(A)

Targeted internodes	IN4 (25 DBH)	IN2 (3DBH)
MM	Mock	Mock
UM	Uniconazole	Mock
GM	Gibberellin	Mock
MU	Mock	Uniconazole
MG	Mock	Gibberellin
UG	Uniconazole	Gibberellin
GU	Gibberellin	Uniconazole

(B)

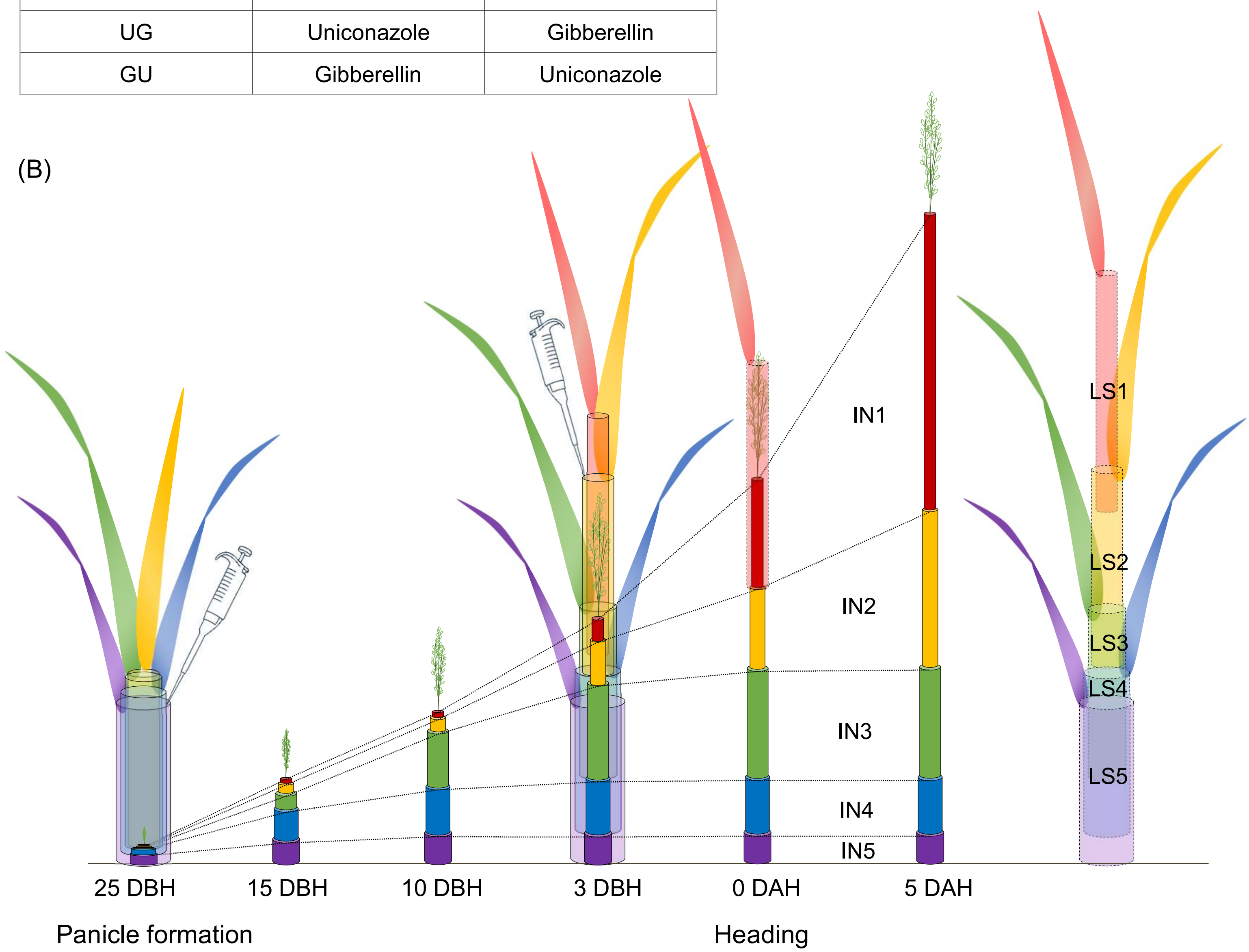

Fig. S1. Experimental design of plant growth regulator treatments targeting specific internodes.
(A) Summarized treatment combinations. (B) The diagram illustrates the developmental progression of internodes (IN1–IN5) and corresponding leaf sheaths (LS1–LS5) from panicle formation to heading. Plant growth regulator treatments were applied at 25 days before heading (DBH) and 3 DBH to modify elongation of IN4 (representing the lower internodes) and IN2, respectively.

