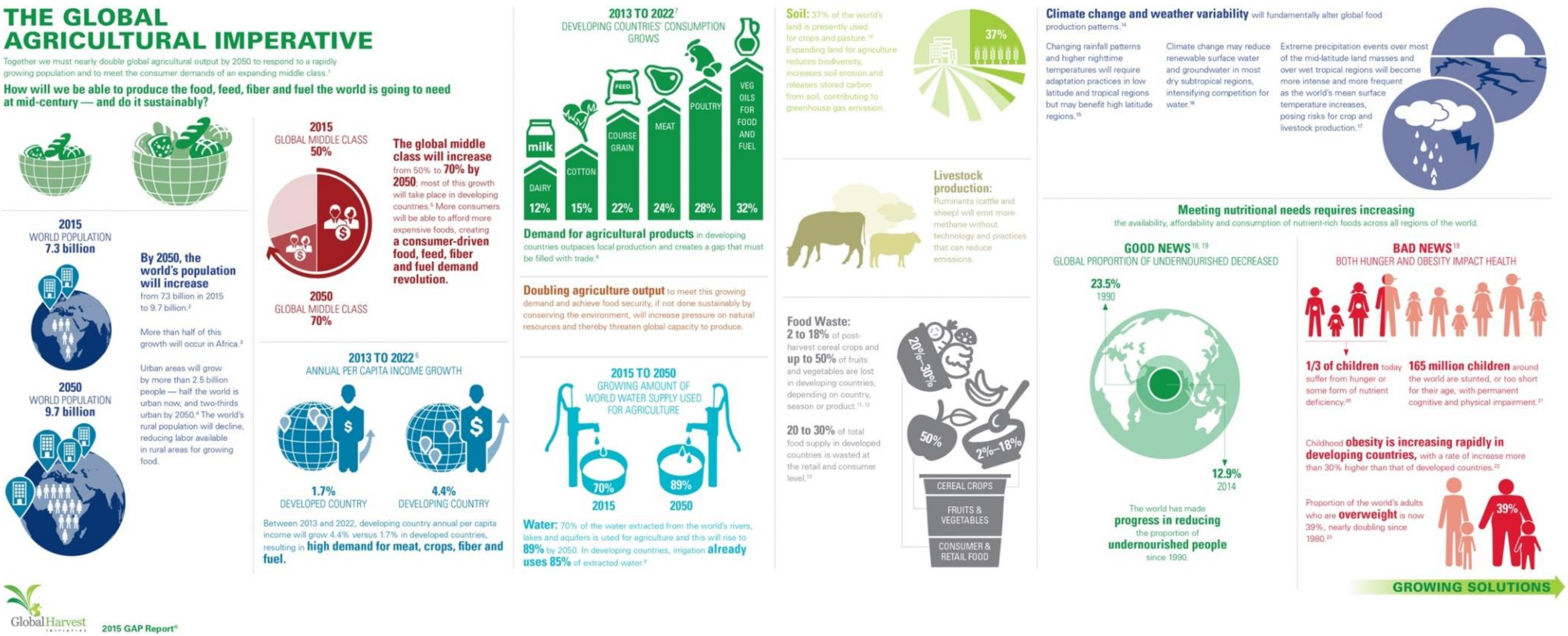
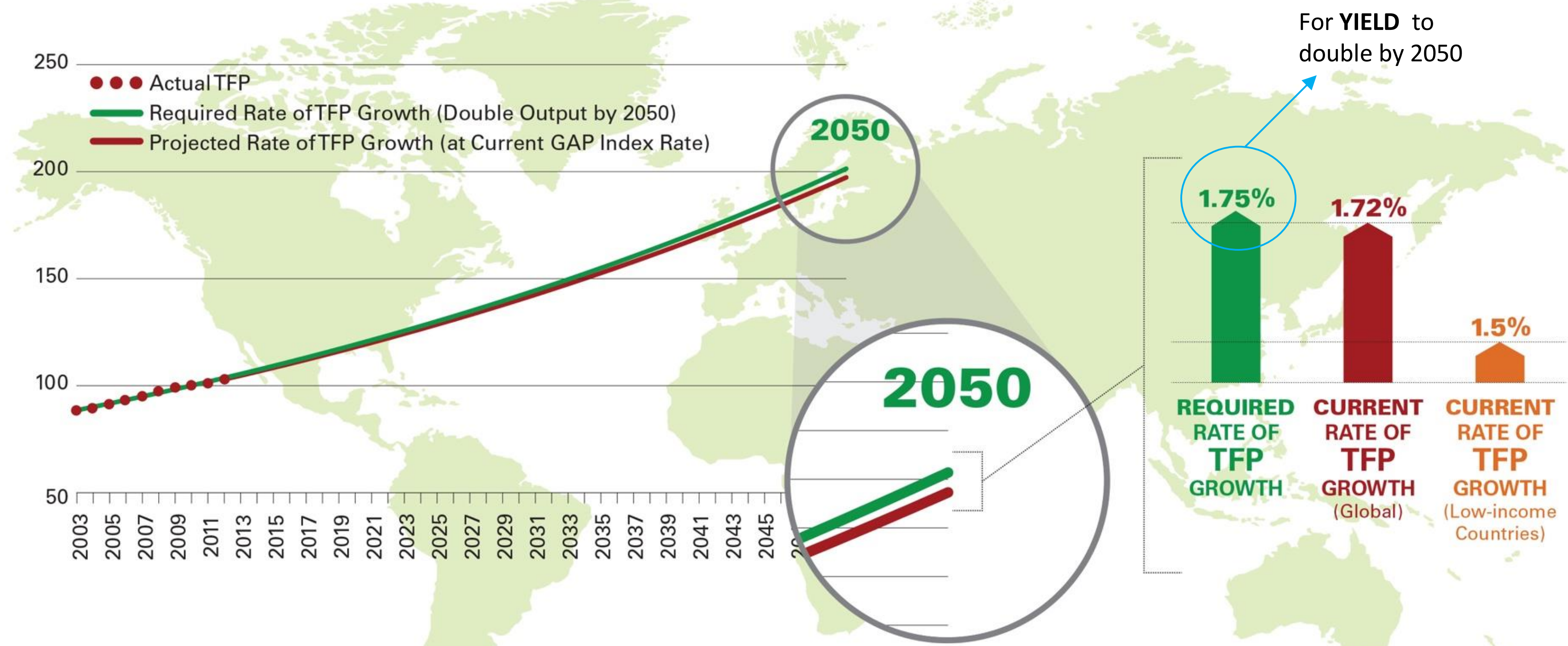
THE ROLE OF FLUIDS IN FUTURE CROP MANAGEMENT

Vatren Jurin
December 2016


THE GLOBAL AGRICULTURAL IMPERATIVE
Together we must nearly double global agricultural output by 2050 to respond to a rapidly growing population and to meet the consumer demands of an expanding middle class.
How will we be able to produce the food, feed, fiber and fuel the world is going to need at mid-century — and do it sustainably?
2015 WORLD POPULATION 7.3 billion
By 2050, the world's population will increase from 7.3 billion in 2015 to 9.7 billion.
More than half of this growth will occur in Africa.
Urban areas will grow by more than 2.5 billion people — half the world is urban now, and two-thirds urban by 2050. The world's rural population will decline, reducing labor available in rural areas for growing food.
2050 WORLD POPULATION 9.7 billion
2015 GLOBAL MIDDLE CLASS 50%
2050 GLOBAL MIDDLE CLASS 70%
The global middle class will increase from 50% to 70% by 2050; most of this growth will take place in developing countries. More consumers will be able to afford more expensive foods, creating a consumer-driven food, feed, fiber and fuel demand revolution.
2013 TO 2022 ANNUAL PER CAPITA INCOME GROWTH
1.7% DEVELOPED COUNTRY
4.4% DEVELOPING COUNTRY
Between 2013 and 2022, developing country annual per capita income will grow 4.4% versus 1.7% in developed countries, resulting in high demand for meat, crops, fiber and fuel.
2013 TO 2022 DEVELOPING COUNTRIES' CONSUMPTION GROWS
milk
DAIRY 12%
COTTON 15%
FEED
COURSE GRAIN 22%
MEAT 24%
POULTRY 28%
VEG OILS FOR FOOD AND FUEL 32%
Demand for agricultural products in developing countries outpaces local production and creates a gap that must be filled with trade.
Doubling agriculture output to meet this growing demand and achieve food security, if not done sustainably by conserving the environment, will increase pressure on natural resources and thereby threaten global capacity to produce.
2015 TO 2050 GROWING AMOUNT OF WORLD WATER SUPPLY USED FOR AGRICULTURE
70% 2015
89% 2050
Water: 70% of the water extracted from the world's rivers, lakes and aquifers is used for agriculture and this will rise to 89% by 2050. In developing countries, irrigation already uses 85% of extracted water.
Soil: 37% of the world's land is presently used for crops and pasture. Expanding land for agriculture reduces biodiversity, increases soil erosion and releases stored carbon from soil, contributing to greenhouse gas emission.
37%
Livestock production: Ruminants (cattle and sheep) will emit more methane without technology and practices that can reduce emissions.
Food Waste: 2 to 18% of post-harvest cereal crops and up to 50% of fruits and vegetables are lost in developing countries, depending on country, season or product.
20 to 30% of total food supply in developed countries is wasted at the retail and consumer level.
20%–30%
50%
2%–18%
CEREAL CROPS
FRUITS & VEGETABLES
CONSUMER & RETAIL FOOD
Climate change and weather variability will fundamentally alter global food production patterns.
Changing rainfall patterns and higher nighttime temperatures will require adaptation practices in low latitude and tropical regions but may benefit high latitude regions.
Climate change may reduce renewable surface water and groundwater in most dry subtropical regions, intensifying competition for water.
Extreme precipitation events over most of the mid-latitude land masses and over wet tropical regions will become more intense and more frequent as the world's mean surface temperature increases, posing risks for crop and livestock production.
Meeting nutritional needs requires increasing the availability, affordability and consumption of nutrient-rich foods across all regions of the world.
GOOD NEWS
GLOBAL PROPORTION OF UNDERNOURISHED DECREASED
23.5% 1990
12.9% 2014
The world has made progress in reducing the proportion of undernourished people since 1990.
BAD NEWS
BOTH HUNGER AND OBESITY IMPACT HEALTH
1/3 of children today suffer from hunger or some form of nutrient deficiency.
165 million children around the world are stunted, or too short for their age, with permanent cognitive and physical impairment.
Childhood obesity is increasing rapidly in developing countries, with a rate of increase more than 30% higher than that of developed countries.
Proportion of the world's adults who are overweight is now 39%, nearly doubling since 1980.
39%
GROWING SOLUTIONS
Global Harvest
2015 GAP Report

