Smart Farming?
Data Science?

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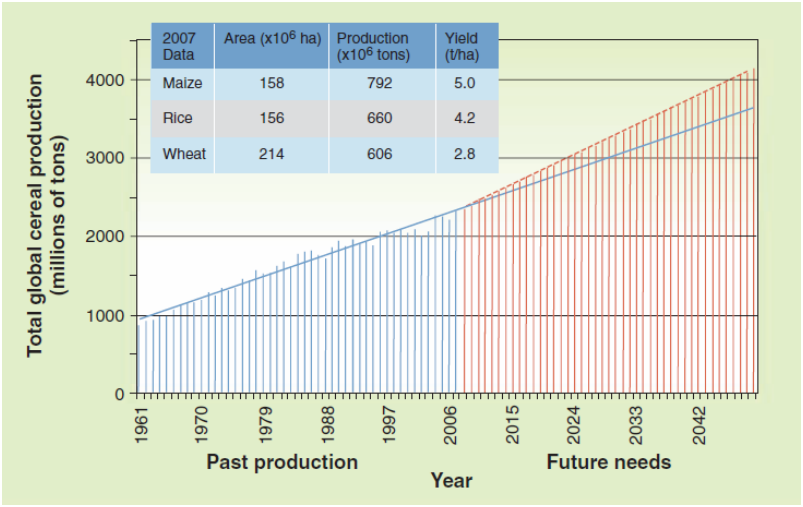
Q.1

What is your first impression on Smart Farming?

Food demand increases

2007 Data	Area ($x10^6$ ha)	Production ($x10^6$ tons)	Yield (t/ha)
Maize	158	792	5.0
Rice	156	660	4.2
Wheat	214	606	2.8



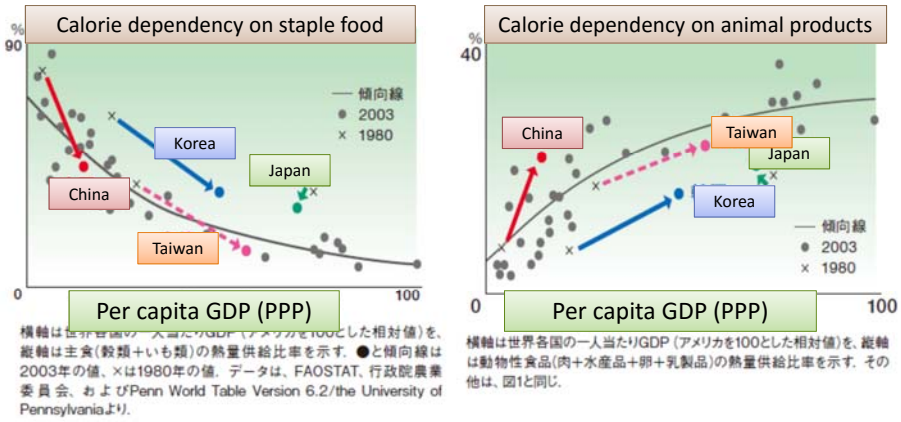
"Breeding Technologies to Increase Crop Production in a Changing World"
Tester and Langridge, Science(2010), **327** (5967): 818-822

Q.2

What does sufficient food mean?

Economic growth accompanies diet transition

Production efficiency of animal product is much lower than staple food



横軸は世界各国の一人当たりGDP（アメリカを100とした相対値）を、縦軸は主食（穀類＋いも類）の熱量供給比率を示す。●と傾向線は2003年の値、×は1980年の値。データは、FAOSTAT、行政院農業委員会、およびPenn World Table Version 6.2/the University of Pennsylvaniaより。

横軸は世界各国の一人当たりGDP（アメリカを100とした相対値）を、縦軸は動物性食品（肉＋水産品＋卵＋乳製品）の熱量供給比率を示す。その他は、図1と同じ。

Prof. Kazuhiko Kobayashi「循環型社会に向けた食遷移への挑戦」
小林和彦，東京大学農学生命科学研究科「弥生」春号（2009）
http://www.a.u-tokyo.ac.jp/pr-yayoi/48.pdf

