



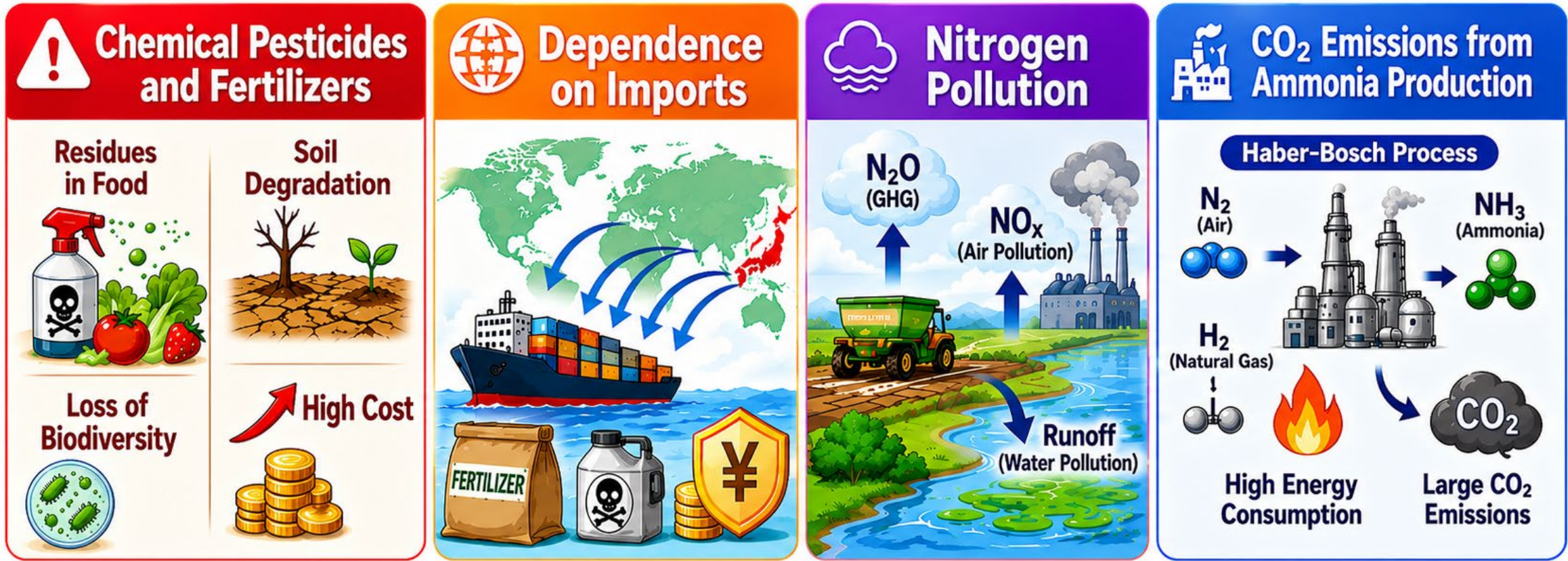
TOHOKU  
UNIVERSITY

***WIPO GREEN Technology Forum 2026***  
***2026.6.5 Online***

**大気圧空気プラズマを用いた持続可能な農業**  
**Sustainable Agriculture Using Atmospheric-Pressure Air Plasma**

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***Graduate School of Engineering, Tohoku University, Japan,***



