BIOTECHNOLOGY IN THE SERVICE OF AGRICULTURE - ARID ZONES

George Martin
Ingenieur I.A.N.
Chevalier de l'Ordre du Merite
France

At the end of the Second World War, the increasing gap between the agro-alimentary and agro-industrial expanding needs, and the agricultural productivity of the planet, allowed us to assume that only big projects and wide development operations could solve the problems and absorb the alarming predictable deficits in basic products such as olive fruits, cereals, sugar, meat and textiles.

At that time, Europe did not seem ready for such projects. Attention has been oriented towards more vast continents. It is for this reason that big enterprises were undertaken, such as the Groundnut scheme in English-speaking Africa (Kenya, Uganda), the French Plan oleagimen in Senegal, the cattle breeding or the industrial plantations' program of south-eastern Asia and Latin America. Everybody was persuaded that the nature of such initiatives was to assure "the supply of a vast world market" and to generate "progress and socio-economical prosperity" of the producer states.

Unfortunately, the situation has evolved more rapidly than expected. Due to scientific progress, the production of industrialized countries has considerably increased. The terms of exchange have been degraded, and deficits have been overfilled. With the exception of those countries situated in humid, tropical, or equatorial regions, disinherited countries could no longer export their products, such as coffee, cocoa, caoutchouc, exotic fruits, etc. which, nevertheless, hardly found purchasers, because of the antagonism between the countries' producers and the established regulating quotas.

In arid countries, due to soil and climate conditions, there are only small specific productions, or none at all, and where industrialization has not developed, the situation has become worse. Most of the big projects have not resulted in the estimated level of prosperity. It is in Africa that this problem is more serious. It is a critical situation for which urgent measures are needed. Presently, we will consider not only the economic aspects but also life and its environment.

In such countries, we must care for small, human-size projects for they are better inserted in the system and are adapted to the local constraints and the solicitations of local inferior markets.

Unfortunately, because of an "industrial vision", we continue to introduce innovations that have no coherence with the components of the human context, the environment, and the agrarian production systems.

Before exposing some ideas on technology and biotechnology, it seems useful to specify some points concerning the systems.

The concept of "Agrary system" signifies, in every country of the world, the territory and those humans who exploit it, in order to produce. This system is the result of a permanent compromise between the geography and the climate, the factors of production (soils/plants), the means of production (implements, cultural techniques) and the socio-economical structure of resident populations. Such systems can be established at the level of a big area (production of cereals, cattle breeding, vine fruits) of a province or a piece of land. A system of production, an agrary system, involves a set of vegetal or animal productions, benefiting from the factors of production such as land, labor and capital, which are "handled" by the producer in order to satisfy his socio-economical aims at the level of his exploitation (without having necessarily a knowledge of the profit).

The cultivator has, in his system, the ability to use the "means of production", aiming to:

- reduce the work
- increase the productivity
- improve the global economics of his unity.

Any introduction of innovation or modification may produce the risk of deep perturbations in "handling" and "equilibrium".

In arid zones, where climate and the type of soil present difficult conditions of exploitation and induce the existence of a fragile agrary system, humans have applied for many centuries, some specific "systems of production" adapted to their social structures. But these were unsteady systems, hardly supporting the forceful transformations. Therefore, we must be attached to the introduction of simple "technologies and biotechnologies" in order to improve the function of the system without perturbing social structures, if their "coherence" is to be cared for.

REFLECTIONS ON LEVELS OF INTERVENTION

To reach this goal, experience shows that it is better to avoid a direct attack to the summit of the pyramid, that is the regained Agrary System. It is necessary, on the contrary, that technological and biotechnological innovations are first introduced at the level of small groups in order for them to be recognized and demanded.

