**Supplementary Table S1** Phenotypic values for traits and their GCA effects in the RILs across four environments and in joint analyses

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Traita | Envb | RILs |  |  |  | GCA |  |  |
|  |  | Range | Skew | Kurt |  | Range | Skew | Kurt |
| RN | 15S | 9.25 to 14.63 | -0.3 | 1.41 |  | -0.04 to 0.05 | 0.68 | 0.64 |
|  | 15X | 8.50 to 15.00 | -0.27 | 1.25 |  | -0.04 to 0.05 | 0.18 | 0.67 |
|  | 16S | 8.00 to 13.63 | -0.43 | 0.27 |  | -0.04 to 0.05 | 0.10 | 1.33 |
|  | 16X | 8.13 to 14.38 | -0.3 | 0.27 |  | -0.03 to 0.04 | 0.22 | -0.32 |
|  | C | 7.79 to 15.96 | 0.02 | 0.29 |  | -1.02 to 1.15 | 0.2 | 0.08 |
| KN | 15S | 14.38 to 35.13 | -0.15 | 0.81 |  | -1.13 to 1.15 | 1.65 | 1.45 |
|  | 15X | 10.57 to 35.63 | -0.25 | 0.09 |  | -1.03 to 0.83 | -0.41 | 0.43 |
|  | 16S | 10.82 to 32.13 | 0.21 | -0.08 |  | -1.14 to 1.56 | -0.13 | 0.25 |
|  | 16X | 14.00 to 33.44 | 0.2 | -0.28 |  | -0.91 to 0.84 | -0.11 | 0.09 |
|  | C | 10.93 to 38.25 | 0.09 | -0.31 |  | -2.74 to 2.72 | 0.11 | -0.04 |
| KT | 15S | 38.24 to 67.21 | 0.67 | 1.62 |  | -0.39 to 0.29 | 0.73 | 0.43 |
|  | 15X | 41.24 to 72.07 | 0.6 | 1.02 |  | -0.40 to 0.54 | 0.23 | 0.71 |
|  | 16S | 41.11 to 69.78 | 0.33 | 0.12 |  | -0.39 to 0.39 | 0.05 | 0.64 |
|  | 16X | 43.14 to 74.22 | 0.51 | 0.61 |  | -0.50 to 0.45 | 0.11 | 0.98 |
|  | C | 36.36 to 68.09 | 0.16 | -0.28 |  | -3.99 to 3.64 | 0.05 | 0.12 |
| KW | 15S | 72.38 to 101.33 | -0.06 | -0.1 |  | -0.34 to 0.32 | 0.07 | 0.01 |
|  | 15X | 76.23 to 107.45 | 0.09 | 0.31 |  | -0.35 to 0.30 | 0.00 | 0.37 |
|  | 16S | 72.27 to 104.60 | 0.27 | 0.59 |  | -0.31 to 0.45 | 0.18 | 0.63 |
|  | 16X | 75.84 to 107.43 | 0.18 | 0.04 |  | -0.41 to 0.63 | 0.55 | 0.63 |
|  | C | 68.28 to 110.58 | 0.11 | -0.13 |  | -5.46 to 5.29 | 0.03 | 0.21 |
| KL | 15S | 80.23 to 116.33 | -0.04 | 0.42 |  | -1.24 to 1.03 | 0.29 | 0.19 |
|  | 15X | 90.64 to 123.01 | -0.06 | -0.14 |  | -1.08 to 0.85 | -0.35 | 0.82 |
|  | 16S | 81.79 to 115.46 | -0.1 | 0 |  | -1.33 to 1.06 | -0.22 | 0.98 |
|  | 16X | 81.05 to 122.51 | 0.24 | 0.02 |  | -1.65 to 1.19 | -0.28 | 1.05 |
|  | C | 78.26 to 122.13 | -0.07 | -0.4 |  | -5.52 to 6.12 | -0.18 | 0.12 |
| VW | 15S | 353.83 to 669.88 | -0.3 | 0.55 |  | -7.00 to 7.77 | 0.53 | 0.45 |
|  | 15X | 492.27 to 824.91 | 0.59 | 0.79 |  | -9.89 to 10.65 | 0.38 | 0.62 |
|  | 16S | 404.62 to 705.43 | -0.18 | 0.56 |  | -9.85 to 11.43 | 0.28 | 0.75 |
|  | 16X | 538.85 to 771.53 | -0.11 | 0.36 |  | -7.08 to 8.20 | 0.22 | 0.44 |
|  | C | 502.15 to 713.78 | -0.01 | -0.2 |  | -29.97 to 30.01 | -0.15 | 0.35 |
| HKW | 15S | 10.13 to 30.09 | 0.31 | 0.7 |  | -0.88 to 0.73 | 0.33 | 0.22 |
|  | 15X | 17.90 to 41.81 | 0.48 | 0.33 |  | -0.89 to 1.03 | 0.13 | 0.12 |
|  | 16S | 12.66 to 31.17 | 0.05 | -0.06 |  | -0.68 to 0.86 | 0.08 | 0.51 |
|  | 16X | 15.92 to 36.57 | 0.2 | -0.15 |  | -1.23 to 0.95 | -0.23 | 1.36 |
|  | C | 10 to 36.53 | 0.11 | -0.2 |  | -2.93 to 2.6 | -0.04 | 0.08 |
| YP | 15S | 158.24 to 774.33 | -0.01 | -0.28 |  | -45.47 to 38.25 | 0.72 | 0.61 |
|  | 15X | 227.30 to 1126.48 | -0.26 | 1.18 |  | -44.84 to 49.17 | 0.23 | 0.78 |
|  | 16S | 154.46 to 843.60 | 0.13 | -0.17 |  | -46.41 to 43.03 | 0.01 | 0.25 |
|  | 16X | 166.25 to 978.21 | 0.03 | -0.35 |  | -56.53 to 42.84 | -0.28 | 1.25 |
|  | C | 73.64 to 948.39 | -0.25 | 0 |  | -89.5 to 77.16 | -0.15 | 0.01 |

aTrait refers to the name of each component of yield-related traits: RN, Row number; KN, Kernel number per row; KT, Kernel thickness; KW, Kernel width; KL, Kernel length; HKW, 100-kernel weight; VW, Volume weight; YP, Yield per plot

bSpecific growing environments: 15S is 2015 Shijiazhuang; 15X is 2015 Xinxiang; 16S is 2016 Shijiazhuang; 16X is 2016 Xinxiang; C represents joint analyses