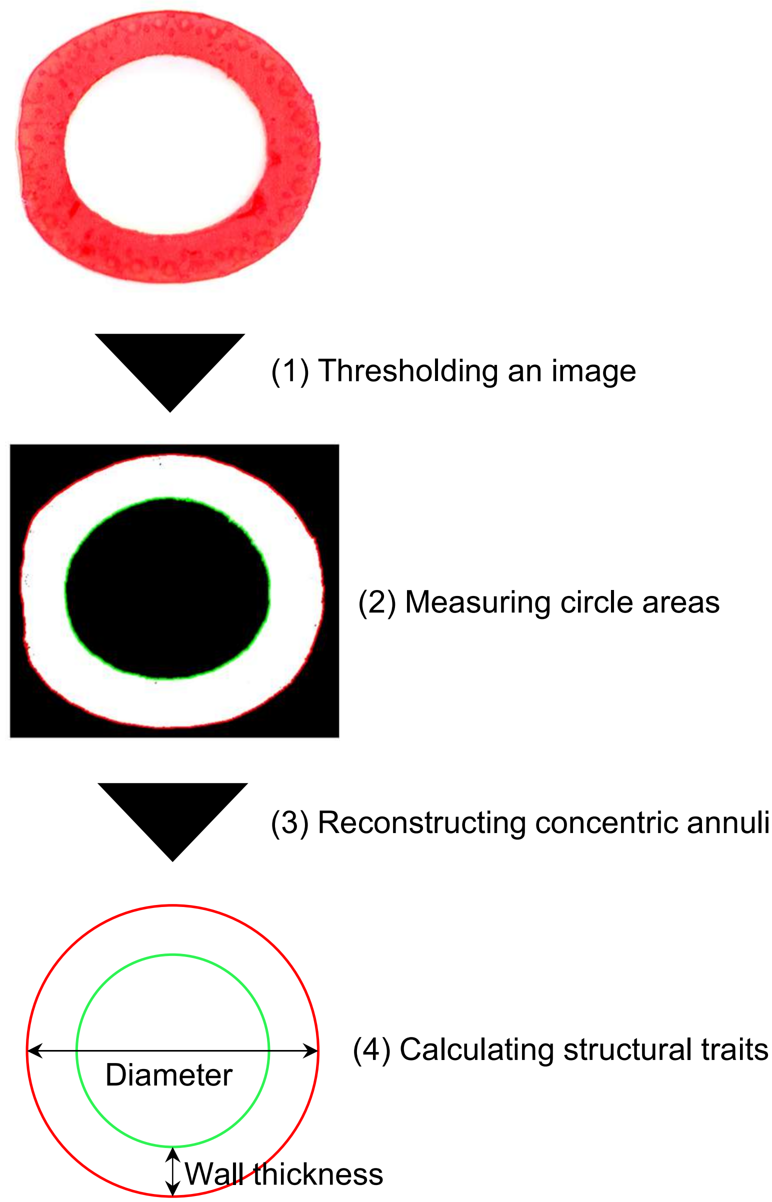

Fig. S2. Workflow for calculating internode cross-sectional traits from scanned images.
The procedure used to obtain internode diameter, wall thickness, and cross-sectional area from scanned cross-sectional images is illustrated. (1) Image thresholding: The raw cross-sectional image is binarized to detect the tissue boundaries in the outer or inner circles. (2) Area measurement: The areas of the outer (red) and inner (green) regions are measured. The cross-sectional area is calculated as the difference between these two areas. (3) Reconstruction of concentric annuli: Idealized concentric circles equivalent in area to the measured outer and inner regions are reconstructed to minimize irregularities caused by tissue deformation or sectioning artifacts. (4) Calculation of structural traits: From the reconstructed circles, the diameter (outer circle) and wall thickness (difference between outer and inner radii) are calculated.

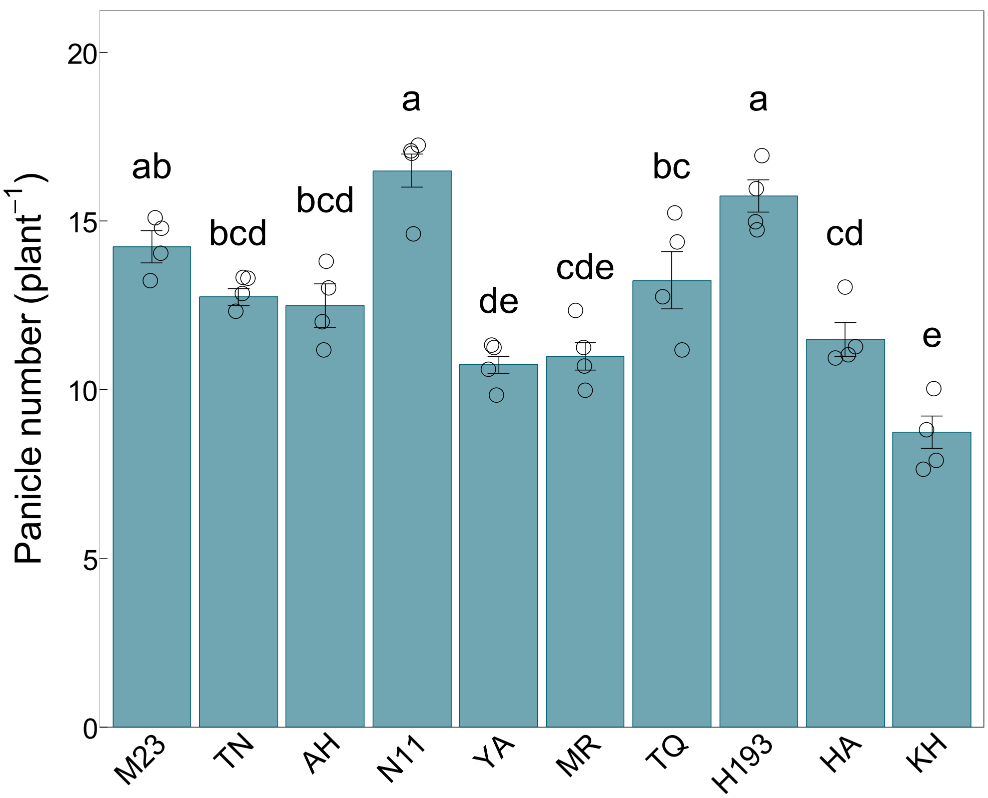

Fig. S3. Panicle number per plant for each cultivar evaluated in the 2022 field experiment. Bars show means ± SE (n = 4). Different letters above the bars indicate significant differences among cultivars (Tukey's HSD test, $P < 0.05$).

