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SOME RECENT RESEARCH FINDINGS

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Cassava is a crop that is not very well known outside of the tropics, but in the hot, humid parts of the world, perhaps one billion people eat it and a third to a half of this number depend upon it for a substantial portion of their calorie intake. Because it is exclusively a tropical crop whose production has very rarely been adopted on a plantation scale, it has received very little attention in the past from research workers. Indeed, the handful of people interested in the crop have often tended to be regarded as eccentrics.

In spite of this, cassava is one of the most effective crops known in terms of energy production per hectare per year. This productivity is usually achieved with the use of minimum inputs, a fact which is extremely important in these days when fertilizer, insecticides and other purchased inputs are so costly.

As the crop has received so little attention, particularly from plant breeders, it seems reasonable to expect that its efficiency could be improved more easily and more rapidly than that of many other crops which have already been subjected to tremendous selection pressure. Indeed, in this context, we can consider cassava as being in the same position as were wheat and rice in the tropics prior to the advent of the efforts which led to the green revolution.

About four years ago, two new International Agricultural Research Centers, namely the International Center for Tropical Agriculture (CIAT) in Colombia and the International Institute for Tropical Agriculture (IITA) in Nigeria, decided to select cassava as one of the crops whose production they would give priority to researching. The larger program is centered in CIAT which is located close to what is believed to be the center of origin of the crop and where a very large range of diverse germ plasm is available. The program at IITA is smaller and is primarily oriented towards overcoming the problem of African mosaic disease which is only known to occur in Africa and India and which is reputed to be capable of causing yield losses of up to 80%.

The program at CIAT involves a team with senior scientists in the fields of agronomy, agricultural economics, animal science, communications, entomology, pathology, plant breeding, physiology, soil science and weed control. The objective of the program is to develop improved germ plasm for a wide range of ecological conditions and to disseminate this material to national programs. The strategy being adopted is to first identify lines with high production potential, wide adaptability, disease and insect resistance and then to combine these characters in a number of lines. The best combined lines enter into an extensive testing program whose ultimate product is a production package which is recommended by national agencies.

The program has found that the leaf area index is relatively low and is difficult to improve by adjusting plant density or the application of nitrogenous fertilizers. It has been possible to improve it by genetic means and a desirable plant ideotype is being selected. This has three major components, greater than normal leaf longevity, a harvest index of .5 to .6 and a large root storage capacity. It seems as if different genotypes will be needed to produce this ideotype for different eco systems.

The pathology program at CIAT has stressed research on cassava bacterial blight, Phoma leaf spot, Cercospora henningsii leaf spot and super-elongation disease. Considerable progress has been made in combating bacterial blight and adequate methods for its elimination have been developed and described. Genetic resistance to the disease occurs in the germ plasm collection and this is being transferred to the better agronomic types. Similar resistance has been found in Phoma leaf spot and to a lesser extent in superelongation, a disease of fungal origin which has been described in detail for the first time by the CIAT team. Genetic resistance to Cercospora leaf spot does not appear to be widespread, although it has been identified in the collection.

The entomology program at CIAT worked initially with hornworm and shootfly, but these two pests appear to be kept under control biologically to such an extent that they are difficult to work with on the CIAT farm. However, a neighboring farm which uses a lot of chemical insecticides appears to do more damage to the predators of these pests than to the pests themselves and does have major problems with both of them.

Most of the entomology work at CIAT has been done with thrips and the germ plasm collection has been classified for thrip resistance which has been shown to be closely associated with pubescence. The pest to which most attention is now being given is the spider mite of which various species occur. One of these, the green spider mite, Mononycellus tanajoa, has recently been accidentally transmitted from the Western Hemisphere to East Africa where it has spread over 150 miles in a period of two years and, in the apparent absence of natural predators, appears to be causing quite serious losses.

The core of the program at CIAT centers around the plant breeding work. The most important activity to date in this program has been to classify the characteristics of the large germ plasm collection which contains between 2000 and 2300 cultivars. As mentioned earlier, some of these show considerable resistance to various pests and diseases and there is also a wide range of difference in yields so that the plant breeder has a great deal of material to work with. The program is producing about 40 thousand seedlings a year by hybridization in addition to selection work from the original germ plasm. The best 300 selections are put under test in the various locations and a smaller number of the more promising materials is being tested in 14 regional trials in different parts of Colombia. It is anticipated that by 1978 improved CIAT germ plasm should be available for national programs to recommend to farmers.

Early this year, CIAT held an International Workshop at which was laid the framework for the development of a Uniform International Testing Program in Latin America and Asia. Guidelines were established for phytosanitary care in the exchange of germ plasm for the design of comparative agronomic trials and for the evaluation of results. The results have been published and a similar type of workshop for African countries is taking place this month.