**Supplementary Table S2** Performance of testcross populations in different environments

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Traita | Envb | TC | | |  | TM | | |
|  |  | Range | Skew | Kurt |  | Range | Skew | Kurt |
| RN | 15S | 12.13 to 16.88 | 0.11 | 0.05 |  | 11.50 to 14.42 | 0.46 | -0.21 |
|  | 15X | 11.50 to 17.38 | -0.02 | 0.35 |  | 11.63 to 14.38 | 0.34 | -0.47 |
|  | 16S | 12.00 to 15.88 | -0.13 | -0.54 |  | 10.50 to 14.25 | 0.01 | 0.91 |
|  | 16X | 12.00 to 17.31 | 0.13 | 0.24 |  | 11.50 to 14.25 | 0.38 | 1.42 |
| KN | 15S | 29.31 to 44.81 | -0.24 | 1.5 |  | 34.94 to 46.63 | -0.23 | -0.33 |
|  | 15X | 29.38 to 44.81 | -0.58 | 1.4 |  | 31.25 to 46.94 | -0.48 | 0.34 |
|  | 16S | 27.75 to 41.00 | -0.12 | 0.27 |  | 24.63 to 45.69 | -0.35 | 0.35 |
|  | 16X | 31.56 to 43.25 | -0.1 | 0.27 |  | 25.00 to 45.31 | -0.39 | 1.42 |
| KT | 15S | 35.65 to 46.76 | 0.14 | 0.27 |  | 37.00 to 48.95 | 0.05 | 0.1 |
|  | 15X | 35.84 to 47.39 | 0.28 | 0.09 |  | 40.03 to 59.33 | 0.1 | 0.41 |
|  | 16S | 33.39 to 45.75 | 0.03 | -0.05 |  | 35.65 to 51.49 | -0.21 | 0.21 |
|  | 16X | 35.66 to 46.63 | 0.54 | 0.22 |  | 39.34 to 53.96 | 0 | 0.01 |
| KW | 15S | 87.09 to 108.31 | 0.11 | 0.52 |  | 85.82 to 106.66 | 0.13 | -0.02 |
|  | 15X | 84.58 to 107.34 | 0.05 | 0.69 |  | 85.21 to 104.65 | 0.11 | 0.15 |
|  | 16S | 82.42 to 106.74 | -0.05 | 0.91 |  | 87.09 to 104.42 | 0.05 | -0.19 |
|  | 16X | 82.92 to 110.46 | 0.47 | 0.16 |  | 83.35 to 106.44 | 0.34 | 0 |
| KL | 15S | 105.53 to 130.16 | -0.28 | 0.52 |  | 97.27 to 122.43 | -0.24 | -0.17 |
|  | 15X | 114.60 to 143.34 | -0.73 | 1.33 |  | 106.19 to 134.03 | -0.18 | 0.76 |
|  | 16S | 105.26 to 132.92 | -0.79 | 0.68 |  | 107.66 to 132.34 | 0.06 | 0.13 |
|  | 16X | 102.70 to 135.00 | -0.13 | 0.08 |  | 104.07 to 131.63 | -0.26 | 0.43 |
| VW | 15S | 421.09 to 612.08 | 0.07 | 0.6 |  | 415.10 to 590.70 | 0.16 | 0.37 |
|  | 15X | 514.09 to 720.61 | 0.34 | 0.02 |  | 502.46 to 716.94 | 0.11 | 0.1 |
|  | 16S | 386.47 to 639.35 | 0.27 | 0.74 |  | 413.93 to 607.05 | 0.23 | 0.39 |
|  | 16X | 532.59 to 707.35 | 0.26 | 0.58 |  | 582.13 to 707.75 | 0.19 | -0.24 |
| HKW | 15S | 16.99 to 34.99 | 0.26 | 1.12 |  | 15.31 to 33.48 | 0.24 | 1.63 |
|  | 15X | 20.46 to 38.79 | 0.19 | 0.47 |  | 21.65 to 35.54 | 0.03 | -0.47 |
|  | 16S | 17.28 to 29.94 | -0.18 | -0.03 |  | 19.35 to 37.14 | 0.61 | 3.02 |
|  | 16X | 16.99 to 33.77 | 0.21 | 0.42 |  | 21.61 to 37.88 | -0.22 | 0.75 |
| YP | 15S | 799.56 to 1696.37 | -0.14 | 0.09 |  | 686.67 to 1402.38 | -0.37 | 0.52 |
|  | 15X | 816.25 to 2119.41 | -0.38 | 1.52 |  | 830.31 to 1797.25 | -0.12 | 0.52 |
|  | 16S | 426.83 to 1393.29 | -0.36 | 0.77 |  | 620.97 to 1489.04 | -0.21 | 0.15 |
|  | 16X | 806.88 to 1652.64 | 0.07 | -0.24 |  | 873.04 to 1694.46 | -0.35 | 0.36 |

aTrait refers to the name of each component of yield-related traits: RN, Row number; KN, Kernel number per row; KT, Kernel thickness; KW, Kernel width; KL, Kernel length; HKW, 100-kernel weight; VW, Volume weight; YP, Yield per plot

bSpecific growing environments: 15S is 2015 Shijiazhuang; 15X is 2015 Xinxiang; 16S is 2016 Shijiazhuang; 16X is 2016 Xinxiang; C is joint analyses

