AGRICULTURAL BIOTECHNOLOGY IN THE SOUTH PACIFIC REGION

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Introduction
The South Pacific Island region covers an area of 525,000 sq. km. with a total population of six million (predicted to rise to 12 million in 30 years time). The whole Pacific region is composed of a vast number of islands which vary in size from Papua New Guinea with a population of around four million, to Niue with a population of less than 2,000. Although not similar in terms of size, geological origins and other characteristics, the islands share many common features, such as their remoteness from markets, limited and fragile agricultural, forest and inland fisheries resources, scarcity of skilled manpower, high population growth, and fragile economies and environment. Subsistence agriculture, (over half of all farms) based on root crop staples is a mainstay of Pacific Island economies. This form of agriculture remains dominant, and has the advantage of being environment friendly but the disadvantage of low productivity.

Although agriculture is mainly subsistence, export markets have been developed for certain crops. Sugar was indigenous to the Pacific Islands and grown for home use. It was developed as an export crop in Papua New Guinea and Fiji, though in recent decades the sugar industry has survived because of preferential treatment. The future of the export sugar market is far from guaranteed, and there are problems with sugar production in Fiji that range from the non-renewal of cane farmers land leases to poor sugar quality. Tonga developed a squash market, supplying a late Autumn niche in the Japanese market. Oversupply and disease are often problems together with competition from New Caledonia, New Zealand, Vanuatu and elsewhere. In addition, problems exist with the soil on which squash has been cultivated, because of the intensive tillage and excessive use of fertilizers and pesticides required for squash. Samoa once had a valuable export market in taro, but this was destroyed by the spread of taro leaf blight (Phytophthora colocasiae) in 1993. Fiji now is the main exporter of taro in the region, but is itself vulnerable to the same disease, as the varieties under cultivation have the same level of susceptibility as those that were cultivated in Samoa.

In relatively recent years markets have opened up for plant species with medicinal properties. The root of kava, (Piper methysticum), is used to prepare a traditional beverage in Polynesia, and parts of Micronesia and Melanesia, and is an essential part of many rituals. Its active ingredients induce relaxation and contentment, reduce pain, and lessen aggressive feelings. Kava has been successful in the herbal market, being packaged as capsules, and sold for reducing stress and aiding sleep. This obviously provided a good source of income for kava growers in the Pacific and the area of land under kava has increased significantly in recent years, sometimes to the detriment of the staple food crops. More recently, there have been some indications, though with little evidence, that kava could encourage liver disease, which poses a threat to this relatively lucrative market.

With the Pacific Island region there is a conflict between the need to produce food for home use and the desire to generate income. Even in relatively remote communities, where excess funds can actually purchase very little, any opportunity to generate these funds will be taken. But as the previous examples show, there is a dangerous fragility in the agricultural export markets open to the Pacific Islanders. Exports are vulnerable to external disturbances, including recession in trading partner countries, the effect of the weather on export supplies, and strong competition...
from larger low-cost countries, such as the Philippines. Niche markets can appear to be safer and there are some successes in this area through the export of ginger, pepper, to name a few. These markets necessitate competing on the basis of the product rather than the price in small-scale, high price products. But again, care must be taken as these markets are by definition small, and their expansion is limited. There has to be a balance between food production and income generation. Some would argue that food production should be for food security and domestic use only, and income generation should come from off-farm sources such as food processing, handicrafts and possibly eco-tourism. Domestic food production has spin-offs such as rural employment, food security, better quality fresh foods and improved nutrition, higher rural incomes and local control over resources.

National and regional institutes and organizations support agriculture in the Pacific. Each country has a Ministry of Agriculture, which is supported by Government funds. In many of the island countries, especially those in the South Pacific, these are under-resourced, and any major research programmes are reliant on donor funding. Public funds are used to maintain staffing levels, which in many cases are inadequate, and staff members often have responsibility for a number of areas. A major problem is, and has been, the sustainability of any research programmes initiated by donor funds. Because of the many failures in this area, there is now a tendency for any major research programme to be applied on a regional basis, that is, involving more than one country, and to be implemented, and eventually incorporated into a regional organization.

