(b)

(a)

(d)

(c)

(f)

(e)

Figure S1. Daily minimum and maximum air temperatures (°C) (a, b) solar radiation (MJ m-2) (c, d) and daily rainfall (mm) (e, f) during the field experiments Exp. S2 from 26 May to 3 October in 2017 and Exp. S4 from 14 May to 24 July in 2018, respectively.

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| Table S1. Root anatomy of IR64 and Sta1-NIL under 9 observations from 4 experiments (Exp. S1-S4) in the combined analysis  |
| Genotype | STA (x103 μm2) | %STA(%) | Rep. No. | Obs. No. | Exp. No. |
| IR64 | Sta1-NIL | *P* value (t.test) |  R64 | Sta1-NIL | *P* value (t.test) |
| GH\_17\_24 | 23.6 | 24.2 | 0.653 | 3.51 | 4.07 | 0.106 | 8 | 1 | S1 |
| WD\_17\_H | 43.7 | 45.1 | 0.462 | 5.40 | 5.73 | 0.127 | 44 | 2 | S2 |
| WW\_17\_H | 28.6 | 30.4 | 0.263 | 3.09 | 3.05 | 0.750 | 44 | 3 | S2 |
| WD\_17\_M | 43.2 | 49.6 | 0.071+ | 4.58 | 5.26 | 0.013\* | 12 | 4 | S2 |
| WW\_17\_M | 29.4 | 29.8 | 0.875 | 2.53 | 2.80 | 0.062+ | 12 | 5 | S2 |
| GH\_18\_36 | 34.3 | 39.9 | 0.135 | 5.33 | 5.16 | 0.668 | 3 | 6 | S3 |
| GH\_18\_63 | 33.4 | 39.7 | 0.004\*\* | 4.35 | 4.69 | 0.478 | 3 | 7 | S3 |
| WD\_18\_63 | 43.1 | 50.0 | 0.120 | 6.27 | 6.19 | 0.751 | 6 | 8 | S4 |
| WW\_18\_63 | 31.1 | 36.2 | 0.019\* | 2.31 | 2.29 | 0.894 | 6 | 9 | S4 |
| STA: stele transversal area; %STA: (STA\*100)/RTA (root transversal area) |
| GH\_17\_24: greenhouse in 2017 at 24 days after sowing;  |  |  |  |  |  |
| WD\_17\_H: water deficit in 2017 at heading stage;  |  |  |  |  |  |
| WD\_17\_M: water deficit in 2017 at maturity stage;  |  |  |  |  |  |
| WW\_17\_H: well-watered in 2017 at heading stage;  |  |  |  |  |  |
| WW\_17\_M: well-watered in 2017 at maturity stage;  |  |  |  |  |  |
| GH\_18\_36: greenhouse in 2018 at 36 days after transplanting;  |  |  |  |  |  |
| GH\_18\_63: greenhouse in 2018 at 63 days after transplanting;  |  |  |  |  |  |
| WD\_18\_63: water deficit in 2018 at 63 days after transplanting;  |  |  |  |  |
| WW\_18\_63: well-watered in 2018 at 63 days after transplanting;  |  |  |  |  |
| \*\*\*, \*\*, \*, +, ns show *P* ≤ .001, .01, .05, .10, and no significance, respectively. |  |  |  |