**Supplementary Table S3** QTL detected for eight yield-related traits in RILs

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Trait Namea | | Nameb | Envc | Chr.d | Marker intervale | intervalf | LODg | | PVEh | | ADDi | CONj | |
| RN | | *qRN1-1* | 16S | 1 | mk227-mk236 | 59.10-65.00 | | 4.17 | | 4.37 | 0.44 |  |
| *qRN1-4* | 15S/15X | 1 | mk530-mk578 | 221.15-237.25 | | 4.62 | | 5.38 | 0.43 |  |
| *qRN2-1* | 16X/C | 2 | mk872-mk890 | 7.70-10.85 | | 4.90 | | 5.52 | 0.41 | \* |
| *qRN2-2* | 16S/16X/C | 2 | mk1053-mk1065 | 203.05-209.10 | | 5.07 | | 5.14 | -0.40 |  |
| *qRN3-2* | C | 3 | mk1599-mk1616 | 203.65-207.50 | | 4.06 | | 4.23 | 0.29 |  |
| *qRN5-2* | 15X/C | 5 | mk2296-mk2312 | 10.35-13.85 | | 5.21 | | 5.79 | 0.40 |  |
| *qRN5-4* | 15S/16S/16X | 5 | mk2543-mk2558 | 160.75-167.55 | | 4.99 | | 5.86 | 0.48 | \* |
| *qRN8-1* | 15X | 8 | mk3626-mk3637 | 11.60-13.75 | | 3.95 | | 4.70 | 0.43 | \* |
| *qRN9-1* | 15S/15X/16S/16X/C | 9 | mk3994-mk4043 | 7.85-16.85 | | 4.13 | | 4.71 | 0.37 | \* |
| *qRN10-1* | 15S/15X | 10 | mk4367-mk4399 | 10.35-19.40 | | 4.72 | | 5.37 | -0.43 | \* |
| KN | *qKN2* | 15X/16X/C | 2 | mk952-mk984 | 171.95-183.20 | | 4.00 | | 4.55 | -1.37 | \* |
| *qKN3-2* | 15S | 3 | mk1477-mk1498 | 165.80-170.85 | | 3.24 | | 3.89 | -1.18 |  |
| *qKN4-2* | 16X | 4 | mk1908-mk1914 | 131.65-139.15 | | 4.15 | | 2.71 | 1.23 | \* |
| *qKN5* | 15X/16S/16X/C | 5 | mk2553-mk2613 | 165.05-183.55 | | 4.30 | | 4.82 | 1.42 |  |
| *qKN9* | 15S | 9 | mk4131-mk4138 | 89.30-94.70 | | 4.45 | | 6.72 | 1.53 | \* |
| *qKN10-1* | 16X | 10 | mk4372-mk4395 | 11.40-16.85 | | 4.34 | | 5.23 | 1.72 |  |
| *qKN10-2* | 15X/16S/C | 10 | mk4456-mk4465 | 91.25-102.60 | | 4.86 | | 6.02 | 1.60 | \* |
| KT | *qKT3-3* | 15S/16S/C | 3 | mk1433-mk1495 | 152.70-170.25 | | 5.37 | | 5.43 | 1.74 |  |
| *qKT4-1* | 15S/16S | 4 | mk1837-mk1857 | 30.00-39.90 | | 4.66 | | 5.93 | -2.07 | \* |
| *qKT4-2* | 15X/16X/C | 4 | mk1904-mk1910 | 128.15-134.4 | | 5.89 | | 6.76 | -1.92 |  |
| *qKT5-1* | 15S/16X | 5 | mk2555-mk2580 | 166.15-173.1 | | 4.55 | | 5.28 | -1.89 |  |
| *qKT6* | 15X/C | 6 | mk2778-mk2789 | 1.30-10.40 | | 3.84 | | 4.30 | -1.53 |  |
| *qKT7-1* | 15S/C | 7 | mk3339-mk3391 | 115.35-134.05 | | 3.52 | | 4.25 | 1.42 |  |
| *qKT10-1* | 16S | 10 | mk4360-mk4376 | 8.75-12.65 | | 5.93 | | 6.83 | -2.56 |  |
| *qKT10-2* | 15X | 10 | mk4464-mk4472 | 100.40-107.30 | | 3.63 | | 5.02 | -2.01 | \* |
| KW | *qKW1-1* | 15X/16S/16X/C | 1 | mk102-mk170 | 19.25-35.35 | | 6.38 | | 6.89 | -2.28 | \* |
| *qKW1-3* | 15S/16S | 1 | mk608-mk698 | 246.90-274.65 | | 3.35 | | 3.27 | -1.75 |  |
| *qKW3-2* | 15S | 3 | mk1327-mk1336 | 34.25-40.85 | | 6.13 | | 6.94 | 2.73 |  |
| *qKW3-3* | 15X/16S/16X/C | 3 | mk1443-mk1475 | 155.05-165.4 | | 8.54 | | 8.75 | 2.64 | \* |
| *qKW4-3* | 16S/C | 4 | mk1989-mk2106 | 173.50-210.70 | | 3.66 | | 2.19 | 1.24 | \* |
| *qKW4-4* | 15X | 4 | mk2160-mk2179 | 229.70-234.05 | | 3.98 | | 4.48 | 2.10 |  |
| *qKW6-1* | 16X | 6 | mk2778-mk2789 | 1.30-10.40 | | 3.18 | | 3.56 | -2.14 |  |
| *qKW6-3* | 15X | 6 | mk2829-mk2835 | 65.00-71.65 | | 3.91 | | 4.05 | -2.01 | \* |
| *qKW6-4* | 15S | 6 | mk3039-mk3055 | 146.10-149.85 | | 5.15 | | 5.77 | -2.33 |  |
| *qKW7-1* | 16S | 7 | mk3314-mk3319 | 96.40-105.35 | | 6.21 | | 6.42 | 2.50 |  |
| *qKW7-2* | 15S/15X/16X/C | 7 | mk3370-mk3438 | 126.10-148.90 | | 6.23 | | 6.97 | 2.20 | \* |
| *qKW8* | 15S/15X16S/16X/C | 8 | mk3862-mk3933 | 161.90-171.35 | | 5.44 | | 5.48 | -1.99 | \* |
| *qKW10* | 16S/C | 10 | mk4464-mk4481 | 100.40-116.80 | | 5.48 | | 5.66 | -2.02 |  |
| KL | *qKL2* | C | 2 | mk832-mk849 | 1.50-3.65 | | 3.49 | | 3.20 | 1.48 | \* |