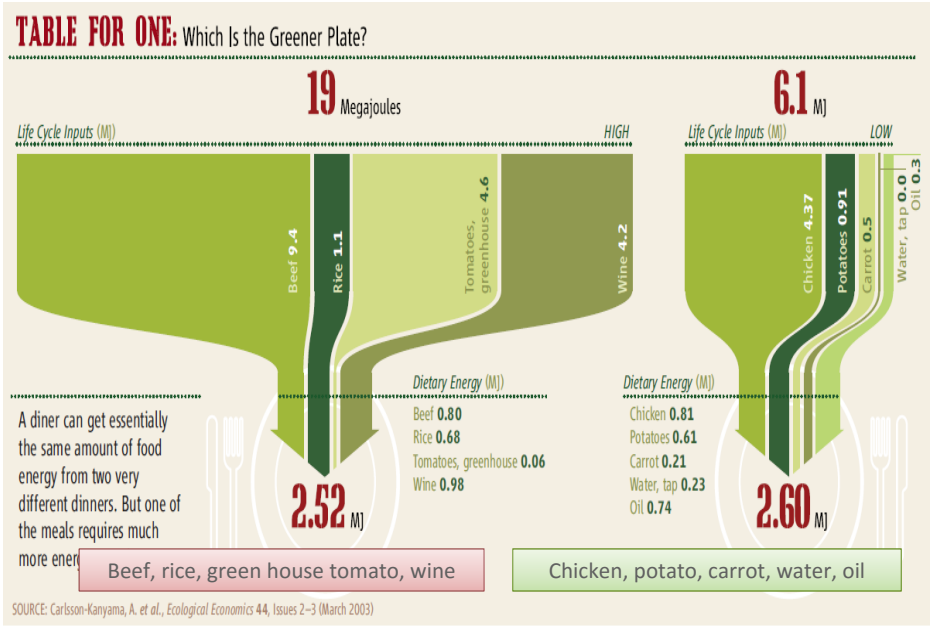
Water consumption for food production

- Water needed to produce 1 kg of agricultural product

Products	Water (t)
Rice	3.6
Barley	2.6
Wheat	2.0
Corn	1.9
Soybean	2.5

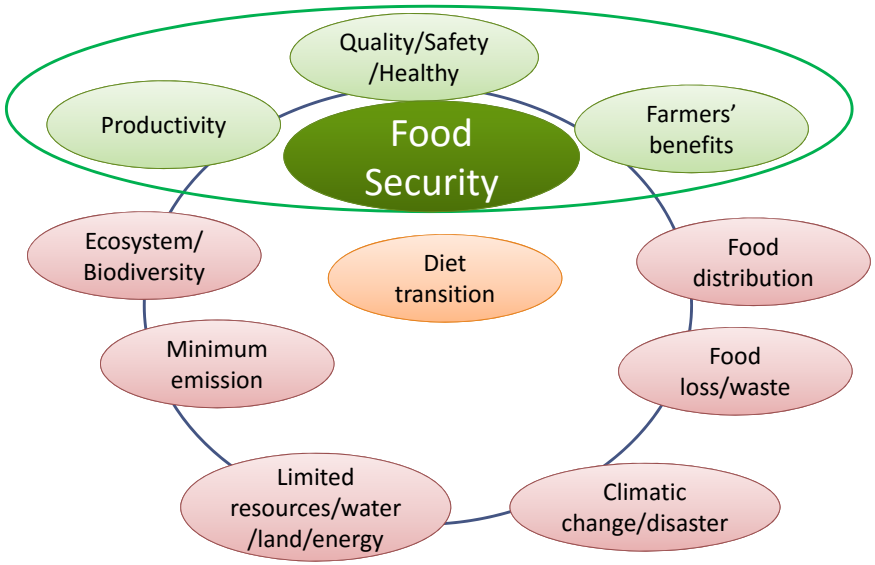
Products	Water (t)
Beef	20.6
Pork	5.9
Chicken	4.5
Egg	3.2

T. Oki, M. Sato, A. Kawamura, M. Miyake, S. Kanae, and K. Musiake, Virtual water trade to Japan and in the world, *Virtual Water Trade*, Edited by A.Y. Hoekstra, Proceedings of the International Expert Meeting on Virtual Water Trade, Delft, The Netherlands, 12-13 December 2002, Value of Water Research Report Series No.12, 221-235, February 2003.