**To Address These Challenges,  
Let's Harness Atmospheric Pressure Plasma!**

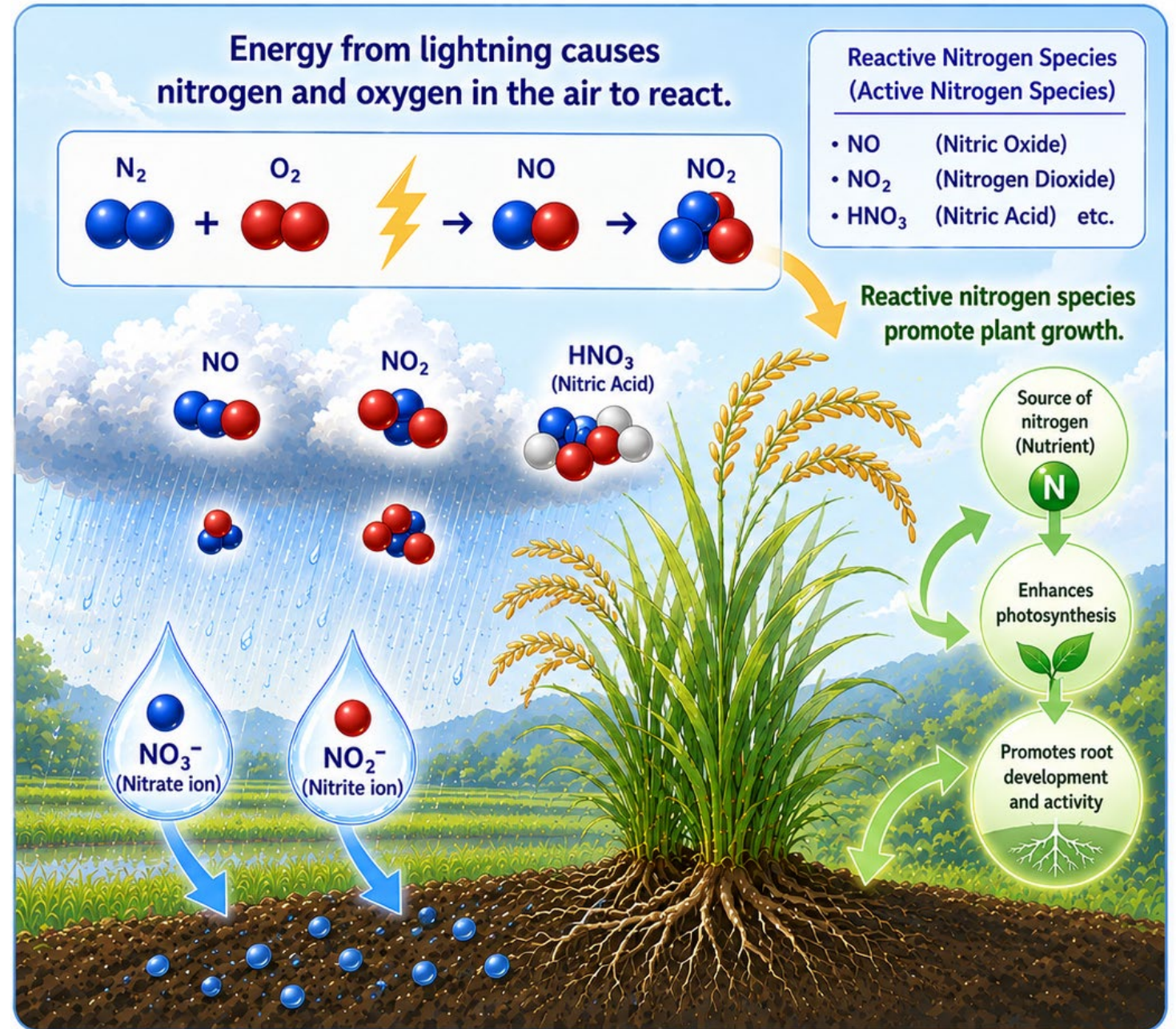
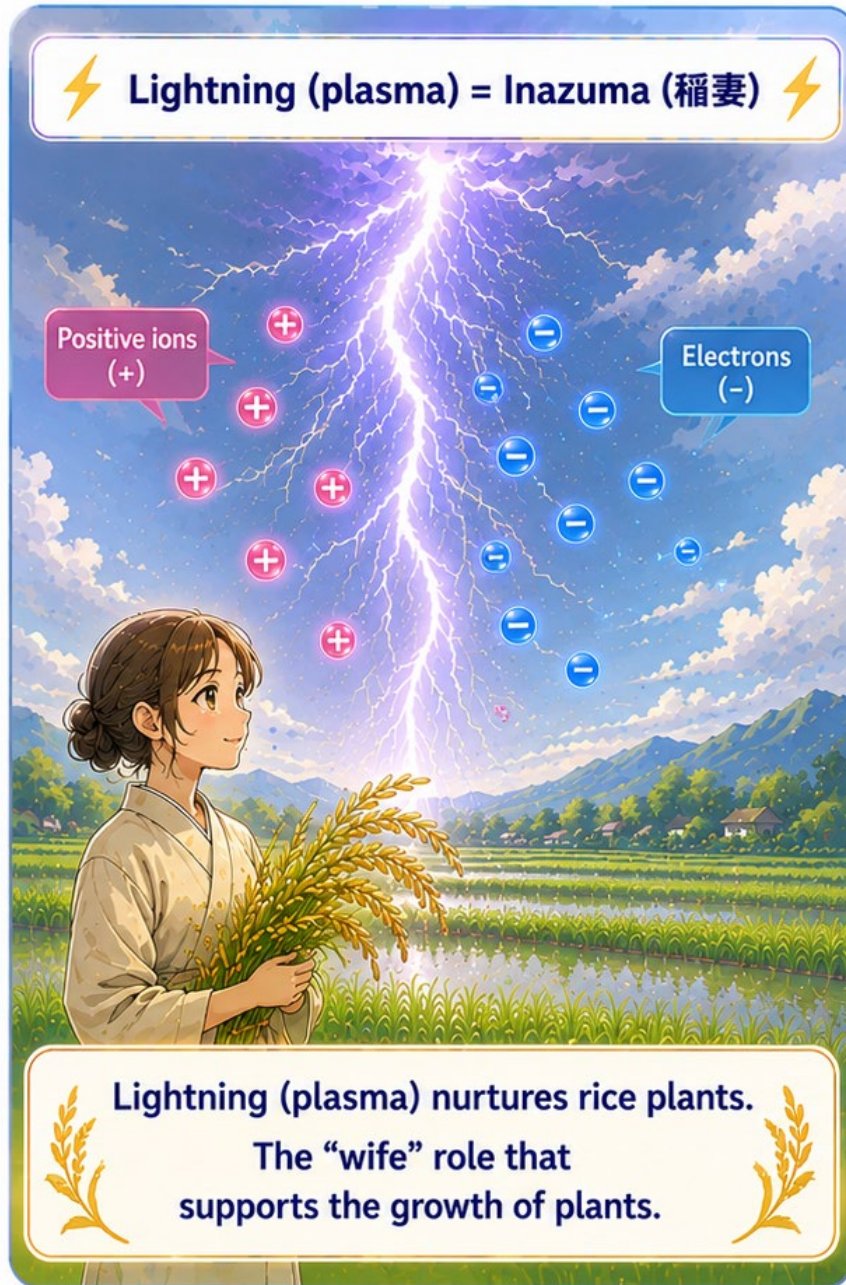


-  Solve Chemical Pesticide & Fertilizer Problems
-  Reduce Dependence on Imports
-  Suppress Nitrogen Pollution
-  Reduce CO<sub>2</sub> Emissions from Ammonia Production

**Toward a Sustainable Future for Agriculture, Environment, and Society**

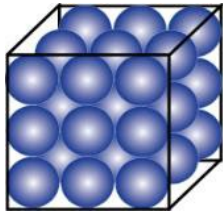


# Plasma Promotes Plant Growth (プラズマが植物成長を助長)



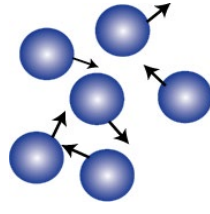
# What is Plasma ? (プラズマとは?)

