THE ROLE OF FLUIDS IN FUTURE CROP MANAGEMENT

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THE GLOBAL AGRICULTURAL IMPERATIVE

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?

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 5.5 billion people—half the world’s urban mass—and two-thirds by 2050. The world’s food population will decline, reducing labor available in roadways for feeding food.

2013 TO 2022

ANNUAL PER CAPITA INCOME GROWTH

1.7% DEVELOPED COUNTRY

4.6% DEVELOPING COUNTRY

Between 2003 and 2022, developing country annual per capita income will grow 0.4% versus 1.7% in developed countries, resulting in high demand for meat, crops, fiber and fuel.

Water: 75% of the water extracted from the world’s rivers and aquifers is used for agriculture and this figure is expected to rise to 85% by 2020. In many 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 reduces stored carbon, contributing to greenhouse gas emissions.

Demand for agricultural products in developing countries is growing; in developed countries, food production exceeds demand and creates a gap that must be filled with trade.

2015 GROWING MOUTH WATER SUPPLY USED FOR AGRICULTURE

2015

85%

2050

95%

Climate change and weather variability will fundamentally alter global food production patterns.

Changing world patterns and higher nitrate 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 sub-tropical regions, increasing competition for water.

Extreme precipitation events over much of the mid-latitudes mean rivers and wetlands may become more intense and more frequent in the winter, with mean surface temperature increases, paneling risks for crop and livestock production.

The world has made progress in reducing the proportion of undernourished people since 1990.

23.3%

10%

2014

12.9%

GROWING SOLUTIONS

Meeting nutritional needs requires increasing the availability, affordability and consumption of nutritious foods among all ages of the world.

GOOD NEWS

GLOBAL PROPORTION OF UNDERNOURISHED DECREASED

173 million children suffer from hunger or some form of nutrient deficiency.

165 million children are stunted, underweight, or short for their age, with permanent damage to their development.

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 or obese has doubled since 1990.

BAD NEWS

Both hunger and obesity impact health.

15 years of additional schooling lead to increases in income by 25-30% among females, 14-18% among males.

15 years of additional schooling for females cuts the risk of being undernourished in half.

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BRANDT
For YIELD to double by 2050

2015 GAP Report

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

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

• INCREASED 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
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
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 know 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..

Published July 2, 2015
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

\[ \text{Y}_{F} - \text{Y}_{A} = \text{YIELD GAP} \]

- THESE DIFFERENCES PROVIDE INSIGHTS INTO THE LIMITATION OF CROP YIELD

INCREASING \( \text{Y}_{F} \) IS THE PATH FOR CLOSING THE YIELD GAP

\[ \text{Y}_{F} \quad \text{Y}_{P} \quad \text{Y}_{A} \]

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

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

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

\[ Y_F - Y_A = \text{THTSE DIFFERENCES PROVIDE INSIGHTS INTO THE LIMITATION OF CROP YIELD} \]

- 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
COOPERATION WITH UNIVERSITIES AND BREEDERS CAN HAPPEN

- Genetic efficiency for fertilizer use efficiency
  - Starter
  - Fertigation
  - Foliar
- Quantify levels of management practices (Dr. IL ??)

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..

GENETICS
Crop improvement from the last 50 years can greatly be attributed to breeders. But evidence know that a yield plateau exists.
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.
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
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.
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)
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Control (HHH)  Phosphate (LHL)  Nitrate (LHL)

Ammonium (LHL)  Potassium (LHL)

10 cm
LEAF
WHAT DOES THIS MEAN
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
To this end, we introduce the concept of the interaction of $G \times E \times M$ as a foundation for moving forward to feed the future world. The rationale for a departure from the classic $G \times E$ 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**
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
- PRE PLANT
- GROWING STAGE
- HARVEST

Mapping
- GPS
- SATELLITE IMAGE
- AERIAL PHOTOGRAPHY

Analysis
- DECISION SUPPORT SYSTEM
- GIS
- DATA MINNING
- CROP AND PEST MODELS

Site Specific Treatment
- 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.
Steps involved in developing agricultural systems.

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Project cycle

- **PHASE 1**: Determining data to be collected.
- **PHASE 2**: Data collection protocols.
- **PHASE 3**: Purchase of measuring equipment.
- **PHASE 4**: Collection.
- **PHASE 5**: Quality assurance.

- **ASSESSMENT**: Compiling data.
  - Data sorting. (Soil, Weather)
  - Data analysis.
  - Development of Algorithms.
  - Data interpretation.

- **PRODUCT DEVELOPMENT**: Product review.
  - Sauza’s reviews.
  - Product construction.
  - Evaluation.

- **PRODUCT DELIVERY**: Orientation.
  - Product launch.
  - Sauza orientation.
  - Training.
  - Product signoff.

- **ONGOING SUPPORT**: Ongoing Support.
Decision Support System

Assessment
- Weather Observations
- Weather Forecasts
- Pest Predictions
- Tactical

Data Collection
- Record Keeping
- Scouting
- In-Field Instrumentation
- Simulated Data

Data Processing
- Storage
- Communication
- Integration
- Quality Control

Data Analysis
- Weather Observations
- Weather Forecasts
- Pest Predictions

Action
- Pest Control Schedules
- Manual Applications

Decision Making

BRANDT
AND NEW TOOLS ARE BECOMING MORE AFFORDABLE

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