"What it takes to make that meal" Science. 2010 Feb 12;327(5967):809

Toward sustainable and sufficient rich food production



Very complex optimization problem for real smart farming

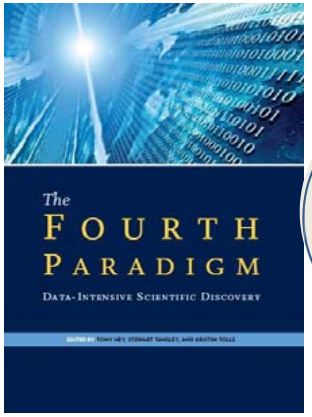
Q.3

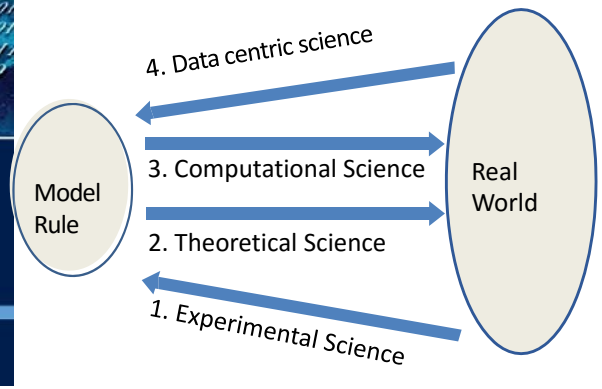
An example of optimization for sustainable food production?

How to solve very complex problems

Can ordinal way of sciences and technologies provide us timely sollutions?

4th Paradigm Shift of Science to Data Centric Science





http://research.microsoft.com/en - us/collaboration/fourthparadigm/contents.asp x

Two contrasts for optimization

- Method
  - o Bioscience/physics based on reductionism
    VS
  - o Data centric science based on big data
- Direction
  - o Local optimization: bottom-up
    VS
  - o global optimization: top-down

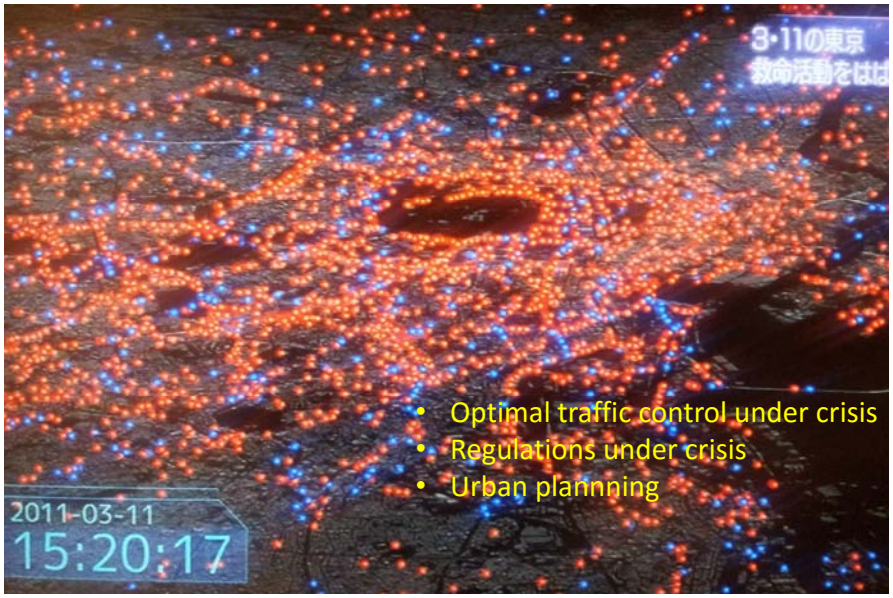
Data-centric science to solve complex problem

