

Value Chain Analysis and Research Direction in Protected Horticulture

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Oct 18, KSHS2018

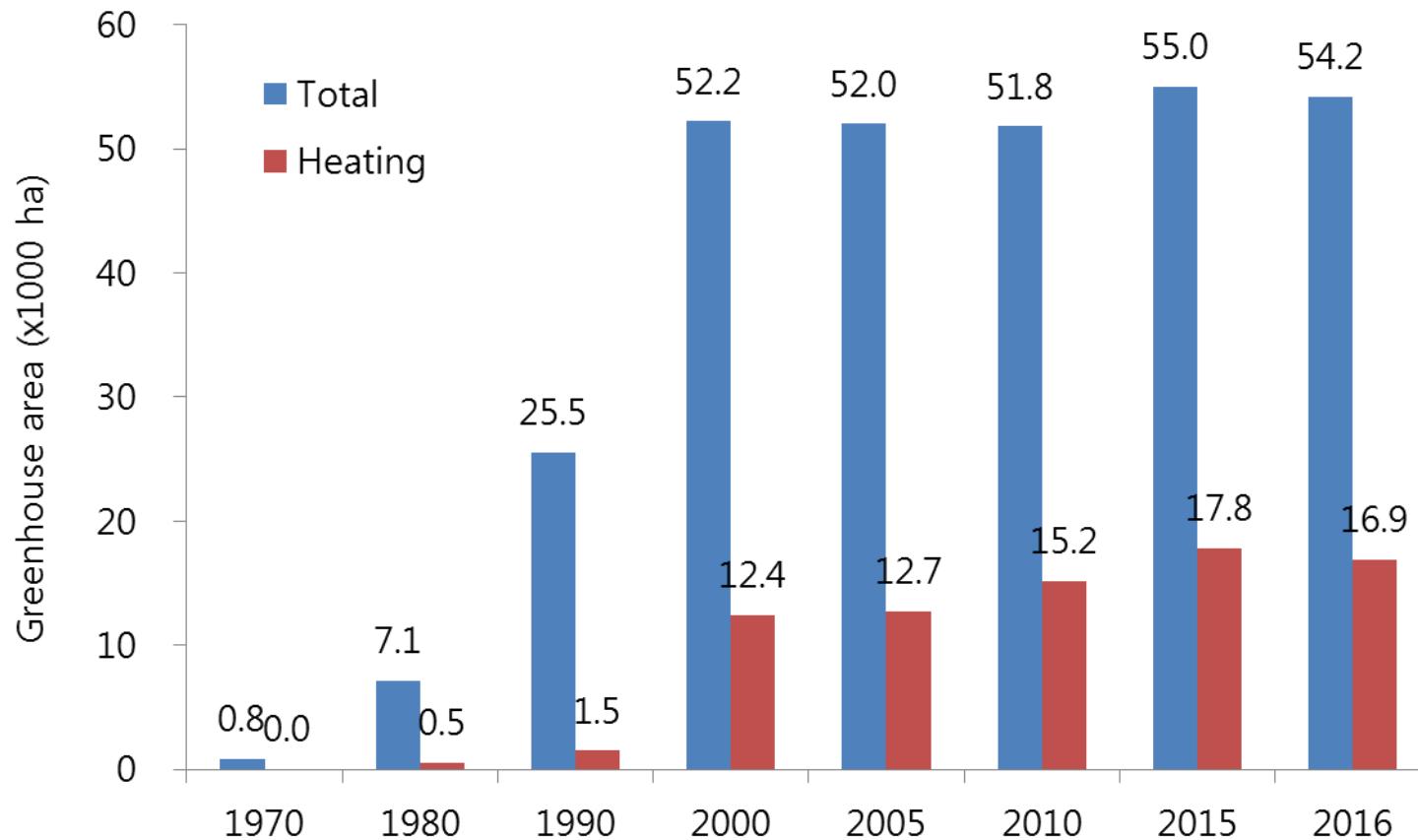
Introduction

Considerations

- ❑ Statistics**
- ❑ Current situation**
- ❑ Current research**
- ❑ Research direction**
- ❑ Conclusion**

