No. A-9-1E

PJ : Agrobiotechnological Direct Air Capture towards Carbon Circulation Society

Theme: DAC agriculture

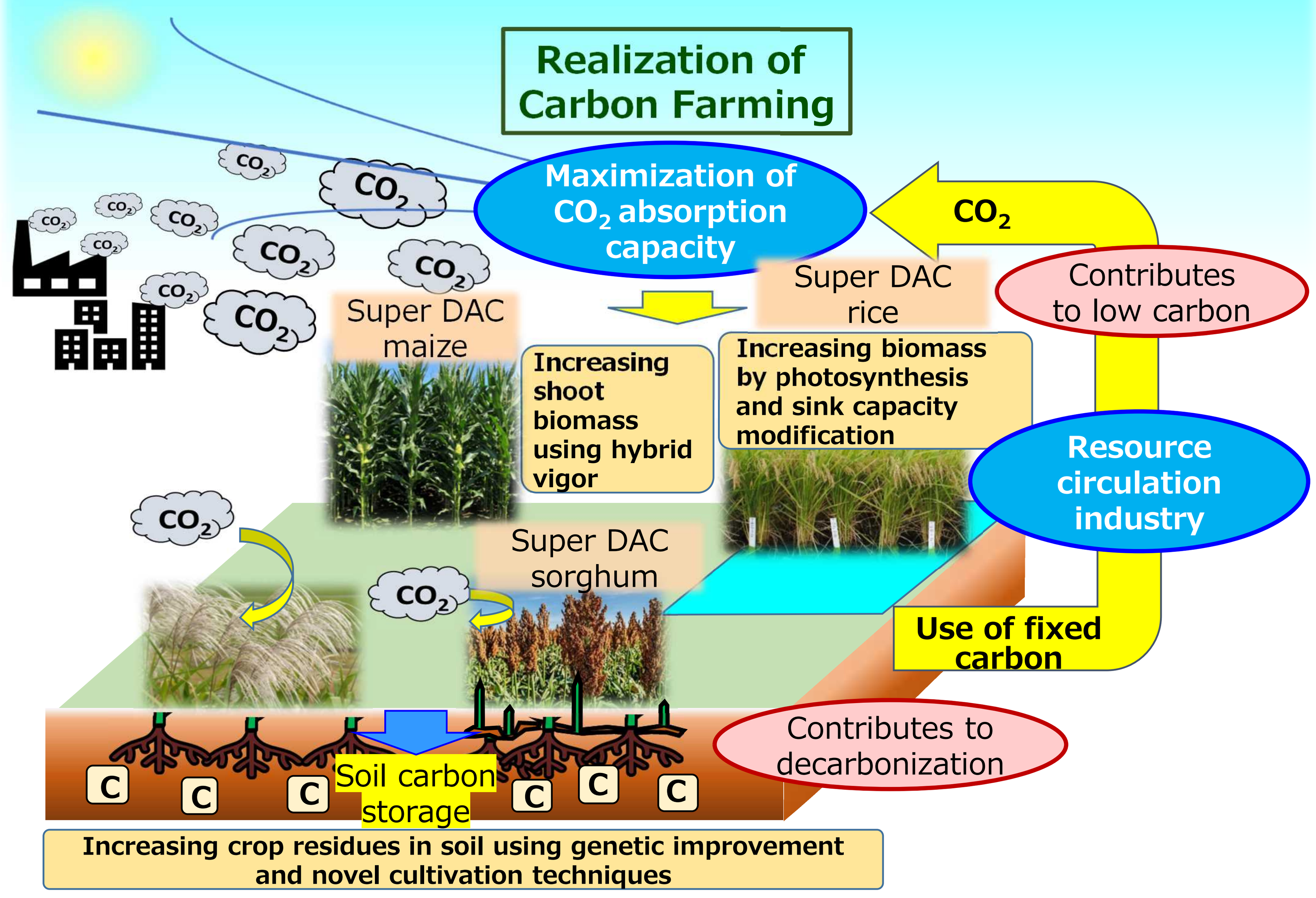
Organization: National Agriculture and Food Research Organization (NARO), Tokyo Univ. Agr. Tech., Nagoya Univ., Univ. Tokyo, Okayama Univ., Shinshu Univ., Univ. Shiga Pref., Saitama Univ.)

Contact: PM:YANO Masahiro e-mail: myano@affrc.go.jp

OUTLINE

Design and evaluation of "super DAC crop" by modifications and optimization of allelic combinations of genes related to CO_2 absorption/fixation and biomass production capacity. Development of techniques to assess the decomposition and carbon dynamics of crop residues in soil. Economic value and life cycle assessments of carbon circulation from crop production to recovery and utilization of valuables.

