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Environment and Energy Lab activities and development prospect

Kenji Ebihara[1],Fumiaki Mitsugi[2], Shin-ichi Aoqui[3], Yoshitaka Yamashita[4], Seiji Baba[5], Henryka D.Stryczewska[6]

1 Environment and Energy Laboratory, 2 Faculty of Advanced Science and Technology,Kumamoto University, 3 Faculty of Computer and Information Sciences, Sojo University, 4 Sanwa hi-tec Co.Ltd., 5 Densoken Co.Ltd.,
6 Faculty of Engineering and Computer Science, Lublin University of Technology

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Aso-Kujyu Mountain range

Contents

1. Purpose

Environment and Energy Laboratory (established at 2009) aims at promoting innovation of environment and energy technologies.
We have developed environmentally friendly systems for agriculture production , soil treatment, air/water purification and biomedical treatment.

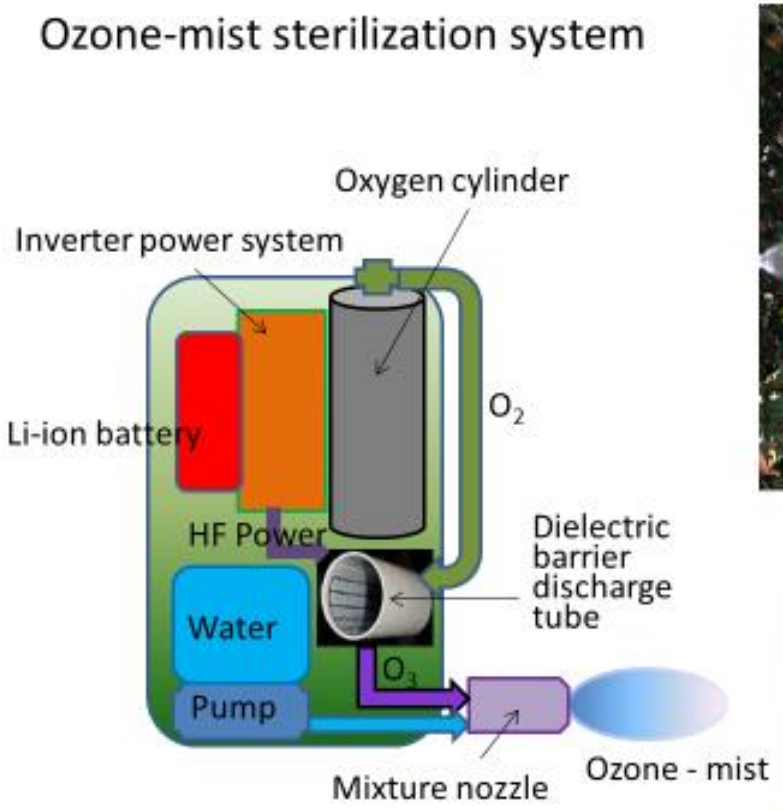
- **Portable ozone-mist sterilization system for non-chemical agriculture**
- **Remote/auto ozone-mist sterilization of insect pest using Deep Learning technology**

Fukuoka Office

2. Background of portable ozone-mist sterilization system

Characteristics

1. Realizes high sterilization rate by ozone-mist chemical free spray in agricultural management.
2. Kills living small insect pests, worms, bacteria, viruses in short operation period.
3. Backpack type system consisting of various functional units.
4. Oxygen gas and water produce an ozone-mist mixture creating pesticide radicals which kill microorganism.
5. Leaves no harmful residue on the agricultural produce.



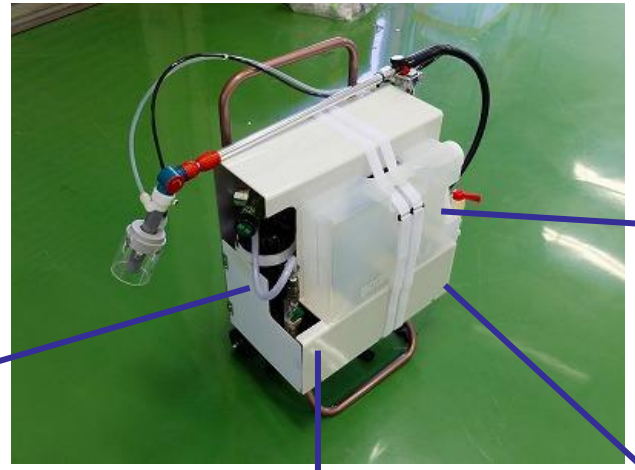
Ozone derivatives radicals

Proto-type No.3

Application of ozone-mist sterilization

Non-chemical farming

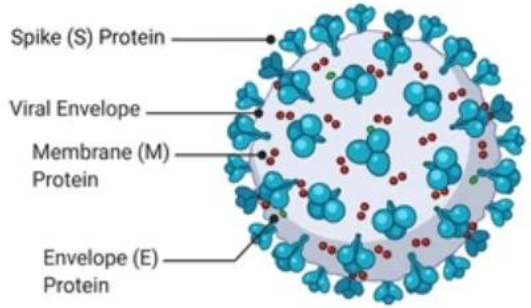
Proto type No.5



Livestock: breeding processes

Eggs: Duck

Disinfection
COVID-19



Epidemics prevention

O3 inactivation:H.Yano,Nara Medical University

Non-chemical ozone-mist sterilization system

Ozone generator

Dielectric barrier discharge tubes

Cylindrical type 6kHz;Plate type 10~13kHz
Oxygen gas 0.5~4 liter /min
Ozone output Max.102g/m³;Max.80g/m³
Power supply
AC440W; DC14.4V Li-ion battery, 3.0Ah, 44Wh 2sets, 150W
Water cooling ;Air cooling

