Project Title **Code: 1.4**	**Biofertiliser inoculant technology for the growth of rice in Vietnam: Developing technical infrastructure for quality assurance and village production for farmers**
Australian Personnel	Professor Ivan Kennedy
Australian Institution	University of Sydney
Vietnam Institution	Hanoi Agri. University
Project Duration	July 2000 – June 2002

Project Description

Biofertilisers are defined in this application as microbial inoculants, isolated from soil or the rhizosphere of plants, assisting the mobilisation of soil nutrients such as N and P and others in the plant rhizosphere and thus promoting the growth rate and yield of plants. Successful biofertilisers can contribute to increases in food production in a highly sustainable manner, with economic and environmental advantages. The extensive use of biofertilisers has the potential to better recycle the current nutrients contained in the soils and water of agricultural ecosystems and to reduce the negative impacts on ecosystems of chemical fertilisers.

This CARD project seeks to provide training and expertise related to quality assurance of mother culture strains of bacteria for biofertiliser inoculants used in paddy rice production in Vietnam. Similar quality assurance is required for biofertilisers produced by farming communities in Vietnamese villages used to inoculate rice seedlings. A range of techniques to identify and count inoculant bacteria have been developed in the SUNFix Centre located at the Universities of Sydney and Western Sydney (see attached report ACIAR project CS/1996/217). The project will simplify, validate and further develop these procedures for routine application in Vietnam.

Objectives

a) To establish simple microbiological and immunodiagnostic tests for providing quality assurance of mother culture strains of bacteria for biofertiliser inoculants used in paddy rice production in Vietnam. Similar quality assurance is required for biofertilisers produced in the field. In addition, more specialised tests using PCR are required to identify inoculant strains of microbes.

b) In a workshop setting, to train scientists in methods of strain selection and quality assurance of strains in biofertilisers.

c) Field training of villagers, particularly women, in methods of biofertiliser production and the use of simple field tests.

d) To carry out research on carrier materials for biofertilisers and methods of ensuring high numbers of inoculant microbes in biofertilisers.

Outputs and Performance indicators

Outputs	Performance Indicators
♦ Techniques for quality assurance of mother cultures	i) Development of tests and protocols for microbial strain typing such as microbiological, immunological or genetic (PCR) tests
♦ Field assessment of carrier materials for biofertilizers	i) Experimental trial for comparison of non-sterile carrier materials
♦ Training and strengthening of Vietnamese scientists existing knowledge on protocols for quality assurance	i) Workshops for training of scientists and technologists in the isolation, counting, and identification of inoculant strains
♦ Training of villagers in biofertiliser production	ii) Workshops in villages given by technologists for training of villagers in selection of materials, production and ensuring the good quality and application of biofertilisers

PROJECT COMPLETION REPORT

Executive Summary

This CARD project has successfully completed the major components of its program design. An important field trial conducted in 2001 provided unequivocal evidence of the effectiveness of BioGro biofertiliser in giving significant yield increases for rice. Two major technical workshops were included in the project design to document activities (the final workshop is to be held October 9-11, 2002 in Hanoi) and several training workshops for farmers have been held in Vietnamese villages. Methods for quality control of biofertiliser products and for field experimentation have been developed and documented. An economic analysis for the biofertiliser technology has been completed, clarifying the economic and social advantages possible from its application. A field study aiming to document farming practice during successful application of biofertiliser has also been completed for rice farms in north Vietnam. A Quality Control Manual is published at the final workshop in October 2002. The performances of personnel from the University of Sydney and the Hanoi University of Science have met expectations, although not all projected activities could be completed because of factors beyond our control.

1. Project Description

1.1 Background and preparation

Biofertilisers are defined in this application as microbial inoculants, isolated from soil or the rhizosphere of plants, which assist the mobilisation of soil nutrients such as N and P in the plant rhizosphere and otherwise promote the growth rate and

yield of plants. Successful biofertilisers should contribute increases in food production in a sustainable manner, with economic and environmental advantages. The extensive use of biofertilisers has the potential to better recycle the current nutrients contained in the soils and water of agricultural ecosystems and to reduce the negative impacts on ecosystems of chemical fertilisers.

This CARD project sought to provide training at several levels and expertise related to quality assurance of starter culture strains of bacteria for biofertiliser inoculants used in paddy rice production in Vietnam. Similar quality assurance is required for biofertilisers produced by farming communities in Vietnamese villages. A range of techniques to identify and count inoculant bacteria needed to be developed at the Universities of Sydney and Western Sydney. The project aimed to simplify, validate and further develop these procedures for routine application in Vietnam.

