Future technology for the Doubly Green Revolution

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The next green revolution, referend to as the Doubly Green Revolution, will only exist if:

- emphasis is put not only on production, but also on the conservation and processing of the products, and it involve production and conversion processes which are viable: i.e. economically repeatable and harmless to the environment.

This note is mainly concerned with the agronomic aspects of the problem, other aspects being covered elsewhere. It aims to show that, like the first green revolution, the second relies on obtaining varieties selected to better exploit the potential of the growing environment. But that will not be enough. Much more than in the case of the first green revolution, which was implemented in potentially the richest environments, the Doubly Green Revolution will be based on the application of production systems better able to develop the potential of very varied agricultural regions, by integrating cultivated plots and livestock in a global management of the area. It will rely on the capacity of agronomists, through continuing dialogue with the players working on the production, processing, and marketing chain, and those concerned with land management, to identify factors limiting production and/or damaging the environment, be it in the short, medium, or long term, and to propose solutions to new challenges.

The Doubly Green Revolution will also need new methods, new research approaches, and new technologies to contribute to the development of the intertropical zone in the next thirty years, taking account of demographic considerations.

In the following text, the accent is deliberately placed on production, both plant and animal. A similar approach could be applied to product transformation.

New approaches for new production systems

The need to conduct detailed research under current conditions to tackle the problems of production and processing of agricultural products was hardly present among the preoccupations of researchers during the period of the first Green Revolution.

The necessity to develop these methods was realised when it was acknowledged that, the problems to be resolved being complex, research in a partially controlled environment provided only a part of what was required to resolve them. In fact the environment of research stations (soil, climate) only represents a small part of the environment of a region: the experimental treatments themselves only correspond to part of the crop or animal husbandry systems practised; the cultural techniques are applied in optimal conditions, which is rarely the case on actual farms. Finally, the economic context is rarely considered. In environments subject to constraints, cultivated plants and animals suffer numerous stresses. To succeed in removing them in conditions which are economically profitable and environmentally friendly, one must resort to precise diagnostic methods and adapted solutions which can only be studied in the context of the actual production conditions.

For the same reasons of complexity of problems and multiplicity of possible solutions related to the farms and their environment, advice to farmers should not be prescriptive, but more of a decision support system for the producers, and more generally for all the participants in the chain of production, processing, and marketing of the products. Several forms of advice are possible under the heading of "decision support systems", from demonstrations, through research programmes involving the farmer, to the use of computer simulation programmes. But the objective remains the same: to leave the decisions to the end-users, to suit their own projects and environment.

The development of such research in real situations and the methods of transferring knowledge rest in part, but only in part, on the blossoming of biotechnology and instrumentation for diagnosis and experimentation, and on modelling, whose recent progress has been related to that of computer science.

Better systems of production fitted into their environment

The first Green Revolution was expressed as a strong artificialisation of the crop environment, often with disastrous consequences for the environment. In future one must turn to integrated management with rational control of all renewable resources, which takes account of the objectives of farmers and stockholders. This should depend on the environment of the production unit, in particular the economic environment, and on the project being undertaken by the leader and his family, and of the context in which the unit is situated.

The technologies which can bring new features into this area are very variable.

The new techniques of remote sensing and geographical information systems offer very interesting perspectives to better explain the phenomena of rural migration, the rules of land occupation and management, and resource management, such as woodland, pasture. They also lead to the formulation of decision aids.

For the development of animal husbandry in the Sahel, there is more to be expected from methods enabling the identification of globally available resources, the understanding of land tenure, and indeed the stockbreeders's own social organisation and place in the social structure of the crop farmers, and their methods of characterisating the individual performance of their animals.

As regards integrated pest control, tests capable of precisely characterising populations and their pathogenicity give a renewed interest to epidemiological studies and allow better characterisation of population dynamics and exchanges between the natural environment and crops, or herds and flocks of domestic animals. Such work is indispensable for achieving effective integrated control. This is even more true when forms resistant to pesticides appear.

New technologies for the management of crop systems

For the reasons indicated in the preceding paragraph, the new technical procedures proposed by agronomists to farmers are more and more diverse. They rest on a certain number of rules, which in turn relate to the necessity for the crop systems to be viable.

To establish the rules, agronomists start with the decisions farmers have to take, and the choices available to them. After choosing production systems, the farmer has to choose cropping systems and cultural techniques: rotation, choice of varieties, cultural techniques for soil preparation, sowing, etc. In such matters one must reason in terms of complete technical procedures rather than individual cultural techniques, bearing in mind the farmer's objectives, such as the intended yield of each crop.

