The use of micropropogation by small scale farmers: case studies from potato seed schemes in Vietnam and Nepal

DRAFT

The Use of Micropropagation by Small Farmers: Case Studies from Potato Seed Schemes in Vietnam and Nepal.

S. Joffe

July 1993

Project No A0147

Natural Resources Institute,
Chatham Maritime,
Kent ME4 4TB
UK

Acknowledgements

Many thanks to Dr Nguyen Van Uyen and to Mr Ngoc in Vietnam. In particular to Dr Gyan Lal Shrestha of ANSAB and to Mr Madhup Dhungana of New Era PVT Ltd in Nepal. Also, to Drs Jack Croucher and John Ferchak at AT International (Washington DC) for permission to research the Nepal case study and advice and comments on drafts.

CONTENTS

SUMMARY

Micropropagation and tissue culture techniques are the most widely adopted of the modern plant biotechnologies in developing countries. They are used in germplasm conservation, to eliminate pathogens and rapidly multiply elite planting material. Amenable crops include many of those which are traditionally propagated vegetatively; eg potato, banana, sugar-cane, cut flowers etc. The relatively high unit costs of micropropagation have restricted its application to high value horticultural, fruit and forestry species.

In low-income developing countries the use of micropropagation remains predominantly within the public sector. It is typically used to produce virus-free basic seed *in-vitro*, for further multiplication on government farms. Private sector involvement has thus far been restricted to more industrially advanced economies such as Brazil, China, Argentina and Thailand.

Government seed schemes have high public costs and may be ineffective in spreading use of the derived seed to small-scale producers and more remote areas. Two case studies are presented here in which farmers themselves use micropropagation techniques within small seed potato enterprises, in an approach which may have potential to decentralise and privatise seed multiplication of potatoes and other crops.

The successful Vietnamese example, in the Dalat Hills area, has been widely reported before. However analyses have often been based on secondary information and have generally created a false impression of the ease by which such an approach might succeed elsewhere. This case study combined desk research with a field visit to interview key individuals, including the most successful of the seed entrepreneurs.

The Nepalese example stems from a current project funded by the US NGO Appropriate Technology International, in collaboration with Nepalese NGO and government counterparts. In this case the field visit included a rapid rural appraisal in targeted production areas to assess the use of and demand for improved potato seed and prospects for seed enterprises adopting micropropagation technology.

The Vietnamese seed enterprise which was analysed for this study is highly productive. It minimises the *in-vitro* micropropagation phase and utilises mostly family labour to rapidly multiply fast growing plantlets by harvesting and re-establishing apical and axillary cuttings. Up to one million plantlets are produced annually and sold on to local farmers.

Production costs are calculated at US$0.18 cents per plantlet (although this contrasts with the producer's own estimate of US$0.4 cents). Plantlets are priced at US$0.6 cents, which undercuts the price of locally available seed tubers by around 30%. Farmers using the plantlets reduce planting costs and can harvest their own high grade seed tubers for use over the following two or three growing seasons, before yields decline and new stock is required.

The Nepalese scheme is at a much earlier stage. It envisages initial *in-vitro* multiplication by a central, private tissue culture laboratory. Farmer seed producers in warm-temperate mid-hill areas have been trained to establish micro-propagated potato shoots in trays of semi-sterile sand, prior to individually potting and planting. First generation seed mini-tubers will be sold to commercial potato producers, or further field multiplied on farm prior to sale as high grade seed tubers. The costs of this approach are higher than those in Vietnam, but are better adapted to Nepal's agroecology and limitations of infrastructure.

On a typical area of 0.25 ha, seed enterprises will incur an estimated $325 incremental costs in planting micropropagated plantlets. Assuming the first generation mini-tubers can be sold at a price which matches planting costs with conventional tubers, the gross incremental income of $900 would offer a net B:C ratio of 2.75:1.

The proposed scheme has considerable potential to improve supply of high yielding potato seed in commercial growing areas, particularly to sub-tropical production pockets where local seed production is impossible. However 'seed entrepreneurs' adopting the sand-rooting technology will face constraints imposed by instability in Nepalese potato markets, lack of provisions to monitor and regulate seed quality, and competition from Indian traders.

Overall the case studies indicate that small farmers with little education can successfully learn micropropagation techniques and use them within small seed enterprises with low start up costs, making productive use of family labour. There are however some important prerequisites:

- strong and effective demand for improved seed;
- publicly supported means to monitor and regulate seed quality;
- technical ability of seed enterprises to consistently supply, and to match or undercut prevalent local seed prices: price stability in seed 'market';
- willingness and ability of local farmers to innovate if offered a different form of planting material (eg plantlets);

- support for seed entrepreneurs from local research and extension institutions; access to credit if required;

- favourable climate for micropropagation with minimum need of additional heat and light;

- favourable fiscal/policy environment for small enterprise development.

These are demanding prerequisites and indicate that the Vietnamese example will not easily be replicated. Further niche opportunities will typically exist in high value cash cropping systems where there is a shortage of high yielding, pathogen-free seed and supply by large scale private or government schemes is constrained or non-existent, eg. for reasons of geography/topography, high costs of conventional seed production or limited volume of seed market.

INTRODUCTION

1. Tissue culture and micropropagation techniques are amongst the least costly of plant biotechnologies and have already been widely adopted in developing countries. At a recent workshop of the Asian Network for Small-Scale Agricultural Biotechnology (ANSAB), representatives of all nine countries participating cited tissue culture as a priority 'mature' technology for extension to field level (Ferchak & Ribeiro 1992).

2. The techniques are commonly used to eliminate pathogens and rapidly multiply elite planting material. Many crops traditionally amenable to propagation by cutting, budding and grafting techniques can be manipulated this way. China grows *in-vitro*[1] cultured virus-free seedlings of potato on about 250,000 ha (10% of the total potato area) giving yield increases up to 150%, and also undertakes commercial micropropagation of cut flowers, sugar-cane, red banana, grapes, *Eucalyptus*, and Chinese fir. India and Pakistan use micropropagation to multiply cut flowers, data palm, potato and other root and tuber crops, spices, and fruit and nut species (Singh 1989). Kenya and other countries of Sub-Saharan Africa are also using or developing tissue culture techniques in propagation of potato, coffee, cut flowers, pyrethrum and various fruit, (agro)forestry and other species (NRI 1991). Thus far the relatively high unit costs of producing seedstock by micropropagation have meant that its impacts have been restricted mostly to high value horticultural, forestry and other cash crops.

3. In low income LDCs, micropropagation research and protocol development undertaken at universities and commodity research institutions is typically applied within formal government seed multiplication programmes. Limited domestic purchasing power and weak private markets have limited private sector involvement in LDCs to more industrially advanced economies such as Brazil, India or China or to export industries such as the orchids industry in Thailand.

4. One result of the restriction of tissue culture-based schemes to formal government seeds programmes is to limit impact on the availability of improved seed to small-scale farmers and those in more remote production areas. For example the Kenyan Potato Research Station at Tigoni uses tissue culture in its seed multiplication programme but less than 5% of Kenyan potato farmers make use of the improved seed, which needs to be backed by continuous re-availability of virus-free material to maintain healthy stocks (ibid.). To this extent the example of micropropagation can be seen

---

1. In-vitro literally means 'in glass' and refers to the practise in tissue culture and early stages of micropropagation, of manipulating plant tissues in sterile test tubes, flasks etc.

as a microcosm of the potential broader impacts of plant biotechnologies. The likelihood that benefits of biotechnology will be restricted to commercial farmers who already have good access to external inputs, markets, research and extension institutions etc has been pointed out by a number of authors (eg Joffe and Greeley 1987, Buttel 1990).

5. The two case studies presented here were undertaken in order to investigate the potential for a decentralised approach to the application of micropropagation; in which small farmers themselves use the techniques to increase local self reliance in seed supply. The two examples both concern seed potato schemes[2].

6. The first case study is from Vietnam. In 1983 a paper published in the American Potato Journal (Uyen and Vander Zaag 1983) described how small farmers in the Dalat Hills had established small scale enterprises using tissue culture to produce and sell high grade seed tubers. This has since been widely cited as an example of 'appropriate' small farmer biotechnology (eg. Biotechnology and Development Monitor 1992). In addition to desk research, a visit of one week was made to Ho Chi Minh City and the Dalat Hills to meet key individuals involved in the scheme and some of the farmers.

7. The second case study is from Nepal. A project funded by the US NGO Appropriate Technology International aims to promote the use of micropropagation techniques by small farmer seed enterprises and set up a viable commercial supply of virus-free seed potato. In this case the author collaborated with the local NGO New Era PVT Ltd to undertake a Rapid Rural Appraisal of the use of and demand for improved seed in three different potato growing areas and assess prospects for seed enterprises to adopt tissue culture techniques.

8. Both examples are innovative in their institutional make-up: involving collaboration between government organisations, small scale enterprises and NGOs. The use of relatively sophisticated technologies by poorly educated farmers is also a radical departure from conventional models.

9. The objective of the case studies is to identify the conditions under which small farmers are able to utilise micropropagation techniques to improve the local availability of virus-free seed potato in Vietnam and Nepal and draw preliminary conclusions regarding the applicability of the scheme in other areas and for different crops.

---

2. The use of micropropagation within potato seed schemes is one of the most widespread of biotechnology applications in the developing world; it is used in some of the poorest countries, eg Burundi and Rwanda in E. Africa (Dodds and Horton 1990).

