Agricultural Higher Education in the 21st century: A global challenge in knowledge transfer to meet world demands for food security and sustainability

Traditional knowledge and innovation in agricultural higher education

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**Accumulation of agricultural knowledge from Cato the Elder to the precision farming**

<table>
<thead>
<tr>
<th>Latin Text</th>
<th>English Translation</th>
<th>Main Subject</th>
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<tbody>
<tr>
<td>I-LII</td>
<td>1-52</td>
<td>Establishing and equipping a farm. The essentials of running one.</td>
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<tr>
<td>LI-LX</td>
<td>53-60</td>
<td>Feeding cattle; feeding and clothing farm workers.</td>
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<tr>
<td>LXI-LXIX</td>
<td>61-69</td>
<td>Planting, harvesting, and pressing olives.</td>
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<td>LXX-LXXIII</td>
<td>70-73</td>
<td>Caring for the health of cattle.</td>
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<td>LXXIV-X</td>
<td>74-90</td>
<td>Recipes for bread, cakes, porridge, starch, purifying salt, cramming fowl.</td>
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<tr>
<td>XCI-CIII</td>
<td>91-103</td>
<td>The many uses of amurca.</td>
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<tr>
<td>CIV-CXXV</td>
<td>104-125</td>
<td>Wine and preparations made from wine; preserved olives, lentils, etc.</td>
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<tr>
<td>CXXVI-XXXIV</td>
<td>126-134</td>
<td>A very miscellaneous small section: medicinal recipes, construction tips, propagation and layering of plants, religious formulas.</td>
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<tr>
<td>CXXXV-CLXI</td>
<td>135-141</td>
<td>Religious rites applicable to farming.</td>
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<td>CLI-LV</td>
<td>142-155</td>
<td>Contractual arrangements.</td>
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<tr>
<td>CLVI-CLVII</td>
<td>156-157</td>
<td>In praise of cabbage.</td>
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<td>CLVIII-CLXII</td>
<td>158-162</td>
<td>A bit of folk medicine, followed by asparagus and ham.</td>
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</table>
**A long way till today:**

Human populations concentrated early to places where agricultural conditions were adequate: Mesopotamia, Nile delta, in the old World, while in the New World connected to the Inca and Maya cultures. Later when the migrations of the tribes slow down or the tribes settled, they developed their own agricultures by brought in their knowledge, and might learned the local knowledge. Knowledge usually summarized in hand written books and connected to the church, where monks had not only the knowledge, but could write.
Early books on different agricultural activities: (XV-XIX centuries)

- Horse breeding
- Crop production
- Plant protection
- Fishing
- Forestry, hunting
- Horticulture

Lippay János’ Boook on Gardening 1664

American Stood Book 1873
The century of the physics

Revolution in agricultural mechanization
Technical discoveries changed formulated new agricultural equipments
Steam engine,
New mills
New type of plough machines
The century of chemistry

Discovery of the role of microelements in crop production

Introduction of the fertilisers

New plant protections based on excessive use of chemicals

Justus von Liebig
The century of biology

Turning point 1953: Watson and Crick with the description of the DNA chain
The biological revolution
The rapid development in molecular biology
Genetic engineering
Application of their product
The GM era
Food safety and security
Today challenges for the education

Meet with the needs
Bioinformatic center for precision agriculture in Beijing

Developing robots

Agriculture in China today
Agriculture in China today

Rice showing

Animal husbandry
Food security a global challenge

Global population growth from 6.7 to 8 bln people by 2025

Increased demand for agricultural products

By 2025 global food output must increase by about 50%
A global food challenge

Population growth – ‘food’ demand
1.2% a year (70-80 million people a year)

Income growth – ‘feed’ demand
Asian economic growth 5-6% a year
Means more meat & dairy consumption

Biofuels expansion – ‘industrial’ demand
Land availability
Potential in Ukraine, Russia, Latin America
Global warming ‘bonuses’?

Technology uptake
Need another ‘green revolution’
Will GM be it?
Incentives for change?

Climate change

Speculation
Important to market liquidity
But can add to price volatility
Responses & challenges

Increase productivity
  – Physical water productivity – more crop per drop
  – Economic water productivity – more value per drop
Invest in rainfed agriculture and irrigation
to improve productivity
Water productivity improvement
Technically feasible, but farmers optimize land productivity rather than returns to water particularly where water is subsidized
What are adequate incentives?
Promote food trade from water rich
highly productive areas to water scarce areas
Reduce losses in the food chain

Anyone who can solve the problems of water will be worthy of two Nobel Prizes – one for peace and one for science” (John F Kennedy)
7 million hectares arable land lost in China during seven years
More pressure on global markets and local ecosystems to supply food needs

The global food system will become even more globalized (with its risks) and trade-offs between food provision and ecosystem quality will emerge.