The Secretariat of the Pacific Community, known as the South Pacific Commission until 1997, is a regional technical development agency, that works in partnership with its members, other organizations and donors, to deliver priority programmes to its member countries and territories. SPC’s integrated work programme covers several areas, including agriculture, fisheries and social resources. It is the largest regional technical agency, with the broadest mandate. The SPC headquarters are in Noumea, New Caledonia, with the main regional office in Suva, Fiji. It was established in 1947, with the establishing agreement signed by six metropolitan countries with territories in the Pacific. In 1983, full membership was extended to all governments and administrations in the region, and membership now stands at 27. Funds for SPC come from member countries, with the foundation members (Australia, France, New Zealand, USA and UK), providing by far the greater contribution. This is known as core funding, but there is also non-core funding, which is provided by donors, and which can obviously vary. The ratio of core to non-core funding is 30: 70. The total SPC budget, which includes operations at Noumea, is approximately US$18mn, with US$7mn being the budget for Suva operations, where agriculture is based. Other programmes, besides agriculture, operate in Suva. Taking these into account, approximately US$2mn is spent on agriculture at SPC, Suva.

Other regional organizations that have some involvement in agriculture are the University of the South Pacific, (USP), the Forum Secretariat and the South Pacific Regional Environment Programme (SPREP). Agricultural education is the concern of the Samoan campus of USP, though some countries do have their own agricultural institutes, such as the Fiji School of Agriculture. The Forum Secretariat, based in Fiji, is responsible for trade, though some policy issues do obviously affect agriculture. There is some collaboration between SPC and the Forum Secretariat with intellectual property rights issues. SPREP has the mandate for environmental issues, but some areas of involvement overlap with SPC, such as the biosafety protocols for GMOs.

Non-Governmental Organizations are also supportive of agriculture in the Pacific. One of the most active is the Planting Material Network, (PMN), in the Solomon Islands. This is a network of farmers, farmer organizations, women’s groups, extension officers, schools, vocational training
centres and NGOs working to conserve farmers crop diversity and to encourage sustainable agriculture and food security. The network, established in 1995, has proved to be a cost effective, sustainable and participatory approach to the provision of planting materials, dissemination of information and strengthening of self reliance. In addition to the PMN there is also the Kastom Garden Project, started by the Appropriate Technology for Community and Environment (APACE) in 1995, at a time when the food production sector was being neglected. Government extension services had promoted a limited number of cash crops and had a centralized research programme, often disconnected from extension and farmers’ needs. The Kastom Garden Project promoted participatory technology development (PTD), where the technologies were proposed and developed by the farmers themselves, with appropriate external expertise. Both PMN and the Kastom Garden Project have been very successful. A national farmers’ network now exists with over 400 members in all of the provinces, concerned with the conservation of crop diversity and the promotion of food security. Seeds are disseminated along with information and awareness raising. PTD has led to the dissemination of farmer developed methods of pest management in subsistence crops in some areas in Malaita. These small organizations have shown themselves to be effective and sustainable. In one area of Choiseul Province infant malnutrition has been reduced by 50% through a programme that combines simple agriculture with nutrition education. The recent civil unrest in the Solomon Islands resulted in the Government agriculture programme grinding to a halt. The main research station on Guadacanal was destroyed and most of the Government workers fled to their homes on the different provinces. The NGOs continued to support the rural communities, and even assisted with a donor-funded project, that had previously been implemented through the Ministry. There is increasing recognition that donors and regional organizations such as SPC, have to work with NGOs, and develop farmer based strategies. Working just with Government services does not reach all the stakeholders involved in agriculture for effective and sustainable agriculture programmes, and is a vulnerable relationship in times of civil unrest.

