

A host plant genome (*Zizania latifolia*) after a century-long endophyte infection



Fig. 1 Enlarged stems of Jiaobai.

菰是我国最早的谷类作物之一，我国古代称菰颖果为菰、雕胡、雕菰米等。最早关于菰米的文献记载始于周朝，《周礼》将菰列为六谷之一，作为贡米供帝王食用。中国古代从晋到唐、宋时期，文人诗作中吟咏描绘雕胡菰米美味的诗句一直不断出现，如李白在《宿五松山媪家》中的“跪进雕胡饭，月光明素盘”，杜甫在《江阁卧病走笔》中的“滑忆雕胡饭，香闻绵带羹”及陆游在《题斋壁·又》

中的“二升菰米晨炊饭，一碗松灯夜读书”等。唐宋以后，随着南方人口激增以及农业大开发，围湖垦田和水稻的推广，菰逐步被水稻取代，清末民国时期，菰米仅作为充饥救荒使用。由此可见，菰米现在已鲜为人知，成为我国消失的作物之一和农耕文明。浙江是我国野生菰重要生长地也是最早菰米种植地之一。浙江省湖州市在2500年前（春秋时）因到处生长着菰，被称为“菰城”（菰城遗址现存于湖州城外）。北美有一种称为“wild rice”的作物（超市有售），其实际为美国上世纪驯化的北美沼生菰(*Z. palustris*)。几个世纪前印第安人就采收野生北美菰作为食物，当时误以为是野生水稻而得名。同时，菰茎基部如有黑粉菌(*Ustilago*)寄生形成共生关系，则可刺激其茎基部组织异常增生，形成鲜嫩的肉质茎。大约2000年前，我们的祖先利用它们的共生关系把菰也同时驯化成为蔬菜作物茭白，沿用至今。秦汉《尔雅》《释草》篇中就可见“蘧蔬”（即茭白）记载（“蘧蔬，似土菌，生菰草中。今江东啖之，甜滑。”）。