As regards soil cultivation research is directed towards the application of techniques which are effective in limiting erosion, and which create and maintain a favourable soil structure.

In the humid tropical zone, where water is a factor that rarely limits yields, but where there is a high risk of erosion, the desire to develop cropping systems that limit erosion as much as possible leads to the adoption of intercropping, with both manual and mechanised cultivation.

Once a favourable soil physical state has been established, a cash crop is intercropped with a ground cover crop using zero tillage. Drilling implements are designed to sow directly into soils covered with living or dead vegetation.

As far as fertilisation is concerned, the basic rules are to limit applications as far as possible, and hence all losses except the amounts exported in the crop. This especially applies to leaching beyond the root zone. As regards fertiliser technology, numerous possibilities exist e.g. partially soluble phosphate, slow release nitrogen

The reasoning behind these technical procedures also aims to make better use of crop by-products.

Phytosanitary products will again have an important role to play in weed control, crop protection, and post-harvest loss. Much can be done to make their use less expensive and less risky for the environment. The range of control methods and products is increasing greatly. The main limitation is the high cost of new, more environmentally-friendly products, and the health of the users. All the diagnostic methods and thresholds for interventions should be developed to limit the use of pesticides to the very minimum necessary.

The application and refinement of agricultural diagnostic methods have led to a major reduction in the number of fungicide treatments against Cercospora leaf spot diseases in banana. By comparison with the strategy of systematic treatment used in certain Central American countries, the number of applications has been reduced from 25 to 6 for Sigatoka Disease (yellow Sigatoka) and from 45 to 16 for Black Leaf Streak Disease (black Sigatoka).

A great deal of work accompanies pesticide research, particularly on populations of insects and parasites which overcome natural or induced resistance, so as to avoid a too rapid appearance of such a breakdown of resistance, and to increase the efficacy of the products.

In the same way, vaccines and products for treating animals evolve rapidly. Biotechnology contributes effectively to this.

In the case of Newcastle disease in poultry, research is focused on finding an oral vaccine which is thermostable at tropical temperatures and can be easily stored.

New varieties, better adapted animals

For plants, research efforts in genetics and varietal selection have been mainly concerned with major arable crops, and less with species of local interest, forests, or natural pastures.

Obtaining higher and more stable yields remains a priority, as does resistance to pests and diseases. Knowledge acquired recently on the genetic structure of parasite populations and on mechanisms of variability of the pathogen allow us to better understand the use of resistance genes, which are better characterised by the molecular approach. The ability to resist stress, and the quality of the products, are becoming increasingly important.

Long-term analysis of the progress made shows that it sometimes results from leaps for major characters (semi-dwarf rice varieties) but more generally from a continuous improvement in a whole range of characters (rice varieties adapted to various water supply situations and resistant to diseases such as rice blast (Magnaporthe grisea).

Recently, progress in biotechnology has contributed to a renewal of selection methods and accelerated of progress. Future progress depends largely on genome mapping, selection assisted by use of markers, tissue culture, and genetic transformation. The use of transgenic plants in which a resistance gene is incorporated is required when, to control a disease or pest, no natural resistance is available.

For cultivated bananas, i.e. the polyploids (di-, tri- and tetraploids), and the natural hybrids of two species of Musa, acuminata and balbisiana, resistance to diseases is a critical problem. For a long time, because of the genetic characteristics of this species, selection of resistant varieties has been an almost insoluble problem, and many programmes undertaken with this objective have not succeeded. Knowledge acquired recently on the plant's genome gives hope for the future: by improving diploid varieties, and after chromosome doubling with colchicine, crossing with another diploid to give hybrid triploids, the first hybrid triploid varieties resistant to Cercospora leaf spot were created by CIRAD in 1994. They are now being tested. Very soon, it will be possible to produce new varieties by genetic engineering.

Arable crops should not be the only ones to receive attention. For rational and ecological use of land, one will resort more and more to species whose primary function is not production. They will have to fulfil several objectives, requiring special selection procedures.

In the realm of animal production, progress is expected in the use of natural tolerance and resistance to diseases and parasites. Knowledge of the physiological mechanisms involved, and of the genes responsible for this tolerance and resistance suggests augurs well for rapid increase in animal performance from this point of view.

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