- *Data-centric science tries to lean latent rules and knowledge through data observed in real world*
- For a very complex problem, it is very difficult to discover common theories to drive it
- Data-centric approach can (may) be only the solution for such a problem
  - Data show us something which has happened in the past and is happing now.
  - Data-centric approach tells us what is going to happen in the future for our decisions based on rules found in data
- Black box
- Artificial intelligence

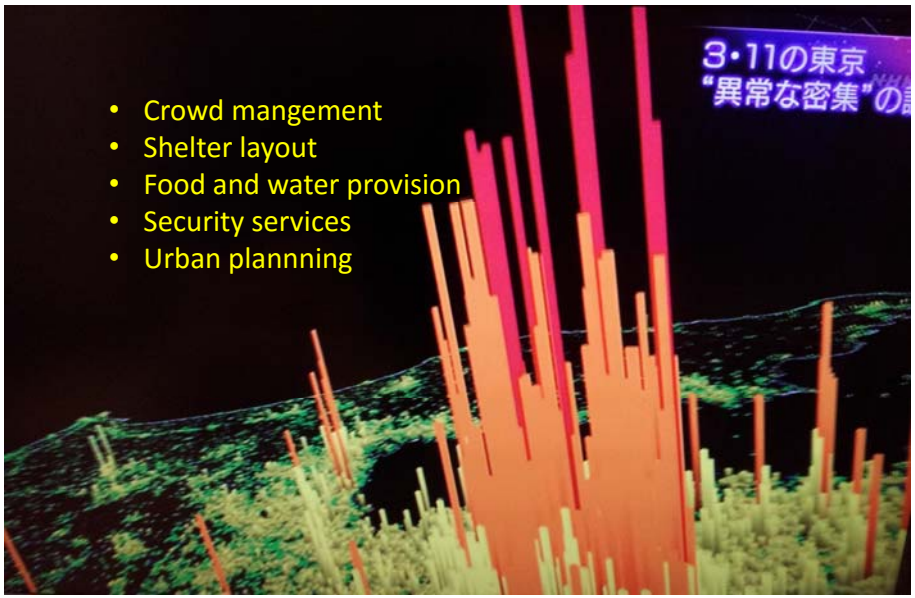
Big data?

- Big data
  - Large scale data from a single resource accessible at once
    - SNS, Mobile phone GPS, Car navigation system,…..
  - Holistically integrated data of distributed comparatively small scale data of the same kind seamlessly accessible
    - Not necessarily to be centralized
  - Holistically integrated data of distributed comparatively small scale data of the different kinds seamlessly accessible
    - Including unstructured data
- Big data studies in Japan started receiving attentions after March 11, 2011

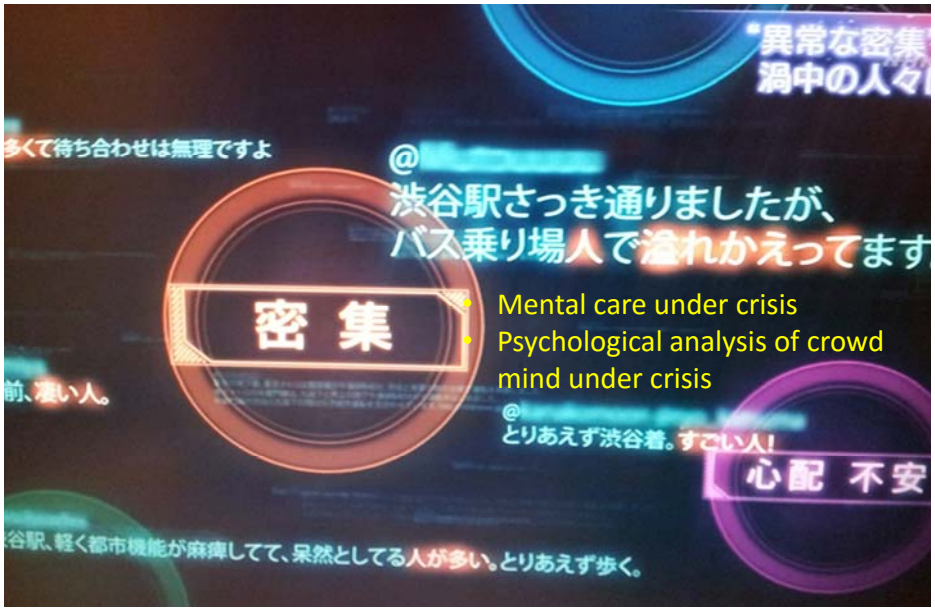
Car locations monitored by car navigation systems in Tokyo



