G. B. MARINI-BETTÒLO (*)

Scientific Research and the Challenge of Agriculture in the Tropics (**)

The purpose of the present meeting is to call attention to a problem of fundamental importance for all mankind. Not only the scientists but also the decision makers need to be aware of the urgency of a modern evolution of agriculture in order to meet the needs of an expanding world population.

This means not only more research, but also more qualified research, drawing upon the experience of the last twenty years in the development of new agricultural techniques.

I hope that on this occasion we will be able to examine the present state of agriculture and make comments and criticisms. But, more, I hope that we shall not leave Rome without having indicated a new way forward to policy makers for the development of agriculture, especially in the tropics and, in particular, in Africa and South America.

The capacity of plants to convert solar energy into chemical energy — that is, food, timber and fibers — has been used from the beginning by man and animals for survival and growth. When man found it too difficult to collect roots and berries in the forest, a certain number of plants were domesticated and cultivated — a very small number when compared to the thousands of species existing. Since then, agriculture has been the fundamental support for the life of mankind on earth.

As a primary source of energy, over the centuries agricultural development was closely related to the growth of human population. In the early 19th century, accurate economic analysis by Malthus (1766-1834) of the growth of

(*) President of the Academy; Dipartimento di Biologia Vegetale, Università di Roma, « La Sapienza », Rome.

(**) To the International Meeting "Towards a Second Green Revolution: from Chemical to New Biological Technologies in Agriculture in the Tropics" (Rome, 8-10 September 1986).

world population and patterns of food production showed the danger of famine for an overpopulated world with insufficient food supplies.

With their research into plant chemistry, Von Liebig (1803-1873) and Boussingault (1802-1887) independently showed the possibility of increasing the yields of crops by supplying to the cultivars not only manure but also chemical products such as the nitrogen derivatives (ammonium salts, nitrates, etc.), phosphates and potassium salts. The use in agriculture of guano, and later of Chilean nitrate, as fertilizers led to a ten-fold increase in the yield of cereals per unit of surface area.

Production of nitrogen fertilizers from the nitrogen of air by the chemical industry (1914-1920) was developed through the theoretical studies of Nernst and the technologies of Haber and Fauser. This made possible an abundant supply of fertilizers, and completely changed the Malthusian perspective of inevitable food shortages in the world. The genetic approach in selecting more valuable cultivars and progress in soil chemistry and plant physiology, together with the use of chemical fertilizers, made possible a real change in agricultural production at the beginning of the present century.

The above considerations apply mainly to the Northern Hemisphere, where the research and mechanization radically changed agricultural practices, producing a pattern of highly specialized organization, with high technical content and limited use of labour. Harvests in some areas were possible even twice a year. Continuing increase in food production seemed only a question of improvement in agrotechniques.

Difficulties, however, arose, especially in the tropics. Noxious insects became resistant to pesticides. Increasing quantities of the latter were used, at times ten-fold the quantity once sufficient to control pests. The result was a massive use of chemicals, which in these conditions became harmful even to useful insects and heavily polluted the environment. Such chemicals contaminated the soil and penetrated the food chain. The environment was damaged, wildlife threatened, the ecological equilibria even disrupted. More potent and toxic products were synthesised to control pests. Examples are the degree of body contamination by chlorinated hydrocarbons in India and the breakdown of the agrosystem in the Canete Valley in Peru.

New strategies were studied to prepare new chemicals, based even on different mechanisms for the control of pests. Some very toxic products are being used for this purpose. The need for increasing amounts of chemicals stimulated the establishment of factories in developing countries. The Bhopal case is so close to our minds that comment is superfluous. Fertilizers have greatly improved crop yields, but they have also greatly contributed to environmental degradation.

Calculated in terms of energy input, the system is still quite positive — with a rate of 1 to 4, but the economic conditions of many countries do not permit such an expensive agriculture, especially as it is often based on imported chemicals.

Plants selected to produce food, generally lose, through genetic improvement

of the quality and the quantity of product, their capacity for defense both against disease (molds, fungi and viruses) and against pests (noxious insects, nematodes and other animals). Furthermore, they must compete with weeds for nutrients.

In the years between 1930 and 1945, chemistry developed powerful synthetic products which act as pesticides (DDT, chlorinated hydrocarbons and phosphate esters, etc.) against molds (fungicides), nematodes and weeds (the herbicides). The large-scale use of those products made possible a substantial increase in the crop production, even in the tropical belt where, because of the climate, conditions are more severe and pests more aggressive (let us just mention locusts and termites).

Before the use of pesticides, it was estimated that one-third of world output was lost or destroyed by various noxious agents. Pesticides made possible dramatic increases in the yield of agricultural products.

Genetic research in some fundamental crops (rice and maize) conducted by Borlaug and Swaminathan, together with the use of chemicals as pesticides and fertilizers, opened the way in the 1950s and 1960s to great changes in methodology in agriculture — with astonishing results in the tropics.

This change has become known as the *Green Revolution*. This is a truly great revolution in methods and materials which, when applied with intelligence and diligence, made possible in a few years the achievement of complete sufficiency in South and South East Asia in cereals production. The same happened in Mexico and other countries in South America, such as Peru. Primary production of food could support in these years the needs of an increasing population.

After twenty years of continuous success, aspects of the Green Revolution need to be rediscussed in the light of new findings and possibilities offered by scientific and technological progress — and negative side effects on environment and health. This re-examination becomes even more necessary now, when we need to build up in Africa a new agriculture able also to take into account problems of soil erosion and drought.

Professor Umberto Colombo, in the opening lecture given last year at our Academy, stated that "agriculture at present represents a system comparable to industry, highly dependent on scientific and technological research, on investment, on capital. This system also requires new methods and approaches, e.g., info-mation technologies, genetic engineering, remote sensing, meteorological data — all of which represents a real revolution in agriculture".

I completely agree with this modern, dynamic view of agriculture. It is certainly impossible today to imagine modern agriculture — the most powerful man-directed system for utilization of solar energy for mankind — without the continuous input of the results of the scientific and technological research — in the biotechnologies, genetic engineering, integrated pest control, new fertilization systems, conservation of organic matter in soil, etc.

Biotechnologies offer many possibilities for obtaining new varieties of plants resistant to disease and to pests; new atmospheric nitrogen-fixing microorganisms can be selected to reduce excess reliance on chemical fertilizers; natural products

acting on insect behaviour can contribute to integrated pest control, reducing the need for heavy pesticide use.

Among the modern techniques in agriculture, we should not forget one of the basic problems of tropical agriculture, i.e., the bad use of soil, as well as the practice of deforestation of new land. Higher yields should compensate for the utilization of new lands for new sources of food. In addition, irrigation and water management should be carefully evaluated according to soil conditions, in order to avoid salination of the soil and health problems.

To overcome all these difficulties and resolve these urgent problems, we need further research and careful planning, with the cooperation and collaboration of scientists in the countries where the new agriculture is most needed. This research should always consider as a priority in its application the economic aspects of any new system to be adopted, as well as the need to respect the ecological equilibria of the different environments, and the balance of energy input and output in an agrosystem.

The scientific and technological aspects of the challenge for a new agriculture underlines for developing countries the need for involvement of this Academy, as well as of the Commission of the European Communities and of ENEA, the Italian Commission for Nuclear and Alternative Energy Sources.

We hope that the issues dealt with at this meeting through a presentation of problems and discussions will not only lead to greater understanding of the problem, but also indicate new strategies and new techniques in agriculture, able to benefit billions of starved and undernourished people and to serve future generations. This will be possible if we respect the delicate balance which governs life on earth.