1st State



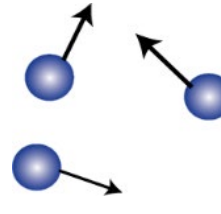
Solid

2nd State



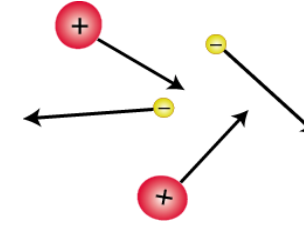
Liquid

3rd State

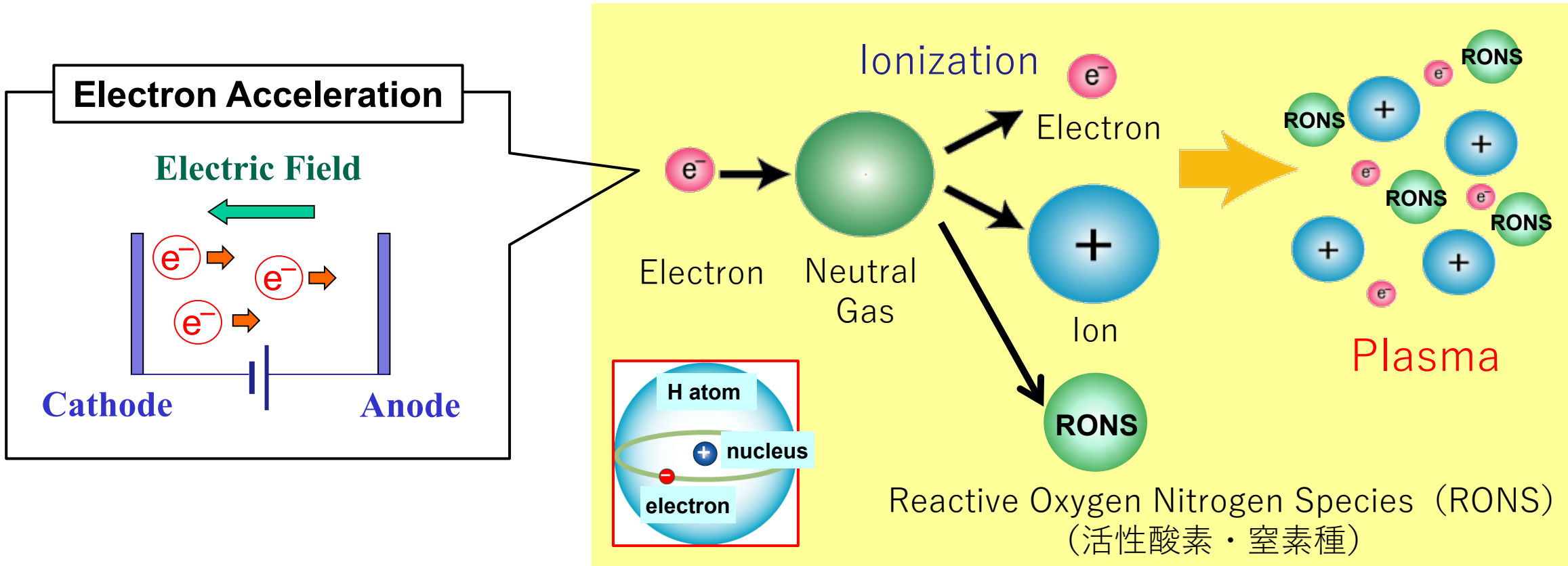


Gas

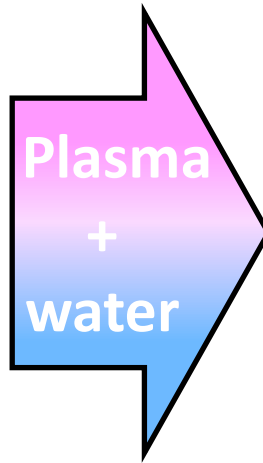
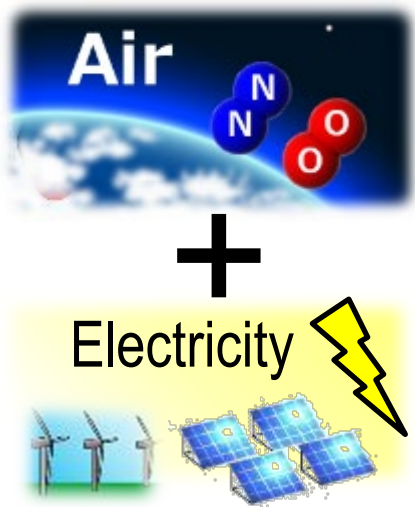
4th State



Plasma



## RONS (活性酸素・窒素種)

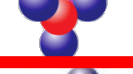


- ✓ **N** source: Air
- ✓ **O** source: Air
- ✓ **H** source: Water

※Ox. Num.: Oxidation Number

| <b>H-O</b>                    |                                                                                     | <b>O</b> | <b>Ox. Num.</b> |
|-------------------------------|-------------------------------------------------------------------------------------|----------|-----------------|
| H <sub>2</sub> O              |  |          | -2              |
| H <sub>2</sub> O <sub>2</sub> |  |          | -1              |
| OH                            |  |          | -1              |
| HO <sub>2</sub>               |  |          | -1/2            |
| O <sub>2</sub>                |  |          | 0               |
| O <sub>3</sub>                |  |          | 0               |

| <b>H-N-O</b>       |  |  |
|--------------------|--|--|
| HNO <sub>2</sub>   |  |  |
| HNO <sub>3</sub>   |  |  |
| HOONO              |  |  |
| HOONO <sub>2</sub> |  |  |
| etc.               |  |  |

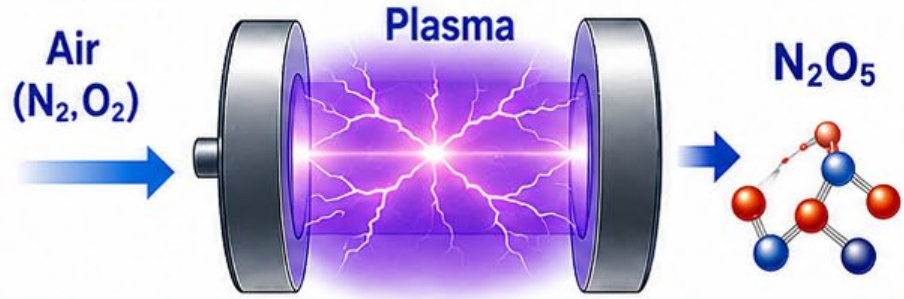
| <b>N-O</b>                    |                                                                                     | <b>N</b> | <b>Ox. Num.</b> |
|-------------------------------|-------------------------------------------------------------------------------------|----------|-----------------|
| N <sub>2</sub> O              |  |          | +1              |
| NO                            |  |          | +2              |
| N <sub>2</sub> O <sub>3</sub> |  |          | +3              |
| NO <sub>2</sub>               |  |          | +4              |
| NO <sub>3</sub>               |  |          | +5              |
| N <sub>2</sub> O <sub>5</sub> |  |          | +5              |