Dielectric Barrier Discharge Tube

Cylindrical type

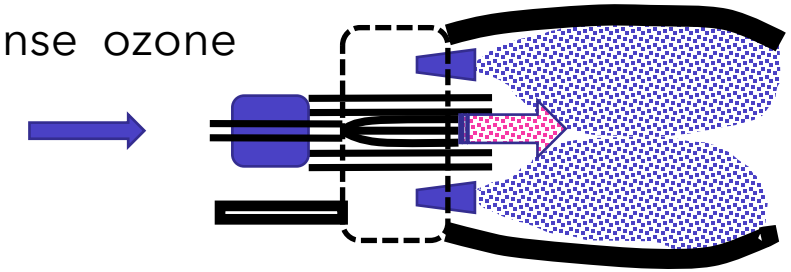
Plate type

Max:102gO_3/m^3
at 3 LO_2/min

Max:80gO_3/m^3
at 1LO_2/min

Ozone solubility ~ 5ppm

High dense ozone



Ozone-mist spray

Sterilization rates of ozone-mist sterilization system

Table Ozone-mist sterilization rate of aphids

Method	Ozone-mist	Gaseous ozone	Water-mist	Chemical synthetics
Conditions	68gO_3/m^3 in 2L/minO_2 Mist-water 330mL/min	68gO_3/m^3 in2L/min O_2	330mL/min	Ortolan (1000-fold dilution)
Sterilization rate	90-100% for treatment time(T)=3min	50% T=2min 100% T=4min	0% T=2min	75% T=5s 90% T=10s

Ozone: 86g/m3 ,1liter/minO2
Ozone solubility:5ppm

Aphid

Technical data of ozone-mist sterilization spray

Insects	Plant	Sterilization rate
Tobacco Myzus persicae		80~90% O_3:86g/m^3 ,1liter/minO_2 Ozone solubility:5ppm Spraying time: 10sec
Tobacco green caterpillar		50% O_3:86g/m^3 ,1liter/minO_2 Ozone solubility:5ppm Spraying time: 20sec
Solidago Canadensis		95~100% O_3:86g/m^3 ,1liter/minO_2 Ozone solubility:5ppm Spraying time: 10sec
Orange Toxoptera citricidus		100% O_3:86g/m^3 ,1liter/minO_2 Ozone solubility:5ppm Spraying time: 10sec
Camellia Simensis (Green tea leaf)		100% by ozone gas O_3:86g/m^3 ,1liter/minO_2 Spraying time: 20sec 90% by ozone-mist

