

Supplementary material

Development of a transplanter-based transplanter for vegetable seedlings cultured in a cuttable nursery mat

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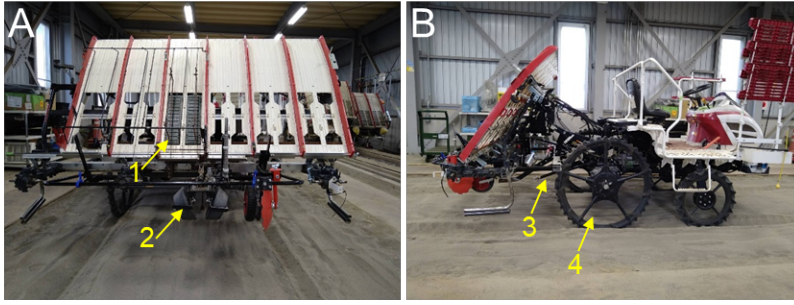


Figure S1. Pictures of the single-row prototype developed in this study. The rear wheels were the same as those in YR6D. Seedling tray with equipping bars (1), soil covering wheels (2), height sensor (3), and rear wheel (4).

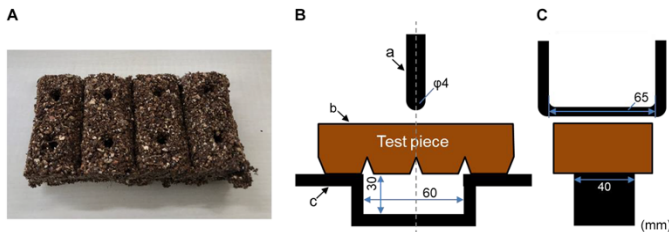


Figure S2. (A) Cuttable nursery mat (CNM) test piece and (B and C) CNM stiffness test: Fixture to compress a test piece (a), test piece (b), and plate (c), respectively.

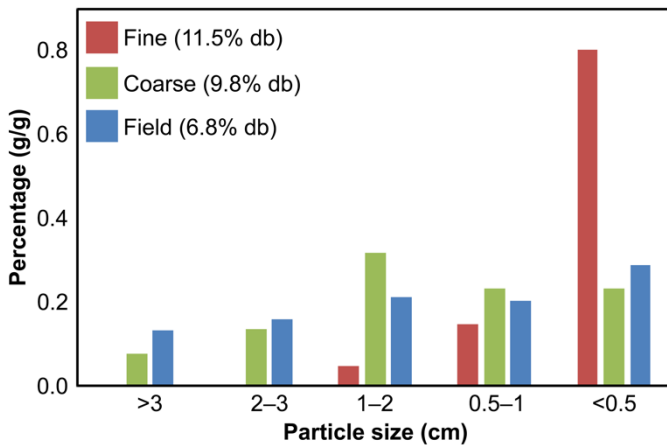


Figure S3. Soil particle size distribution. Two texture types of soil, fine and coarse soil.

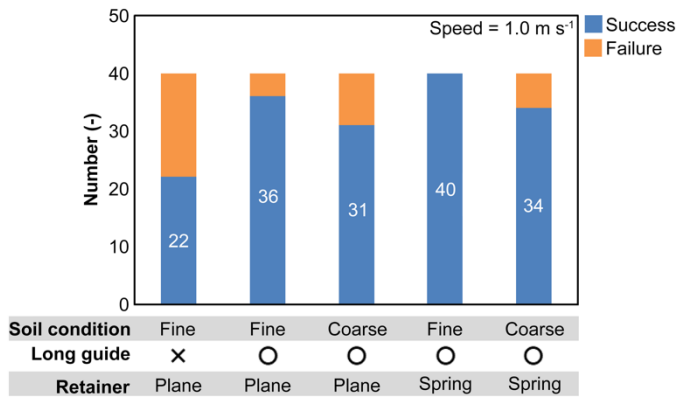


Figure S4. Effect of a long guide and retainers on transplanting CNM seedlings (CNMS) in different soil texture types. The block lacking seedlings was ignored.