THE GLOBAL AGRICULTURAL PRODUCTIVITY (GAP) INDEX™



Source: Food Demand Index is from Global Harvest Initiative (GHI) (2015);
Agricultural Output from TFP Growth is from USDA Economic Research Service (2015).

Global Harvest INITIATIVE

2015 GAP Report®

Total
Factor
Productivity

PRODUCTIVITY GROWTH → Is the measure of output per unit of growth. By examining the TFP we can get the information needed to improve our agricultural systems. …

Global Harvest Initiative | **2015 GAP Report**

EXPANSION

- USING MORE LAND
- EXPANDING IRRIGATION TO LAND THAT'S NOT IRRIGATED

INTENSIFICATION

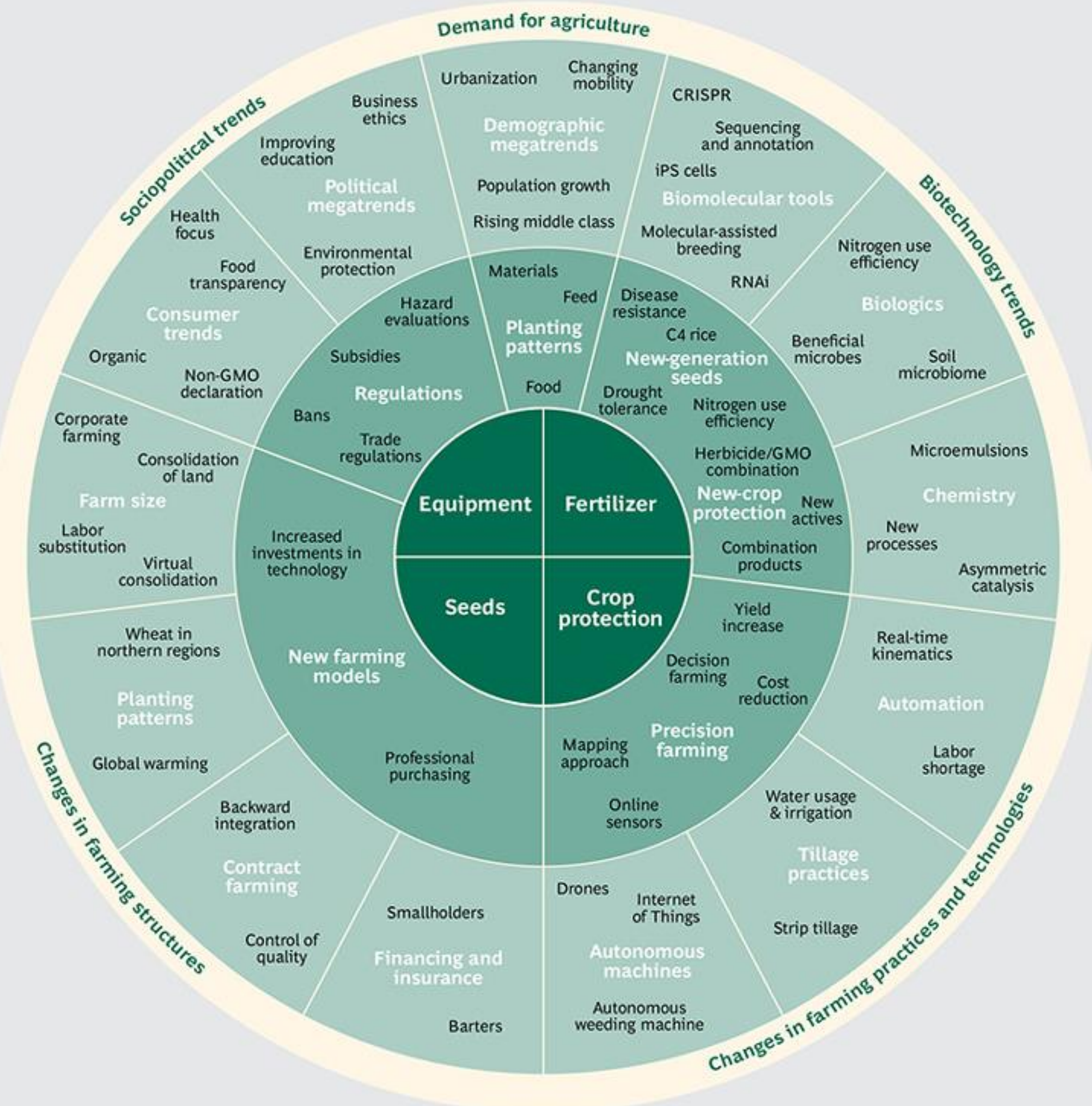
- INCRESED USE OF FERTILIZER, LABOR, MACHINERY AND OTHER INPUTS

EFFICIENCY

- ADOPTING TECHNOLOGIES AND FARMING PRACTICES THAT RESULT IN MORE OUTPUT FROM EXISTING RESOURCES – MEASURED BY **TFP**

FLUID FERTILIZERS

EXHIBIT 1 | Trends That Will Shape Crop Farming Through 2030



Sources: BCG interviews with a panel of farmers in France, Germany, Poland, and the U.K.; interviews with industry experts; analysis of approximately 16,000 Derwent World Patent Index patent families registered from 2010 through 2014; BCG analysis.