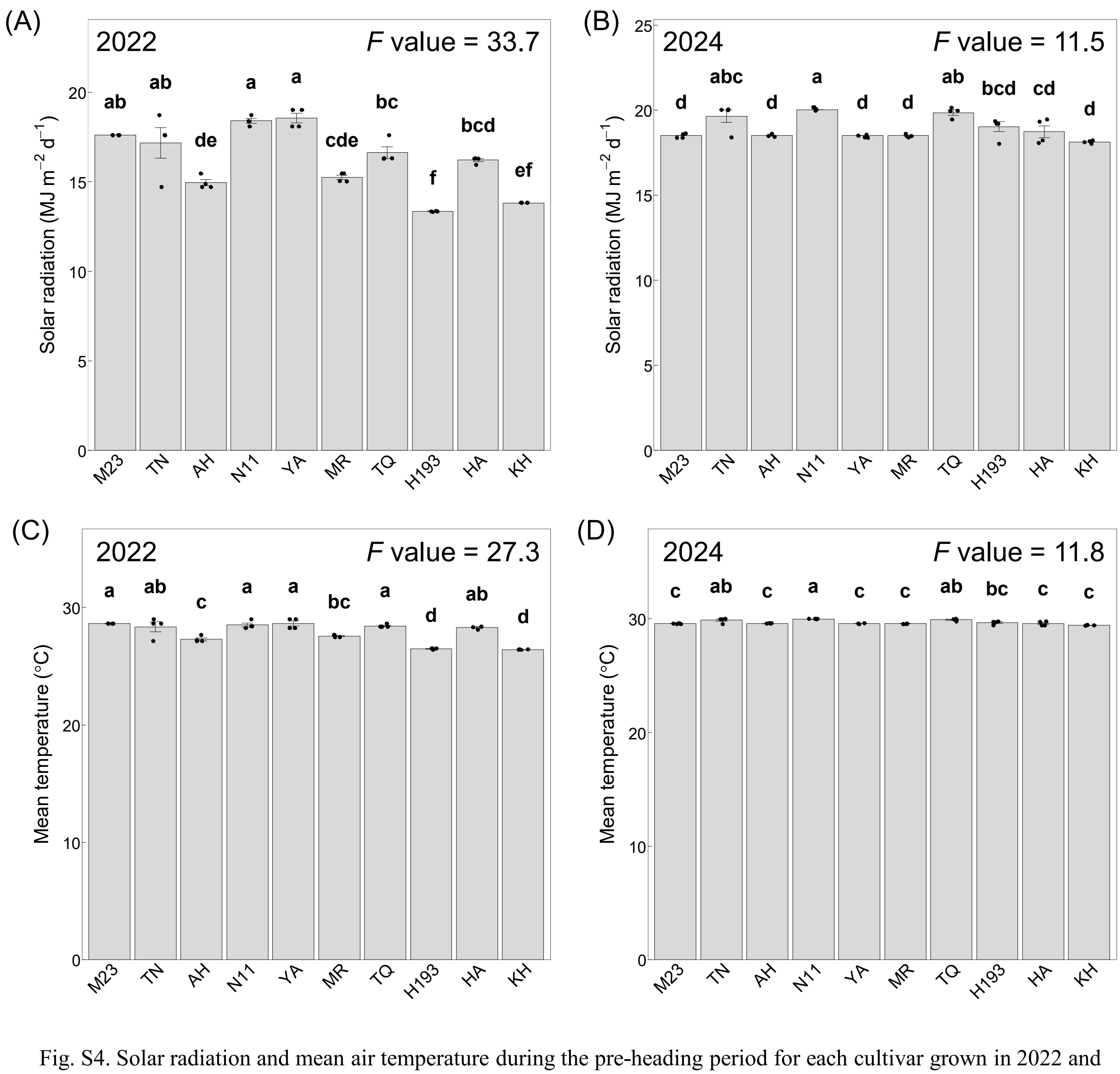

Fig. S4. Solar radiation and mean air temperature during the pre-heading period for each cultivar grown in 2022 and 2024.

(A, B) Daily solar radiation (MJ m^{-2} d^{-1}) averaged over the period from panicle formation to heading in 2022 (A) and from panicle formation to full heading in 2024 (B). (C, D) Mean air temperature (° C) during the same period in 2022 (C) and 2024 (D). Bars show means ± SE (n = 4). Different letters above the bars indicate significant differences among cultivars (Tukey's HSD, $P < 0.05$). F values from one-way ANOVA are shown above each panel.

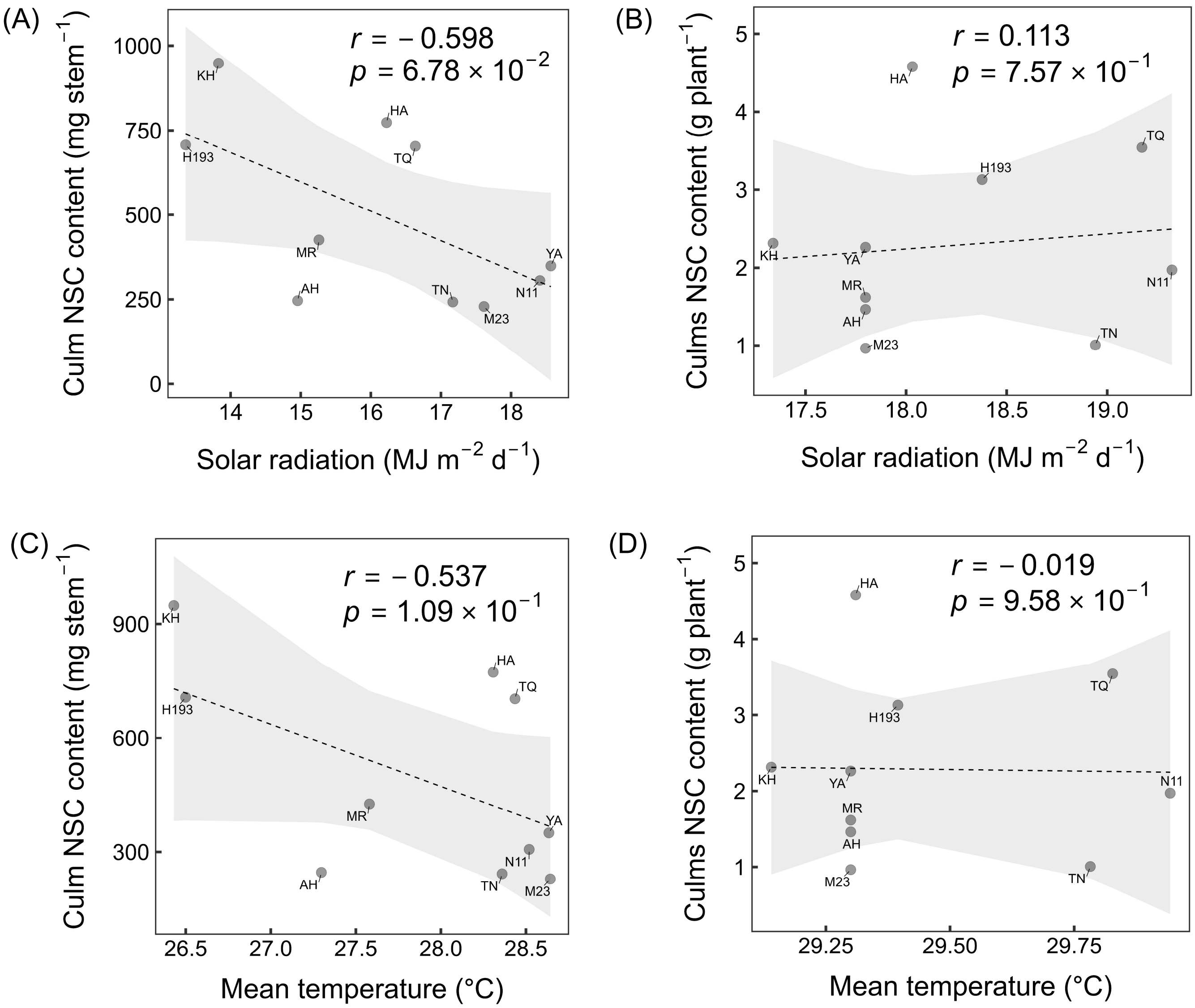

Fig. S5. Relationships between culm NSC content and climatic conditions before heading.
(A) Relationship between solar radiation and main culm NSC content in 2022. (B) Relationship between solar radiation and whole-plant culm NSC content in 2024. (C) Relationship between mean air temperature and main culm NSC content in 2022. (D) Relationship between mean air temperature and whole-plant culm NSC content in 2024. Regression lines are shown with 95% confidence intervals (shaded). Correlation coefficients (*r*) and *P*-values are from Pearson's tests (n = 10).