Image of DAC agriculture in 2050

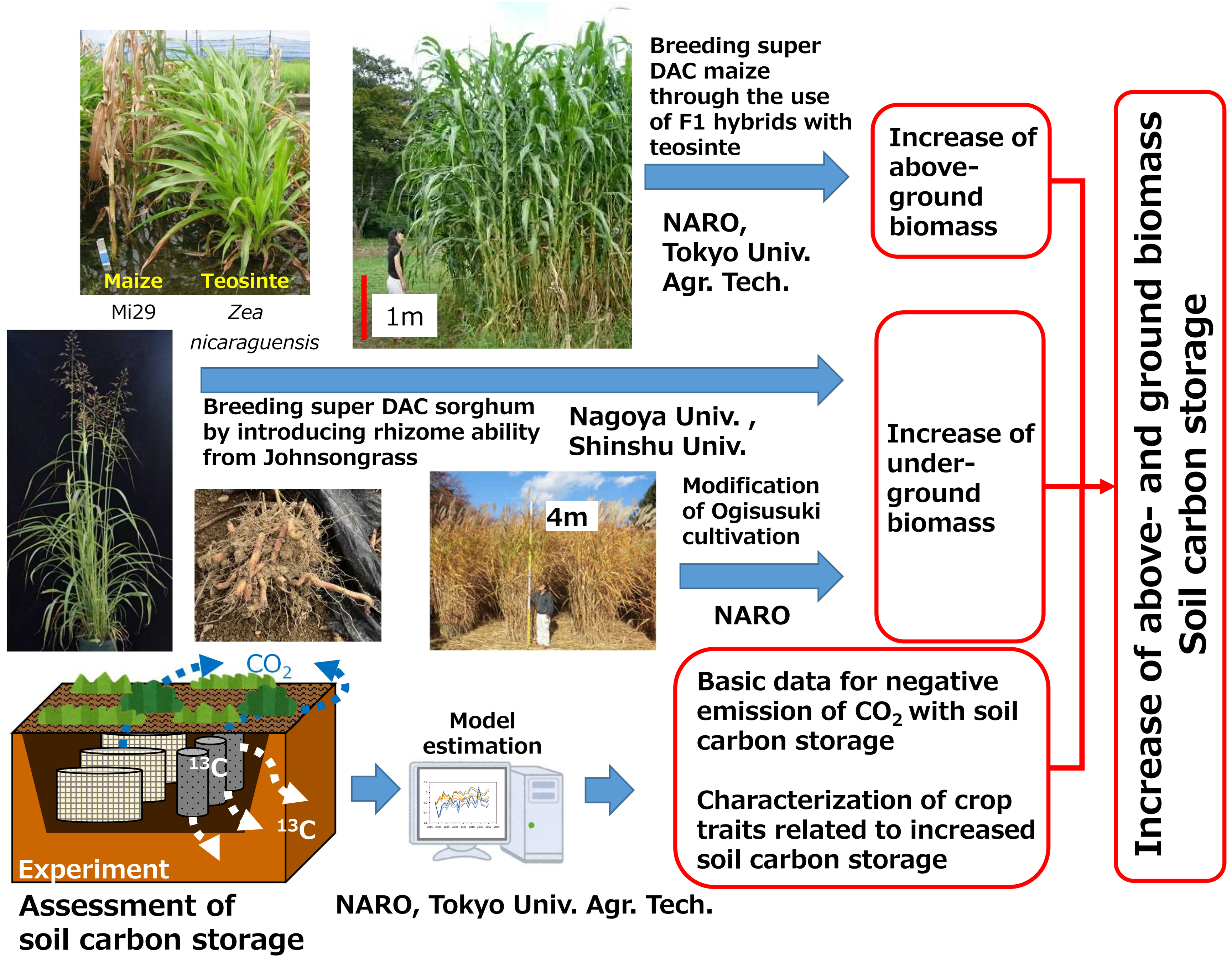


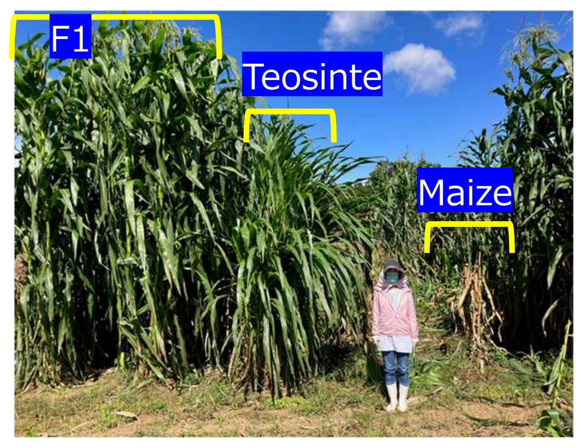
Challenges, Goals, and Research theme

Technical challenges	Achievement goal (Year 2030)	Research theme
Doubling CO_2 fixation ability of crops 1	Development of Super DAC crops Rice grain : 50%↑ Maize shoot : 100%↑	Theme I Development of Super DAC Rice by increasing CO_2 absorption/ fixation ability Theme II Research on carbon fixation by increasing crop biomass
Biomass storage in soil 2	Increase in underground biomass and soil carbon assessment. Sorghum root, rhizome : 100%↑	Theme II Research on carbon fixation by increasing crop biomass
Circular utilization of above-ground biomass 3	Research and analysis of breakthrough(s) in resource circulation by Super DAC crops	Theme Ⅲ : Economic value and life cycle assessments of processes for resource utilization in DAC agriculture

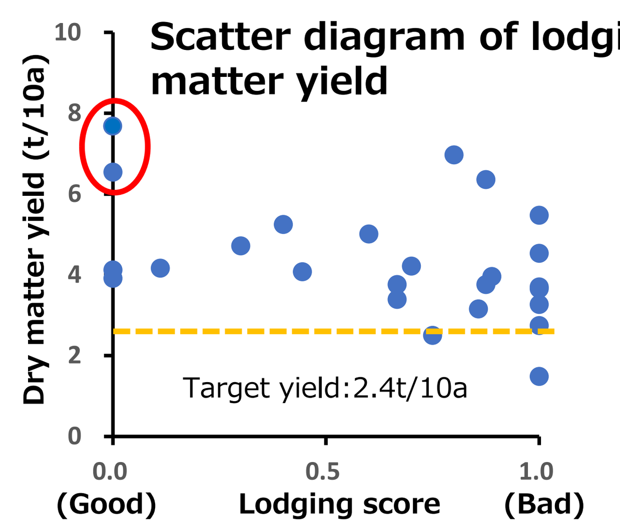
Representative institution : National Agriculture and Food Research Organization (NARO)
Participating institutions:
Theme I (Tokyo Univ. Agr. Tech., NARO, Nagoya Univ., Univ. Tokyo, Okayama Univ.)
Theme Ⅱ (NARO, Nagoya Univ., Tokyo Univ. Agr. Tech., Shinshu Univ.)
Theme Ⅲ (NARO, Univ. Tokyo, Univ. Shiga Pref., Saitama Univ.)

