

Supplementary Materials:

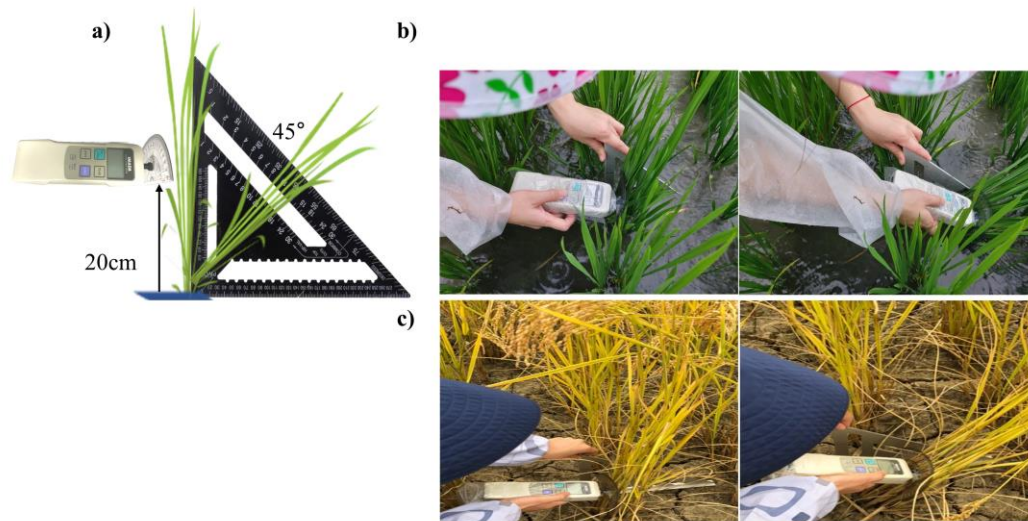


Figure S1. Measurement of pushing strength of the lower stem before heading date and after 45 days of heading date (a) pushing strength of the lower stem was measured when the plants were pushed to an angle of 45° from the vertical direction; (b) measurement of the pushing strength of the lower stem before heading date; (c) measurement of the pushing strength of the lower stem after 45 days of heading date.

Table S1. Pushing strength of the lower stem (After 45 days of the heading date), pushing strength of the lower stem (Before heading date) and yield of 120 Cheongcheong/Nagdong double haploid (CNDH) population.

Plant Traits	Year	Parents		DH Population
		Cheongcheong	Nagdong	
Pushing strength of the lower stem (kgf) (After heading date)	2018	1.25±0.11	0.75±0.11	1.10±0.32
	2019	1.09±0.11	0.58±0.13	0.90±0.23
	2020	1.09±0.09	0.57±0.10	0.89±0.21
Pushing strength of the lower stem (kgf) (Before heading date)	2018	0.92±0.12	0.29±0.05	0.64±0.19
	2019	0.93±0.06	0.39±0.03	0.67±0.19
	2020	0.94±0.03	0.40±0.05	0.72±0.20
Yield (kg/10a)	2018	672.40	362.10	313.00
	2019	692.30	339.60	353.90
	2020	712.20	317.10	394.90

Data are presented as mean ± standard deviation

Table S2. QTL related to the pushing strength of the lower stem of the CNDH population

Characteristics	Year	Locus	Chromosome	Interval Markers ^a	LOD	Add. Effect ^b	R ² ^c	Increasing effects ^d
Pushing strength of the lower stem (After heading date)	2018	qPSLSA1	1	RM3412-RM1287	3.14	0.11	0.34	Cheongcheong
		qPSLSA6	6	RM439-RM20318	3.43	0.14	0.40	Cheongcheong
	2019	qPSLSA5	5	RM18130-RM3381	5.23	0.08	0.32	Cheongcheong
		qPSLSA6-1	6	RM439-RM20318	3.02	0.08	0.46	Cheongcheong
	2020	qPSLSA6-2	6	RM439-RM20318	3.23	0.09	0.42	Cheongcheong
		qPSLSA8	8	RM6999-RM22334	3.02	0.07	0.31	Cheongcheong
Pushing strength of the lower stem (Before heading date)	2018	qPSLSB5-1	5	RM5311-RM4691	3.67	0.07	0.33	Cheongcheong
		qPSLSB6-3	6	RM3343-RM20318	4.43	0.07	0.30	Cheongcheong
	2019	qPSLSB5-2	5	RM5311-RM440	3.12	0.06	0.36	Cheongcheong
		qPSLSB6-4	6	RM3343-RM20318	3.83	0.06	0.33	Cheongcheong
		qPSLSB9	9	RM24288-RM1896	4.40	0.09	0.35	Cheongcheong
	2020	qPSLSB5-3	5	RM5311-RM440	3.35	0.06	0.35	Cheongcheong
		qPSLSB6-5	6	RM439-RM20318	3.13	0.06	0.33	Cheongcheong
		qPSLSB7	7	RM21527-RM21438	3.47	0.06	0.34	Cheongcheong
		qPSLSB9-1	9	RM24288-RM1896	3.61	0.08	0.34	Cheongcheong

PSLSA: Pushing strength of the lower stem after 45 days of heading date; PSLSB: Pushing strength of the lower stem before heading date; ^a Interval Marker are those within the significance threshold on each border of the QTL range. ^b Additive effect. ^c Phenotypic variation explains each QTL. ^d Increase allele is the source of the allele causing an increase in the measured trait.