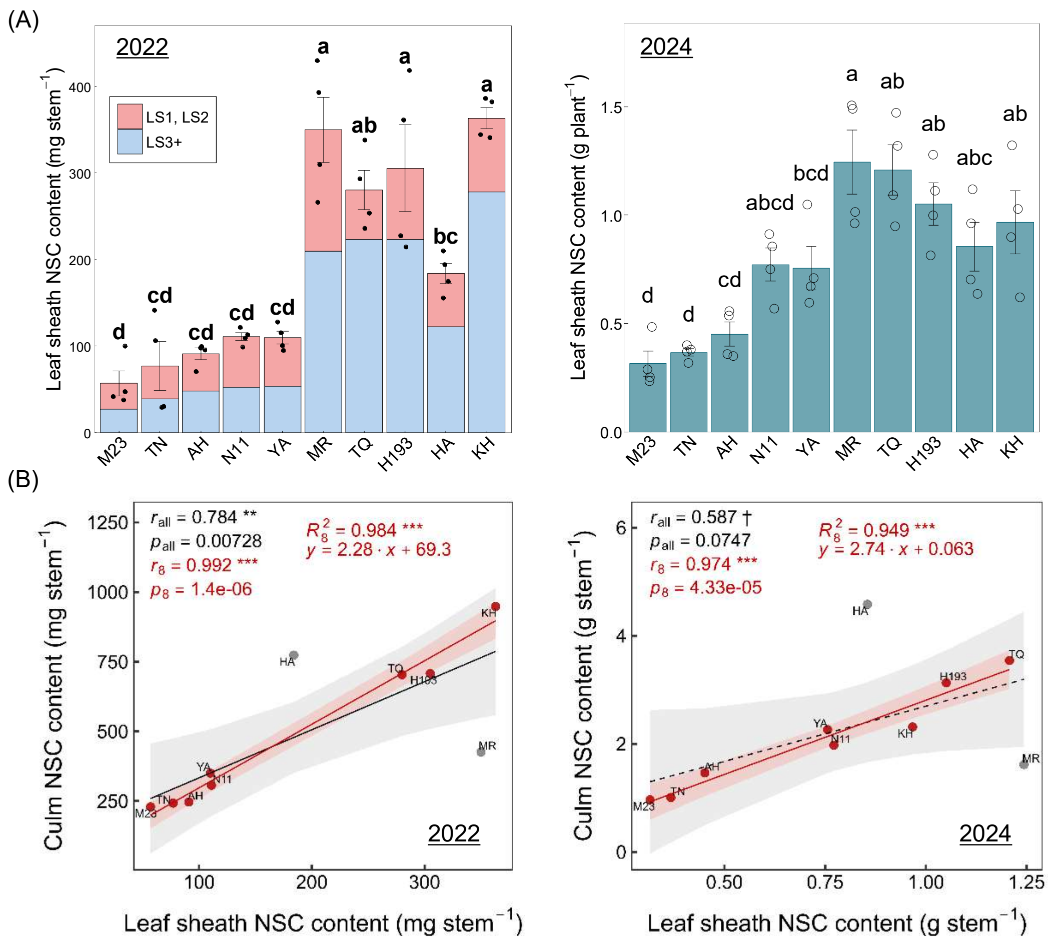

Fig. S6. Leaf sheath NSC content and its association with culm NSC content in rice cultivars. (A) Leaf sheath NSC content of each cultivar in 2022 (left) and 2024 (right). In 2022, leaf sheath NSC content is shown as stacked bars separating LS1–LS2 and LS3+ (leaf sheaths at and below LS3), whereas in 2024 total leaf sheath NSC content is shown. Bars show means ± SE (n=4). Different letters above bars indicate significant differences among cultivars (Tukey's HSD, $P <$ 0.05). (B) Relationships between leaf sheath NSC content and culm NSC content in 2022 (left) and 2024 (right). Black solid lines and gray shaded areas indicate the regression lines and 95% confidence intervals calculated using all cultivars, whereas red solid lines and red shaded areas indicate those calculated using eight cultivars excluding MR and HA. Pearson's correlation coefficients (r), p-values, coefficients of determination (R^2), and regression equations are shown in each panel.

