----------------------------|
| I | II | 0.220 |
| I | III | 0.268 |
| II | III | 0.151 |

Supplemental Table 6. Marker–trait associations (MTAs) over multiple years for the days to heading (DH)

| Chr. | Position | Marker | Year | log10(-p) | Marker R ² |
|-------------|------------------|------------------|-------|-----------|-----------------------|
| 4D | 497,933,062 | G_Ch4D_497933062 | 2018 | 4.216 | 0.179 |
| | | | 2017 | 3.416 | 0.129 |
| | | | 2020 | 3.122 | 0.112 |
| 6B | 35,332,901 | G_Ch6B_35332901 | 2019 | 3.814 | 0.148 |
| | | | 2018 | 3.667 | 0.150 |
| | 35,332,935 | G_Ch6B_35332935 | 2019 | 3.814 | 0.148 |
| | | | 2018 | 3.667 | 0.150 |
| | 35,332,964 | G_Ch6B_35332964 | 2019 | 3.814 | 0.148 |
| | | | 2018 | 3.667 | 0.150 |
| | 35,465,452 | G_Ch6B_35465452 | 2019 | 3.814 | 0.148 |
| | | | 2018 | 3.667 | 0.150 |
| | 35,612,523 | G_Ch6B_35612523 | 2019 | 3.607 | 0.138 |
| | | | 2018 | 3.497 | 0.142 |
| | 35,633,064 | G_Ch6B_35633064 | 2019 | 3.607 | 0.138 |
| | | | 2018 | 3.497 | 0.142 |
| | 35,633,083 | G_Ch6B_35633083 | 2019 | 3.814 | 0.148 |
| | | | 2018 | 3.667 | 0.150 |
| | 35,858,833 | G_Ch6B_35858833 | 2019 | 3.607 | 0.138 |
| | | | 2018 | 3.497 | 0.142 |
| | 35,859,846 | G_Ch6B_35859846 | 2019 | 3.814 | 0.148 |
| | | | 2018 | 3.667 | 0.150 |
| 36,569,353 | G_Ch6B_36569353 | 2019 | 3.393 | 0.128 | |
| | | 2016 | 3.058 | 0.112 | |
| 36,600,945 | G_Ch6B_36600945 | 2019 | 4.013 | 0.158 | |
| | | 2017 | 3.402 | 0.129 | |
| | | 2018 | 3.300 | 0.132 | |
| | | 2016 | 3.227 | 0.119 | |
| 36,600,970 | G_Ch6B_36600970 | 2018 | 3.643 | 0.149 | |
| | | 2016 | 3.270 | 0.121 | |
| | | 2019 | 3.016 | 0.111 | |
| 130,680,696 | G_Ch6D_130680696 | 2017 | 3.909 | 0.153 | |
| | | 2020 | 3.642 | 0.136 | |
| | | 2019 | 3.386 | 0.128 | |
| | | 2018 | 3.225 | 0.128 | |
| 6D | 133,764,781 | R_Ch6D_133764781 | 2017 | 3.559 | 0.136 |
| | | | 2020 | 3.241 | 0.118 |
| | | | 2019 | 3.050 | 0.112 |
| | | | 2018 | 3.042 | 0.119 |
| 300,930,272 | G_Ch6D_300930272 | 2017 | 3.464 | 0.132 | |
| | | 2020 | 3.271 | 0.119 | |
| | | 2019 | 3.255 | 0.122 | |

Supplemental Table 7. Marker–trait associations (MTAs) detected over multiple years for the culm length (CL)

| Chr. | Position | Marker | Year | log ₁₀ (-p) | Marker R ² |
|------------|------------------|------------------|-------|------------------------|-----------------------|
| 2D | 22,056,470 | G_Chr2D_22056470 | 2020 | 3.775 | 0.162 |
| | | | 2018 | 3.570 | 0.151 |
| | 22,056,546 | G_Chr2D_22056546 | 2020 | 3.775 | 0.162 |
| | | | 2018 | 3.570 | 0.151 |
| | 22,106,696 | G_Chr2D_22106696 | 2020 | 3.775 | 0.162 |
| | | | 2018 | 3.570 | 0.151 |
| | 22,106,742 | G_Chr2D_22106742 | 2020 | 3.775 | 0.162 |
| | | | 2018 | 3.570 | 0.151 |
| | 23,050,974 | G_Chr2D_23050974 | 2020 | 3.775 | 0.162 |
| | | | 2018 | 3.570 | 0.151 |
| | 23,050,984 | G_Chr2D_23050984 | 2020 | 3.775 | 0.162 |
| | | | 2018 | 3.570 | 0.151 |
| | 23,051,001 | G_Chr2D_23051001 | 2020 | 3.775 | 0.162 |
| | | | 2018 | 3.570 | 0.151 |
| | 23,070,511 | G_Chr2D_23070511 | 2020 | 3.775 | 0.162 |
| | | | 2018 | 3.570 | 0.151 |
| | 23,071,570 | G_Chr2D_23071570 | 2020 | 3.775 | 0.162 |
| | | | 2018 | 3.570 | 0.151 |
| | 23,071,583 | G_Chr2D_23071583 | 2020 | 3.775 | 0.162 |
| | | | 2018 | 3.570 | 0.151 |
| | 23,071,624 | G_Chr2D_23071624 | 2020 | 3.775 | 0.162 |
| | | | 2018 | 3.570 | 0.151 |
| | 23,698,547 | G_Chr2D_23698547 | 2020 | 3.775 | 0.162 |
| | | | 2018 | 3.570 | 0.151 |
| | 23,849,102 | G_Chr2D_23849102 | 2020 | 3.650 | 0.155 |
| | | | 2018 | 3.330 | 0.138 |
| | 23,849,108 | G_Chr2D_23849108 | 2020 | 3.650 | 0.155 |
| | | | 2018 | 3.330 | 0.138 |
| | 23,849,120 | G_Chr2D_23849120 | 2020 | 3.650 | 0.155 |
| | | | 2018 | 3.330 | 0.138 |
| | 23,860,361 | G_Chr2D_23860361 | 2020 | 3.650 | 0.155 |
| | | | 2018 | 3.330 | 0.138 |
| 23,860,412 | G_Chr2D_23860412 | 2020 | 3.650 | 0.155 | |
| | | 2018 | 3.330 | 0.138 | |
| 23,860,424 | G_Chr2D_23860424 | 2020 | 3.650 | 0.155 | |
| | | 2018 | 3.330 | 0.138 | |
| 23,860,716 | G_Chr2D_23860716 | 2020 | 3.650 | 0.155 | |
| | | 2018 | 3.330 | 0.138 | |
| 23,860,723 | G_Chr2D_23860723 | 2020 | 3.650 | 0.155 | |
| | | 2018 | 3.330 | 0.138 | |
| 23,860,740 | G_Chr2D_23860740 | 2020 | 3.650 | 0.155 | |
| | | 2018 | 3.330 | 0.138 | |
| 23,935,165 | G_Chr2D_23935165 | 2020 | 3.650 | 0.155 | |
| | | 2018 | 3.330 | 0.138 | |
| 23,963,647 | R_Chr2D_23963647 | 2020 | 3.650 | 0.155 | |
| | | 2018 | 3.330 | 0.138 | |
| 24,024,355 | G_Chr2D_24024355 | 2020 | 3.650 | 0.155 | |
| | | 2018 | 3.330 | 0.138 | |
| 24,029,297 | G_Chr2D_24029297 | 2020 | 3.650 | 0.155 | |
| | | 2018 | 3.330 | 0.138 | |
| 24,046,218 | G_Chr2D_24046218 | 2020 | 3.650 | 0.155 | |
| | | 2018 | 3.330 | 0.138 | |