In other words, it is suitable to "develop" and "reinforce" the basis of the edification by analyzing the problems at the level of systems of production and taking care that the innovations:

- are useful to the unity of the exploitation, even at the center of their system (improvement of already cultivated plants, use of plants already known to villagers, but also with technologic qualities underestimated by local populations, protection of cultures, progressive restoring of the equilibrium of the system, improvement of the production techniques, etc.);
- improve productivity, paying equal respect to the capacities of the unity of work (energy, implements, etc.);
- provide a "tangible" additional income;
- improve the quality of life (energy, farm staff, building materials for homes);
- contribute directly, or indirectly, to the progressive improvement of the agrary system and stop the annihilation of material resources.

AN EXAMPLE OF ANALYSIS

In order to illustrate these points, let us take, as an example, a fundamental problem such as the loss of production between the implementation of culture and consumption.

Numerical samples on production, issued by statisticians, correspond to what might be called "availabilities", but do not necessarily correspond to the "potentialities" of cultures, particularly applied alimentary ones. Extensive literature on these issues states the importance of these losses. Numbers reach 35 to 40% of the potential production, on a worldwide basis. In arid tropical zones, costs are lower (15 to 20%) but still remain considerable in relation to the total level of their productivity. This loss at production level has to do with many stages of the culture:

- during its development (bad germination, attacks from parasites, virus from insects, etc.);
- at harvest time (various parasites, birds, rodents, bad implements, etc.);
- during threshing, or barking (quantitative losses, fragments, wounds due to the lack of suitable material and protection, etc.);
- during manipulations and transportations; and,
- during storing (mushrooms, bacteria, insects, rodents, etc.).

To all these elements the effects of humidity are added. The humidity of grains causes fermentation warming with a subsequent proliferation of the microflora and insects and condensation on sheet-iron covers, hardly isolated from heat, tardy rains or corroded silos, etc..

The incidence of these losses is considerable since not onlyquantitative, but also qualitative losses (decrement of proteins, hydro-carbons, vitamins), as well as the commercial ones are added (value reduced, products unsold).

If we do not take into consideration these elements, we might realize that several "high technology" innovations such as irrigation, fertilization, and diffusion of highly-productive species, do not result in the pre-estimated profits and may even be inefficient.

Therefore, we must attack the bad at its root, and realize that the solution to this problem does not require enormous investments: the means of implementation are simple, and we do not have to "overthrow" the traditional cultural systems. It is only needed:

- to diffuse the varieties selected for their resistance to diseases and aridity rather than to diffuse the highly productive ones;
- to establish "rural seed stores" for the distribution of dried and disinfected seeds;
- to diffuse the small threshing, barking and selecting materials as well as to provide the necessary energy;
- to develop small storage means and to disinfect silos.

Thus, with the help of simple technologies or biotechnologies, it should be possible to ameliorate production by more than 10% without supplementary work or expansion of the cultivated soils.

Being partially, if not completely, and rapidly appropriated, the transformation of the basis would, then, be attempted. When new habits would appear, the next step would consist of the introduction of modifications in the structures of the "systems of production", for instance, high productive varieties and implements aiming to master the different phases of their culture, and then to apply an alternative model to the agrary system.

SIMPLE TECHNOLOGIES OR BIOTECHNOLOGIES

A. Means of Production - Energy

In relation to energy, it is not always desirable to make an appeal for elaborate forms such as ethanol (which must be produced in important unities before being sold) and solar energy (which requires special material and care). There are simpler formulas. Among those who easily come to mind there is one which is worthy of our attention: "The inventory of everything existing already", i.e. the study of plants which can be spontaneously or subspontaneously used on a perpeptual basis in order to fix the soils.

Many of them are known by local populations and even used in some cases, but have never constituted an object of further development, since cultivators do not know their use, or because they do not present any particular commercial value. Technology actually allows us to reveal their different uses, it is then possible to study, with the assistance of yeomen, the way that these plants can be exploited.

The pourghere (Jatropna curcas) is a plant belonging to the family of olivary, Euphorbiancees, which grows in semi-arid regions of a tropical and insular savanna. It grows by itself or is cultivated by yeomen in all continents and islands of the Indian Ocean. Although this plant is repulsive to beasts, it is often and traditionally used for the realization of living fences, around villages or fields, not only to provide protection, but also because it produces wood when cut every 2 or 3 years. This plant of the resin family produces seeds which contain oil. This non-edible oil is occasionally used at local pharmacies and also possesses lubricant, combustible, and viscous properties.