CASE STUDY ONE - DALAT HILLS OF VIETNAM

THE POTATO AND SEED SUPPLY IN VIETNAM

10. The potato is called "Khoai Tay" in Vietnam, which means "Western root" or "French tuber". It was introduced to the Red River Delta in 1890 by European missionaries, where it remained a minor vegetable crop. During the 1970's, population growth, typhoon damage of rice crops, and the availability of shorter-duration rice varieties, contributed to the increasing importance of potato as a dry season crop. By 1979 production had reached a peak of 93,000 ha, 98% of which remained concentrated in the Red River Delta. The Dalat Hills, in central southern Vietnam became another important area, of some 450ha (Ho et al 1987).

11. A national potato program was established in 1981 and cooperation with the International Potato Centre (CIP) started in early 1982. By 1987 the potato was ranked second to rice as a priority food crop. Exports were also increasing, at 15,000 mt that year (ibid.).

12. By that time seed stocks had become degenerated and the availability of high yielding seed had become a constraint on further expansion of the sector[3]. Attempts to develop 'western-style' centralised seed programmes in Vietnam were unsuccessful, due in part to the high costs and technical sophistication required. These factors contributed to an ongoing dependence on imported seed stocks from temperate, developed countries such as Holland and Germany (Uyen and Vander Zaag 1983).

13. During the 1980s, the Vietnamese potato program and CIP investigated three different techniques for indigenous rapid potato seed multiplication: sprout cuttings, true potato seed production and tissue culture. The last of these approaches proved to be a particular success in the Dalat region, Southern Highlands (Uyen and Vander Zaag, 1985).

14. Three varieties[4] were selected for their resistance to late blight (*Phytopthora infestans*), a locally severe production constraint, from 16 originally provided by CIP. The new varieties spread very rapidly and average yields in the area grew from 8t/Ha in 1980 to 18t/ha in 1984 (ibid.).

15. The role that small farmers have played in the tissue culture production and supply of potato seed plantlets in Dalat is frequently cited as a model of effective, decentralised, small-scale biotechnology.

---

3. Seed tuber multiplication on-farm is slow and diseases tend to increase with each multiplication. The fact that about 2 tons of potential food are planted per ha also acts as a disincentive (Uyen and Vander Zaag 1984).
4. 'B71-240.2', 'CFK-69.1' and 'Atzimba'.

CASE STUDY APPROACH

16. Information was gathered by a review of available literature and a visit of one week to Ho Chi Minh City and the Dalat Hills. Informal semi-structured interviews were held with key respondents, including officials from the Biotechnology Research Centre, the most successful of the small farmer tissue culturists, Mr Ngoc, and some local farmers.

POTATO SEED FROM TISSUE CULTURE IN THE DALAT HILLS

Local Agricultural Overview (from Uyen and Vander Zaag 1985)

17. The Dalat area lies at 1500 m elevation; it has an undulating topography with highly weathered soils and 1500mm of rainfall occurring during the 6 summer months. The mean maximum and minimum temperatures are 23 and 14°C with a seasonal range of 2°C.

18. In the 1870's the French established a resort town here at a distance of 300Km from Ho Chi Minh City. They also brought the potato to Dalat. The Dalat region compromises about 1200 ha of arable land which produces over 2000 ha of crops annually. Principal crops are vegetables such as cabbage, cauliflower, artichoke, carrot, lettuce, bean, onion, strawberry and potato, and some flowers. The average farm size is 0.1-0.2 Ha, with intensive use of family labour. Road access to Ho Chi Minh City (300km) is good.

The Tissue Culture Technology

19. The technology for simple, low-cost rapid multiplication of seed potato plantlets was adapted for use in Vietnam in the early 1980's at the Dalat Hills Research Station of the Centre for Experimental Biology, with technical assistance from CIP[5]. A key low cost 'farmer-friendly' aspect of the scheme is that the main multiplication phase does not need to be undertaken *in-vitro* (ie. maintained and manipulated under carefully controlled, sterile conditions).

20. Farmers maintain only a small nuclear stock of plantlets *in-vitro*. The main multiplication phase is done by regular harvesting of apical and axillary buds from

---

5. At the time there was a debate concerning the relative merits of stem-cuttings or true potato seed (TPS). A strong factor in favour of the former, asexual approach, was the preference of local potato producers for uniform, large round tubers which are preferred by the market (the TPS approach would have introduced 'unwelcome' heterogeneity) (Uyen pers comm).

vigorously growing juvenile plantlets which are maintained in wooden trays containing sand, or sand/sub-soil (Table 1).

Table 1: Propagation Protocol Recommended by CIP and the Vietnamese Centre for Experimental Biology

1x	*in-vitro* plant
	multiplication taking 5 cuttings/tube/month x 2 months
25x	*in-vitro* plants
	1 month growing period
100x	single node cuttings rooted in sand bed at density of 1000/m2
	harvested weekly over three months
1000x	apical and axillary bud cuttings rooted in sub-soil-manure medium in beds at 1000/m2
	harvested weekly over two months
10,000x	bud cuttings rooted as plantlets in pots; after 15-20 days ready for sale and transplant to the yield for commercial production
	4 month growing period
Harvest	large tubers for consumption: small ones for seed

21. In the recommended protocol, cuttings are rooted in beds of well aggregated sub-soil and manure at a 50:50 ratio, also at a density of 1000/m2. After these are rooted, weekly harvests of apical and axillary cuttings are taken for 2 months. These are then potted in a similar sub-soil and manure mixture contained in 3x5 cm banana leaf pots with open bottoms. In 15 days they are rooted and sold to farmers, who directly transplant them to the field. Based on present farming practices, three *in-vitro* plants can produce enough planting material for 1 ha based on the multiplication rates outlined above (Uyen and Vander Zaag 1985).

One Farmer's Tissue Culture Business

22. Mr Ngoc was the first, and remains the most successful of the farmer tissue culturists in the Dalat area. He has adapted and extended the above basic model in several ways.

A. TECHNICAL ASPECTS

Germplasm Bank

23. Mr Ngoc maintains 7-10 potato varieties in his own germplasm bank. Some of the tubes were contaminated but he was unconcerned; his priority is to ensure that at least 1 or 2 tubes of each variety remain infection free. He can always reorder from the research station. Mr Ngoc had succeeded in starting a new variety in culture by taking sprout-tip cuttings, surface sterilising them and establishing *in-vitro* on standard agar/nutrient medium base. He had apparently lost most of the tubes to infection but some remained free and formed the basis for production and marketing of 'rose variety' (see below, para 38). This move upstream (ie not just receiving *in-vitro* plantlets from the research station but initiating new varietal cultures) is extraordinary under such circumstances.

Sterile Work Area and Equipment

24. His equipment is listed in some detail below, but the basic sterile work area comprises one corner of an upstairs room divided off by plastic sheets, in which sits a wooden cabinet containing necessary tools such as razor blades, forceps, petri dishes, all of which is regularly swabbed down with alcohol. Test tubes are sterilised in a home-made autoclave adapted from an oil drum plus pressure valve and gauge, which is heated on a wood fire.

Control of *Phytopthora infestans* and *Pseudomonas solanacearum*

25. Once out of the *in-vitro* phase, control of diseases remains important in the nursery beds and through to established potted plantlets. Both late blight (*Phytopthora infestans*) and bacterial wilt (*Pseudomonas solanacearum*) are problems in the Dalat area and could potentially seriously affect production and marketability of the plantlets. The blight problem is minimised in this case as both the cultivars in production at the time of my visit, known as "6" (CIPs CFK-69.1) and "rose variety" (locally sourced) were highly resistant; residual problems are controlled by spraying with Benlate. *Pseudomonas* wilt is controlled by careful soil management; Mr Ngoc brings sandy aggregate in from a distant, non potato-growing area and mixes this with sub-soil and manure.

Climate Control

26. Light intensity, daylength, humidity and temperature are key variables affecting successful growth of the plantlets. Light intensity is controlled by draping plastic sheets or grass mats over an open wooden frame surrounding the nursery beds. The same measures help to control humidity along with regular misting using a knapsack sprayer. Daylength is important as it affects the plantlets' tendency towards stem growth/canopy development vs (undesirable) tuberisation. Mr Ngoc adds around 5 hours per day in the winter months using electric bulbs. There are no problematic extremes of temperature to contend with in the Dalat area.

Harvesting Cuttings and Potting

27. Mr Ngoc maintains 'mother plants' (those established direct from the test tubes and maintained as a source of cuttings for further multiplication) for around 6 months, which is twice as long as the original research station protocol. He and his wife have become experts at harvesting bud cuttings; they can take up to 5000 per day according to demand. These are either re-established in nursery beds to provide the next generation of plantlets, or, in response to a specific order, are potted. The pots are made of leaves from a local weedy plant (not banana leaves as in the original protocol), filled with a standard mix of sand-subsoil-manure, which is treated with Benlate to protect against blight. Mr Ngoc has experimented with pot size and composition and reached an optimum which maintains a plantlet for about one month. The optimum time between potting and sale is 21-27 days depending on season and variety (another variation from the original protocol). The pots, which are open at the bottom, are planted along with the plantlet and break down in the soil.

B. COMMERCIAL ASPECTS

Costs

28. Table 2 outlines costs involved in running a business in Dalat for the production and sale of 1 million potato plantlets per annum using the above technology. It is based on data from Uyen and Vander Zaag 1985 plus 1992 interview data from Mr Ngoc. An exchange rate of 1USD = 11,000 Vietnamese dong has been used. Equipment (fixed) costs have been depreciated over two years to allow for wear and tear.

