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in

Romagosa I. (ed.), Navarro M. (ed.), Heath S. (ed.), López-Francos A. (ed.).
Agricultural higher education in the 21st century : a global challenge in knowledge transfer to meet world demands for food security and sustainability

Zaragoza : CIHEAM
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 113

2015
pages 121-125

Recognition of traditional knowledge and innovative developments in agricultural higher education

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I – Introduction

The World population continues to grow at about 1.5% a year. The projected 7 billion for last year were reached and the UN statistics are estimating 8 billion for 2020. Nowadays contrary to the advanced agriculture and the extensive use of agrochemicals more than 40% of the crop productivity is lost due to the competition with pests and pathogens. Additional loss is attributed to the postharvest period. This could reach a very high figure in the developing countries due to the lack of advanced storage facilities. The challenge is here, because we have to double our food production on less per capita land, with less water, and under non adequate environmental conditions. Today one can realize in the northern, developed countries that the societies of the farmers are aging. Les as less young people are interested in to learn agronomy. This is an alarming issue in the OECD countries, where agricultural knowledge are advanced, but its transfer far behind and cannot attract the new generations. This raises concerns about communications, and a gap are existing in understanding between the agriculture and the society as a whole. In the developing world especially in the Mediterrean countries more classical agricultural educations are needed with an emphasis on the advanced techniques, too. By studying the development of the farming systems throughout the history one can realize that how big changes had happened. These rapid accumulations are exponentially grown along with the enormous discoveries in natural sciences. Those discoveries are completely reorganized and revolutionized the farming systems, and increased their productivities. This also had an impact on the agricultural higher education. All novel techniques have to be incorporated into the agricultural curricula, not forgetting teaching the classical agronomy and transfer a holistic approach in the education.

"De Agri Culture", written by Cato the Elder 160 years before Christ, is the earliest existing work summarising the contemporary theory and practice of agriculture. A comparison of the agricultural knowledge recorded by this ancient philosopher over two thousand years ago with current agricultural practice presents a clear picture of how this time-honoured activity has developed. Writings on agricultural development reveal an exponential increase in the quantity of knowledge and experience accumulated over the centuries. The nomadic hunters and gatherers gradually became settlers as they turned to crop production and animal husbandry. Even today, however, there are still nomadic tribes who follow their livestock as their ancestors did, and gather plants to supplement their diet and cure their ills. Traditional knowledge in agriculture and medicine is still widely used both in China and South Africa. The enormous rise in the human population over the last hundred years has been accompanied by substantial developments in the efficiency of agriculture. To give just one example, maize breeders discovered that hybrids yielded far more than the varieties previously grown. Nowadays, compared to the 1.5 tonnes that can be produced with land races, up-to-date maize hybrids are capable of reaching yields of 10-12 tonnes, thus making a massive contribution to feeding the world population. The exploitation of the genetic potential of plants and livestock is still able to provide sufficient food for mankind, but we will soon reach the limits of sustainability if we fail to put new research results and innovations into practice. It is important to remember, however, that while the world population is rising, the amount of water and agricultural land available per capita is declining. As the earth can be regarded as a closed system, this will be decisive for the future.

Further developments in agriculture are indispensable and both the present and future generations will be faced with the task of optimising technologies to improve efficiency. This, however, will require up-to-date knowledge on agricultural science. Over the past centuries experts in crop production, horticulture, viniculture, forestry and game management and livestock breeding have summarised their knowledge in books that have been used as agricultural textbooks in secondary and higher education. As the volume of knowledge expanded, agricultural science has become increasingly specialised. Developments in science have had a decisive effect on both agricultural disciplines and farming practice. Figures 1 to 6 are representative of the technical development of farming practices during the last hundred years.

The 18th century was the age of physics and resulted in enormous technological progress in agriculture. The invention of the steam engine was the first step in the modernisation of soil cultivation, and the numerous technological innovations in the milling industry provided the framework for the establishment of the food processing industry. The age of chemistry came in the 19th century, when the use of chemicals in agriculture revolutionised plant nutrition. Justus von Liebig discovered not only which elements are of importance for plant nourishment but also the significance of the mutual ratios of these nutrients. He established the fact that each nutrient must be available in optimum quantities if the plant is to develop satisfactorily. Even when well supplied with most nutrients, if there is an insufficient amount of one, say calcium, in the soil, the plant will turn yellow and eventually die. To illustrate his hypothesis, Liebig used the example of an old barrel, the staves of which are rotted to different extents. Even if most of the staves are in good condition, the barrel can only be filled to the height of the most rotted stave. In the language of physiology, this is the limiting factor.

Fig. 1. Threshing in Hungary 1940.does not.

Fig. 2. Threshing in Hungary 1940.

The direct aim of manuring, or fertilisation, is to provide crops with nutrients, but indirectly it serves to increase the fertility of the soil. Information on how soil fertility can be maintained and improved can be gained by analysing cultivation systems. The insight gained into the importance of crop rotation crystallised in the elaboration of a new technology known as the Norfolk four-course system. The development of these new methods depended greatly on progress in social and economic conditions. An analysis of developments in farming systems reveals three distinct periods.

Fig. 3. Weed control 1956 in Hungary.

Fig. 4. Harvest in 2000.

Fig. 5. Global Positioning System directed seeding 2012.

Fig. 6. Small field plot threshing machine 2012.