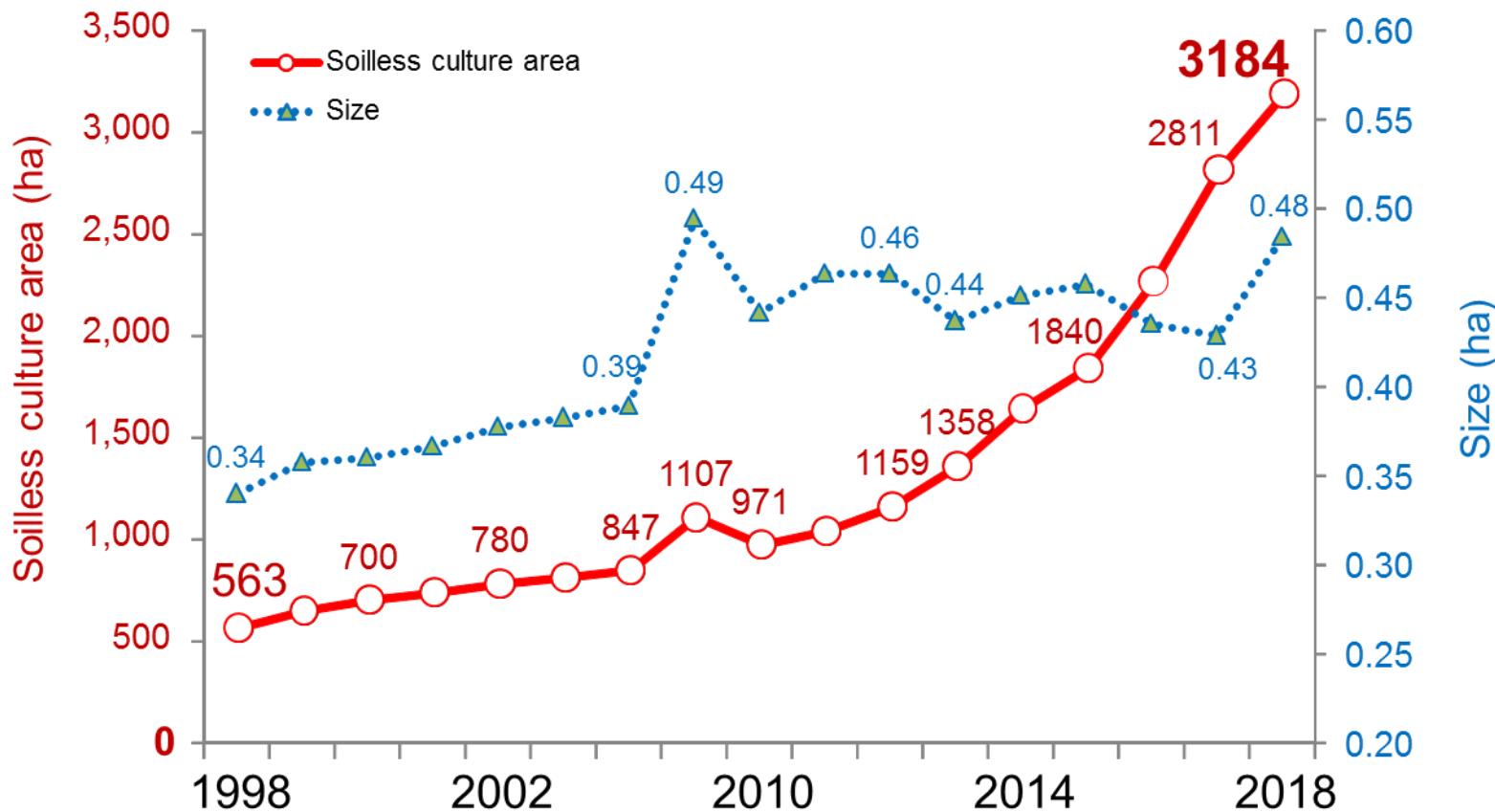
Statistics

Total greenhouse area and heated area

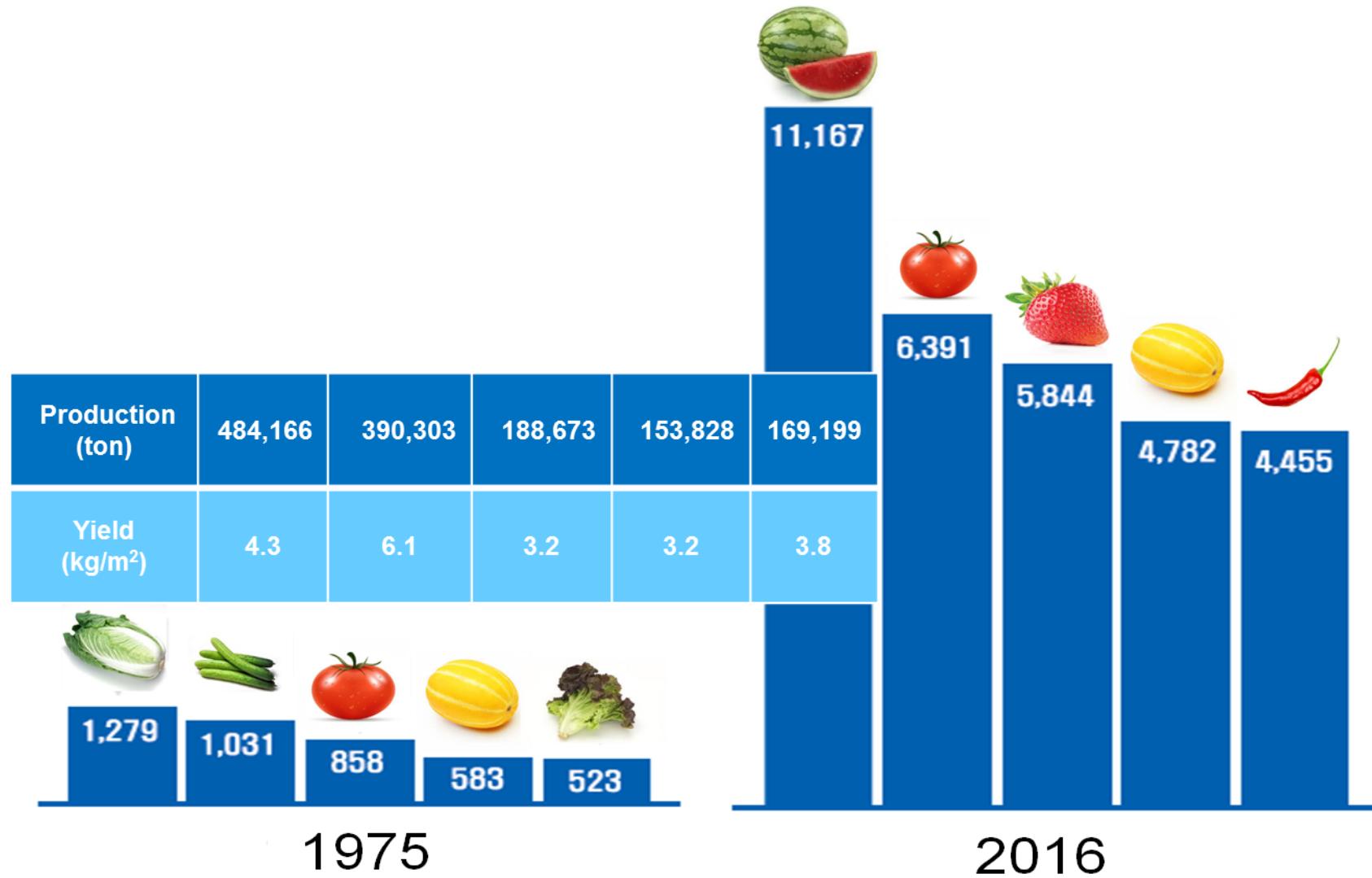


* Source from MAFRA

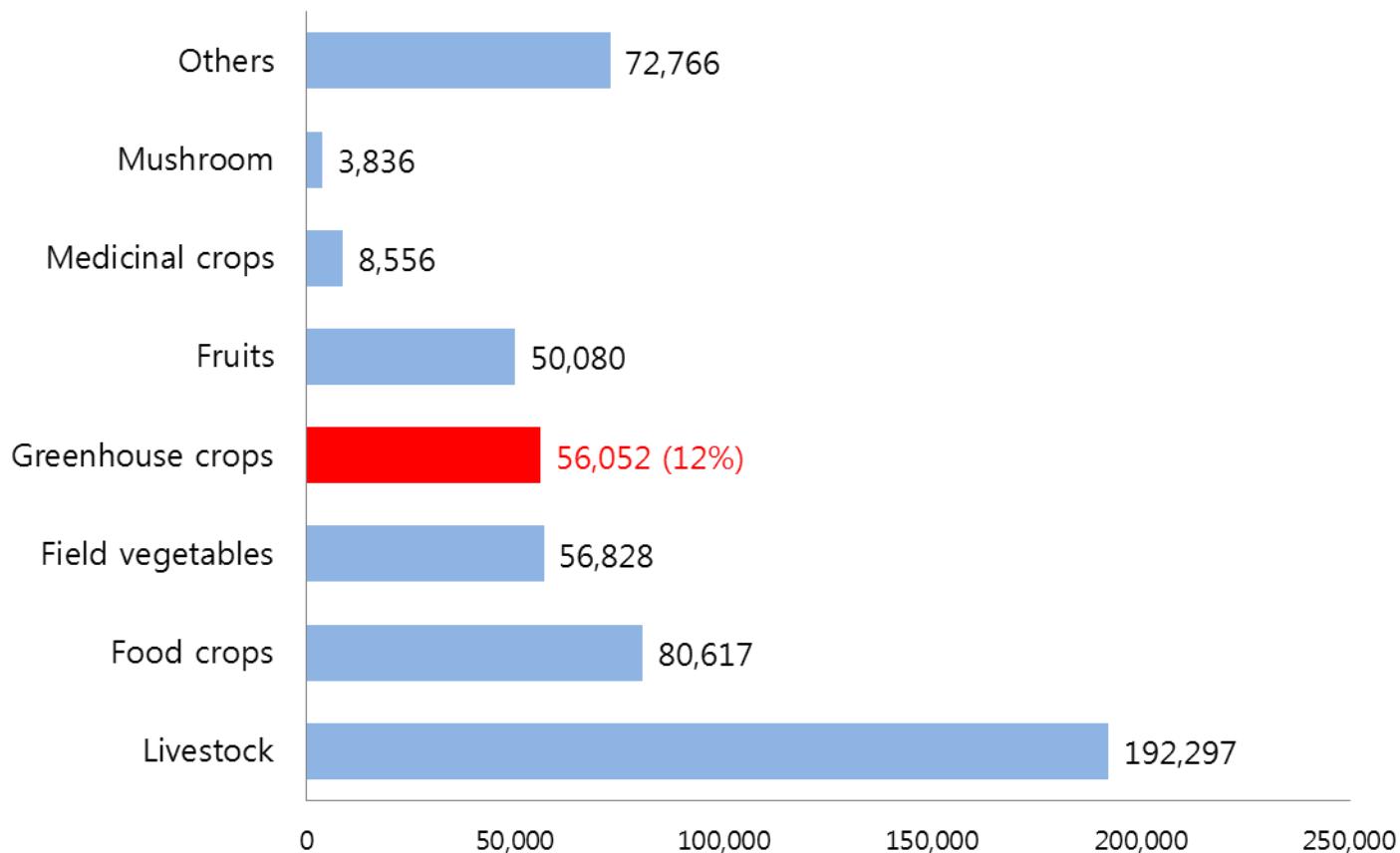
Soilless culture area and size



Cultivation area of major greenhouse crops

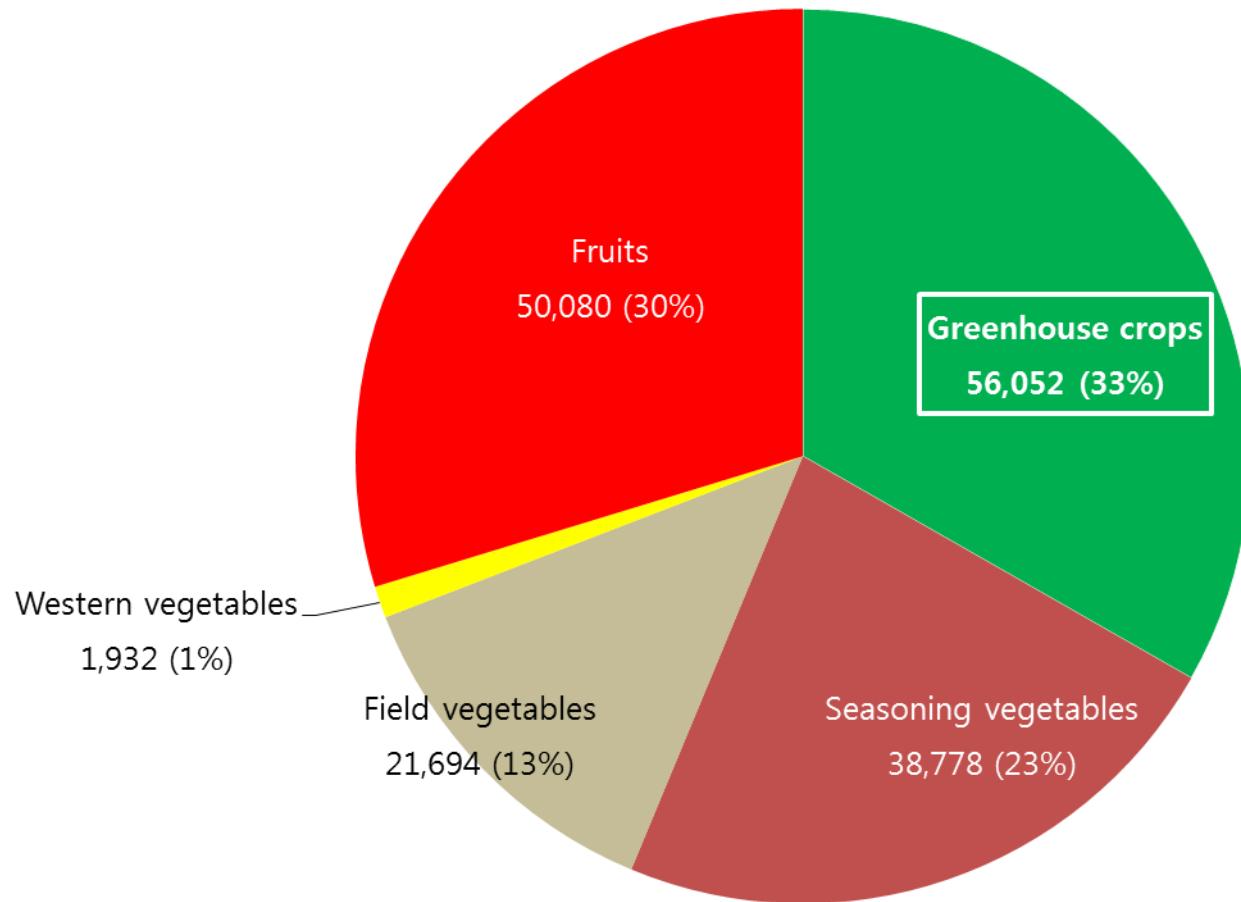


Share of greenhouse crops in agricultural production value in 2016



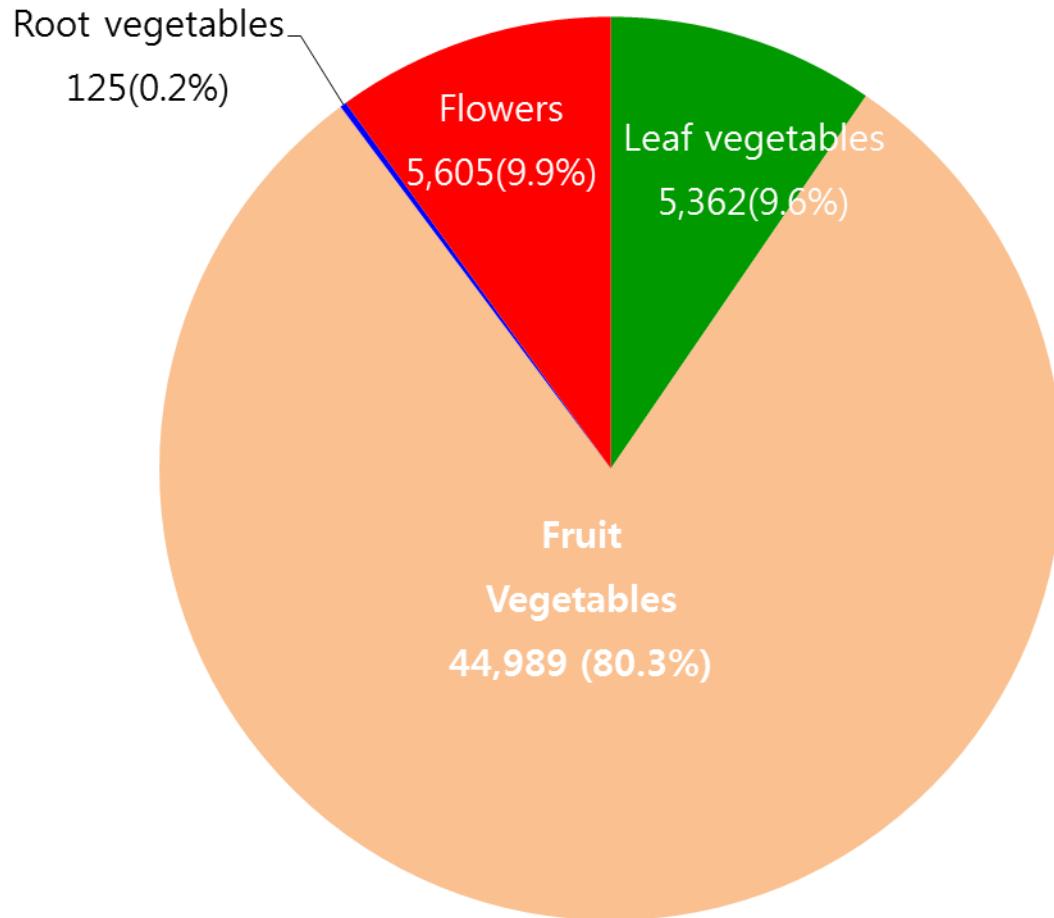
* Source from MAFRA

Share of greenhouse crops among horticultural production value in 2016



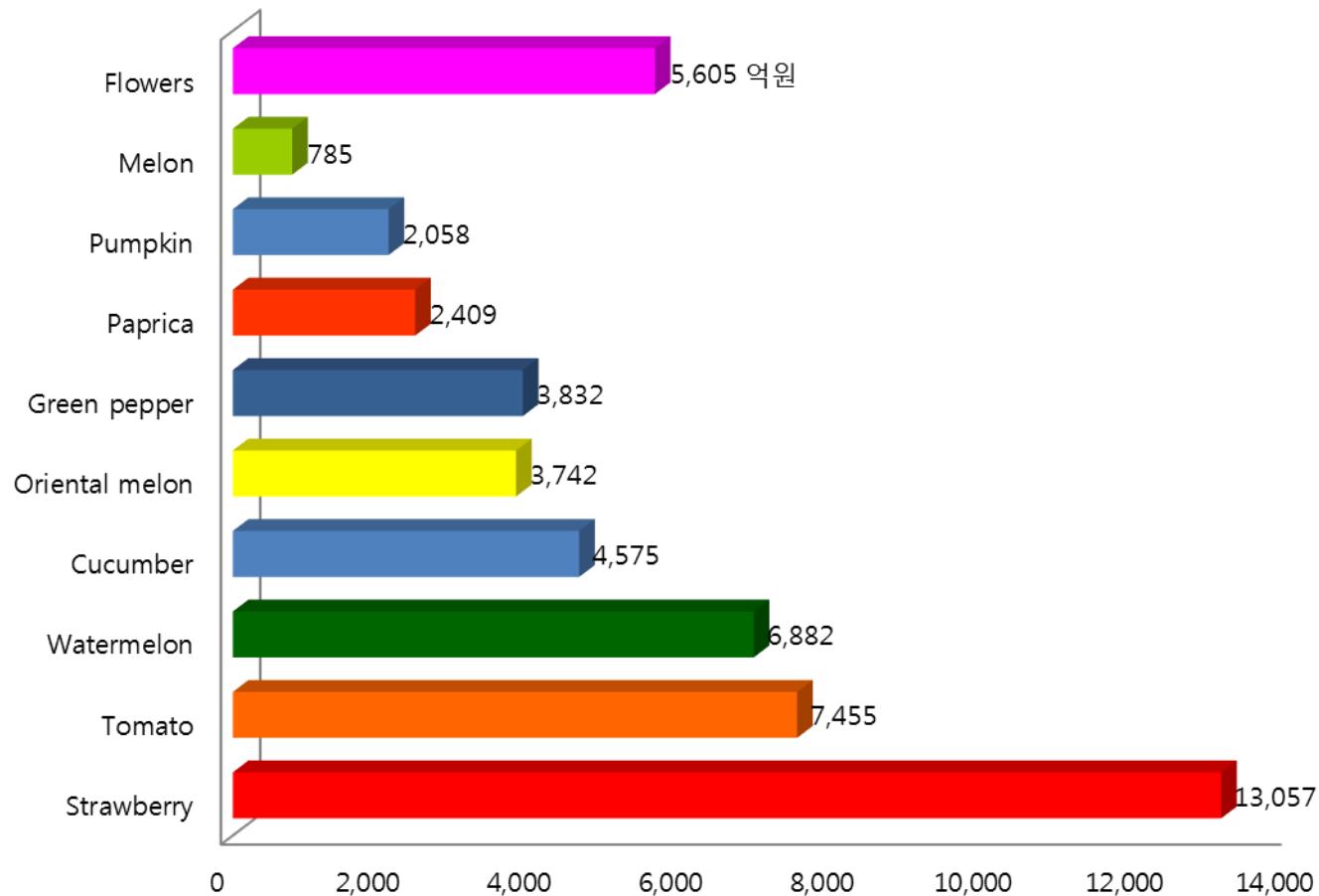
* Source from MAFRA

Share of production value of greenhouse crops in 2016



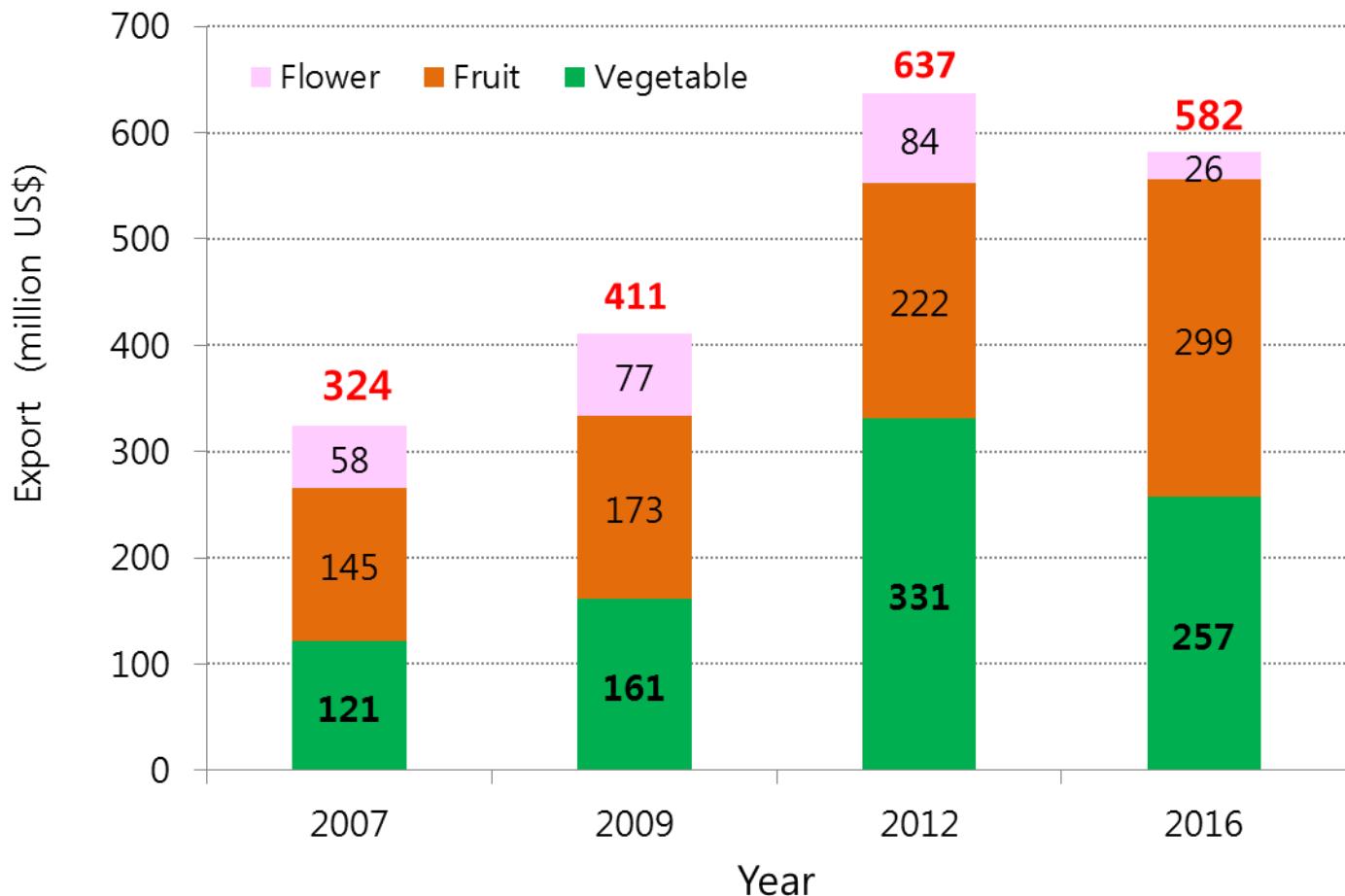
* Source from MAFRA

Production value of different greenhouse crops in 2016



* Source from MAFRA

Export of horticultural crops



Market size of agricultural materials for protected horticulture

Total	Frame	Film	Irrigation	Environment control	Protection	Seedling
11,167	3,576	3,751	981	1,015	326	1,518

(2013, 억원)