For more than 30 years, this plant has been an object of research. At that time the "oil of Pourghere" was studied as a carburant substance and had confirmed a good behaviour on diesel motors. In 1982, and 1983, some tests on a German motor chatz, mono-cyclinder, 8 CV, largely used in Africa and particularly applied to Staub Moto-Cultivators, proved that the direct use of this carburetter oil by the rural population of developing countries would allow them to be freed from energetic constraints. In Thailand, other tests on Yanmar, Japanese motors or on Isuzu KBD 21, diesel vans, also proved that nothing had to be changed, irrespective of the structure of motors.

Populations have manual ways to extract this oil, but mechanical presses of small capacity will certainly result in a better yield of oil. An integrated cultivation of this plant would, therefore, provide for limited agricultural mechanisation, due to the simple extraction of the oil in a rural surrounding; in other words, it would increase the capacity of production without further waste in carburetted substance. The idea consists of cultivators collecting these seeds (even children can collect them) and bringing them to a small mill. This will enable them to bring about, free of charge, a restitution of 75% of the oil, which will then be used to feed small diesel motors of low or average power and, therefore, to activate irrigation pumps or small fixed motors, barking machines, cracking or threshing machines, or moto-cultivation. Twenty-five per cent of the oil retained can serve to assure the mill's function.

As rural houses would have nothing to spend on carburetted substances, they would definitely appreciate this final increase of their incomes and they would benefit from the increase in the production realized by the simple use of modern means without any supplementary expenditures.

Bio Gas

In order to exploit the remnants of the harvest, family or village residues, the production of gas from vegetable remainders by fermentation, seeks, according to the importance of the installations, either to improve domestic function or to integrate it in the system, as a means of gas production. Thus, it is possible to obtain a free source of energy, in order to improve the sanitation of the surroundings, and, in addition, to fertilize soils by the use of selected effluvium.

Generally, this machinery called "Digestor" consists of two elements: a fermentation compartment, where organic matter (village, animal or vegetable residues) are digested, and a reservoir containing the produced gas.

In China, there must be more than 5 million subterranean digestors. Their depth never reaches more than 2.50m. SAHEL, the digestors recommended are those who use straw substratum. With a useful volume of 9 or 10m3, they produce from 5 to 7m3 of bio gas per day (more in warm seasons).

These installations can, therefore, serve for cooking (saving wood and time for it to be gathered), while the operation of a dual-fuel moto alternator serves the activation of an irrigation pump or farm implements.

Implements

Although locally manufactured manual tools are diverse, we must find more creative equipment. In the middle of different cultural posts, there is a risk of establishing an atmosphere of "suffocators" in a multi-cultural system, so that the introduction of certain materials may play a significant role. If the family unit does not provide sufficient energy, we can introduce:

small rolling or centrifugal manual sowers and;

- small threshing machines for rice, shelling machines for corn, threshing machines for hazel-nuts (by manivelle or pedal).

If cultivators, those of Pourghere for instance, or bio gas, provide a free source of energy, why should they not use moto-cultivators or even more elaborate machinery?

B. Systems of Production

The systems of production concern larger domains: among them we refer to vegetal material, conservation and diffusion of selected seeds, protection of cultures, and conservation of the products.

Vegetable Material

The varying culture techniques on tissues, vegetal organs, genetic manipulations and selection, open the way for a new "Green Revolution." In order to protect cultures, we produce an arsenal of biodegradable chemical products of increasing importance and specific techniques of application. Thus, an advanced technological panoply in terms of conservation of stocks and seeds is now sufficiently provided. (by neutral gas, void, cold temperature ...)

Unfortunately, the great majority of these methods can hardly be afforded by cultivators of arid sectors in the Third World. On the other hand, they are adapted by industrialized countries, within totally opposed contexts. Therefore, this is a very sensitive domain called the "Transfer of Technologies." It is at this very moment when the most judicious choice must be made, in favor of the exploiters.