玉溪紅塔煙草集団有限責任公司
Hongta Group Tobacco Industrial Co.Ltd

Yunnan Agricultural University（Kunming）

Agricultural fields assessment
１）玉溪市　Yuxi
２）徳宏自治州

Visit for assessment at tobacco farms in China

Myanmar

Non-chemical tobacco farms for Ethnic minorities


中国工業見本展示会計画中

Lunghwa University of Technology

坪林消毒御茶畑
Non-chemical tee farm

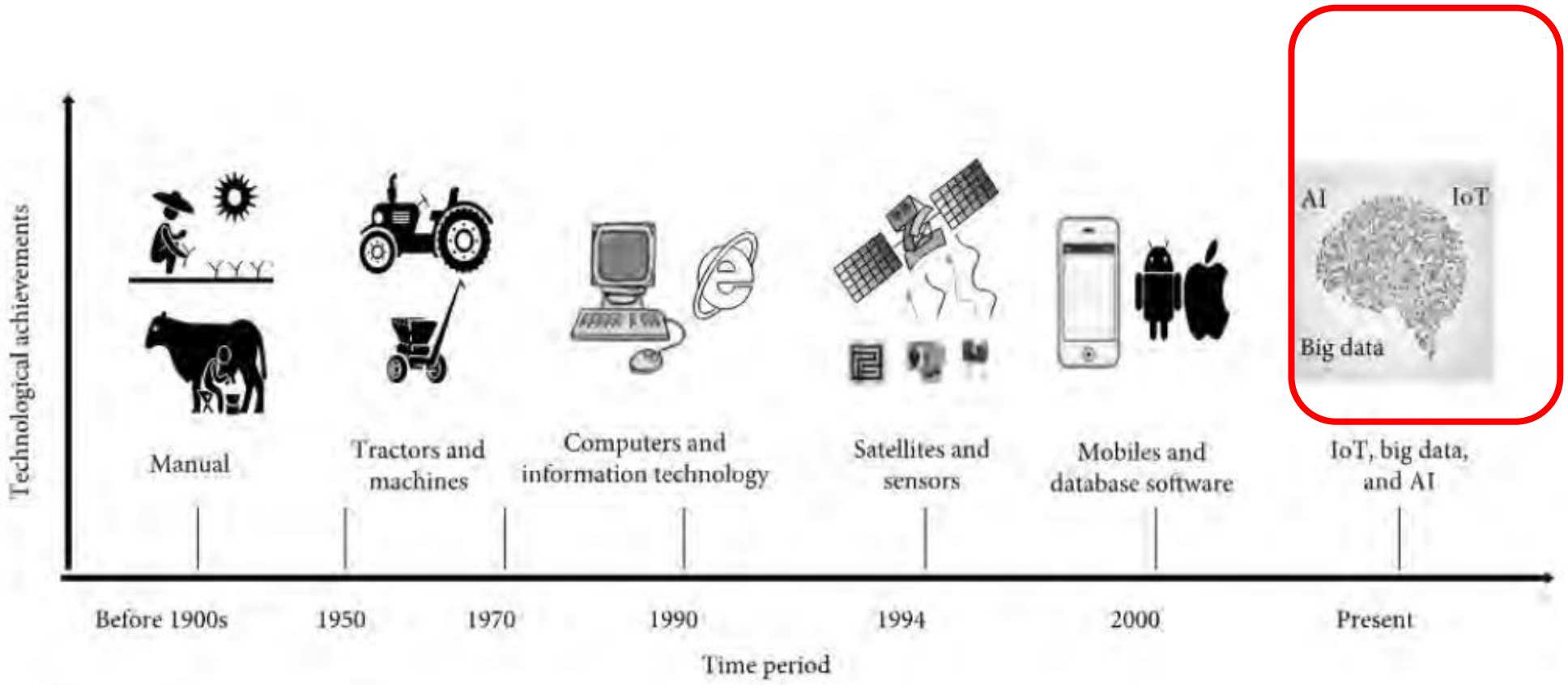
Taiwan Agricultural Research Institute

Livestock Rearch Institute Ilian Branch

National Ping Tung University of Science and Technology

3. Evolution of different technologies in agriculture sector

- Current precision agriculture has introduced AI technologies to increase food production. AI technologies use Big data such as plants, pests, diseases and weather



- IoT
- Big Data
  - plants
  - disease
  - pests
  - meteorology
- AI
  - sensing
  - detection
  - identification

(IEEE Access, Vol.7,45110,2019)

AI technologies for sustainable agriculture

Typical applications of AI

- Corp yield prediction and Price forecast
- Intelligent spraying
- Predictive Insights

  Right time for sowing, weather conditions
- Agriculture Robots
- Corp and soil monitoring
- Pest recognition and Disease diagnosis

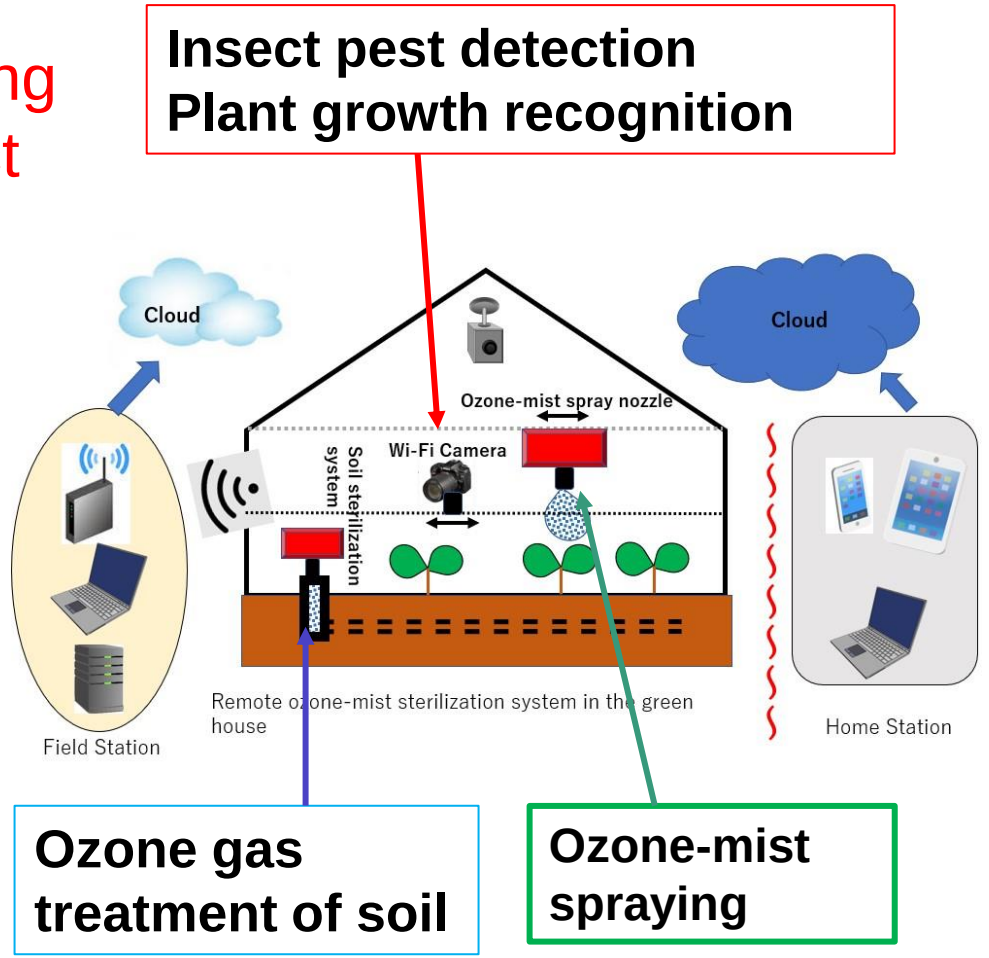
Drone spraying at rice farm

Auto spray system

Outline of intelligent ozone-mist spraying system

The aim of present work is development of an intelligent ozone-mist spraying system incorporating the **deep learning(DL)** method to recognize insect pests and plant growth.

- The **YOLO object detection** based on the deep learning is adopted to make detection and classification of insect pests.
- The deep learning (**TensorFlow**) is applied to analyze plant images for recognition of plant growth.
- The **greenness index** (=2G-R-B:Green G,Red R, Blue B) of plant images is used to predict the photosynthetic activity of plants. This index is one of quantitative indicators of plants, agricultural farms and forests.