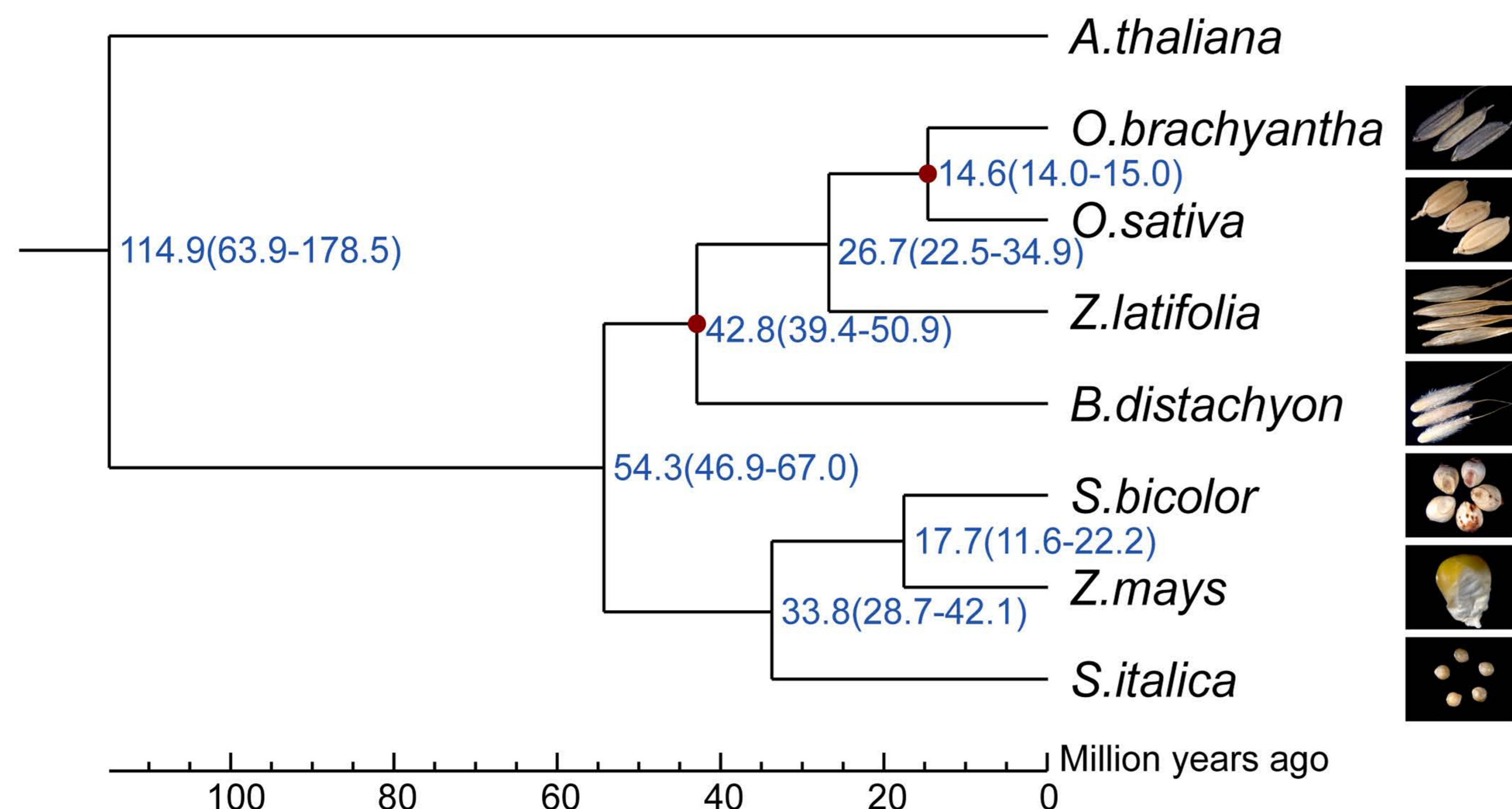


Fig. 2 Estimation of the time of divergence (with error range shown in parentheses) of *Z. latifolia* and four other grasses based on orthologous single-copy gene pairs, with red dots indicating the calibration time.

In nature, many important host-microbe interactions are long-term, often lasting decades or longer. Despite their importance in natural ecosystems, agriculture and medicine, the study on long-term (especially decades or longer) host-microbe interactions is few and the impact of long-term microbial colonization on the dynamics of host genomes is not well understood. We sequenced a wild *Z. latifolia* plant (accession ‘HSD2’) lacking the *U. endophyte* with a total of 83.4 Gb Illumina high-quality sequence data (130.1 Gb of raw data), representing about 140-fold genome coverage. *De novo* assembly of sequence data resulted in an assembly containing 604.1 Mb, with a scaffold N50 length of 604.9 Kb. Genomic analysis showed novelty of the *Zizania* genome, such as an independent genome duplication and, the most important, a scenario of loss and mutations of plant immunity genes in Jiaobai during the long-standing *Ustilago* interaction with the host genome.