| | | | | | |
|----|-------------|-------------------|------|-------|-------|
| | 73,102,274 | G_Chr2D_73102274 | 2019 | 3.423 | 0.142 |
| | | | 2018 | 3.173 | 0.130 |
| | 73,105,801 | G_Chr2D_73105801 | 2019 | 3.423 | 0.142 |
| | | | 2018 | 3.173 | 0.130 |
| | 73,815,962 | G_Chr2D_73815962 | 2019 | 3.423 | 0.142 |
| | | | 2018 | 3.173 | 0.130 |
| | 73,815,974 | G_Chr2D_73815974 | 2019 | 3.423 | 0.142 |
| | | | 2018 | 3.173 | 0.130 |
| | | | 2019 | 3.575 | 0.150 |
| | 7,337,076 | G_Chr5A_7337076 | 2016 | 3.325 | 0.135 |
| | | | 2020 | 3.289 | 0.136 |
| | | | 2018 | 3.132 | 0.128 |
| | | | 2018 | 4.857 | 0.222 |
| | 9,857,051 | G_Chr5A_9857051 | 2019 | 4.187 | 0.183 |
| | | | 2020 | 4.117 | 0.180 |
| | | | 2016 | 3.227 | 0.130 |
| | 11,895,571 | snp3197_1 | 2018 | 3.306 | 0.137 |
| | | | 2019 | 3.057 | 0.124 |
| | 12,220,141 | R_Chr5A_12220141 | 2018 | 3.306 | 0.137 |
| | | | 2019 | 3.057 | 0.124 |
| | 439,765,378 | R_Chr5A_439765378 | 2019 | 3.449 | 0.144 |
| | | | 2018 | 3.220 | 0.133 |
| | 439,765,655 | R_Chr5A_439765655 | 2019 | 3.449 | 0.144 |
| | | | 2018 | 3.220 | 0.133 |
| | 439,954,753 | G_Chr5A_439954753 | 2019 | 3.449 | 0.144 |
| | | | 2018 | 3.220 | 0.133 |
| | 439,954,764 | G_Chr5A_439954764 | 2019 | 3.449 | 0.144 |
| | | | 2018 | 3.220 | 0.133 |
| | 439,954,816 | G_Chr5A_439954816 | 2019 | 3.449 | 0.144 |
| | | | 2018 | 3.220 | 0.133 |
| | 440,147,925 | R_Chr5A_440147925 | 2019 | 3.449 | 0.144 |
| | | | 2018 | 3.220 | 0.133 |
| | 440,148,043 | R_Chr5A_440148043 | 2019 | 3.449 | 0.144 |
| | | | 2018 | 3.220 | 0.133 |
| 5A | 440,148,140 | R_Chr5A_440148140 | 2019 | 3.449 | 0.144 |
| | | | 2018 | 3.220 | 0.133 |
| | 440,249,756 | R_Chr5A_440249756 | 2019 | 3.449 | 0.144 |
| | | | 2018 | 3.220 | 0.133 |
| | 440,249,799 | R_Chr5A_440249799 | 2019 | 3.449 | 0.144 |
| | | | 2018 | 3.220 | 0.133 |
| | 440,249,853 | R_Chr5A_440249853 | 2019 | 3.449 | 0.144 |
| | | | 2018 | 3.220 | 0.133 |
| | 440,406,043 | G_Chr5A_440406043 | 2019 | 3.449 | 0.144 |
| | | | 2018 | 3.220 | 0.133 |
| | 440,426,536 | G_Chr5A_440426536 | 2019 | 3.449 | 0.144 |
| | | | 2018 | 3.220 | 0.133 |
| | 440,426,580 | G_Chr5A_440426580 | 2019 | 3.449 | 0.144 |
| | | | 2018 | 3.220 | 0.133 |
| | 440,819,271 | G_Chr5A_440819271 | 2019 | 3.449 | 0.144 |
| | | | 2018 | 3.220 | 0.133 |
| | 442,100,000 | R_Chr5A_442100000 | 2019 | 3.503 | 0.146 |
| | | | 2016 | 3.096 | 0.123 |
| | | | 2018 | 4.693 | 0.212 |
| | 665,410,239 | G_Chr5A_665410239 | 2017 | 3.462 | 0.146 |
| | | | 2019 | 3.416 | 0.142 |
| | | | 2020 | 3.153 | 0.129 |