29. Uyen and Vander Zaag's costs were calculated for production of 200,000 plantlets and have been adjusted accordingly - capital fixed costs have not been changed as it is assumed that the same items would cope with the extra throughput, although another item has been added at Mr Ngoc's suggestion for the costs of the small wooden trays in which potted plantlets are maintained prior to sale (assumed the same as costs of wood for making nursery bed frames). Variable costs have been increased by a factor of five where they relate to the *ex-vitro* multiplication phase, eg for chemical fungicide and manure (*in-vitro* variable costs including fuel for the autoclave are assumed unchanged). An item has been added for the costs of bringing in sandy aggregate (assumed the same as manure costs). The labour costs have been adjusted for actual 1992 rates and now contain two categories; firstly for production of 1 million prepared plant pots - this is a pure labour cost as the helpers collect and provide there own materials except for soil which is costed elsewhere - Mr Ngoc pays a total of 6 local part time helpers 12 Vietnamese dong each per pot, which comes to US$1,090 dollars per annum or S$15.15/month per person; secondly for family labour (including himself, his wife and son) which Mr Ngoc costs at the same rate of ca. US$15.15/person or a total of US$545/annum.

30. Apart from the already adjusted labour costs, Uyen and Vander Zaag's original figures have been inflated by a further 20% to account for rising costs since 1987. This inflation figure is based on the fact that the sale price of the plantlets has risen 20% in this time which is assumed to be the result of increased costs passed on to the consumer.

31. Table 2 shows that costs/plantlet come out at 0.176 US cents (which is almost identical to Uyen and Vander Zaag's 1987 figure). Uyen and Vander Zaag's consumables costs are very low (eg for fungicide) and an element of subsidy appears to be involved (these items are obtained from the local agricultural research station). However such a subsidy, if removed, would make little difference to the total costs per plantlet given the overwhelming importance of labour. Having said that, Mr Ngoc's own estimate of costs was 40 dong per plantlet, which gives rise to concern that the costs are underestimated here; alternatively it is conceivable that he himself provided a high estimate in order not to be perceived as making 'excessive' profits.

Sales: Price, Volume, Marketing

32. Mr Ngocs selling price for the plantlets has remained fairly stable over the last five years (since Uyen and Vander Zaag's paper), rising from 50 to the present 60 Vietnamese dong.

33. The price of plantlets has always been deliberately kept well below the equivalent price for a seed tuber purchased elsewhere (around 100 dong on average) to increase their attractiveness to farmers.

34. As a further incentive, Mr Ngoc originally offered a money back guarantee, in which farmers only paid for these plantlets that remained in good condition 3 weeks after being planted by the buyer. This policy is no longer necessary and has now been withdrawn.

35. Mr Ngoc's estimated figure of 1 million plantlets sold per year is possible but bears scrutiny. He is one of two major producers of plantlets in the area and the total available potato planting area in Dalat is 450 ha, or an annual equivalent of 900 ha. If all farmers plant 10% of their land to plantlets every second year, at a density of 30,000/ha, then a maximum market potential of 1.35 million plantlets per year exists.

Table 2: Small Enterprise Costs of Producing 1 Million Potato Plantlets per annum from Tissue Culture in the Dalat Hills of Vietnam

Capital Equipment Items	**Cost USD**
Sterile culture working box (wooden with glass window, ultra violet light) and plastic sheets to make isolation room	30.00
Test tubes (500: 2.5cm x 20cm)	12.00
Alcohol lamp, long forceps, razor blades	6.00
Autoclave - a converted gas cylinder with manometer and safety valve	36.00
Knapsack sprayer for misting/fungicides	48.00
Wood to make frames for nursery beds (12 x 4m2)	12.00
Wood for making trays to hold potted plantlets	12.00
Plastic to cover nursery beds (50m2)	12.00
Bamboo mats for shade (50m2)	6.00
Subtotal equipment	174.00
Subtotal per annum costs (depreciated over two years)	87.00
Consumables	
Alcohol (for hand washing and lamp)	2.40
Agar (5ml/tube @ 8g/l) plus nutrient: knopmedia	6.00
Wood or coal to heat autoclave	1.20
Cotton to plug test tubes	1.20
Fungicide (Benlate) vs *P.infestans*	6.00
Manure	12.00
Sand and soil	12.00
Subtotal consumables	40.80
Labour	
To make 1 million plant pots	1,090.00
Family x 3 @ USD15.15/month	545.00
Subtotal labour	1,635.00
TOTAL COSTS FOR I MILLION PLANTLETS	1,762.80
TOTAL COST/PLANTLET	US$ Cents .176

36. Mr Ngoc spoke of two seasonal peaks in demand, late April-early June and October/November. The first peak, when he can expect sales to be double the normal monthly average, corresponds with the beginning of the rainy season when daylength and temperatures (ca 25oC) are at their maximum. The second peak is just after the end of the rainy season ready for winter planting. One reason for the very high demand at the start of the rainy season is that the plantlets fair relatively well vs tubers during this time when all potato cultivation is particularly subject to attack by blight.

37. In general, demand for the plantlets is strong and outstrips Mr Ngoc's capacity to supply. Any farmer wanting to purchase plantlets from him has to place an order two months in advance. The order is placed for a particularly day; Mr Ngoc is then able to plan his regimen of harvesting and potting accordingly. His policy is never to underestimate demand and thus disappoint a customer; better to throw out any plantlets which are surplus to demand. Mr Ngoc exercises strict quality control, rogueing out any plantlets that are sick or weedy.

38. Product range: As mentioned above, Mr Ngoc maintains 7 different clones of potato in a germplasm bank, including the two - '6' and 'rose variety' that are currently marketed. He therefore has the capacity to multiply up new varieties at any time in response to changing consumer demand. An example of this flexibility is the way in which he managed, in response to a request from farmers, to establish 'rose variety' in culture. This is a local variety which is thought to have 'originated' from India; it has good blight resistance and is held in high regard by consumers for its taste and rose pink skin colour. Farmers wanted the same sort of uniform high quality tubers already obtainable from CIP improved varieties and asked Mr Ngoc to "do the same thing he'd done with '6'". Now rose variety is as widely grown as the CIP-derived varieties and a major Singaporean export contract has been won at a price of 3500 dong/Kg for a 1000 kilo load - which compares very favourably with the normal local market price for '6' of between 2000-3000 dong/Kg.

Competition

39. In 1981 ten farmers in the Dalat region established rapid multiplication enterprises producing rooted potato cuttings. Between 1981 and 1984 the total area planted to potato in Dalat grew from 250 to 450 ha and the proportion of this land under improved varieties grew from 0 - 100%. However growth in the sales of plantlets was not stable; in fact area planted to rooted cuttings changed from around 33 ha in 1981, via a peak of some 66 ha in 1983, back to 27 ha in 1984 (Uyen and vander Zaag 1985).

40. The reason is that farmers found they could replant the first and second generation of tubers *derived* from the cuttings (G1 and G2) without significant loss of yield; by

G3 the yields did tail off markedly. Saturation of the market inevitably penalised the less efficient and technically successful multiplication enterprises; by 1984 there were only three remaining; by the time of my visit in 1992 there were only two.

Impacts on Farm: interviews with local farmers

41. Three local farmers were interviewed. Two were in their fields, some 10Km outside of Dalat City although well connected by road; the third was a customer of Mr Ngoc's who was purchasing plantlets on the day I visited. Interviews were informal, my questions being relayed and translated via Dr Nguyen Van Uyen (Director of Biotechnology Research Centre, Ho Chi Minh City) and Mr Ngoc. The following represents the combined findings of the three interviews; data are individually attributed where relevant.

42. Farmers have to plant the rooted cuttings within a day of purchase and then irrigate them every day for the first three days. Thereafter, until successfully rooted, special care is required to ensure that they don't dry out. This includes shading them from direct sunlight, which can be achieved by planting the cuttings between rows of a broadleaved shade crop such as beetroot and/or sticking pieces of dried ferns into the soil.

43. The extra labour involved in the initial planting and maintenance of the cuttings is supplied as by neighbours and was not regarded as a constraint.

44. The two farmers interviewed in their fields were regarded by themselves and my hosts as typical in the Dalat area; each had holdings of 0.6 ha (one of the farmers, Mr Hoi, had built up his holding by buying out neighbours, a practise only permitted since reforms in 1988). Both farmers were engaged in intensive production of vegetables and fruits (cabbage, potato, carrot, onion, beetroot, persimmon) for the Dalat City and Ho Chi Minh City markets, taking two or three crops per year.

45. There was a year round water supply from a stream running through the farms. Mr Hoi, had invested in a petrol driven pump for irrigation, which was also leased to his neighbours.

46. Land is key limiting factor; farmers invest in land improvement by buying in soil for terracing. There is some use of tractors for land preparation but, access problems, scale of holding and hilly topography mean that most is still by hand.

47. Each was growing only improved, tissue culture-derived potato; both '6' and 'rose' varieties. They felt that the improved varieties had brought major benefits to farmers over the last ten years. These have resulted from reduced unit factor costs of production:

i) Land: average yields have risen from 8 to, apparently, over 20 mt/ha (clearly other factors will have played a part in this increase, eg fertiliser use; a more extensive survey would be required to diseggregate these factors);

ii) Labour: for the first 2 - 3 generations the tissue culture-derived plantlets are relatively free of late blight infection; this has reduced the time spent on spraying;

iii) Capital: the plantlets and derived seed tubers are relatively cheaper than conventional sources of planting material; farmers also save on fungicides vs blight.