Theme II. Research on carbon fixation by increasing crop biomass



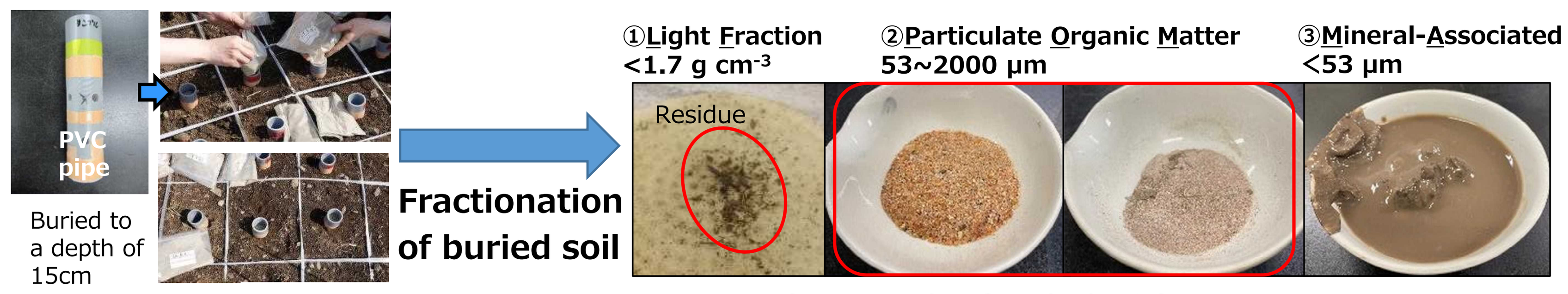


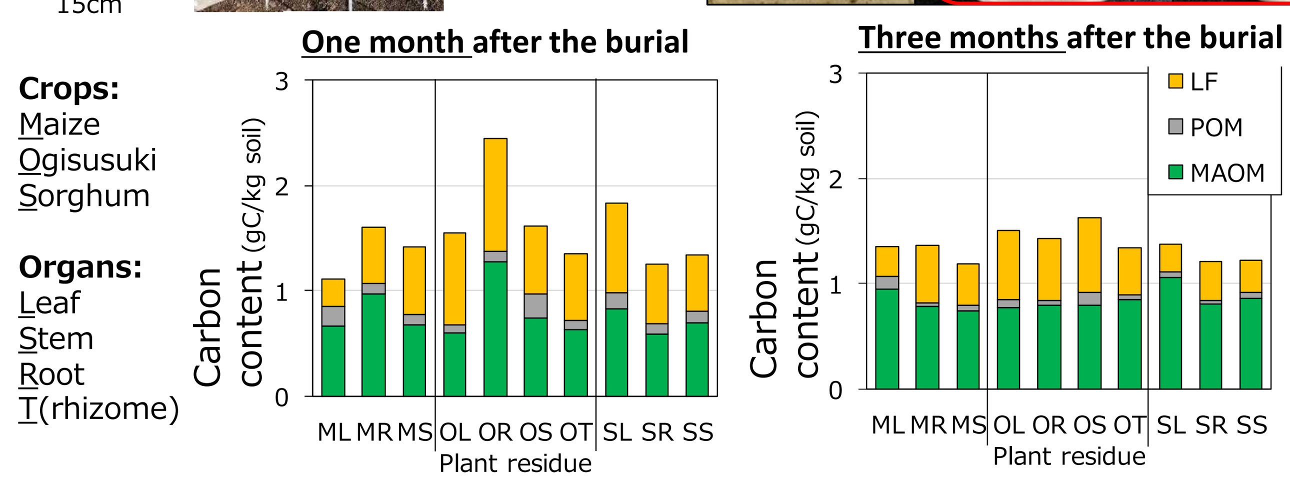
Field test for Super DAC maize



・Target yield of 2.4 t/10a was achieved in many lines.

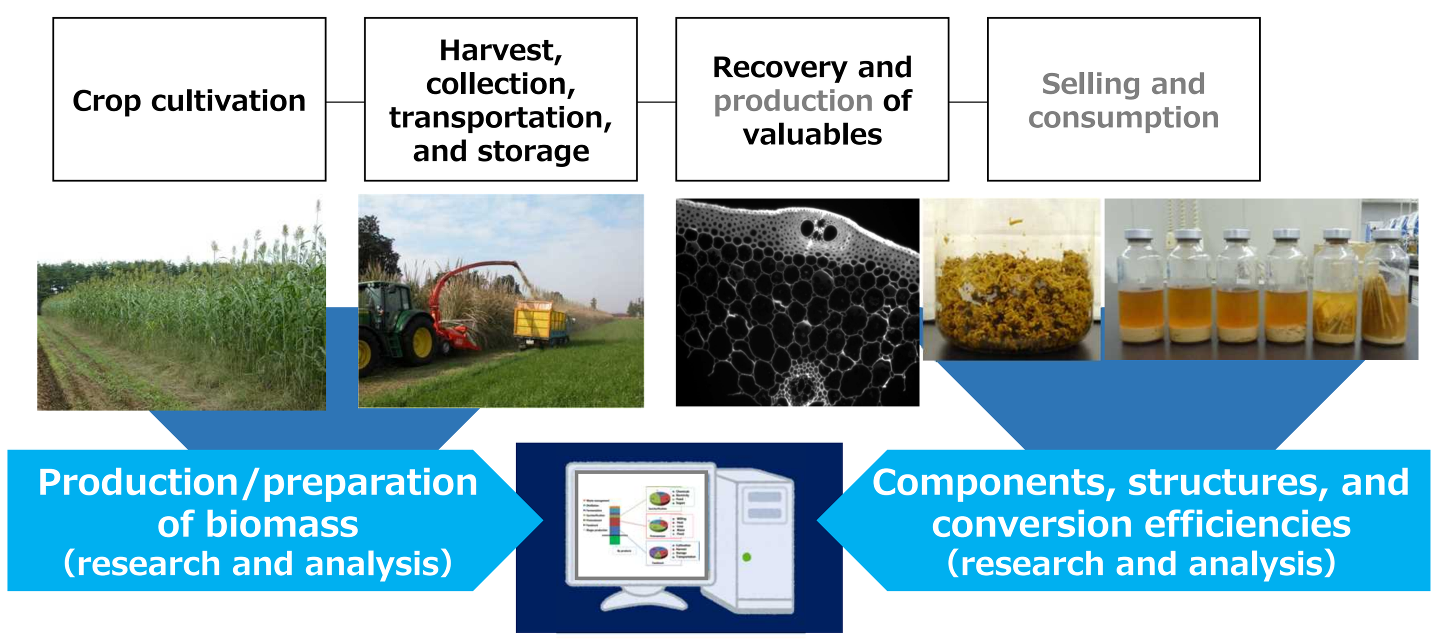
・High-yielding with lodging-resistant lines (red circles)





