宮崎大学
University of Miyazaki

草類遺伝資源育種学研究室
Laboratory of forage grass genetic resource and breeding

Toward a New Understanding of Zoysia Diversity: A Reassessment of Its Classification Based on Digital 3D Imaging and Genomic Data

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About me

Sorawich Pongpiyapaiboon

Education:

～ **2017** Kasetsart University Laboratory school (Satit Kaset)

2017-2021 University of Miyazaki, Faculty of Agriculture, Department of Animal and Grassland science

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Work:

April 2026～　Researcher at SDS Biotech KK., Japan

Zoysiagrass (*Zoysia*)

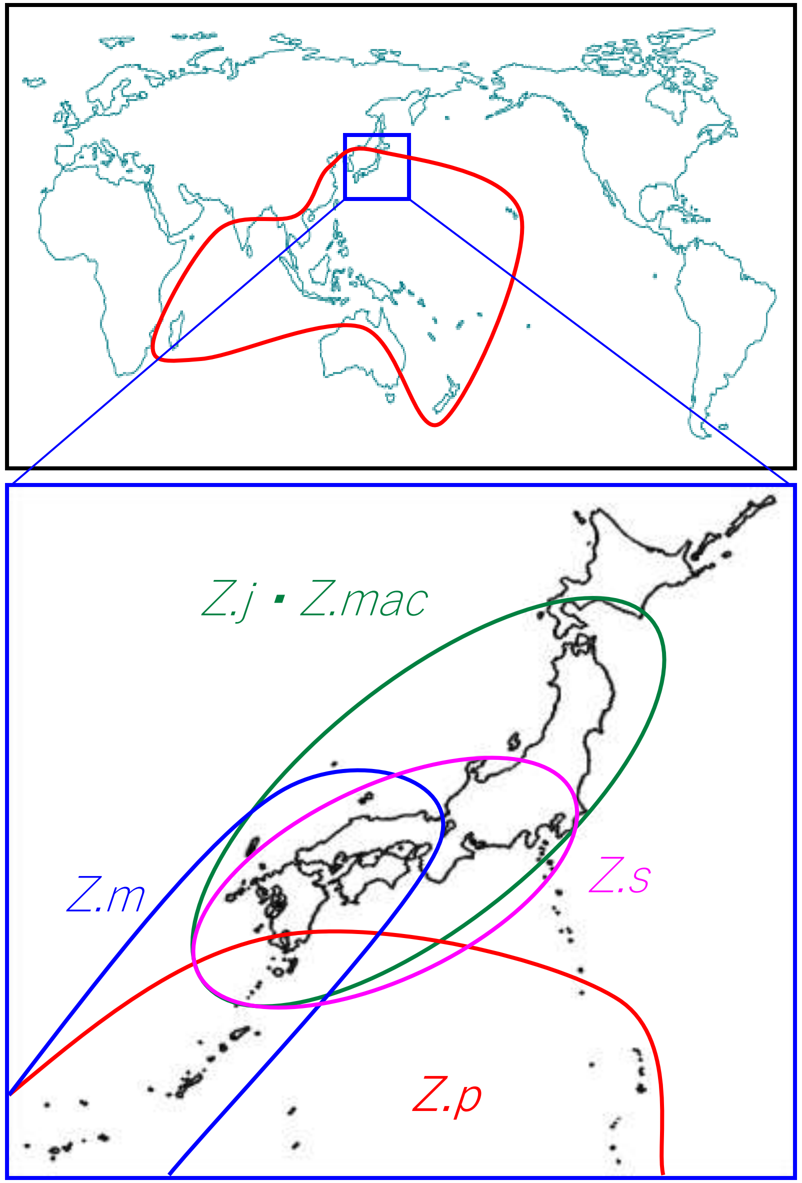
Genus *Zoysia*

The genus Zoysia is a warm-season turfgrass widely distributed across Asia, extending south to New Zealand, west to Madagascar, and east to the Hawaiian Islands.

Although numerous synonyms exist, the following five species are native to Japan:

- Shiba (*Z. japonica*)
- Koushun-shiba (*Z. matrella*)
- Kourai-shiba (*Z. pacifica* (*Z. tenuifolia*))
- Oni-shiba (*Z. macrostachya*)
- Kooni-shiba (*Z. sinica*)

Its chromosome number is 2n=40, allowing interspecific hybridization, and hybrid cultivars have also been developed. It is used as lawn grass in gardens and as a forage species for livestock grazing. Zoysiagrass also have deep connection with cultural aspect of Japan



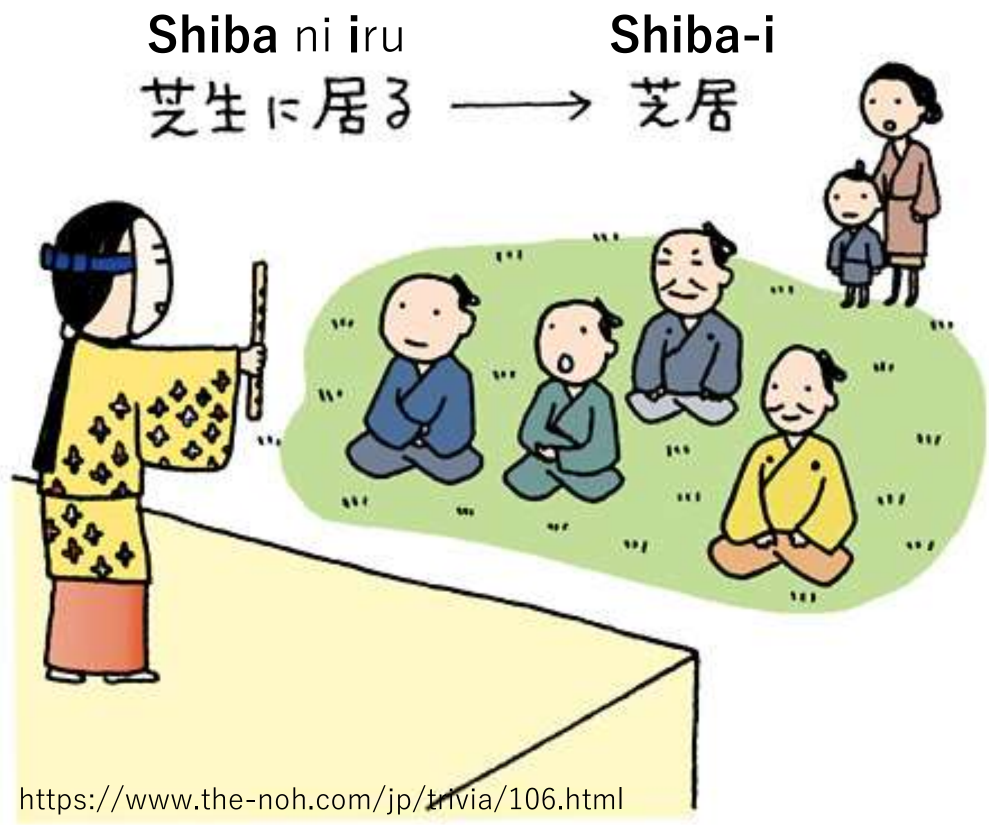
Word ‘Shibai’ and its connection to *Zoysia*

In Japan, zoysiagrass has been used since the Heian period (794～) as lawn grass in gardens and park. Also, as a forage grass for livestock grazing in mountainous and wild areas

In the Muromachi period (1336～), traditional performances and entertainments like ‘Noh’ and ‘Kagura’, were often held in the precincts of temples and shrines where people could easily gather.

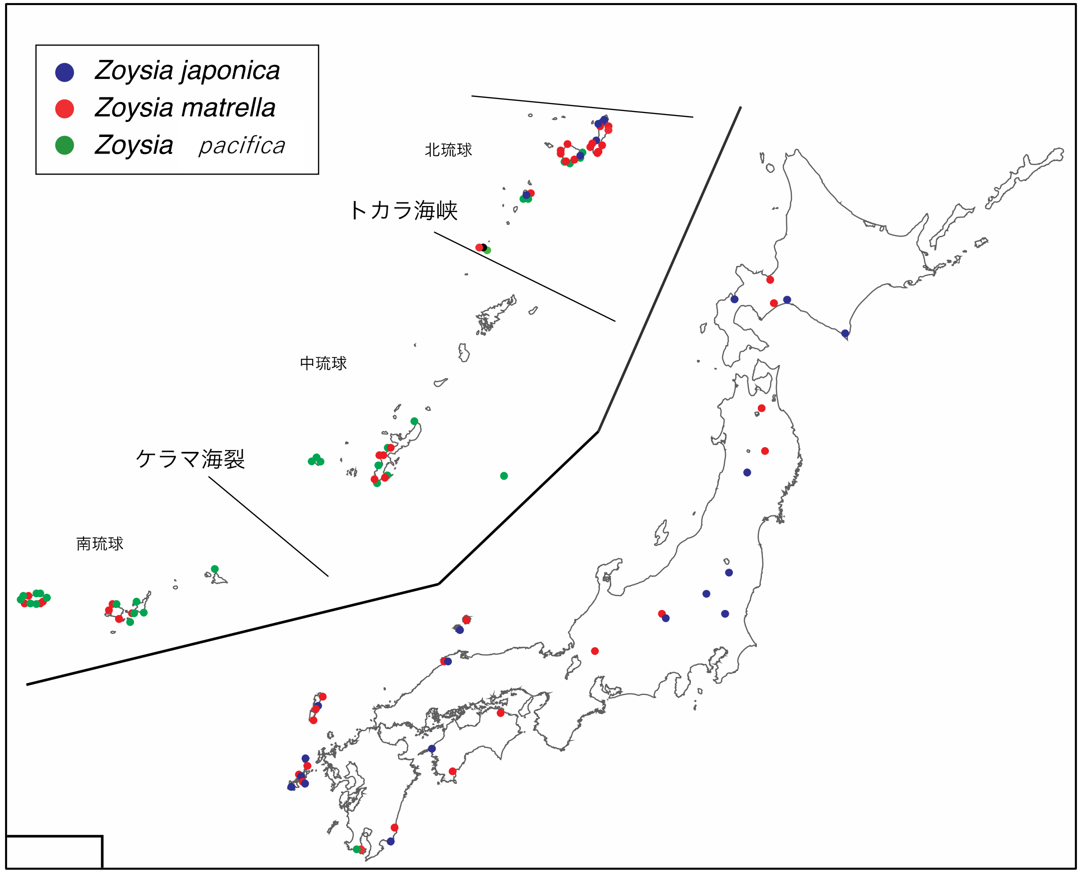
At that time, there were no fixed audience seats, so people sat on the grass to watch. It is said that the word **shibai** originated from this situation—literally from people “being (sitting) on the grass” (shiba = grass, i/iru = to be/sit).