| | | | | | |
|-------|-------------|----------------------|------|-------|-------|
| | | | 2018 | 4.693 | 0.212 |
| | 666,602,459 | G_Ch5A_666602459 | 2017 | 3.462 | 0.146 |
| | | | 2019 | 3.416 | 0.142 |
| | | | 2020 | 3.153 | 0.129 |
| | 708,796,936 | G_Ch5A_708796936 | 2020 | 3.427 | 0.143 |
| | | | 2018 | 3.416 | 0.143 |
| | 420,419,443 | R_Ch5B_420419443 | 2017 | 3.075 | 0.126 |
| | | | 2018 | 3.029 | 0.123 |
| 5B | 420,419,473 | R_Ch5B_420419473 | 2017 | 3.075 | 0.126 |
| | | | 2018 | 3.029 | 0.123 |
| | 422,158,046 | R_Ch5B_422158046 | 2017 | 3.075 | 0.126 |
| | | | 2018 | 3.029 | 0.123 |
| | 552,393,964 | G_Ch5D_552393964 | 2018 | 3.221 | 0.133 |
| | | | 2017 | 3.165 | 0.130 |
| 5D | | | 2019 | 3.143 | 0.128 |
| | | | 2018 | 3.221 | 0.133 |
| | 552,849,649 | G_Ch5D_552849649 | 2017 | 3.165 | 0.130 |
| | | | 2019 | 3.143 | 0.128 |
| | 128,687,482 | G_Ch6A_128687482 | 2018 | 4.194 | 0.185 |
| | | | 2017 | 3.461 | 0.146 |
| | | | 2019 | 3.371 | 0.140 |
| | 138,855,000 | G_Ch6A_138855000 | 2018 | 4.194 | 0.185 |
| | | | 2017 | 3.461 | 0.146 |
| | | | 2019 | 3.371 | 0.140 |
| 6A | 609,939,415 | G_Ch6A_609939415 | 2018 | 3.502 | 0.147 |
| | | | 2019 | 3.253 | 0.134 |
| | | | 2017 | 3.168 | 0.130 |
| | 609,939,438 | G_Ch6A_609939438 | 2018 | 3.502 | 0.147 |
| | | | 2019 | 3.253 | 0.134 |
| | | | 2017 | 3.168 | 0.130 |
| | 609,939,460 | G_Ch6A_609939460 | 2018 | 3.502 | 0.147 |
| | | | 2019 | 3.253 | 0.134 |
| | | | 2017 | 3.168 | 0.130 |
| | 717,676,609 | G_Ch6B_717676609 | 2019 | 4.055 | 0.176 |
| | | | 2016 | 3.900 | 0.164 |
| | | | 2018 | 3.745 | 0.160 |
| | | | 2020 | 3.431 | 0.143 |
| | 717,788,119 | G_Ch6B_717788119 | 2019 | 4.680 | 0.210 |
| | | | 2018 | 4.660 | 0.211 |
| 6B | | | 2020 | 4.351 | 0.193 |
| | | | 2016 | 3.836 | 0.161 |
| | | | 2017 | 3.246 | 0.134 |
| | 718,083,564 | G_Ch6B_718083564 | 2019 | 3.333 | 0.138 |
| | | | 2016 | 3.145 | 0.126 |
| | 718,666,921 | G_Ch6B_718666921 | 2019 | 3.480 | 0.145 |
| | | | 2018 | 3.235 | 0.134 |
| | 718,985,803 | R_Ch6B_718985803 | 2019 | 3.480 | 0.145 |
| | | | 2018 | 3.235 | 0.134 |
| | 719,479,762 | G_Ch6B_719479762 | 2019 | 3.480 | 0.145 |
| | | | 2018 | 3.235 | 0.134 |
| 7D | 114,214,642 | G_Ch7D_114214642 | 2019 | 3.243 | 0.133 |
| | | | 2018 | 3.180 | 0.131 |
| chrUn | 18,482,772 | G_ChUnknown_18482772 | 2020 | 3.775 | 0.162 |
| | | | 2018 | 3.570 | 0.151 |
| | 18,482,783 | G_ChUnknown_18482783 | 2020 | 3.775 | 0.162 |
| | | | 2018 | 3.570 | 0.151 |