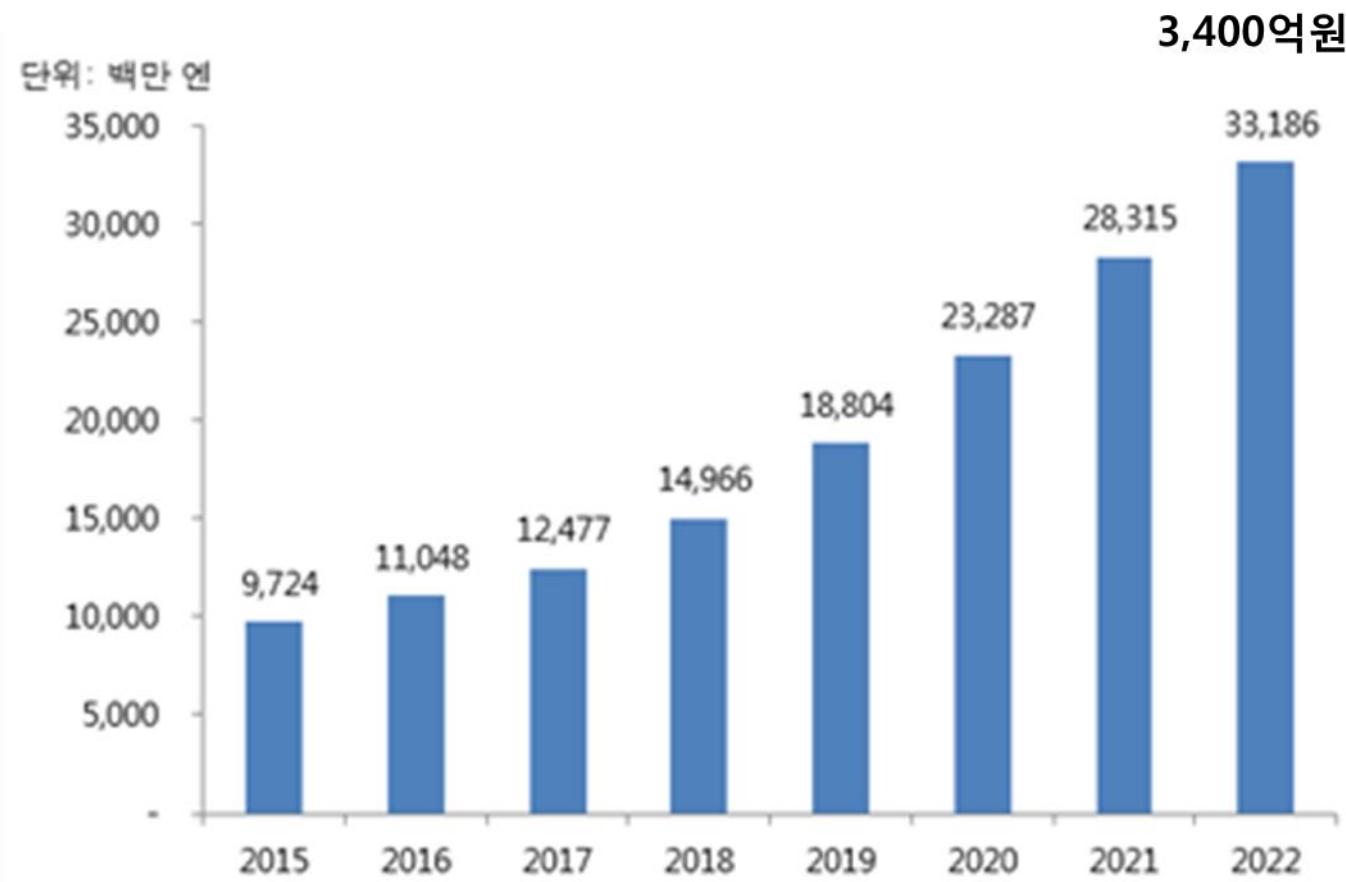
* KREI(R772), 시설원예 생산자재산업의 현황과 발전방안 (2015)

Market size of smart farm (greenhouse)

Year	- 2013	2014	2015	2016	2017	- 2020	계
Area (ha)	345	60	364	1,077	2,154	3,000	7,000
Market size (억원)	172.5	30	182	539	1,077	1,500	3,500

(0.5억 원/ha. 2017)

Market size of smart farm (greenhouse) in Japan



Yano economic. inst. (2015)

Analysis

- Greenhouse crops: 56,000(2016) (Unit, 억원)
 - 12% share of agricultural products
 - 33% share of horticultural crops
- Agricultural materials: 11,000(2013) → increasing
- Smart farms: 1,500(2017)
 - 3,400(2020) → increasing

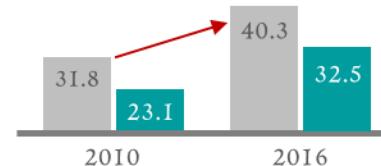
Current Situation

Current situations - agriculture and rural area

- Aging, population decline
- Small cultivation area
- FTA
- Difference in income between urban and rural areas



■ 농가 ■ 어가
65세 이상 비율(%)



- Urban agriculture
- Returning to rural area
- High-valued agricultural technologies
- Smart farms

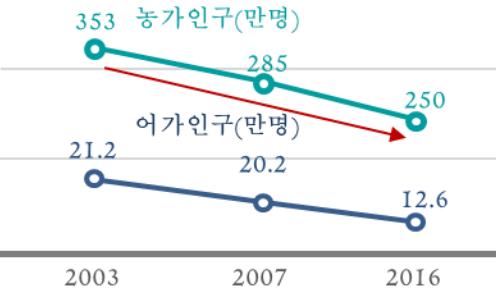


- Wana-do-farming
- Convenient farming
- Expecting high-income

353 농가인구(만명)

21.2 어가인구(만명)

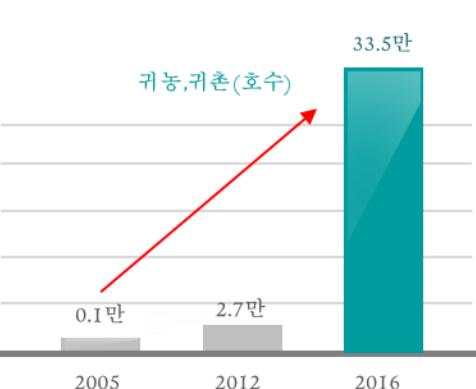
2003 2007 2016



귀농,귀촌(호수)

2005 2012 2016

33.5만



Poor vegetable greenhouses



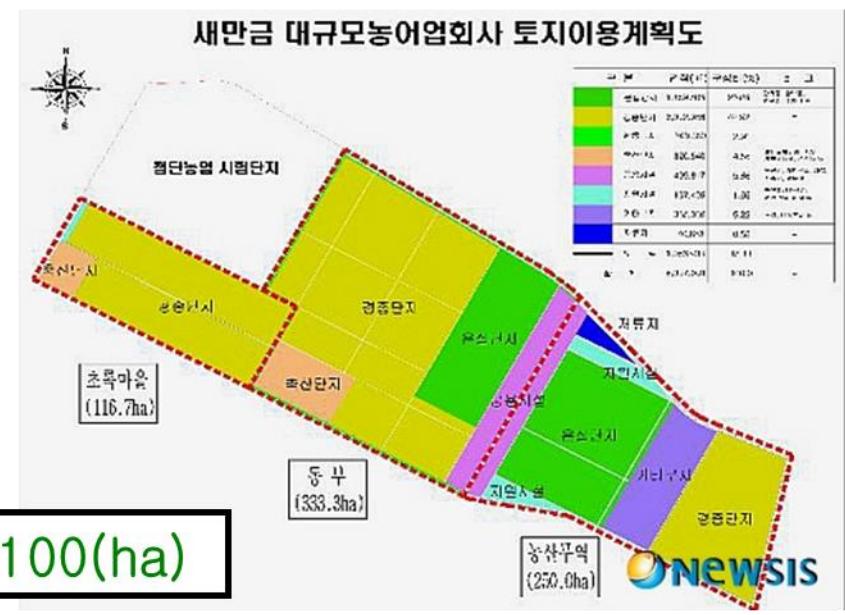
Single-span plastic
greenhouse 85%

Critical situation !!

Failure of Saemangeum greenhouse complex (A)



Glasshouse 100(ha)



Agricultural situation change in Japan

Accelerating next-generation greenhouse complex

Export of greenhouses and plant factories



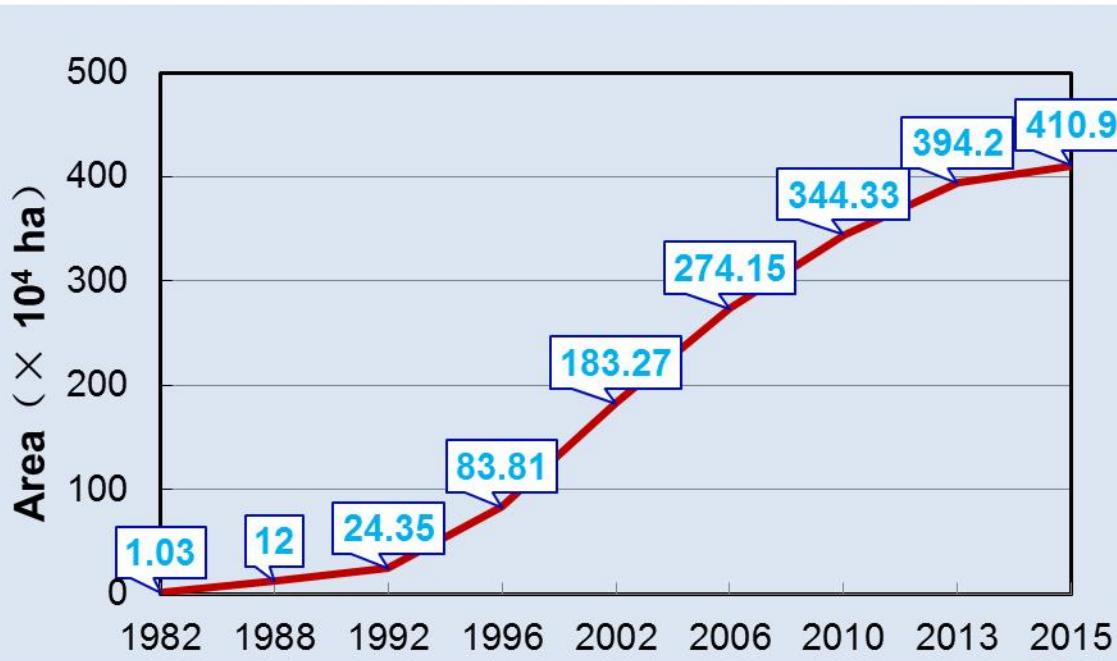
Next generation 10 greenhouse complex

- Use of local energy
- Production-process-distribution
- Cost-saving
- Job creation
- Increasing income
- Consortium of farms
- Large-scale, environment-control
- Activation of local economy

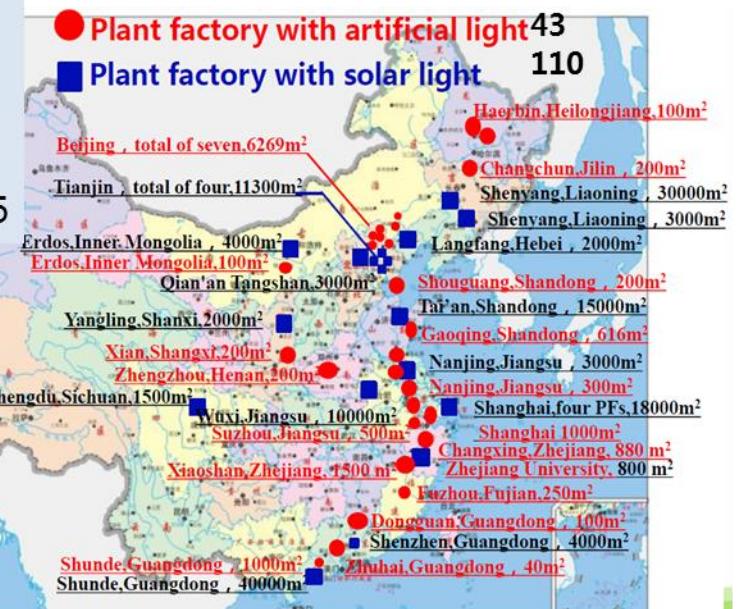


Current situation in China

Greenhouse area



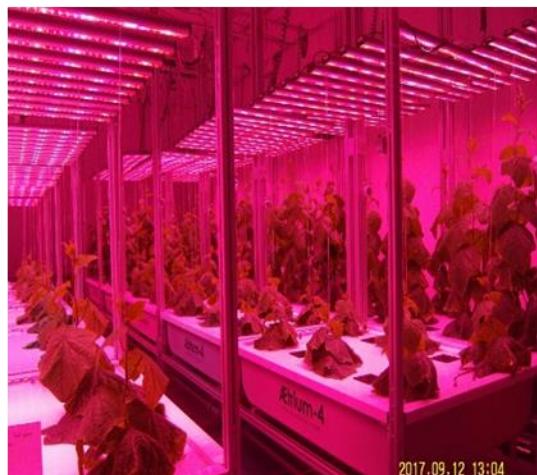
Plant factory



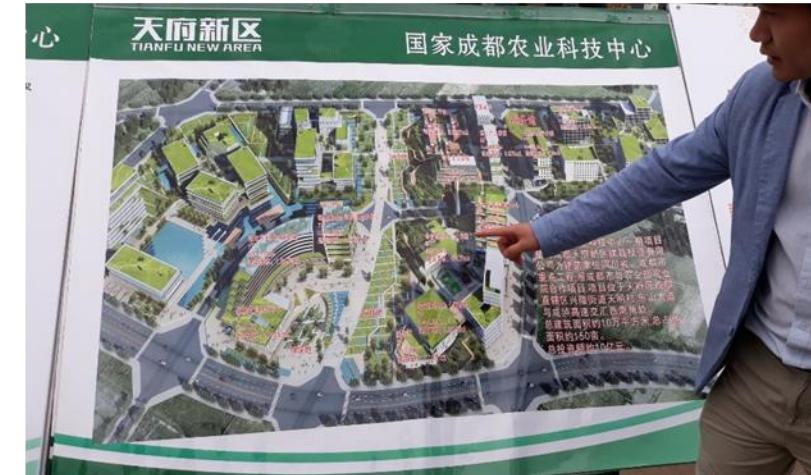
Yang (2015)

Agricultural situation change in China

- Drastic increase in vegetable consumption
- Population movement from rural to urban areas
(8,000만명, 2020)
- Needs of additional greenhouses (420,000ha)
- Advances of USA, EU, and Japanese companies to China
→ Technology-based industrial infra-structure



(ex) AessenseGrow (USA+China)



(Urban agriculture Institute, 2020)

New trend in USA

Green Sense Farms: Indiana



AeroFarms: Newark



Needs of agricultural policy change in Korea



- Difficulty in exporting crops to Japan
- Possibility in importing crops and technologies from China



- Needs of the development of technologies with global competitiveness and cost-saving
- Needs of high-valued smart farm technologies including production system, cultivation SW, and agricultural materials enough to export

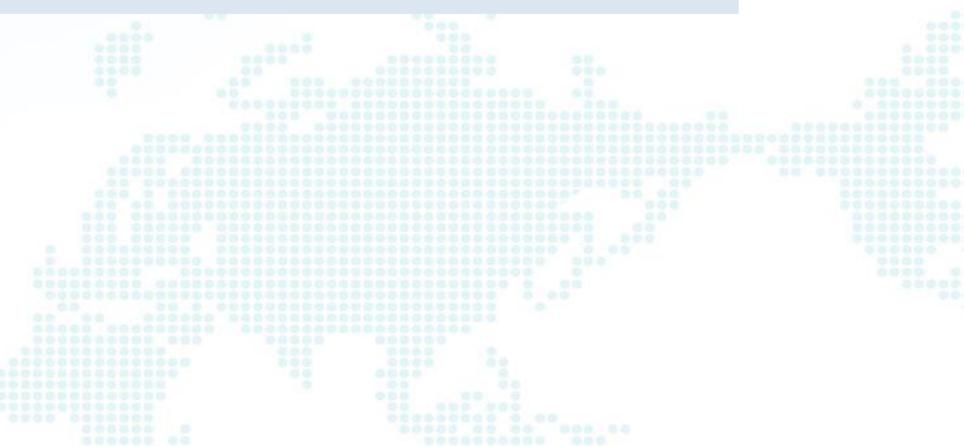


- Technology development by major companies
- Reasonable policy for coexistence of farmer and companies

Countermeasure trends of several countries

- USA: ICT and big data-based agriculture innovation
- Japan: Support of smart agriculture
- China: Smart agriculture and modernization

Korea ?