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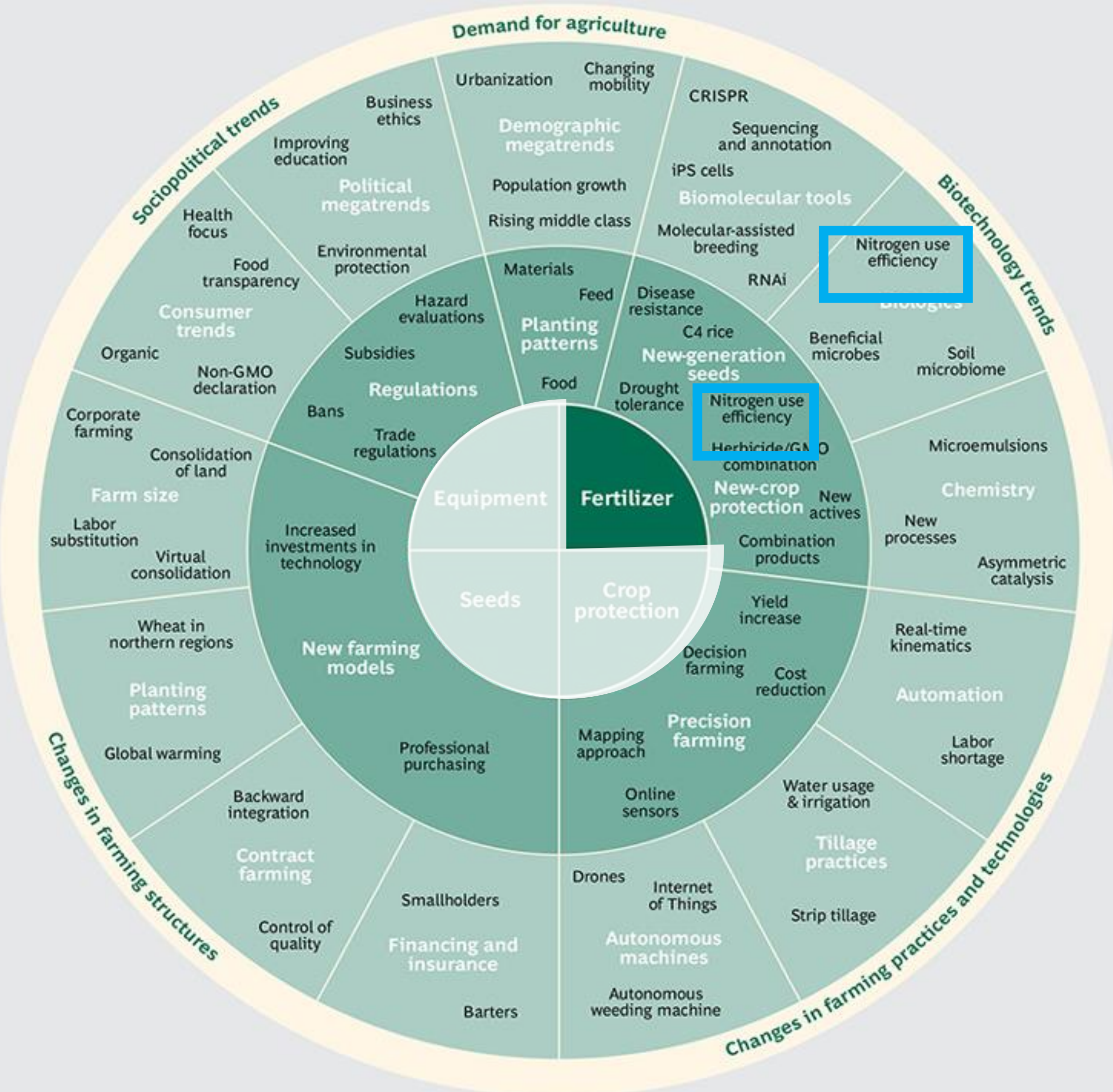


Sources: BCG interviews with a panel of farmers in France, Germany, Poland, and the U.K.; interviews with industry experts; analysis of approximately 16,000 Derwent World Patent Index patent families registered from 2010 through 2014; BCG analysis.

FLUIDS

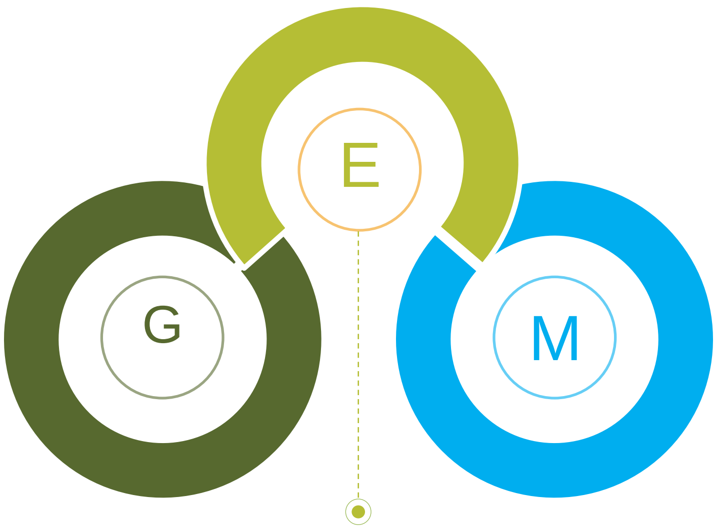
- Liquid vs. Dry
- Placement
- Delivery systems
- Fertigation
- Micronutrients

Published July 2, 2015

Review & Interpretation

Meeting Global Food Needs: Realizing the Potential via Genetics × Environment × Management Interactions

Jerry L. Hatfield* and Charles L. Walthall



GENETICS

Crop improvement from the last 50 years can greatly be attributed to breeders. But evidence now shows that a yield plateau exists.

ENVIRONMENT

Changes on weather patterns are bringing change to water and temperature events

MANAGEMENT*

Farm management practices need to be integrated into multi-disciplinary teams of agronomists, breeders, pathologists, entomologists, weed scientists and human nutritionists ..

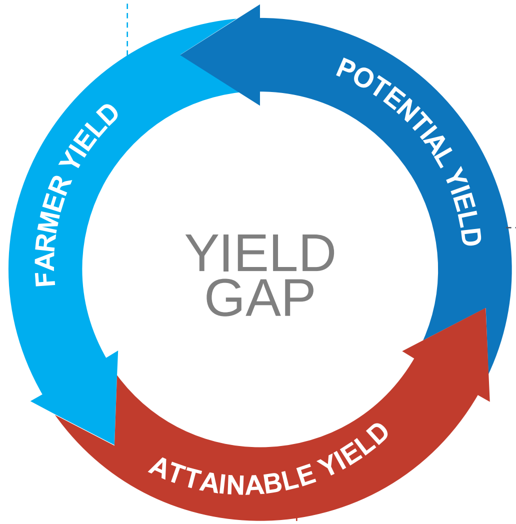
MANAGEMENT

- HERE IS WHERE FLUID FERTILIZERS PLAY A ROLE

CROP YIELDS ARE CONSTRAINED BY THREE FACTORS

- WATER
- TEMPERATURE
- FERTILITY

- TWO OUT OF THREE ARE DIRECTLY INFLUENCED BY MANAGEMENT PRACTICES



Y_F
- Cultivar grown in ideal environment
- Water is not limiting
- Fertilizer is not limiting
- Pests are effectively controlled

Y_P
- Capacity of a crop to convert solar radiation into dry matter with no stress during the growing season

Y_A
- Yield achieved by a producer under near optimum weather and management inputs.

$Y_F - Y_A =$ THESE DIFFERENCES PROVIDE INSIGHTS INTO THE LIMITATION OF CROP YIELD

INCRESING Y_F IS THE PATH FOR CLOSING THE YIELD GAP

THREE LIMITATION TO CROP PRODUCTION FROM THE PERSPECTIVE OF

G x E x M

NITROGEN

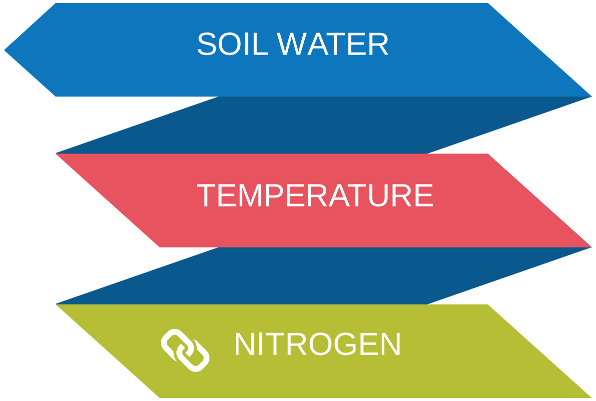
NITROGEN IS KING. Maximizing FARMERS YIELD requires and adequate supply of nitrogen… and the other nutrients

TEMPERATURE

Mainly heat has a direct effect on crops during critical stage of yield development

SOIL WATER

Supplying more available water to the crop insures that FARMER YIELD is closer to YIELD POTENTIAL



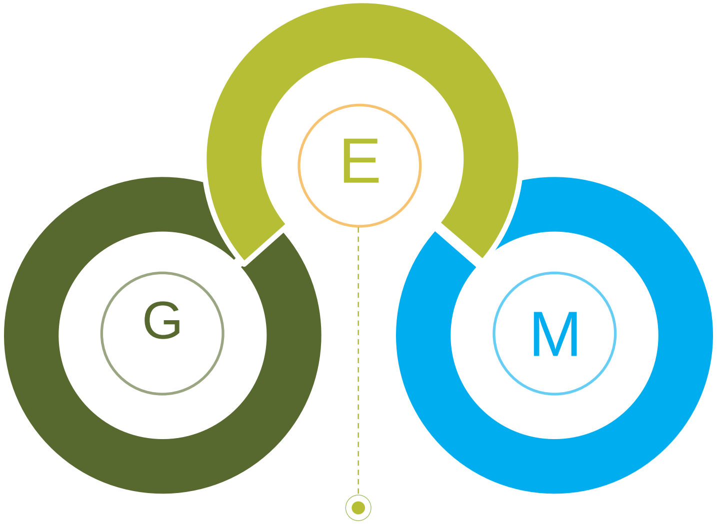
FERTILITY MANAGEMENT

$Y_F - Y_A =$ THESE DIFFERENCES PROVIDE INSIGHTS INTO THE LIMITATION OF CROP YIELD

- NATIONAL CROP COMMODITY PRODUCTIVITY INDEX
  - Uses the soil survey database (NASIS) to assess relative soil productivity.
  - BUT ONCE YOU IRRIGATE A FIELD THE INDEX BECOMES IRRELEVANT

- HATFIELD AND WALTHALL propose that STANDARD MANAGEMENT PRACTICES be used when breeding the crops of the future ….. FLUID FERTILIZER ENTER THE EQUATION

- A PARADIGM SHIFT ON HOW RESEARCH IS CONDUCTED NEEDS TO HAPPEN



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MANAGEMENT *

Farm management practices need to be integrated into multi-disciplinary teams of agronomists, breeders, pathologists, entomologists, weed scientists and human nutritionists ..