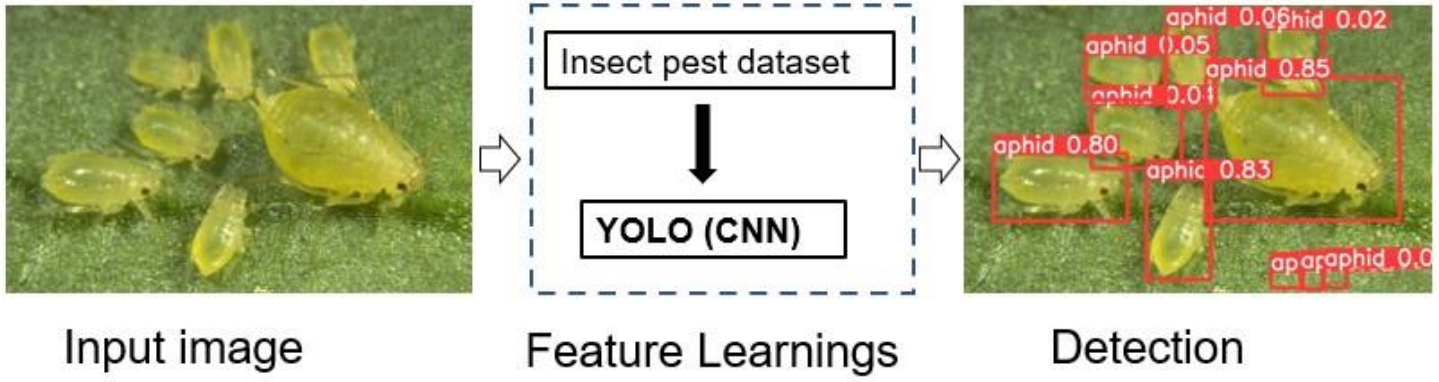


YOLO and TensorFlow are software libraries including a variety of DL algorithms.

4. Insect pest recognition by Deep learning

YOLO Detection of Insect Pests

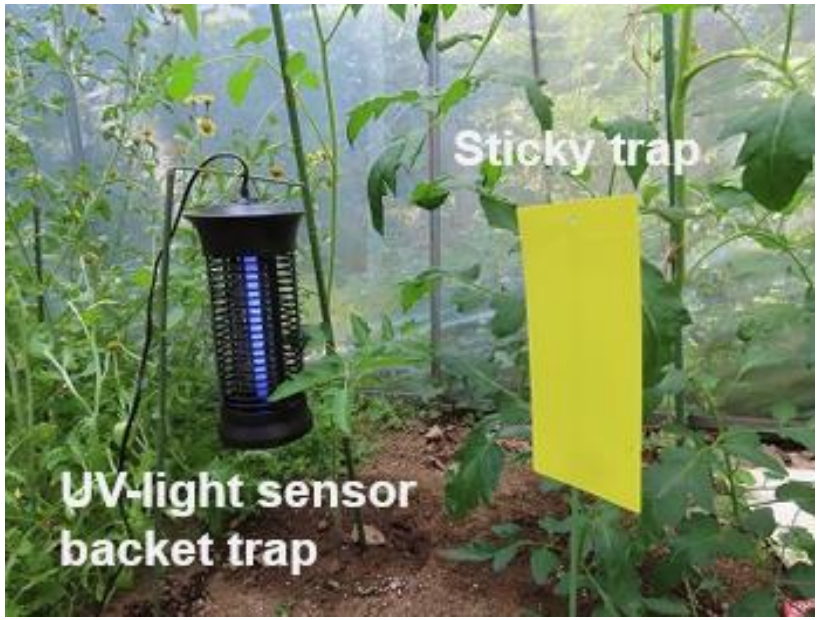
- YOLO deep learning method is adopted to detection and identification of insect pests. Pest images were tested.
- 45 images of insects including 41 aphids, 15 moths, 5 beetles, 8 flies, and 9 ants were trained.
- Each image has 640x640 pixels.

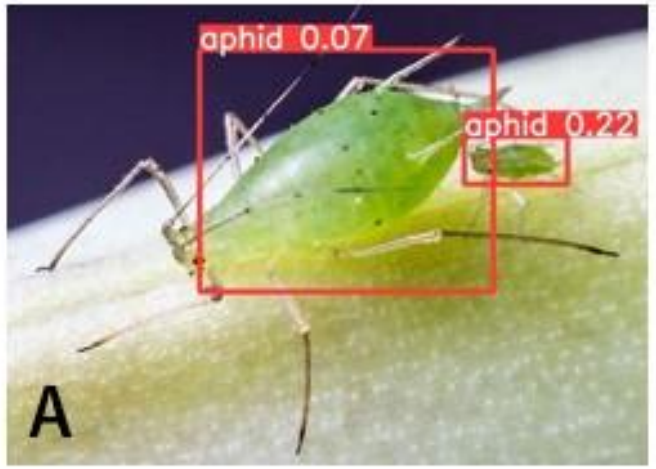


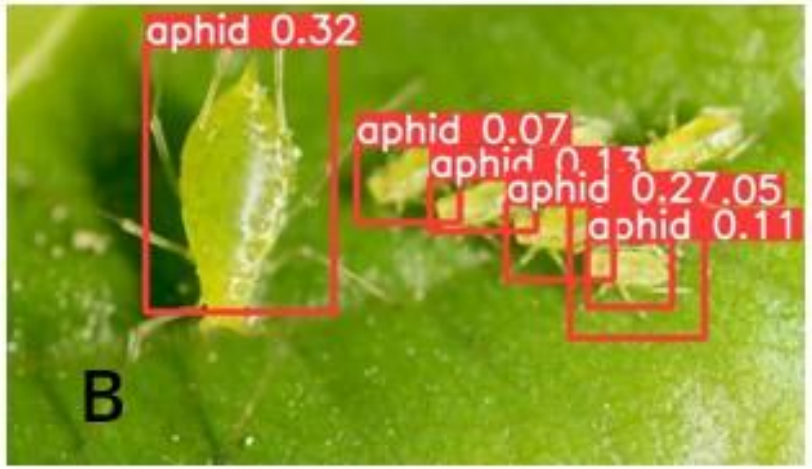
Input image　　Feature Learnings　　Detection

- The bounding box includes confidence and the point information of the box
- Class(names), a center coordinate(x,y), Hight, Width .