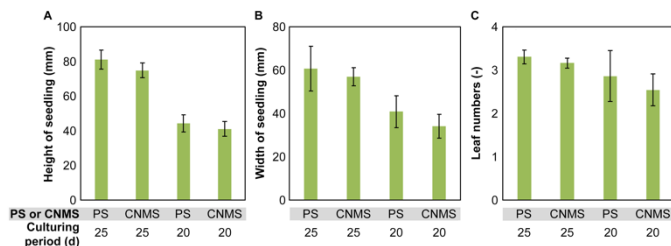


Figure S5. Characteristics of CNMS and plug seedlings (PS) transplanted in the field: (A) Height, (B) width, and (C) leaf numbers. The bar and the error bar indicate the average and standard deviation, respectively.

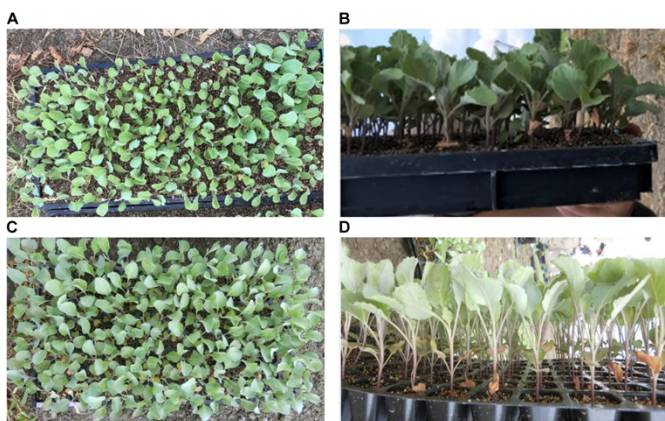


Figure S6. (A and B) CNMS and (C and D) PS cultured for transplanting and cultivating on the field. Seedlings were cultured for 25 days.

Table S1. Specifications of manufactured fully automatic transplanters.

No.	1	2	3	4	5	6	7
Catalog number	Our study	TRE 140	FUT 6017	KMR-2	PW20RA	SKP-200	YR6DA
Company	-	Hortech S.r.l.	Ferrari growtech S.r.l.	TTSB.V.	Yanmar Agribusiness co. ltd	Kubota co.	Yanmar Agribusiness co. ltd
Country	-	Italy	Italy	Netherlands	Japan	Japan	Japan
Planting system	Cutting and transplanting CNMS with an end-effector on transplanting arm rotated by a planetary gear mechanism	Feeding PSs with belts and separating them with a pneumatic device, and dropping it onto a field	Extracting PSs with cylindrical plungers combined with moving fingers from trays, and dropping it onto a field	Picking up PSs from trays and dropping it onto a field	Picking up PSs from trays and dropping it onto a field	Picking up PSs from trays and dropping it onto a field	Cutting and transplanting seedlings with an end-effector on transplanting arm rotated by a planetary gear mechanism
Planting speed (plants/min/row)	250	83.3	150	100	115	132	854
Maximum planting speed (m/s)	1.0	-	-	-	0.5	0.55	1.85
Minimum hill distance (m)	0.24	0.18	0.25	0.15	0.26	0.25	0.13
Maximum number of rows (-)	^a 4	4	12	8	2	2	6
Mass (kg)	^d 807	600	>1,250	-	639	685	807
Is tractor required?	no	yes	^b yes	yes	no	no	no
Tractor power required (HP)	-	60	70	-	-	-	-
^c List price (\$)	^d 21,410	-	^e 63,680	-	20,083	21,204	21,410
Main adaptable plants	Cabbage	Leaf vegetables	Tomato, Celery, Pepper, Fennel, and Brassicas	Lettuce, Tomato, Broccoli, and Cabbage	Cabbage, Chinese cabbage, and Italian broccoli	Cabbage, Chinese cabbage, and Italian broccoli	Rice
Seedlings type	CNMS	Seedlings cultured with soil block	PS	PS	PS	PS	Mat seedlings

^aThe prototype was a single-row transplanter but the row number could be increased to ≥ 4 ; ^bThis machine has a self-propelled version; ^cThe exchange rate was calculated as 1 US\$ = 145.4 yen; ^dYR6D estimation; ^eWe referred to the list price of Elite Metal Tools.

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