The need for quality assurance had been identified in a previous small ACIAR project and it was the main aim of the CARD project to provide this. Such quality assurance is considered to be needed in producing commercial products and for their effectiveness in the field. The main beneficiaries of the improved technology are rice farmers, who obtain improved yields of rice and more income and the workers in village factories producing the biofertilisers, as a result of more reliable technology.

1.2 Context and rationale

The current context for biofertiliser production involves a 3 - stage process. Strains of micro -organisms selected for their effectiveness biological nitrogen fixation, phosphate mobilisation and plant-growth promotion - PGPR are cultured in fermentors as pure cultures at the University of Hanoi by Professor Hien's staff. Three of these strains are then added separately to a peat carrier to be transported to factories located in villages in the field. Field staff in these factories then multiply about 80 - fold the cultures separately in a two stages in peat to which rice husks and sugar are added and the final inoculant biofertiliser product (BioGro, see attached brochure). The BioGro product is then transferred to farmers while fresh and used to inoculate rice seedlings in paddies at transplanting.

The CARD project was based on a small ACIAR research project that had previously established the probable validity of applying biofertilisers to rice. There is interest in obtaining such products for application in Vietnam, but no other case is known to me of such extensive application in the field on farms. The CARD project has adopted a more-production oriented approach and has included an economic analysis to test the validity of the technology. This is innovative technology that has no counterpart in Vietnam or other countries, although there is great interest in the development of such technology (see RIRDC book, *Biofertilisers in Action).* In this sense, this is a landmark project that could provide an essential stimulus to more widespread application of biofertiliser technology. There are important environmental advantages as well as economic advantages

possible using the technology if it can be shown to be a viable process. To further stimulate this process, it is anticipated that a new large ACIAR project may be initiated, to provide supporting strategic research to help optimise the technology.

The design of the project was decided by the nature of this 3 - stage process. Although the project could have been pursued in different ways, the options chosen (technical and field training workshops, supporting research on development of quality control procedures) were based on the need to help guarantee the success of the technology and to reduce the risk of failure. A considerable network of participants was involved in Vietnam, including the Women's Union (see attached English translation of the BioGro brochure developed during the project).

1.3 Project objectives and scope at design

The main objectives and inputs are:

To establish simple microbiological and immunodiagnostic tests for providing quality assurance of biofertiliser mother cultures and for biofertilisers produced in the field. In addition, more specialised tests using PCR are required to identify inoculant strains of microbes

In a workshop setting, to train scientists in methods of strain selection and quality assurance of strains in biofertilisers.

Field training of villagers, particularly women, in methods of biofertiliser production and the use of simple field tests.

To carry out research on carrier materials for biofertilisers and methods of ensuring high numbers of inoculant microbes

The measurable outcomes were expected to be:

The training of teams of Vietnamese scientists and teachers in methods needed for effective biofertiliser production

The development of a new village industry generating cash flow for village women

A cleaner agricultural environment producing more rice for home and export consumption at lower input costs

Significant progress towards achieving these objectives has been made, although much remains to be done and the area may represent a major opportunity for effective investment in future.

These objectives are considered to be strongly consistent with AusAID's country objectives, and partner government programs in proposing an innovative approach to developing rural industry infrastructure aiming to develop a more sustainable production system. Women play a particularly strong role in this project as scientists and technicians, village producers and farmers. The project also has a positive environmental impact, possibly reducing global warming by improving the efficiency of utilisation of nitrogen as a crop nutrient.

1.4 Implementation arrangements

The implementation of the project has been quite smooth, without significant administrative problems. Good communications had already been established during the previous ACIAR project. Only one university centre was primarily involved in each country. Nevertheless, the availability of email communication has been essential to the project allowing information exchange to occur almost immediately in only a day or two. The availability of Dr Rodney Roughley as an Honorary Associate of the SUNFix Centre for Nitrogen Fixation to participate in the project in Vietnam has been most fortunate. His years of experience with national quality assurance for Rhizobium in Australia have also provided a strong boost to this CARD project and for the development of the Quality Control Manual to be completed in Oc tober. Dr Roughley has supervised the field trials in Vietnam and t he collection and analysis of data from farmers regarding on - farm trials of BioGro. Administrative staff at both universities have been cooperative and supportive of the activity.

