SPIKE, a quantitative trait locus for increasing the number of spikelets per panicle, enhances rice grain yield under low-yield conditions

Rice is an important food source in Asia and Africa; however, poor soil fertility and nutrient availability considerably limit rice production in these regions. In addition, the majority of local farmers lack the finances to purchase sufficient fertilizer. Therefore, it is necessary to develop genetically improved rice varieties with high nutrient-use efficiencies. Previously, a quantitative trait locus, *SPIKE*, was reported to have increased the number of spikelets per panicle in rice. Because tillering, and thus the number of panicles, is restricted under nutrient-poor soils, we expected that *SPIKE* may be useful in enhancing rice productivity under low-yield conditions.

In this study, we grew IR64 and the near-isogenic line (NIL) for *SPIKE* in the IR64 genetic background. They were grown in research plots at the International Rice Research Institute (IRRI) in the tropics across 11 seasons from 2011 to 2017, and in 2018 under high and low nitrogen (N) fertilizer conditions, where mean yield variation was 4.2–6.7 t ha^{-1}. In multiseasonal trials, overall yield performance of NIL-*SPIKE* was 11% superior to that of IR64. Significant variety × season interaction clarified that NIL-*SPIKE* was superior to IR64 in the lower-yield seasons (< 5 t ha^{-1}) but the difference decreased or disappeared completely in the higher-yield seasons (> 5 t ha^{-1}) (Fig. 1). A subsequent N application trial with two levels of N fertilizer (45 and 180 kg N ha^{-1}) confirmed a similar variety × N interaction for *SPIKE*; NIL-*SPIKE* tended to be superior to IR64 for grain yield under low-N application (4.3 t ha^{-1}), while the difference disappeared under high-N application (6.75 t ha^{-1}) (Fig. 2). The advantage of NIL-*SPIKE* under low-N application was due to more spikelets m^{-2} compared to IR64 but the difference disappeared under high-N application because there were fewer panicles m^{-2} in NIL-*SPIKE* compared to IR64 (Fig. 3).

The results of this study indicate that *SPIKE* is effective at increasing rice yield under low-yield conditions (< 5 t ha^{-1}), namely low-N application or low soil fertility. Therefore, *SPIKE* should be used in breeding programs aimed at regions where soil fertility is poor, or where farmers cannot purchase adequate fertilizer.

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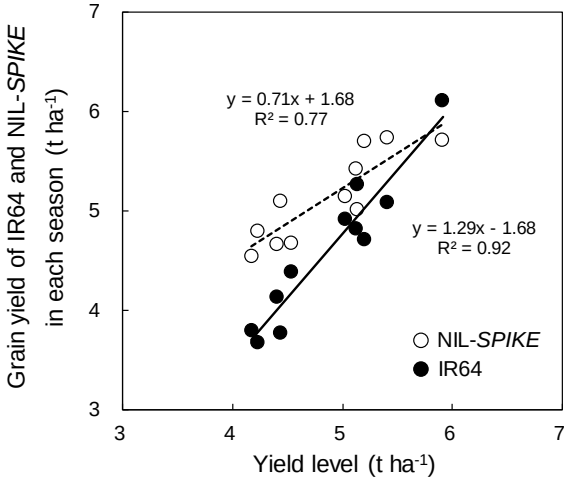

Fig. 1. Comparison of grain yield between IR64 and NIL-*SPIKE* across 11 seasons. Yield level shows mean yield between IR64 and NIL-*SPIKE* in each season.

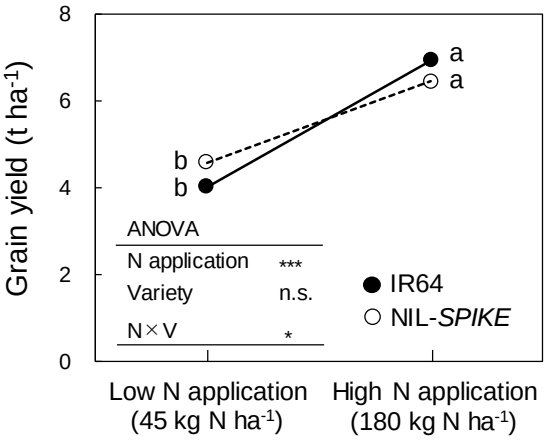

Fig. 2. Comparison of grain yield between IR64 and NIL-*SPIKE* under low- and high-N applications. *** and * show significance at 0.1% and 5% levels, respectively, while n.s. indicates not significant. Different letters show significant difference at 5% level.

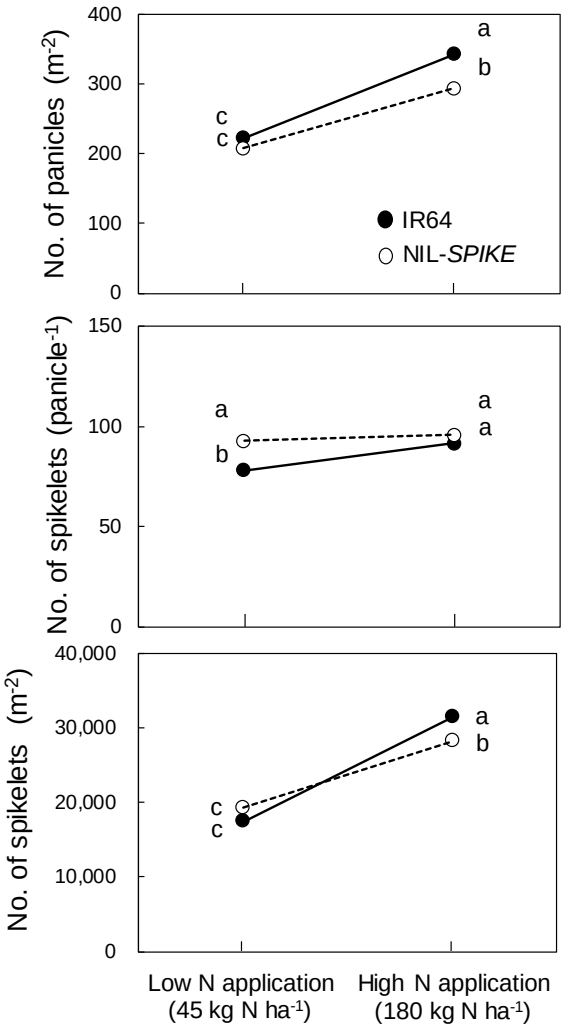

Fig. 3. Comparisons of the number of panicles m^{-2}, the number of spikelets per panicle, and the number of spikelets m^{-2} between IR64 and NIL-*SPIKE* under low- and high-N applications. Different letters show significant difference at 5% level.