In fact, it appears to be unreasonable to distribute, within the actual context, seeds selected for their high productivity but still more fragile than the traditional ones, without furnishing the necessary apparatus to cultivators so that they can handle the increased work needed for those varieties (increased harvest, threshing, etc.)

Thus, it is primarily needed to furnish the varieties resistant to disease, in order to give them the opportunity to harvest quantities compatible to work put on their cultivation (variety of corn resistant to viruses) as well as those plants resistant to acidity (cereals, filbert). In order to enlarge the varieties cultivated by the local population, we must also reform the productions in danger, such as the date trees which disappears from the oasis because of the fusarium mushroom.

To reach this goal, the established biotechnological program, following real needs, should be expanded to include multiplication of the seedlings, the control of distribution, the creation of village silos for the conservation of the seeds and the delivery of disinfected products exposed to insecticides and fungicides, so that their germination is protected.

Protection of Cultures

The Neem Azadirachta indica is a member of the honey family (of which mahogany is a member). This tree originated in India. It finds its natural habitat in savannas and dry zones where the pluviometer reaches from 400 to 500 m/m per year and a long dry season of 6 to 8 months is presented. We generally use it for reforestation. Since 1925, this tree has been largely introduced to that effect in Sudan, Senegal, Mali, Burkina-Faso, Niger, Nigeria, Tchad and many other countries.

This is a tree of persistant foliation, with a rounded top which can reach 20m. Its bark is deep grey in the exterior while its internal surface is reddish-brown. This ornamental tree is situated in hedges, road borders and village squares. It can serve as a good source of firewood and is known for tolerating salt-rich soils. Its fruit is an ellipsoid nut, 1.5cm long. It contains one (rarely two) olivary seed which furnishes an acrid garlic-tasting oil, the so-called "Oil of Margousier". The adult Neem produces 30-50 kilos of fruit per year.

This tree owes its reputation to its resistance to ravaging insects, to the attacks of locusts, as well as to other diseases. According to the "Cereal Food World", December 1985, the US Department of Beltsville noticed that the extracts of these seeds have an insecticide activity against 128 species of parasites. They contain, in fact, numerous compounds, notably a triterpenite complex (inside the seeds, the bark, the fruit and the leaves) whose structure is so complicated that it is hardly possible to synthesize it (Bio-Future-March 1986).

It is under the title of "protection of cultures", that this plant is to be noticed. The losses in harvest due to the attacks of insects or cryptogamics (field and stock parasites) are rising to percentages reaching 40% of the production in the whole of Africa. If the harm caused by the Nematoids of the soil as well as other ravagers is added, then the sum corresponds to very high losses. Nevertheless, these costs are unavoidable, since cultivators cannot afford to acquire the necessary products or the proper protective means.

Since ancient times, the Chinese, the Persians, the Indians, and the Romans exploited the insecticide or fungicide abilities of some vegetal plants (Hellebore, Devris, Pyrethre, Yabae, etc.). Traditionally, the Indo-Pakistanians use the Neem in order to protect their harvests. Given that the Neem already exists in Africa, it would be enough to promote its cultivation, as well as to indicate to cultivators how to use it.

They must be aware that one can:

- conserve 100 kgs of seeds by mixing them with 2 to 5 kgs of dried leaves;
- disinfect the Jute bags (in order to protect their contents by first dipping them into a mixture of 2 to 10 kgs of leaves with 100 litres of water; or,
- disinfect the soil against the Nematods by spreading the sediment obtained after the extraction of the oil (100 to 120 kgs of sediment cover a hectare of the fields). Note that the extracted oil can serve in the fabrication of local soap.

A small number of trees per exploitation would be sufficient, given that 100 kgs of leaves can conserve 2 to 3 tons of seed and their production of fruit will provide for the treatment of one hundred acres of land.

Drying and Storage

In arid zones, natural drying is sufficient due to sunlight and temperature. In addition, it is convenient to avoid contact with the soil and condensation. Artificial drying is not recommended, especially the wood-heating drying method, because there is an alarming lack of wood.