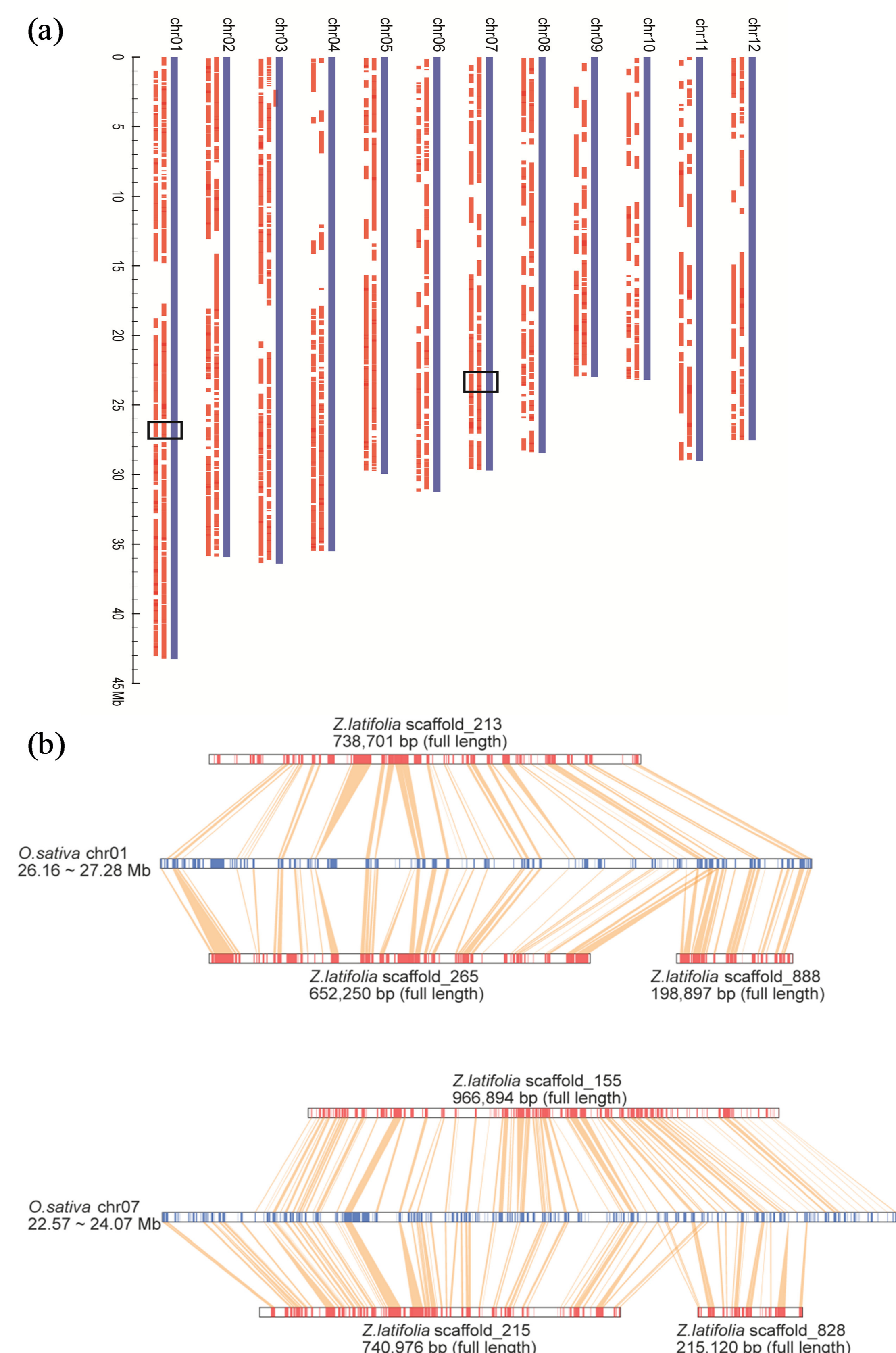


Fig. 3 Genomic synteny between *Oryza* and *Zizania*. (a) Syntenic blocks shared between *Zizania* and rice genomes due to the most recent WGD event of the *Zizania* genome. (b) Details of two examples of syntenic blocks in rice chromosome 1 and 7 (indicated by black boxes in Figure 3a).