| *qKL3-2* | 15S/C | 3 | mk1328-mk1346 | 34.80-51.95 | | 6.63 | | 6.05 | 2.63 |  |
| *qKL3-3* | 15X/16S/16X | 3 | mk1460-mk1477 | 159.05-165.8 | | 3.80 | | 5.94 | 3.14 |  |
| *qKL3-4* | 15S/16S/C | 3 | mk1626-mk1673 | 209.10-217.25 | | 7.53 | | 7.84 | 2.72 | \* |
| *qKL4-1* | 15X | 4 | mk1837-mk1847 | 30.00-34.95 | | 4.40 | | 5.44 | 2.86 | \* |
| *qKL4-2* | 16X | 4 | mk1893-mk1896 | 91.60-101.10 | | 3.27 | | 3.00 | 2.45 |  |
| *qKL4-3* | 15S/C | 4 | mk1936-mk1958 | 152.25-159.20 | | 4.44 | | 5.19 | 2.25 | \* |
| *qKL4-4* | 16S | 4 | mk2170-mk2196 | 231.75-236.90 | | 3.12 | | 4.11 | 2.35 |  |
| *qKL5-2* | 15S | 5 | mk2640-mk2684 | 190.85-201.6 | | 3.03 | | 3.30 | -2.08 |  |
| *qKL7-1* | 16S | 7 | mk3249-mk3260 | 24.50-29.80 | | 3.23 | | 4.25 | 2.38 |  |
| *qKL7-2* | 15S/15X/16X/C | 7 | mk3397-mk3449 | 137.05-151.50 | | 5.78 | | 6.19 | 2.53 | \* |
| *qKL7-4* | 15S | 7 | mk3514-mk3531 | 163.95-167.15 | | 4.15 | | 4.54 | 2.52 |  |
| *qKL10-2* | 15X/C | 10 | mk4438-mk4486 | 82.55-118.65 | | 3.46 | | 3.59 | -2.01 | \* |
| VW | *qVW1* | 16X | 1 | mk568-mk583 | 234.05-239.30 | | 4.25 | | 2.57 | -11.82 |  |
| *qVW3-2* | 16S | 3 | mk1423-mk1438 | 148.65-154.10 | | 3.22 | | 5.06 | -20.44 |  |
| *qVW4-2* | 15S | 4 | mk1955-mk1964 | 157.40-163.40 | | 3.45 | | 4.22 | -19.03 |  |
| *qVW6-2* | 15S | 6 | mk2854-mk2870 | 83.55-89.85 | | 3.14 | | 3.53 | 17.57 |  |
| *qVW8-1* | 15X | 8 | mk3673-mk3679 | 74.30-79.65 | | 4.08 | | 4.65 | -21.86 |  |
| *qVW8-2* | 15S | 8 | mk3927-mk3947 | 170.75-173.05 | | 3.45 | | 4.06 | 18.59 |  |
| *qVW10-1* | 15X/16S/C | 10 | mk4332-mk4379 | 4.05-34.60 | | 5.07 | | 4.26 | 13.77 |  |
| *qVW10-2* | 15S | 10 | mk4456-mk4461 | 91.25-96.90 | | 5.22 | | 7.85 | 26.58 |  |
| *qVW10-3* | 16X | 10 | mk4524-mk4545 | 136.15-140.55 | | 3.42 | | 3.41 | 13.63 |  |
| HKW | *qHKW1-1* | 16X/C | 1 | mk105-mk139 | 19.85-26.85 | | 6.02 | | 5.84 | -1.43 | \* |
| *qHKW1-2* | 15X/16S | 1 | mk287-mk298 | 86.30-93.15 | | 3.49 | | 4.04 | -1.45 |  |
| *qHKW1-3* | 15S/16S/16X/C | 1 | mk612-mk638 | 249.15-277.15 | | 4.73 | | 4.51 | -1.14 | \* |
| *qHKW2-1* | C | 2 | mk864-mk882 | 6.05-9.65 | | 4.19 | | 4.68 | -0.94 | \* |
| *qHKW2-3* | 16X | 2 | mk1084-mk1108 | 213.10-218.20 | | 4.33 | | 4.20 | -1.46 |  |
| *qHKW3-2* | 15S/15X/16S/16X/C | 3 | mk1449-mk1483 | 156.45-167.60 | | 8.66 | | 8.89 | 1.64 |  |
| *qHKW5-2* | 15X/15S/C | 5 | mk2552-mk2619 | 164.95-184.45 | | 3.76 | | 4.36 | -1.21 |  |
| *qHKW6-1* | 15X | 6 | mk2829-mk2835 | 65.00-71.65 | | 3.26 | | 3.98 | -1.61 |  |
| *qHKW7-1* | 16S | 7 | mk3248-mk3260 | 24.15-29.80 | | 4.76 | | 5.04 | 1.44 |  |
| *qHKW7-3* | 15S/16X/C | 7 | mk3401-mk3461 | 138.55-153.95 | | 7.97 | | 8.01 | 1.56 | \* |
| *qHKW8* | 16X/C | 8 | mk3859-mk3892 | 161.35-166.15 | | 4.38 | | 4.14 | -1.12 | \* |
| *qHKW10* | 15X/16S/C | 10 | mk4435-mk4488 | 82.00-118.90 | | 4.26 | | 4.76 | -1.44 |  |
| YP | *qYP1* | 15S/C | 1 | mk466-mk488 | 201.95-207.95 | | 3.54 | | 4.04 | -37.90 |  |
| *qYP2-1* | 15X | 2 | mk952-mk965 | 171.95-177.90 | | 3.21 | | 3.94 | -55.96 |  |
| *qYP2-3* | 16S/16X/C | 2 | mk1013-mk1044 | 190.40-199.05 | | 4.64 | | 5.73 | -50.69 |  |
| *qYP3-1* | 16X | 3 | mk1570-mk1585 | 194.75-200.20 | | 4.84 | | 6.74 | 77.77 |  |
| *qYP4* | 15S | 4 | mk1731-mk1751 | 0.35-3.75 | | 3.32 | | 3.51 | -41.74 |  |
| *qYP5-1* | 15X | 5 | mk2595-mk2609 | 176.30-182.30 | | 3.62 | | 4.60 | 60.42 |  |
| *qYP6-1* | 15X | 6 | mk2859-mk2870 | 85.55-89.85 | | 6.13 | | 8.52 | -97.00 |  |
| *qYP6-2* | 15X | 6 | mk2914-mk2929 | 104.35-108.90 | | 3.67 | | 4.91 | 72.54 |  |
| *qYP7* | 15S | 7 | mk3475-mk3495 | 157.05-160.75 | | 5.70 | | 6.96 | 59.03 |  |
| *qYP9-1* | 16S/C | 9 | mk4144-mk4167 | 98.10-105.55 | | 3.92 | | 5.13 | 43.46 |  |