- COOPERATION WITH UNIVERSITIES AND BREEDERS CAN HAPPEN
  - Genetic efficiency for fertilizer use efficiency
    - Starter
    - Fertigation
    - Foliar
  - Quantify levels of management practices (Dr. BELOW)

SO HOW DO WE QUANTIFY MANAGEMENT PRACTICES ….

- Functional trait-based ecology
  - Has been used for many years by ecologist to understand natural plant communities.
  - .. An approach to understanding or predicting the causes and consequences of biotic and abiotic species interactions, as a function of the physiological, morphological, chemical or phenological characteristics of organisms.

Journal of Applied Ecology

Review

REVIEW: Plant functional traits in agroecosystems: a blueprint for research

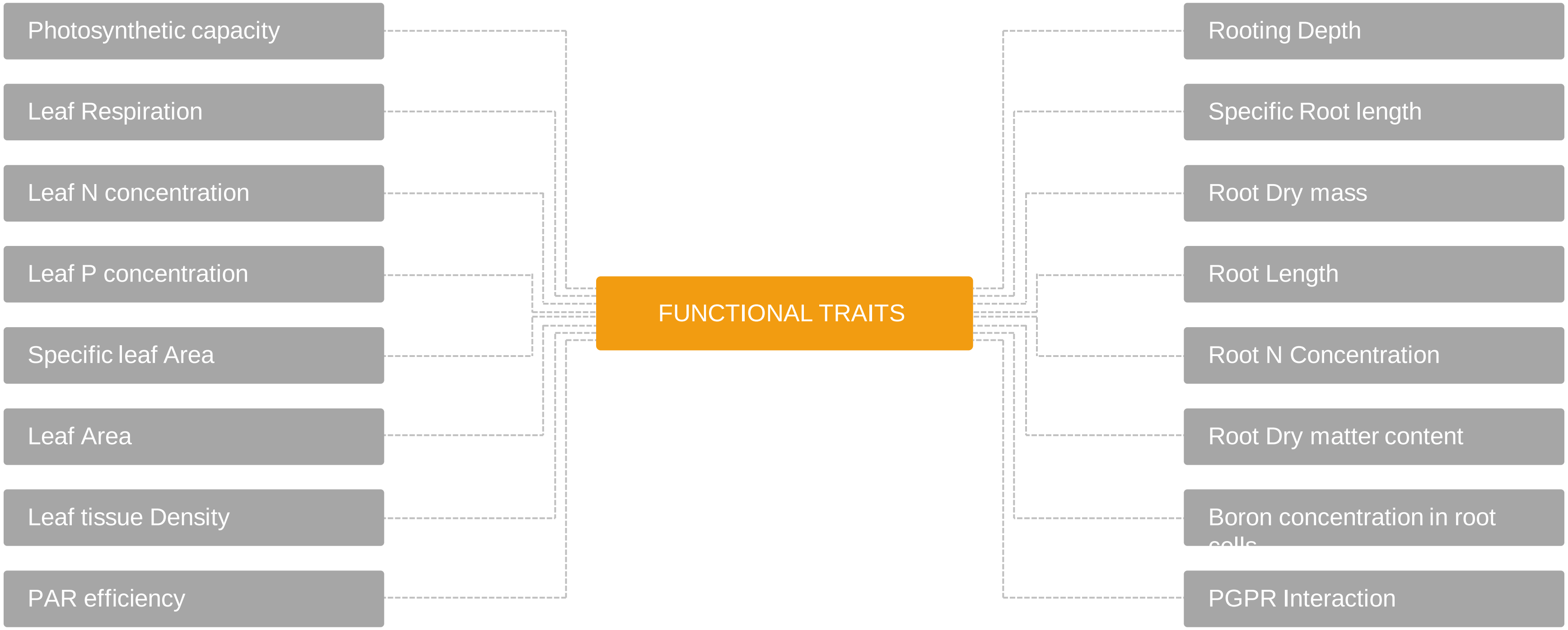
Adam R. Martin and Marney E. Isaac*

Article first published online: 25 SEP 2015
DOI: 10.1111/1365-2664.12526

Issue

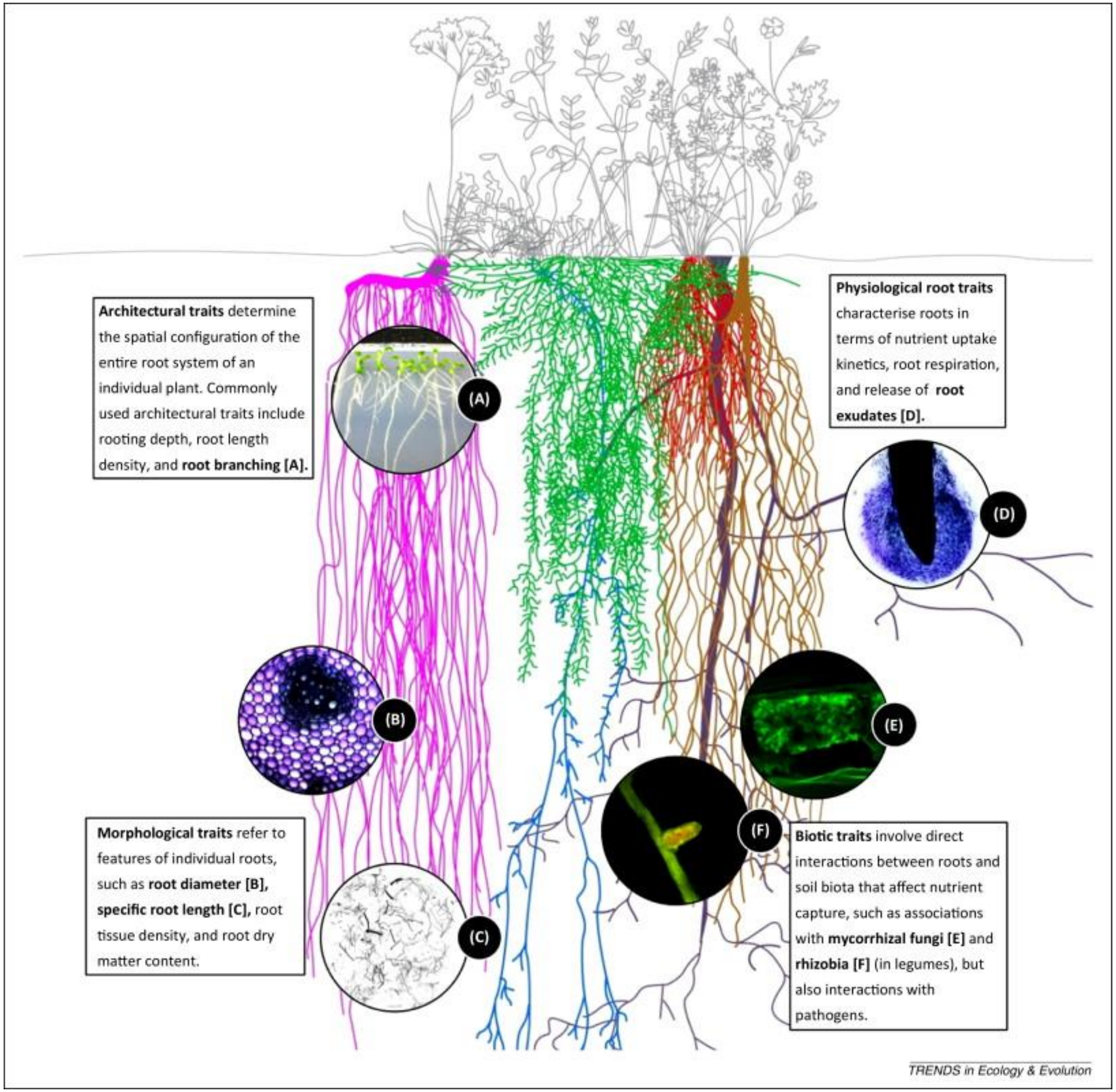
Journal of Applied Ecology
Volume 52, Issue 6, pages 1425–1435, December 2015

Functional Traits that can be used with specific Fertility management strategies that can help understand the contribution farmers management practices have on the Genetic expression of the Crop