Unusual crowds in Tokyo monitored by mobile phones



People's concerns in Tokyo monitored by Twitter



What we need for data-centric science in agriculture

- Utilization of legacy data
  - Yield data, variety data, quality data, soil data, market data, ……
  - Need to rescue such data
- Sensor innovation IOT
  - To efficiently monitor the fac
    processing,….
  - To collect knowledge of farm
- Data integration and efficient usage
  - Common platform for seamless data exchange with standard
  - Agricultural cloud and database

Big data cs,

- Tools to analyze and to support decisions/ Models
  - Statistics, data-mining , knowledge extraction, risk managements
  - Big data-based optimization
  - Enrichment of commonly usable APIs
- Communication innovation/ Service science
  - Efficient Knowledge transfer to farmers

In other words, to achieve sustainable and sufficient rich food production, we need

- To monitor what is happening
  - IoT on multiple platforms
  - Legacy data
- To understand the present status
  - Analytics/models
- To predict what is going to happen
  - Models
- To design most optimal food production
  - Models/policy

Some examples of sensor innovations

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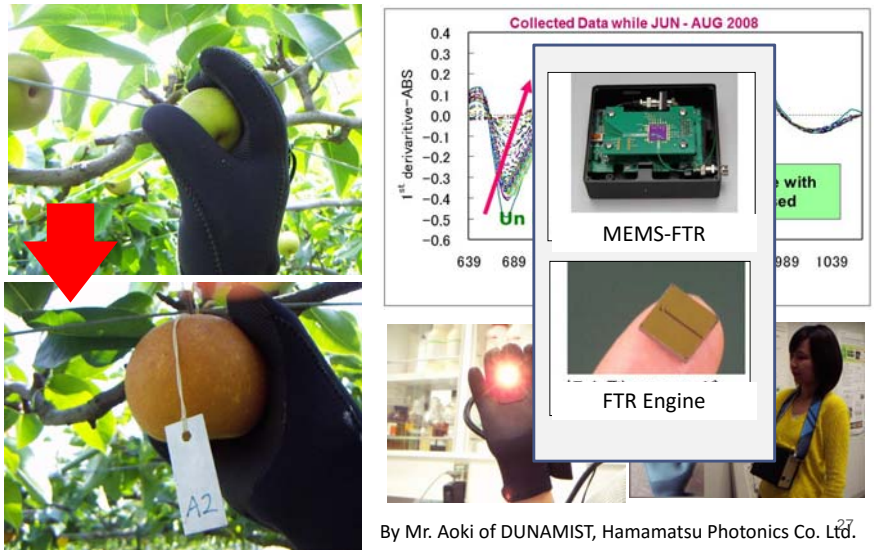
Types of information in farming

- Environmental information
- Farm management information
  - Tacit knowledge
- Biological information (crop information)
  - Phenomics data
  - Genomics data
- Efficient and low cost acquisition of crop condition data is still quite challenging outdoor