Confidence : probability that the bonding box contains the objects.







Detection of images of aphids on leaves (A,B) and on sticky traps (C,D). The numerical values of the bounding box are the confidence.

5. Remote identification of plant growth by TensorFlow

Deep learning(TensorFlow) analysis of plant images

■Plant images and their sizes of leaves were taken during young to ripeness stages (about 70 days).

■ Three color channels (Red, Green, Blue : R, G, B)of their leaves have intensity levels from 0 to 256 (integer valued).

■The greenness index intensity is calculated by Smn = 2G-R-B at a pixel (row:m, column:n) and is a predicator of photosynthesis of plants.

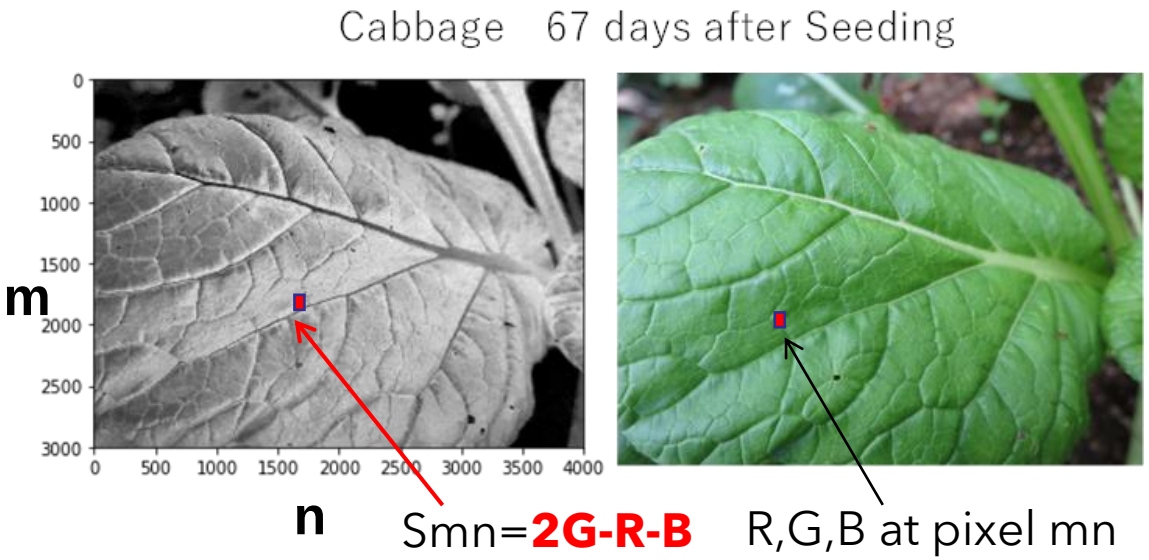
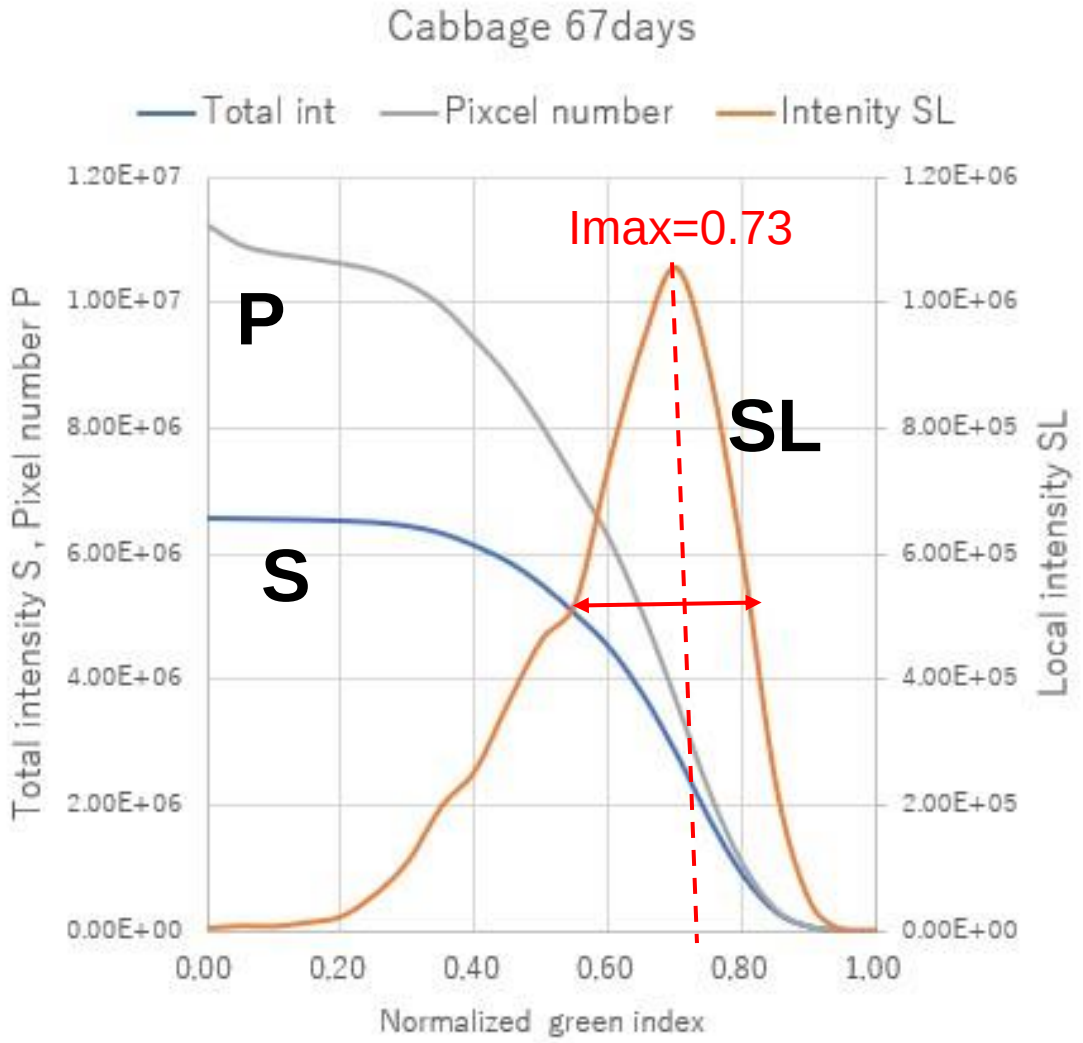