48. The rooted cuttings would yield around 0.8Kg of tubers, of which 50% were of marketable size; the rest were typically around 20gm weight and would be kept for seed. The next two generation would yield around 1.0Kg of mostly marketable tubers. The yield declined if the G3 generation was planted so farmers would return for more rooted cuttings.

49. The increased productivity available from improved varieties allows many local farmers to take more time for off-farm leisure and business activities in Dalat City.

50. It is not possible to assess on this much evidence the overall relative land/labour/capital saving characteristics of the rooted cuttings and derived seed tubers. For example labour saved in spraying time is presumably compensated to a degree by increased labour absorption at harvest; these issues are beyond the scope of this brief case study.

The Role of Govt 'vs' Entrepreneurship: Policy Context

51. Publicly funded R&D clearly had a major role in the initial development of this entrepreneurial potato seed supply scheme; the original tissue culture protocol was developed at the local research station with technical assistance from CIP (which also provided the improved germplasm).

52. One individual, the then Director of the local research station Dr Nguyen van Uyen, was primarily responsible for teaching local farmers how to do tissue culture and subsidising their initial supplies of equipment and reagents. Mr Ngoc, the farmer interviewed for this study, had been working at the research station as a general 'hand' with no technical training; he showed interest in the tissue culture work, became friendly with the Director who showed him how it was done, and thereafter demonstrated a high degree of aptitude, innovation and business acumen.

53. At the time Dr Van Uyen was apparently criticised by the authorities for 'giving away national secrets'. Nowadays the same authorities are very happy with the outcome, not least because a lucrative export contract has been won from Singapore on the basis of the reliable high quality of Dalat potato. The Provincial government have given Mr Ngoc, an award acknowledging his work plus a 100% tax break, and are encouraging him to scale up; delegations arrive from Hanoi to study the scheme and assess its applicability to the Red River Delta - the main potato growing area in Vietnam.

SUMMARY OF FACTORS FAVOURING SEED MICROPROPAGATION ENTERPRISES IN THE DALAT HILLS

54. Dalat has natural and infrastructural advantages as a potato production area. The area is climatically well suited to year round plantlet production, having a mean temperature range of 14-23 centigrade (with a 2 degree seasonal range) and 1500mm of rainfall in six summer months. Road access to Ho Chi Minh City (300Km) is good and local services (water, electricity) reasonably reliable.

55. Mr Ngoc initially received advice and support from the Director of Biotechnology Research Centre in Ho Chi Minh City. He learned to manipulate daylength to control early tuberisation and has become adept at in-vitro manipulation of his nuclear stock. He has access to nutrient media, alcohol and blades etc. from the local research station.

56. The commercial market for ware potato (in Ho Chi Minh City and for export) is strong and consistent; a premium is paid for large uniform tubers. Potato production is more profitable locally than other vegetables such as cabbage. Two or even three potato crops per year are possible in Dalat, thus demand for plantlets is virtually year round (demand is so strong that they have to order tissue cultured plantlets from Mr Ngoc two months in advance).

57. The seed enterprise can produce plantlets at ca US $0.35 cents each and markets them at $0.5 cents. This is only about 60% of the normal local seed tuber price and reduces planting costs for the area under plantlets from about $270/ha to about $180/ha.

58. Growers have adapted their own practices so as to successfully cultivate the plantlets; eg, by intercropping the transplants with a shade crop such as beetroot and irrigating each day for first 3 days. The plantlets give a normal (0.8Kg) tuber yield; generations 1 - 3 are usually replanted on farm before more plantlets are purchased. Farmers cite benefits from uniform high yields and cash savings on labour hire and fungicide treatments.

59. The local provincial authorities provide an incentive to Mr Ngoc's seed enterprise, via a 100% tax break.

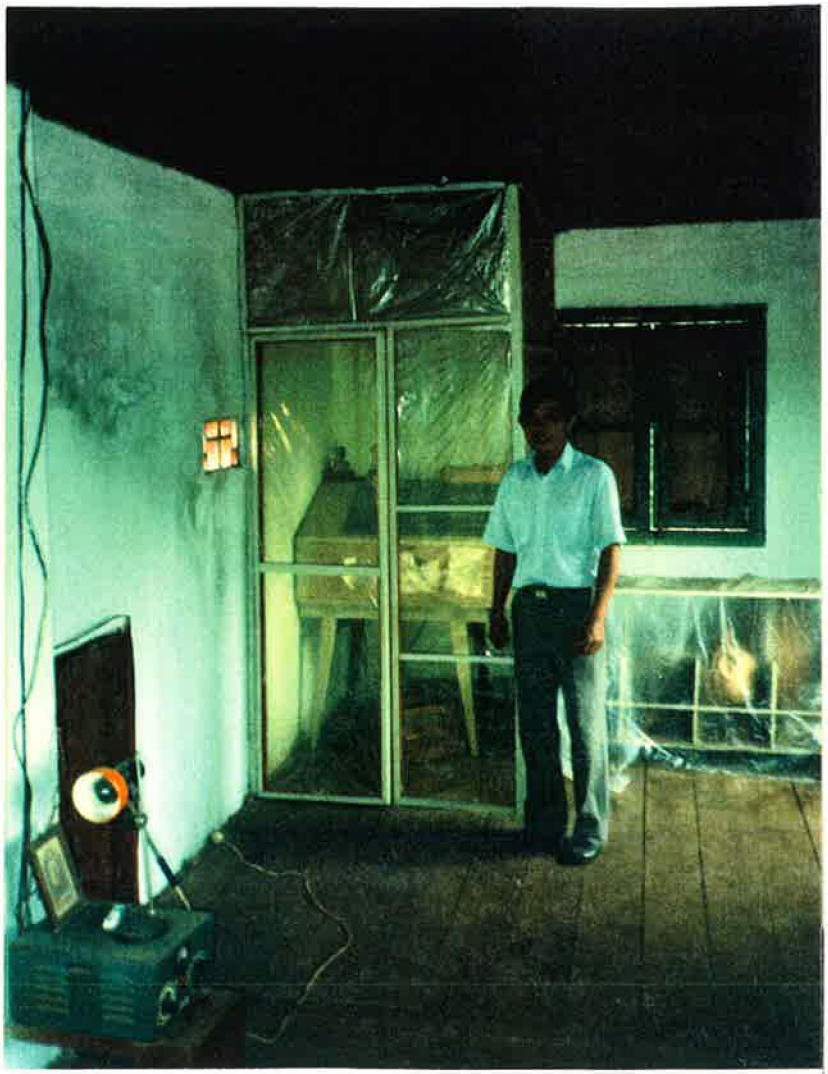
A SCHEME FOR THE RED RIVER DELTA (RRD)

60. The Red River Delta in North Vietnam is the country's largest potato growing belt. This is a hot, humid, lowland tropical area. Potato is a staple food here; it is planted in the winter around November-January and farmers often try for a second crop before planting a spring, short season IRRI variety of rice (ca. May). This is followed by main summer rice crop. An advantage of the second potato planting is that it reduces the necessary storage period prior to the main winter potato planting in November (storage being a big problem in the hot conditions). When rice is abundant potato is little consumed but when it fails, as periodically occurs due to monsoon flooding, demand for potato rises. One rationale for an improved potato seed scheme in RRD therefore is its status as a food security crop. Another rationale is that the authorities would like to export surplus potato in the same way that Dalat does currently via Ho Chi Minh City.

61. The local provincial authorities have been assessing the potential of the 'Dalat model' seed supply scheme for RRD; attempts to apply traditional European style clonal propagation schemes having been unsuccessful. In discussions with Dr Nguyen Van Uyen and Mr Ngoc they put forward the following scheme:

62. It would not be possible to utilise the rooted cutting approach in RRD as the climatic conditions are far too extreme. Thus Mr Ngoc would like to establish a business in Dalat to supply minitubers to RRD. Rooted cuttings planted at high density (100,000/Ha) could produce at least 1 million minitubers/Ha, or enough to plant 30ha in RRD. Thus 20 Ha in Dalat (contracted out to local growers) could provide for 6000ha in RRD. As the minitubers need 6 months to break dormancy, cuttings would be planted in January, harvested 3 months later and sent to RRD 6 months after that, ready for the November planting. A major advantage of this for Mr Ngoc's business is that it would provide him with a high demand for cuttings in January - a time of weak demand in Dalat.

63. The minitubers would need to be transported as far as the coastal railway and then by train to RRD. He would sell initially to a local RRD cooperative, ultimately he would need a formal agreement with the Provincial authority and the National Seed Co to cover marketing and distribution arrangements as demand escalated. Mr Ngoc was moderately confident of making the scheme work, despite the increased transport and storage costs involved and the need to aim for a very low target mini-tubers price; potato producers in RRD are poor and do not spend more than 40dong/seed tuber at most (as compared to 60-100 dong in Dalat).



Plates 1 and 2:
Mr Ngoc's sterile work area, and germplasm bank with 7 potato varieties in culture.

Plate 3: The 'mother beds' of tissue-cultured plantlets. Electric bulbs are used to extend daylight as necessary.

Plate 4: Mr Ngoc and his wife can take up to 5000 cuttings per day; these are maintained in sand trays in this open shed - the mats are used to adjust temperature and light levels.

Plate 5: This local school girl can earn $15 a month by making around 14,000 pots. She supplies the leaves from a common local plant; Mr Ngoc provides the sand-soil mixture.

Plate 6: This is the product which farmers receive. They pay US$.55 cents each and need around 3000 to plant 0.1 ha: the pot breaks down in the soil.