2. Appropriateness of Project Design and Objectives

2.1 Appropriateness of Objectives

Objecti ve No	Objective description	Appropriateness Rating
1.	Development of techniques for quality assurance of mother cultures and of simple tests for field inoculant biofertilisers for rice produced by villagers, using microbiological, immunological and genetic (PCR) approaches.	4
2. (Revise d)	Field trial in Viet Nam to determine the need and optimum level of farm-yard manure for positive effects from biofertiliser inoculants. [Greenhouse trial in Australia at BioCare Technology to compare results using sterile carrier (gamma-irradiated) with those using non-sterile media (peat or organic soil) as used at present in Vietnam. Not performed because of delays in preparing the case to obtain permission from AQIS to use inoculant strains elsewhere than the University of Sydney.]	4
3.	Workshops to teach scientists and technologists in Vietnamese institutions techniques of biofertiliser production and quality assurance.	4
4.	Training by technologists instructing village women and others in biofertiliser production, sampling for simple tests of quality and methods for field application.	4

2.2 Appropriateness of Design

Description of design feature	Appropriateness Rating
Two technical Workshops for scientists in Hanoi to define project methods and to produce documented manuals and a Quality Control Manual	4
Research in Australia, to identify strains using molecular (ribosomal RNA, PCR) and determinative (Bergey's) techniques, to develop methods for quality control (antibiotic resistance, ELISA tests from antibodies to strains, colony DNA-probe blotting, nutritional tests, etc.)	3
Research in Viet Nam, to isolate new strains, to verify positive effects on crop yields using field trials with replicated plots and split plots on individual farms	4
Economic research in Viet Nam (Barrett and Marsh), including field assessment of the technology	4

5- Best Practice; 4- Fully Satisfactory; 3- Satisfactory overall; 2- Marginally Satisfactory; 1- Weak

3. Implementation Performance

3.1 Project Components and Outputs

Component No.	Component Description	Outputs	Performance Indicators	Performance Rating
1	Develop test methods and train methods for quality control	PCR tests for identification of mother culture strains, immunodiagnostic tests and DNA blot tests completed	Four tests developed as pilot methods for five microbial strains	4
2	Produce good quality biofertiliser mother cultures for field trials with rice crops.	Replicated field trials and split farm trials	One field trial, 60 farmer trials	4
3	Training of Vietnamese scientists and technologists in techniques of	Technical training workshops	Two technical workshops (June 2001, October 2002), training	4

	biofertiliser production with adequate quality control and quality assurance.		more than 20 scientists	
4	Training of village women in techniques of biofertiliser production	Field training workshops	Six field workshops training of 400 villagers and farmers (see attachment from Hien)	4

5: Exceeding time and quality targets, 4: Achieving time and quality targets and on budget; 3: Moderate progress towards targets, some issues about quality, budgets or costs but these are being adequately addressed; 2: Some progress towards targets, but slippage in schedule and cost overruns; & 1: Significant problems in achieving targets, quality outputs unlikely to be achieved and substantial cost increases affecting overall budget.

Apart from minor changes regarding implementation of methods, only one major approved change was made during the project. This was to gain approval to delay the final workshop to avoid clashes with busy periods in biofertiliser starter culture production, harvests and the hot season. This will be held in mid-October, 2002, when the final outputs of the project will be delivered. This variation will prove beneficial, allowing more time for test development and preparation of the Quality Control Manual, the main output of the project. A Supplementary Report will be prepared for AusAID in mid - October.

A major factor affecting the implementation of the project in a positive sense was the highly effective network in rice-growing rural areas established by Professor Hien over the past ten years. Another factor was the strong commitment of the Vietnamese team to obtaining results in the field. This provided a complementary opportunity for the Australian team to carry out supporting research relying on facilities and expertise available in Australia but not in Vietnam.

3.2 Project Outcomes

The main outcomes of the project include:

Confirmation of the effectiveness of inoculant biofertiliser (BioGro) in field trials (documented in Nguyen, Roughley and Kennedy, 2002, in *Biofertilisers in Action*, attached).

Confirmation of the effectiveness of BioGro in farmer trials (documented in Nguyen et al., 2002).