Even now, the word **‘Shibai’** mean traditional play, show, theater, opera, and generally people still use and say ‘to watch shibai’



This story highlights **the deep cultural connection** between shiba (zoysiagrass) and Japanese society, extending beyond landscaping into historical and cultural practices.

Zoysiagrass in the wild



Confusion in identifying zoysiagrass

Poaceae family

Genus *Oryza*

Different species easy to identified

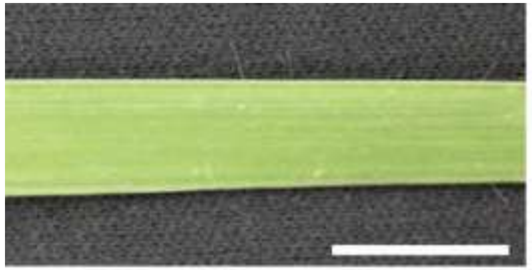
Sanchez, Paul & Wing, Rod & Brar, Darshan. (2013).
The Wild Relative of Rice: Genomes and Genomics. 10.1007/978-1-4614-7903-1_2.

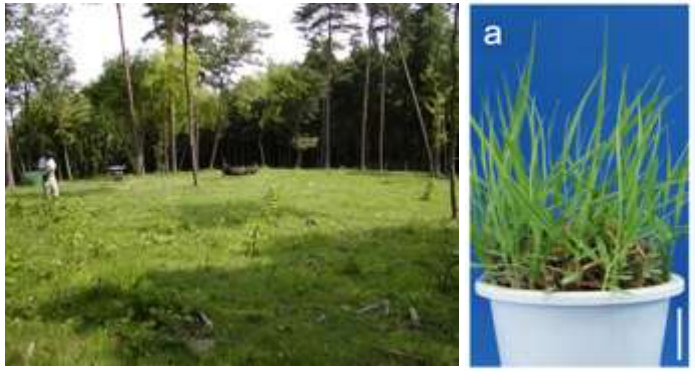
Genus *Zoysia*

Different species hard to identified

Characteristics of 3 main *Zoysia* species

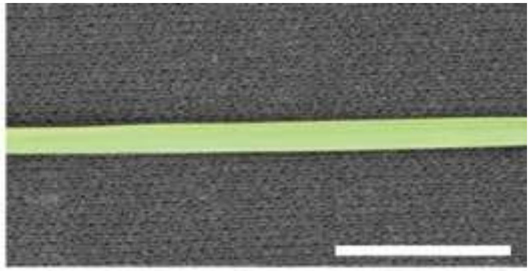
- *Z. japonica*





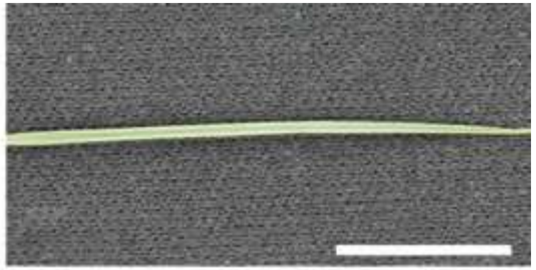
- Excellent growth potential
- Protective plants for **road embankments** and **pasture grass** species
- Most cold-tolerant within its genus
- High dormancy

- *Z. matrella*



- Narrow leaf width forms beautiful turf
- Suitable for **parks and stadiums**
- High salt tolerance, moderate dormancy

- *Z. pacifica*



- Forms compact, dense, beautiful turf
- Suitable for **low-traffic**, **small-scale areas**
- Slow growth (low maintenance)
- Highest salt tolerance and low dormancy

Flowers (spikelets) with pistils




Creeping stem of zoysiagrass

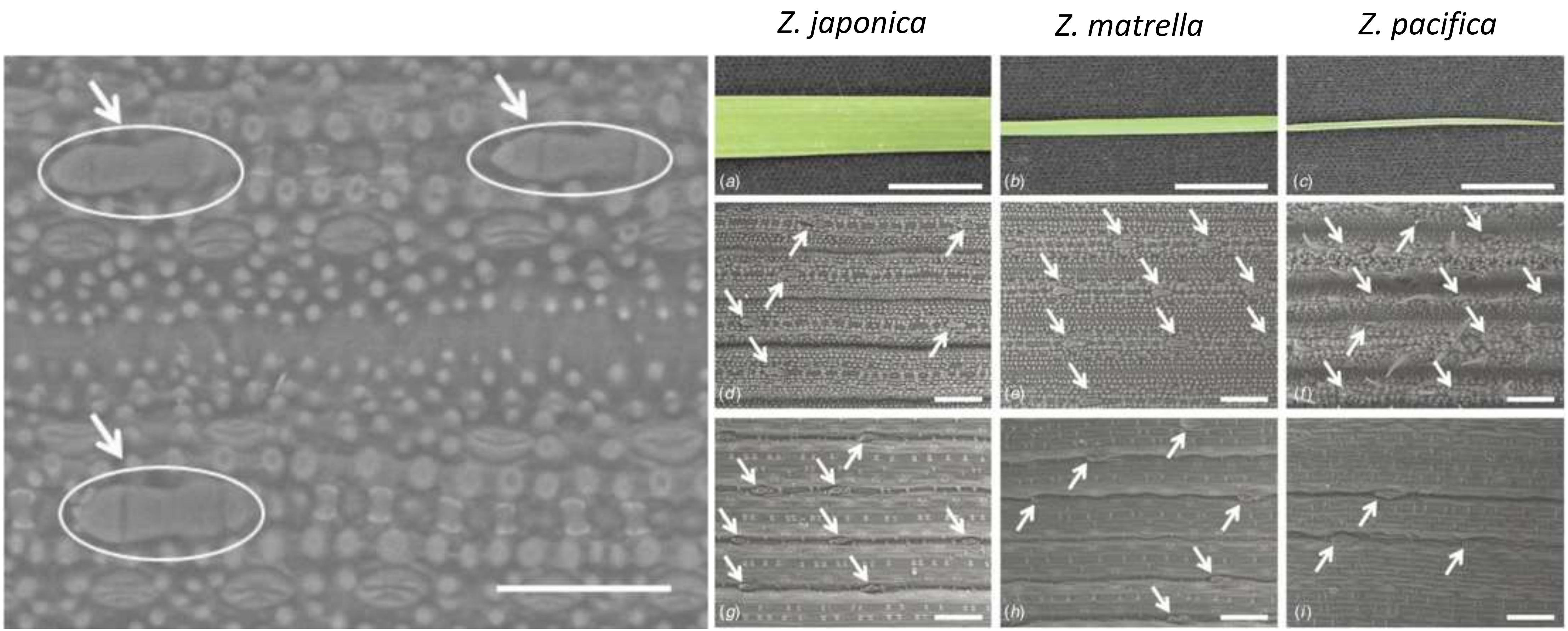
Comparison of *Zoysia* morphology

Parts	Traits	*Z. japonica*	*Z. matrella*	*Z. pacifica*	*Z. macrostachya*	*Z. sinica*
Plant	Plant lenght	15 cm ~	10~25 cm	10~20 cm	-	10-25 cm
Leaf	Leaf lenght	4.0 cm~	1.0~4.0 cm	2.5~5.0 cm	3.0~5.0 cm	3.0–7.0 cm
	Leaf structure	Triangular type / moderately broad type	Triangular type / moderately broad type	Linear type	Moderately broad type	Linear type
	Leaf width	2.0-5.0 mm	1.0-4.0 mm	1.0 mm以下	2.0-4.0 mm	2.0–3.0 mm
	Leaf cross-section	H-Type･V-Type	V-Type･U-Type	V-Type･R-Type	H-Type･V-Type	V-type or U-type
	Large vascular bundles	7～	～7	～3	～7	~7
	small vascular bundles	Around 30 (4–6 between each large vascular bundle)	Around 20 (3–4 between each large vascular bundle)	Around 6 (2–3 between each large vascular bundle)	-	-
	Leaf bud (vernation)	Spirally coiled about turns (large diameter)	Spirally coiled about 1.5–2 turns (medium diameter)	Folded in two (conduplicate) (small diameter)	Spirally coiled about 2–2.5 turns (large diameter)	Spirally coiled
Runner	Stem lenght	10-20 cm	7-20 cm	7-20 cm	15-20 cm	-
Flower	Panicle lenght	3-5 cm	1-3 cm	1-3 cm	3-4 cm	3-5 cm
	Panicle width	2-7 mm	2-4 mm	2-4 mm	6-8 mm	-
	Spikelets lenght	3 mm	2.5-3.5 mm	2.5-3.5 mm	6-8 mm	4-5 mm
	Spikelets width	1.2-1.5 mm	0.5-0.8 mm	0.5-0.8 mm	1.8-2.2 mm	-
	Flowering period	May - July	May - October	September - November	May - September	May–June