aTrait refers to the name of each component of yield-related traits: RN, Row number; KN, Kernel number per row; KT, Kernel thickness; KW, Kernel width; KL, Kernel length; HKW, 100-kernel weight; VW, Volume weight; YP, Yield per plot

bThe name of each QTL is a composite of the influenced trait: RN, KN, KT, KW, KL, HKW, VW or YP

cChr., chromosome

dSpecific growing environment: 15S is 2015 Shijiazhuang; 15X is 2015 Xinxiang; 16S is 2016 Shijiazhuang; 16X is 2016 Xinxiang; C is joint analyses

eMarker interval, the markers flanking the QTL

fInterval, confidence interval between two bin markers

gLOD, the logarithm of odds score

h PVE, the phenotypic variance explained by an individual QTL

iADD, the value of additive effects. LOD scores, PVE values, and ADD values are shown as mean values for QTL with multiple effects

jCON， QTL consistent with previous study represented by the symbol \*.

**Supplementary Table S4** QTL detected for the GCA effects of eight yield-related traits

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Trait Namea | Nameb | Envc | Chr.d | Marker intervale | intervalf | LODg | PVEh | ADDi |
| RN | *qRN1-2* | 16X | 1 | mk249-mk264 | 70.85-76.70 | 3.45 | 3.85 | -0.01 |
| *qRN1-3* | 16X | 1 | mk430-mk444 | 190.95-196.50 | 3.75 | 3.49 | 0.00 |
| *qRN2-1* | 15X/C | 2 | mk876-mk904 | 8.65-13.30 | 4.34 | 3.46 | 0.08 |
| *qRN3-1* | C | 3 | mk1298-mk1313 | 21.45-25.65 | 8.12 | 7.03 | -0.21 |
| *qRN3-3* | 16S | 3 | mk1663-mk1681 | 215.40-220.15 | 3.78 | 4.72 | -0.01 |
| *qRN4-1* | C | 4 | mk1749-mk1784 | 3.45-11.90 | 3.53 | 3.68 | 0.15 |
| *qRN4-2* | 15S | 4 | mk1976-mk1993 | 170.75-175.15 | 4.03 | 3.07 | 0.00 |
| *qRN4-3* | C | 4 | mk2047-mk2117 | 189.65-216.40 | 5.47 | 3.71 | -0.15 |
| *qRN5-1* | 15X | 5 | mk2246-mk2253 | 3.05-4.15 | 5.05 | 4.93 | -0.01 |
| *qRN5-2* | 16S/C | 5 | mk2286-mk2367 | 8.75-26.20 | 3.35 | 3.46 | 0.06 |
| *qRN5-3* | 16S | 5 | mk2493-mk2496 | 105.15-119.70 | 3.86 | 4.03 | -0.01 |
| *qRN5-4* | C | 5 | mk2519-mk2596 | 147.05-176.95 | 3.71 | 1.10 | 0.09 |
| *qRN6* | C | 6 | mk3078-mk3095 | 156.15-159.15 | 8.53 | 7.89 | 0.22 |
| *qRN7* | C | 7 | mk3154-mk3169 | 0.35-2.65 | 4.22 | 3.02 | -0.14 |
| *qRN8-2* | C | 8 | mk3892-mk3916 | 166.15-169.15 | 4.36 | 2.84 | -0.13 |
| *qRN9-1* | C | 9 | mk4010-mk4039 | 10.90-16.00 | 7.58 | 5.83 | 0.19 |
| *qRN9-2* | 16X | 9 | mk4255-mk4271 | 133.50-136.75 | 4.97 | 3.19 | 0.00 |
| *qRN10-2* | C | 10 | mk4458-mk4464 | 95.05-100.40 | 10.20 | 8.51 | -0.23 |
| KN | *qKN1-1* | C | 1 | mk64-mk91 | 12.55-17.55 | 3.15 | 3.81 | -0.38 |
| *qKN1-2* | 15X | 1 | mk146-mk165 | 28.30-33.75 | 4.73 | 5.41 | -0.15 |
| *qKN1-3* | 15S | 1 | mk444-mk459 | 196.50-200.15 | 4.97 | 4.90 | -0.13 |
| *qKN1-4* | C | 1 | mk484-mk505 | 207.05-213.05 | 4.75 | 4.80 | -0.43 |
| *qKN1-5* | 16X | 1 | mk582-mk597 | 238.45-244.00 | 3.49 | 4.10 | 0.12 |
| *qKN1-6* | C | 1 | mk686-mk700 | 270.35-275.00 | 9.06 | 8.43 | 0.57 |
| *qKN3-1* | 15X/C | 3 | mk1239-mk1302 | 9.95-22.40 | 4.86 | 4.51 | -0.25 |
| *qKN3-3* | C | 3 | mk1534-mk1555 | 183.35-188.50 | 4.94 | 3.48 | -0.36 |
| *qKN3-4* | 16S | 3 | mk1659-mk1681 | 214.70-220.15 | 3.20 | 3.71 | -0.17 |
| *qKN4-1* | 15X | 4 | mk1873-mk1876 | 64.55-70.55 | 3.37 | 3.76 | 0.12 |
| *qKN6* | 15X | 6 | mk3116-mk3132 | 162.10-164.90 | 3.48 | 3.13 | 0.11 |