Supplemental Table 8. Marker–trait associations (MTAs) detected over multiple years for the spike length (SL)

| Chr. | Position | Marker | Year | log10(-p) | Marker R ² |
|------------|-----------------|------------------|-------|-----------|-----------------------|
| 2A | 594,606,956 | R_Ch2A_594606956 | 2018 | 3.516 | 0.149 |
| | | | 2020 | 3.061 | 0.126 |
| | 596,914,455 | R_Ch2A_596914455 | 2018 | 3.516 | 0.149 |
| | | | 2020 | 3.061 | 0.126 |
| | 604,204,391 | R_Ch2A_604204391 | 2018 | 3.516 | 0.149 |
| | | | 2020 | 3.061 | 0.126 |
| 2B | 803,096,394 | G_Ch2B_803096394 | 2020 | 3.407 | 0.144 |
| | | | 2018 | 3.071 | 0.126 |
| | 19,667,354 | R_Ch2D_19667354 | 2020 | 3.726 | 0.161 |
| | | | 2018 | 3.462 | 0.146 |
| | | | 2019 | 3.298 | 0.138 |
| | | | 2017 | 3.089 | 0.127 |
| | | | 2020 | 3.726 | 0.161 |
| | | | 2018 | 3.462 | 0.146 |
| | 19,667,575 | R_Ch2D_19667575 | 2019 | 3.298 | 0.138 |
| | | | 2017 | 3.089 | 0.127 |
| | | | 2020 | 3.726 | 0.161 |
| | 19,670,544 | G_Ch2D_19670544 | 2018 | 3.462 | 0.146 |
| | | | 2019 | 3.298 | 0.138 |
| | | | 2017 | 3.089 | 0.127 |
| 19,868,310 | G_Ch2D_19868310 | 2020 | 3.726 | 0.161 | |
| | | 2018 | 3.462 | 0.146 | |
| | | 2019 | 3.298 | 0.138 | |
| 19,868,322 | G_Ch2D_19868322 | 2017 | 3.089 | 0.127 | |
| | | 2020 | 3.726 | 0.161 | |
| | | 2018 | 3.462 | 0.146 | |
| 19,868,386 | G_Ch2D_19868386 | 2019 | 3.298 | 0.138 | |
| | | 2017 | 3.089 | 0.127 | |
| | | 2020 | 3.726 | 0.161 | |
| 20,446,572 | G_Ch2D_20446572 | 2018 | 5.242 | 0.246 | |
| | | 2020 | 4.762 | 0.218 | |
| | | 2017 | 3.271 | 0.137 | |
| 21,120,861 | G_Ch2D_21120861 | 2018 | 5.242 | 0.246 | |
| | | 2020 | 4.762 | 0.218 | |
| | | 2017 | 3.271 | 0.137 | |
| 21,128,584 | G_Ch2D_21128584 | 2018 | 5.242 | 0.246 | |
| | | 2020 | 4.762 | 0.218 | |
| | | 2017 | 3.271 | 0.137 | |
| 21,128,621 | G_Ch2D_21128621 | 2018 | 5.242 | 0.246 | |
| | | 2020 | 4.762 | 0.218 | |
| | | 2017 | 3.271 | 0.137 | |
| 21,260,160 | G_Ch2D_21260160 | 2018 | 5.242 | 0.246 | |
| | | 2020 | 4.762 | 0.218 | |
| | | 2017 | 3.271 | 0.137 | |
| 21,268,060 | G_Ch2D_21268060 | 2018 | 5.242 | 0.246 | |
| | | 2020 | 4.762 | 0.218 | |
| | | 2017 | 3.271 | 0.137 | |

| | | | | | |
|----|------------|-----------------|------|-------|-------|
| | | | 2018 | 5.242 | 0.246 |
| | 21,279,081 | G_Ch2D_21279081 | 2020 | 4.762 | 0.218 |
| | | | 2017 | 3.271 | 0.137 |
| | | | 2018 | 5.242 | 0.246 |
| | 21,279,086 | G_Ch2D_21279086 | 2020 | 4.762 | 0.218 |
| | | | 2017 | 3.271 | 0.137 |
| | | | 2018 | 5.242 | 0.246 |
| | 21,279,100 | G_Ch2D_21279100 | 2020 | 4.762 | 0.218 |
| | | | 2017 | 3.271 | 0.137 |
| | | | 2018 | 5.242 | 0.246 |
| | 21,295,292 | G_Ch2D_21295292 | 2020 | 4.762 | 0.218 |
| | | | 2017 | 3.271 | 0.137 |
| | | | 2018 | 5.242 | 0.246 |
| | 21,319,179 | G_Ch2D_21319179 | 2020 | 4.762 | 0.218 |
| | | | 2017 | 3.271 | 0.137 |
| | | | 2018 | 5.094 | 0.237 |
| | 22,056,470 | G_Ch2D_22056470 | 2020 | 4.851 | 0.223 |
| | | | 2019 | 3.719 | 0.160 |
| | | | 2017 | 3.073 | 0.127 |
| | | | 2018 | 5.094 | 0.237 |
| | 22,056,546 | G_Ch2D_22056546 | 2020 | 4.851 | 0.223 |
| | | | 2019 | 3.719 | 0.160 |
| | | | 2017 | 3.073 | 0.127 |
| | | | 2018 | 5.094 | 0.237 |
| | 22,106,696 | G_Ch2D_22106696 | 2020 | 4.851 | 0.223 |
| | | | 2019 | 3.719 | 0.160 |
| | | | 2017 | 3.073 | 0.127 |
| | | | 2018 | 5.094 | 0.237 |
| | 22,106,742 | G_Ch2D_22106742 | 2020 | 4.851 | 0.223 |
| | | | 2019 | 3.719 | 0.160 |
| | | | 2017 | 3.073 | 0.127 |
| | | | 2018 | 5.094 | 0.237 |
| | 23,050,974 | G_Ch2D_23050974 | 2020 | 4.851 | 0.223 |
| | | | 2019 | 3.719 | 0.160 |
| | | | 2017 | 3.073 | 0.127 |
| 2D | | | 2018 | 5.094 | 0.237 |
| | 23,050,984 | G_Ch2D_23050984 | 2020 | 4.851 | 0.223 |
| | | | 2019 | 3.719 | 0.160 |
| | | | 2017 | 3.073 | 0.127 |
| | | | 2018 | 5.094 | 0.237 |
| | 23,051,001 | G_Ch2D_23051001 | 2020 | 4.851 | 0.223 |
| | | | 2019 | 3.719 | 0.160 |
| | | | 2017 | 3.073 | 0.127 |
| | | | 2018 | 5.094 | 0.237 |
| | 23,070,511 | G_Ch2D_23070511 | 2020 | 4.851 | 0.223 |
| | | | 2019 | 3.719 | 0.160 |
| | | | 2017 | 3.073 | 0.127 |
| | | | 2018 | 5.094 | 0.237 |
| | 23,071,570 | G_Ch2D_23071570 | 2020 | 4.851 | 0.223 |
| | | | 2019 | 3.719 | 0.160 |
| | | | 2017 | 3.073 | 0.127 |
| | | | 2018 | 5.094 | 0.237 |
| | 23,071,583 | G_Ch2D_23071583 | 2020 | 4.851 | 0.223 |
| | | | 2019 | 3.719 | 0.160 |