Zoysiagrass winter dormancy

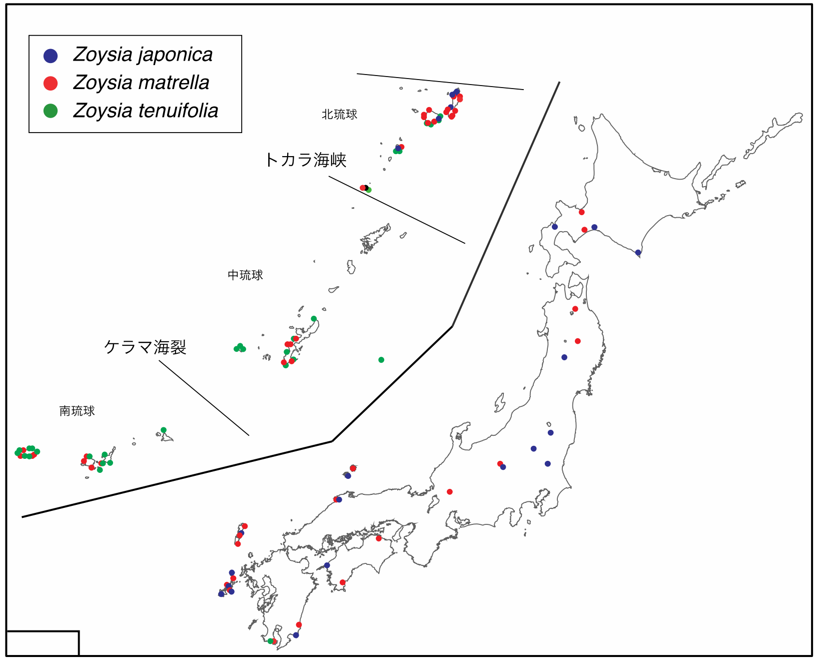
Arima CC. Hyogo prefecture, Japan
http://www.arimacc.jp/report/post-6766

Salt tolerance: Leaf blade salt gland



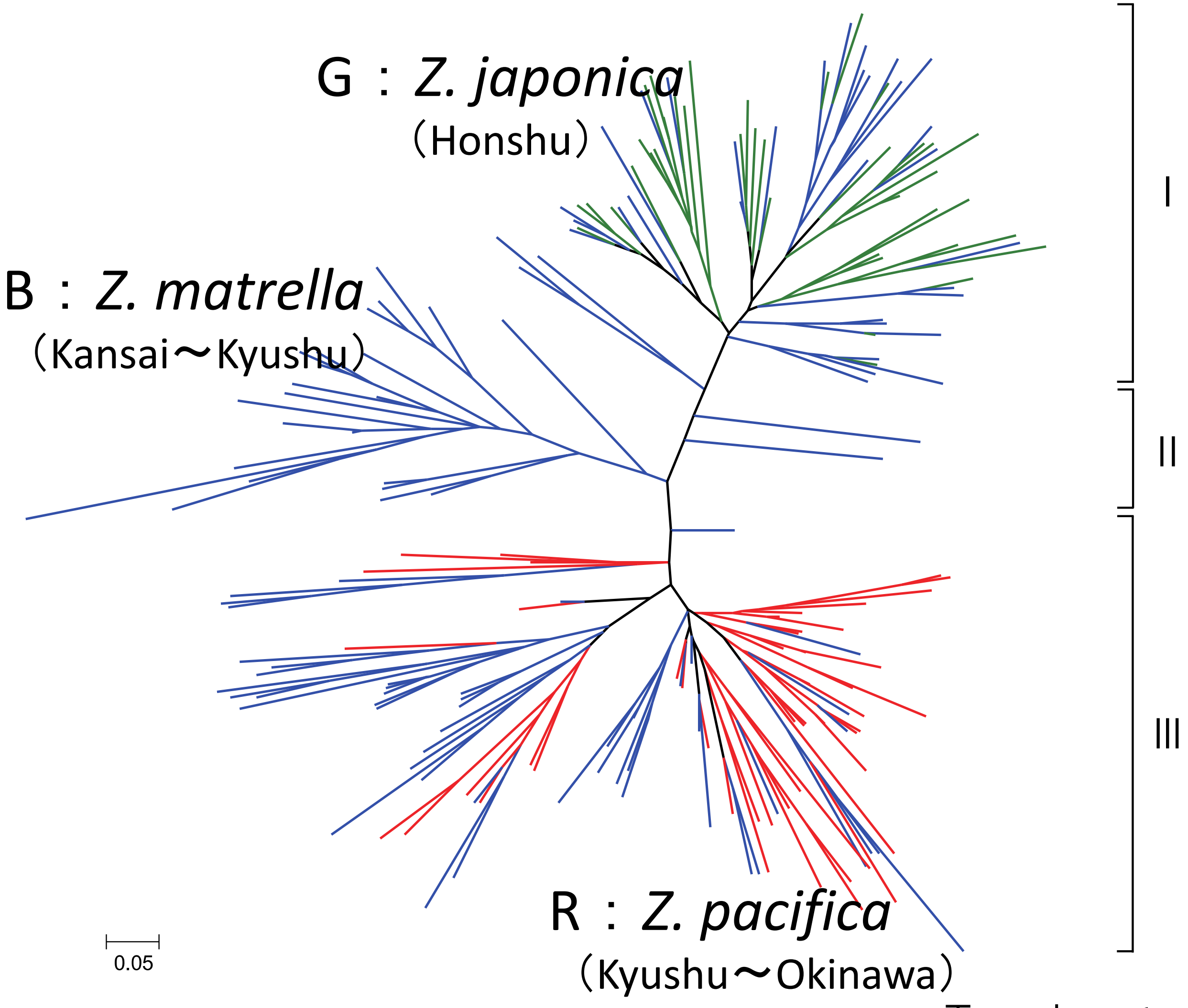
Yamamoto, Hashiguchi et al. 2016

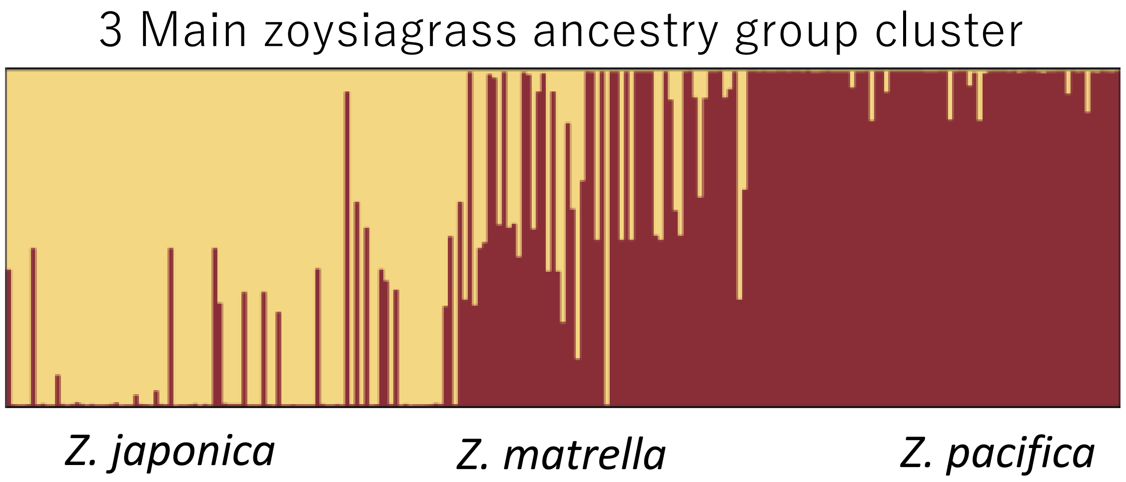
Zoysia genetic resource and breeding

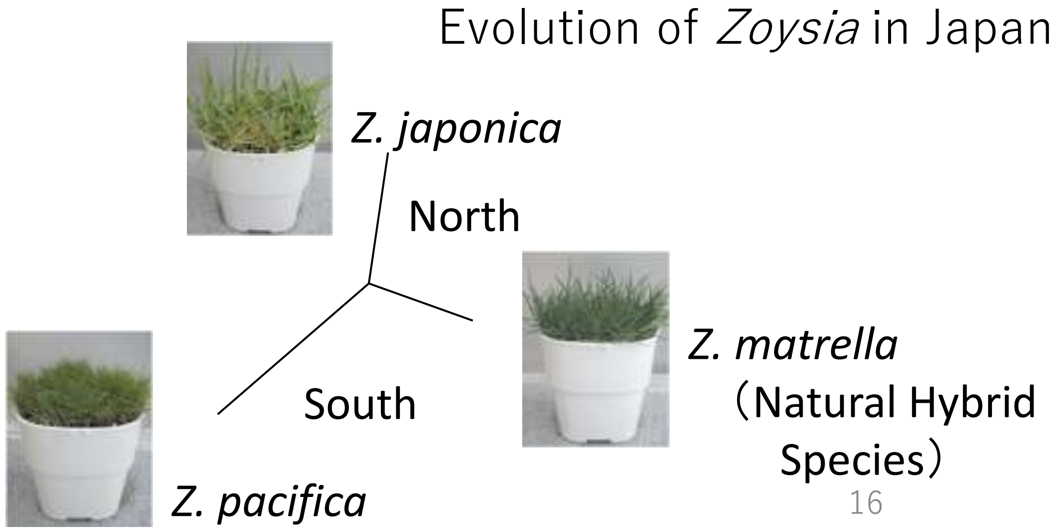


300+ wild accessions from Hokkaido to Kyushu and southern islands

Phylogenetic Analysis of the Genus *Zoysia*







Tanaka et al., 2016

Zoysiagrass conventional breeding

Z. japonica
Variety ‘Asakake’

- Broadleaves
- fast growing
- High dormancy

X

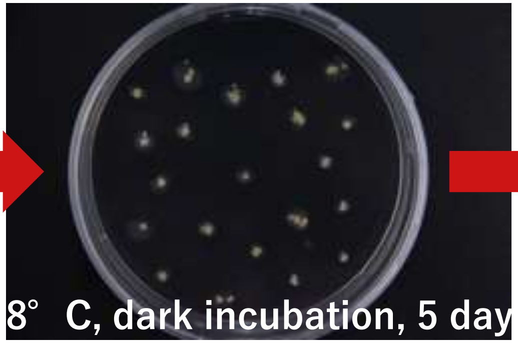
Z. matrella
Wild *Zoysia* ‘Zanpa 2’

- Small leaf blade
- Low dormancy

Zoysiagrass molecular breeding

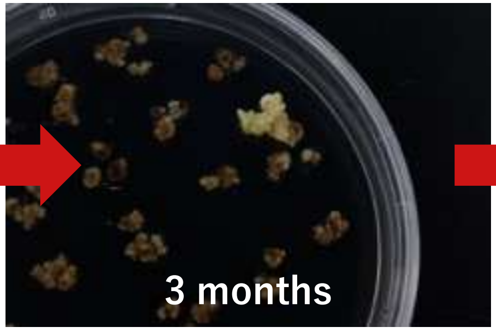
Embryogenic callus induced from stolon node.