Smart Farm Project

- Agriculture as a future growth industry



- Increase: income by 30%
- Increase: productivity by 30%
- Reduction: labor cost by 10%



- Upgrade of the existing modernized greenhouses (7,000ha) -> **Smart farms** by 2020

Smart Farm-Innovation Valley (2018)



- Total 4 places in Korea (by 2022)
- 20 ha (smart-greenhouse production, industrial research, education-training) / each place
- Max. 180 million USD / each place

Current research at RDA

New greenhouse models for crops

Paprika



Tomato



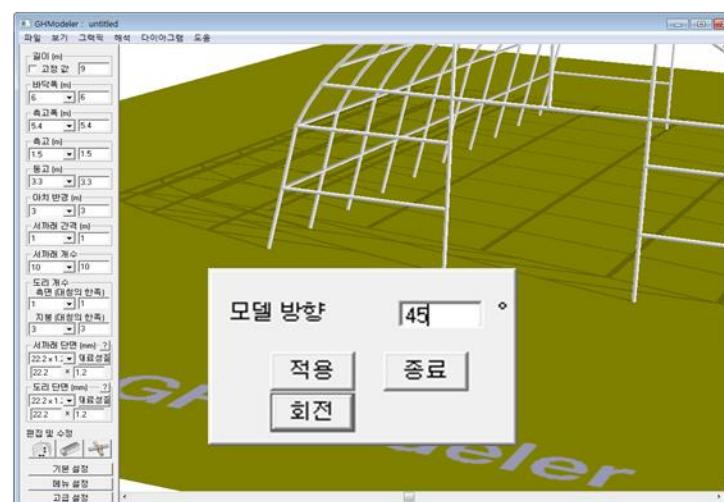
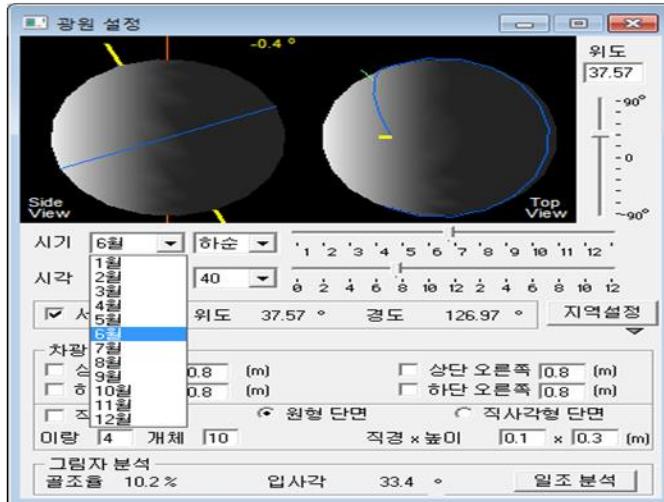
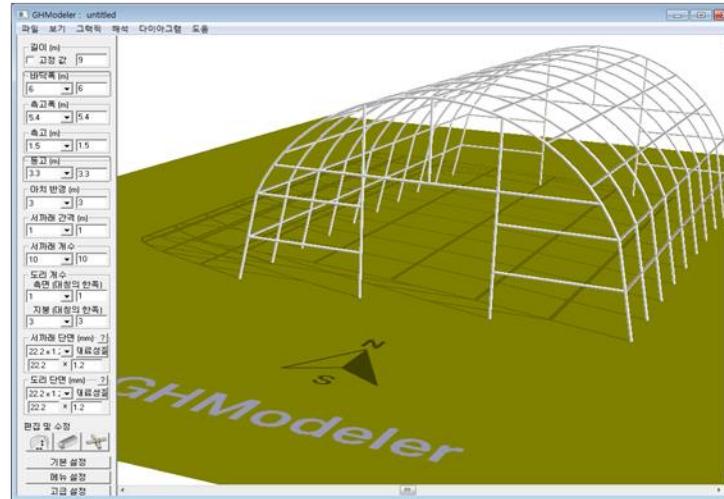
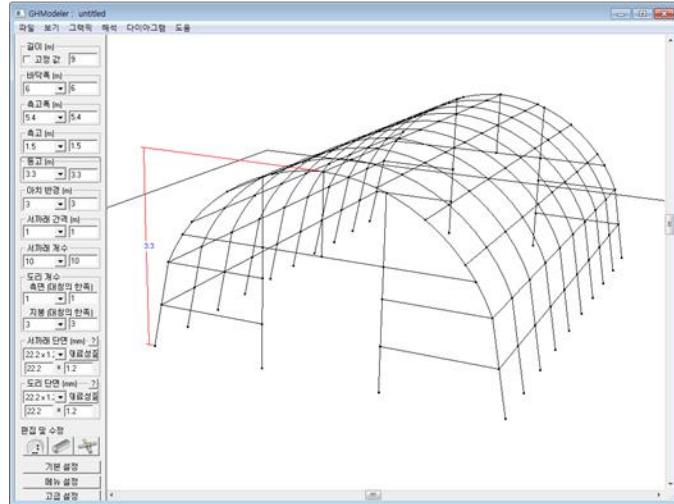
Strawberry



Grape



Greenhouse modeling program (GH Modeler - Shade)



Greenhouse shade analysis by latitude, direction, frame, time, etc.

Greenhouse insulation and energy efficient technologies

Greenhouse insulation technologies



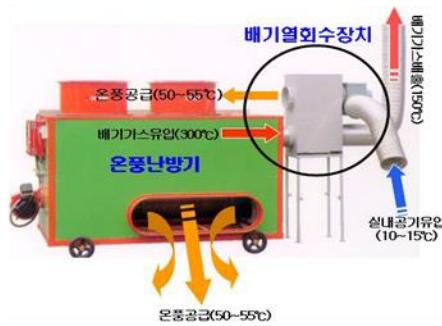
Multi-layered insulation curtain Outside coverings

Automatic tunnel coverings

Energy efficient technologies



Recycling water curtain system



Recovery device of exhaust heat



Local heating and cooling for strawberry



Heating duct (moving up and down)

Utilization of new regeneration energy

Heating and cooling systems using geothermal or underground water heat

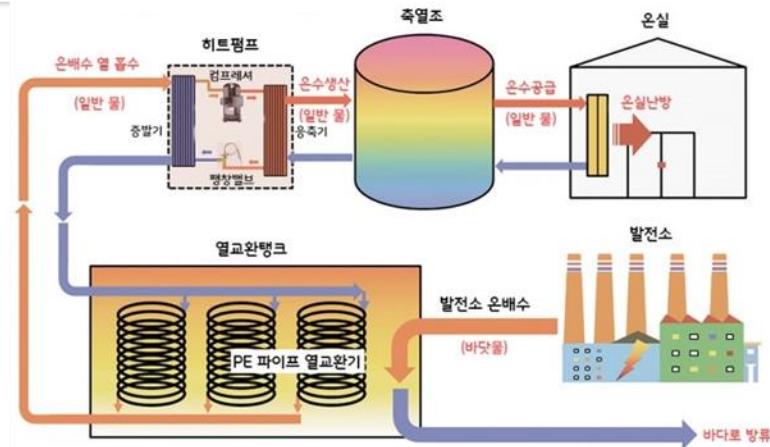


Geothermal heat

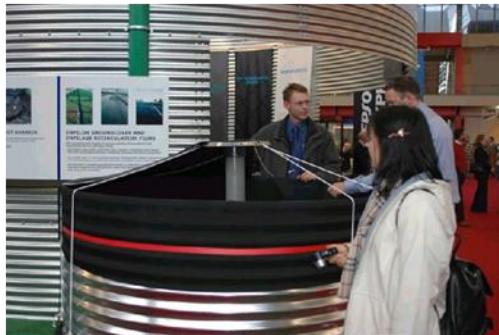


Underground-water heat

Heating and cooling systems using industrial waste heat



Storage and utilization of rainwater



Practical cooling techniques in hot season



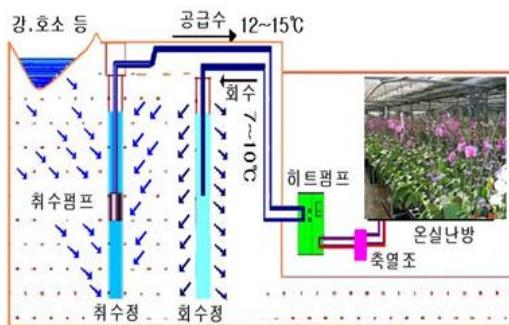
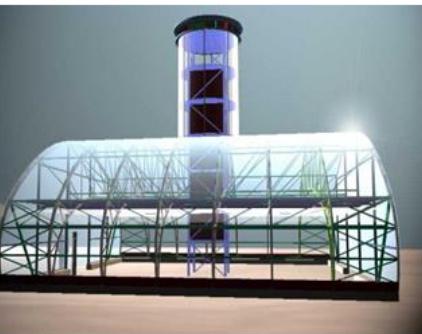
Cooling by fog system



Cooling and heating by fan coil unit



Application techniques of natural energy



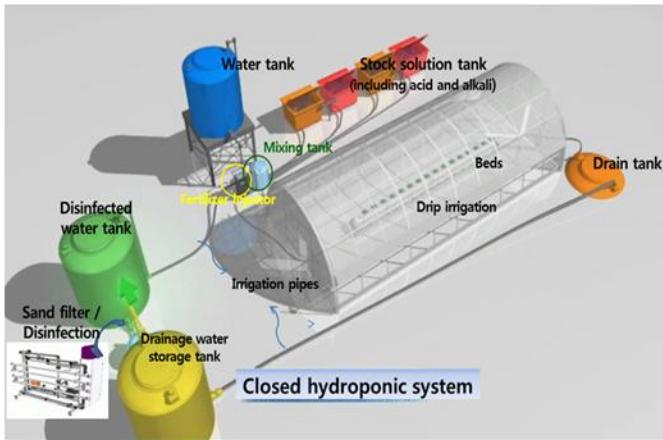
Horizontal ground source
heat pump for greenhouse

Groundwater heat pump
system

Heat storage of
surplus solar

Closed-loop hydroponic cultivation

- ✓ Ratio of closed systems in hydroponics
 - Netherland 95%, Japan 45%, Korea < 5%



Precise control of soil moisture content or nutrient solutions

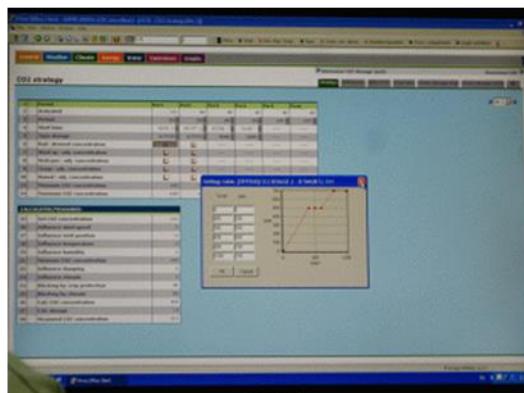
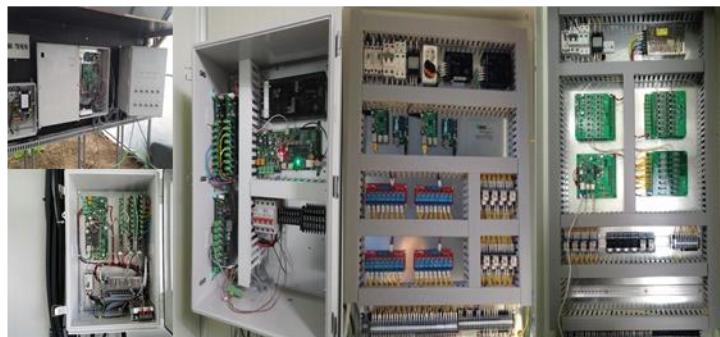


Precise control of soil moisture content by tensiometer



Precise irrigation control by load cel)

Greenhouse environment control by multi-variable environment factors



Supplemental lighting with light-efficient and energy-saving lamps



LED lamp



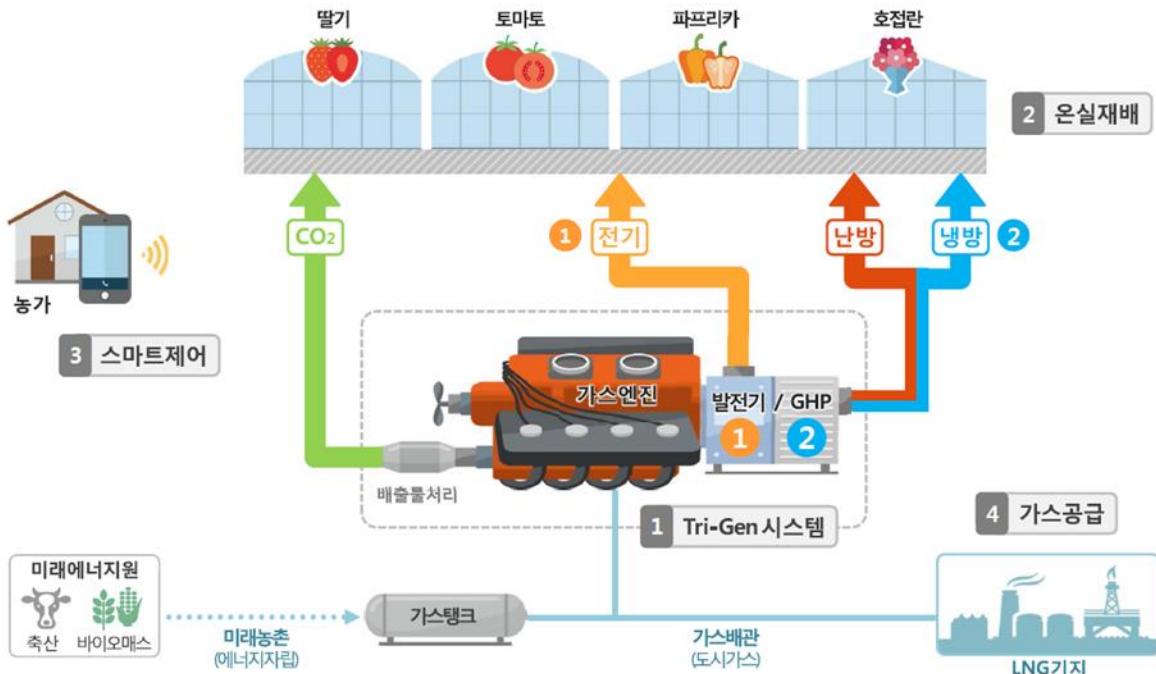
Plasma lamp



High pressure sodium lamp



Integrating management system in greenhouse environment and energy



LPG Tri-Gen system



Test bed (paprika greenhouse)

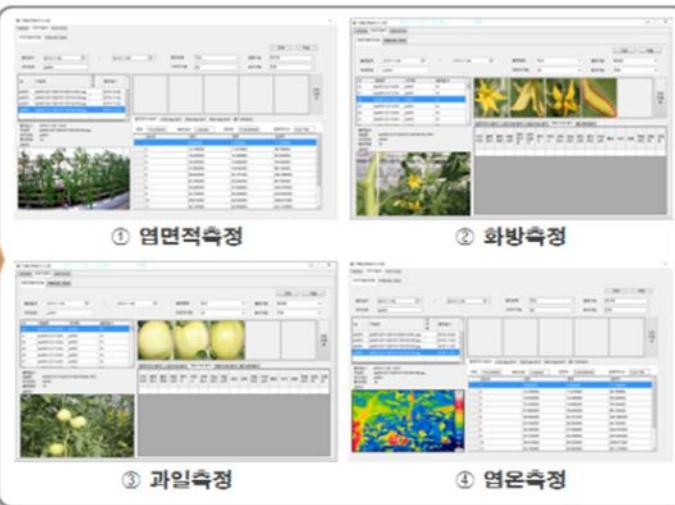
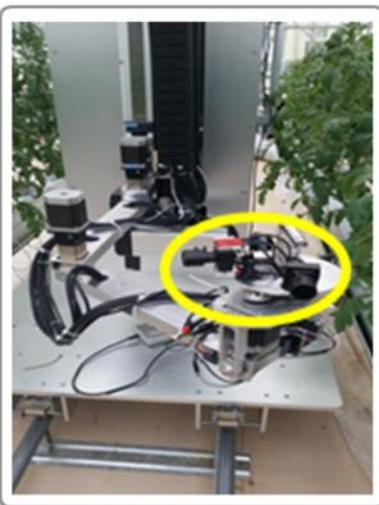
Automatic measurement vegetable growth information