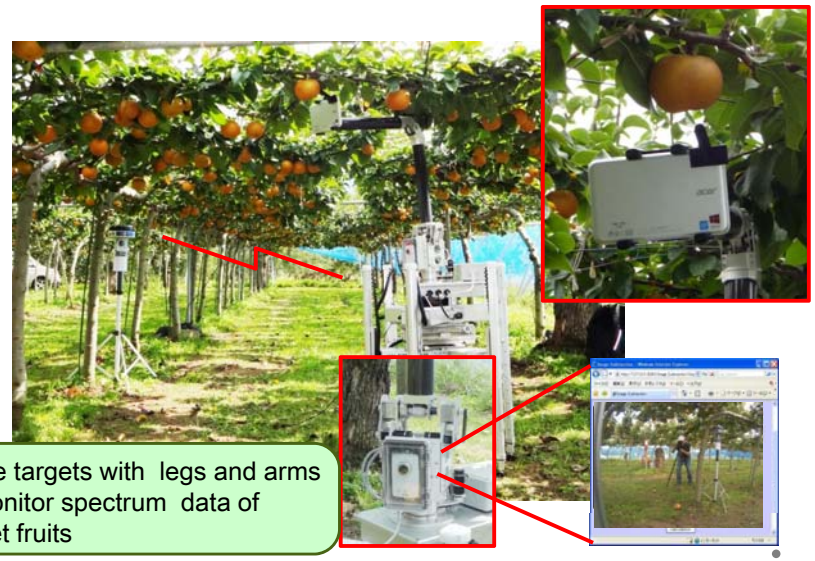
Low cost sensor networks are now available

Glove type NIR analyzer for intact fruits



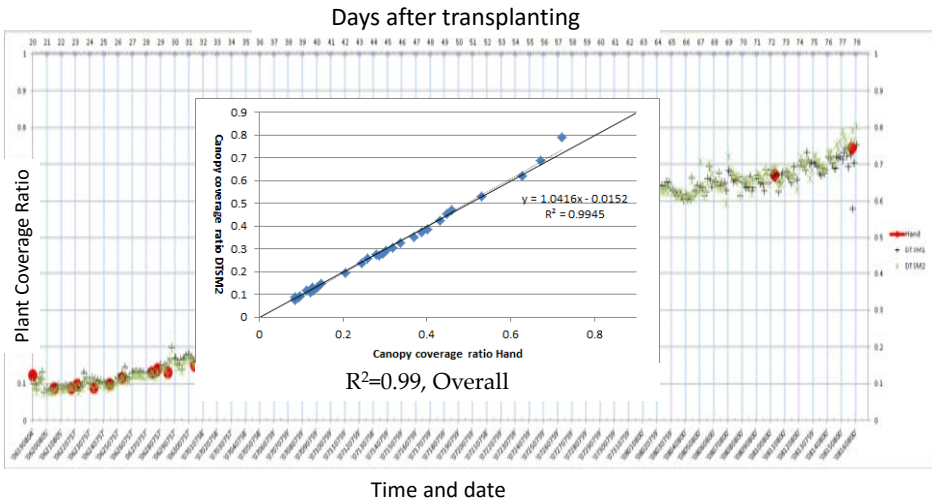
By Mr. Aoki of DUNAMIST, Hamamatsu Photonics Co. Ltd.