| *qKN7-1* | C | 7 | mk3337-mk3344 | 113.10-117.70 | 11.85 | 12.24 | -0.67 |
| *qKN7-2* | 16S | 7 | mk3388-mk3399 | 132.60-138.35 | 3.70 | 3.63 | -0.16 |
| *qKN7-3* | C | 7 | mk3581-mk3593 | 174.45-176.65 | 3.72 | 2.73 | 0.32 |
| *qKN8-1* | 16S | 8 | mk3787-mk3792 | 131.45-137.40 | 9.33 | 9.10 | 0.26 |
| *qKN8-2* | 16S/C | 8 | mk3925-mk3938 | 170.45-171.95 | 4.52 | 4.05 | 0.24 |
| KT | *qKT1-1* | 16S | 1 | mk352-mk364 | 160.40-166.70 | 3.18 | 1.63 | -0.03 |
| *qKT1-2* | 15S/16X | 1 | mk472-mk493 | 203.55-208.95 | 4.89 | 5.72 | 0.01 |
| *qKT1-3* | C | 1 | mk677-mk697 | 266.35-274.40 | 5.54 | 4.12 | -0.53 |
| *qKT2* | C | 2 | mk837-mk847 | 2.05-3.20 | 6.80 | 7.25 | -0.71 |
| *qKT3-1* | C | 3 | mk1201-mk1212 | 2.45-4.80 | 3.02 | 2.00 | 0.39 |
| *qKT3-2* | 16S | 3 | mk1423-mk1438 | 148.65-154.10 | 3.37 | 3.61 | 0.05 |
| *qKT3-3* | C | 3 | mk1442-mk1463 | 154.85-160.25 | 6.08 | 2.94 | 0.47 |
| *qKT4-2* | 15X/C | 4 | mk1903-mk1922 | 126.50-144.75 | 8.54 | 7.63 | -0.45 |
| *qKT5-2* | 15X/C | 5 | mk2696-mk2728 | 203.70-210.80 | 3.64 | 2.47 | 0.21 |
| *qKT7-1* | C | 7 | mk3337-mk3348 | 113.10-118.90 | 5.22 | 5.50 | 0.63 |
| *qKT7-2* | 15S | 7 | mk3538-mk3560 | 168.25-171.75 | 3.23 | 4.53 | -0.04 |
| *qKT8* | C | 8 | mk3805-mk3848 | 147.05-159.75 | 3.81 | 2.17 | 0.39 |
| *qKT9* | C | 9 | mk4040-mk4051 | 16.20-18.45 | 3.83 | 2.76 | -0.43 |
| *qKT10-1* | C | 10 | mk4397-mk4402 | 18.10-23.60 | 5.37 | 4.56 | -0.56 |
| KW | *qKW1-2* | 15X | 1 | mk286-mk297 | 85.30-90.75 | 4.98 | 2.41 | -0.03 |
| *qKW1-3* | C | 1 | mk665-mk681 | 262.90-268.25 | 5.45 | 5.56 | -0.92 |
| *qKW3-1* | C | 3 | mk1282-mk1317 | 18.85-27.80 | 4.22 | 0.28 | 0.29 |
| *qKW3-2* | C | 3 | mk1331-mk1343 | 36.35-49.85 | 3.55 | 0.01 | 0.07 |
| *qKW3-3* | C | 3 | mk1426-mk1454 | 149.65-157.55 | 5.25 | 1.37 | 0.59 |
| *qKW3-4* | 16X | 3 | mk1605-mk1608 | 205.10-205.80 | 5.41 | 3.20 | 0.05 |
| *qKW4-1* | C | 4 | mk1832-mk1860 | 26.30-43.90 | 4.06 | 0.35 | 0.41 |
| *qKW4-2* | C | 4 | mk1870-mk1907 | 58.15-130.70 | 3.41 | 0.13 | 0.25 |
| *qKW4-3* | C | 4 | mk2065-mk2084 | 195.20-201.10 | 8.23 | 4.78 | 0.86 |
| *qKW5-1* | C | 5 | mk2434-mk2486 | 63.80-90.65 | 3.10 | 0.06 | -0.16 |
| *qKW5-2* | C | 5 | mk2496-mk2532 | 119.70-154.8 | 3.83 | 0.64 | -0.54 |
| *qKW6-2* | 16S | 6 | mk2809-mk2819 | 32.80-38.85 | 3.16 | 3.34 | -0.04 |
| *qKW6-4* | 15X/C | 6 | mk3034-mk3053 | 140.70-149.65 | 9.06 | 8.69 | -0.65 |
| *qKW6-5* | 16X/C | 6 | mk3131-mk3153 | 164.75-168.75 | 4.71 | 4.31 | -0.46 |
| *qKW7-2* | C | 7 | mk3374-mk3385 | 127.05-131.10 | 7.89 | 6.32 | 0.98 |
| *qKW7-3* | 15S | 7 | mk3419-mk3436 | 143.30-148.55 | 3.35 | 2.31 | 0.03 |
| *qKW7-4* | 16S | 7 | mk3523-mk3545 | 165.65-168.95 | 4.18 | 3.21 | -0.04 |
| *qKW9* | 15X/C | 9 | mk3969-mk4040 | 2.70-16.20 | 3.51 | 3.24 | -0.31 |
| KL | *qKL1-1* | C | 1 | mk290-mk336 | 88.20-148.65 | 3.09 | 2.42 | -0.67 |
| *qKL1-2* | 16X/C | 1 | mk433-mk468 | 191.75-202.6 | 6.13 | 4.44 | -0.53 |
| *qKL1-3* | 15X | 1 | mk573-mk586 | 234.85-240.5 | 4.01 | 3.82 | -0.11 |
| *qKL1-4* | 16S | 1 | mk701-mk711 | 275.20-277.85 | 3.94 | 0.08 | -0.02 |
| *qKL2* | 15S/C | 2 | mk837-mk884 | 2.05-10.05 | 7.67 | 7.01 | 0.74 |
| *qKL3-1* | 15S | 3 | mk1293-mk1314 | 20.80-26.20 | 3.55 | 3.81 | 0.16 |
| *qKL3-4* | 16X/C | 3 | mk1600-mk1724 | 204.25-230.45 | 4.12 | 4.07 | 0.47 |