Movable automatic measuring system of growth information

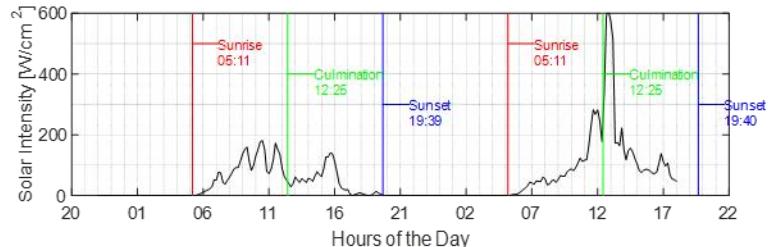
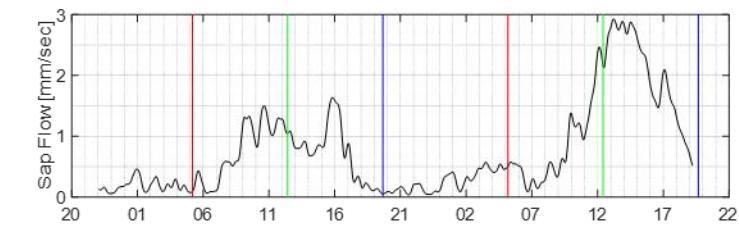
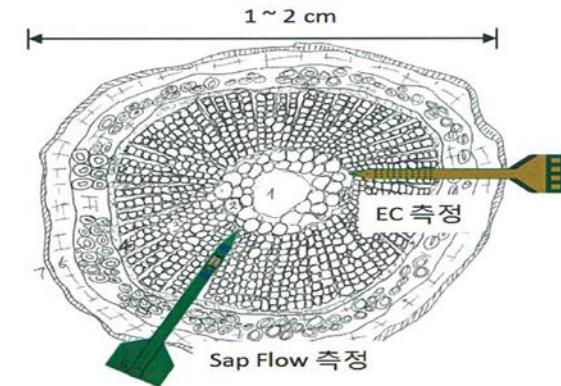
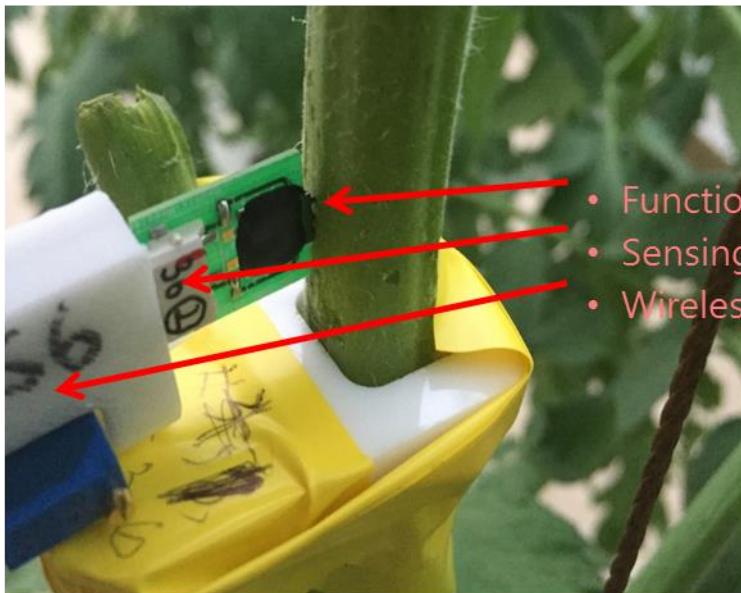


Automatic image analysis



Sample	151110-3	이비지 분석SI/W측정값	
초장	126.1	평균경계	0.87
염면적	3781.6165	염면적지수	0.9454
영장		영폭	영면적
1st	8.92	7.193	10.4803
2nd	22.89	18.4596	98.5132
3rd	9.23	7.4435	11.5752
4th	11.69	9.4274	21.7724
5th	33.76	27.2258	220.5281
6th	41.22	36.2214	328.2497
7th	29.87	27.683	207.4504
8th	45.11	40.9346	394.3678
9th	35.69	31.6962	276.7584
10th	30.27	30.5141	229.2271
11th	37.495	37.5701	347.0177
12th	44.72	43.8001	504.2683
13th	37.83	32.612	327.1477
14th	25.03	19.8493	207.763
15th	12.23	9.2792	20.1793
16th	33.12	24.9022	287.9628
17th	29.48	22.0164	223.0904
18th	16.23	11.693	65.2847
전체			3781.617

Irrigation control by biometric information using micro sensors



Intensive culture of greenhouse crops for high production and income



Two-layered culture of strawberry



Three-layered culture of strawberry



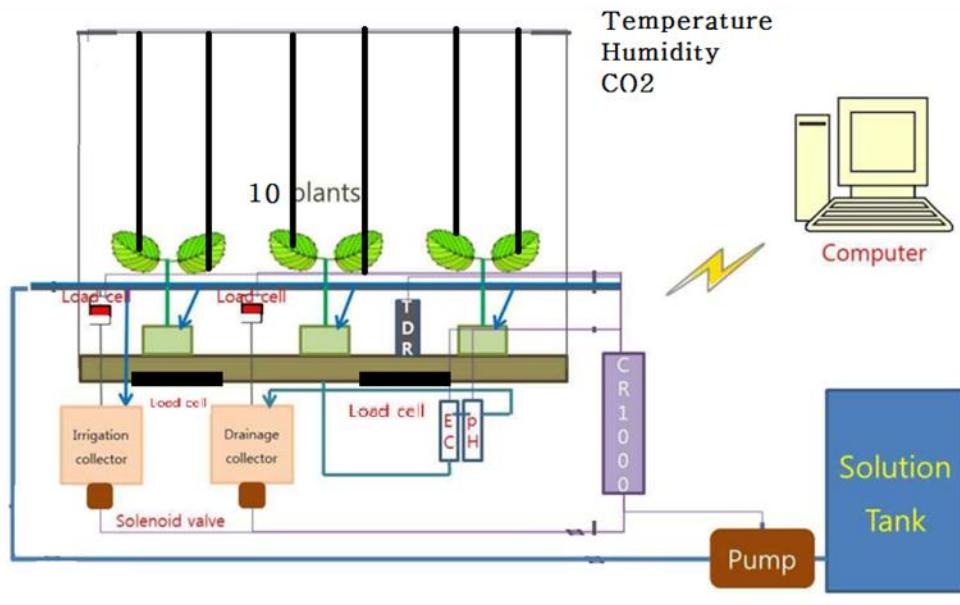
Hanging culture of strawberry



Vertical plant factory

Current research at SNU

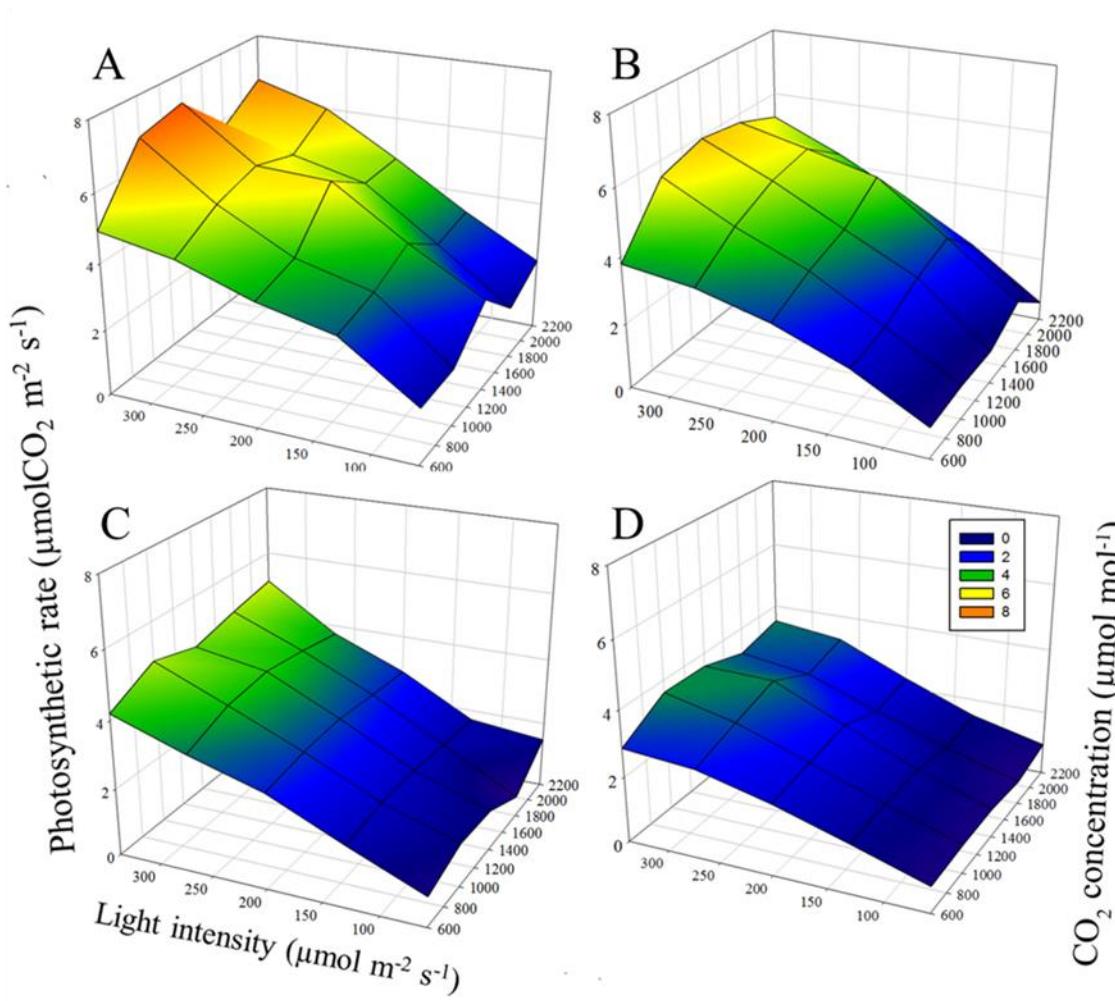
Growth and environment measurement system



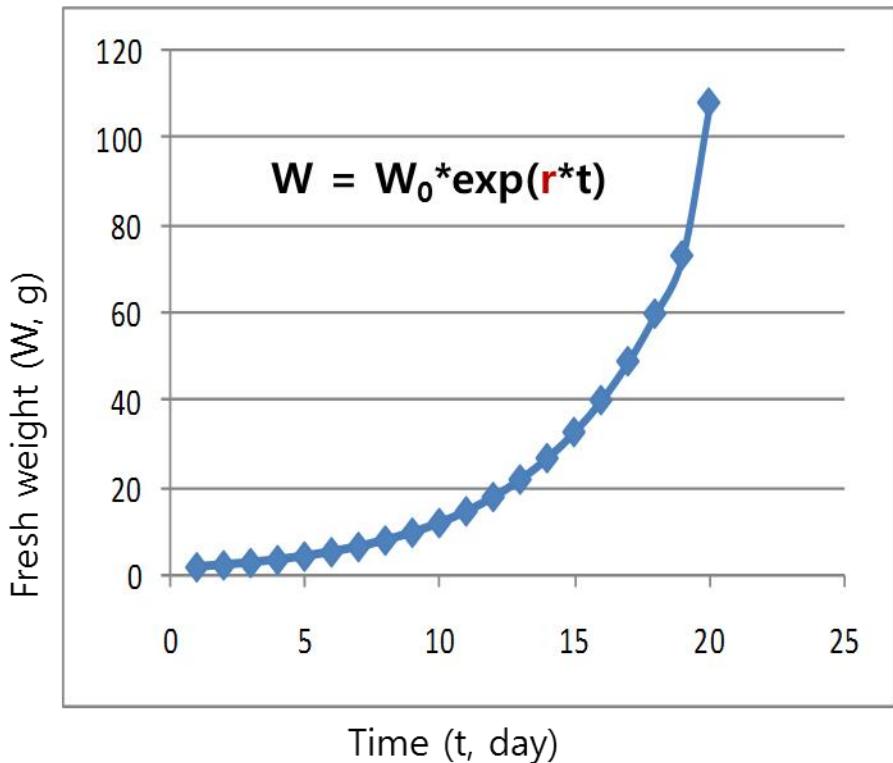
- Moisture content, EC, pH, CO₂, temperature, relative humidity, system weight, drainage weight, irrigate weight, and growth.

Multi-variable photosynthetic modelling

[light Intensity (or temperature) x CO₂ levels x growth stage]



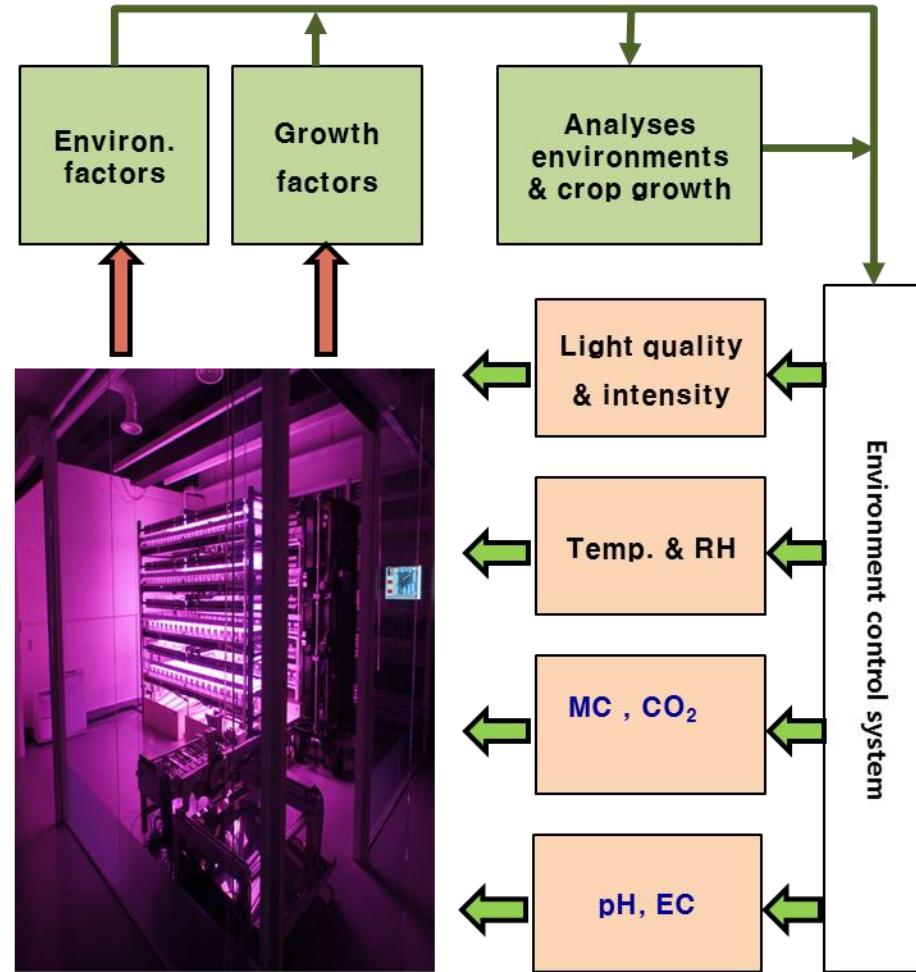
Environment control using growth model



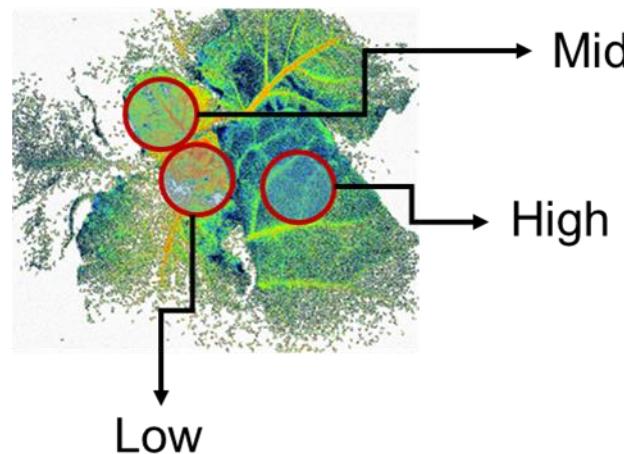
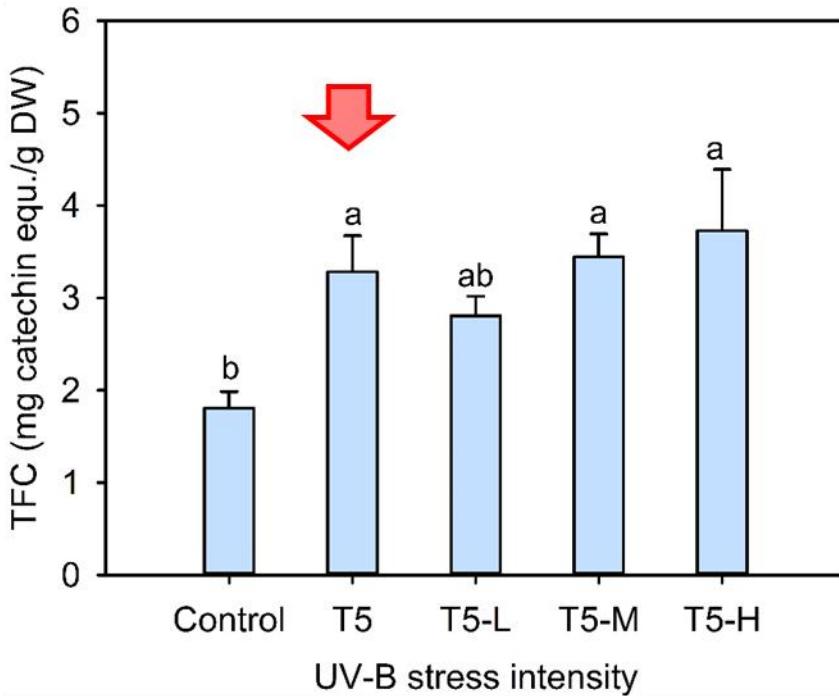
(ex) Relative growth rate (r)= $a*I*L/(1+b*I)$,