Identification of inoculant strains of bacteria (documented in Workshop 1 Manual (previously submitted) and Workshop 2 Manual (in preparation, see programme attached as Appendix 2)

Economic assessment of biofertiliser (documented in Barrett and Marsh, 2002, in *Biofertilisers in Action*, attached)

3.3 Sectoral Impact

This project was mainly carried out by Vietnamese women, with a ratio of female to male participants in the project of more than 2 to 1. The majority of the staff producing biofertiliser in the project were women and the Vietnam Women's Union played a strong role in providing acceptance of the technology by farmers, many of whom were also women. The field trial was established and harvested solely by women. Concern of such community groups for better environmental outcomes was also a factor in acceptance of biofertiliser technology. The generation of additonal cash flow in villages is a potential advantage of this technology, compared with the importation of chemical fertilisers, often assisting household budgets particularly for women.

3.4 Costs and Financing

The budgeted costs for the project design approximately matched expenditure within 95%, both in Australia and in Vietnam, as shown in the acquittal in the Appendix A1.0. However, about $10,000 cash over-expenditure is anticipated by the completion of the project in October because of additional costs in achieving objectives at the University of Sydney and expenses incurred for the October Workshop 2. This over - run was largely a result of the need to employ new research staff and for un-budgeted technical assistance in the project period, leaving the Workshop largely unfunded.

3.5 Monitoring of project

The project directors have been responsible for overall project monitoring, together with periodic discussion (e.g. see Trip Reports by Australian participants visiting Vietnam). They were assisted by University staff including accountants. Institutional contributions were assessed using standard estimates of in-kind support. The Faculty also supplied administrative support (Ms Annette Vervoort) who assisted with six - monthly reporting required to be sent to the University of Wollongong. These arrangements allowed sufficient indication that milestones were being met more or less on schedule.

However, relatively little feed-back was received during the project, in contrast to projects funded from other sources (e.g. ACIAR). An advantage of this was that the time for project activities could be focussed on carrying out the project design. A request was made to receive feed-back from a review of the project conducted for AusAID in Vietnam in 2001. However the advice received was that this review was for AusAID's use only. I am of the opinion that this may have represented a

missed opportunity for project improvement, judging from some comments made by our Vietnamese colleagues.

3.6 Technical Assistance, Training and Capacity Building

Capacity building has involved the generation of quality control methods for application in Vietnam as well as in increased proficiency of participating staff. The working relationship between both institutions has been very good with no time lost on this account. Capacity building has occurred as a result of (i) training of new staff at both institutions and of many field workers in Vietnam. (ii) technical developments providing greater convenience in the identification and quantification of microbial strains, from work in both Vietnam and Australia. (iii) published material as outcomes of the project (see 4 papers in *Biofertilisers in Action* attached. There were some difficulties in retaining essential staff in work in Australia. The Vietnamese team of about six scientists at the Biofertilizer Laboratory (HUS) was more stable in composition.

The training activities including technical workshops and field workshops help provide a working structure for work of this kind, assist in establishing networks and assessing acceptance of the biofertiliser technology. They are considered to be essential components and this opinion was re-inforced during the project.

3.7 Management of Constraints, Issues, Risks and Change

A smooth working relationship was already established between the Biofertiliser Laboratory at Hanoi University of Science and the SUNFix Centre for Nitrogen Fixation at the University of Sydney. The advantage of the participants being well known to each other and frank in discussions has helped avoid serious constraints or significant issues developing during the project. Kennedy and Roughley from the University of Sydney made ten visits to Viet Nam, generally at separate times (except during the two technical workshops), thus magnifying the interface for interaction and allowing independent assessments of progress in the project, while Hien made a single visit to Australia to participate in the 8 th International Symposium on Nitrogen Fixation with Non-Legumes. Some current difficulties at the Ba Vi biofertiliser production facility are still being resolved, but it is anticipated that discussion and analysis at Workshop 2 in October will provide useful information regarding the eventual acceptance of this technology.

3.8 Project Management

As Project Director, I consider that promised commitments of in -kind support from the University of Sydney have been satisfactorily met. Changes in staff personnel (e.g. departure of Dr Nirmala Gunupala) have cause some inefficiency but satisfactory substitutes have been found (e.g. Dr Misi Kecskes). We have met all projected milestones.