Infection of callus with *Agrobacterium*.

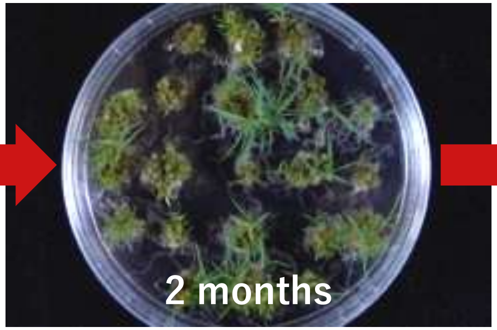


Co-cultivation stage of infected callus.

Rinse to remove excess *Agrobacterium*.



Emergence of resistant callus at selection stage.



Shoot regeneration of transformed callus.

Root regeneration.

Plants were transplanted into soil.

Development of 3D Digital Phenotyping System (DPS) for zoysiagrass

"Phenotyping bottleneck"

Full Paper

Sequencing and comparative analyses of the genomes of zoysiagrasses

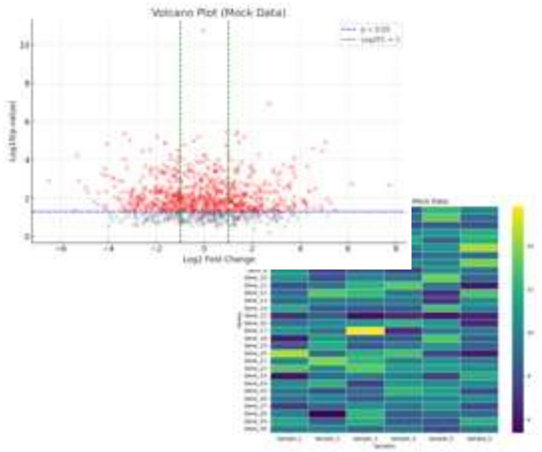
Hidenori Tanaka, Hideki Hirakawa, Shunichi Kosugi, Shinobu Nakayama, Akiko Ono, Akiko Watanabe, Masatsugu Hashiguchi, Takahiro Gondo, Genki Ishigaki, Melody Muguerza, Katsuya Shimizu, Noriko Sawamura, Takayasu Inoue, Yuichi Shigeki, Naoki Ohno, Satoshi Tabata, Ryo Akashi, and Shusei Sato

Establishing an abundant and efficient explant system for the *Agrobacterium*-mediated transformation of zoysiagrass

Crop Science

ORIGINAL RESEARCH ARTICLE

Differences in proteome response to cold acclimation in *Zoysia japonica* cultivars with different levels of freeze tolerance



RESEARCH ARTICLE — Open Access

Physiological and transcriptomic analyses reveal the mechanisms underlying the salt tolerance of *Zoysia japonica* Steud

Jingjing Wang, Cong An, Hailin Guo, Xiangyang Yang, Jingbo Chen, Junqin Zong, Jianjian Li and Jianxiu Liu

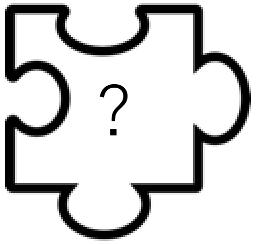
Genome

Proteome

Phenome

Transcriptome

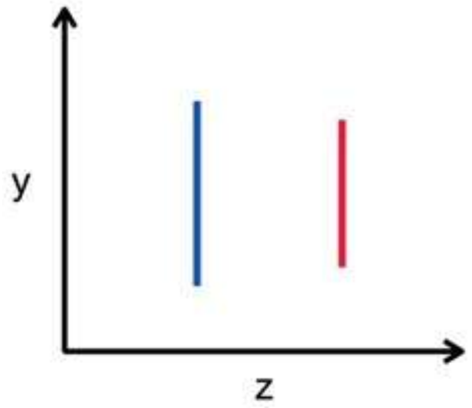
Etc.