Plate 7:
Mr Ngoc's daughter loading potted plantlets into a basket ready for transport.

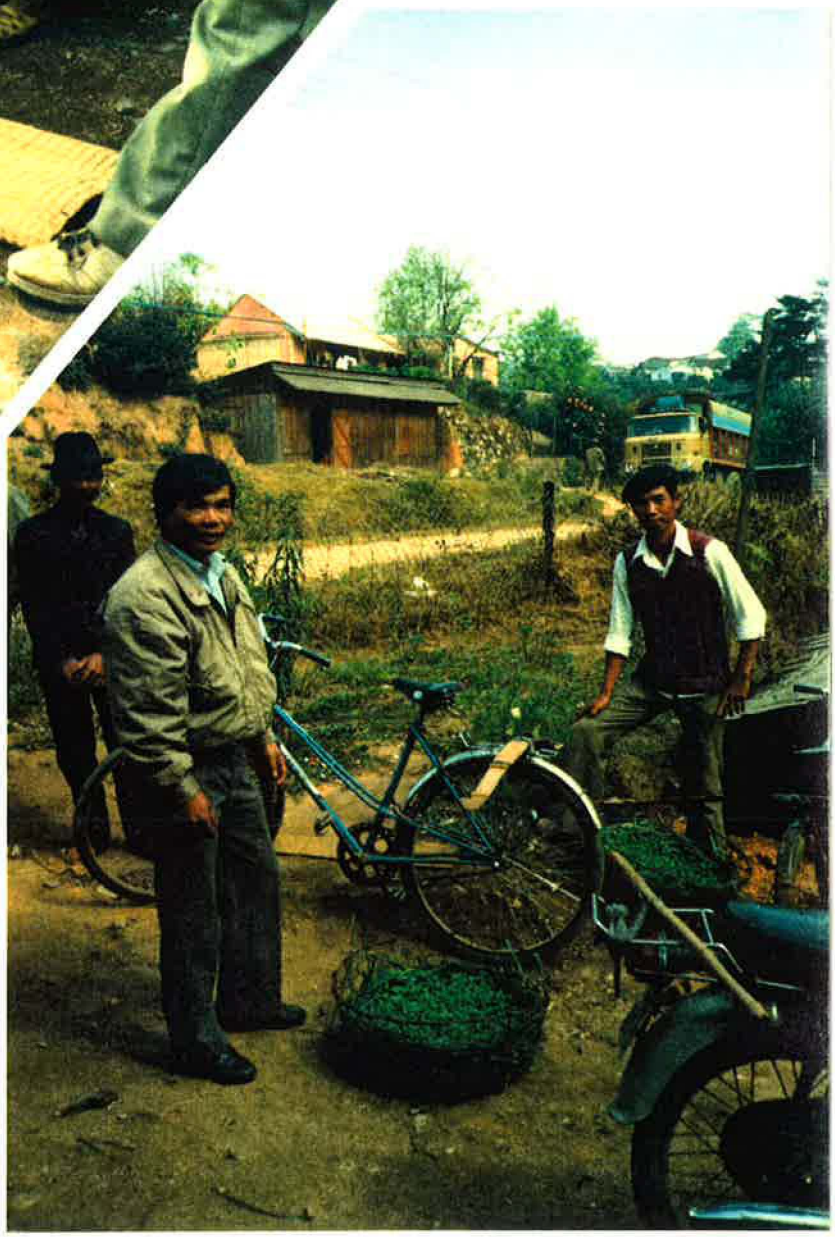


Plate 8: Farmers load the baskets on to bicycles for transport to their fields.

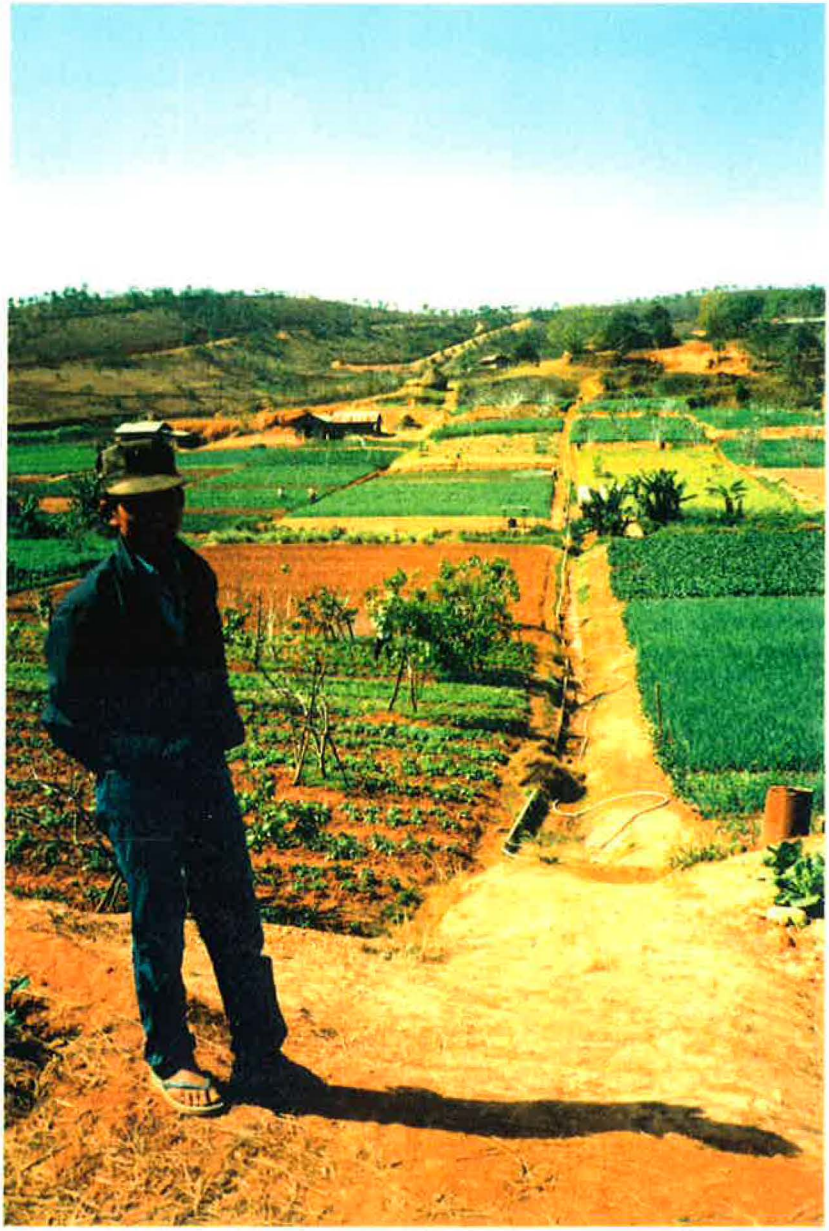


Plate 9: A local potato farmer and customer of Mr Ngoc. He will water the plantlets daily for three days after planting and keep them shaded from direct sun. They will yield normally (ca 0.8Kg/plant), producing high grade GI seed tubers for sale or use as seed.

CASE STUDY TWO - NEPAL

THE POTATO AND SEED SUPPLY IN NEPAL

64. The potato has been grown for food in Nepal almost as long as in Europe; first accounts date back to 1793 (Rhoades 1985). By the early 19th Century it was already an important crop - nowadays it is the most common vegetable in production,. The area under potato in 1987/8 was around 80,000 ha, 77% of which in the hill areas; the national average yield was 8.72 mt/ha in 1989/90 (HMG Nepal 1988). Yields in Europe ranged from 8.5 mt/ha in Portugal to 41 mt/ha in The Netherlands in 1986 (Commission of the European Communities 1987).

65. Potato production systems vary according to altitude and topography:

- Terai plains, and in sub-tropical river valleys (<1000m): autumn/winter crop typically in rotation with rice or jute.

- Mid-elevation hill areas (1000m - 2000m): winter/spring crop where irrigation is possible, typically rotated with rice or wheat; in non-irrigated areas and at elevations above about 1500m it is a summer/autumn crop typically in mixed systems with or after maize

- High hills (<3000m): spring/summer crop, grown in mixed systems with cereals such as wheat or barley.

66. It is possible to distinguish farm systems where potato is produced for commercial markets and where it is a staple:

67. Market oriented: irrigated fields in Terai and mid-hill areas characterised by relatively good access to urban markets - extensive use of purchased inputs - almost exclusively high yielding varieties.

68. Staple: mid and high hill areas characterised by poor access to urban markets, little use of external inputs including improved seed; non-irrigated; seasonal food deficit common.

69. The commercial market is growing - official statistics record 357,000 mt in 1985/86 and 640,000 in 1988/89. The national annual average retail price was Rs2.18/Kg in 1978/9 and Rs4.47/Kg in 1987/8 (HMG Nepal 1991).

70. There are essentially three supply peaks associated with harvests in the Terai, and sub-tropical and warm temperate mid-hill areas.

71. Potato is transported between the plains and the hills, to take advantage of the often wildly fluctuating price

movements. The Nepalese markets are influenced heavily by activities of Indian traders who truck large volumes in and out of the country depending on relative prices at the different markets.

72. The market dominance of traders from the plains helps to create uncertainty in Nepalese potato markets. In October 1991 prices in Khatmandu reached an unprecedented high, causing the Government to place restrictions on southwards trade. Other than such occasional embargoes, there is no formal mechanism to regulate the market or counter extremes of supply and demand, for example via buffer stocks.