Organic carbons in the degradable fraction (LF) were decreased for all residues and some of them were transferred to the stable soil fraction (MAOM).

Theme III. Economic value and life cycle assessments of processes Research and analysis for scenario proposal



2022-2024 : FS stage

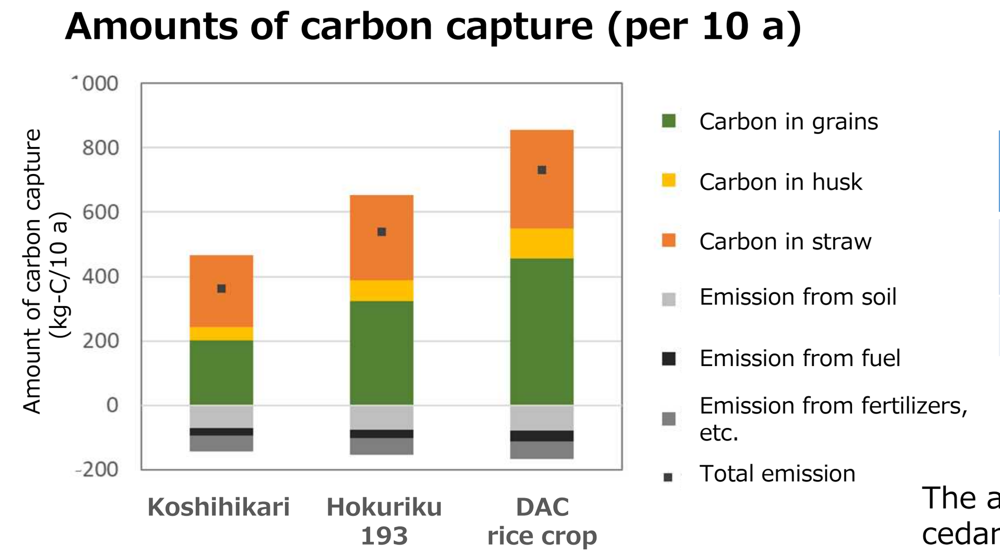
Evaluation of material characteristics and conversion properties of crop biomass
Proposal of scenarios for foundation of novel businesses by resource circulation

2025-2030 : Full project

Demonstration of technologies for utilization of resources from Super DAC crops

DAC ability of Super DAC rice crop

Amounts of carbon capture (per 10 a)



Values of biomass recoveries used for calculation

	Koshi hikari	Hokuriku 193	DAC rice crop
Seeds (Grains)	636 (530)	1020 (850)	1440 (1200)
Straw	700	830	960

kg/10a、moisture content of 15%

The amount of absorbed CO_2 by 36- to 40-year-old cedar plantation per hectare is estimated to be approximately 8.8 t per year.
(https://www.rinya.maff.go.jp/j/sin_riyou/ondanka/20141113_topics2_2.html)

Amounts of CO_2 capture (per hectare)

CO_2 Capture (t/ha)	11.7	18.3	25.3

7 t-CO_2/ha

Further strengthening the advantage of grass !

Super DAC rice crop is expected to capture **25.3 t/ha of CO_2.**

No. A-9-2E

PJ : Agrobiotechnological Direct Air Capture Towards Carbon Circulation Society

Theme: Development of Super DAC Rice with Enhanced CO_2 Absorption and Fixation Capacity（Theme I)