High-end robotic Field Server



Grape cluster identification

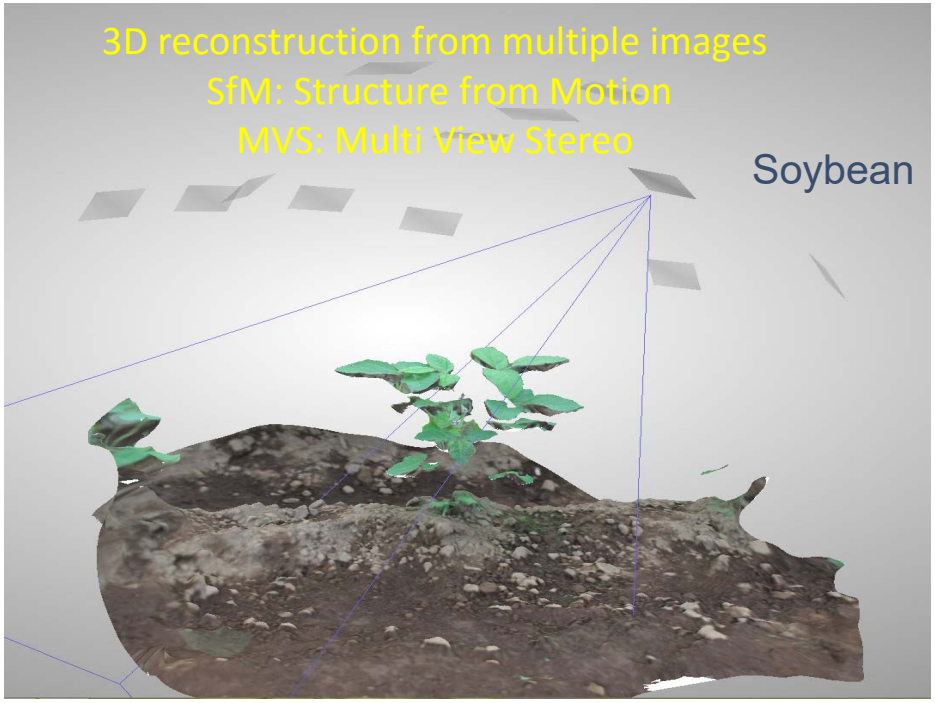
Estimation of canopy coverage of paddy rice