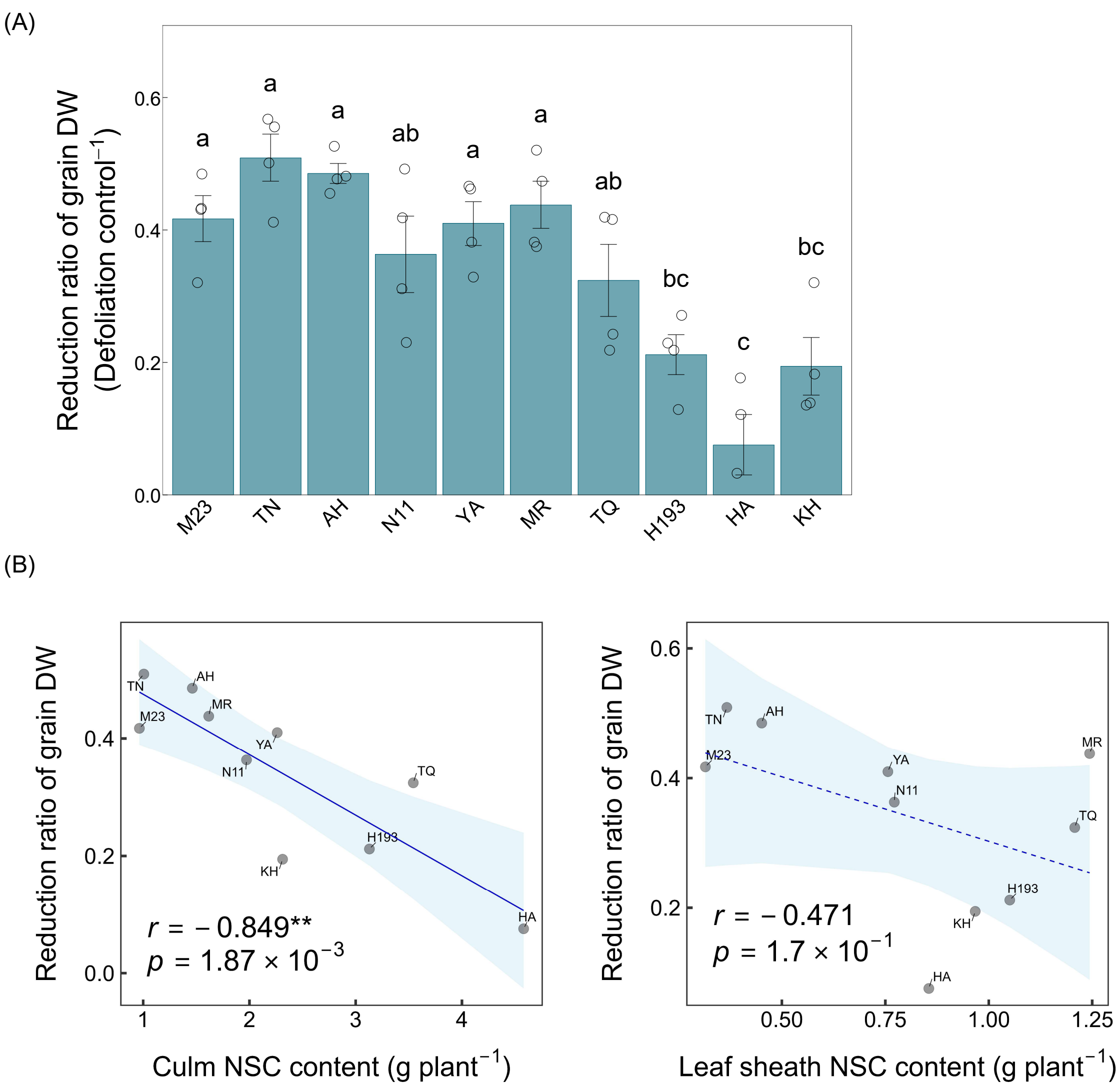

Fig. S7. Relationship between culm or leaf sheath NSC and yield reduction under defoliation. (A) Reduction ratio of grain dry weight (DW) under defoliation treatment of each cultivar. Bars show means ± SE (n=4). Different letters above bars indicate significant differences among cultivars (Tukey's HSD, $P < 0.05$). The reduction ratio was calculated as grain DW under defoliation relative to the non-defoliated control. (B) Relationships between the reduction ratio of grain DW under defoliation and NSC content at the whole-plant level in the culm (left) and the leaf sheath (right). Regression lines are shown with 95% confidence intervals (shaded). Correlation coefficients (r) and P-values are from Pearson's tests (n = 10).

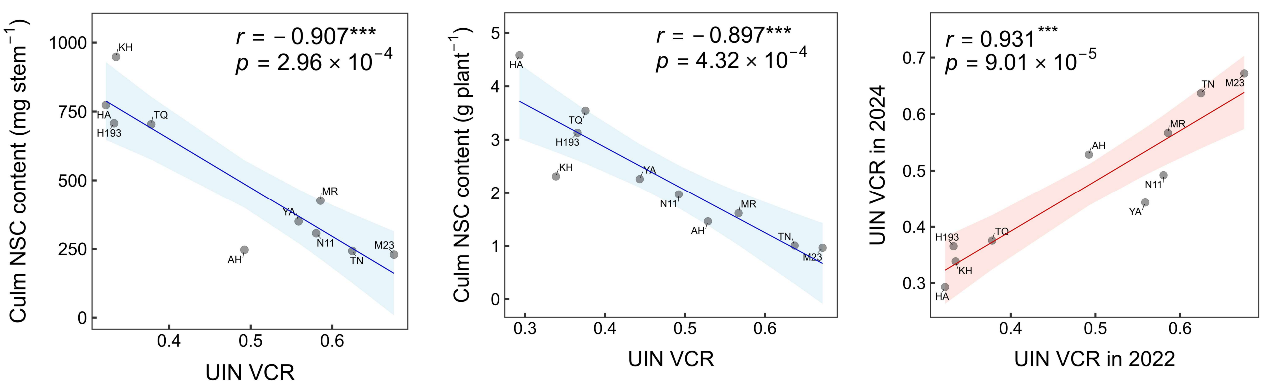

Fig. S8. Relationships between the upper internodes (UIN) VCR and culm NSC accumulation, and year-to-year reproducibility.

Relationships between UIN VCR and main culm NSC content in 2022 (left), between UIN VCR and whole-plant culm NSC content in 2024 (middle) and between UIN VCR in 2022 and 2024 (right), showing year-to-year stability. Regression lines are shown with 95% confidence intervals (shaded). Correlation coefficients (*r*) and *P*-values are from Pearson's tests ($n = 10$).

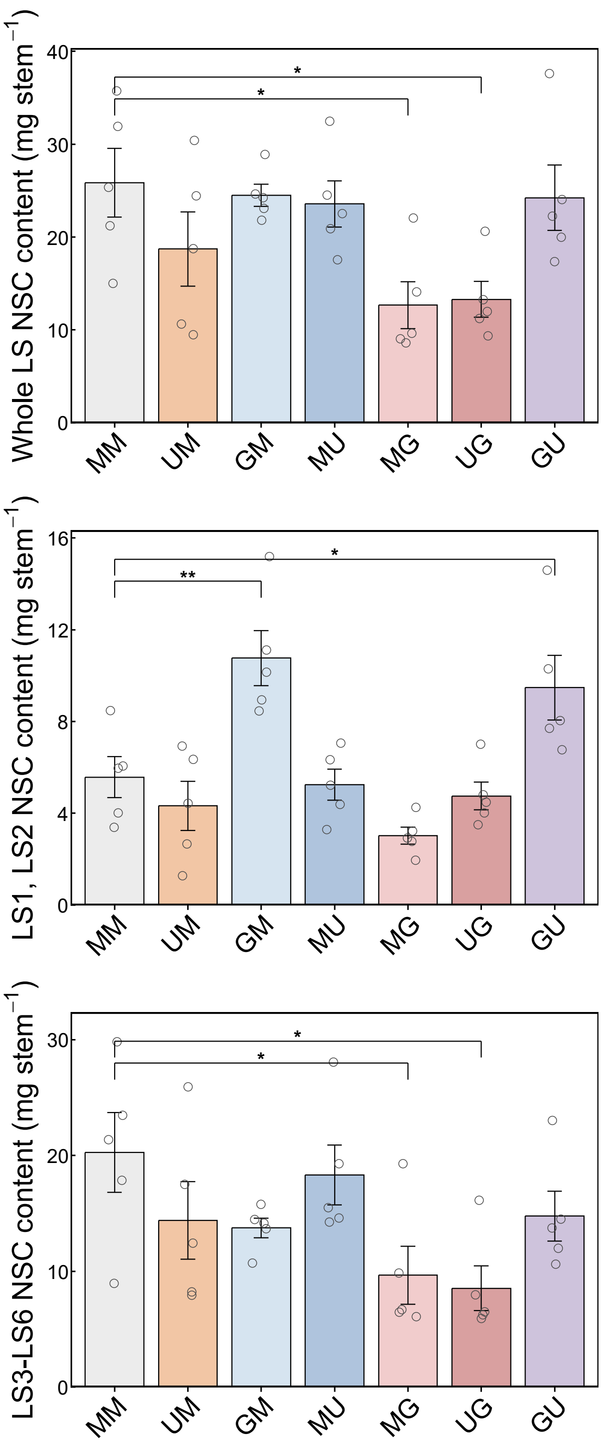

Fig. S9. Effects of internode morphological modification on leaf sheath NSC accumulation. Leaf sheath (LS) NSC content in the whole leaf sheath (LS) (top), upper leaf sheaths (LS1, LS2) (middle), and lower leaf sheaths (LS3–LS6) (bottom) under different plant growth regulator treatments. Bars show means ± SE (n = 5). Horizontal brackets indicate statistically significant differences among treatments (Dunnett vs. MM, * $P < 0.05$, ** $P < 0.01$).