**What are the issues, concerns and challenges?**

Agricultural intensification is a problem in the Pacific Island region, and is largely due to pressures resulting from rapid population growth. One negative impact of this is soil erosion. Forest clearing, agriculture on steep slopes and excessive extraction further exacerbates this situation. The consequence is reduced productivity, increased flooding and damaged reefs. Only 16% of Fiji is suitable for sustained agriculture, and marginal land brought into production deteriorates rapidly. Other problems resulting from intensification are declining fallow periods, pest and disease problems, erosion of crop genetic resources, loss in forest biodiversity, and loss of traditional knowledge used in agriculture and resource management. The level of education available to most Islanders does not provide them with the information with which to understand all of the problems, short and long term, associated with intensification. They are aware of the immediate problems, such as increased pest presence, but do not see what the implications are on a long-term basis. There are, of course, positive lessons to be learnt from intensification, such as, farmers having to innovate, and develop and adopt new crops, and to modify their farming systems to the changing situation. Intensification can result in increased income, but this can have a negative impact with declining nutritional levels. Illnesses related to nutritional deficiencies are a common occurrence in many of the islands. The change from healthy traditional Pacific Island diets to imported foods rich in sugar, fats and salt is leading to a rising incidence of non-communicable diseases in adults in many of the island countries. There is also a tendency for the young people in the islands to drift away from traditional crops and farming systems, and to regard non-Pacific foods, whether produced domestically or imported, as desirable.
The pest and disease situation in the Pacific is an interesting one. Despite the geographical isolation, there are many serious pest and disease problems. Many of the important crops are vegetatively propagated, which enhances pest and disease problems, especially viruses. On the other hand, the geographic separation of the islands can act as a natural barrier to diseases spreading between the islands. As a result, some diseases are not found on all islands where susceptible crops are present. However, this natural barrier is not foolproof. In a region where there can be significant human movement, natural “spaces” between islands are not insurmountable. Added to this extreme climatic conditions can also assist in the dispersal of plant pathogens. This was illustrated by the spread of taro leaf blight between American Samoa and the Samoa Islands. The use of traditional breeding on research stations in the Pacific has not contributed significantly to disease control in many of the important crops in the Pacific. In addition, as these crops are of little global importance, and are largely important to resource poor farmers, they receive little attention outside of the Pacific.

One of the dormant issues in the Pacific is that of HIV/AIDS, especially in Papua New Guinea, where if current trends continue, 25% of the population will be infected with HIV within ten years. This will lead to an increase in rural poverty, further disruption of traditional food production practices, and a decline in the already weak rural institutions and services. Added to this, there are many of the Pacific Island countries experiencing conflicts, which are likely to continue, and even more likely to increase. Papua New Guinea has been experiencing law and order problems for years, and despite efforts, the crime rate continues to escalate, and to spread to parts of the country that ten years ago were considered “safe”. The recent situation in the Solomon Islands demonstrates how relatively unstable some of the countries in the region are. The thirst for power, coupled with ethnic tension erupted in conflict between two groups, which continued for 18 months. The Government fell apart, and with it all the Ministries and the infrastructure supported by these Ministries, foreign investment pulled out, and so too did donor funding. The victims of this collapse were the people, and mainly the rural people (85% of the population). Their dependence on imported rice greatly threatened food security during this time. Fiji has also been through civil unrest in recent years. Uncertainties about the future still exist, and unemployment is on the increase.

Climate change and predicted sea level rises are other external influences posing a challenge to many of the islands in the Pacific. Although it will obviously be the atoll countries that could be most severely affected by rising sea levels, communities on many of the larger islands tend to live on the coastal margins. For example, villages on both of the two main islands of Samoa are located on the coastal areas, and would be affected by rising sea levels.

Any agricultural developments have to take into account all of these issues, yet at the same time acknowledge the importance of rural communities, the need for food security, and the fragile environment in the Pacific. Biotechnological activities actually being carried out in the islands are what would be considered low-tech, and focus on the provision of improved, pathogen-tested planting material and conservation of genetic resources, utilizing tissue culture to achieve this.

**What is the current use of biotechnology in the Pacific?**

**The regional approach.**

Tissue culture as a technology was first introduced into the region in the mid-80s by SPC as part of its Plant Protection Service. The aim of the laboratory at SPC, Fiji was to facilitate the distribution of varieties of root and tuber crops in the region through their pathogen-tested status. In the late 80s another regional laboratory was established with European Union funding at the
Samoa campus of the University of the South Pacific, (USP). This laboratory collaborated with the laboratory in Fiji, but also focussed on research.

An important output of both laboratories, was an increasing awareness of the benefits that tissue culture can bring to agriculture through improved utilization and conservation of germplasm. The advantages of tissue culture for distribution and multiplication were very apparent in solving the dilemma that Samoa was in as a result of taro leaf blight (TLB). Tissue culture enabled TLB-tolerant varieties to be imported from the Philippines and Palau, and then facilitated the bulking up of that material for distribution to the Samoan farmers. The greater security of accessions conserved in vitro compared to conservation in field genebanks has also been demonstrated in the Pacific Island region. Vanuatu lost all of its taro collection as a result of extreme climatic conditions and an agricultural workers’ strike, but this same taro, was still available as pathogen-tested tissue cultures in both the USP and SPC laboratories.