One of the more interesting research programs at CIAT is a collaborative one with the Tropical Products Institute in London and involves studying the development of a cheap and simple method for fresh cassava storage after harvest on the farm. The program has identified the reasons for root deterioration and has developed two storage systems, one in clamps in the ground and the one other by storing roots in boxes surrounded by moist sawdust. Both of these systems have been described in the literature. A great deal of postharvest work has been carried out at CIAT in relation to the use of cassave in animal feed, particularly for swine. This has shown that cassava can be included in swine rations at levels of up to 60% providing that the ration contains appropriate additives, especially methionine.

A final aspect of the program at CIAT which would appear to warrant special mention is the documentation center which is acquiring, abstracting and publishing a bibliography of the world's cassava literature now believed to be between 3500 and 4000 documents. Over 3000 of these documents have been acquired and about two thousand abstracted and an interim bibliography containing these abstracts is due for publication shortly. Additionally, the documentation center is publishing specialized disciplinary reviews including some of the papers that I have referred to already.

As I mentioned earlier, the program in IITA is somewhat smaller than the CIAT one and is concentrating on working on the reduction of losses due to cassava mosaic. A major aspect of this program has been a large hybridization activity which has led to the production of 300,000 genotypes in the past four years. These are screened for disease resistance and other characteristics and then the most promising one thousand or so clones produced each year are screened again on a larger scale using different locations in Nigeria and neighboring countries. The most promising germ plasm in terms of mosaic resistance appears to originate from work carried out in East Africa between 1937 and 1956 and which involved crossing cassava with the cassava rubber tree M. glaziovii. Fortunately, the East African program is still intact as there are a number of other glaziovii crosses than those possessed by the IITA, which may have a usable potential.

The pathology program at IITA works mainly on mosaic and also on bacterial blight which appears to have been introduced to Africa quite recently and is causing immense losses in Nigeria and Zaire. Under African conditions, this disease appears to be more difficult to control than it is in Latin America and this may be a function of soil and moisture conditions.

One of the important findings of the mosaic work at IITA has been to confirm observations made by workers at the East African Agriculture and Forestry Research Organization (EAAFRO) laboratory at Muguga in Kenya, that the causative agent in this disease may undergo a period of dormancy through at least one, and possibly two, generations, so that extreme care is necessary in moving plant material from countries where mosaic exists to those where it is absent.

The program at CIAT has been largely funded by the Canadian government who have also provided funding for basic research activities in Canada which relate to the CIAT program, but which appear more economic to carry out in Canada, even though cassava does not grow in the cold climate of that country. One of the studies carried out in Canada involved looking at the market prospects for cassava as food, feed and industrial starch so that if the International Centers do bring about a revolution which will increase the production of cassava, there will be available knowledge regarding its market prospects. This study showed that the demand for cassava as human food was likely to continue to grow at the past pace of about 3% per year, at least for the next decade. There were also promising prospects for growth in the cassava starch market, although this was a highly competitive one and often subjected to tariff barriers. However, the real growth potential lay in the use of cassava as a substitute for grains in animal feed in both developed and developing countries. At the time when this study was made in 1973, international trade in dried cassava chips or pellets, mainly from Thailand, was worth about 100 million U.S. dollars a year. The value of the trade doubled in 1974 and it is expected to reach around 500 million dollars by 1980, if not sooner. Cassava pellets have an energy value very similar to corn and a feed value perhaps 10 to 15 dollars a ton less and even allowing for shipping costs, it appears to be attractive to producers in many countries to produce roots at 15 to 20 dollars a ton for them to be dried, pelleted and shipped to distant markets. The prospects in domestic markets are even greater since this use avoids transportation costs and frequently imported animal feeds are extremely costly in developing countries.

Other studies being carried out in Canada involve physiological work in growth rooms studying the effects of environment on growth patterns, photosynthesis and tuberization. Work in Canada has also taken place, so far without any success, on attempting to identify the causative agent of cassava mosaic. There are some suggestions from this work and from work elsewhere that more than one agent (possibly viruses) are involved and that transmission through the vector white fly Bemesia tabaci may be an important factor.

A sub-product of the mosaic research in Canada which has had considerable success is one to develop a method for regenerating whole cassava plants by apical meristem tissue culture. The National Research Council's Prairie Regional Laboratory at Saskatoon have developed a reliable technique by which they can also produce symptom-free plants from ones that are badly infected by mosaic. If a certain diagnosis for mosaic could be developed, this technique could prove very important in ensuring that stock was disease-free before distributing it. However, because of the apparent ability of the disease to remain dormant, it is not possible to use the tissue culture technique with any reliability, at the present time, in terms of guaranteeing that material is disease-free. Current discussions in the tissue culture program involve further work on the preservation of apical meristem in liquid nitrogen in order to reduce the cost and space required for the maintenance of germ plasm collections.

Another small project in Canada involves studying the toxicity of cassava. This is commonly attributed to its cyanide content and it is assumed that cyanide is produced by the breakdown of the cyanogenic glucosides linamarin and lotaustralin. However, the chemistry of this process is somewhat theoretical and most of the research done on cassava toxicity has used the raw cyanide rather than starting with the glucosides and studying their behavior in the animal body. The recent production of pure linamarin in adequate quantities has made it possible to use this product in toxicity research.