W_0 =initial weight, a, b=constants

I=light intensity, photoperiod=L (energy)

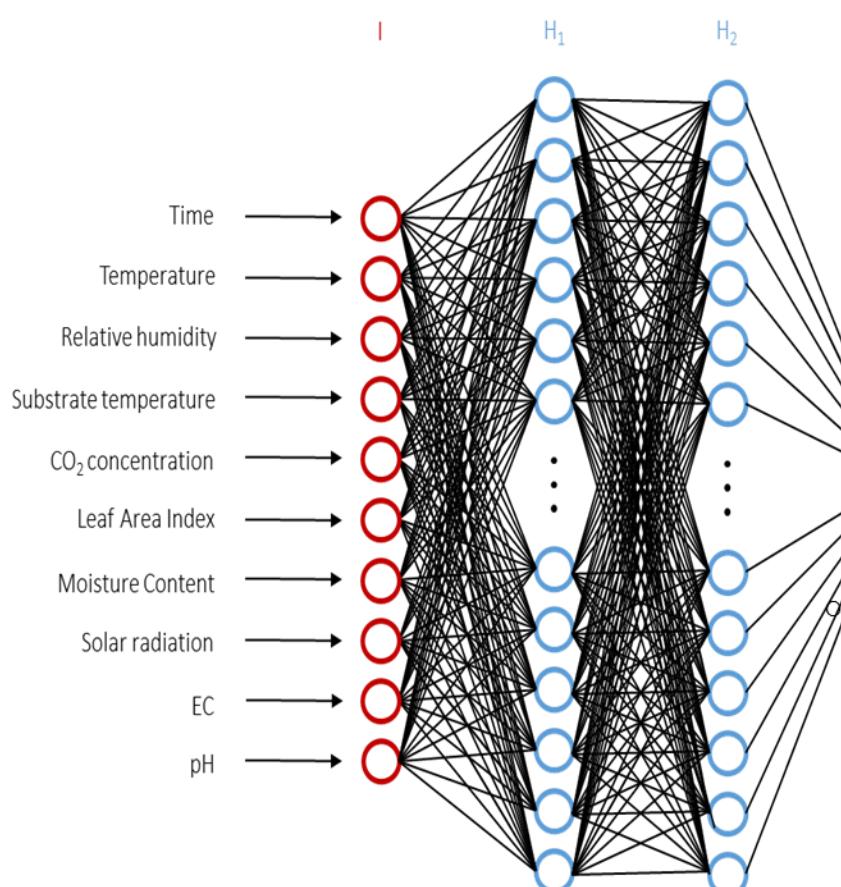


Total flavonoid content (TFC) by location in leaves (ex)



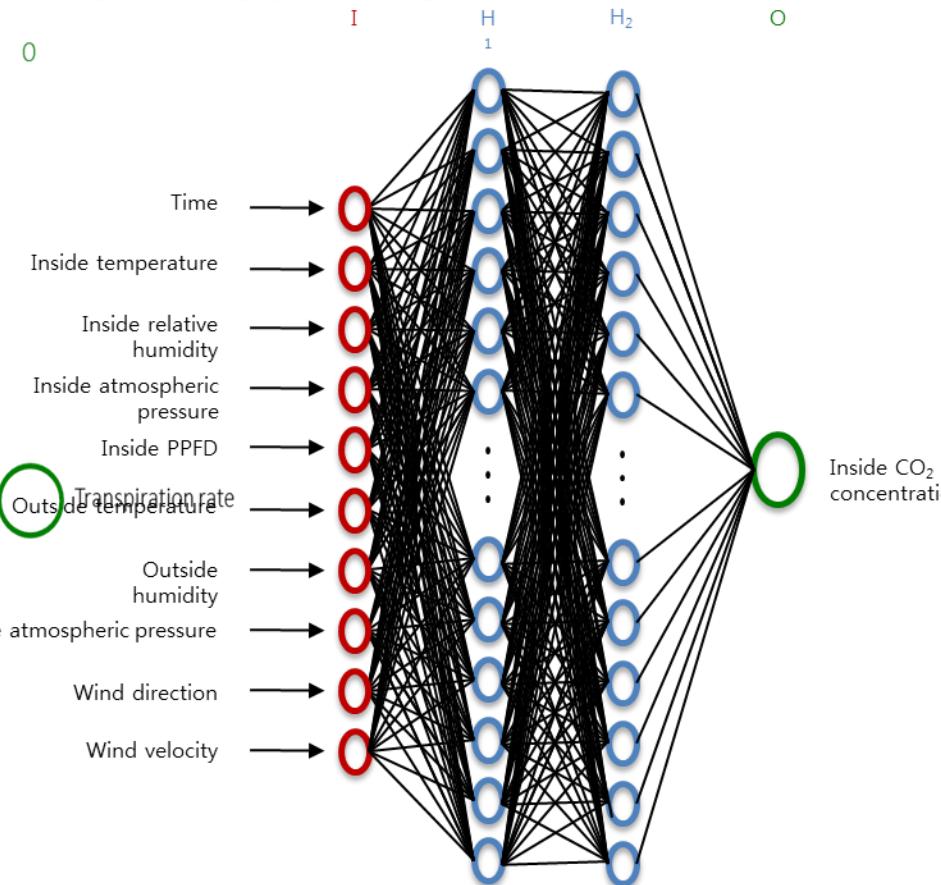
- Flavonoids accumulation were increased at UV-B stress
- TFC were significantly higher at UV-B stress treatment than the control.

Application of artificial neural network in greenhouse environment control



Transpiration rate

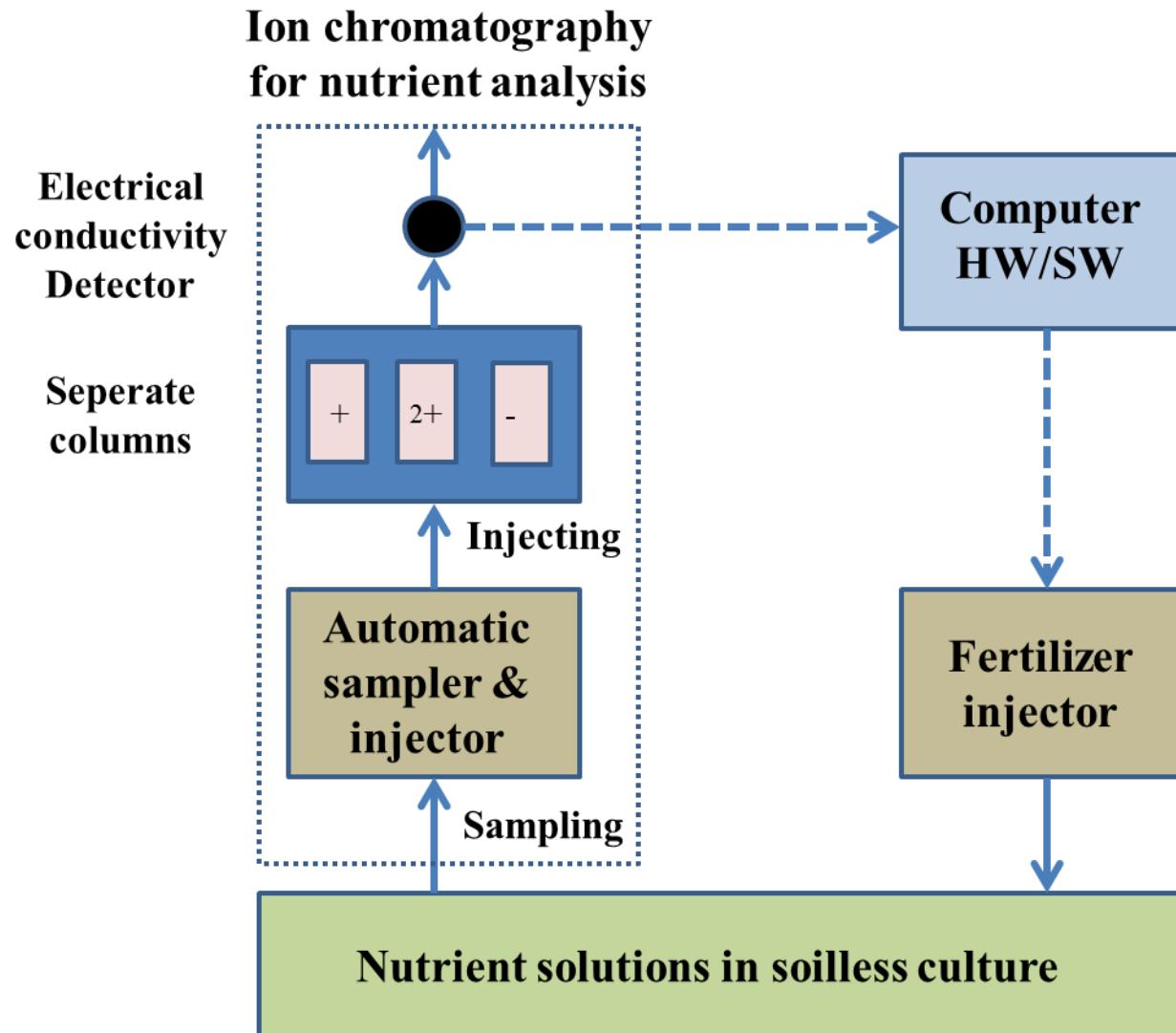
Nam, Son et al. (2017)



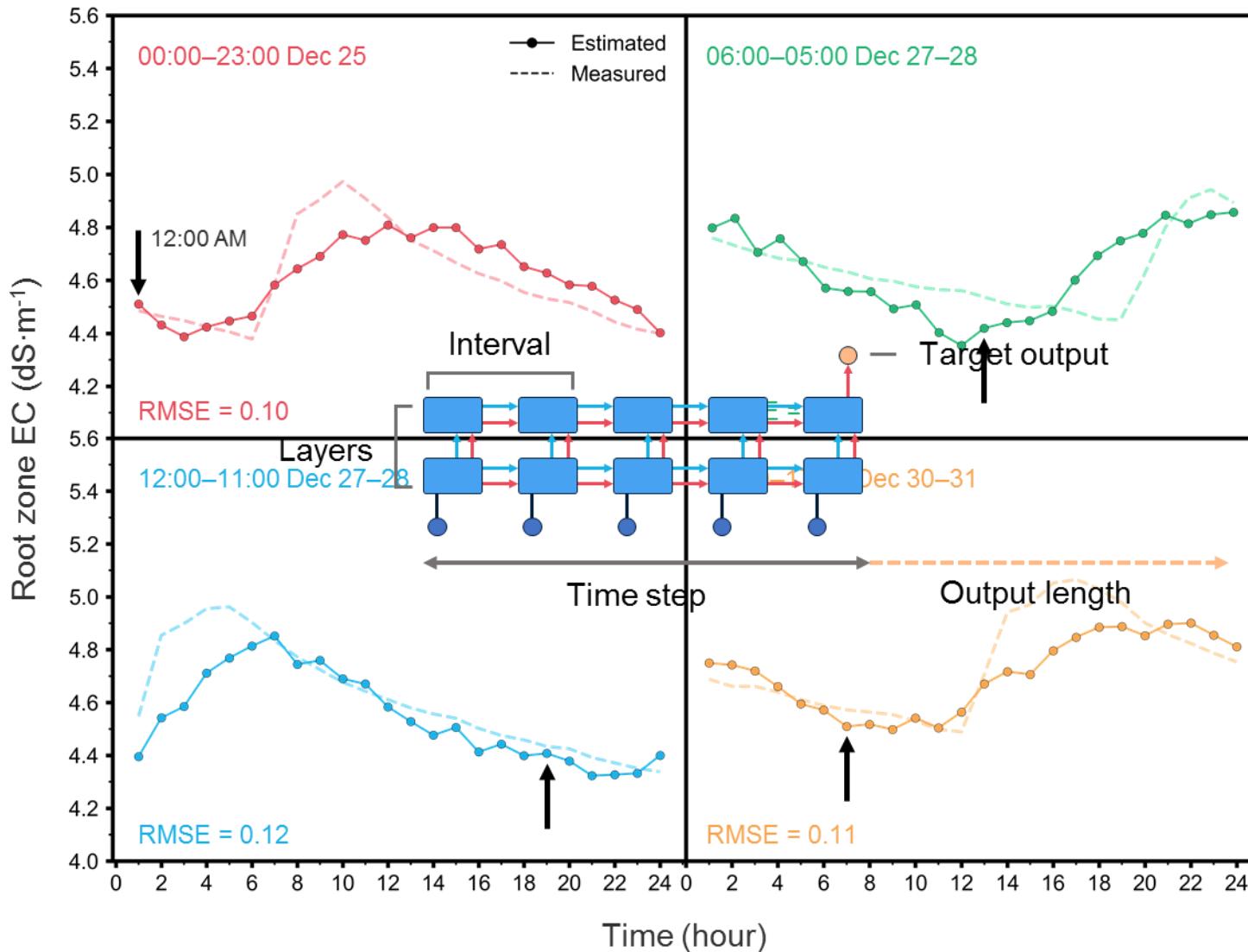
Carbon dioxide concentration

Moon, Son et al. (2017)