Image for green index intensity Smn(left) and the photo (right) of a cabbage leaf.

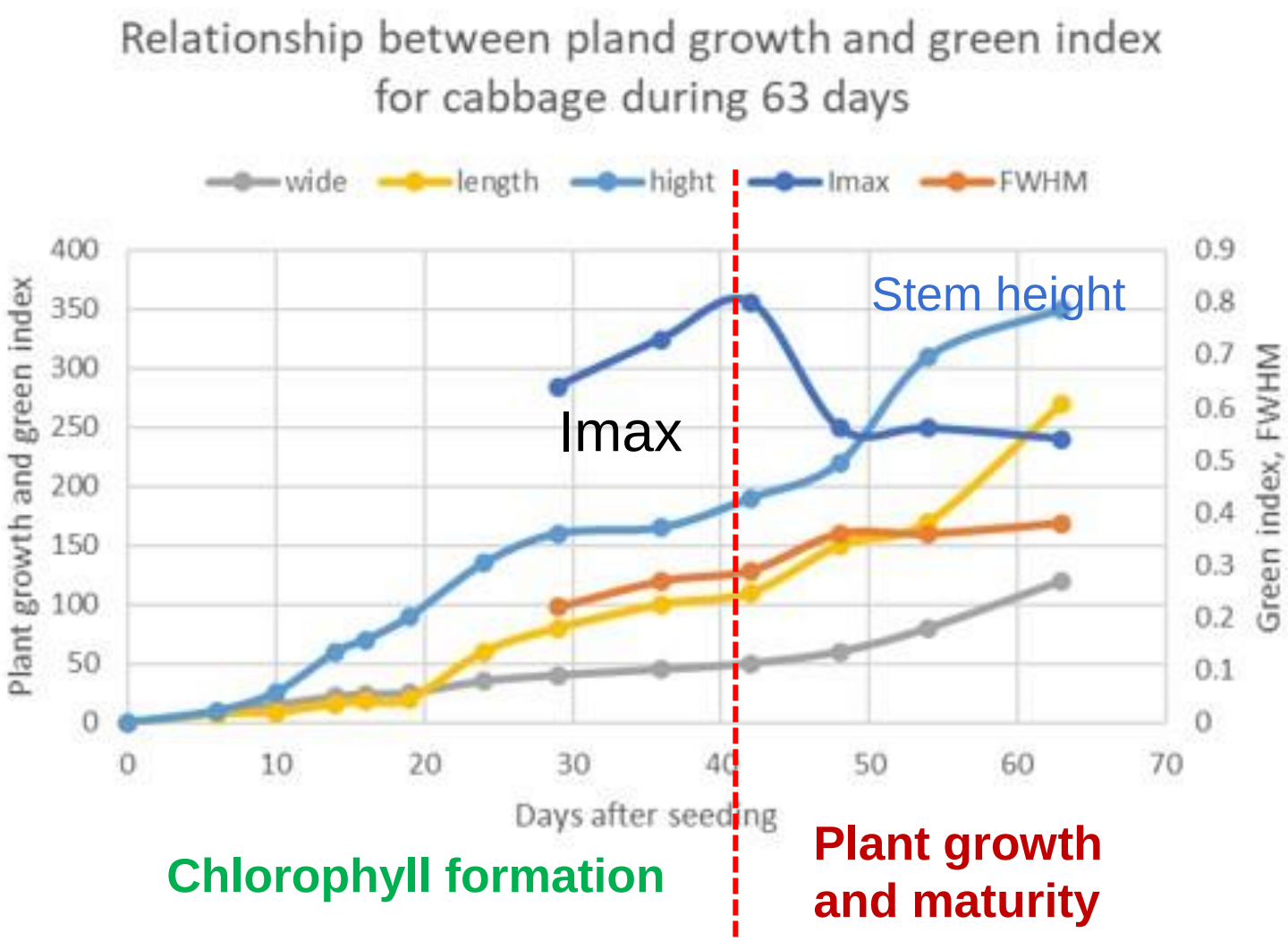
P = total sum of pixel mn =3000x4000=12Mega
S = total sum of Smn

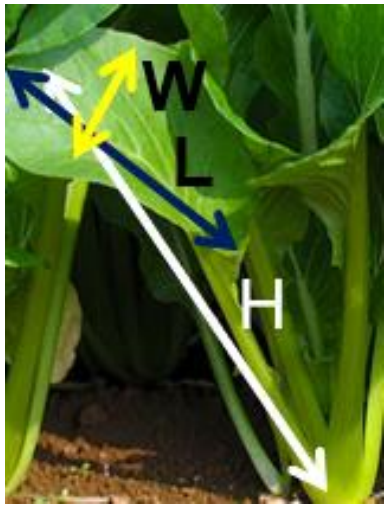


Total pixel number P, total intensity S and local intensity SL as a function of normalized greenness index

- The local intensity ,SL , as a function of the normalized greenness index value Index(=Smn/Smn(maximum)).
- The SL profile f has a maximum value of 1.16×10^5 at Index(=Imax) =0.73 and the full width at half maximum (FWHM) of 0.27.
- The peak index (Imax) and the FWHM valus are specific predictors which are closely related to the plant growth behavior (photosynthetic activity).