Another project in Canada whose ultimate outcome is still uncertain involves an attempt to classify the large CIAT germ plasm collection and related material elsewhere, using phenolic differences in the plant. Were such a classification feasible, it would serve as a means of eliminating identical materials quickly from the germ plasm bank and it would facilitate comparison of material from different geographical regions where quarantine restrictions prevent the free movement of plant material. The project has involved the chemotaxonomic analysis of about 3000 leaf samples to date. There is some limited evidence that the phenolic content may be related to disease resistance and more evidence that the technique has some value in grouping large collection, however, this remains to be validated.

Perhaps the most exciting program in Canada relates to the enrichment of cassava with microbial protein. This project, at the University of Guelph, has developed a practical low-cost process for the production of protein-rich animal feed by the conversion of cassava starch and inorganic nitrogen into microbial protein. The researchers used a filamentous fungus which produces amylase and is capable of growing at a pH of less than 3.4 and a temperature which exceeds 45°C. These highly selective growth conditions inhibit most contaminants and eliminate the need for sterilization of the substrate and the fermentation tanks. It is also not necessary to chemically hydrolize the starch since the organism itself does this. Cooling is not required to remove excessive heat and the filimentous nature of the organism, which is readily accepted by rats as feed, provides the basis for a cheap filtration process for recovering the bimass without the need for high speed centrifugation. A self-aspirating fermentor has been specifically designed for this process and experimental devices for harvesting the biomass are under investigation.

This technique enables 100 grams of fresh cassava to be fermented in 20 hours to give 24 grams of dry product which contains 37% crude protein and appears to be non-toxic to rats.

The project has been extremely successful in the laboratory and has now been scaled up to a 3000 liter fermentor size and this fermentor is being tested in the swine unit on the CIAT farm where it provides sufficient product for feeding 50 pigs daily. There are still many details to be worked out, more particularly the economic ones, before it can be seen whether this project can be used safely and economically in cassava growing areas or with cassava starch factory residues.

The International Institutes and the Canadian Assistance given to them can provide a new technology and can test it in a limited number of areas. However, the testing, adaptation and modification of this technology and the development of new technology for specific local requirements must be the responsibility of national agencies who have direct contact with their local producers.

In these circumstances, the investments in cassava research at the International Institutes und in Canada can only be justified if they produce results that are accepted and applied by national agencies. In order to bring this about, in many countries such agencies require considerable strengthening, especially in the extremely neglected field of root crop research.

The structure and mandate of the International Centers is such that they are organized not only to fulfill a research role but also to provide the training element necessary to help strengthen national institutes. My own organization, the International Development Research Centre (IDRC) has also placed great emphasis on developing strong linkages between International Centers and National Research Agencies. This has been done a) by identifying specific problem areas and bringing scientists from the national and international institutes together to discuss these in a series of interdisciplinary workshops whose findings are usually published; b) by identifying promising personnel for training at various levels at the International Institutes; and c) by sponsoring programs for assisting the development of National Research Programs with cassava.

One of the features of the program that we have tried to stress is the linkage between the basic research in donor countries such as Canada, the germ plasm based applied research at the International Institutes and the research in national programs. These linkages are a basic aspect of the program. The tissue culture, microbiology and electron microscopy work in Canada are all very basic but do relate closely to the needs of applied programs designed to be of direct benefit to the cassava producer.

A second import feature of cassava research at the present time is its international nature and the effective dialogue which exists not only between our agency and the International Institutes, but also with the British, Dutch, German, Japanese and U.S. aid programs, with the private sector involved in industrial cassava production in Brazil, Guyana, Indonesia, Nigeria and Thailand and with national programs in about 20 cassava producing countries.

A third important feature of current cassava research is the stress which is being placed on utilization. The crop has traditionally been regarded as a low-protein crop for very poor people and very little thought has been given to utilizing its energy potential for starch and animal feed. Only in the last decade has this been recognized and only in the last two or three years have the prospects for producing microbial protein from a cassava substrate been looked at intensively.

I would like to conclude with a word of caution. At the present time, cassava research, long despised, has become a very fashionable occupation. As a result of this, lots of people have become interested in the crop and are moving cassava material around the world. Traditionally the crop was supposed to have been relatively free from diseases. However, in the last two years, to my knowledge, there have been bad outbreaks of disease from green spider mites in East Africa and bacterial blight in Malaysia due to enthusiastic scientists moving promising cassava material around the world without applying strict phytosanitary controls.

At the present time, some people are talking of cleaning up cassava from mosaic by subjecting it to tissue culture, yet we still do not know what causes cassava mosaic and we do know that it can remain dormant through at least one, and perhaps two or more, generations of healthy plants. If African cassava mosaic were introduced into Latin America or certain areas of South East Asia, it could have devastating effects on both export incomes and food supplies. For this reason, the efforts of

International Institutes to develop international standards for the exchange of cassava germ plasm (both seeds and stakes), are extremely important and it is essential that any country wishing to capitalize on the new developments that are being made in cassava research should be extremely careful, particularly from the standpoint of introducing new germ plasm.

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