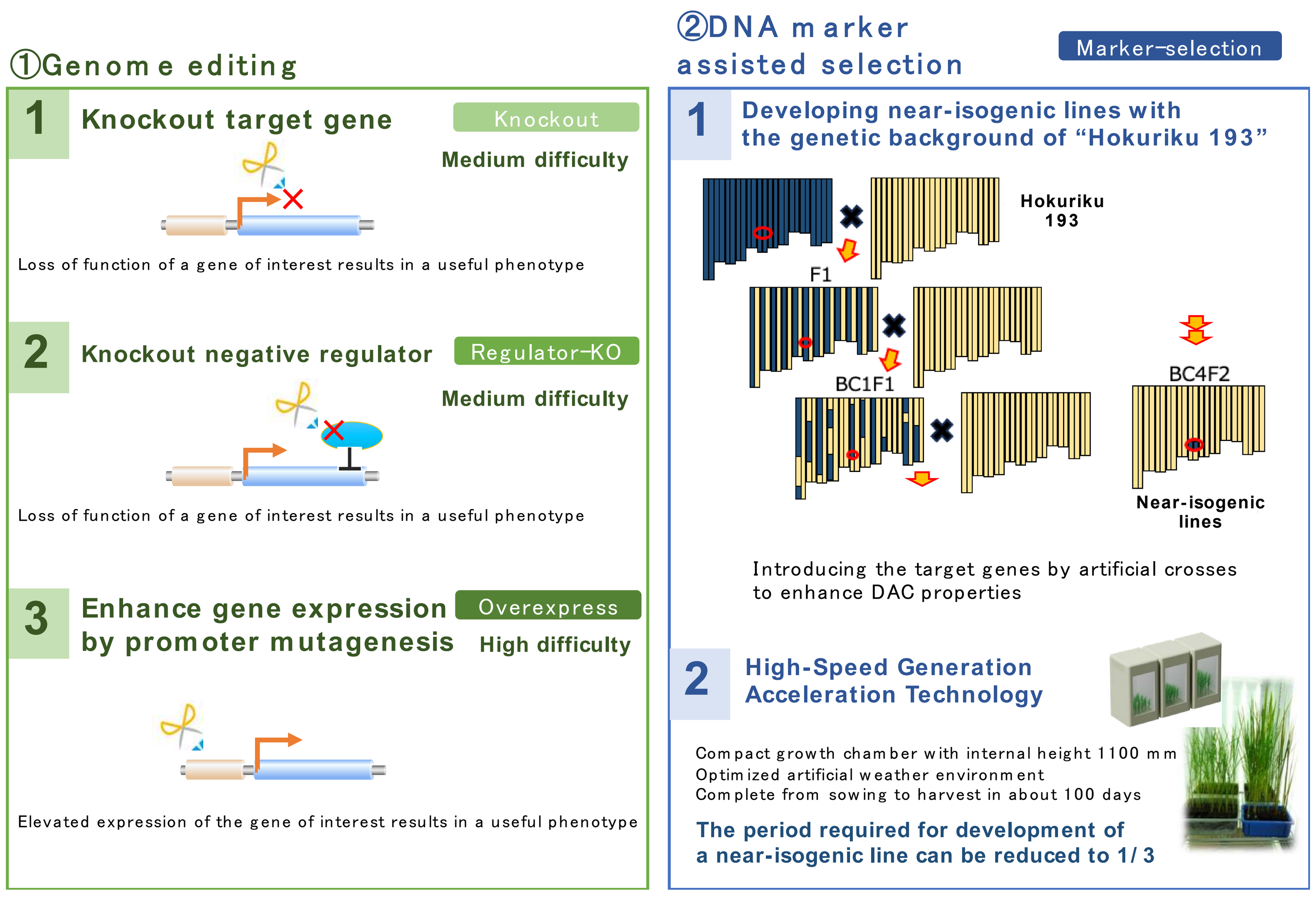
Organization: NARO, TUAT, Nagoya Univ, Tokyo Univ, Okayama Univ

Contact: Shunsuke Adachi（TUAT）e-mail: adachi@go.tuat.ac.jp

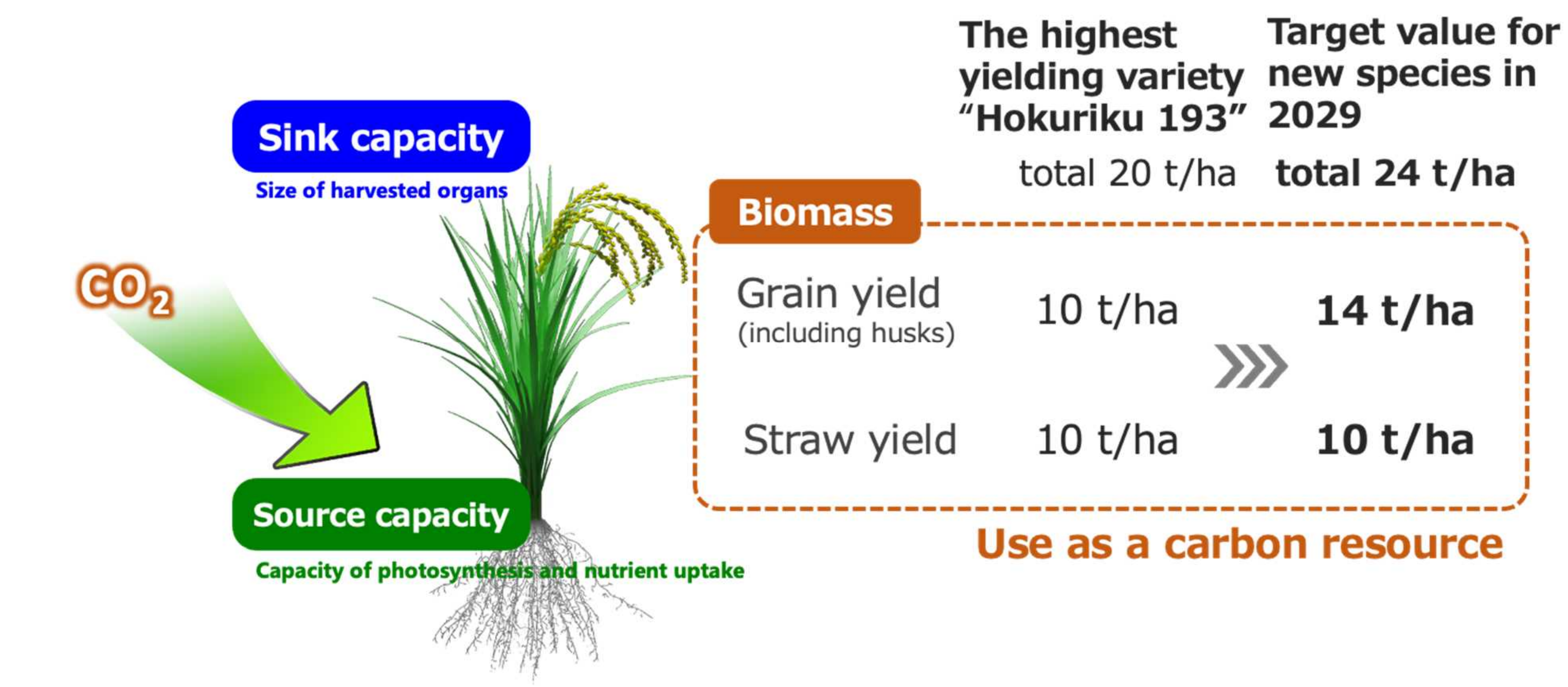
Research outline

We aim to develop “Super DAC rice”, which has extremely high CO_2 absorption and fixation capacity. To achieve this, we will make gene modifications using genome-editing technology, with particular attention to genes related to the photosynthetic capacity of leaves, nutrient absorption capacity of roots, and sink capacity determined by the number and size of seeds.