**dinitrogen pentoxide**  
**(五酸化二窒素)**

| <b>H-N</b>        |                                                                                       |                               |                                                                                       |                               |                                                                                       |
|-------------------|---------------------------------------------------------------------------------------|-------------------------------|---------------------------------------------------------------------------------------|-------------------------------|---------------------------------------------------------------------------------------|
| NH <sub>3</sub>   |  | N <sub>2</sub> H <sub>4</sub> |  | N <sub>2</sub> H <sub>2</sub> |  |
|                   |                                                                                       | N <sub>2</sub>                |  |                               |                                                                                       |
| <b>N Ox. Num.</b> | -3                                                                                    | -2                            | -1                                                                                    | 0                             |                                                                                       |

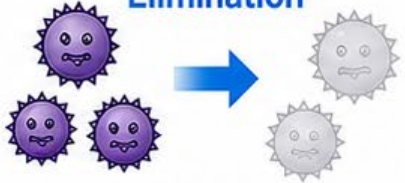
Focus on N<sub>2</sub>O<sub>5</sub>, the reactive nitrogen species with the largest oxidation number

## Plasma Synthesis of $\text{N}_2\text{O}_5$ from Air

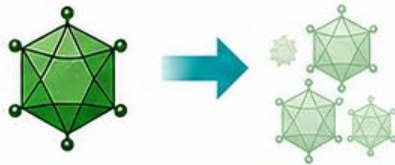


## Sterilization & Virus Inactivation

### Bacterial & Fungal Elimination



### Virus Inactivation



## Nitrogen Fertilizer Effect



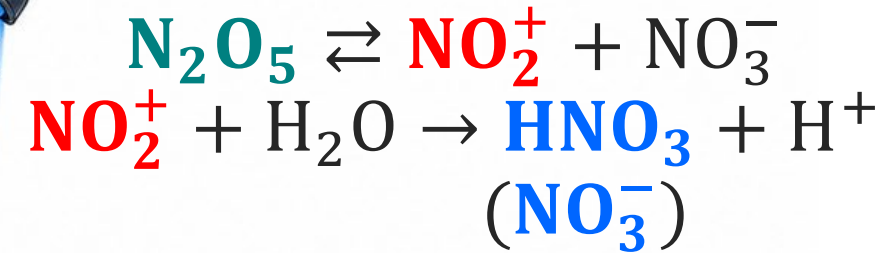
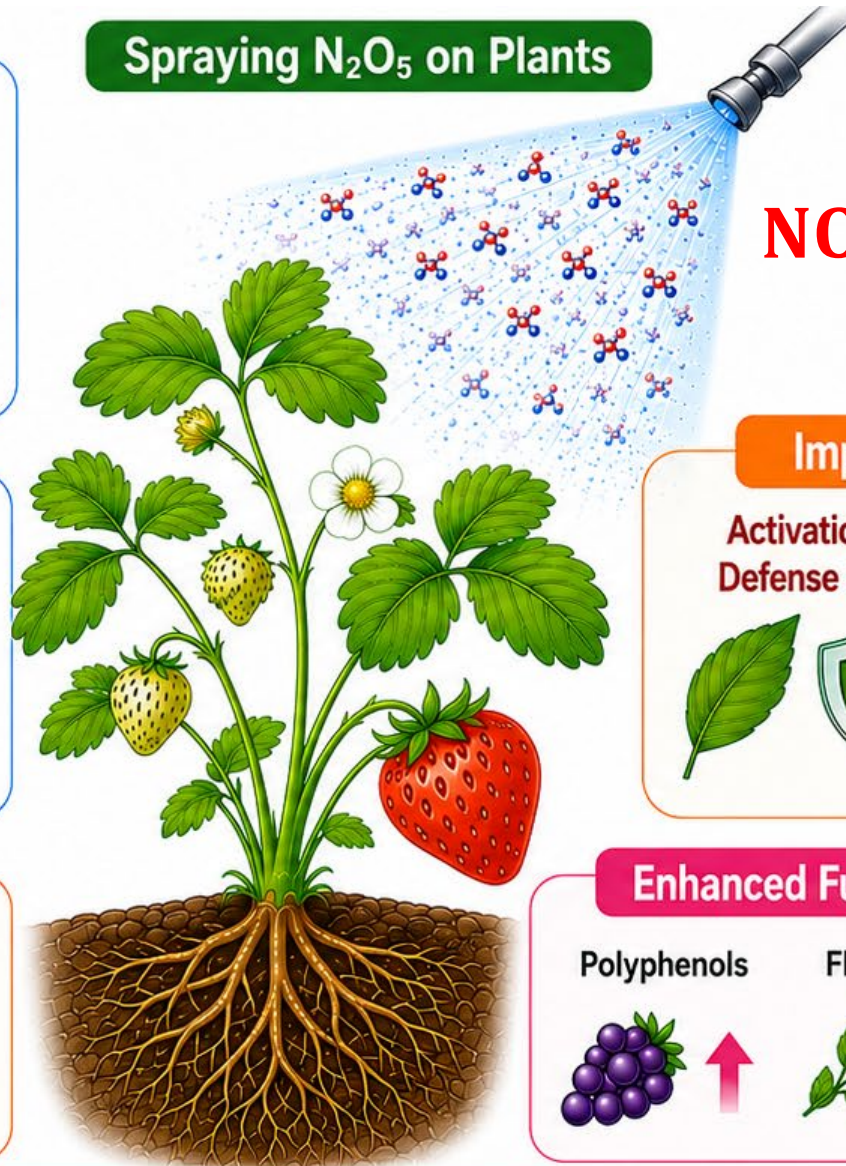
Nitrate ( $\text{NO}_3^-$ )