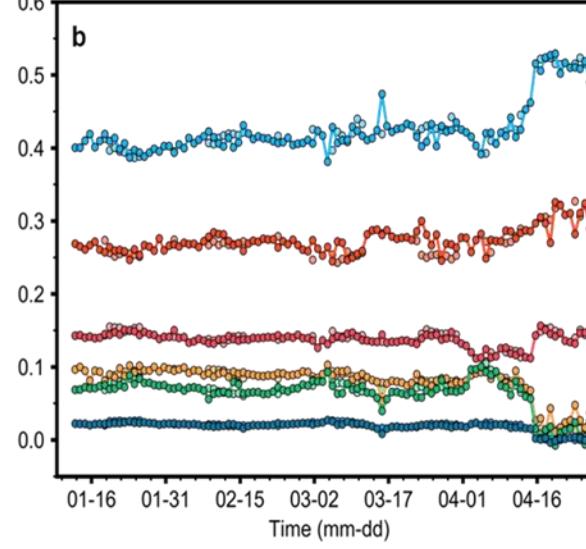
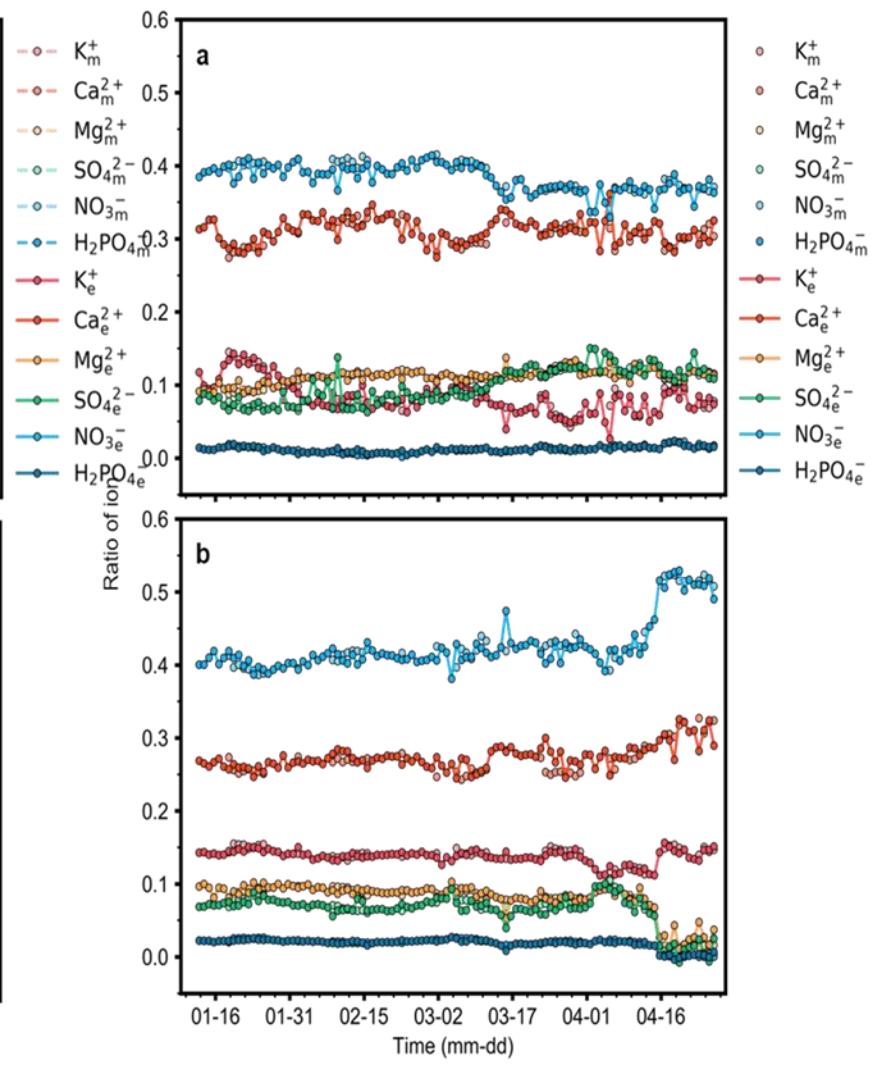
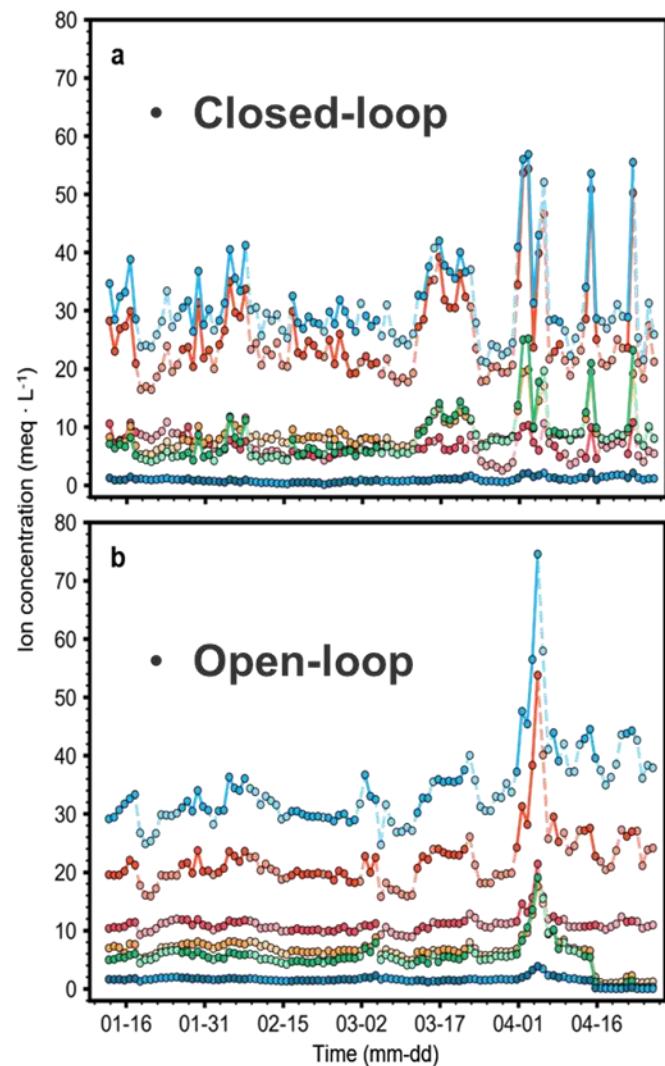
Concept of an on-line nutrient analyzer



Estimation of EC using deep learning



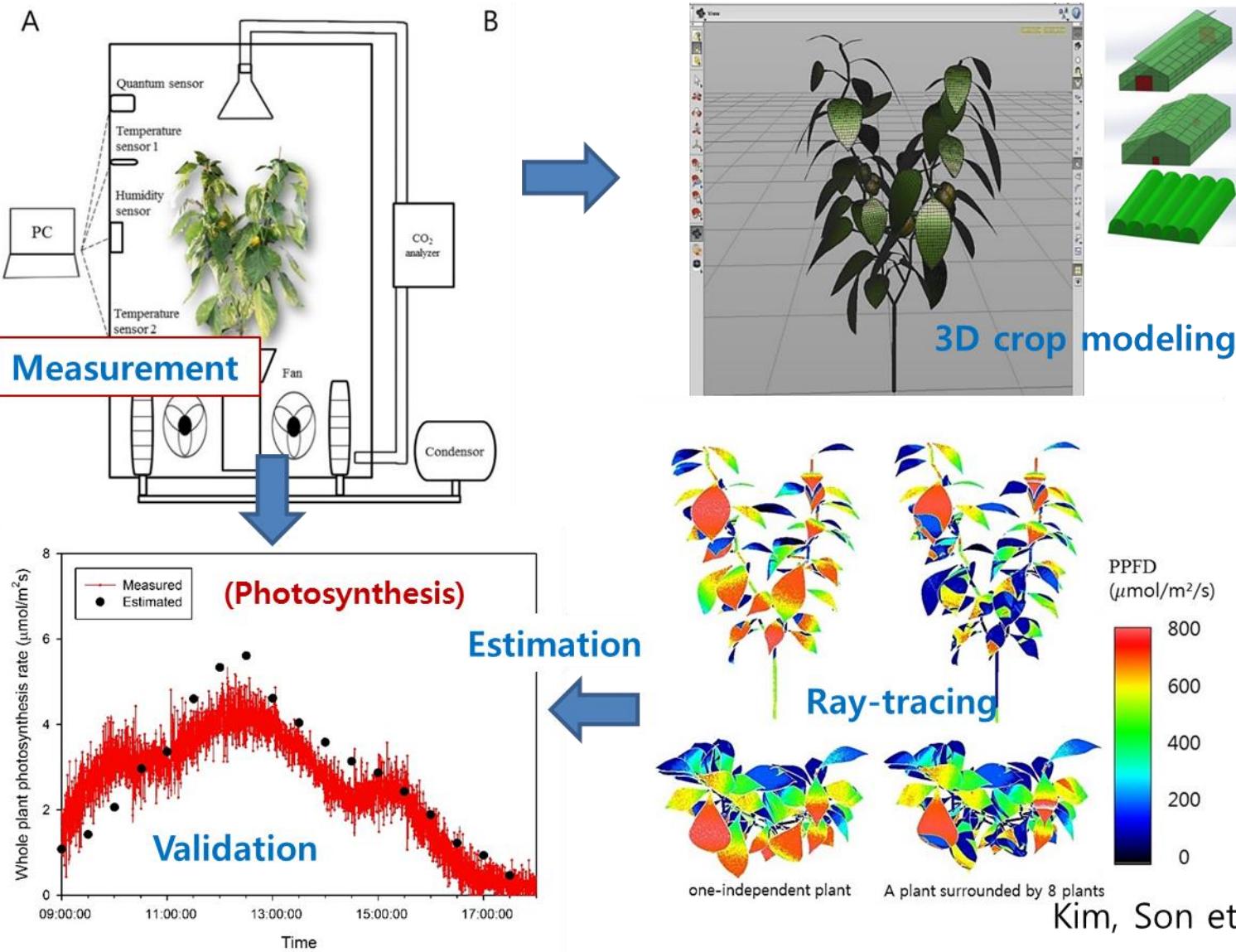
Estimation of ion concentration and balance



Photomorphogenesis of cucumber plants

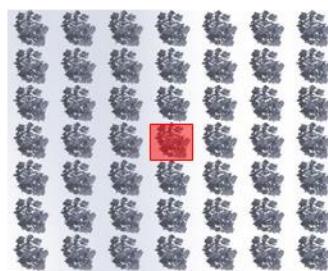
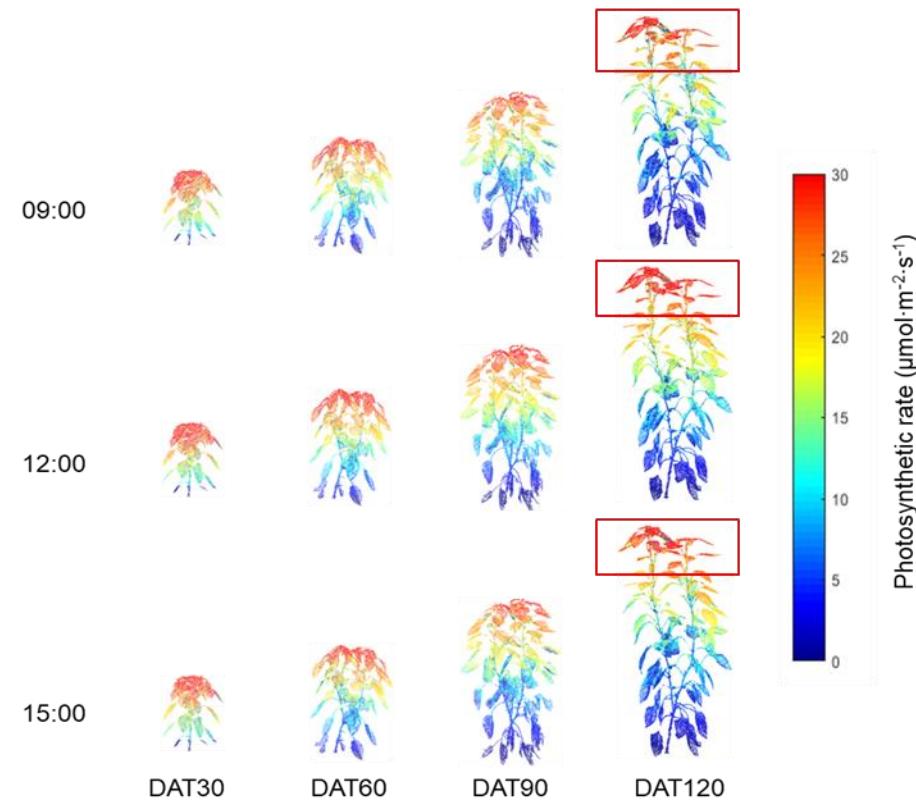
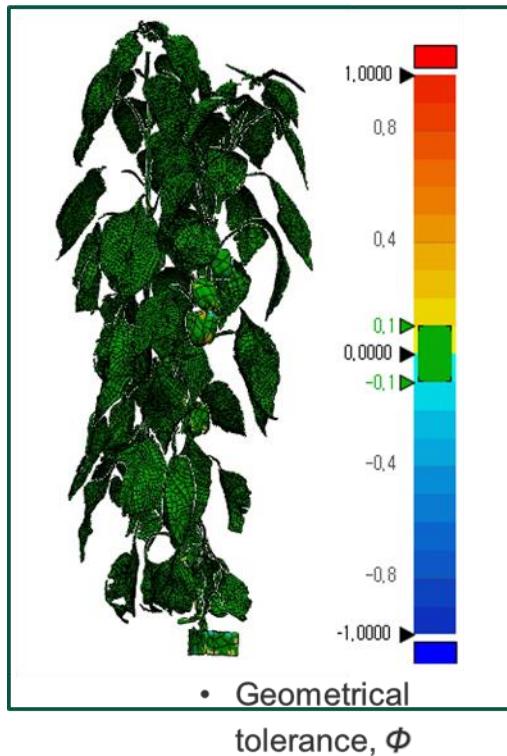


Estimation of canopy photosynthesis by 3D modelling and ray-tracing

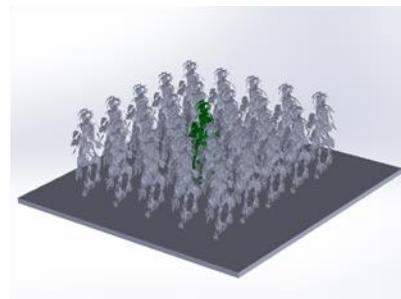


Kim, Son et al. (2016)

Change in canopy photosynthetic rate



7 x 7 arrangement

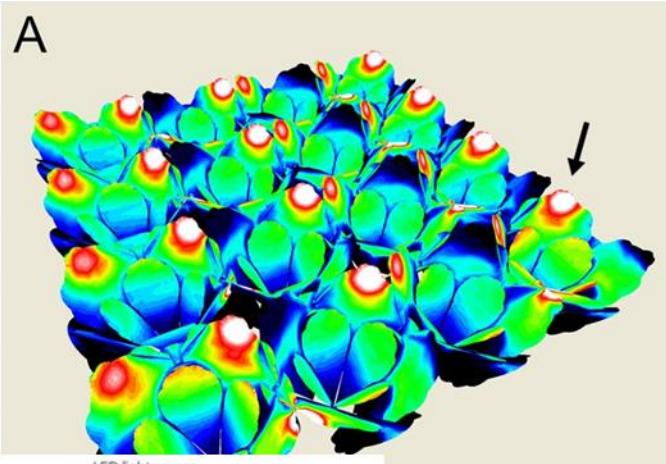


Hwang, Kim, Son et al. (IHC2018)

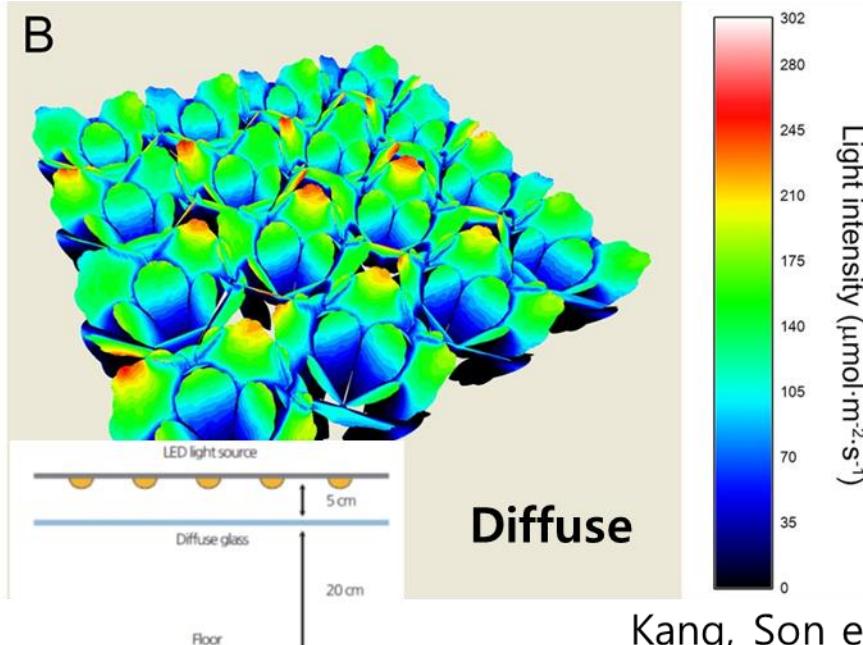
Light use efficiency with diffuse radiation

Lettuce

Treatment	Fresh weight (g)	Dry weight (g)	Leaf area (cm^2)	Light use efficiency (LUE)	LUE of diffuse fraction
Control	81.5 b ^z	4.6 b	1065.6 c	13.6 b	13.6 b
Haze 40%	85.2 ab	4.9 ab	1138.4 b	14.4 ab	15.6 a
Haze 80%	88.5 a	5.2 a	1267.0 a	15.1 a	15.5 a