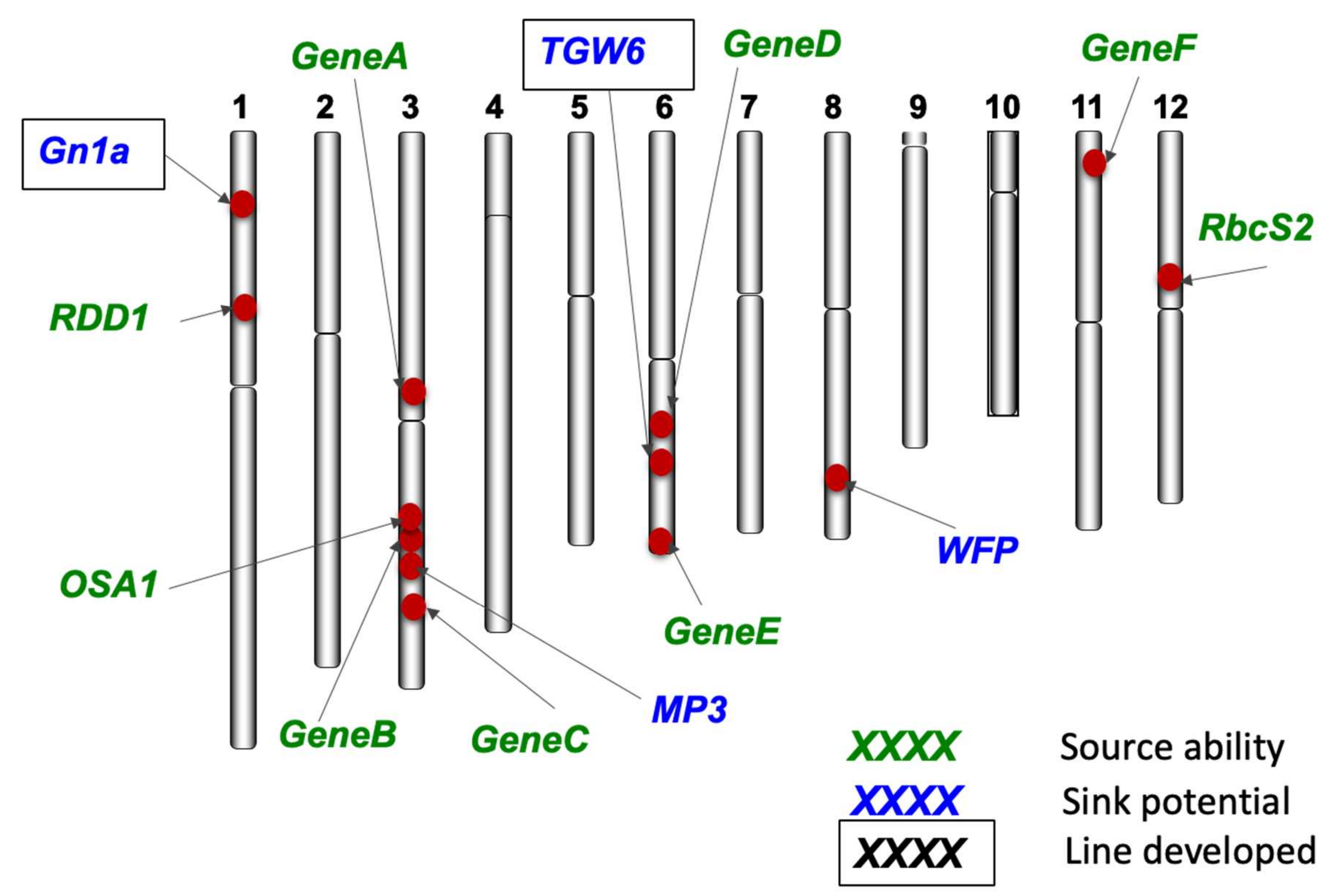
Two approaches for development of super DAC rice