| | | | | |
|------------|------------------|------|-------|-------|
| | | 2017 | 3.073 | 0.127 |
| | | 2018 | 5.094 | 0.237 |
| 23,071,624 | G_Chr2D_23071624 | 2020 | 4.851 | 0.223 |
| | | 2019 | 3.719 | 0.160 |
| | | 2017 | 3.073 | 0.127 |
| | | 2018 | 5.094 | 0.237 |
| 23,698,547 | G_Chr2D_23698547 | 2020 | 4.851 | 0.223 |
| | | 2019 | 3.719 | 0.160 |
| | | 2017 | 3.073 | 0.127 |
| | | 2020 | 3.996 | 0.175 |
| 23,758,078 | G_Chr2D_23758078 | 2019 | 3.479 | 0.147 |
| | | 2018 | 3.068 | 0.126 |
| | | 2020 | 3.996 | 0.175 |
| 23,758,087 | G_Chr2D_23758087 | 2019 | 3.479 | 0.147 |
| | | 2018 | 3.068 | 0.126 |
| | | 2018 | 4.873 | 0.224 |
| 23,849,102 | G_Chr2D_23849102 | 2020 | 4.367 | 0.196 |
| | | 2019 | 3.039 | 0.124 |
| | | 2018 | 4.873 | 0.224 |
| 23,849,108 | G_Chr2D_23849108 | 2020 | 4.367 | 0.196 |
| | | 2019 | 3.039 | 0.124 |
| | | 2018 | 4.873 | 0.224 |
| 23,849,120 | G_Chr2D_23849120 | 2020 | 4.367 | 0.196 |
| | | 2019 | 3.039 | 0.124 |
| | | 2018 | 4.873 | 0.224 |
| 23,860,361 | G_Chr2D_23860361 | 2020 | 4.367 | 0.196 |
| | | 2019 | 3.039 | 0.124 |
| | | 2018 | 4.873 | 0.224 |
| 23,860,412 | G_Chr2D_23860412 | 2020 | 4.367 | 0.196 |
| | | 2019 | 3.039 | 0.124 |
| | | 2018 | 4.873 | 0.224 |
| 23,860,424 | G_Chr2D_23860424 | 2020 | 4.367 | 0.196 |
| | | 2019 | 3.039 | 0.124 |
| | | 2018 | 4.873 | 0.224 |
| 23,860,716 | G_Chr2D_23860716 | 2020 | 4.367 | 0.196 |
| | | 2019 | 3.039 | 0.124 |
| | | 2018 | 4.873 | 0.224 |
| 23,860,723 | G_Chr2D_23860723 | 2020 | 4.367 | 0.196 |
| | | 2019 | 3.039 | 0.124 |
| | | 2018 | 4.873 | 0.224 |
| 23,860,740 | G_Chr2D_23860740 | 2020 | 4.367 | 0.196 |
| | | 2019 | 3.039 | 0.124 |
| | | 2018 | 4.873 | 0.224 |
| 23,935,165 | G_Chr2D_23935165 | 2020 | 4.367 | 0.196 |
| | | 2019 | 3.039 | 0.124 |
| | | 2018 | 4.873 | 0.224 |
| 23,963,647 | R_Chr2D_23963647 | 2020 | 4.367 | 0.196 |
| | | 2019 | 3.039 | 0.124 |
| | | 2018 | 4.873 | 0.224 |
| 24,024,355 | G_Chr2D_24024355 | 2020 | 4.367 | 0.196 |
| | | 2019 | 3.039 | 0.124 |
| | | 2018 | 4.873 | 0.224 |
| 24,029,297 | G_Chr2D_24029297 | 2020 | 4.367 | 0.196 |
| | | 2019 | 3.039 | 0.124 |