ROOTS

NATURAL ROOT ECOSYSTEM



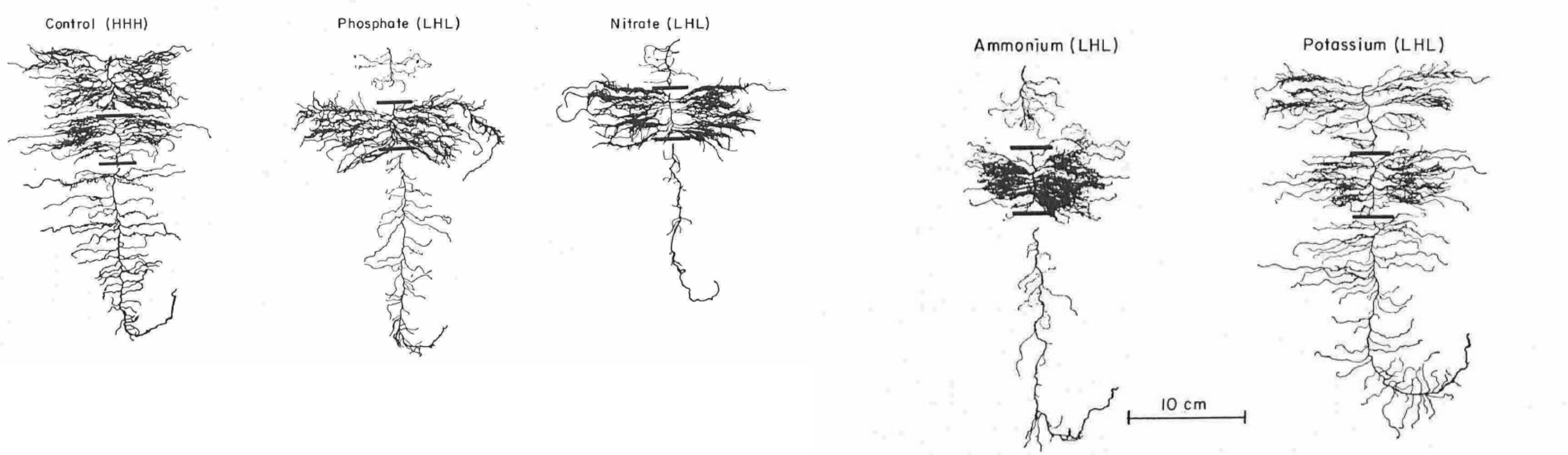
New Phytol. (1975) **75**, 479–490.

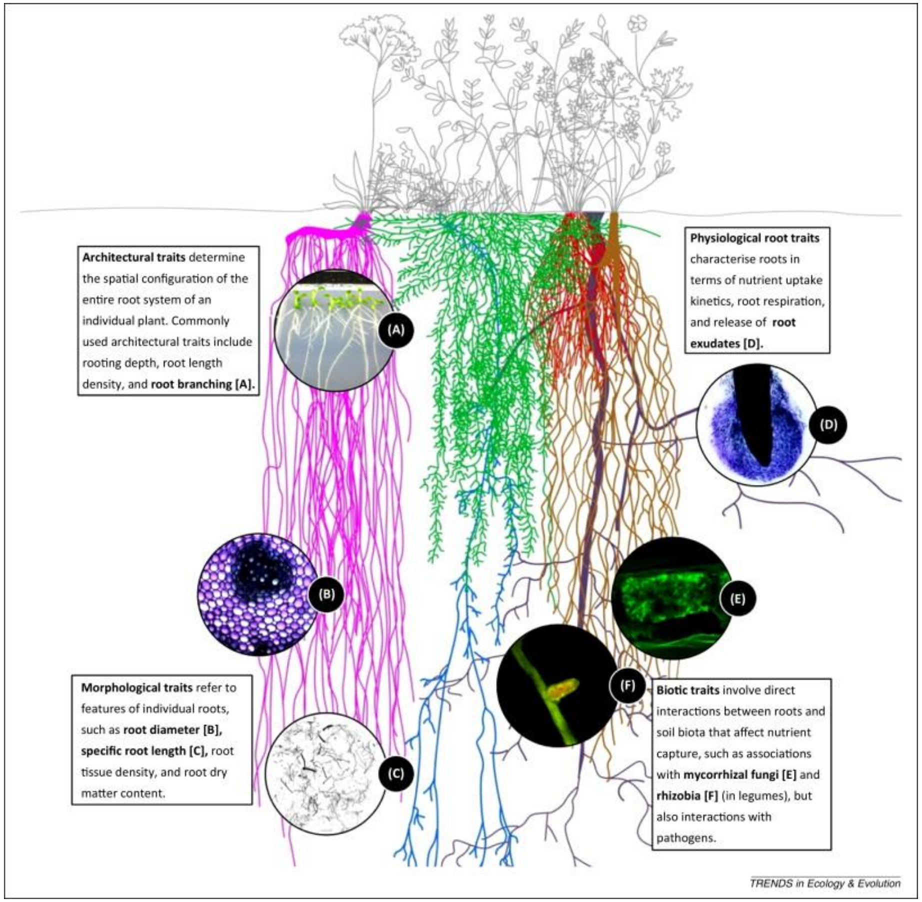
COMPARISON OF THE EFFECTS OF A LOCALIZED SUPPLY OF PHOSPHATE, NITRATE, AMMONIUM AND POTASSIUM ON THE GROWTH OF THE SEMINAL ROOT SYSTEM, AND THE SHOOT, IN BARLEY