| *qKL4-1* | C | 4 | mk1838-mk1850 | 30.25-36.20 | 5.29 | 5.91 | 1.00 |
| *qKL4-4* | 15S | 4 | mk2146-mk2165 | 225.5-230.85 | 3.16 | 3.51 | 0.15 |
| *qKL5-1* | 15S | 5 | mk2588-mk2605 | 174.45-180.00 | 3.28 | 3.63 | -0.15 |
| *qKL5-2* | C | 5 | mk2700-mk2715 | 204.35-206.65 | 4.95 | 3.59 | -0.77 |
| *qKL6* | 15X | 6 | mk2776-mk2787 | 0.35-4.10 | 3.16 | 4.22 | -0.12 |
| *qKL7-3* | 16S | 7 | mk3470-mk3496 | 155.90-160.90 | 3.82 | 2.04 | -0.09 |
| *qKL8-1* | 15S | 8 | mk3792-mk3799 | 137.40-143.55 | 4.80 | 5.27 | 0.18 |
| *qKL8-2* | 16S | 8 | mk3869-mk3899 | 163.45-166.95 | 3.75 | 3.26 | -0.12 |
| *qKL9* | C | 9 | mk4169-mk4259 | 106.10-134.25 | 3.91 | 2.60 | 0.66 |
| *qKL10-1* | 15X | 10 | mk4328-mk4337 | 3.05-4.65 | 3.49 | 3.52 | -0.11 |
| *qKL10-2* | C | 10 | mk4456-mk4462 | 91.25-97.7 | 9.89 | 9.50 | -1.27 |
| VW | *qVW3-1* | 15S | 3 | mk1321-mk1332 | 31.65-37.05 | 5.83 | 7.45 | -1.26 |
| *qVW3-3* | 15X/16X | 3 | mk1465-mk1499 | 161.00-171.25 | 3.45 | 1.76 | 0.75 |
| *qVW3-4* | 16S | 3 | mk1566-mk1579 | 193.00-198.40 | 3.02 | 3.37 | 1.13 |
| *qVW4-1* | C | 4 | mk1839-mk1851 | 31.00-36.70 | 6.94 | 6.73 | -5.51 |
| *qVW4-3* | 16S | 4 | mk2031-mk2034 | 183.35-185.55 | 5.63 | 4.26 | -1.28 |
| *qVW5-1* | 16X | 5 | mk2439-mk2454 | 67.20-73.70 | 3.24 | 0.04 | -0.09 |
| *qVW5-2* | C | 5 | mk2625-mk2775 | 187.20-217.35 | 3.14 | 2.62 | -3.42 |
| *qVW6-1* | 15X/C | 6 | mk2776-mk2787 | 0.35-4.10 | 4.89 | 5.58 | 3.38 |
| *qVW10-1* | 16S | 10 | mk4399-mk4404 | 19.40-25.75 | 7.28 | 7.96 | 1.75 |
| *qVW10-2* | 15S/C | 10 | mk4464-mk4473 | 100.40-108.35 | 8.92 | 9.31 | 4.44 |
| HKW | *qHKW1-3* | 16X/C | 1 | mk665-mk687 | 262.90-271.20 | 10.37 | 10.78 | -0.46 |
| *qHKW2-2* | 16S | 2 | mk1012-mk1024 | 190.25-193.25 | 4.76 | 4.70 | 0.11 |
| *qHKW3-1* | C | 3 | mk1274-mk1302 | 16.90-22.40 | 8.14 | 2.74 | 0.37 |
| *qHKW3-2* | 15X/C | 3 | mk1416-mk1499 | 142.55-171.25 | 4.31 | 5.57 | 0.26 |
| *qHKW3-3* | 15S | 3 | mk1670-mk1676 | 216.80-217.65 | 5.65 | 3.22 | 0.10 |
| *qHKW4* | 15X/C | 4 | mk1736-mk1763 | 1.55-6.10 | 3.66 | 4.34 | -0.26 |
| *qHKW5-1* | 16S/16X | 5 | mk2257-mk2354 | 4.95-21.60 | 6.51 | 5.12 | 0.12 |
| *qHKW6-1* | 16S | 6 | mk2829-mk2835 | 65.00-71.65 | 3.69 | 4.32 | -0.10 |
| *qHKW6-2* | C | 6 | mk3075-mk3153 | 155.15-168.75 | 4.61 | 3.27 | -0.35 |
| *qHKW7-2* | C | 7 | mk3370-mk3386 | 126.1-131.55 | 8.89 | 7.49 | 0.53 |
| *qHKW9* | C | 9 | mk4005-mk4045 | 9.55-17.25 | 3.25 | 2.51 | -0.31 |
| YP | *qYP1* | 15S/C | 1 | mk444-mk464 | 196.50-201.10 | 7.47 | 7.38 | -12.41 |
| *qYP2-2* | 15S | 2 | mk980-mk998 | 181.65-186.40 | 3.16 | 4.17 | 5.46 |
| *qYP3-2* | 15S | 3 | mk1619-mk1643 | 208.05-212.20 | 3.64 | 4.29 | 5.55 |
| *qYP3-3* | 16S | 3 | mk1665-mk1676 | 216.05-217.65 | 3.71 | 3.46 | -4.96 |
| *qYP4* | 15X | 4 | mk1731-mk1740 | 0.35-2.20 | 4.88 | 5.86 | -6.66 |
| *qYP5-2* | 15S/16X | 5 | mk2724-mk2755 | 209.40-214.45 | 3.84 | 3.54 | -4.96 |
| *qYP6-3* | 16S | 6 | mk2954-mk2973 | 115.75-121.05 | 3.17 | 3.82 | -5.17 |
| *qYP8-1* | 16X | 8 | mk3661-mk3663 | 51.50-59.50 | 6.05 | 5.33 | -6.17 |
| *qYP8-2* | 16S | 8 | mk3787-mk3792 | 131.45-137.40 | 5.02 | 6.09 | 6.56 |
| *qYP9-2* | C | 9 | mk4288-mk4294 | 149.15-153.55 | 3.83 | 5.23 | 13.86 |
| *qYP10* | C | 10 | mk4432-mk4449 | 80.35-85.70 | 7.30 | 9.18 | -18.62 |