| | | | | | |
|-------|-------------|------------------------|------|-------|-------|
| | | | 2018 | 4.873 | 0.224 |
| | 24,046,218 | G_Chrc2D_24046218 | 2020 | 4.367 | 0.196 |
| | | | 2019 | 3.039 | 0.124 |
| | | | 2018 | 5.627 | 0.268 |
| | 24,726,982 | tarc1446 | 2020 | 4.863 | 0.224 |
| | | | 2017 | 4.153 | 0.184 |
| | | | 2019 | 4.000 | 0.175 |
| | | | 2016 | 3.567 | 0.151 |
| | 60,189,000 | tarc0517 | 2018 | 3.827 | 0.166 |
| | | | 2020 | 3.376 | 0.142 |
| 3A | | | 2018 | 3.278 | 0.137 |
| | 716,812,904 | G_Chrc3A_716812904 | 2016 | 3.177 | 0.130 |
| | | | 2019 | 3.106 | 0.128 |
| | | | 2018 | 4.917 | 0.227 |
| | | | 2020 | 4.564 | 0.207 |
| 3D | 576,645,901 | G_Chrc3D_576645901 | 2017 | 4.321 | 0.194 |
| | | | 2016 | 3.271 | 0.135 |
| | | | 2019 | 3.035 | 0.124 |
| | 107,925,196 | G_Chrc4A_107925196 | 2018 | 3.312 | 0.138 |
| | | | 2020 | 3.281 | 0.137 |
| 4A | | | 2018 | 3.312 | 0.138 |
| | 145,251,348 | G_Chrc4A_145251348 | 2020 | 3.281 | 0.137 |
| | | | 2018 | 3.593 | 0.153 |
| | 385,614,577 | R_Chrc5B_385614577 | 2020 | 3.386 | 0.142 |
| | | | 2017 | 3.094 | 0.128 |
| 5B | | | 2018 | 3.593 | 0.153 |
| | 385,636,679 | G_Chrc5B_385636679 | 2020 | 3.386 | 0.142 |
| | | | 2017 | 3.094 | 0.128 |
| | 99,226,546 | G_Chrc7B_99226546 | 2016 | 3.131 | 0.128 |
| | | | 2017 | 3.018 | 0.124 |
| | 100,132,247 | G_Chrc7B_100132247 | 2016 | 3.131 | 0.128 |
| | | | 2017 | 3.018 | 0.124 |
| | 100,579,102 | R_Chrc7B_100579102 | 2016 | 3.131 | 0.128 |
| | | | 2017 | 3.018 | 0.124 |
| | 100,579,115 | R_Chrc7B_100579115 | 2016 | 3.131 | 0.128 |
| | | | 2017 | 3.018 | 0.124 |
| 7B | | | 2016 | 3.131 | 0.128 |
| | 100,579,166 | R_Chrc7B_100579166 | 2017 | 3.018 | 0.124 |
| | | | 2016 | 3.131 | 0.128 |
| | 100,579,194 | R_Chrc7B_100579194 | 2017 | 3.018 | 0.124 |
| | | | 2018 | 3.397 | 0.143 |
| | 203,239,104 | G_Chrc7B_203239104 | 2017 | 3.180 | 0.132 |
| | | | 2020 | 3.177 | 0.132 |
| | 712,264,197 | G_Chrc7B_712264197 | 2020 | 4.208 | 0.187 |
| | | | 2018 | 3.551 | 0.151 |
| | | | 2018 | 5.094 | 0.237 |
| | 18,482,772 | G_ChrcUnknown_18482772 | 2020 | 4.851 | 0.223 |
| | | | 2019 | 3.719 | 0.160 |
| | | | 2017 | 3.073 | 0.127 |
| chrUn | | | 2018 | 5.094 | 0.237 |
| | 18,482,783 | G_ChrcUnknown_18482783 | 2020 | 4.851 | 0.223 |
| | | | 2019 | 3.719 | 0.160 |
| | | | 2017 | 3.073 | 0.127 |

Supplemental Table 9. Marker–trait associations (MTAs) detected over multiple years for the spike density (SD)

| Chr. | Position | Marker | Year | log10(-p) | Marker R ² |
|------------|------------------|------------------|-------|-----------|-----------------------|
| 2D | 15,341,074 | G_Chr2D_15341074 | 2019 | 3.318 | 0.139 |
| | | | 2017 | 3.133 | 0.128 |
| | 15,341,132 | G_Chr2D_15341132 | 2019 | 3.318 | 0.139 |
| | | | 2017 | 3.133 | 0.128 |
| | 19,667,354 | R_Chr2D_19667354 | 2018 | 3.182 | 0.132 |
| | | | 2019 | 3.144 | 0.130 |
| | | | 2020 | 3.048 | 0.122 |
| | 19,667,575 | R_Chr2D_19667575 | 2018 | 3.182 | 0.132 |
| | | | 2019 | 3.144 | 0.130 |
| | | | 2020 | 3.048 | 0.122 |
| | 19,670,544 | G_Chr2D_19670544 | 2018 | 3.182 | 0.132 |
| | | | 2019 | 3.144 | 0.130 |
| | | | 2020 | 3.048 | 0.122 |
| | 19,868,310 | G_Chr2D_19868310 | 2018 | 3.182 | 0.132 |
| | | | 2019 | 3.144 | 0.130 |
| | | | 2020 | 3.048 | 0.122 |
| | 19,868,322 | G_Chr2D_19868322 | 2018 | 3.182 | 0.132 |
| | | | 2019 | 3.144 | 0.130 |
| | | | 2020 | 3.048 | 0.122 |
| | 19,868,386 | G_Chr2D_19868386 | 2018 | 3.182 | 0.132 |
| | | | 2019 | 3.144 | 0.130 |
| | | | 2020 | 3.048 | 0.122 |
| | 20,446,572 | G_Chr2D_20446572 | 2020 | 3.863 | 0.165 |
| | | | 2018 | 3.804 | 0.165 |
| 2017 | | | 3.283 | 0.136 | |
| 2019 | | | 3.228 | 0.134 | |
| 21,120,861 | G_Chr2D_21120861 | 2020 | 3.863 | 0.165 | |
| | | 2018 | 3.804 | 0.165 | |
| | | 2017 | 3.283 | 0.136 | |
| | | 2019 | 3.228 | 0.134 | |
| 21,128,584 | G_Chr2D_21128584 | 2020 | 3.863 | 0.165 | |
| | | 2018 | 3.804 | 0.165 | |
| | | 2017 | 3.283 | 0.136 | |
| | | 2019 | 3.228 | 0.134 | |
| 21,128,621 | G_Chr2D_21128621 | 2020 | 3.863 | 0.165 | |
| | | 2018 | 3.804 | 0.165 | |
| | | 2017 | 3.283 | 0.136 | |
| | | 2019 | 3.228 | 0.134 | |
| | | | 2020 | 3.863 | 0.165 |