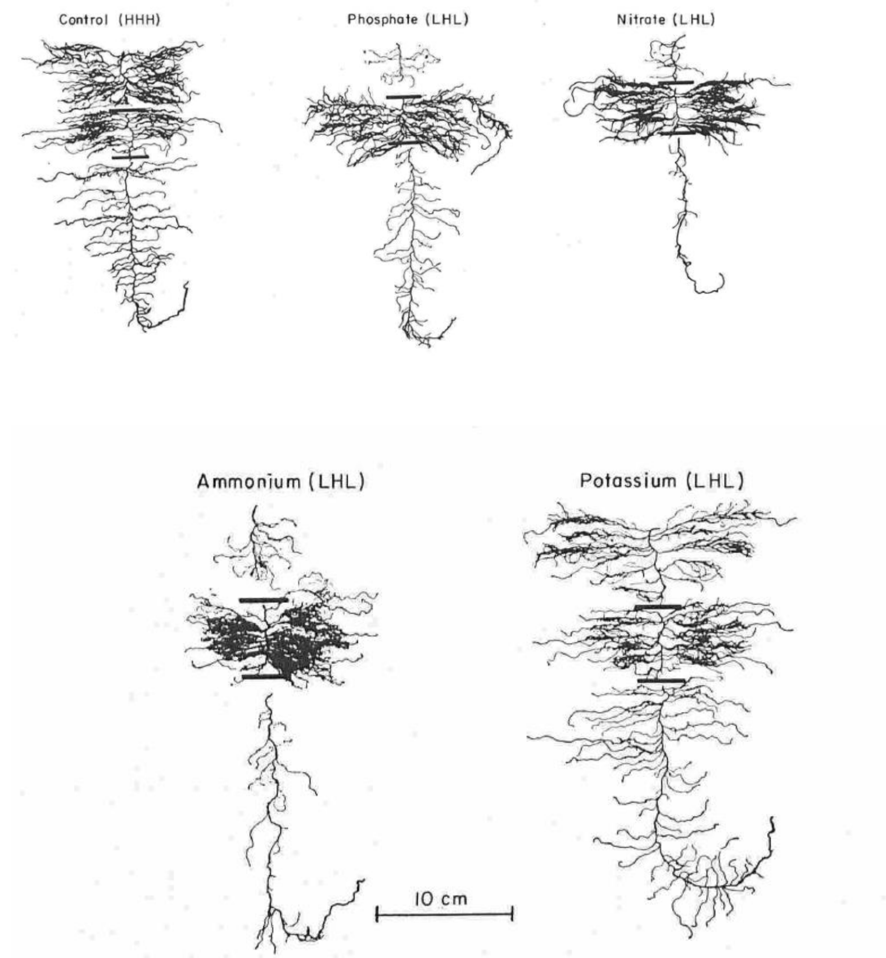
BY M. C. DREW

Agricultural Research Council, Letcombe Laboratory, Wantage, OX12 9JT, England

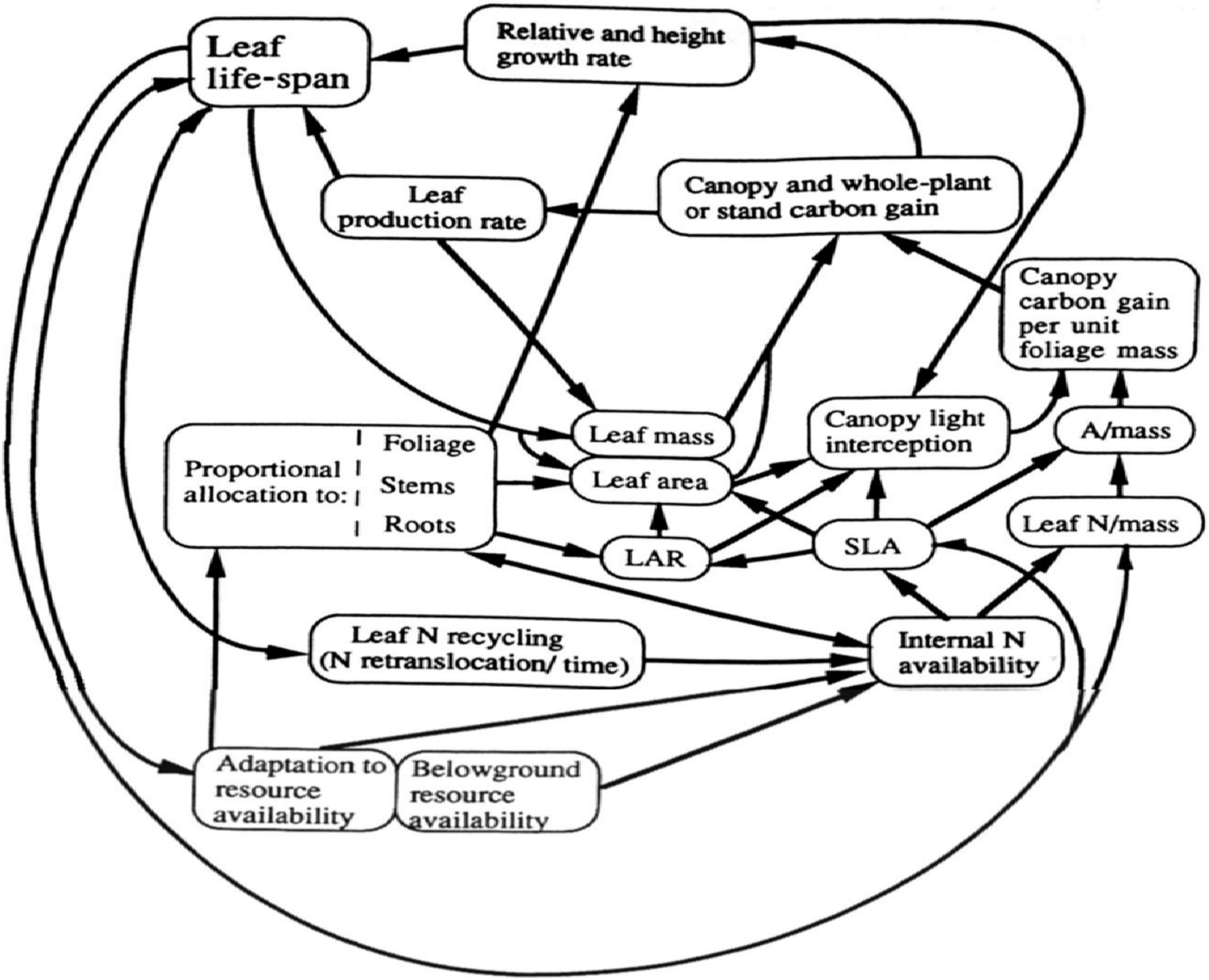
(*Received* 17 *March* 1975)

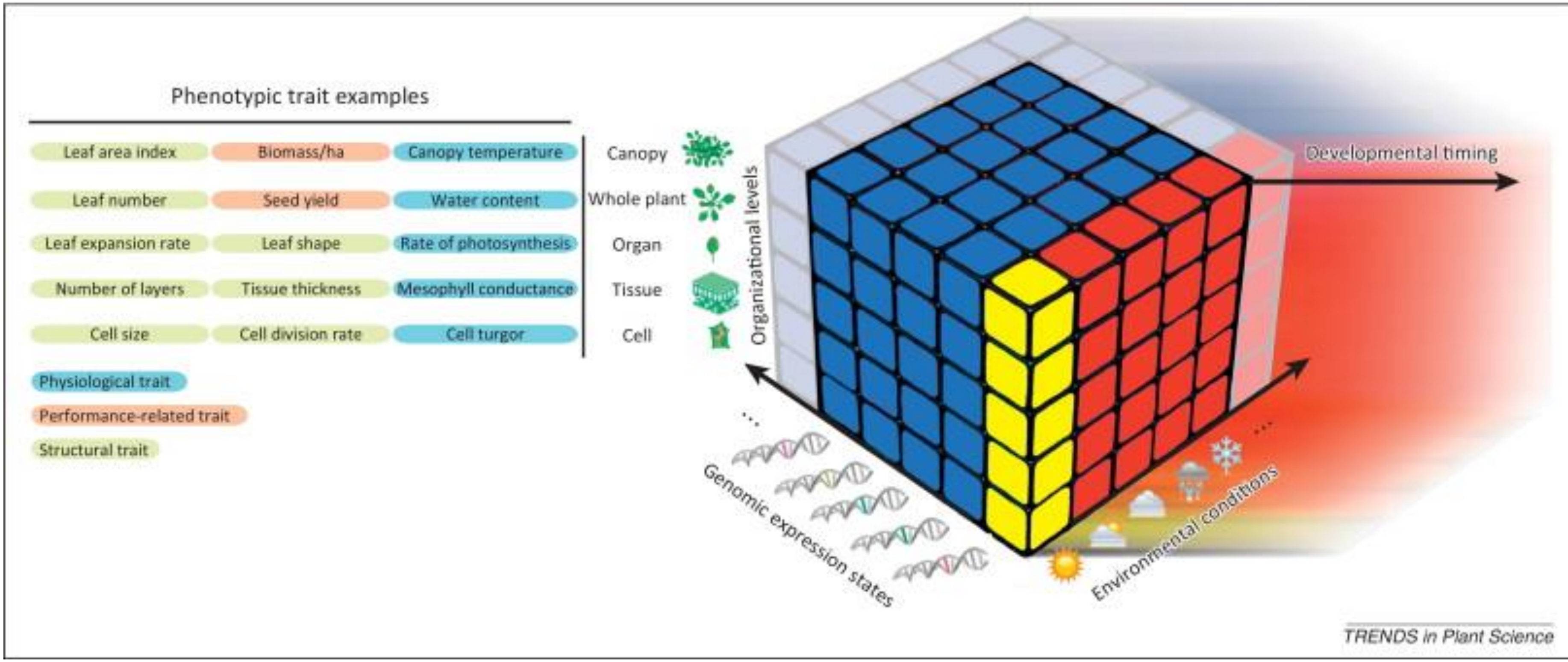



Architectural traits determine the spatial configuration of the entire root system of an individual plant. Commonly used architectural traits include rooting depth, root length density, and **root branching [A].**
Physiological root traits characterise roots in terms of nutrient uptake kinetics, root respiration, and release of **root exudates [D].**
Morphological traits refer to features of individual roots, such as **root diameter [B], specific root length [C],** root tissue density, and root dry matter content.
Biotic traits involve direct interactions between roots and soil biota that affect nutrient capture, such as associations with **mycorrhizal fungi [E]** and **rhizobia [F]** (in legumes), but also interactions with pathogens.
(A)
(B)
(C)
(D)
(E)
(F)
TRENDS in Ecology & Evolution


Control (HHH)
Phosphate (LHL)
Nitrate (LHL)
Ammonium (LHL)
Potassium (LHL)
10 cm

LEAF

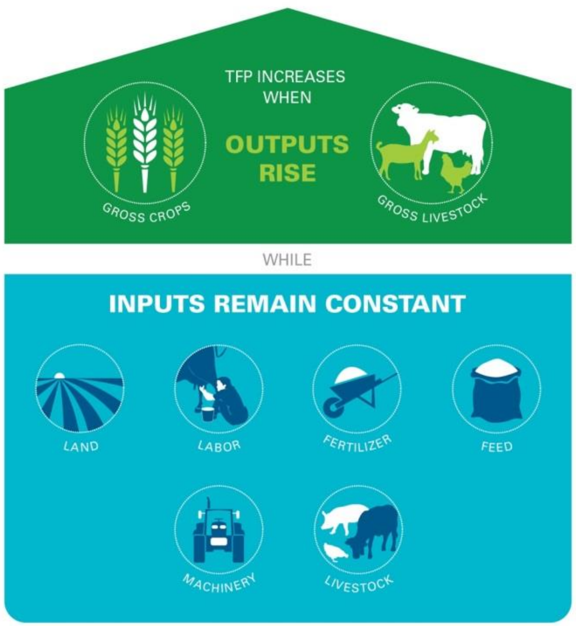

Leaf life-span
Relative and height growth rate
Leaf production rate
Canopy and whole-plant or stand carbon gain
Canopy carbon gain per unit foliage mass
Leaf mass
Canopy light interception
A/mass
Proportional allocation to:
Foliage
Stems
Roots
Leaf area
LAR
SLA
Leaf N/mass
Leaf N recycling (N retranslocation/ time)
Internal N availability
Adaptation to resource availability
Belowground resource availability


Phenotypic trait examples
Leaf area index
Biomass/ha
Canopy temperature
Leaf number
Seed yield
Water content
Leaf expansion rate
Leaf shape
Rate of photosynthesis
Number of layers
Tissue thickness
Mesophyll conductance
Cell size
Cell division rate
Cell turgor
Physiological trait
Performance-related trait
Structural trait
Canopy
Whole plant
Organ
Tissue
Cell
Organizational levels
Developmental timing
Genomic expression states
Environmental conditions
TRENDS in Plant Science

WHAT DOES THIS MEAN

1.75% TFP

Figure 1: Total Factor Productivity



Global Harvest Initiative 2015 GAP Report®

Hatfield and Walthall propose a new …

- Method for screening genotypes that take into account not only the environment but MANAGEMENT PRACTICES
- Incorporate the grower into applied research to determine what practices are feasible from their perspective and solicit their feedback on technologies and approaches

- BUT I DISAGREE WITH THIS STATEMENT

To this end, we introduce the concept of the interaction of G × E × M as a foundation for moving forward to feed the future world. The rationale for a departure from the classic G × E interaction is to highlight the effects of climate variability on the environment factor and the opportunities for management to enhance performance of genetic resources under varying environmental conditions.