Uptake and utilization by plants



## Spraying $\text{N}_2\text{O}_5$ on Plants



## Improved Disease Resistance

Activation of Plant Defense Responses



Stronger Resistance to Diseases



## Enhanced Functional Compounds in Plants

Polyphenols



Flavonoids



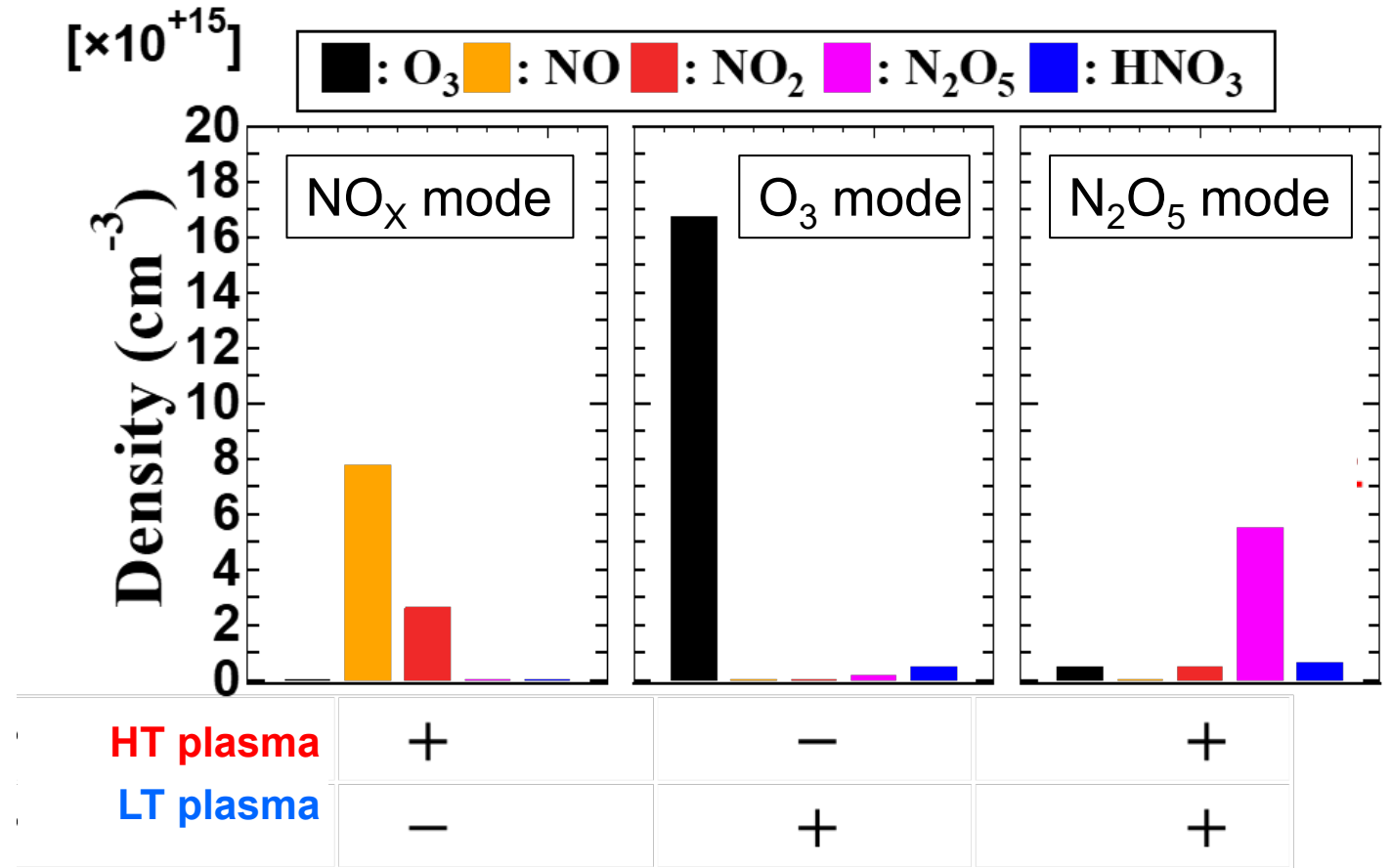
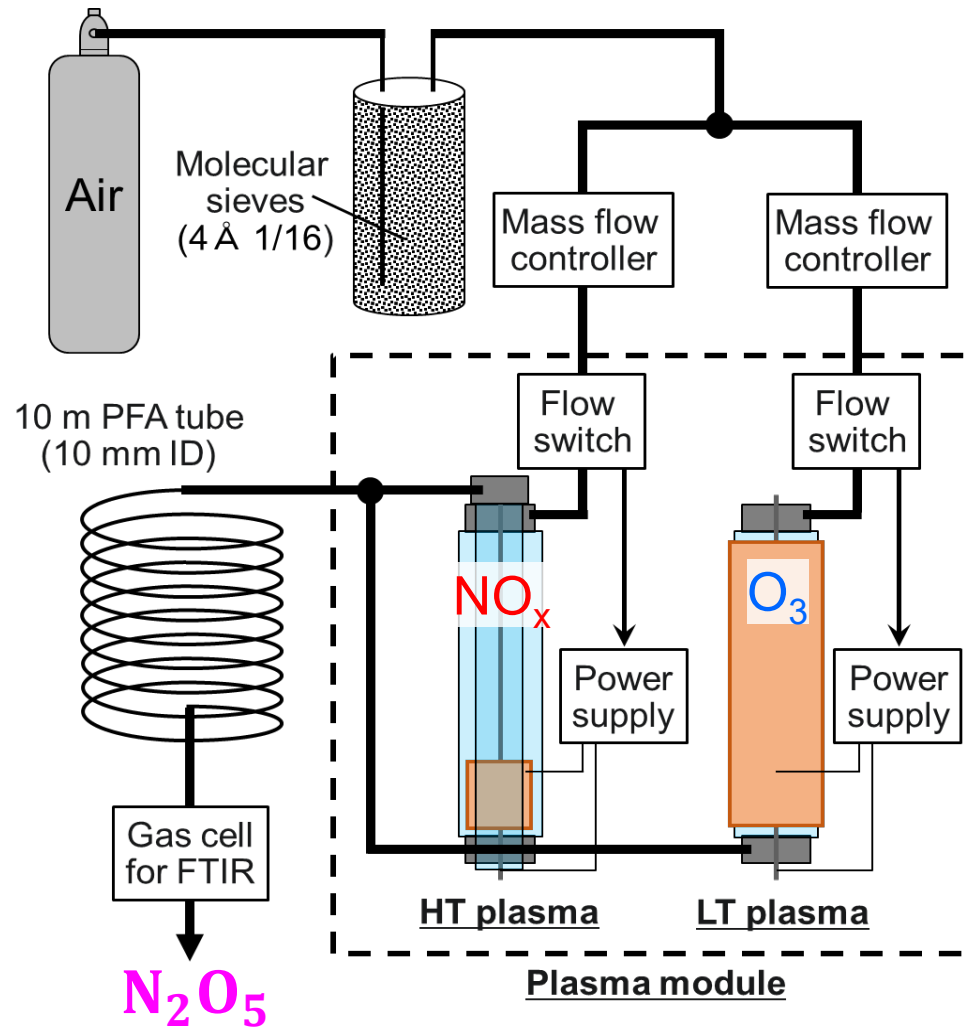
Vitamin C