Professor Nguyen Thanh Hien has shown herself to be a very capable cooperator in this project. Her staff and her contacts with the rice farming industry have proved

to be very effective. The Vietnam Women's Union has provided her with effective support. She has a reputation for achieving practical outcomes and we have been fortunate. However, some proposed arrangements within Vietnam have foundered (e.g. a sugarcane trial proposed in the February 2002 Report failed because promised support from a producer did not eventuate). I would rate Professor Hien 's performance as Fully Satisfactory (4), although it is not evident that the Hanoi University of Science should take major credit for this other than their support at Workshops. This project is driven by her enthusiasm and experience. Activity by the Hanoi University of Science group is strongly oriented towards field application of the technology, the University providing an umbrella for this activity. There has been only a minor impact on teaching within the university from this project since teaching is not its focus.

5: Best Practice; 4: Fully Satisfactory; 3: Satisfactory Overall; 2: Marginally Satisfactory; 1: Weak.

4. Performance and Outcomes

4.1 Assessment of Performance Against Objectives and Design

We consider that the project has been successful regarding outcomes well within expectations. Significant progress has been made in the development of quality assurance. The stage is set for further advancement. It should be noted that the use of inoculant biofertilisers is not universally favoured in Vietnam. Rather official Government agencies within Vietnam have encouraged chemical fertiliser production and cheaper fertiliser imports are also available. This provides strong competition for the development of biofertiliser technology, sometimes encouraged by cash flow support. However, we consider poverty reduction as a goal may be better served by biofertiliser technology, since it involves reduced inputs and can improve the effeciency of use of chemical fertilisers. In a freer market, GOV research and development priorities should increasingly favour such developments, given that there are also environmental benefits. The project is very well aligned with CARD program objectives, aimed at providing infrastructure for innovative technology directly aimewd at rural development. At this stage, there is no direct GOV involvement, although MARD and the Plant Protection Department have expressed intrerest in attending the final Workshop in October.

4.2 Sustainability

A rating of 3, Satisfactory Overall, is suggested as appropriate. As an innovative technology, it seems that commercial independence for the technology is not yet feasible, although the activity of Mr Nguyen Thoan, an entrepreneur now operating two factories, suggests that such independence may emerge soon.

However, there will be a need to encourage financial interest and to provide strategic research support during the next ten years if the technology is to become

self - sufficient. A major expansion phase is now desirable. Women are prominent in this activity and gender sustainability regarding their participation is not an issue.

5: Best Practice; 4: Fully Satisfactory; 3: Satisfactory Overall; 2: Marginally Satisfactory; 1: Weak.

4.3 Development Impact

With effective support, this technology has the potential to expand many hundreds of times in Viet Nam and elsewhere (see *Biofertilisers in Action)*. This may be the case in ten years time. We propose that this process should be strongly fostered and are using the outcomes of this project to support such a future impact. We have applied for an ARC Linkage grant with Bio - care Technology and Yates Seeds for development of similar technology for rice and turf grass in Australia. If this occurs, this CARD project will have been a key component in this development.

5. Conclusions

5.1. Overall assessment

The project design specified achievements related to (i) training of personnel in biofertiliser starter production and in villages where c ommercial product is made; (ii) the development of new tests for quality control were also specified as well as, (iii) confirmation that biofertilisers were effective. All these objectives have been achieved. Nevertheless, there is still much to be done and the achievements are limited. Only a pilot stage has been the substantial outcome. There is a need for more effective and convenient quality control methods that can be directly used by farmers and villagers with minimal training. Work in Australia using sterilised peat was not carried out because of a need to ensure safety in introducing Vietnamese strains of bacteria to Australian ecosystems. Extension of the technology to sugarcane in Vietnam also failed to be achieved.

It is difficult to speculate on how a different project design could have improved the scale of achievements.

It seems obvious that effective business plans for development of this technology will be required, together with a suitable scale of capital investment. We intend to investigate these possibilities at the October technical Workshop 2 and will be inviting participation by organisations such as ADB and JICA.

5.2. Lessons Learned

This project has demonstrated that introducing innovative solutions will always cost a lot in human commitment. The continued enthusiasm and even faith exhibited in the eventual success of biofertiliser technology by Professor Hien is an essential feature of this project. Similarly, the Australian participants, as a result of the success they have enjoyed using legume seed inoculant of Rhizobium, have been driven by a strong desire to give this technology with such potential for huge success in the long run to be fairly assessed. There is a significant international

effort with a similar purpose but there are few cases of such concerted action in the field as in this project. Technical lessons learnt emphasise the need for very simple methods that are inexpensive to apply and applicable by people with limited technical training. The funds requested for this project were modest but commensurate with available committed resources.