Together with the increasing awareness of the role tissue culture can play in the utilization and conservation of plant genetic resources, (PGR), there was also a growing consensus that a regional approach provided the only effective and sustainable way of tackling PGR conservation and utilization. Recognition of the importance of regional cooperation in the conservation of plant genetic resources in the Pacific Island region was acknowledged by the Ministers of Agriculture from six ACP countries at a regional meeting held in Fiji in 1996. The resolution put before the Ministers was ‘Conserving genetic diversity is the key to crop performance and thus its neglect could imperil agriculture. Linked to this is the need to protect and utilize plant genetic resources so that there is an equitable sharing of benefits. The Honourable Ministers of Agriculture are urged to put in place both in their countries and through regional cooperation policies to conserve, protect and best utilize their plant genetic resources’. This resolution was endorsed by the Ministers, and together with several others was conveyed to the meeting of Forum officials in November 1996. The need for regionality and the acknowledgement that tissue culture was a preferred method of conservation cumulated in a regional tissue culture centre being identified as the right direction for conservation of the main regional crops. It was realized that such a Centre could provide storage for Pacific Island crops that were not conserved in any of the International Agricultural Research Centres (IARCs). For example, none of the IARCs has an international mandate to conserve taro. Similarly, with yams, IITA, Nigeria, maintains collections of African yams, but has no Pacific yams in its collection. In addition, such a Centre would be a source of germplasm for breeding programmes, and improved germplasm for farmers. The regional centre would also support national, low cost tissue culture laboratories that are basically propagation and distribution units for individual countries. As a result, the RGC was established at SPC, Suva, under EU and Australian Government funding. The RGC was officially opened in March 1999.

There are currently several projects operating within the RGC. The major project is concerned with the conservation and utilization of taro genetic resources (TaroGen), and is funded by the Australian government. TaroGen provides a model of how biotechnology is used in the region, and how overseas institutes provide inputs from technologies, more demanding of resources. Tissue culture has been used to collect taro from eight different Pacific Island countries. Fiji has a lucrative market in exporting taro and so would only allow tissue-cultured taro into the country for quarantine reasons. This taro has been maintained and multiplied within the RGC, and samples have been sent, again as tissue cultures, to the University of Queensland, Australia, for DNA fingerprinting.

The DNA fingerprinting was carried out as the final step in a process aimed at establishing a core collection of taro, representative of the genetic diversity present in the whole collection. The final taro collection under TaroGen amounted to some 2,500 accessions. The maintenance of this large
collection was not feasible either by the countries as individual national field collections, or as tissue cultures in the RGC, however it was agreed that a core collection of some 250 accessions was manageable as a tissue culture collection. In addition, as has been shown in previous studies a 10% sample can “trap” the range of genetic diversity existing in a base collection. Analysis of morphological descriptors enabled the collection to be initially reduced to 20%, and so it was this 20%, which was examined genetically. Microsatellites, also known as Simple Sequence Repeats (SSRs), were used for the analysis, and with the microsatellite enriched genomic library that was generated, it was possible to decide which accessions should be part of a core collection. The advantages of carrying out this work overseas are obvious, yet at the same time, it is realized that if possible this technology should be transferred to the region. Sustainability is the key issue here, and once again a regional approach is being adopted, with a possible collaboration between USP, Fiji and SPC. USP, Fiji already has a reasonably well-equipped laboratory within their marine studies department for carrying out some molecular marker studies. Expanding this facility, and having it located within an institute where research is not just focussed on agriculture, and where a larger number of researchers are based should ensure a greater use of the technology.

Another component of the taro project is virus indexing. Again because of the resource demands of this project, this work has been carried out at the Queensland University of Technology. The project objective has been the diagnosis and detection of taro viruses in PNG and other Pacific countries so as to facilitate the safe international movement of taro germplasm. PCR-based diagnostics have been developed for several of the taro viruses, (taro bacilliform badnavirus, dasheen mosaic potyvirus and taro reovirus). Work is on-going to develop the same for two putative rhabdoviruses, taro large bacilliform virus and taro vein chlorosis virus. Electron microscope examination of sap dips is currently the only available indexing technique for these two viruses. The RGC is meristem culturing all accessions in the core collection to eliminate all virus particles. Taro plants can contain more than one virus and it is believed that a complex of the large bacilliform virus and the bacilliform badnavirus results in the fatal alomae disease. Past studies have shown that meristem culture can eliminate these virus particles. Developing Pacific Island capability in virus indexing is also a project objective. Again discussions have centred on sustainability, and the possibility of having a virus indexing capability within the RGC is being considered. This illustrates, as with the DNA fingerprinting that advanced technologies will be introduced into the region and will become part of the region’s capabilities, as long as one can predict with some accuracy the sustainability of these technologies.