Anthocyanins



**$\text{N}_2\text{O}_5$  Improves Plant Health and Value!**

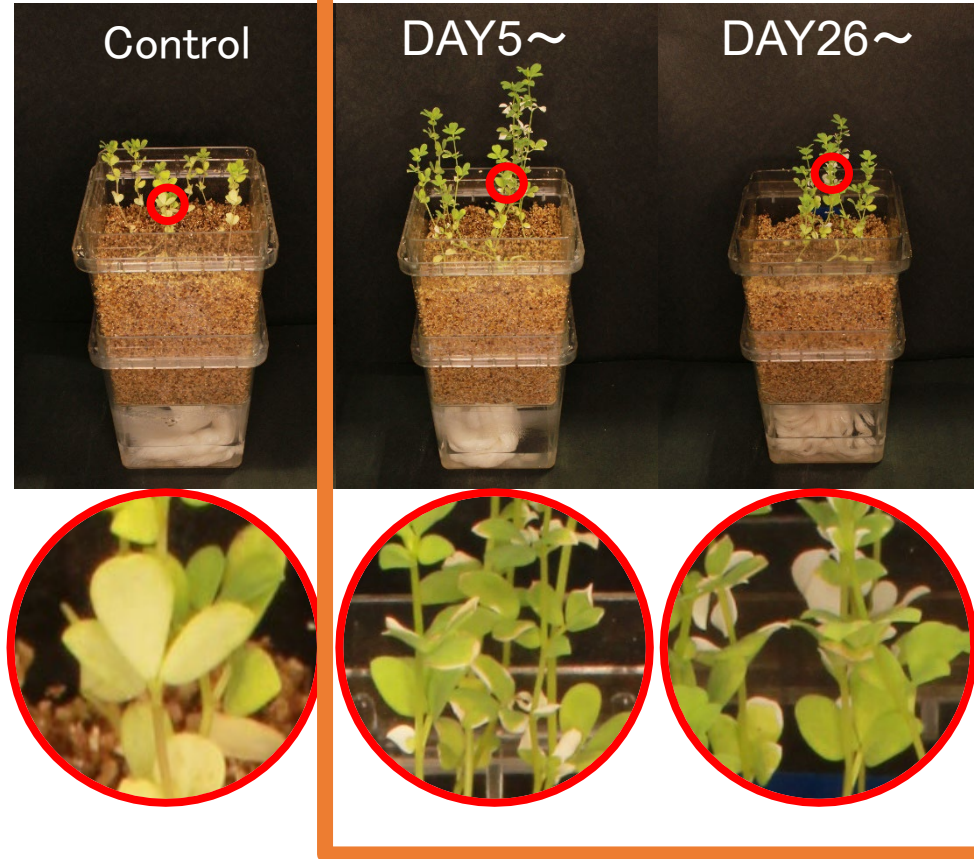


This Air APP device can precisely control reactive species composition easily.

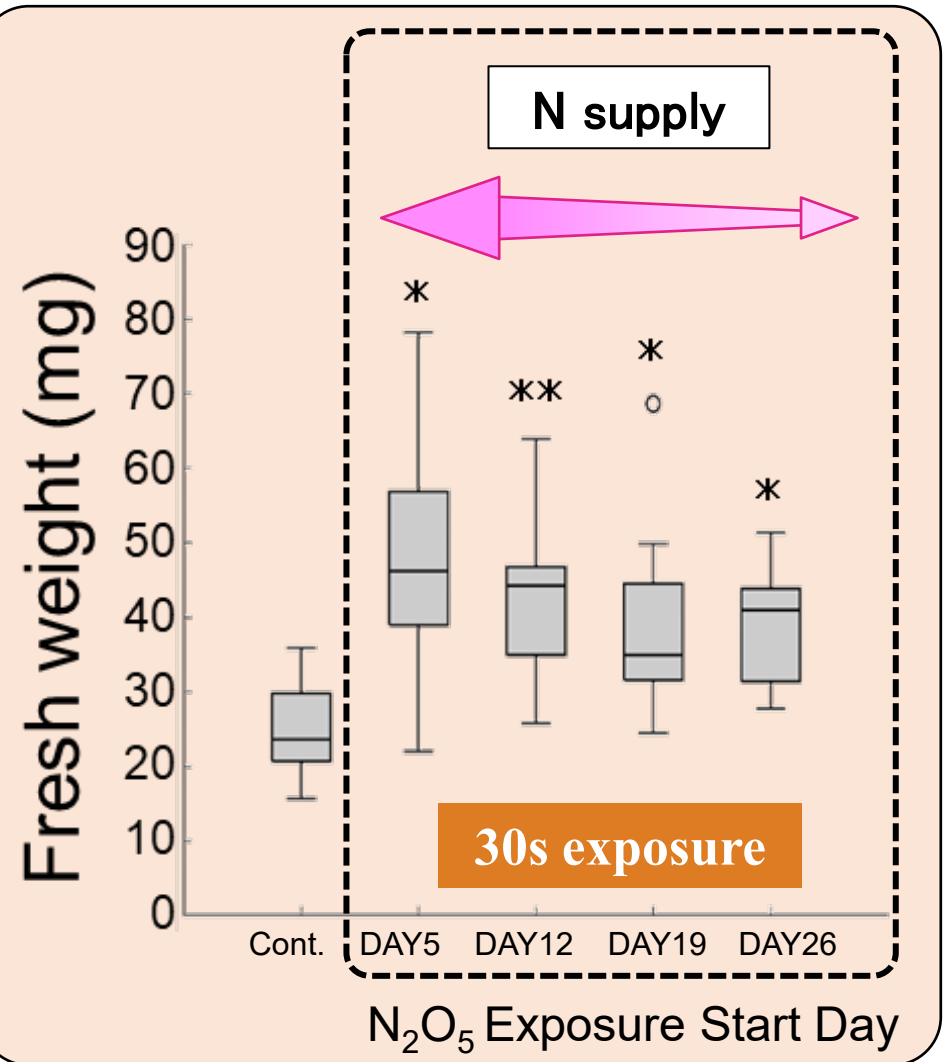
S. Sasaki, K. Takashima, and T. Kaneko: Ind. Eng. Chem. Res. **60**, 798 (2021).