SL~ greenness index=2G-R-B





The sizes of the leaf width, the leaf length and the stem height rapidly increase with time. The growth is mostly based on the photosynthesis due to blue light with the red light.

The Imax has a peak value at 42days and then rapidly decreases following a constant value.

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Seeding~42 days :

chlorophyll formation

42 days ~ 63 days :

plant growth and maturity

The dominant process of photosynthesis is chlorophyll formation at early stage and shifts to production of glucose which makes new leaves and other plant parts.
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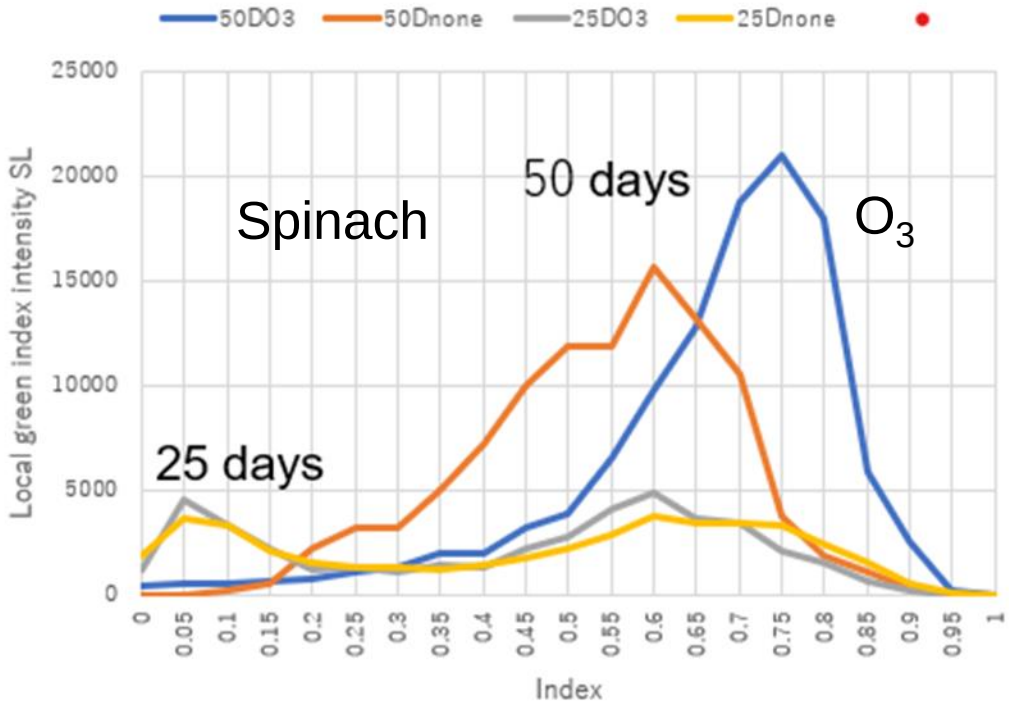
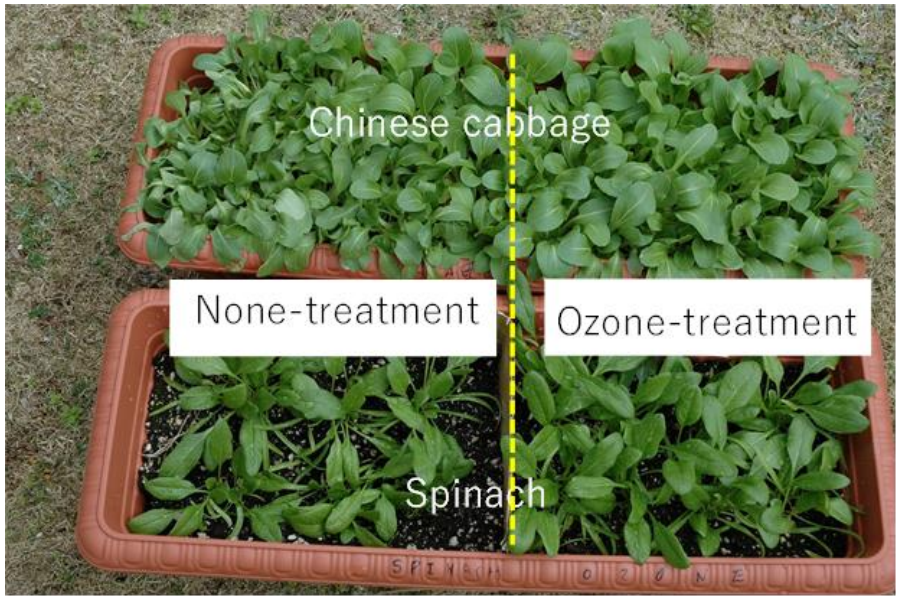
Plant growth in ozone-treated soil

Local green index distribution



Ozone treatment conditions : the ozone of 12 g was injected into the soil of 3kg; 100gO_3/m^3, 2LO_2/min, 60min.



50 days after seeding

High green index in ozone treated- soil shows the enhancement of plant growth.