Cryopreservation has long been recognized as a practical and efficient technique for long-term storage of vegetatively propagated plants, requiring minimum space and of relatively low cost. Added to this, it provides a conservation method, which preserves genetic integrity. For these reasons, cryopreservation has been investigated as a method for conserving the base collection of taro. It has been the focus of a Masters study under the TaroGen project. Some success has been achieved with a vitrification procedure, and research is continuing in this area to optimize the methodology so that it can be extended to other varieties. The strategy is that skills developed in this technique will not just be confined to taro, but can be used on other crops, such as yam and sweet potato.

An EU funded project on yams (D alata), operates within the RGC. This is similar to TaroGen in that yam collections are established in several of the countries. Selections are made based on certain characteristics, and these are established in tissue culture in the RGC. Meristem culture is being used to provide cultures to the Natural Resources Institute (NRI), UK for virus indexing. Cryopreservation (encapsulation-dehydration), is also being investigated as a storage technique, with support from Institut de Recherche pour le Developpment (IRD), France.
The RGC also works with INIBAP in the distribution of a few varieties of Sigatoka disease resistant bananas to the countries. Some work is also carried out under the COGENT umbrella. An international field genebank for Pacific coconut accessions is located in Madang, Papua New Guinea (PNG). Countries have to send their elite accessions to Madang for establishment in the field genebank. As coconut embryo culture is the preferred method for transferring coconut germplasm between countries, the RGC is assisting with training and also evaluating the various ways of transferring coconut germplasm (“naked” embryos, endosperm plugs, germinated embryos). The RGC also has a collection of some 150 pathogen tested sweet potato accessions, an output of an EU funded project under the Pacific Regional Agricultural Programme (PRAP). This collection contains largely varieties from PNG and Solomon Islands, which have been evaluated for yield, scab resistance, tuber shape and colour. Evaluation has mainly taken place off farm and in PNG, so the RGC is now distributing these to the countries for on-farm evaluation in individual countries. There are plans to look at yield decline due to virus build-up, in collaboration with the farmers in the PMN in Solomon Islands.

The national approach

Tissue culture laboratories exist in many of the Pacific Island countries and are largely concerned with multiplication and distribution of varieties of certain crops. In vitro conservation is practiced in some laboratories but not to any large degree due to the resources required. These laboratories have been active for some time, and are generally supported by Government funds with some input from donor agencies. Other laboratories have been started but have failed due to lack of Government support. Attempts have been made to establish laboratories that are self sustaining through the production of a high value product, such as ornamentals, but this has not proved to be successful, either because strategies have not been sufficiently considered, and/or because of too small a market.

The national laboratory in Samoa is very successful because it is supplying the farmers in Samoa with varieties of taro, which are tolerant/resistant to taro leaf blight. Because of its success, and the need to get taro to the farmers the laboratory is currently receiving funds from FAO and JICA. As well as the laboratory having a well-defined role to play in agriculture in Samoa, it was also well supported by the Government, who saw its potential in the light of the taro problem, and invested the necessary resources into the facility. Similarly the Micronesia Plant Propagation Research Centre in Kosrae, Federated States of Micronesia has Government support together with separate US funding to distribute several varieties of banana, including one high in Vitamin A. Laboratories also exist in French Polynesia, New Caledonia, PNG, Tonga, Fiji and Guam.

Biocontrol

Taro beetle is a significant pest of taro, and over the past 12 years a project has been investigating various means of controlling this pest. Initially the EU under PRAP funded this project. It is now funded by ACIAR (Australian Centre for International Agricultural Research), and is implemented by SPC. The project is currently focussing on the use of *Metarhizium anisopliae*, and large scale field trials and investigations into methods of low cost mass production are planned for 2002. The potential of *Pangium edule* extract is also being evaluated. *P. edule* is a tree found in PNG and Solomon Islands. Laboratory bioassay studies have confirmed that the compound is highly toxic to taro beetle adults. The project operates in two countries, Fiji and PNG.