Seed Supply

73. Traditionally, seed potato is grown in the high hills, where disease pressure is lowest and then brought down to the main production areas where it can be exchanged for maize or other commodities. These traditional seed flows still exist in many areas but the rapid growth in commercial potato production in recent years has meant that demand for 'clean' seed now outstrips supply.

74. The National Potato Development Programme (NPDP), with technical assistance from the Swiss, has adopted a European style seed multiplication programme. About 30-40 farmers are regularly contracted to multiply approved seed, which is then distributed by the state extension services. The system is over-stretched (the Director only has 7 staff, including one associate plant pathologist and no social scientist); only a small proportion of Nepalese potato farmers have access to seed supplies from Government farms.

75. Several potato pathogens negatively affect attempts at seed multiplication in the mid hills, especially late blight (*Phytopthera infestans*) and bacterial wilt (*Pseudomonas solanacearum*). The NPDP recommends a 5 year crop rotation and is trying to increase the availability and use of resistant varieties. The NPDP tries to encourage farmers to practise positive and negative selection, grading etc, in on-farm seed production.

76. The unstable Nepalese market conditions create problems in encouraging 'good practice' in seed production. The tendency of many farmers is simply to plant the cheapest potato available at planting time; this is often supplied by traders who claim it to be 'certified seed' from India or elsewhere. In the face of such competition local producers of high grade seed cannot be assured that the market will pay a premium reflecting the extra time and labour invested.

77. An interview with the Seed Entrepreneurs Association of Nepal identified several reasons why the Nepalese private sector has not got more involved in potato seed multiplication and distribution, as it has for a variety of other horticultural crops such as tomato, radish etc (R.P Shrestha, pers comm):

- regulatory bureaucracy
- local municipal taxes on internal movement of food including seed grains and tubers
- government transport of potato seed (via NPDP) which undercuts private distribution (transporting potato is very expensive).

PROPOSED TISSUE CULTURE-BASED SEED SUPPLY SCHEME

78. The US NGO, Appropriate Technology International is funding a project in Nepal, in collaboration with the local NGO New Era PVT Ltd, designed to address the problem of poor availability of disease-free potato seed. The project is based on two key innovations,

i) the involvement of private micropropagation enterprises to produce and supply *in-vitro* plantlets to farmers,

ii) training farmers to produce high grade seed potato from the tissue-cultured plantlets after hardening off via the 'sand-rooting technique'.

The Sand-Rooting Technique

79. The sand-rooting technique was developed by Dr S.B. Rajbhandary at Godwari Tissue Culture Laboratories, National Herbarium Plant Laboratories.

80. Axillary shoot proliferation is used to multiply the selected variety *in-vitro*. This takes place under laboratory conditions (sterile - controlled temperature, humidity, daylength and light intensity). The multiplication stage takes place in glass jars, approximately jam jar sized.

81. The idea is that such a jar, containing 50-100 shoots would be sold to farmers. The price is likely to be around Rs50 per jar.

82. The farmers need a shaded, protected structure - ideally a polytunnel, where some control of temperature and humidity is possible (see later). They have to carefully remove the shoots from the jar and transplant them into trays of sand, which have been washed of all soil and dried in sun to effect a sort of semi-sterilisation.

83. No nutrients or chemicals are apparently needed but supply of various micronutrients by foliar spraying would be advantageous.

84. Trays of ca 12x14x14 inches are used at a density of ca 80 plantlets/tray. After 3 weeks the plantlets are well rooted - and 3 weeks after that they are ready to transplant to the field.

85. These plantlets will apparently produce at least 10 tubers per plant and up to 40/50 under good conditions, which are harvested as basic seed. The seed can apparently also be harvested as mini-tubers. 'MS42.3' has been selected as the variety of choice for the project on the basis of high yield and good blight resistance, and was already being trialed in farmers fields in various locations at the time of my visit.

Institutional Arrangements for the Proposed Tissue Culture-Based Potato Seed Scheme in Nepal

National Potato Development Programme	--	Screen and select appropriate varieties - help select and train farmers - assess/inspect proposed seed producing farms - distribute seed;
Godwari Tissue Culture Laboratory	--	'Basic' development of tissue culture protocols - maintain nuclear stock - technical advice;
'Botanical Enterprises' PVT Ltd	--	Micropropagation of nuclear stock from Godwari - sell jars of potato plantlets to farmers - help train farmers in sand rooting technique;
Farmer Seed Enterprises	--	Produce the first generation of basic seed from micropropagated plantlets - multiply further via subsequent field generation(s) - sell to NPDP and other farmers.

CASE STUDY APPROACH

86. A visit was made to Nepal in February/March 1992. The purpose of the study was to assess the demand for high yielding seed potato and the prospects for uptake of the sand-rooting technology by farmer seed enterprises.

Data Collection

87. A) Analysis of available secondary literature plus interviews with key informant scientists, government and project personnel in Nepal such as the Department of Food and Agricultural Marketing Services (DFAM)s, the National Potato Development Programme (NPDP), the regional Agricultural District Offices (ADOs).

88. B) Field survey : Given the time (3 weeks total) and resource constraints, the most practical option was to adopt an RRA methodology - the team consisted of a Nepali

agronomist, Dr G L Shrestha, an NRI agricultural economist, S. Joffe, and two Nepali interviewers/translators. This was supplemented at various times by officials of local Agricultural District Offices (ADO).

89. The team visited potato production areas in Kavre and Rasuwa Districts in Central Nepal. The two sites in Kavre District were Panchkaal VDC (Village Development Committee) which is a sub-tropical river valley area, and Nala VDC, which is a warm temperate area; both were producing intensively, predominantly for the Khatmandu market. In Rasuwa District a total of four villages in Goljhung and Chilime VDCs were visited; these were producing mainly for subsistence consumption purposes. In total, 42 individual interviews and 8 different group discussions were held. Interviews were informal and semi-structured, based on a check-list of points to be covered. Full details of the RRA methodology are provided in Appendix 2 - and further background information on the sites visited in Appendix 3.

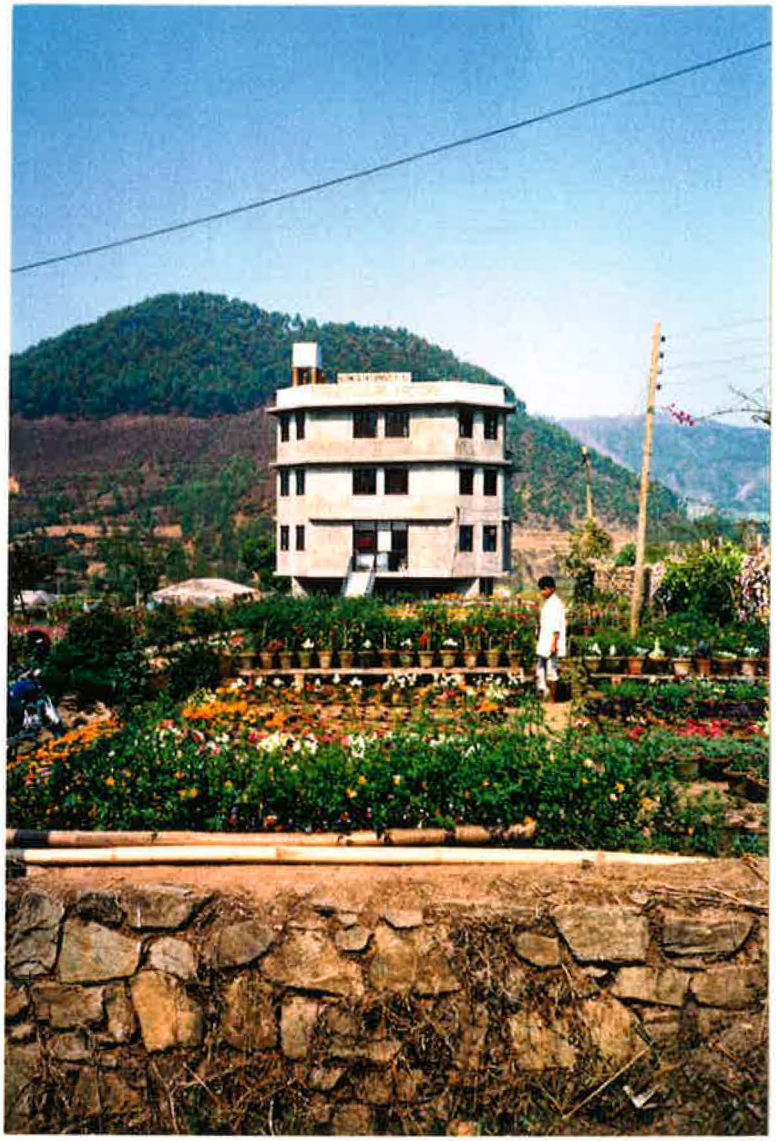
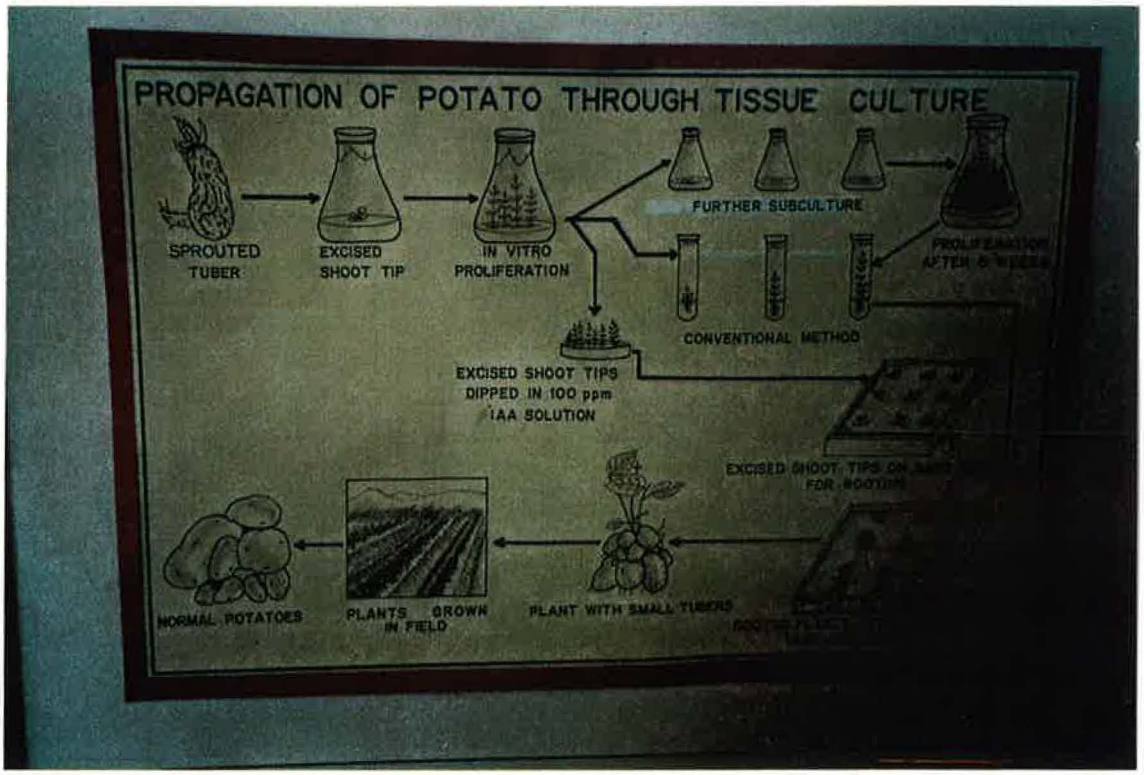