The first, when slave labour was used, was characterised by a low standard of soil utilisation and agronomic knowledge was still purely empirical. During the second period, which lasted until the end of feudalism, there was a gradual development in the field of natural sciences. The third period began with the rise of capitalism, when rapid developments in the sciences had a great influence on both industry and agriculture. Developments in industry also had an intensive effect on agriculture. The farming systems in each of these periods were all of different standards and used different methods to maintain soil fertility. In the earliest systems the regeneration of soil fertility was basically left to natural processes, while today it is mostly accomplished through human intervention in the form of manuring, mineral fertilisation, irrigation, soil amelioration, etc. Agricultural literature distinguishes the following farming systems: ***1. fallow, pasture and forest rotation, 2. fallow, 3. crop rotation, 4. grassland, 5. free or monoculture farming system, including precision farming and 7.recently, the so called organic production.***

Around 35% of the crops produced worldwide are destroyed by pests. The need for efficient pest control and the elaboration of up-to-date crop production technologies requiring less live labour made it essential to use pesticides on a wide scale. Chemical pest control first involved inorganic salts (copper, mercury, arsenic) and natural active agents (nicotine, pyrethrum), but chlorinated hydrocarbons, produced from petroleum, soon appeared, followed by the organic phosphoric acid esters and carbamates originally designed for chemical warfare. Later, pharmaceutical companies specialised in the manufacture of pesticides. By the end of the 1990s around 700 chemical and biological compounds were utilised in crop protection. These products contain biologically active ingredients capable of killing weeds, insects or fungi, but if the technology is not strictly adhered to they may also destroy useful organisms, lead to the proliferation of certain pests or the development of resistance, and pollute the environment. The application of pesticides introduces toxic and persistent chemicals either directly into the soil, by surface distribution or ploughing in, or into both the soil and surface waters, via aerial spraying, and in many cases these compounds drift away from the target area (off-target effect), leach into rivers and lakes (run-off effect) or exert their effects on non-target organisms. The contradictions involved in the use of crop protection agents can be illustrated through the example of DDT. Paul Müller was awarded the Nobel Prize for proving the efficiency of DDT against insect pests. The introduction of this compound into crop protection in the 1940s during the Second World War solved numerous medical and food supply problems. Thanks to its use, malaria disappeared from Europe, it killed the lice that tormented both soldiers and civilians during the throes of the Second World War, and it helped to save the population of Europe from starvation. However, the success achieved with this insecticide caused both users and the chemical industry to become complacent and no efforts were made to develop other biologically active molecules as an alternative to DDT and other chlorinated hydrocarbons.

The 20th century wrote itself into history as the century of biology. The single page report by Watson and Crick in Nature (1953) on the structure of the hereditary material completely changed our thinking on heredity. The discovery not only proved that the two geniuses of the 19th century, Darwin and Mendel, had been right, but also formed the basis for a revolution in biology, which later led to breakthroughs in molecular biology. The first milestone in the biological revolution opened up enormous possibilities. After the key to the genetic code was found, it proved possible to determine which part of the hereditary material was responsible for certain traits, after which these were isolated and then transplanted into other living organisms. The development of the first transgenic organism by Paul Berg was soon followed by many others. The breaking of the genetic code, the identification and isolation of genes for individual traits and their incorporation into other organisms launched the science of genetic engineering. In 1983 two independent research teams, led by Mary Dell Chilton (North Carolina, USA) and Jeff Schell (Belgium) reported the development of the first transgenic plants, thus extending genetic engineering to plants. The success achieved in this field can be illustrated by the fact that in 1996 the first transgenic plants grown for commercial purposes were cultivated on only 1.6 million hectares, whereas today this area is over 184 million hectares (compared with the approx. 6 million hectares of cultivable land in Hungary). Following the prophetic warnings published by Rachel Carson in her book Silent Spring on the dangers of chemicals and herbicide resistance, and on the need for biological plant protection, the first transgenic plants were designed to have resistance to viruses, fungi and insects. Unfortunately, the social acceptance of these crops in Europe is based not on their usefulness and economic advantages, but on the demagogic repetition of presumed risks designed to mislead a population with no real knowledge of the science involved. The biological discoveries made in recent years have placed plant and animal breeding on a new basis and have put the favourable properties of microbes at the service of farmers and the food industry. Breeders can now use a wide variety of molecular techniques during the work of selection, including marker-assisted selection, and the plants produced in this way cannot be considered as genetically modified organisms in the classical sense of the word. It should be noted here that the whole issue has been over-politicised and has no basis in reality, since the system that has arisen due to the proliferation of regulations in the EU is only favourable for multinational companies, who alone have the capital required to apply for registration.

In the meantime new developments in agricultural technology also have enormous potential for innovation. The use of informatics has led to the establishment of geoinformation systems that allow growing areas to be accurately identified, including the crops grown on them, the amount of weed cover, the presence of epidemics, etc. The use of robots may also be part of the environment-friendly technology of the future. Nor should the rapid developments in the food industry be forgotten, where we turn a blind eye to the use of genetically modified (and completely risk-free) microbes, which now play a decisive role in European food processing, too.

The arguments outlined above make it quite clear what enormous developments have been made in agriculture and related fields of science and raise the question of what should be taught in the higher education system. As stated at the conference, genetics alone doubles the quantity of knowledge available to us every three years, and, if not to quite the same extent, this is also true of science in general, not to mention informatics, which is developing even more rapidly. It is becoming increasingly clear that the regional requirements of agricultural higher education should be given priority. Aims must be defined, and demands must be adjusted to the conditions available. Practice-oriented higher education is more effective than that based purely on theory. At undergraduate level practice-oriented courses satisfying regional requirements should be preferred, while in developed countries it would be worth basing agricultural higher education on efficient, up-to-date technologies.

Acknowledgement

The illustrations are highly appreciated and thanked to Attila Vécsy, photo artist, responsible for the Martonvásár' institute photo archives.

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