The regional fruit fly project began its activities in 1990, and has continued since then under a number of donors that include FAO, UNDP, and the Australian and New Zealand governments. It is now part of the SPC Plant Protection Service, and is largely funded by the Australian government. The project has developed a protein bait spraying system, which is based on a yeast
autolysate produced by enzymatic autolysis. The bait attracts the female fly, which requires a meal of protein before it can lay fertile eggs. While feeding on the bait, the fly consumes a toxic dose of insecticide. This method of control is environmentally sound, reduces the amount of insecticide used and the possibility of insecticide residues in produce, and conserves beneficial insects. A plant converting waste yeast from the Royal Brewery in Tonga into yeast autolysate has been established. This plant converts waste yeast into protein autolysate through a process of heating, together with the addition of the enzyme papain and the food preservative, potassium sorbate. The product, known as “Royal Tongalure” was launched in early 1998. A similar plant was established in Vanuatu in early 2001. This combination of protein bait spraying with other control methods such as bagging fruits, has given good control of fruit flies in guava, mango, papaya, capsicum and chilli.

Some parasitoids is used in the control of this pest, but this is minimal because there have been relatively few instances where the use of biocontrol agents has been a sustainable success. The populations of mango fly are very high throughout the year on Pohnpei and Kosrae (FSM). *Fopius arisanus* and *Diachasmimorpha longicaudata* were introduced in 1997 on both these islands. *F. arisanus* has become quickly established on Pohnpei, but it is too early to assess its long term impact on the mango fly population. The establishment of *D longicaudata* on Kosrae is being confirmed at present.

**Intellectual Property Rights.**
This is a very sensitive topic in the Pacific, and one that countries and organizations are attempting to solve through national and regional legislation. Some of the island countries feel that they have already lost benefits, which should have accrued to them in the past from the use of their genetic resources. National legislation is being put in place by some of the countries, for example, PNG and Fiji. This legislation tends to address bioprospecting issues. The RGC currently uses Material Transfer Agreements when distributing germplasm from the Centre. These MTAs follow closely the format used by the IARCs. The main problem with IPR in the Pacific, is that none of the existing mechanisms can be applied to “protect” the traditional crop plants in the region. They do not fit the requirements for patents or for a UPOV type system of PBR. A recently initiated project on plant genetic resources funded by the Australian and New Zealand government aims to address this problem.

**GMOs and Biosafety**
Papaya ringspot virus resistance in papaya in Hawaii (coat protein mediated resistance) has been used for several years and is being trialled in Guam (Northern Pacific). There is substantial importation, not always declared, of seeds from countries, such as China and Taiwan. It is possible that these are LMOs but this is not known.

None of the Pacific Island countries currently have specific legislation governing GMOs, though Kiribati is currently drafting new biosecurity legislation. GMO issues are usually dealt with under agricultural quarantine legislation, though some countries, such as Cook Islands, Federated States of Micronesia, Kiribati, Papua New Guinea, Papua New Guinea and Samoa, also have additional environmental legislation. Within the region, there is generally a lack of expertise and resources for formulating and implementing legislation. At a SPC Biosafety meeting in Samoa, 2001, it was recommended that the countries consider, in the interim, the use of biosafety guidelines to regulate GMOs and LMOs. This would provide the time necessary for legislation and risk management procedures to be formulated.
The future of biotechnology in the Pacific

In evolving more sustainable production systems, agriculture and rural development efforts should focus on three objectives: food security, employment and income generation in rural areas, and natural resource conservation. All three objectives are crucial for the sustainable development of agriculture in the Pacific. Biotechnology can assist in achieving these objectives through the use of several technologies, such as the simple techniques of tissue culture for multiplication of desirable planting material, to the production of plants with resistance to a virus.

In the Pacific, biotechnology through tissue culture has assisted in the utilization of improved varieties and has enabled “new” material to reach the farmers’ fields faster than through using the conventional propagation methods. It has also played a significant role in the conservation of plant genetic resources, proving to be a more secure and cost effective method than the traditional field genebanks. Cryopreservation provides the Pacific with a long term storage method, so that relatively large collections can be maintained with minimum inputs and at a low cost. This will enable the Pacific to conserve the biological resources, which are crucial to meeting new challenges in the future. Using tissue culture, plant material can be propagated in an aseptic environment, thus ensuring the production of disease-free stocks, and simplifying quarantine procedures for the international exchange of germplasm. Through meristem culture plants can be freed of pests and diseases, which are a constraint on productivity. Biotechnology will continue to make a substantial contribution in these areas.