| | | | | | |
|----|-------------|-------------------|------|-------|-------|
| | 21,260,160 | G_Chr2D_21260160 | 2018 | 3.804 | 0.165 |
| | | | 2017 | 3.283 | 0.136 |
| | | | 2019 | 3.228 | 0.134 |
| | | | 2020 | 3.863 | 0.165 |
| | 21,268,060 | G_Chr2D_21268060 | 2018 | 3.804 | 0.165 |
| | | | 2017 | 3.283 | 0.136 |
| | | | 2019 | 3.228 | 0.134 |
| | | | 2020 | 3.863 | 0.165 |
| | 21,279,081 | G_Chr2D_21279081 | 2018 | 3.804 | 0.165 |
| | | | 2017 | 3.283 | 0.136 |
| | | | 2019 | 3.228 | 0.134 |
| | | | 2020 | 3.863 | 0.165 |
| | 21,279,086 | G_Chr2D_21279086 | 2018 | 3.804 | 0.165 |
| | | | 2017 | 3.283 | 0.136 |
| | | | 2019 | 3.228 | 0.134 |
| | | | 2020 | 3.863 | 0.165 |
| | 21,279,100 | G_Chr2D_21279100 | 2018 | 3.804 | 0.165 |
| | | | 2017 | 3.283 | 0.136 |
| | | | 2019 | 3.228 | 0.134 |
| | | | 2020 | 3.863 | 0.165 |
| | 21,295,292 | G_Chr2D_21295292 | 2018 | 3.804 | 0.165 |
| | | | 2017 | 3.283 | 0.136 |
| | | | 2019 | 3.228 | 0.134 |
| | | | 2020 | 3.863 | 0.165 |
| | 21,319,179 | G_Chr2D_21319179 | 2018 | 3.804 | 0.165 |
| | | | 2017 | 3.283 | 0.136 |
| | | | 2019 | 3.228 | 0.134 |
| | | | 2020 | 3.863 | 0.165 |
| | 24,726,982 | tarc1446 | 2018 | 3.799 | 0.165 |
| | | | 2016 | 3.785 | 0.162 |
| | | | 2020 | 3.504 | 0.146 |
| | | | 2019 | 3.380 | 0.142 |
| | | | 2017 | 3.059 | 0.124 |
| | | | 2020 | 3.690 | 0.155 |
| 3D | 576,645,901 | G_Chr3D_576645901 | 2016 | 3.674 | 0.156 |
| | | | 2017 | 3.622 | 0.153 |
| | | | 2019 | 3.483 | 0.148 |
| | | | 2020 | 3.690 | 0.155 |
| 4D | 35,728,462 | G_Chr4D_35728462 | 2020 | 4.054 | 0.175 |
| | | | 2019 | 3.281 | 0.137 |
| | 541,072,981 | G_Chr5B_541072981 | 2019 | 3.975 | 0.174 |
| | | | 2020 | 3.132 | 0.127 |
| | | | 2019 | 4.166 | 0.185 |
| 5B | 544,302,059 | G_Chr5B_544302059 | 2020 | 3.910 | 0.167 |
| | | | 2016 | 3.886 | 0.167 |

| | | | | | |
|----|-------------|------------------|------|-------|-------|
| | | | 2017 | 3.111 | 0.127 |
| | | | 2019 | 4.166 | 0.185 |
| | 544,733,353 | G_Ch5B_544733353 | 2020 | 3.910 | 0.167 |
| | | | 2016 | 3.886 | 0.167 |
| | | | 2017 | 3.111 | 0.127 |
| | 174,924,572 | R_Ch6A_174924572 | 2016 | 3.211 | 0.132 |
| | | | 2019 | 3.024 | 0.124 |
| 6A | 190,309,836 | R_Ch6A_190309836 | 2018 | 3.423 | 0.145 |
| | | | 2016 | 3.091 | 0.126 |
| | | | 2019 | 3.023 | 0.124 |
| | 192,673,544 | R_Ch6A_192673544 | 2018 | 3.217 | 0.134 |
| | | | 2016 | 3.080 | 0.125 |
| | 3,469,660 | G_Ch7B_3469660 | 2016 | 3.810 | 0.163 |
| | | | 2018 | 3.080 | 0.127 |
| | 99,226,546 | G_Ch7B_99226546 | 2019 | 3.257 | 0.136 |
| | | | 2017 | 3.152 | 0.129 |
| | 100,132,247 | G_Ch7B_100132247 | 2019 | 3.257 | 0.136 |
| | | | 2017 | 3.152 | 0.129 |
| 7B | 100,579,102 | R_Ch7B_100579102 | 2019 | 3.257 | 0.136 |
| | | | 2017 | 3.152 | 0.129 |
| | 100,579,115 | R_Ch7B_100579115 | 2019 | 3.257 | 0.136 |
| | | | 2017 | 3.152 | 0.129 |
| | 100,579,166 | R_Ch7B_100579166 | 2019 | 3.257 | 0.136 |
| | | | 2017 | 3.152 | 0.129 |
| | 100,579,194 | R_Ch7B_100579194 | 2019 | 3.257 | 0.136 |
| | | | 2017 | 3.152 | 0.129 |
| | | | 2020 | 3.197 | 0.130 |
| 7D | 31,636,771 | G_Ch7D_31636771 | 2019 | 3.084 | 0.127 |
| | | | 2016 | 3.005 | 0.122 |