Of course, there are many possibilities of using solar energy but photovoltaic devices should be avoided, if they are fragile or very sophisticated. It is preferable to choose a simple solution, for instance, to build a drying tunnel of semi-circular section, using black sheet-iron filling to absorb the heat. The seeds are placed inside the tunnel spread on plants through which the air penetrates and comes out charged with humidity.

Three-quarters of agricultural production is kept in villages. The mechanisms originate from long tradition and are perfectly adapted to local conditions. They should, nevertheless, be improved.

Polten-made stores should be internally covered by a mixture of polten and cement in order to avoid cracks and splits allowing insects to enter.

The use of:

- plastic should constitute an important perfection for internal silos;
- plastic bags firmly closed should be generalized;
- old metallic, well-cleaned and firmly-closed barrels is also recommended in order to protect the products from rodents.

The Introduction of New Plants

The cooperative structures established within several village sectors, with precise objectives for production, are naturally receptive to all projects concerning the introduction of cultivation techniques different from the traditional ones, with commercial aims, especially contracts with importers from other continents so that their products are sure to be absorbed. The receptivity is different when individual cultivators are concerned, since arid zones have cultures of no specific value. Consequently, it has proved necessary to introduce economically valuable plants or useful for the proper function of the production unit.

In order to avoid perturbing the traditional system, these plants must occupy a small space, require little or no supplementary work, and need little water. In most cases, only perennial plants respond to these conditions. Among those that can be proposed is the Jojoba (Simmondsie chine.sis) which produces a fluid of great industrial and commercial value (5-6 USD/kilo of oil).

Cultivated in large fields this product would permit the exploitation of the introduced techniques. If, in addition, a system similar to that described could be protected from the attacks of cattle by the natural pourghere hedges, we could (as has been shown) dispose a free carburetted substance and a financially valuable plant, contributing to the fixation of the desert.

CONCLUSION

Given that the questions on communication, media, interior markets and socio-economic developments are the most important elements, it is nevertheless needed to examine the problem of technical and technological choices.

According to the affirmations of J. Giri, in his book Africa Broken Down, Africa has several potentialities. Only a few things are needed for its "take-off". It will be only at this moment that the historical basis of the agro-pastoral system will be transformed. The adoption of this change in the rural world and the different nations will be realized in Africa. Only when African people are persuaded of the disastrous effects of the old systems compared to the new economic ones. This gain of knowledge will result in the intensification of instruction and

information, particularly of the female population. In Africa, the southern Sahara, 60 to 80% of elementary agriculture is exercised by women. Consequently, no development action can be achieved without defining the population concerned. This instruction and the introduction of simple technologies and biotechnologies will help Africa to avoid the "long technological pathway" that other people have crossed during their history.

It is, finally, this "by-pass" which will enable Africans to modify their agrary systems to stop the desertification and to construct a new dynamic system. For the moment, Africa shares three options:

- to let things go on their own, knowing that the demographic expansion and the increasing gap between Africa and the developed countries will lead to the "drama" of the next century;
- to choose an intermediate solution (quite well received by a certain philosophy), controlled and directed productions without considering the local socio-economic context. This solution will also result in a serious conflicting situation;
- to adopt the progressive evolution, starting from the basis, in order to achieve a real development, which would offer to Africa its requested ulterior independence.

It is that last solution which is the most attractive, and may be applied in agriculture by the spreading of technology and simple biotechnology systems.

Georges Martin is a leading expert in the area of arid zone agricultural projects in developing countries, now residing in Paris. His scientific training as an Ingenieur IAN is in agronomic engineering He is also a consultant in international co-operation in agriculture, and has worked as director of agricultural missions and agronomic research, publishing numerous articles on the exploitation of agrarian systems. In recognition of his work, he has been appointed Chevalier de l' Ordre National du Merite. He is also a founding member of the Biopolitics International Organisation International University for the Bio-Environment (I.U.B.E.).