Other areas where there biotechnology will continue to make an impact in the Pacific, albeit indirectly through collaboration with overseas institutes, will be in the areas relating to conservation and germplasm health. Through the use of DNA-based marker methods, biotechnology will continue to improve the quality of germplasm collections, and their efficient management. The taro core collection established under Tarogen has been the first collection to be rationalized using molecular markers. It has been reduced to a size that is manageable yet at the same time contains all of the diversity that was present in the whole collection. Similarly as shown with the taro viruses, biotechnology can provide a range of rapid, sensitive methods for detecting viruses without the need for bioassays and continued propagation of tissue. Ideally future advances will focus on the development of broad-spectrum tests capable of detecting the majority of viruses in a group. Where possible through capacity building these technologies will become incorporated into the relevant regional institutes in the Pacific, but only if it is felt that they are sustainable, and of long term benefit to the development of the Pacific.

Biotechnology can assist in other areas. As stated previously, there are many serious pest and disease problems in the Pacific. There is substantial potential for the use of disease resistant transgenic crops in the Pacific, initially to control viruses, and in the longer term, bacteria and fungi. Even if much greater effort was put into traditional breeding the chances of finding virus resistance and incorporating it into desirable cultivars is slight. There has been some discussion concerning the disease problems that occur with taro, such as the notorious viruses from PNG and the Solomon Islands. It is argued that the use of transgenics could be a far easier solution to this problem, as it is relatively easy to source virus “resistance” genes in the form of virus CP genes, replicase genes. Therefore one of the most likely uses of transgenics in the near future would be the control of taro viruses. Another role for transgenics could be in squash cultivation. As previously stated squash is an important crop from Tonga, and other Pacific Island countries. However, ZYMV, WMV and CMV all infect the crop. ZYMV is the most serious virus, and 100% infection is common by the end of the season. There is no effective chemical or cultural
control, and mild strain cross protection has been trialled, but not used commercially. CMV, WMV and ZYMV resistant squash are now available.

A recent development of possible benefit to the Pacific region has been that of transgenic sweetpotato germplasm resistant to Sweetpotato Feathery Mottle Virus (SPFMV), a serious constraint to sweetpotato production in Africa. This project is the result of a combined effort from Monsanto, Kenya Agriculture Research Institute and CFRIC, Indonesia. The new lines have been transformed with the Sweet Potato Feather Mottle Virus coat protein and are expressing the transgene. These lines are being tested in host countries before confirmation of resistance to SPFMV can be demonstrated. Such a development could have benefits for the Pacific in that sweet production is hampered by yield decline due to virus accumulation. Studies have shown that pathogen-tested plants, free of virus, can only retain this “clean” status, and significant yield increase for two to three years.

There are other areas that could be of benefit to agriculture in the Pacific, and these would include biopesticides and biofertilizers. As stated in the twelve-point action plan of the Chennai Declaration, there should be coordination between biotechnology and organic farming so that farming practices can be developed, which eliminate or minimize the use of chemical pesticides and mineral fertilizers. Gene technology now allows the speeding up of screening programmes for new compounds, therefore thousands of substances can be tested for their biological activity rapidly and inexpensively.

In summary, it is safe to say that biotechnology will continue to play an important role in the development of agriculture in the Pacific. If through biotechnological methods, it is possible to obtain more food from the land, both in terms of quantity and quality, with less energy input (fertilizers) and less problematic plant protection, then this is of great advantage to farmers, large and small. However, the importance of the farmer must be foremost at all times. The technology has to be appropriate and has to be tested under farm conditions. Any new technology should not “sold” in isolation but should be integrated into a system that encourages diversification and low external inputs. In addition, as one of the most ecologically vulnerable regions in the world, care must be taken in the importation and use of any GMO in the Pacific. The Pacific Islands need to have biosafety regimes in place. It will be the prerogative of the countries to make decisions on this issue but there are obviously regional implications, because of the movement of freight and human resources between the islands. Every effort must be made to take advantage of new technologies, but only if they are appropriate, sustainable and safe.