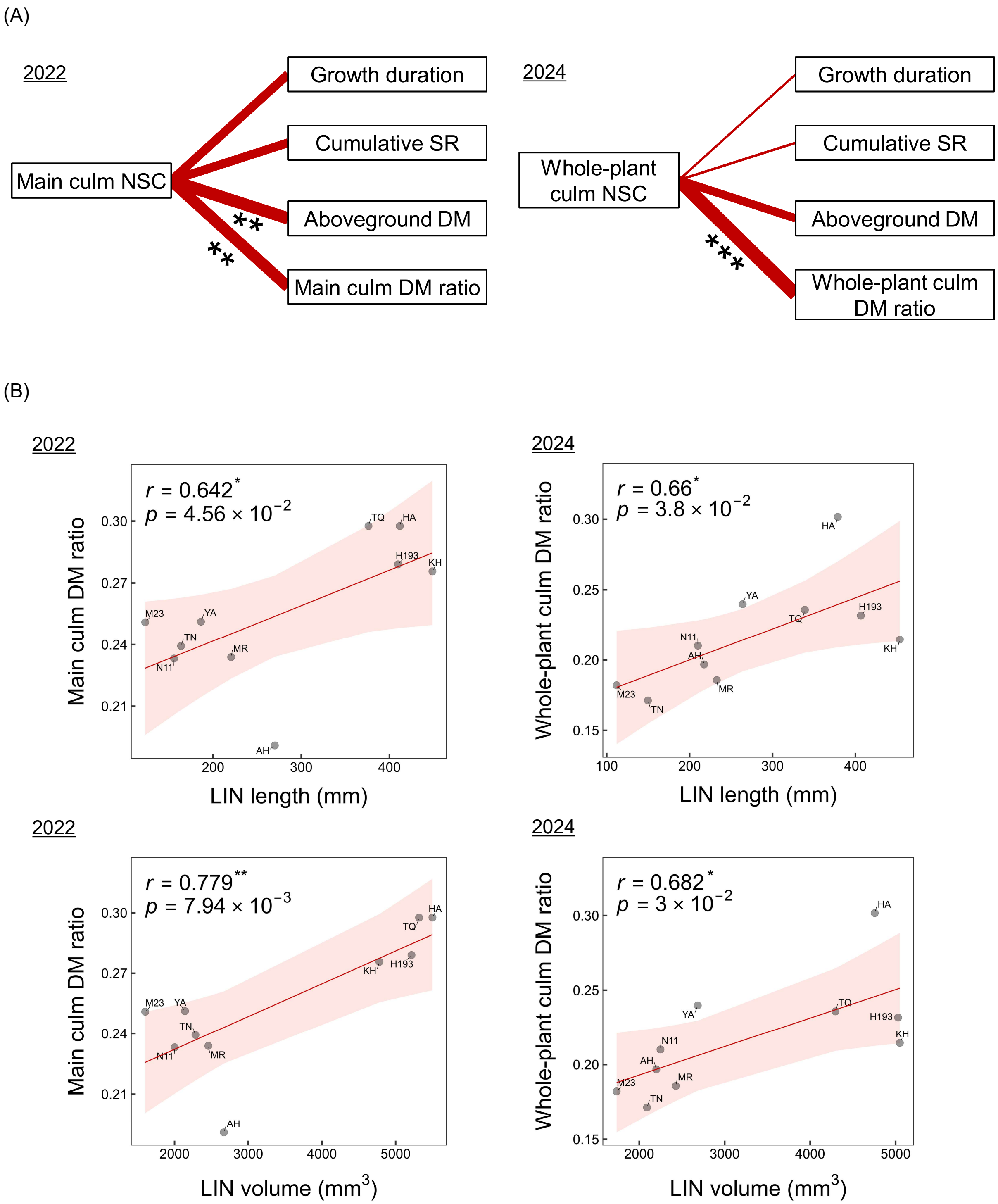

Fig. S10. Relationships between culm NSC and traits associated with growth duration or dry matter production/allocation.
(A) Correlation pathways showing the relationships of culm NSC content with growth duration, cumulative solar radiation (SR), aboveground dry matter (DM), and culm DM ratio before heading (in 2022: left) or full-heading (in 2024: right). Red line indicates positive correlations. Line thickness corresponds to correlation strength. Significance levels: ** $P < 0.01$, *** $P < 0.001$ ($n = 10$). (B) Relationships between culm DM ratio and the length (top) or volume (bottom) of LIN in 2022 (left) and 2024 (right). Regression lines are shown with 95% confidence intervals (shaded). Correlation coefficients (r) and P-values are from Pearson's tests ($n = 10$).