Supplemental Table 10. Marker–trait associations (MTAs) detected over multiple years for the grain numbers per spike (GNS)

| Chr. | Position | Marker | Year | log10(-p) | Marker R ² |
|------|-----------|------------------|------|-----------|-----------------------|
| 2B | 29505126 | G_Ch2B_29505126 | 2016 | 3.721 | 0.160 |
| | | | 2017 | 3.467 | 0.146 |
| | | | 2019 | 3.445 | 0.141 |
| | | | 2020 | 3.035 | 0.123 |
| | 728671668 | G_Ch2B_728671668 | 2017 | 4.609 | 0.208 |
| | | | 2018 | 3.775 | 0.163 |
| | | | 2020 | 3.467 | 0.145 |
| | | | | 3.117 | 0.127 |
| 3A | 668364722 | G_Ch3A_668364722 | 2017 | 3.100 | 0.127 |
| | | | 2020 | 3.117 | 0.127 |
| | 668364729 | G_Ch3A_668364729 | 2017 | 3.100 | 0.127 |
| | | | 2020 | 3.886 | 0.167 |
| 6B | 728450934 | G_Ch6B_728450934 | 2016 | 3.381 | 0.142 |
| | | | 2019 | 3.201 | 0.129 |
| | | | 2020 | 3.939 | 0.170 |
| | 730329182 | G_Ch6B_730329182 | 2019 | 3.932 | 0.166 |
| | | | 2016 | 3.046 | 0.124 |
| | | | | | |

Supplemental Table 11. Marker–trait associations (MTAs) detected over multiple years for the grain numbers per spikelet(GNSL)

| Chr. | Position | Marker | Year | log10(-p) | Marker R ² |
|------|-------------|-------------------|------|-----------|-----------------------|
| | | | 2020 | 3.590 | 0.150 |
| 2B | 728,671,668 | G_Chr2B_728671668 | 2018 | 3.125 | 0.127 |
| | | | 2017 | 3.086 | 0.114 |
| 7B | 711,853,721 | G_Chr7B_711853721 | 2019 | 3.223 | 0.130 |
| | | | 2017 | 3.076 | 0.113 |

Supplemental Table 12. Marker–trait associations (MTAs) detected over multiple years for the thousand-kernel weight (TKW)

| Chr. | Position | Marker | Year | log10(-p) | Marker R ² |
|-------------|-------------------|-------------------|-------|-----------|-----------------------|
| 3A | 533,585,802 | G_Chr3A_533585802 | 2018 | 3.284 | 0.137 |
| | | | 2017 | 3.032 | 0.121 |
| | 535,032,606 | R_Chr3A_535032606 | 2018 | 3.284 | 0.137 |
| | | | 2017 | 3.032 | 0.121 |
| | 535,032,633 | R_Chr3A_535032633 | 2018 | 3.284 | 0.137 |
| | | | 2017 | 3.032 | 0.121 |
| | 536,261,781 | R_Chr3A_536261781 | 2018 | 3.284 | 0.137 |
| | | | 2017 | 3.032 | 0.121 |
| | 536,295,152 | G_Chr3A_536295152 | 2018 | 3.284 | 0.137 |
| | | | 2017 | 3.032 | 0.121 |
| | 536,666,153 | G_Chr3A_536666153 | 2018 | 3.284 | 0.137 |
| | | | 2017 | 3.032 | 0.121 |
| 6A | 523,909,250 | G_Chr6A_523909250 | 2019 | 3.331 | 0.138 |
| | | | 2017 | 3.127 | 0.126 |
| | 524,053,443 | R_Chr6A_524053443 | 2019 | 3.331 | 0.138 |
| | | | 2017 | 3.127 | 0.126 |
| | 524,203,903 | R_Chr6A_524203903 | 2019 | 3.331 | 0.138 |
| | | | 2017 | 3.127 | 0.126 |
| | 524,683,741 | R_Chr6A_524683741 | 2019 | 3.331 | 0.138 |
| | | | 2017 | 3.127 | 0.126 |
| | 524,789,877 | G_Chr6A_524789877 | 2019 | 3.331 | 0.138 |
| | | | 2017 | 3.127 | 0.126 |
| | 525,558,660 | G_Chr6A_525558660 | 2019 | 3.331 | 0.138 |
| | | | 2017 | 3.127 | 0.126 |
| | 525,718,380 | R_Chr6A_525718380 | 2019 | 3.331 | 0.138 |
| | | | 2017 | 3.127 | 0.126 |
| | 525,725,661 | R_Chr6A_525725661 | 2019 | 3.331 | 0.138 |
| | | | 2017 | 3.127 | 0.126 |
| | 525,725,681 | R_Chr6A_525725681 | 2019 | 3.331 | 0.138 |
| | | | 2017 | 3.127 | 0.126 |
| | 525,809,715 | R_Chr6A_525809715 | 2019 | 3.331 | 0.138 |
| | | | 2017 | 3.127 | 0.126 |
| 525,809,725 | R_Chr6A_525809725 | 2019 | 3.331 | 0.138 | |
| | | 2017 | 3.127 | 0.126 | |
| 525,809,776 | R_Chr6A_525809776 | 2019 | 3.331 | 0.138 | |
| | | 2017 | 3.127 | 0.126 | |
| 526,638,684 | G_Chr6A_526638684 | 2019 | 3.331 | 0.138 | |
| | | 2017 | 3.127 | 0.126 | |
| 535,968,276 | G_Chr6A_535968276 | 2019 | 3.710 | 0.158 | |
| | | 2016 | 3.455 | 0.144 | |
| 537,981,999 | R_Chr6A_537981999 | 2019 | 3.710 | 0.158 | |
| | | 2016 | 3.455 | 0.144 | |
| 6D | 485,252,487 | G_Chr6D_485252487 | 2016 | 3.375 | 0.140 |
| | | | 2019 | 3.095 | 0.126 |