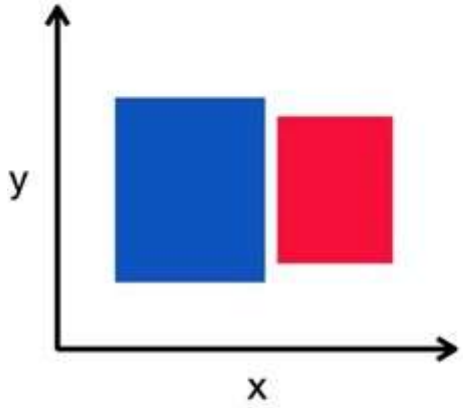


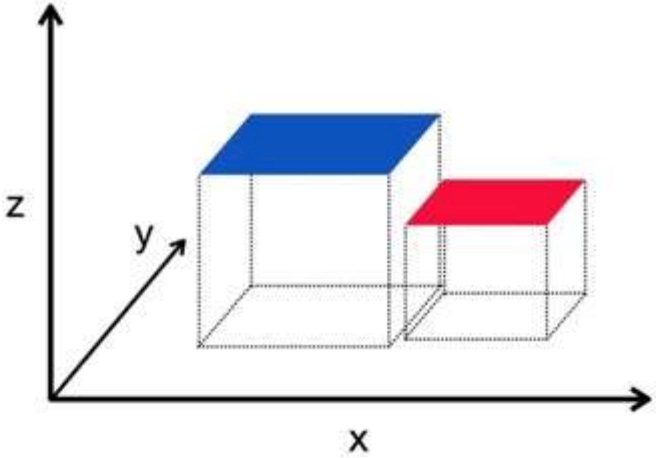
High-throughput phenotyping

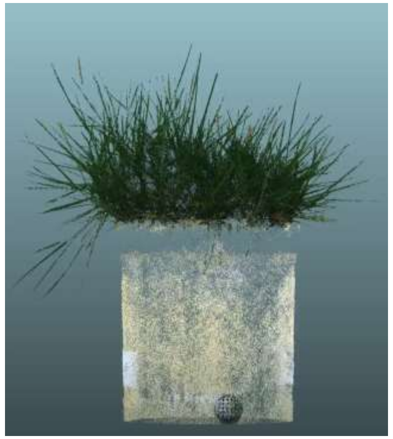
Big Data, Large-scale, Fast, Low-cost

Transition to 3D model phenotyping







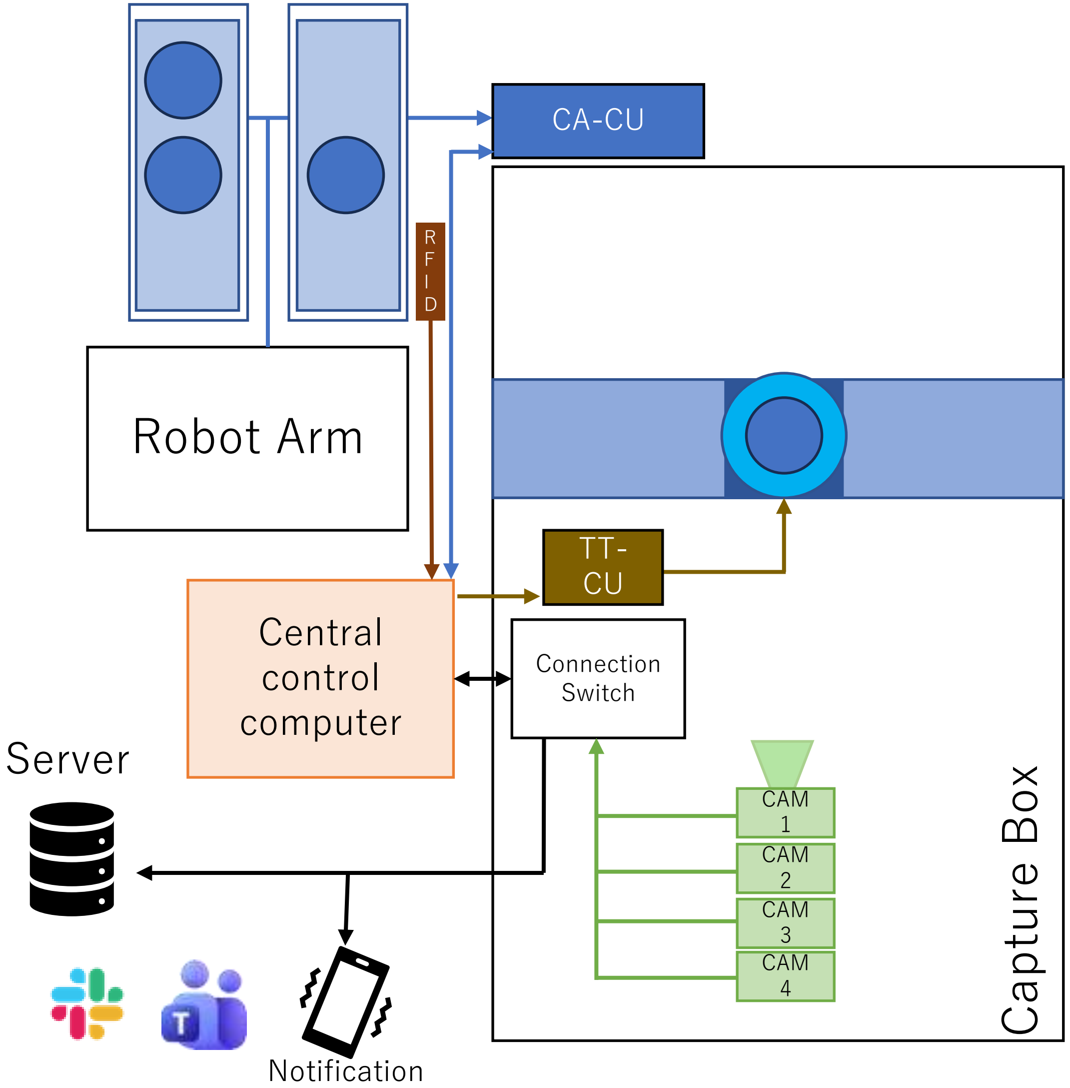


- Destructive
- Subjective
- Time-consuming

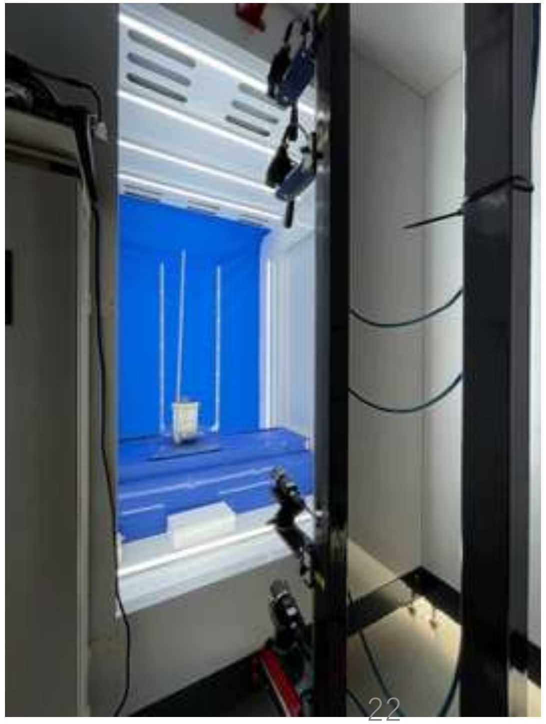
- More efficient but…
- Loses 3D structural information
- No representation of canopy volume

- Depict real object
- No dimension loss
- Reproducibility for data collection

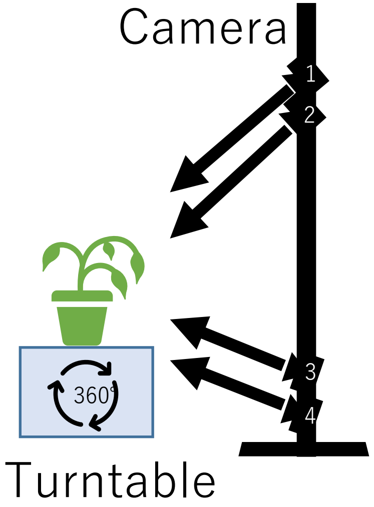
Digital Phenotyping System (DPS)

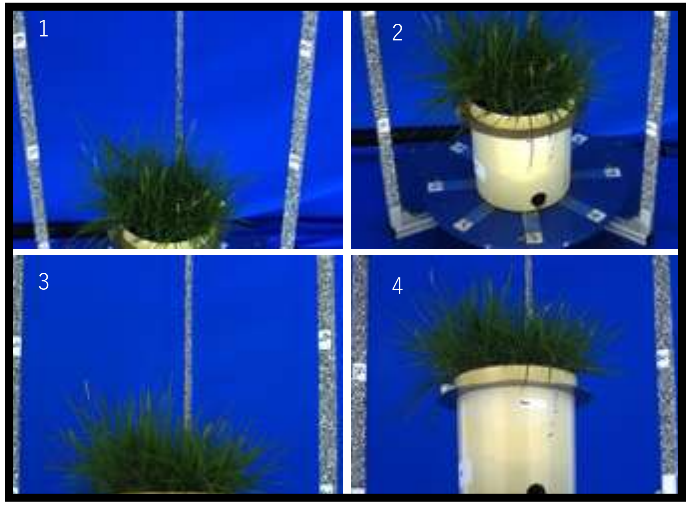


View inside capture box

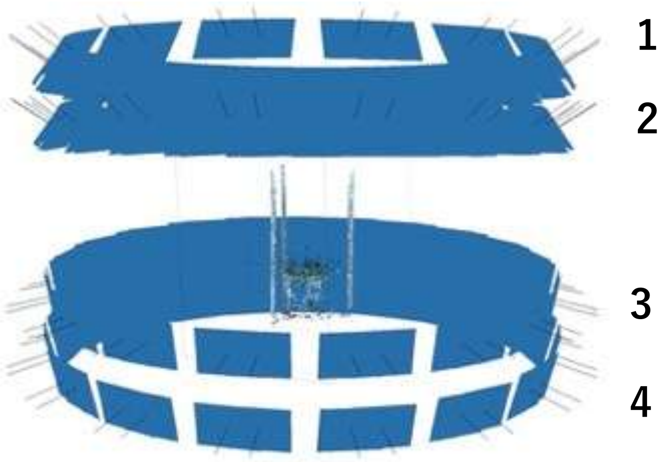


3D model reconstuction



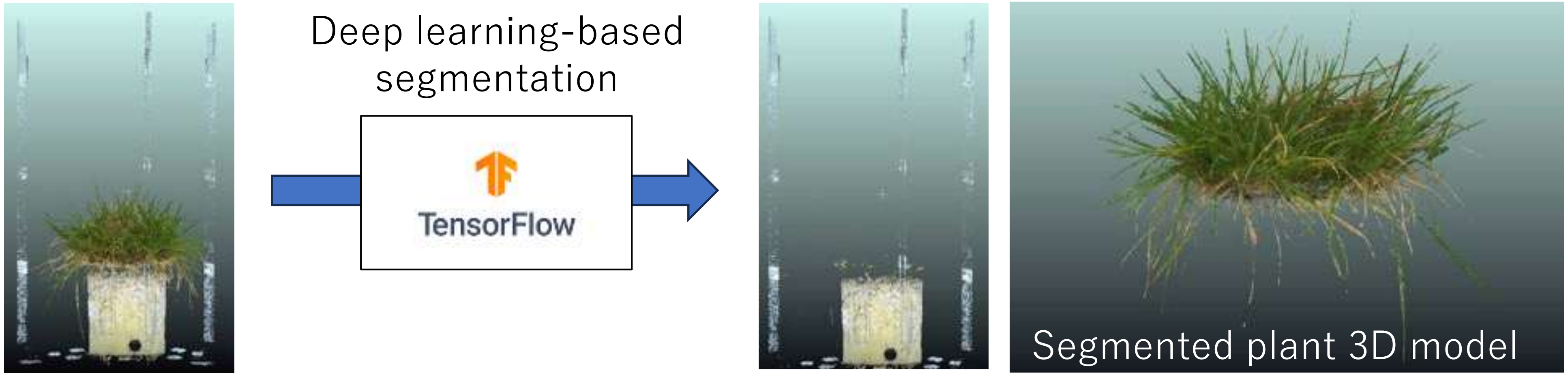


Metashape Application



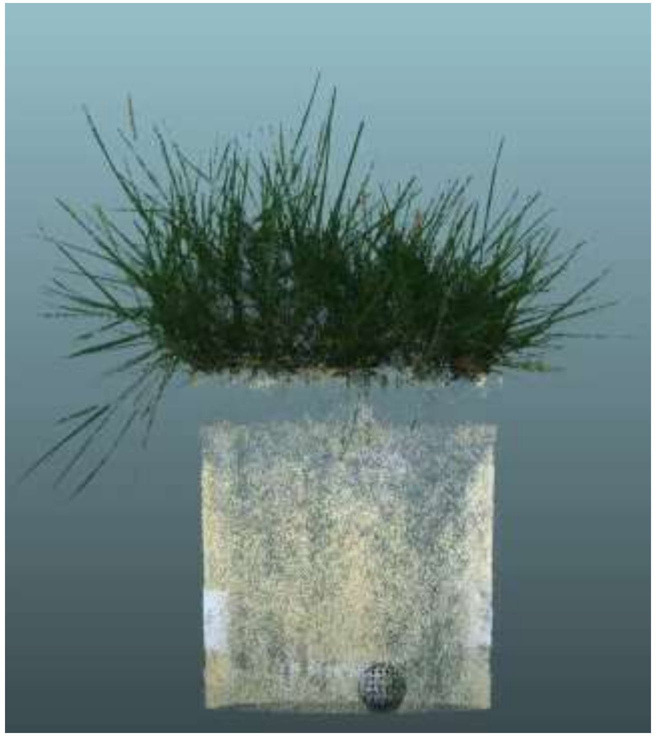
Structure from Motion (SfM)