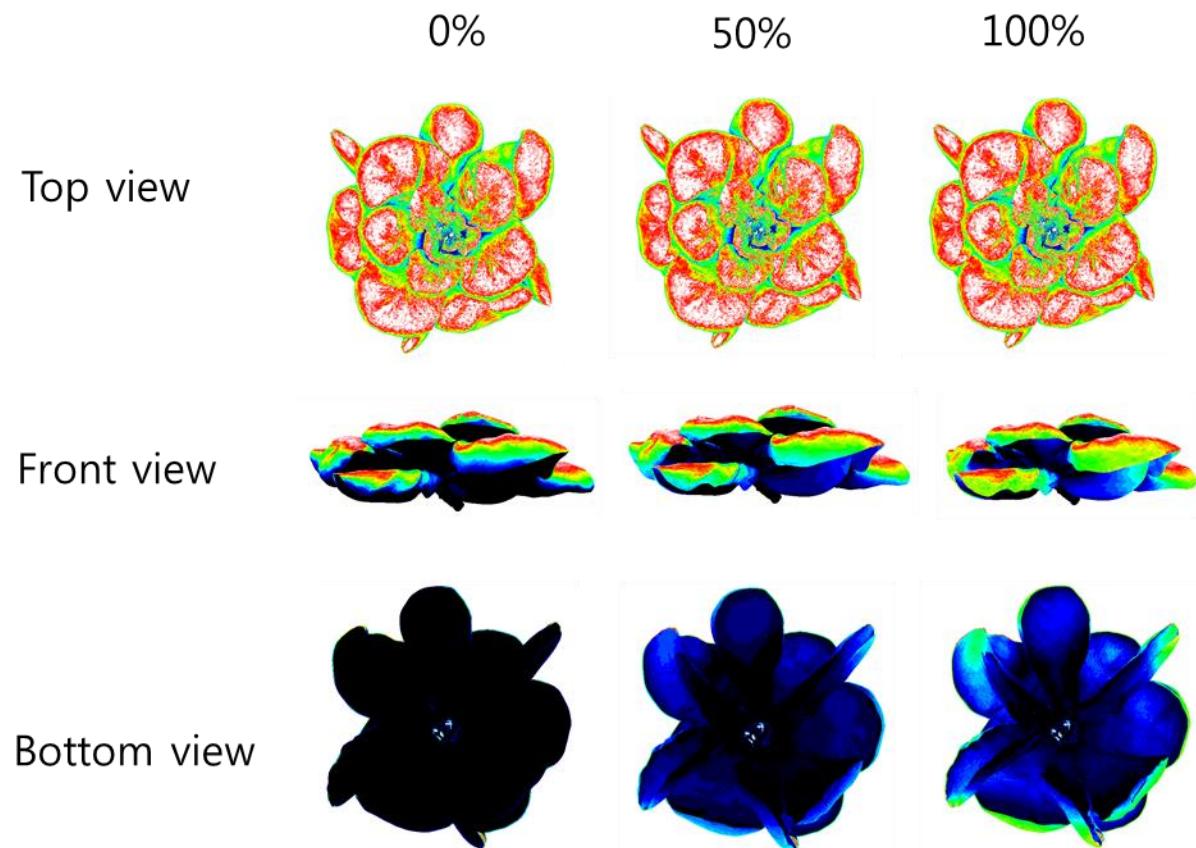
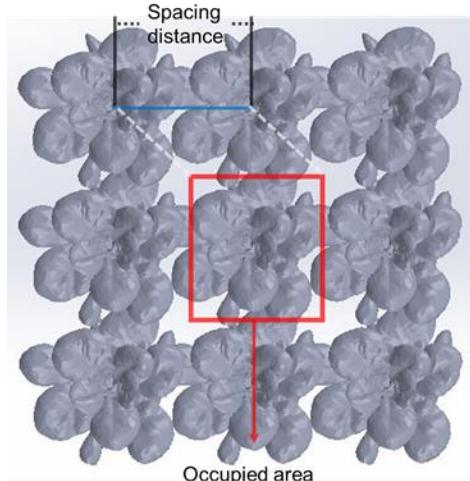


Direct



Kang, Son et al. (2016)

Light interception by floor reflectance in plant factory



Research Direction

Consideration factors for research in Korea

- Local climate (four seasons)
- Local regional situation
- Surrounding environments
- New technology and trend
- Road map and platform

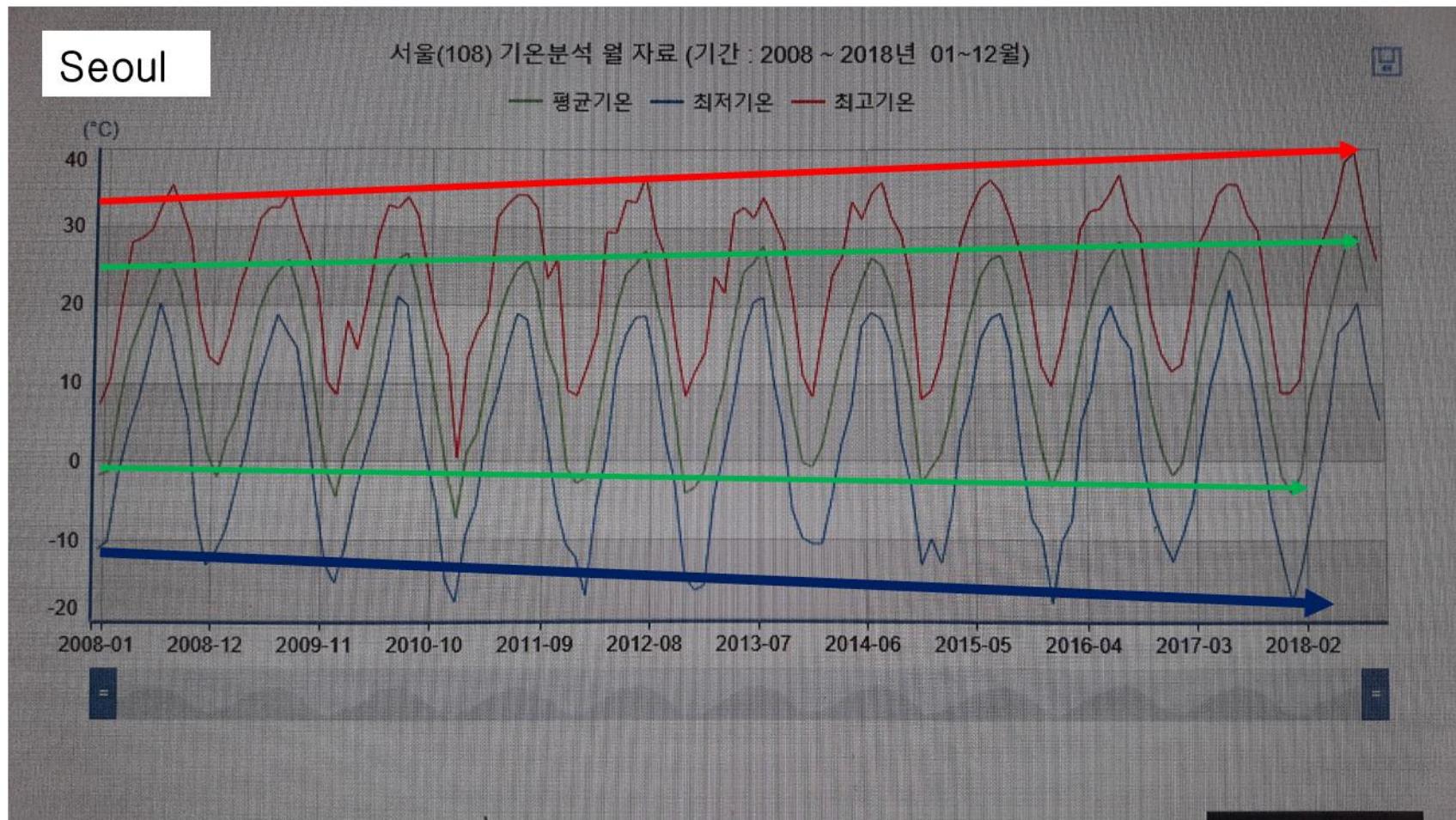
Changes in surrounding environments

- Japan: local and small-scale agriculture
 - global and large-scale agriculture
- China: low-input production
 - large-scale and advanced technology
- EU: large-scale glasshouse and automation
 - Expanding to plant factory
- USA: large-scale but local agriculture
 - Expanding to plant factory and export

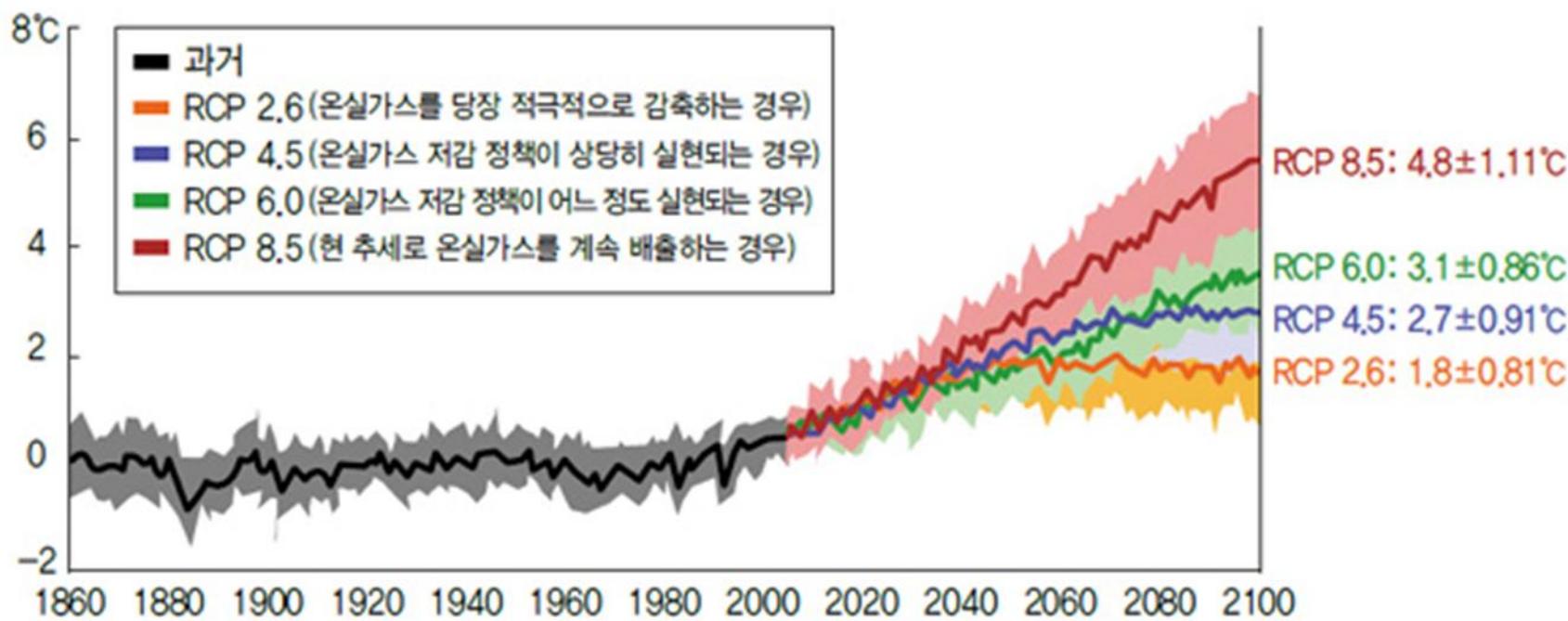
Countries of the Same Latitude on Earth



Changes in maximum, minimum, and average temperatures for recent 10 years



Scenario of climate change in Korea



출처: 한국 기후변화 평가보고서 2014

Local situation

- A short history in development of theory and technology (from 1970-1980)
- Emphasis on applications and evaluation of the theory and technology imported from advanced countries.

- Establishment of total strategies for year-round cultivation under clear four seasons
 - ✓ Non-linear conditions (cf. Netherlands)
 - ✓ Different conditions (cf. Japan)
 - ✓ Package-type technologies suitable for Korea

Conclusion

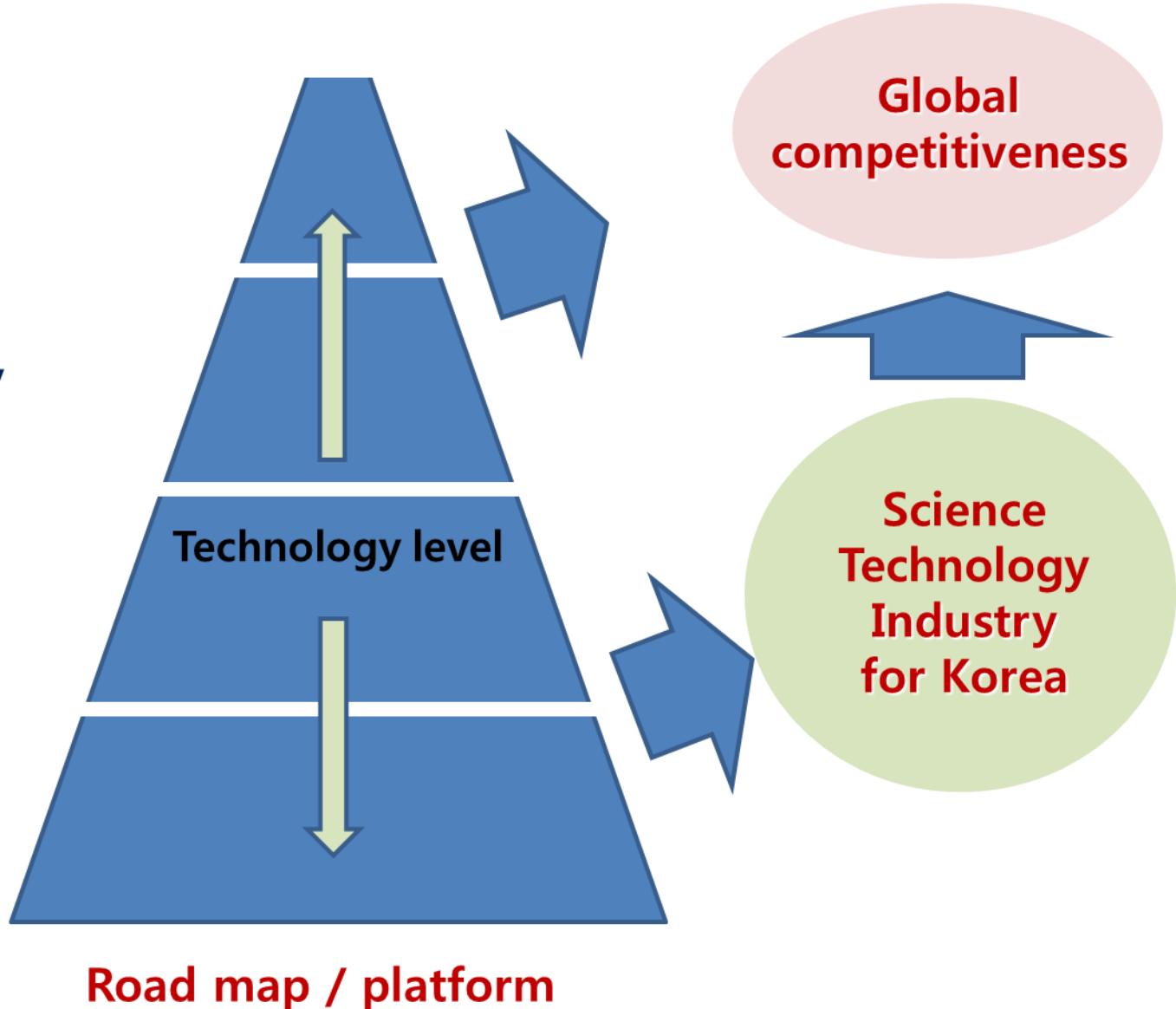
Research direction in protected horticulture

Global issue

Smart technology

Regional climate

Regional practice



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Thank you for your attention!

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2018. 10. 19, KSHS