Continue to rely on key producing regions and also on key crop and animal varieties to meet our needs.

Need more reliance on productivity growth, but land will inevitably expand with trade-offs to ecosystem quality.

Has implications for biodiversity and the environment.

We need more cooperation (relax trade barrier) and innovation (technology sharing).
Drivers of water use

Urbanization: domestic & industrial water use more than doubles
Climate change: more climate variability
Energy prices: hydropower, biofuels, pumping costs, desalinization agri-inputs

Without water productivity gains,
crop water consumption doubles by 2050!

Food demand and changing diets: 70-90% more food demand in 2050
**Water use**

**Drinking water** 2-5 liters per person per day  
**Household use** 20-500 liters per person per day

- **Wheat**: 500-4,000 liters per kilo
- **Meat**: 5,000-15,000 liters per kilo
- **Biofuel**: 1,000-3,500 liters per liter
- **Cotton t-shirt**: 2,000-3,000 liters
- **Agriculture**: 3,000 liters per person per day
  - 1 liter per calorie

Globally food crops evaporate 7,100 km³ per year, that is:

- 7,100,000,000,000,000 liters

About 78% of water for food comes directly from rain. Increasing part is met by irrigation. Total irrigation water 2650 km³ (70-80% of total), i.e. about 1100 liters per person per day diverted.
A record 18 million farmers, in 28 countries, planted 181.5 million hectares (448 million acres) in 2014, a sustained increase of 3 to 4% or 6.3 million hectares (~16 million acres) over 2013.

Source: Clive James, 2014.
CLASSICAL AGRICULTURE

Reincarnation of the Rousseau philosophy

„BACK TO THE NATURE”

Today this manifested in organic farming
Development in plant breeding

Selection
Drastic changes after Medel’s description on trait heritages
Discoveries of chromosomes and individual genes
Methodological highlights
Recognition of hybrid vigor and its introduction in the maize breeding
Chemical and irradiation mutagenesis
Genetic engineering
New breeding techniques (zink finger, oligonucleotid directed mutagenesis, grafting GM scions to non GM rootstock)
Plant protection

Physical methods
Chemical control
Use of pesticides, herbicides, fungicides, nematicides

Paradigma change after Rachel Carson published the „Silent Spring” book

Biological control
Molecular methods using in the current way of the biological control
Traditional knowledge in the higher education

• In China
  
  1517 – 1593  
  Li Shizhen wrote the General Outlines and Divisions of Herbal Medicine (Ben Cao Gang Mu) which is the greatest contribution to Chinese herbal medicine in history

  1911-1950  
  End of the Qing dynasty, and the beginning of modern medicine, TCM was banned

• In South Africa
  
  Taken from A.T. Bryant (1966) Zulu Medicine and Medicine Men.
  No written history - on oral tradition
Traditional knowledge in the higher education

• 2003
  • Regulation of the People’s Republic of China on Traditional Chinese Medicine (Promulgated 02-04-2003; Effective 01-10-2003)
  • Currently there are:
    • 14 Government Departments with sections dedicated to the administration of TCM
    • 2868 TCM hospitals
    • 270 000 practicing TCM doctors
    • >100 independent academies and institutions engaged in the scientific study of TCM
    • 1300 TCM professionals
    • 20 000 part-time TCM researchers

• 2003
  • Traditional Health Practitioners Bill aims to provide for the establishment of the Interim Traditional Health Practitioners Council of the Republic of South Africa

• 2008
  • The Draft National Policy on African Traditional Medicine in South Africa
    • enacted to provide “an enabling environment for African Traditional Medicine in its entirety and scope, covering but not limited to:
      • the regulation of African traditional medicine in South Africa;
      • registration and regulation of African traditional medicines and medicinal products in South Africa;
      • protection of African traditional medicine knowledge and intellectual property rights; and
      • the protection of the rights of persons involved in the discipline of African traditional medicine in South Africa”
Previously mentioned examples in the development in different agricultural sector: lead to the specialization in the higher education systems

Crop production
Animal husbandry,
Forestry
Horticulture
extended today up to 20 Master Studies Life Sciences

Environmental Sciences

Social Sciences
Paradigmal changes in agricultural higher education

Reorganization of Education "vis a vis" Bologna System

Education driven: by economy, science, knowledge,