Reconstructed 3D model



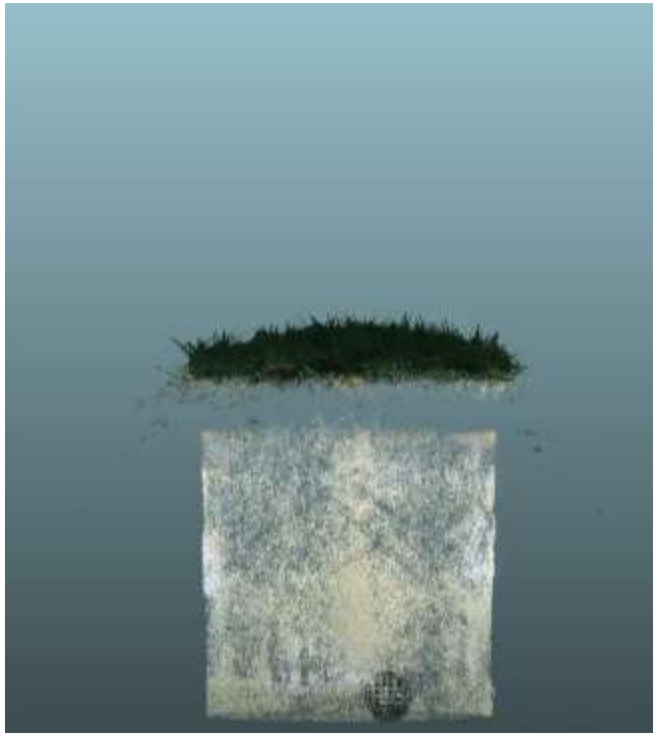
Reconstructed 3D models of zoysiagrass

Z. japonica

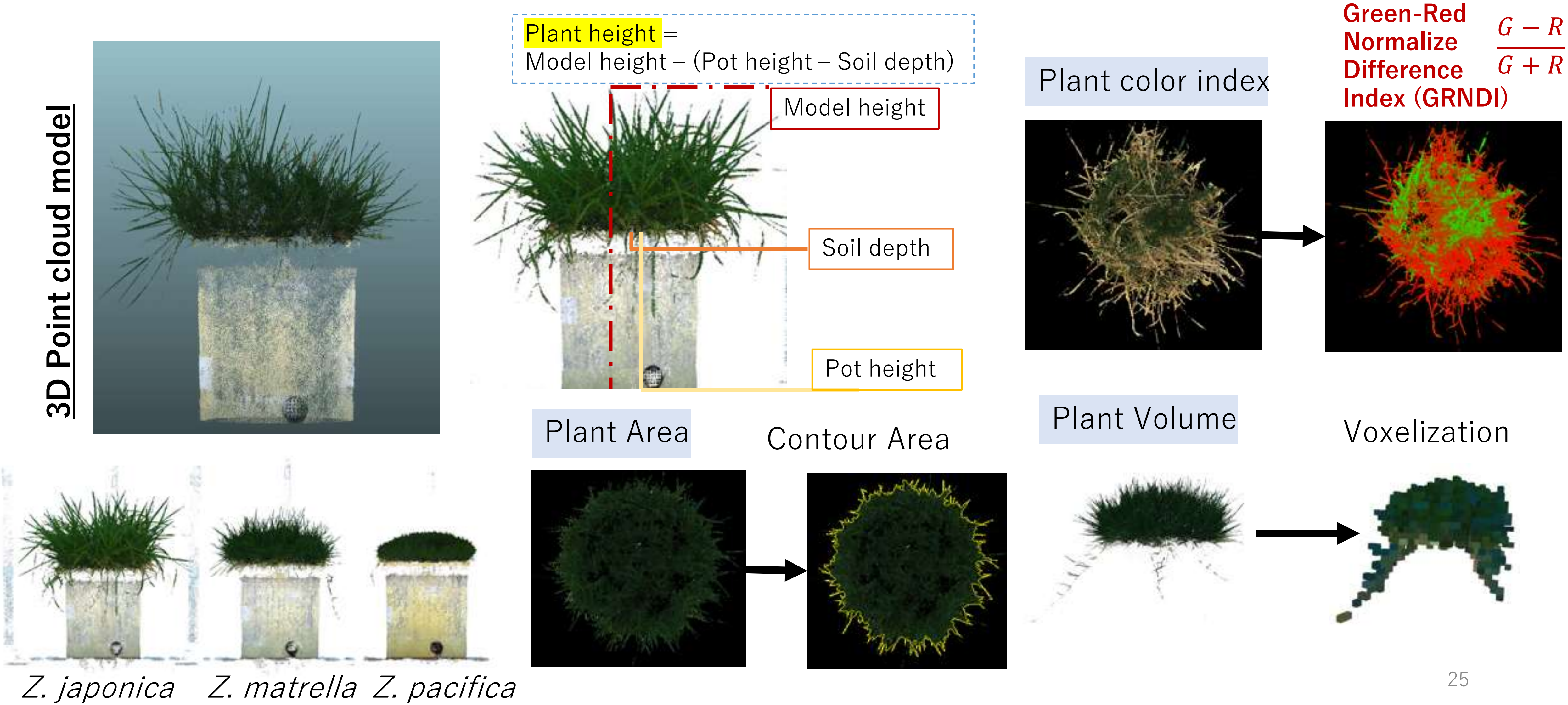


Z. matrella

Z. pacifica



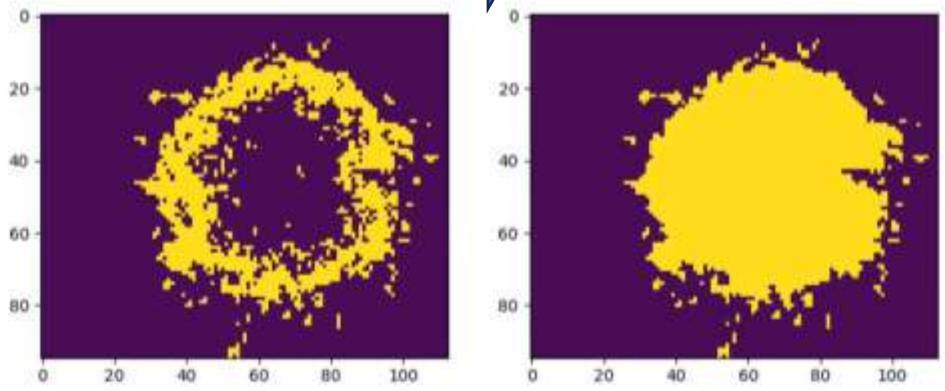
Plant morphological analysis using 3D model