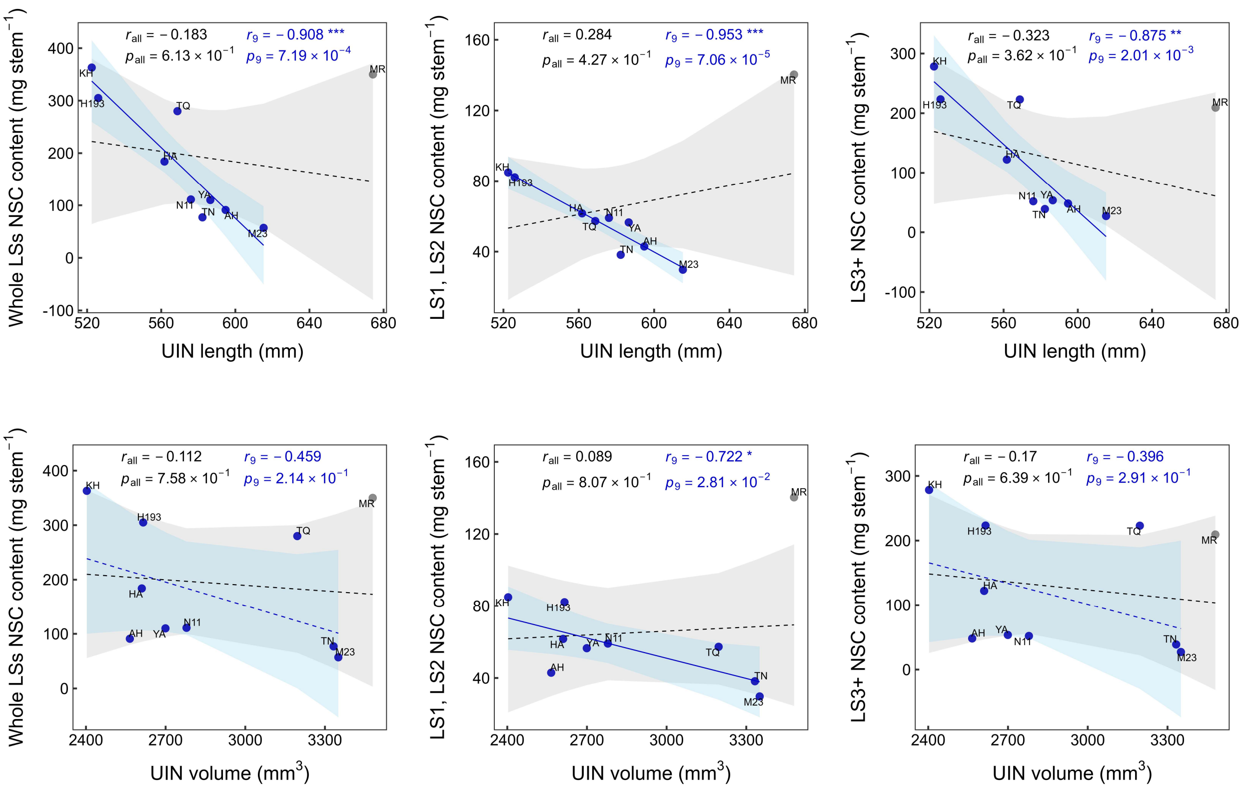

Fig. S11. Relationships between length or volume of upper internodes (UIN) and leaf sheath NSC content. Relationships between length (top) or volume (bottom) of UIN and NSC contents of the whole leaf sheaths (LS) (left), the upper leaf sheaths (LS1, LS2) (middle) and the lower leaf sheaths (LS3+) (right). Black lines and gray shaded areas indicate the regression lines and 95% confidence intervals calculated using all cultivars, whereas blue lines and shaded areas indicate those calculated using nine cultivars excluding MR. Pearson’s correlation coefficients (*r*), *P*-values, coefficients of determination (R^2), and regression equations are shown in each panel.

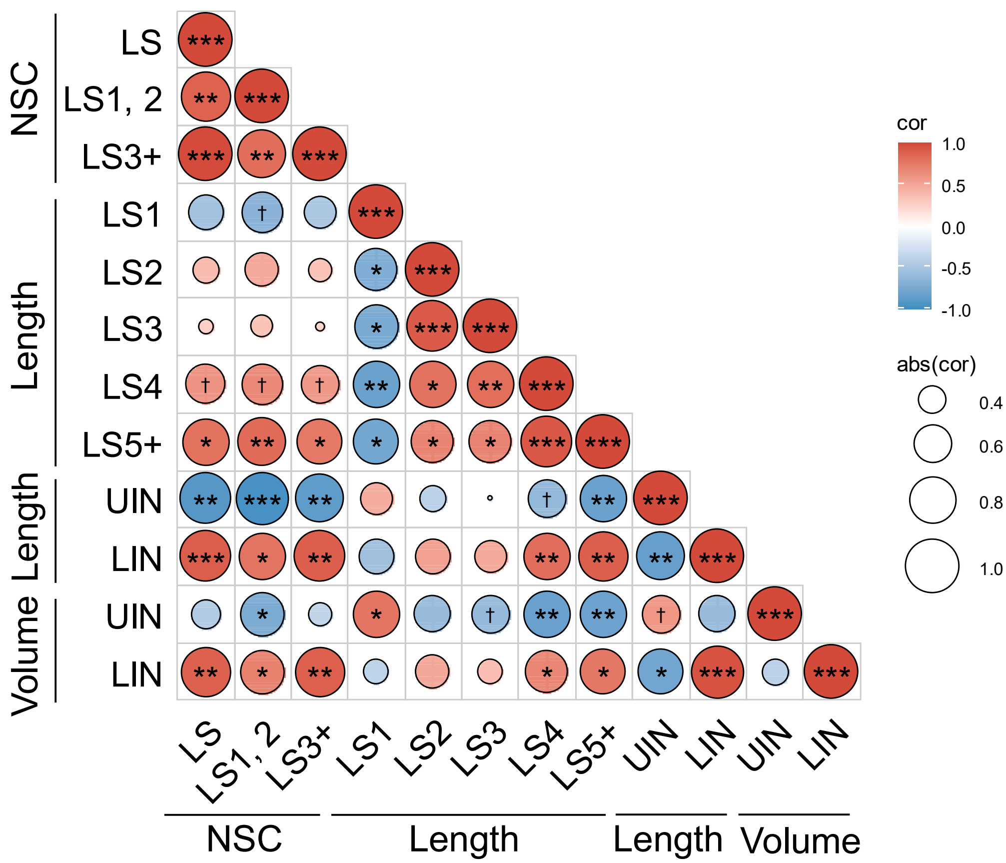

Fig. S12. Correlation matrix of leaf sheath NSC, leaf sheath length, and internode morphology in 2022.

Correlation matrix among NSC content in leaf sheaths, leaf sheath length, and morphological traits of the upper and lower internodes in 2022. Leaf sheath NSC content was evaluated for all leaf sheaths combined (LS), LS1-2, and LS3 and below (LS3+). Leaf sheath length was analyzed for individual leaf sheaths (LS1–LS4), and LS5+ represents the mean length of leaf sheaths at and below LS5. Internode morphological traits were summarized as length and volume of the upper internodes (UIN; IN1–IN2) and lower internodes (LIN; IN3–IN5+). Correlation analyses were performed using data from nine cultivars, excluding MR. Circle size and color indicate correlation strength and direction, respectively (Pearson's *r*). Significance levels: † $P < 0.10$, * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$ ($n = 9$).