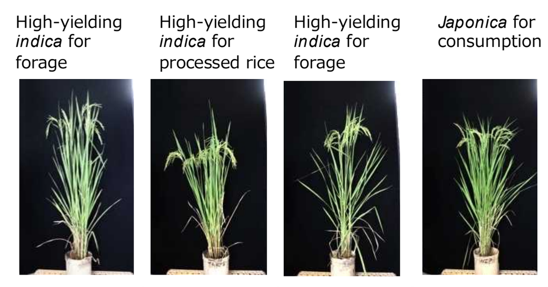
Development goals of super DAC rice



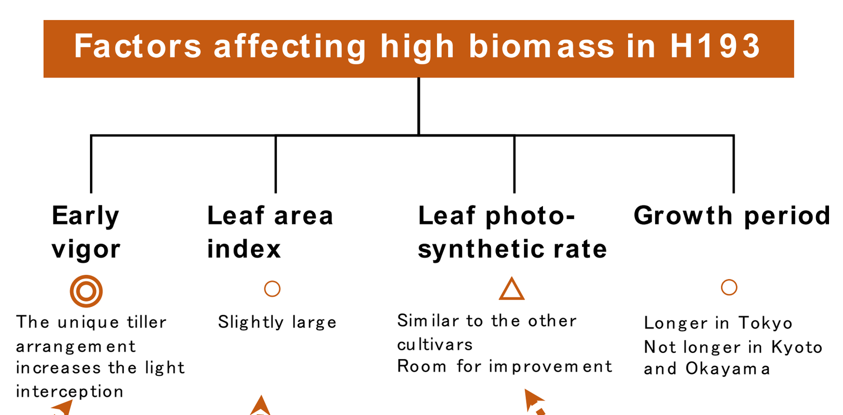
List of genes subject to modification

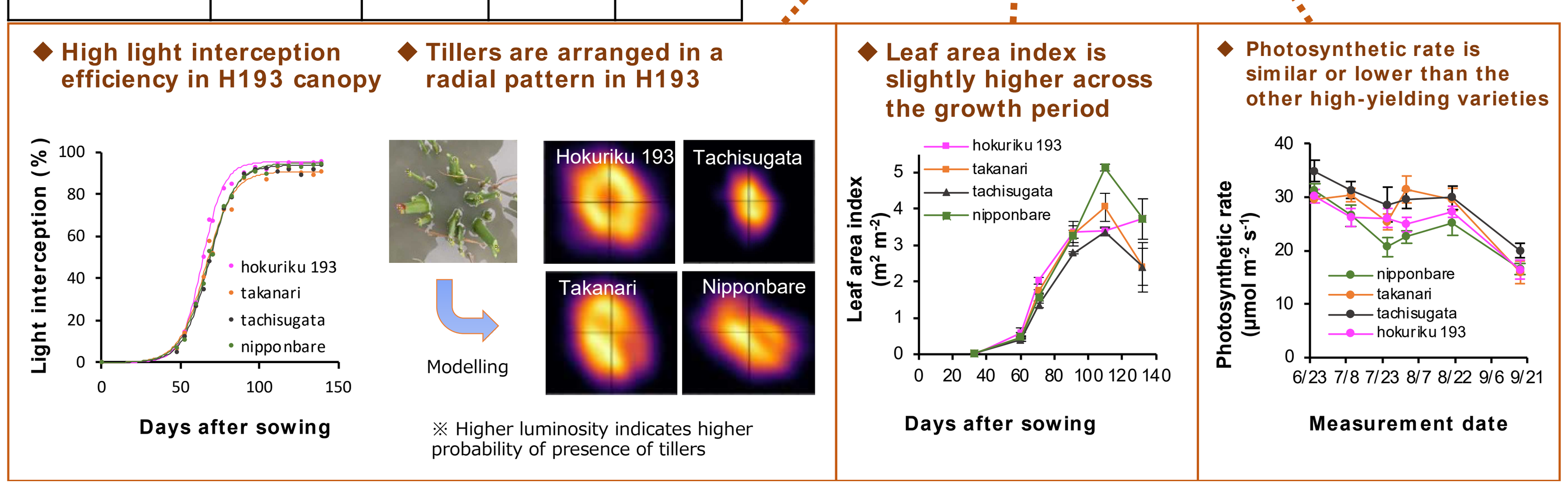


DAC properties of “Hokuriku 193”