MUCH HAPPENS IN THE FARM THAT BREEDERS AND UNIVERSITY RESEARCHERS CAN'T REPLICATE - *THEY NEED TO INCORPORATE INTO THEIR EXPERIMENTAL DESIGNS METHODS THAT REPLICATE FARM CONDITIONS*

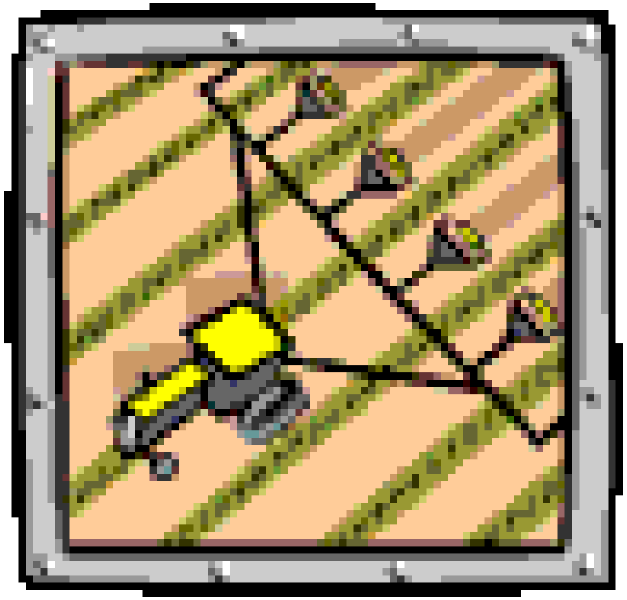
Crop Systems for the new century

Presentation I gave to the University of Illinois Supercomputer Application Center in 2000

- Vatren Jurin

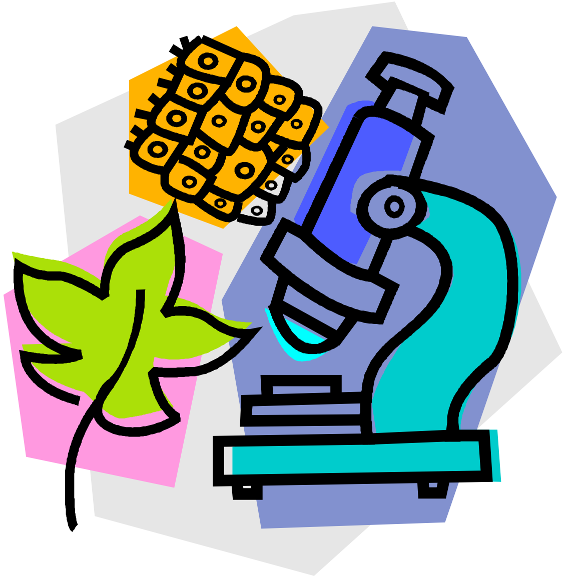
What is involved in a new Crop System

- Food Safety
- Nutrient Management.
  - Forecasting Nutrient responses and requirements.
- Soil Management.
- Predicting irrigation requirements and crop water needs.
- Maximizing genetic potentials.



What is involved in a new Crop System

- Crop modeling.
- Pest Management.
  - Pest modeling.
  - Weed management.
- Biometrical analysis of experimental data.
- Environmental impact.



Steps involved in development and implementation of new Agricultural Systems

Data Collection	Mapping	Analysis	Site Specific Treatment
PRE PLANT GROWING STAGE HARVEST	GPS SATELLITE IMAGE AERIAL PHOTOGRAPHY	DECISION SUPPORT SYSTEM GIS DATA MINNING CROP AND PEST MODELS	CULTURAL AND AGRONOMICAL PRACTICE LOGISTIC MANAGEMENT

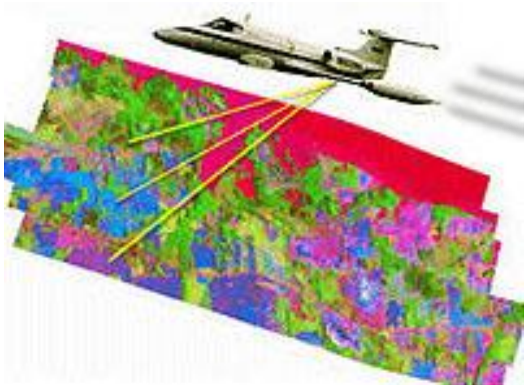
Post harvest

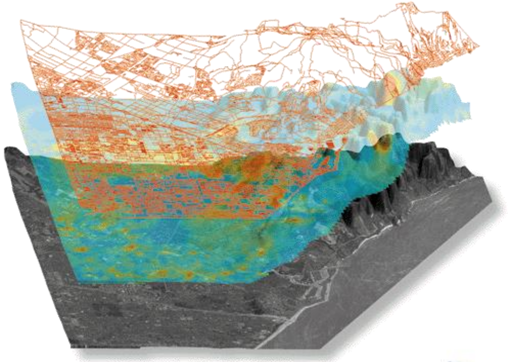
Data Collection

- Soil testing
- Tissue Testing
- Pest Scouting
- Weather Data
- Harvesting Data
  - Yield
  - Quality
- Asset Management

Mapping

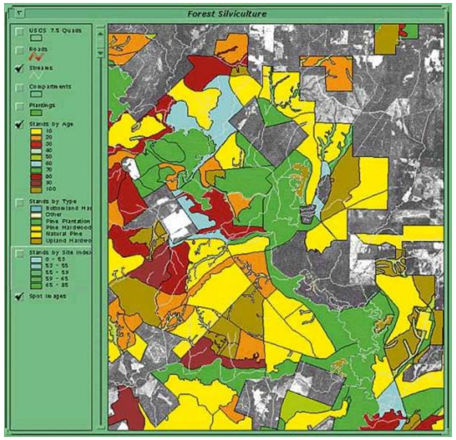
- Aerial Photography
- Satellite Imagery
- Global Positioning System

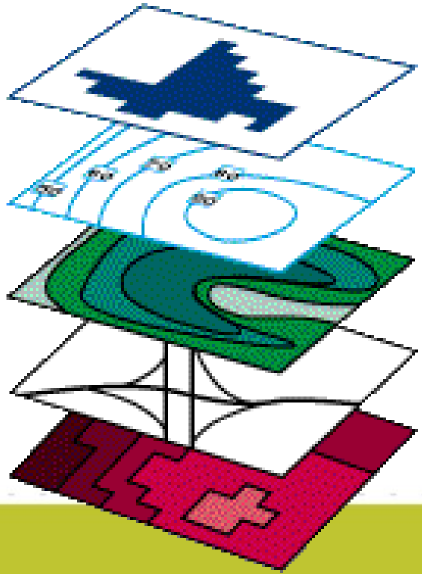




Analysis

- Geographical Information System.
- Decision Support Systems.
- Data mining.
  - Prediction and development.
- Modeling.
  - Pests (Fusarium spp.).
  - Weather.
  - Crop.