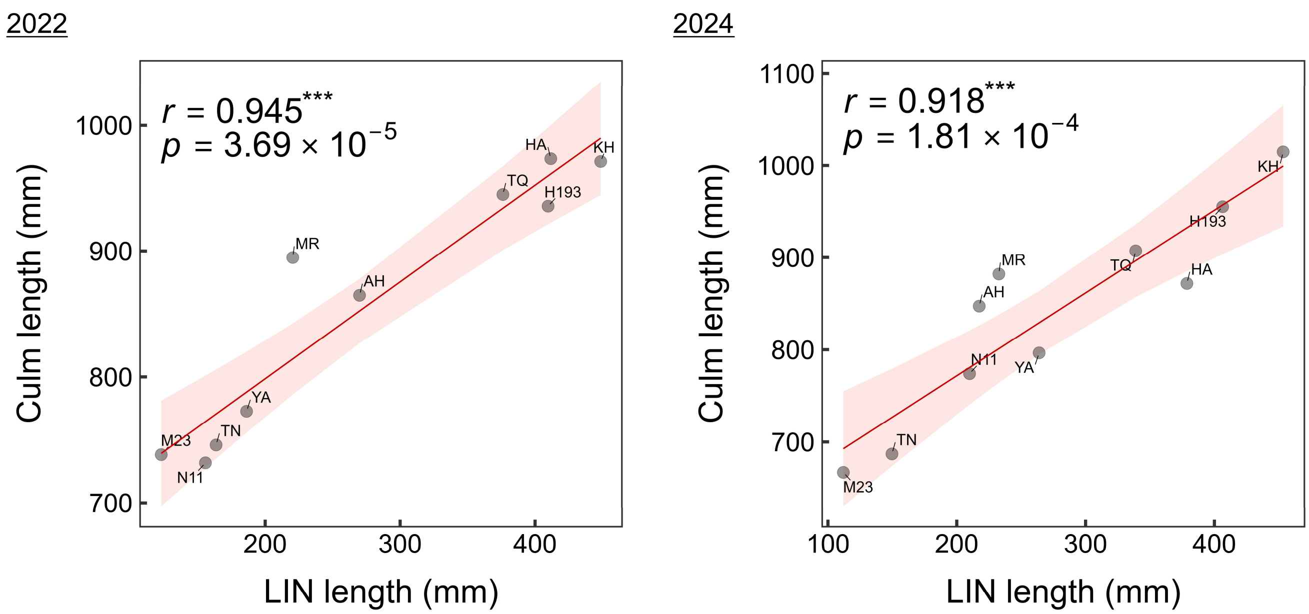

Fig. S13. Relationship between lower internode length (LIN) and culm length.
Relationships between LIN length and culm length of main stem in 2022 (left) and in 2024 (right). Regression lines are shown with 95% confidence intervals (shaded). Correlation coefficients (*r*) and *P*-values are from Pearson's tests ($n = 10$).

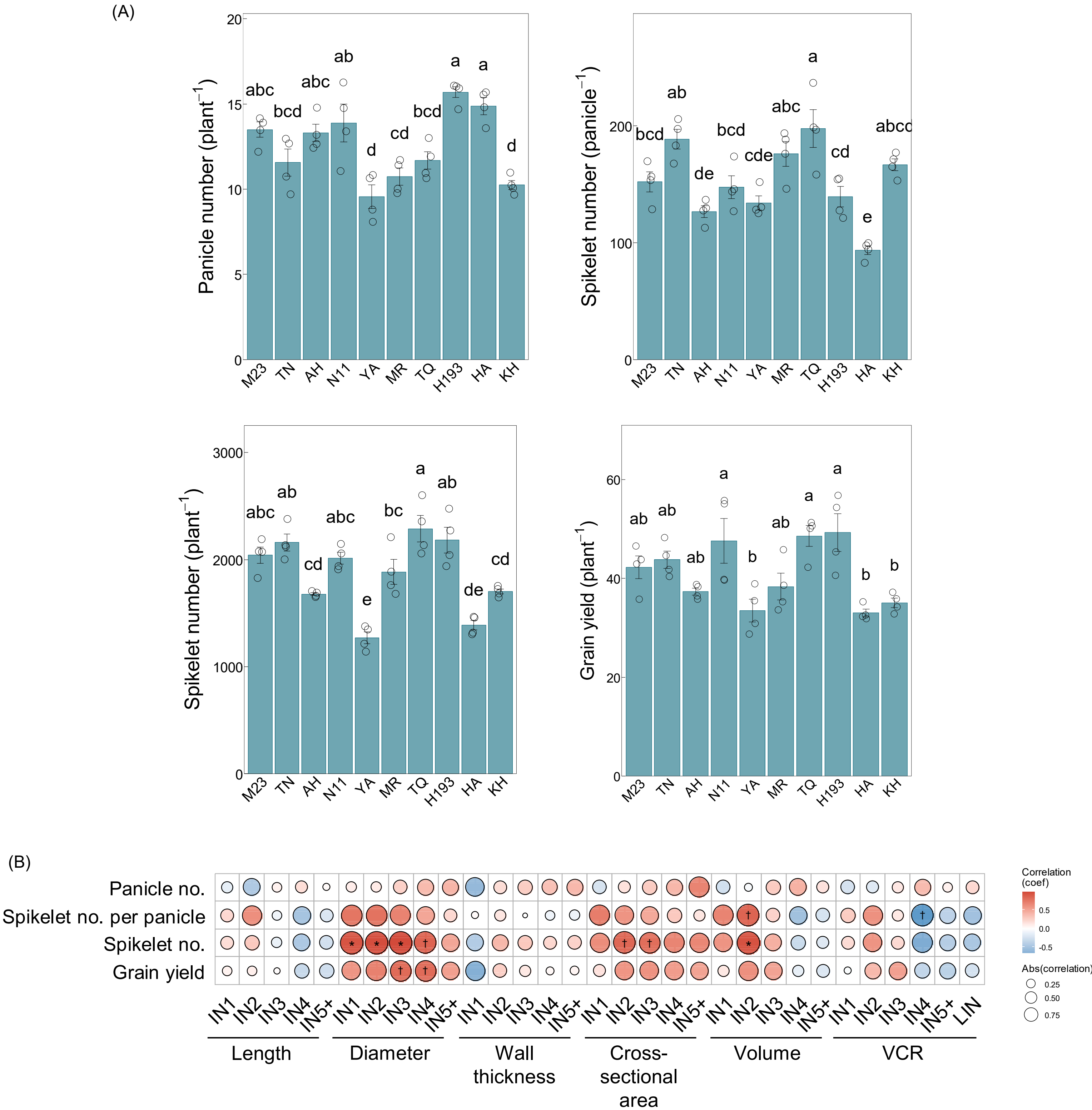

Fig. S14. Yield traits and their relationships with internode morphology in 2024.
(A) Panicle number per plant (top left), spikelet number per panicle (top right), spikelet number per plant (bottom left), and grain yield (bottom right) of each cultivar in 2024. Grain yield was adjusted to 15% moisture content. Bars show means ± SE (n=4). Different letters above bars indicate significant differences among cultivars (Tukey's HSD, $P < 0.05$). (B) Correlation matrix between yield traits and internode morphological traits (length, diameter, wall thickness, cross-sectional area, volume, and VCR). Circle size and color indicate correlation strength and direction, respectively (Pearson's r). Significance levels: † $P < 0.10$, * $P < 0.05$ ($n = 10$).