3D Phenotyping advantage: Volume

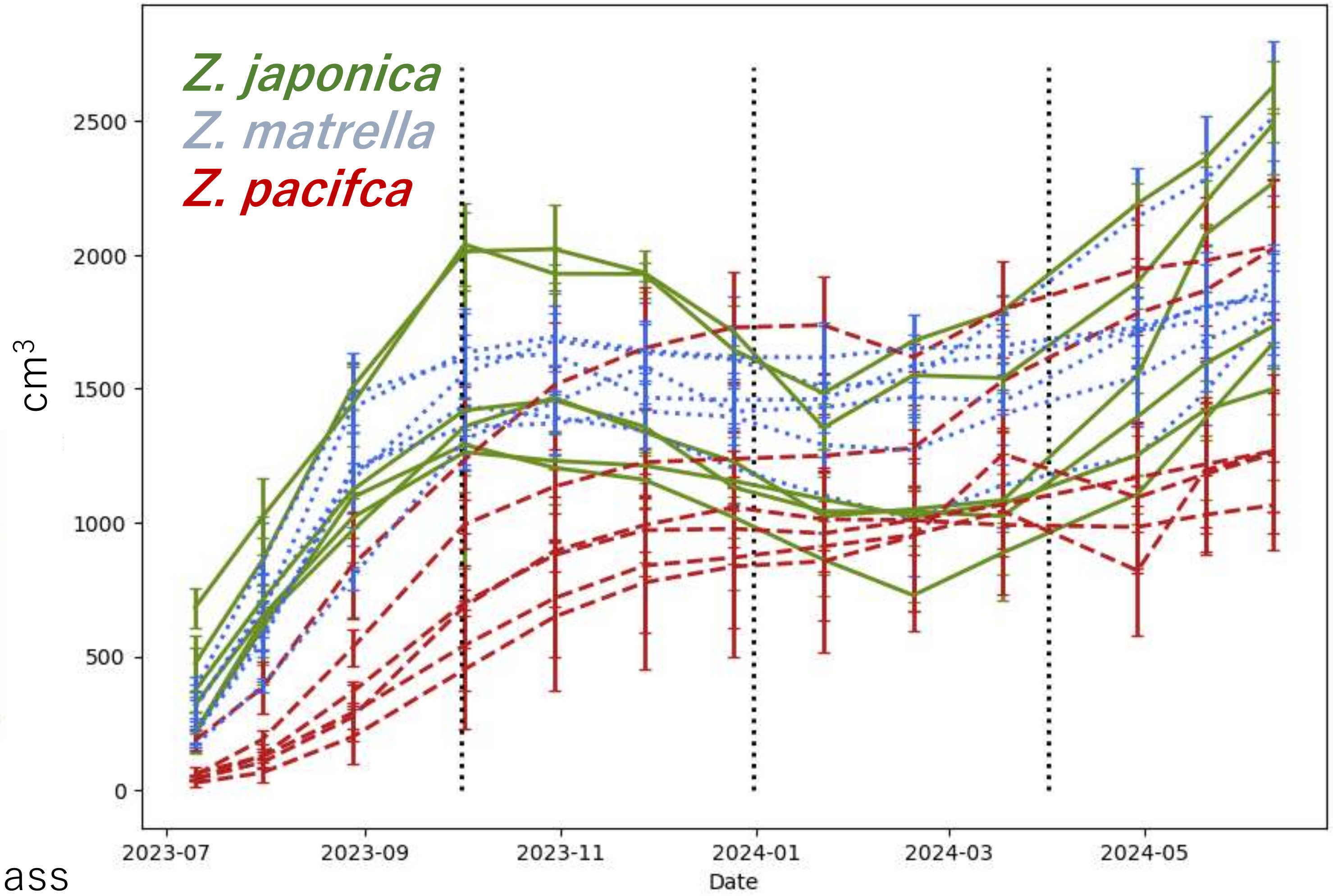
Voxelized 3D model

Filled 3D model



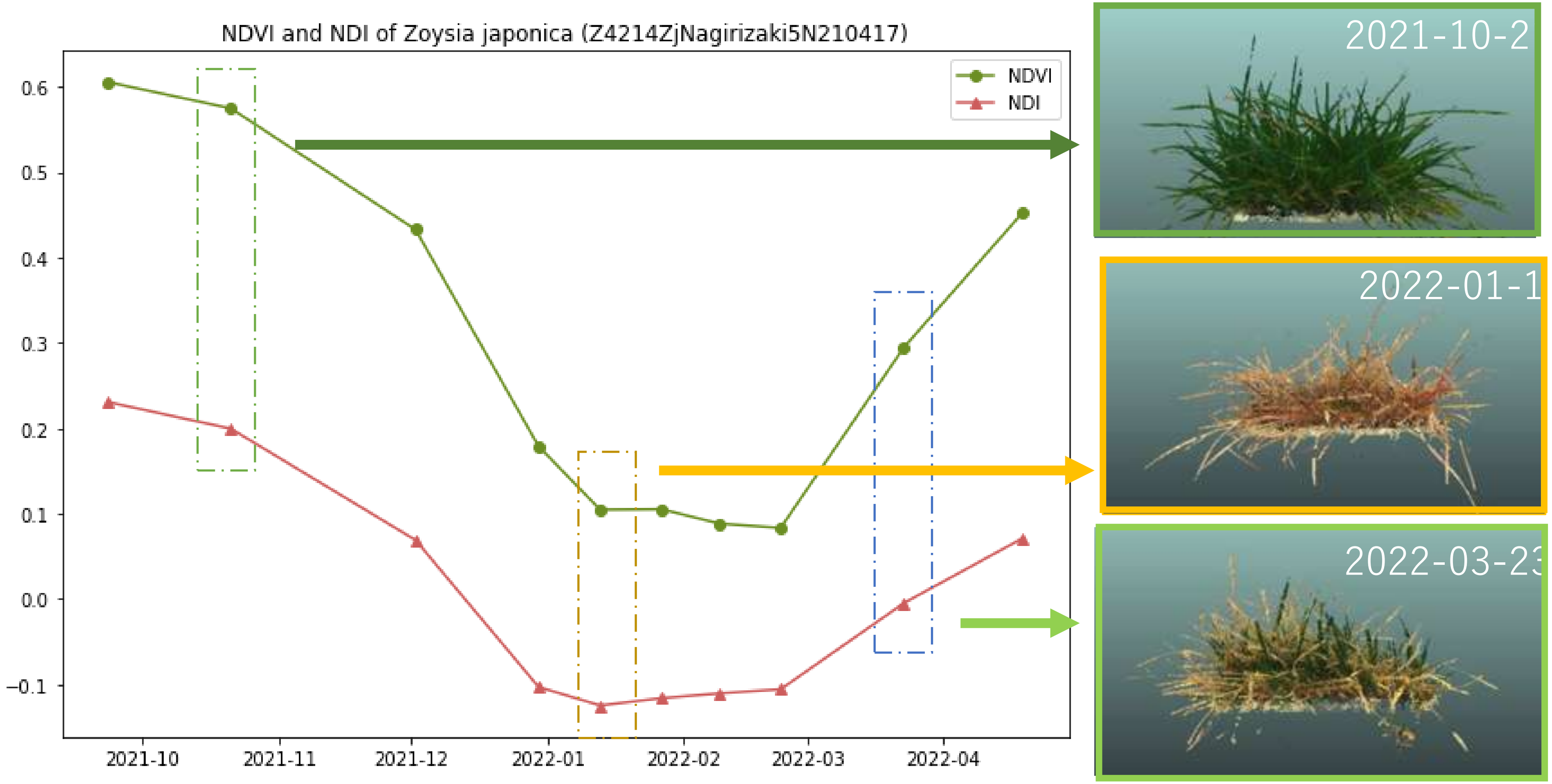
Calculate volume and estimate biomass

Plant biomass (Volume, cm^3)



Comparison of GRNDI to NDVI

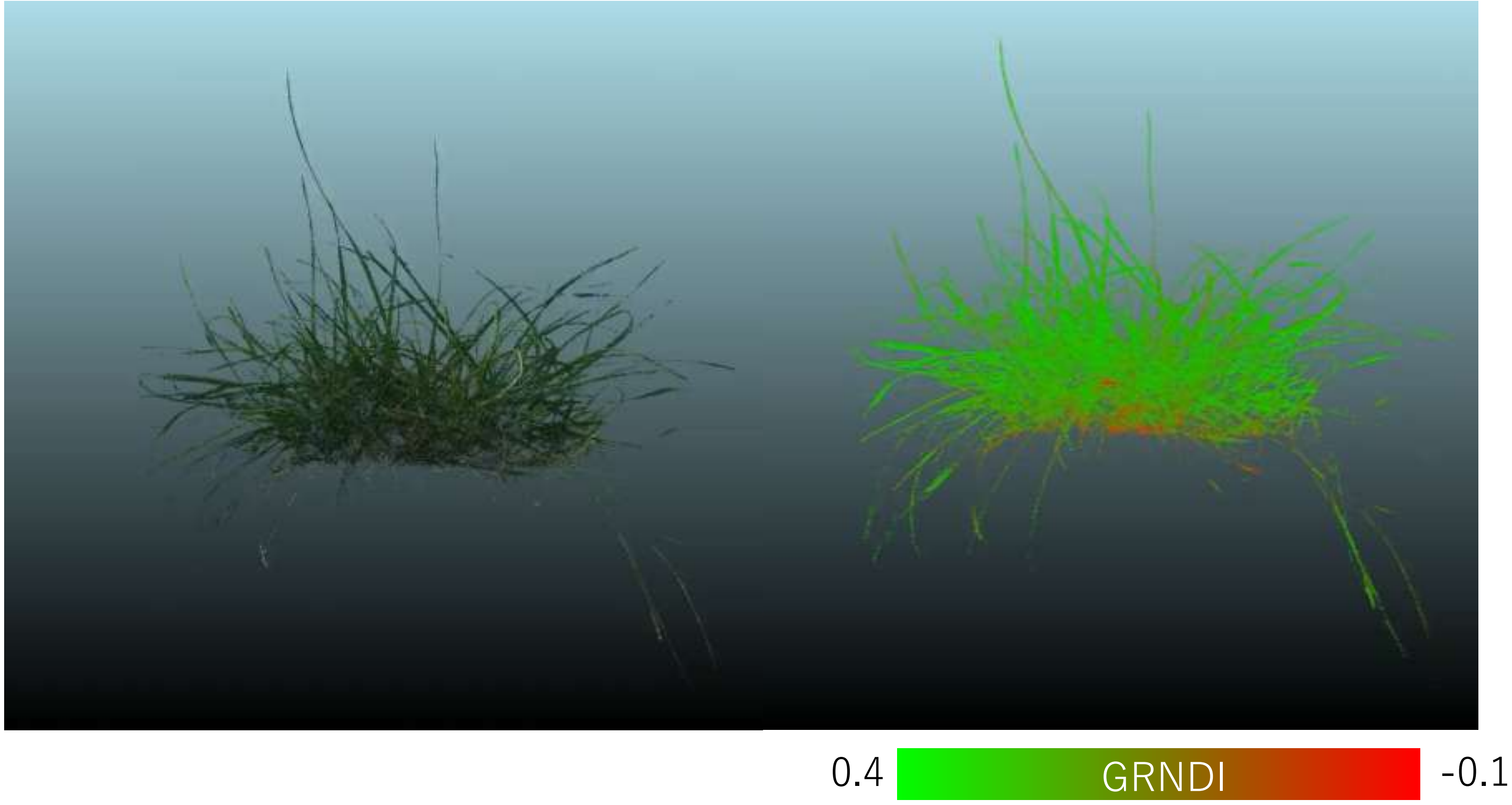
Measuring NDVI using SpectrumTechonology TC500 Turf Color Meter



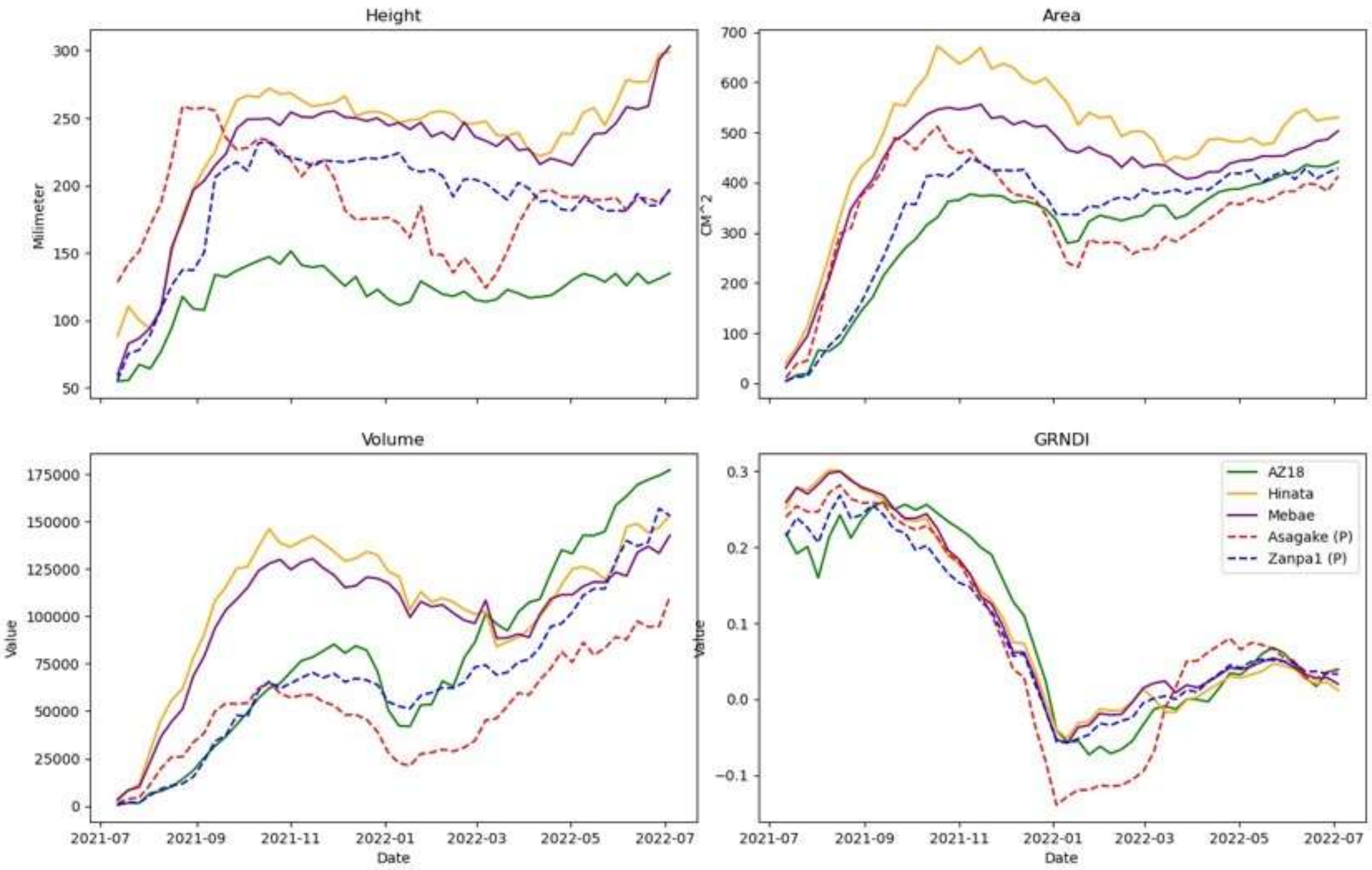
Color indices: visualized in 3D

Beyond non-contact measurement

- Quantifies color across the entire plant
- Extracts phenotypic information unavailable through conventional approaches