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| Table S2. Meta-analysis of grain yield, aboveground biomass, and harvest index of IR64 and Sta1-NIL under 14 environments from 7 experiments (Y1-Y7) |
| Environment | Grain yield (g m-2)  | Aboveground biomass (g m-2) | Harvest index | Rep. No. | Env. No. | Exp. No. |
| IR64 | Sta1-NIL | *P* value (t.test) | IR64 | Sta1-NIL | *P* value (t.test) | IR64 | Sta1-NIL | *P* value (t.test) |
| D\_13\_AWD | 756 | 791 | 0.420 | 1600 | 1627 | 0.333 | 0.473 | 0.487 | 0.888 | 3 | 1 | 1Y |
| D\_13\_FL | 589 | 640 | 0.428 | 1209 | 1306 | 0.808 | 0.487 | 0.489 | 0.398 | 3 | 2 | 1Y |
| D\_13\_RU | 371 | 447 | 0.227 | 887 | 1012 | 0.346 | 0.417 | 0.443 | 0.316 | 3 | 3 | 1Y |
| D\_14\_AWD | 780 | 769 | 0.744 | 1900 | 1790 | 0.346 | 0.411 | 0.430 | 0.026\* | 3 | 4 | 2Y |
| D\_14\_FL | 761 | 773 | 0.808 | 1844 | 1732 | 0.137 | 0.413 | 0.447 | 0.428 | 3 | 5 | 2Y |
| D\_14\_RU | 603 | 519 | 0.164 | 1344 | 1142 | 0.126 | 0.449 | 0.454 | 0.526 | 3 | 6 | 2Y |
| Ya\_14\_FL | 602 | 647 | 0.203 | 1307 | 1319 | 0.820 | 0.461 | 0.491 | 0.193 | 3 | 7 | 3Y |
| Ya\_15\_FL | 503 | 475 | 0.565 | 1120 | 1088 | 0.598 | 0.446 | 0.438 | 0.737 | 6 | 8 | 4Y |
| Ya\_16\_FL | 584 | 620 | 0.388 | 1023 | 1078 | 0.423 | 0.570 | 0.576 | 0.759 | 6 | 9 | 5Y |
| Y\_16\_AWD | 622 | 656 | 0.269 | 1308 | 1387 | 0.477 | 0.462 | 0.486 | 0.034\* | 6 | 10 | 6Y |
| Y\_16\_FL | 607 | 688 | 0.481 | 1313 | 1416 | 0.333 | 0.476 | 0.471 | 0.807 | 6 | 11 | 6Y |
| Y\_16\_RU | 354 | 385 | 0.458 | 920 | 974 | 0.496 | 0.383 | 0.396 | 0.591 | 6 | 12 | 6Y |
| Y\_17\_FL | 781 | 809 | 0.378 | 1700 | 1708 | 0.890 | 0.459 | 0.474 | 0.263 | 3 | 13 | 7Y |
| Y\_17\_RU | 430 | 438 | 0.921 | 1174 | 1211 | 0.835 | 0.366 | 0.358 | 0.716 | 3 | 14 | 7Y |
| D\_13\_AWD: Deshmukh et al. (2017) in 2013 under alternative wetting and drying with surface fertilization |
| D\_13\_FL: Deshmukh et al. (2017) in 2013 under flooded lowland with surface fertilization |
| D\_13\_RU: Deshmukh et al. (2017) in 2013 under rainfed upland with surface fertilization |
| D\_14\_AWD: Deshmukh et al. (2017) in 2014 under alternative wetting and drying with surface fertilization |
| D\_14\_FL: Deshmukh et al. (2017) in 2014 under flooded lowland with surface fertilization |
| D\_14\_RU: Deshmukh et al. (2017) in 2014 under rainfed upland with surface fertilization |  |
| Ya\_14\_FL: Yaginuma (2017) in 2014 under flooded lowland with surface fertilization |
| Ya\_15\_FL: Yaginuma (2017) in 2015 under flooded lowland with deep and surface fertilization |  |  |  |
| Ya\_16\_FL: Yaginuma (2017) in 2016 under flooded lowland with deep and surface fertilization |  |  |  |
| Y\_16\_AWD: Y et al. (unpublished data) in 2016 under alternative wetting and drying with deep and surface fertilization |
| Y\_16\_FL: Y et al. (unpublished data) in 2016 under flooded lowland with deep and surface fertilization |  |  |  |
| Y\_16\_RU: Y et al. (unpublished data) in 2016 under rainfed upland with deep and surface fertilization |  |  |  |
| Y\_17\_FL: Y et al. (unpublished data) in 2017 under flooded lowland with surface fertilization |  |  |  |
| Y\_17\_RU: Y et al. (unpublished data) in 2017 under rainfed upland with surface fertilization |  |  |  |  |
| \*\*\*, \*\*, \*, + show *P* ≤ .001, .01, .05 and .10, respectively. |