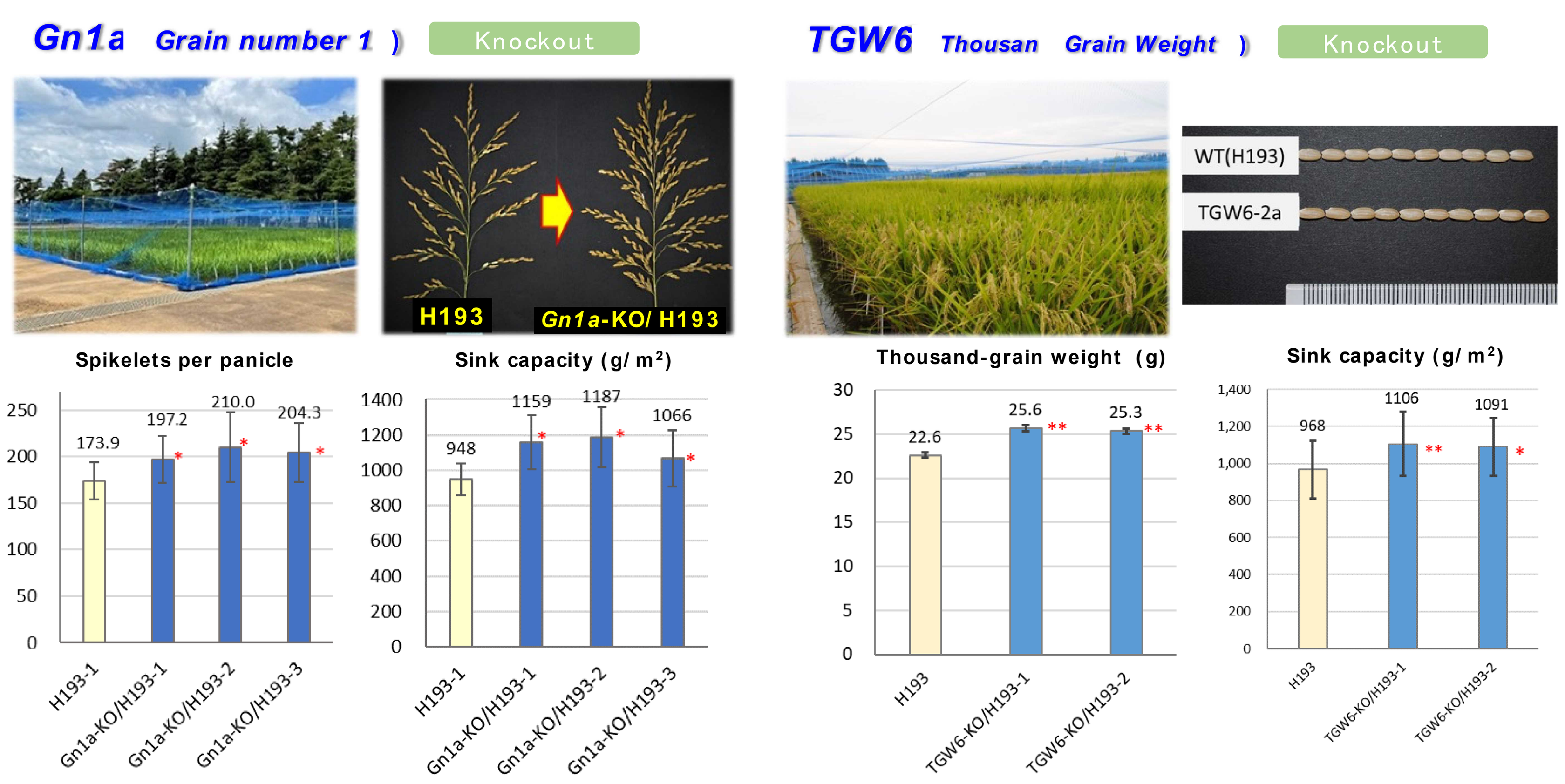


Biomass (t ha⁻¹)	Hokuriku 193	Takanari	Tachi-sugata	Nippon-bare
Tokyo in 2022	19.1	17.2	15.6	15.4
Kyoto in 2022	15.1	12.4	11.2	13.4
Tokyo in 2023	18.9	16.0	15.2	14.8
Okayama in 2023	15.5	12.0	11.3	11.9





Improvement of sink capacity（*Gn1a*, *TGW6*)

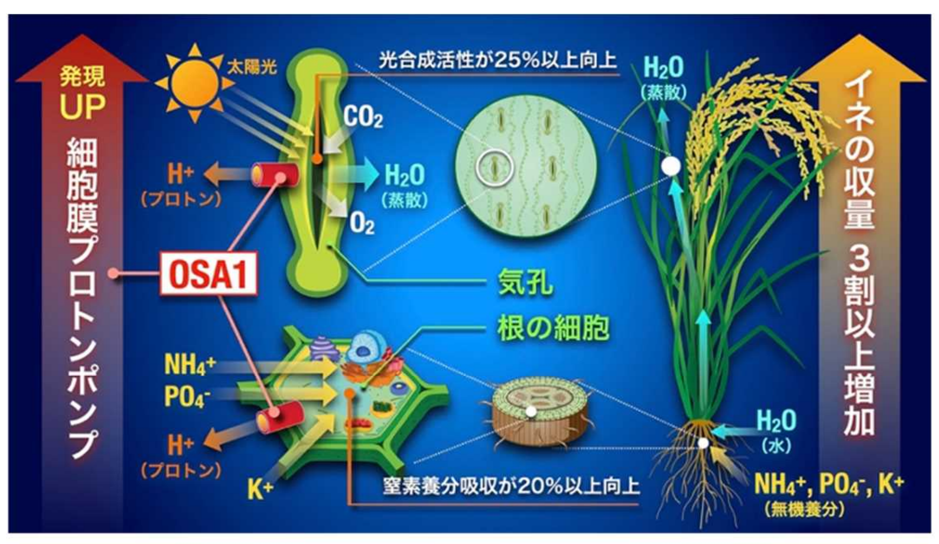


✓ *Gn1a*-KO genome-edited lines grown in field isolation increased **sink capacity by up to 25%** compared to Hokuriku 193

✓ *TGW6*-KO genome-edited lines grown in field isolation increased **sink capacity by up to 14%** compared to Hokuriku 193

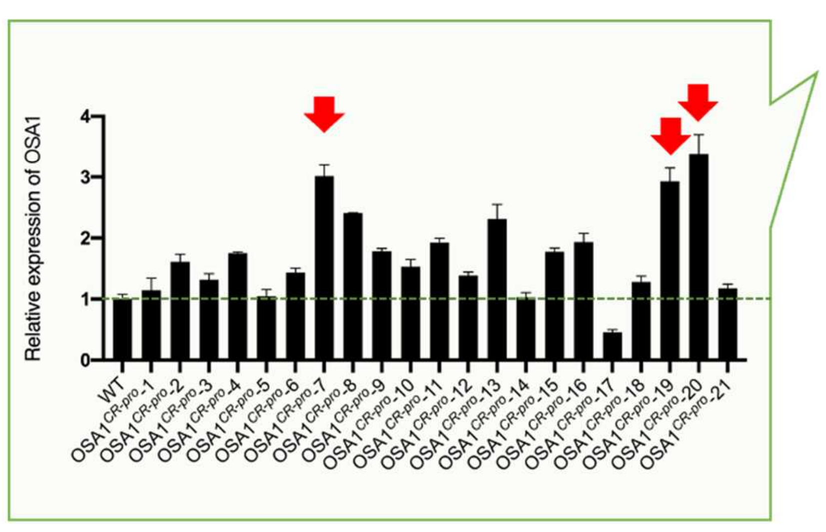
✓ The pyramiding lines will be developed for field evaluation — Marker-selection

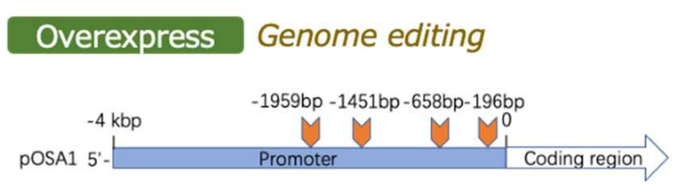
Improvement of source capacity (*OSA1* overexpression)



Overexpression of *OSA1* in rice variety "Nipponbare" **significantly improves photosynthesis and yield**

Zhang, Kinoshita et al. 2021 Nature Communications 12: 735





✓ Mutations were introduced into the promoter region by genome editing to achieve a transformation-independent increase in *OSA1* expression.

✓ In Nipponbare background T0 plants, several lines with higher expression levels than Nipponbare appeared.

Strategies for improving DAC capacity

(Present) (2022-2024 : FS stage) (2025-2030)

- ✓ Development of breeding material by **genome editing**
- ✓ Evaluation under growth chamber
- ✓ Staking of genes **by generation acceleration**
- ✓ Evaluation under field condition