Example of DPS potential in breeding program

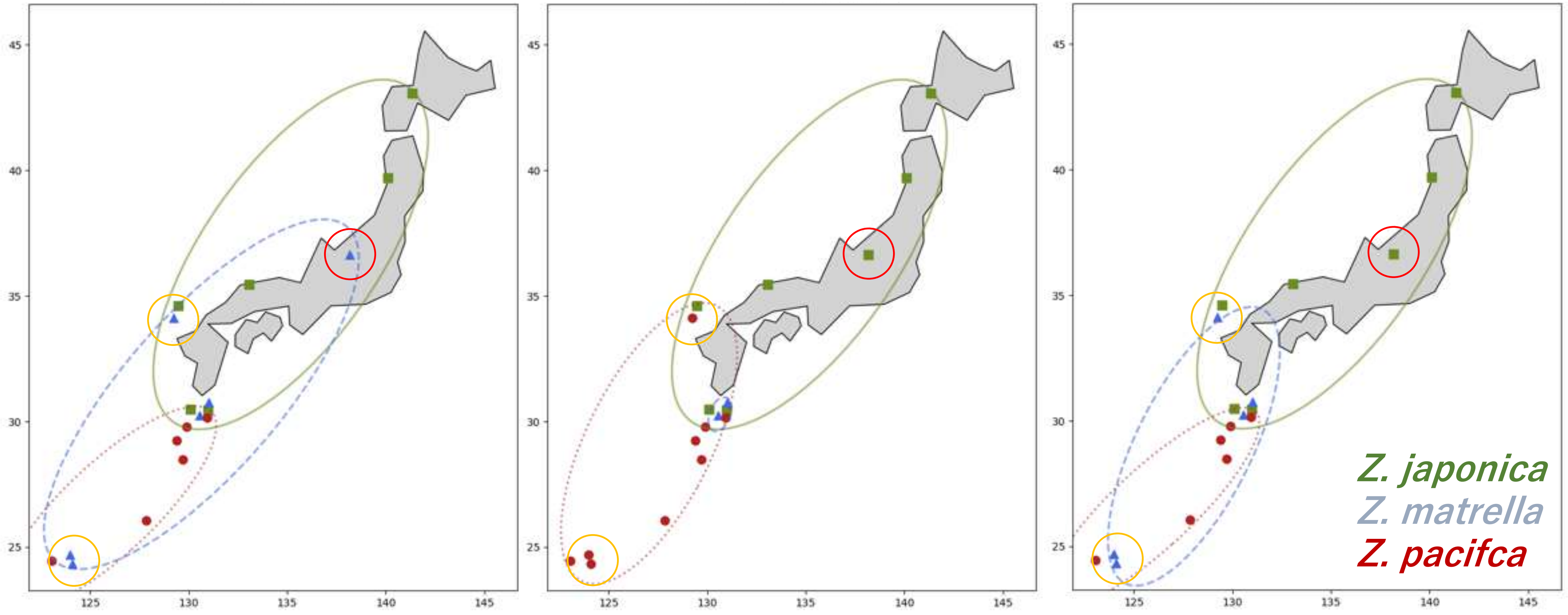


--- Parent line (A,Z)

— F_1 Line

Diversity assessment and classification of zoysiagrass ecotypes

Manual Observation | SSR Markers (Genotype) | Digital Phenotype + Growths trend



Conclusion

Zoysiagrass: Key Takeaways

- Zoysiagrass is a culturally and economically important turfgrass in Japan and Asia
  - Use as lawn grass, sport turf, forage grass
- Displays substantial morphological diversity across species
  - Genetics wise, there are some overlap between species
  - Three main species have different morphology and usage

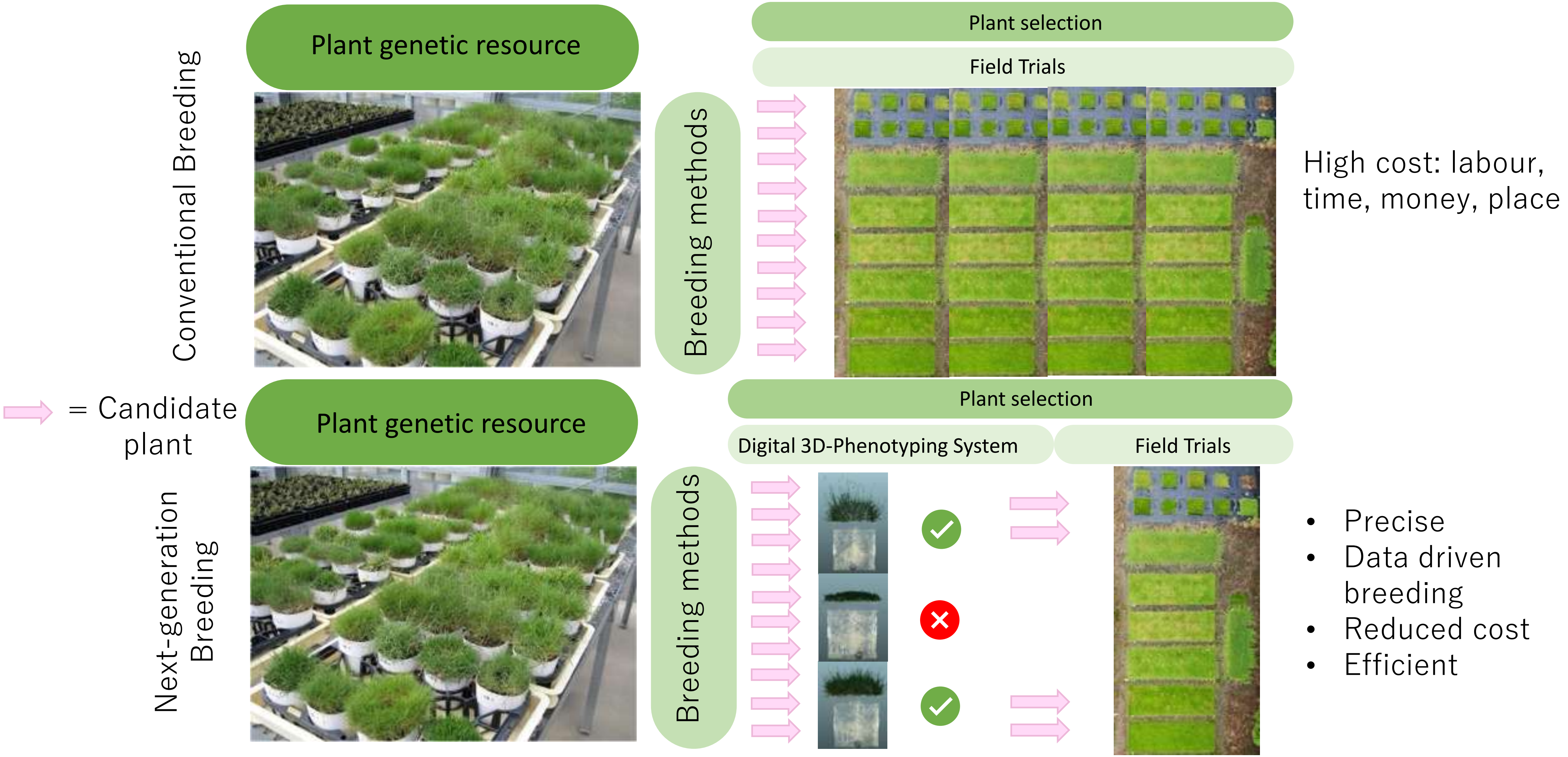
Conclusion (2)

- Traditional classification based on morphology alone is often ambiguous
  - Leaf width etc.

- Now using digital technology we can increase speed in phenotyping and breeding and give more data to look at
  - Volume, GRNDI
  - Data-driven strategy

- Combine with genomic data to further increase research output in zoysiagrass and other turfgrass

Implementing 3D-DPS into breeding research



Acknowledgement

This research is supported by

- JST CREST (grant number JPMJCR16O1)
- JST SPRING (grant number JPMJSP2105)
- The Ito Foundation (grant numbers 39 (2023) and 38 (2024))
- Nippon Steel Engineering Co., Ltd.

Reference

Pongpiyapaiboon S, Tanaka H, Hashiguchi M, Hashiguchi T, Hayashi A, Tanabata T, Isobe S, Akashi R (2023) Development of a digital phenotyping system using 3D model reconstruction for zoysiagrass. Plant Phenome Journal 6: e20076.

Hayashi A, Kochi N, Kodama K, Isobe S, Tanabata T (2025) CLCFM3: An advanced photogrammetry algorithm for high-precision plant 3D modeling. bioRxiv 10.1101/2024.10.10.617704

Tanabata T, Kodama K, Hashiguchi T, Inomata D, Tanaka H, Isobe S (2022) Development of a plant conveyance system using an AGV and a self-designed plant-handling device: A case study of DIY plant phenotyping. Breed Sci 72: 85–95.