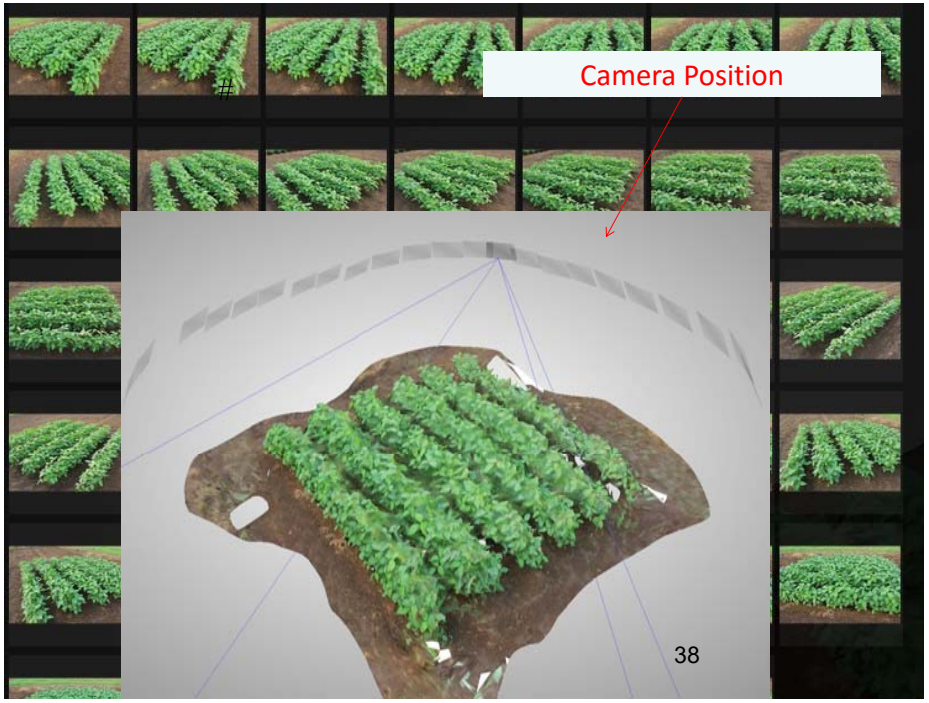


R^2=0.99, Overall

Separation of crops from weeds

Field monitoring using drones





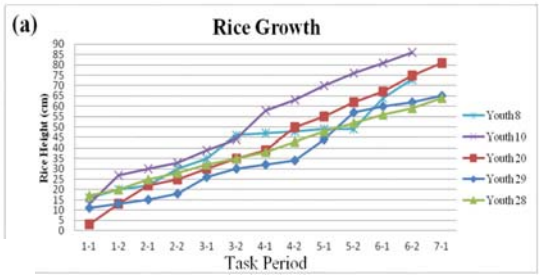
Heading of sorghum for biomass

Utilization of legacy data

表８－８　生産力検定本試験成績（晩播）

類別	試験番号	品種名または系統名	開花期(月.日)	成熟期(月.日)	結実日数	生育中の障害 倒伏	蔓化	枝折	SMV	立枯	主茎長(cm)	主茎節数	分枝数	最着莢下高(cm)	茎太(mm)	草型	全重
早生	1.	東山１６４号	8.10	10.12	63	無	無	無	無	無	48	13.3	4.3	15	5.1	中間	56.6
	2.	東山１６５号	8.12	10.14	63	微	無	無	無	無	48	13.5	3.6	14	5.2	半閉	52.8
	3.	東山１６７号	8.11	10.13	63	無	無	無	無	無	52	12.8	2.8	13	5.4	半閉	52.2
	4.	東山１６８号	8.13	10.16	64	無	無	無	無	無	51	13.2	3.4	15	5.3	半閉	58.5
	5.	ワセシロゲ	8.9	10.10	62	微	無	無	微	無	53	12.9	4.3	11	5.5	半閉	51.3
	6.	ホウレイ	8.11	10.10	60	微	無	無	無	無	45	12.8	3.8	11	5.1	中間	53.3
	7.	シロセンナリ	8.12	10.15	64	無	微	無	少	無	43	13.1	3.2	9	5.7	半閉	51.6
	8.	アヤヒカリ	8.11	10.14	64	微	少	無	無	無	55	12.9	5.3	14	4.7	中間	52.3
	9.	スズユタカ	8.12	10.15	64	無	微	無	無	無	49	13.2	4.3	10	5.8	半閉	58.4
	10.	エンレイ	8.11	10.13	63	微	無	無	微	無	57	13.1	3.8	16	5.0	半閉	52.7
	LSD(0.05)		1	2	3						6	0.5	1.4	3			9.6
中生	1.	東山９４号(変)	8.13	10.23	71	無	微	無	無	無	57	13.0	3.9	15	5.7	半閉	61.4
	2.	東山１５５号	8.13	10.18	66	中	少	無	微	無	70	13.6	2.6	21	5.3	中間	54.3
	3.	東山１５８号	8.16	10.22	68	無	微	無	無	無	50	13.6	3.4	15	5.6	半閉	56.3
	4.	東山１６１号	8.16	10.16	61	無	無	無	無	無	47	13.4	3.7	12	6.1	中間	55.0
	5.	東山１７７号	8.13	10.17	65	無	無	無	無	無	51	12.8	4.1	16	5.1	中間	53.5
	6.	東山１７８号	8.14	10.17	64	無	少	無	無	無	63	13.6	3.3	14	5.8	閉鎖	56.4

Crowd sourcing: Kids' sensors in Vietnam



Q.4

What kind of sensors do you like to develop for farming?

• • •

Open data/Open science

- Restoration and utilization of legacy data
  - Data possessed by agricultural experimental stations and scientist
  - Digitization and metadata development
- Data management & data interoperability
  - Standardization & common APIs
- Citizen science & open science
  - Data collection and phenology observations by citizens
- Software library sharing
  - Data-centric methods
  - Trans-disciplinary collaboration

Q.5

How do you think open science/citizen science contributes to sustainable food production?

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Summary

- Data-centric approach with big data will help us to achieve smart agriculture which provides us sustainable and sufficient food production for quality life of all the humans
  - Sensor innovation and IOT
  - Restoration and utilization of legacy data
  - Model innovation
  - Model and data integration platform
  - Open data, open science
- Innovations in agricultural sciences
  - Breeding, cultivation methods, integrated managements,..
  - Field robotics, machinery, irrigation system
- Innovations in communication and education
  - Efficient Knowledge transfer
- Service science

Homework

- To sketch a system to support sustainable farming
  - Objectives
  - Methods
    - Present availability of the methods is not necessary
    - Sensor technologies
    - Prediction models etc.