A quantitative locus, *MP3*, which increases panicle number, enhances grain yield under an elevated atmospheric CO_2 environment

The atmospheric concentration of CO_2, one of the greenhouse gases, is projected to reach 430－1,000 ppm by the end of this century, increasing the average global temperature by 1.0−5.7°C above pre-industrial levels (1850~1900). While the increase in temperature will have a negative effect on crop productivity in some regions, the increase in atmospheric CO_2 concentration will have a positive effect on plant photosynthesis. Therefore, crops with sufficient spikelets to store increased photosynthetic assimilates are expected to contribute to increased yield, and the utilization of such crops under high CO_2 concentrations may lead to sustainable crop production under climate change. We have previously shown that a quantitative locus, *MP3* (*MORE PANICLES 3*), found in the temperate *japonica* rice cultivar Koshihikari, promotes tillering and increases panicle number in the high-yielding *indica* cultivar Takanari. The purpose of this study is to identify the causal gene of *MP3* by map-based cloning, clarify the rice groups in which *MP3* is effective, and verify that increased panicle number due to *MP3* contributes to increased grain yield under an elevated atmospheric CO_2 environment.

We can see the results of map-based cloning in Fig. 1. The causal gene of *MP3* is *OsTB1* (*TEOSINTE BRANCHED1*) located on chromosome 3, and there are three sequence differences in the gene between Koshihikari and Takanari. Classifying rice cultivar groups based on the sequence differences, 74% of temperate *japonica* cultivars and 10% of tropical *japonica* cultivars have the same sequence as Koshihikari (Koshihikari type). On the other hand, 60% of the *indica* cultivars have the same sequence as Takanari (Takanari type) (Fig. 2). Then, near-isogenic lines (NILs) carrying the Koshihikari *MP3* in the high-yielding *indica* cultivars, IR64 and Hokuriku 193, also increase panicle number by 20−30% compared to the parental cultivars as in the case of Takanari (Fig. 3). Interestingly, Takanari-NIL enhances grain yield by 6% compared to Takanari under open-air CO_2 enrichment (FACE, 580 ppm CO_2 in the air), whereas it does not under ambient condition (390 ppm CO_2 in the air) (Fig. 4).

Since *indica* cultivars are grown on more than 80% of the world's rice cropping areas, the Koshihikari *MP3* is expected to be widely used in rice breeding in Japan and abroad to address climate change accompanied by rising atmospheric CO_2 levels. However, it should be noted that the effect of *MP3* on panicle number and grain yield under high-temperature conditions needs to be verified in the future.

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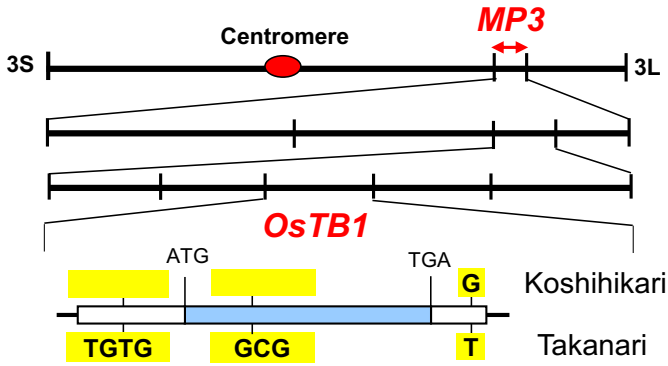

Fig. 1. Map-based cloning of *MP3*
Sequence differences exist in the three locations highlighted in yellow. Blank yellow indicates that the corresponding sequence is deleted.

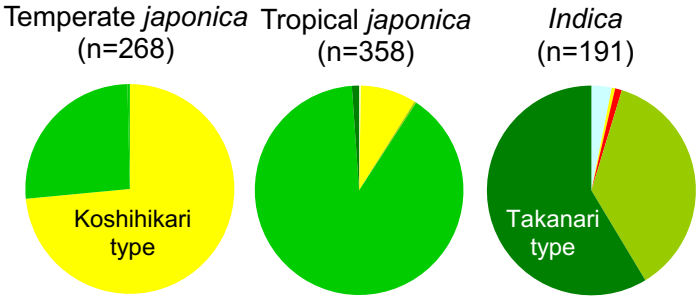

Fig. 2. Type of *MP3* among temperate *japonica*, tropical *japonica*, and *indica*
n means the number of cultivars.

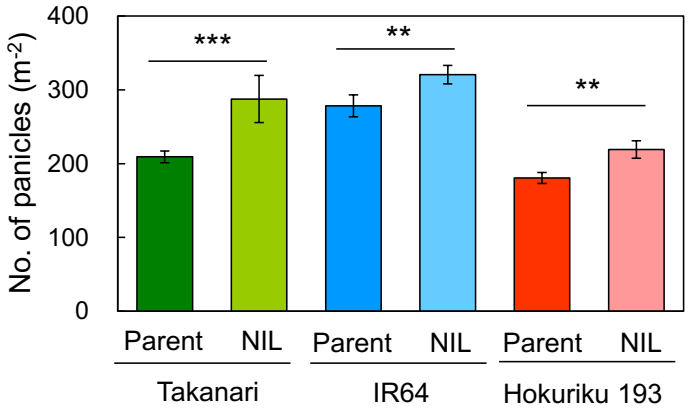

Fig. 3. Comparisons of panicle number between the parental cultivars and its near-isogenic lines (NILs)
*** and ** show significance at 0.1% and 1% levels, respectively.

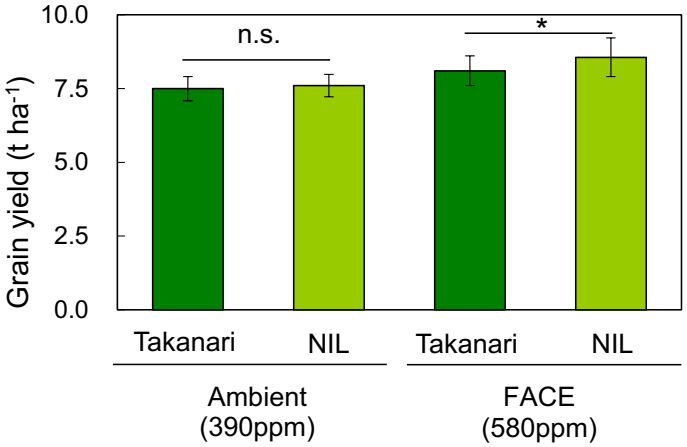

Fig. 4. Comparisons of grain yield between Takanari and its NIL grown in ambient CO_2 and open-air CO_2 enrichment (FACE) conditions
n.s. and * show non-significance and significance at 5% levels, respectively.

Reference: Takai et al. (2023) *The Plant Journal* 114: 729–742.
The figures were reprinted/modified from Takai et al. (2023).