特許 第7823889号：五酸化二窒素生成装置および五酸化二窒素生成方法 (2026).

## Observation: DAY47

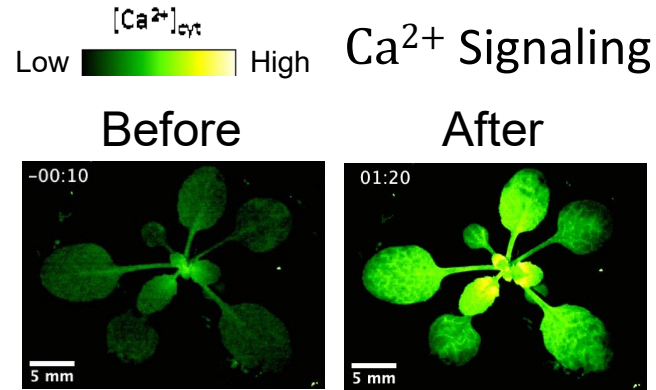


Nitrogen deficient *Lotus japonicus* (ミヤコグサ)

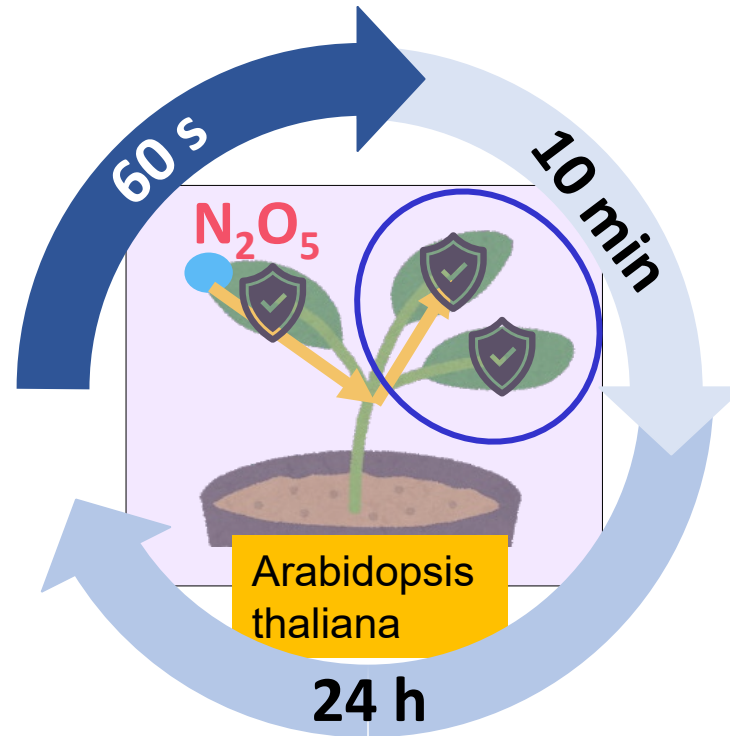
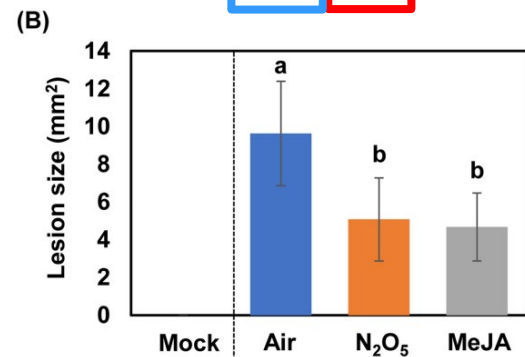
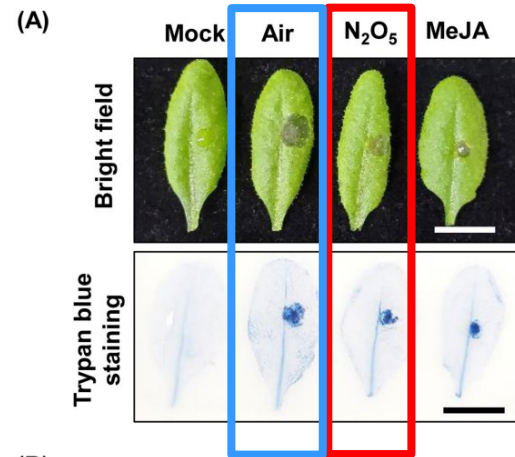


Growth was accelerated by  $N_2O_5$  exposure compared to control.

# Activation of Plant Immunity by $N_2O_5$ (五酸化二窒素による植物免疫向上)



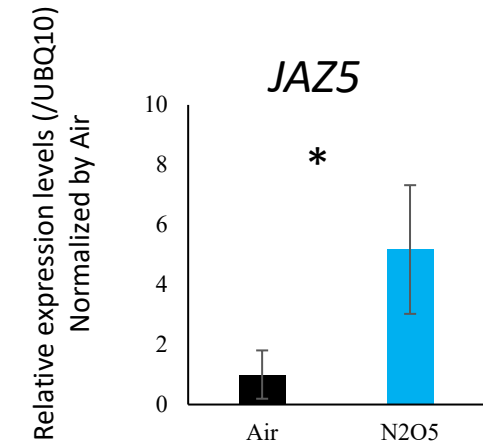
S. Sasaki, H. Iwamoto, K. Takashima, M. Toyota, A. Higashitani, T. Kaneko: PLoS One **20** (2025) e031857.