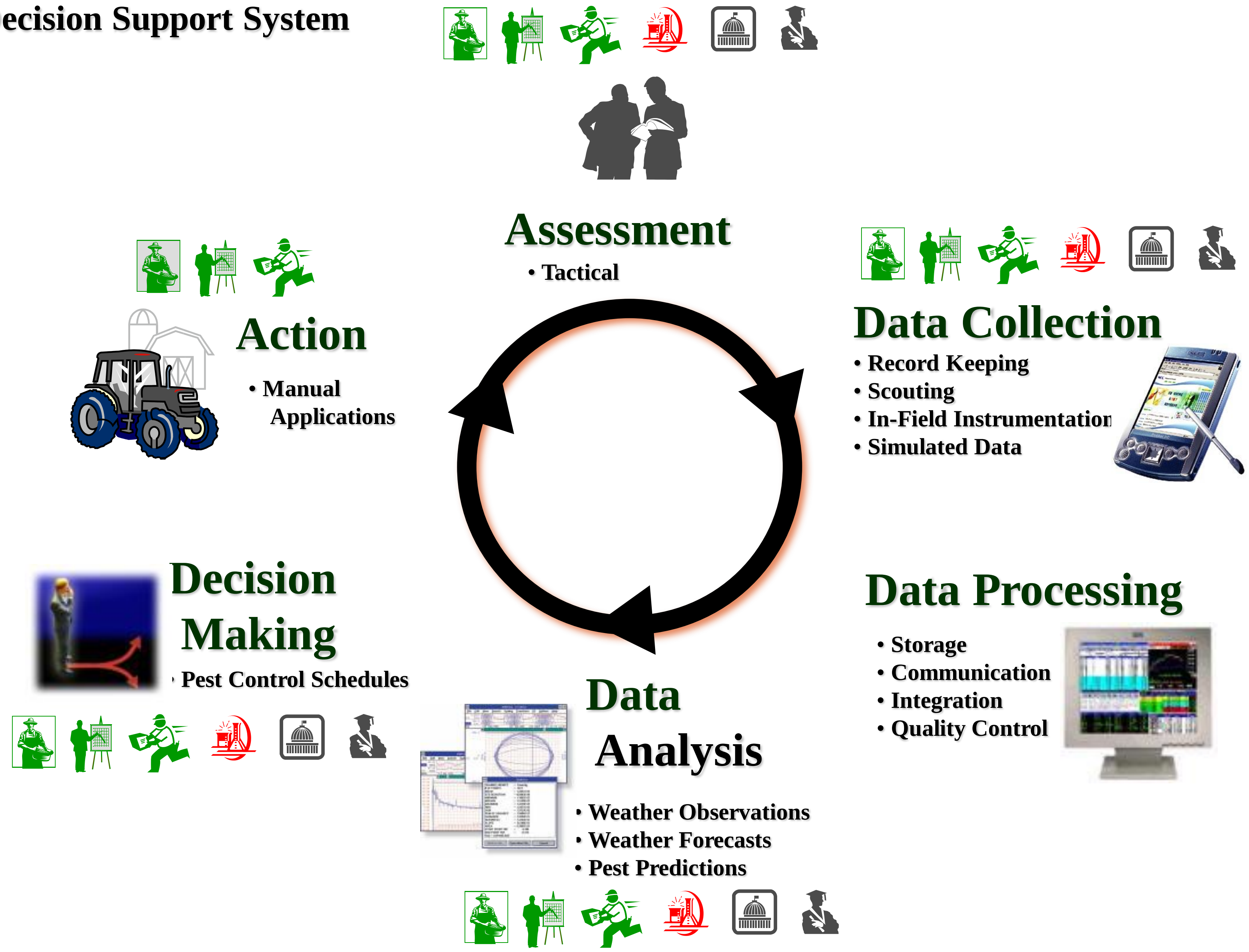


Project cycle

Steps involved in developing agricultural systems.

	PHASE 1	PHASE 2	PHASE 3	PHASE 4	PHASE 5
DATA COLLECTION	Determining data to be collected.	Data collection protocols.	Purchase of measuring equipment	Collection	Quality assurance
ASSESMENT	Compiling data.	Data sorting. (Soil, Weather) Product review	Data analysis.	Development of Algorithms.	Data interpretation.
PRODUCT DEVELOPMENT	Product design. (Irrigation schedule)	Sauza's reviews. Orientation	Product construction.	Evaluation	Sauza reviews products.
PRODUCT DELIVERY	Product launch.	Sauza orientation.	Training	Product signoff.	Ongoing Support.

Decision Support System



- **AND NEW TOOLS ARE BECOMING MORE AFFORDABLE**

- DRONES
- ROBOTS
- CAMERAS
- LIGHTING
- PHENOTYPING
- DIY BIOLOGY
- OPEN SOURCE GENETICS
  - SCREENING
  - BREEDING
- DATA DATA DATA

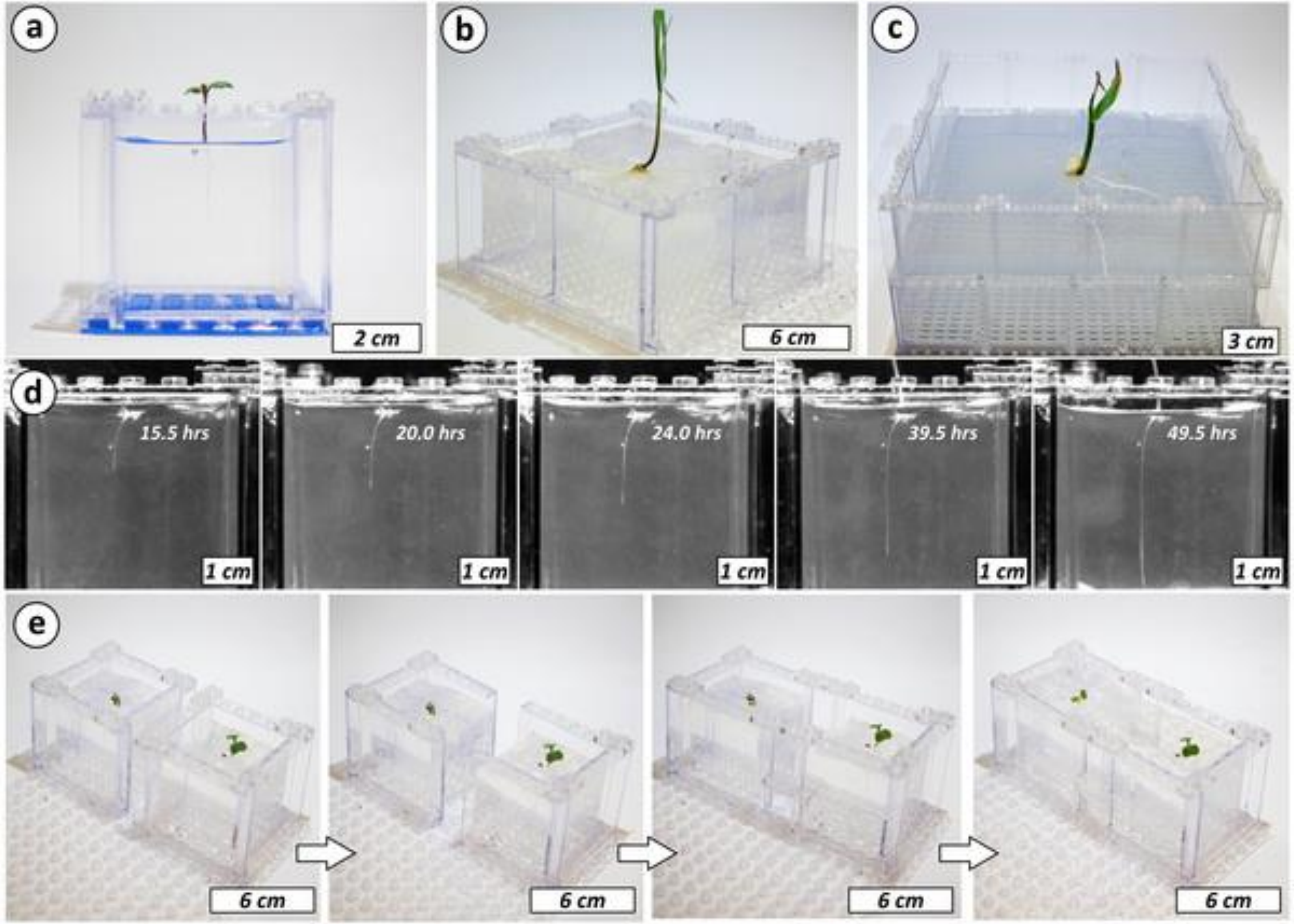

DIY BIO
WWW.DIYBIO.ORG


Crops, Soils, Agronomy
csa news
November 2015
Your Societies. Your Magazine
Crop Science Society of
Society of America | American Society of Agronomy
Can Plant
BREEDING
Go Open
SOURCE?
Science | News & Perspectives | Career & Education

LEGO® Bricks as Building Blocks for Centimeter-Scale Biological Environments: The Case of Plants

Kara R. Lind, Tom Sizmur, Saida Benomar, Anthony Miller, Ludovico Cademartiri

Published: June 25, 2014 • DOI: 10.1371/journal.pone.0100867



DRONES and CAMERAS

The Association for Unmanned Vehicle Systems International, the trade group that represents producers and users of drones and other robotic equipment, predicts that 80% of the commercial market for drones will eventually be for agricultural uses.

http://www.ageagle.com/

***In Situ* 3D Segmentation of Individual Plant Leaves Using a RGB-D Camera for Agricultural Automation**

Chunlei Xia [1,2], Longtan Wang [2], Bu-Keun Chung [3] and Jang-Myung Lee [2,*]

- PHENOTYPING

OPEN SOURCE PHENOTYPING IS COMING

MORE THAN EVER TOOLS ARE HERE AND ATTITUDES ARE CHANGING …

VALIDATING –CONFIRMING – ADVANCING
THE USE OF FLUIDS

ITS UP TO US TO FIND THIS **TOOLS** AND **PARTNERS**

THANKS