aTrait refers to the name of each component of yield-related traits: RN, Row number; KN, Kernel number per row; KT, Kernel thickness; KW, Kernel width; KL, Kernel length; HKW, 100-kernel weight; VW, Volume weight; YP, Yield per plot

bThe name of each QTL is a composite of the influenced trait: RN, KN, KT, KW, KL, HKW, VW or YP

cChr., chromosome

dSpecific growing environment: 15S is 2015 Shijiazhuang; 15X is 2015 Xinxiang; 16S is 2016 Shijiazhuang; 16X is 2016 Xinxiang; C representing joint analyses

eMarker interval, the markers flanking the QTL

fInterval, confidence interval between two bin markers

gLOD, the logarithm of odds score

h PVE, the phenotypic variance explained by an individual QTL

iADD, the value of additive effects. LOD scores, PVE values, and ADD values are shown as mean values for QTL with multiple effects

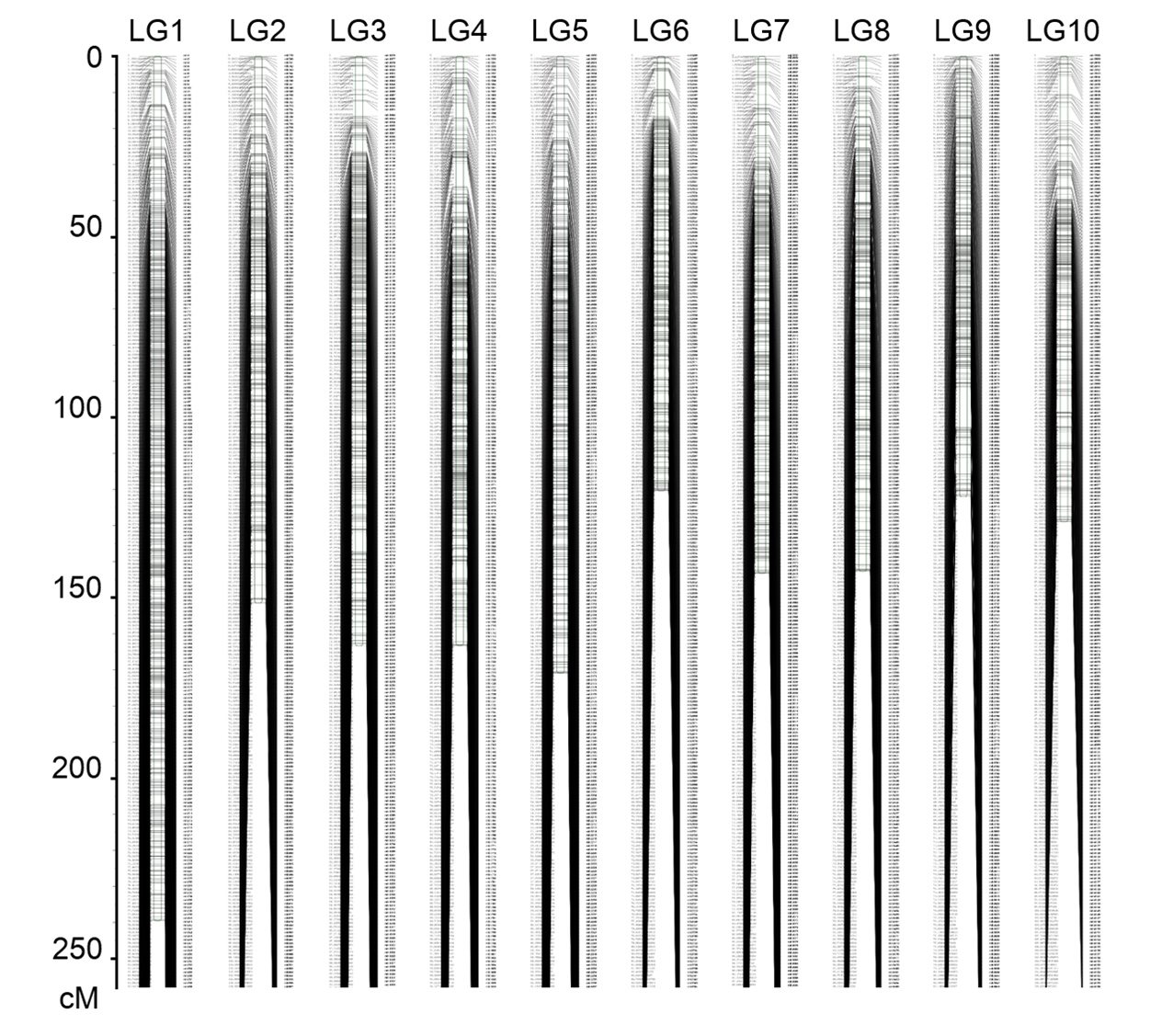


Figure S1 The high density genetic map created derived from 4602 bin markers (Zhou *et al.*, 2016)