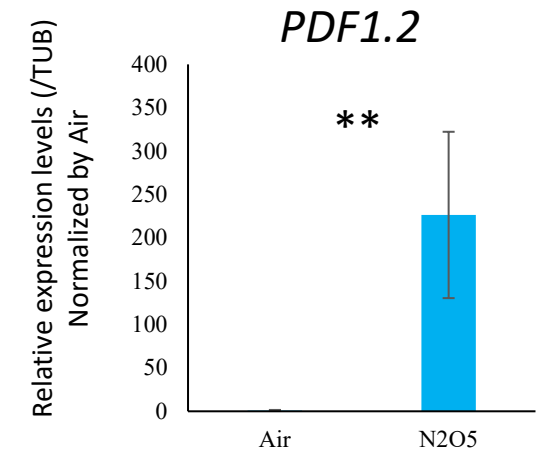
## Activation of Plant Immunity

D. Tsukidate, K. Takashima, S. Sasaki, S. Miyashita, T. Kaneko, H. Takahashi, S. Ando: PLOS ONE **17**, e0269863 (2022).

## Jasmonic acid-related gene expression



## Expression of genes encoding antimicrobial peptides



## SUSTAINABLE FARM



SOLAR  
POWER



AIR  
AS RAW  
MATERIAL



CHEMICAL-FREE  
FARMING



SUSTAINABLE  
PRODUCTION

1 AIR INTAKE  
( $O_2$ ,  $N_2$ ,  $CO_2$ )



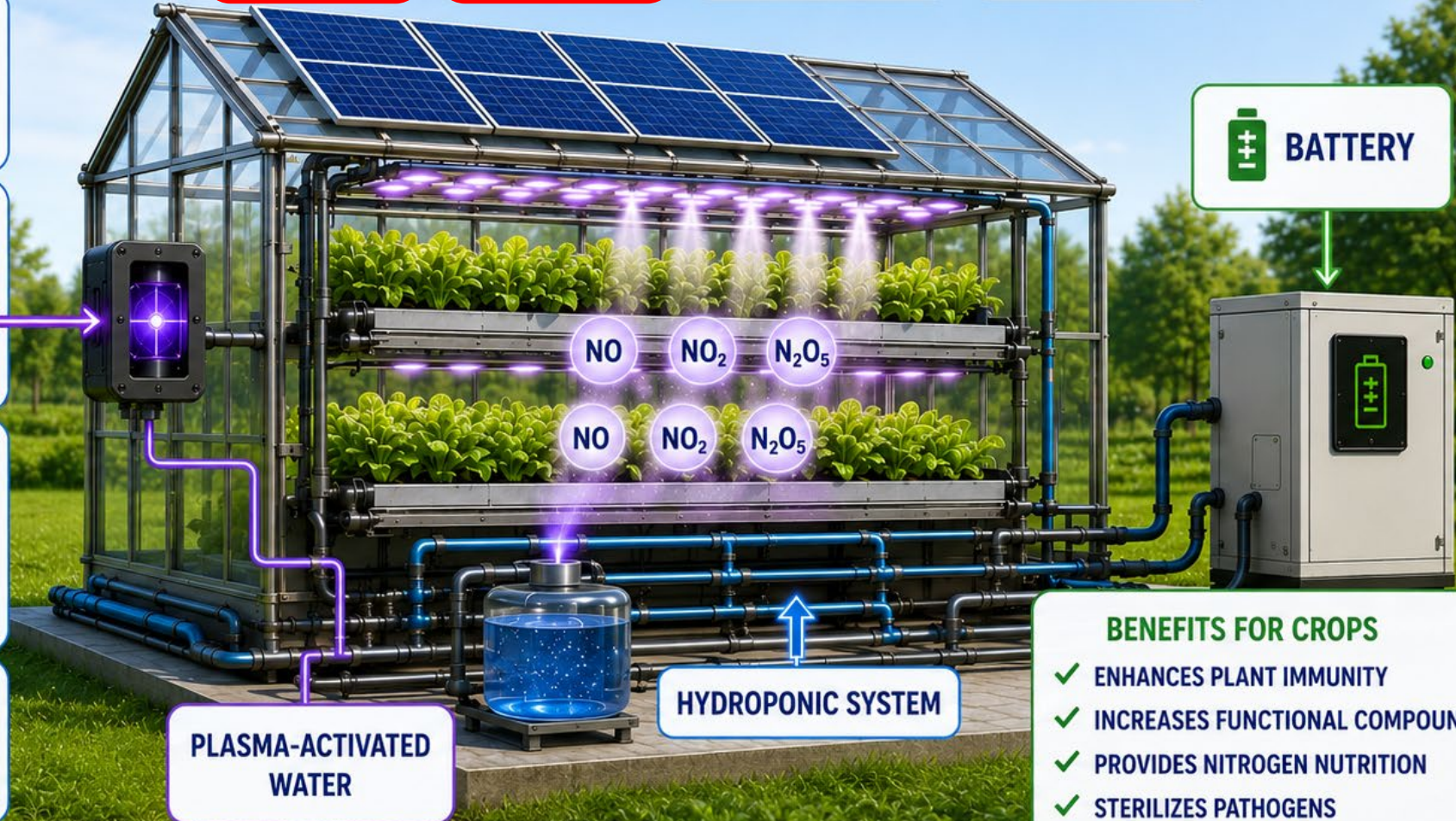
2 PLASMA GENERATOR  
(NON-THERMAL PLASMA)



3 REACTIVE NITROGEN  
SPECIES (RNS)  
 $NO$ ,  $NO_2$ ,  $N_2O_5$



4 NATURAL FERTILIZER  
AND PESTICIDE  
(SOIL / HYDROPONICS)



### BENEFITS FOR CROPS

- ✓ ENHANCES PLANT IMMUNITY
- ✓ INCREASES FUNCTIONAL COMPOUNDS
- ✓ PROVIDES NITROGEN NUTRITION
- ✓ STERILIZES PATHOGENS