Plate 10: This micropropagation factory near Khatmandu will sell 'jam jars' of 50-100 micropropagated potato shoots, to farmer seed enterprises, for around Rs50 (US$1).

Plate 11 (below): The tissue culture protocol developed at the National Herbarium Plant Laboratories by Dr Rajbhandary.



Plates 12 & 13: Farmers being trained to establish micropropagated potato shoots in sand trays; after 3 weeks they have rooted and are transferred to individual pots; 3 weeks later they can be planted out.

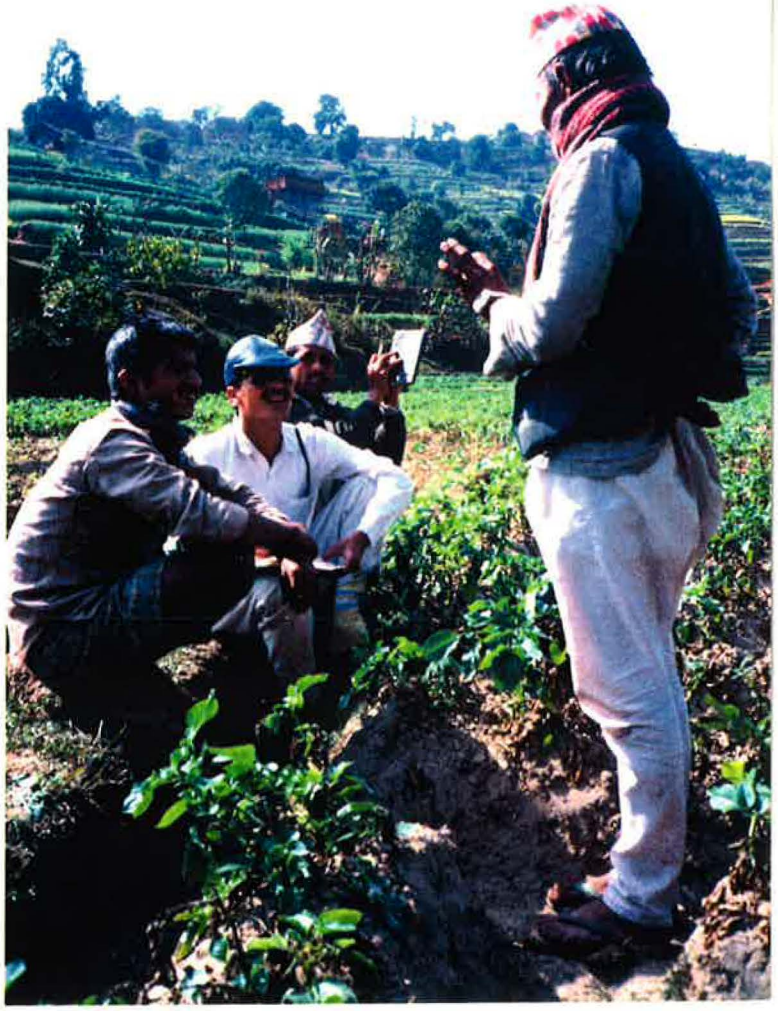


Plate 14 (above): The sub-tropical potato farming system in Panchkaal VDC, Kavre District.

Plate 15: A farmer from Panchkaal VDC discussing local constraints in seed supply.

Plates 16 & 17:
The warm temperate potato farming system in Nala VDC, Kavre District.

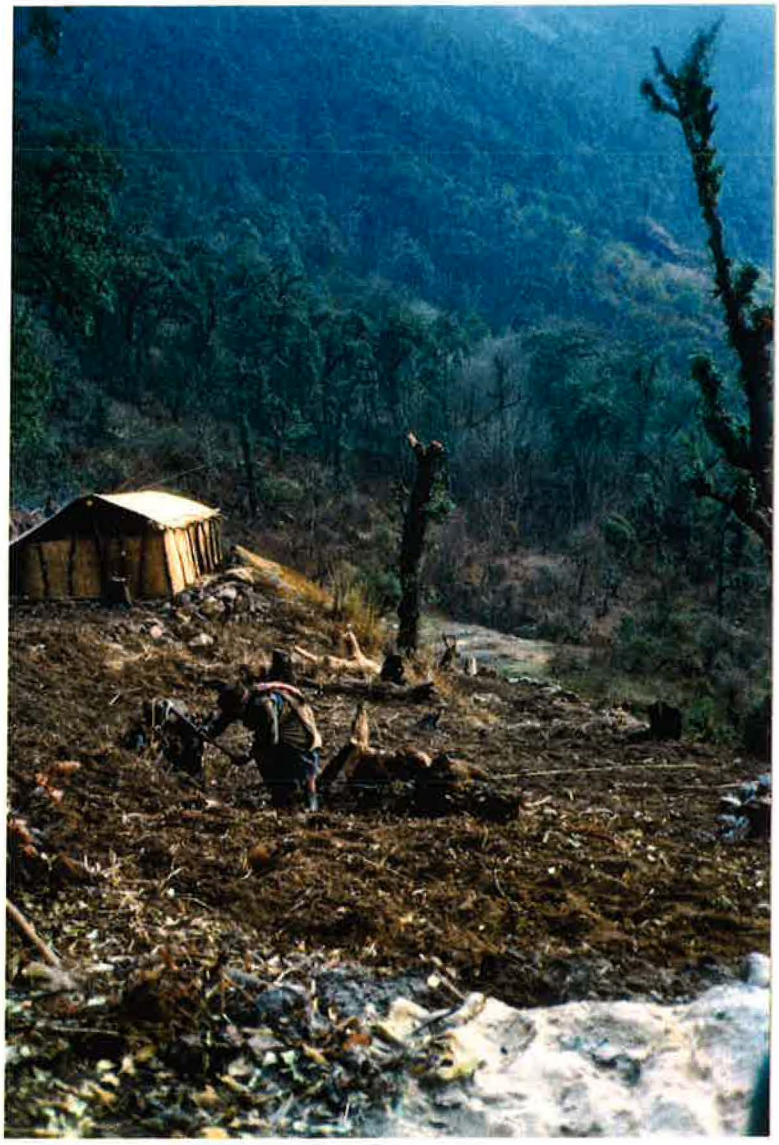


Plate 18 (above): The valley in Rasuwa District (ca 3000m) where subsistence farmers from Goljhung and Chilime VDCs were interviewed.

Plate 19: Potato being planted in newly cleared forest around Paragang village, Rasuwa District.

Plate 20: (above): A focused group discussion involving mainly Tamang women from Chilime Village, Rasuwa District.

Plate 21: A farmer being interviewed in Paragang village, Goljhung VDC, Rasuwa District.

RESULTS OF RAPID RURAL APPRAISAL

The results of the rapid rural appraisal are presented below as a series of tables:

Table 3: Description of Sample

	Groups Discussions	Individual Interviews
Kavre District		
Panchkaal VDC	2	n=10
Nala VDC	2	n=15
Rasuwa District		
Goljhung VDC	1	n=10
Chilime VDC	3	n=07
		n=42 (33 male, 9 female)

Table 4: Land Holdings (n = 42)

Mean size of holding:	1.1 ha
Modal class:	0.5-1.0 ha
Range:	0.1-4.0 ha

The smallest fields were in Rasuwa/Chilime VDC, and the largest in Kavre and Panchkaal VDCs.

Table 5: Proportion of Available Land Planted to Potato

Kavre District:	apprx 50%
Rasuwa District	apprx 20%.