6. Remote/auto ozone-mist sterilization system

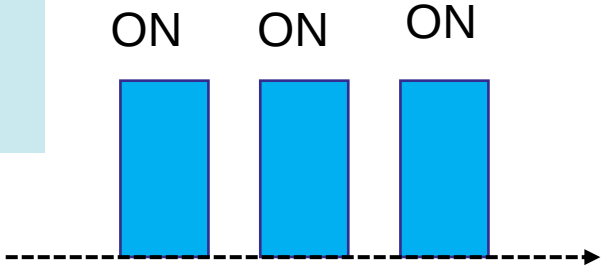
Deep learning

- Pest species
- Growth stage of plant

Database of ozone-mist sterilization

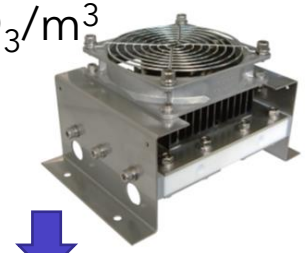
Sterilization conditions
- Class(Pest name)
- Ozone concentration
- Treatment time
- Distance to target

Applied power



Max:102gO_3/m^3

Max:80gO_3/m^3



Raspberry Pi

Single-board computer

The ozone generator is operated by a single-board computer (Raspberry-Pi) which is connected remotely to the main computer.

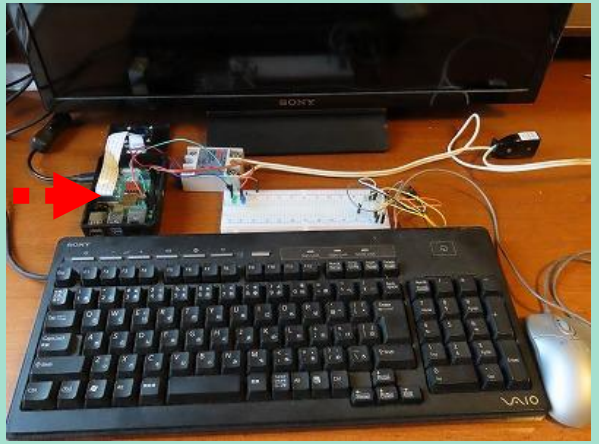
Current status of progress on remote/auto ozone-mist sterilization system

Deep Learning

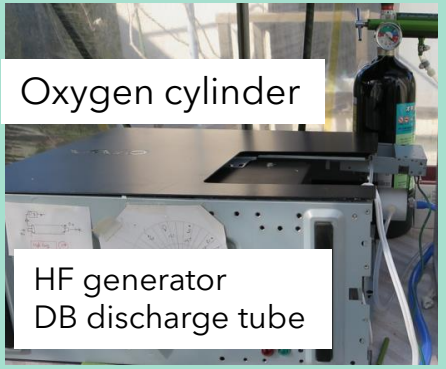
- Image capture
- Pest identification
- Accounting number

- Sterilization conditions
- **Ozone concentration**
- **Treatment time**

Wi-Fi



Raspberry Pi system
(**Single-board computer**)



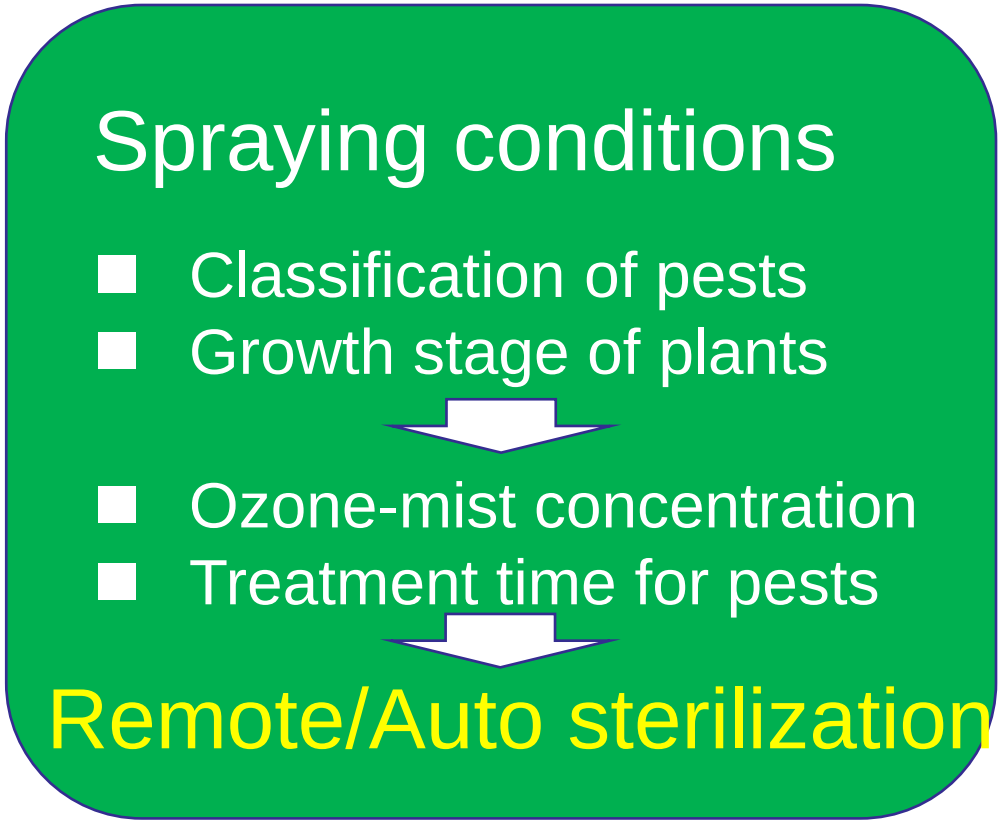
Ozone generator system

Remote control station

Agriculture field (Greenhouse)

5.Conclusion

1. **Insect pest detection and plant grow of vegetables can be clarified by the Deep Learning technique.**
2. **Remote and auto-ozone-mist spraying will be available to realize the sustainable agriculture.**



Remote /auto ozone-mist sterilization

NAWA Project International Seminar at Kumamoto
July 4-6,2022

Thank you for your kind attention!