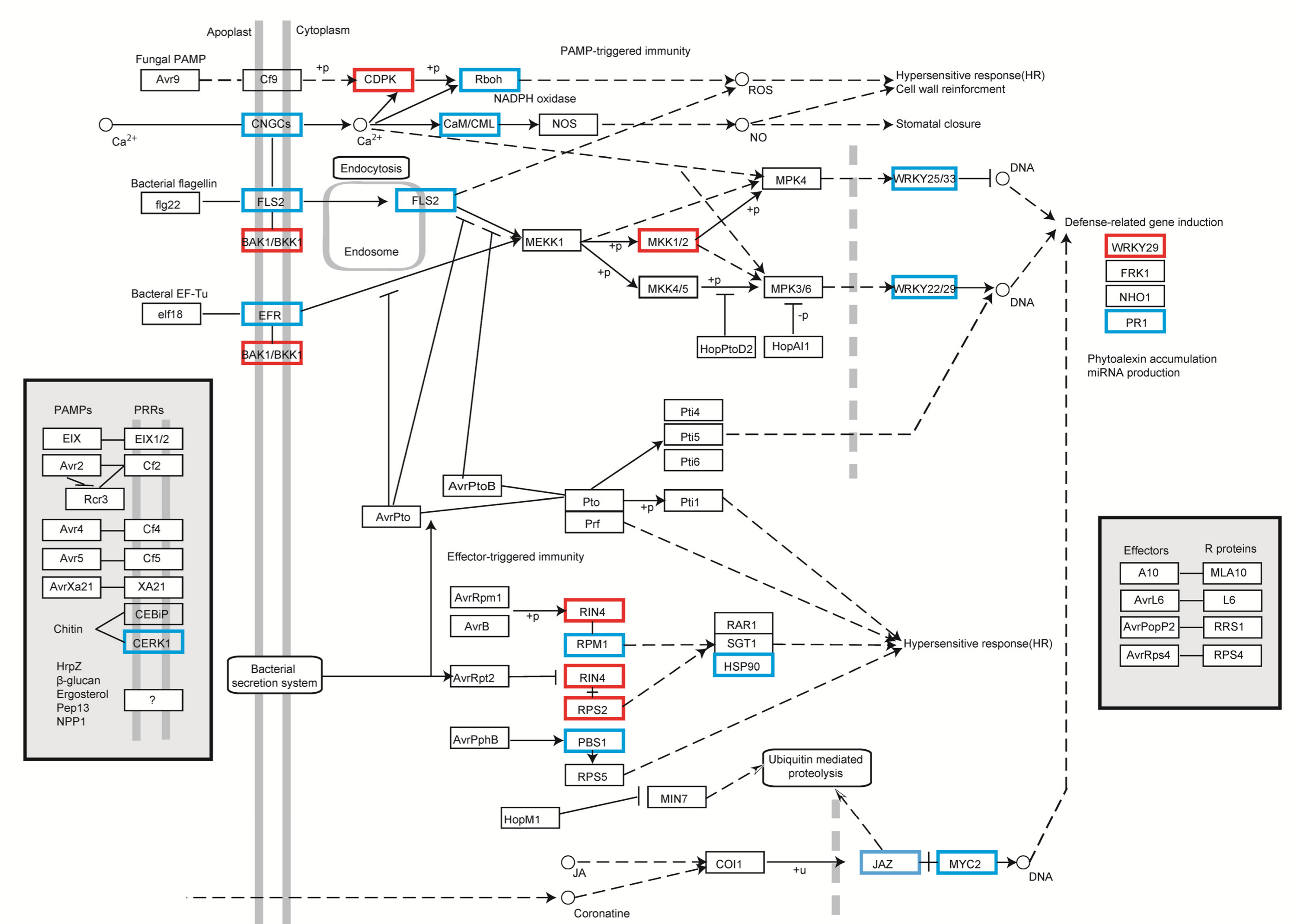


Fig. 4 Gene loss and mutations in Jiaobai after long-standing *Ustilago* fungal infection. A schematic depicting part of the plant-pathogen interaction pathway in KEGG. Blue boxes indicate loss or mutation of genes belonging to the corresponding gene families in both Jiaobai cultivars (‘Zhejiao2’ and ‘Jiayou1’), whereas red boxes indicate gene loss or mutations in one cultivar.