This situation seems to reflect the less commercially oriented production in Goljhung and Chilime VDCs.

Table 6: Potato Consumption versus Market

Kavre District	Range:	5 - 25% of output consumed
	Median:	less than 10%
Rasuwa District	Range:	50 - 100% of output consumed. 13 out of 17 respondents, including all of the Paragang villagers consumed all they could grow.

Table 7: Open Question on 'Most Important Problems in Production'

A. SEED AVAILABILITY

In Panchkaal VDC (Kavre District), 8 out of 9 respondents cited availability of 'good' seed as their most important production constraint . The tropical climate makes local storage impossible; these producers are dependant on seed brought in from cold stores by local businessmen and Indian merchants; quality control is highly variable.

In Nala VDC (Kavre District), only one of 16 farmers had a problem getting 'good seed'. The reasons became evident from individual and group discussions:

i) in the Nala area the climate (warm temperate) allows on-farm storage;

ii) a local seed production project (NPDP: Swiss funded) has taught a number of farmers husbandry practises eg rogueing essential in seed production;

iii) farmers form cooperatives to organise transport to, and space in Khatmandu cold storage facilities.

These factors ensure most of the farmers a reliable supply of locally produced seed as well as allowing them to sell ware potato under the most favourable market conditions.

In Goljhung and Chilime VDCs (Rasuwa District) seed availability problems were mentioned by about half of the respondents. This is associated with the fact that most production is for family consumption. Households regularly experience seasonal food deficits and only a minority manage to save sufficient seed for the next season.

B. OTHER

Timely fertiliser availability was a common complaint in Panchkaal and Nala VDCs (Kavre District); as was the price and quality of pesticides sold by local private retailers; fertiliser availability was also cited frequently in Goljhung VDC (Rasuwa District). Labour constraints in potato production were relatively rare, but were cited by some upland farmers in the Nala area.

Table 8: Varieties Grown

In Panchkaal VDC (Kavre District) all respondents were growing 'Cardinal' variety; 6 out of 9 were also growing 'Lal gulaf' and/or 'Sindhuri kapoor' varieties which had been brought in by traders from India. Group discussions confirmed that 'Cardinal' was most popular variety but that several Indian varieties were also common, based on their availability and price at planting time.

In Nala VDC (Kavre District) 'Cardinal' and 'Kufri jyoti' were about equally popular; 'Hybrid 14' was mentioned by upland farmers as being well suited to rainfed production.

In Goljhung and Chilime VDCs (Rasuwa District) all respondents were growing 'Kufri jyoti' improved variety; against expectation cultivation of local varieties seemed rare even in villages growing purely for own consumption; only 3 out of 17 grew local varieties; one of these predominantly so.

Table 9A: Varietal Selection Criteria: Whole Sample

Respondents were asked to think of three important characteristics a potato variety should possess, and to rank these 1,2, and 3[6]. This table indicates firstly the total number of times a particular trait was mentioned, secondly the number of times it was ranked first:

WHOLE SAMPLE (n=42)

	mentioned	ranked 1st
Yield	29	15
Size of tuber	22	6
Food quality	14	4
Market price	10	3
Disease resistance	9	8
Early maturity	5	3
Storage quality	3	0
'Seed quality'	3	3
		(n = 42)

6. These categories are based on the interviewers interpretation of responses given; they are clearly not mutually exclusive. For example the 'seed quality' category only came up in Kavre/Panchkaal VDC where it was probably synonymous with 'disease resistance'. 'Storage quality' was also very likely correlated with 'disease resistance'.

Table 9B: Varietal Selection Criteria: By District

	Panchkaal & Nala VDCs (Kavre District)		Goljhung & Chilime VDCs (Rasuwa District)	
	mentioned	**ranked 1st**	**mentioned**	**ranked 1st**
Yield	13	5	16	10
Size of tuber	11	2	11	4
Market price	10	3	5	2
Food quality	9	2	1	0
Disease res.	8	7	1	1
E. maturity	4	3		**n=17)**
Store quality	4	0		
Seed quality	3	3		
		n=25)		

90. Note: The sample is too small to draw significant inferences, but does point in some interesting directions. Yield was overwhelmingly the most important criterion. 'Food quality' (a catch-all category for taste, ease of processing and cooking) was a popular category but rarely the most important. When 'disease resistance' was mentioned at all it tended to be considered important, suggesting that farmers who did not mention it may not have been aware of 'disease resistance' as something carried by seeds.

Table 10: Sources of Seed

Panchkaal VDC Kavre District)	--	Brought in from cold stores by local businessmen or traders from as far as India - locally produced seed is degenerated and infected with virus and bacterial wilt.
Nala VDC Kavre District)	--	Mostly locally produced seed - stored in Khatmandu cold storage or in houses; larger farmers were self-sufficient, others would buy from neighbours.
Goljhung & Chilime VDCs Rasuwa District)	--	Six out of 17 respondents saved sufficient seed from their own fields, and stored it in bamboo baskets. The rest would run out of potato too early and rely on purchasing seed from neighbours at planting time (they could earn the cash for this by working in their neighbour's fields). One or two of the better off Goljhung villagers were specialising in seed production; The nearby Gatlang village was also mentioned several times as a good source of seed.

Table 11: Price of Seed (Seed potato prices at planting time from individual and group discussions)

Kavre District	Range:	Rs 8 - 14/Kg
	Mean:	Rs 10/Kg
Rasuwa District	Range:	Rs 3 - 5/Kg: some exchange for oil, salt, labour.

Table 12: Seed as a Production Cost

Respondents were asked to rank their top three costs in production: 26 out of 29 respondents gave 'seed' as either 1st or 2nd 'most important' production cost and there was no noticeable difference between Kavre and Rasuwa in this respect.

Table 13: Market Price of Ware Potato (from individual and group discussions)

Panchkaal VDC (Kavre District)	Range:	Rs 2.8 - 4.4/Kg depending on market conditions
	Mean:	Rs 3.3/Kg
Nala VDC Kavre District)	Range:	Rs 2.0 - 8.0/Kg depending on market conditions
	Mean:	Rs 3.75/Kg
Rasuwa District	Range:	Rs 2.0 - 4.3/Kg

Table 14: Potato Pests

Respondents were asked which pests caused them problems. The answers were interpreted by interviewers: not all pest mentioned were identifiable by the team.

Late Blight
Far and away the most important problem mentioned by farmers in Kavre District; here, control is based on spraying Dithane 45 fungicide, without which production is severely constrained. Also mentioned by 4 out of 17 farmers in Rasuwa District (where sprays are not used).

Animals
Far and away the most important problem experienced by farmers in Rasuwa District; in the Village of Paragang farmers had to watch their fields virtually day and night to prevent potatoes being consumed by boar, bear, porcupine monkeys and others.

Insect Pests
The second most commonly reported problem in all areas - including red ants, 'cut-worms', tuber moths and others which the team could not identify.

Bacterial wilt
Mentioned only 5 times by respondents and also uncommon in group discussions; almost certainly under-reported as there was evidence of infection in stored potatoes (brown ring in cut tuber) and the field. A degree of infection may be considered 'normal'.

Viruses
Evidence of potato leaf roll virus in Kavre District, in the Panchkaal area especially, although it was not often reported by farmers in the survey. It may be that farmers do not associate it with any loss of yield.

DISCUSSION

Availability of and Demand for Improved Seed

91. There is a widespread problem of availability of good quality potato seed in Nepal, which goes beyond the surveyed areas in Kavre and Rasuwa Districts. The rapid growth in commercial production has outstripped the capacity of traditional seed systems, and formal seed programmes have had limited success (Cromwell 1990).

92. Producers in sub-tropical and tropical areas are dependant on supplies of seed from more favourable seed producing areas as locally produced seed is likely to be virus-infected and local storage is not possible unless refrigerated facilities are available. Producers in Panchkaal VDC, Kavre District, complain of being 'at the mercy' of traders who will bring in potato of dubious

quality at planting time and charge inflated prices (Tables 7 & 10).

93. Producers in more favourable mid-hill locations have potential to produce good quality local seed as is demonstrated by the successful efforts of farmers in Nala VDC, Kavre District (Tables 7 & 10). However the self-sufficiency of these farmers is probably quite unusual, having been made possible via a combination of training by the Swiss-funded NPDP seeds programme, reliable access to the nearby Khatmandu cold storage facilities and cooperative organisation to overcome constraints on transport, labour, storage space etc.

94. In subsistence production areas such as those visited in Rasuwa District, shortage of planting material is linked to overall food availability (Table 6). Households unable to produce sufficient surplus to last through to the next season will purchase in cash or kind from more fortunate households (Tables 7 & 10). The scope for raising yields via improved seed production technology has to be viewed realistically in the light of multiple constraints on production and the primary need to rely on locally appropriate, low cost interventions. These would most usefully be based on strengthening and supporting existing local seed flows.

The Potential use of Sand-Rooting Technology by Private Seed Producers.

95. There are several projects in Nepal providing farmers in favourable seed producing areas with improved varieties, training them in good seed production practises, and encouraging them to store and later sell their surplus for use as seed by other farmers locally or further afield[7] .

96. The question this case study asks is whether the use of the new sand-rooting technology can help to improve the profitability of such enterprises and would be readily adoptable by them.

A. Technical Considerations

97. According to Dr Rhajbandary, the scientist who originally developed the sand-rooting technology in Nepal, the key technical constraints to be overcome by farmers using the sand-rooting procedure are:

- light intensity: very important - the farmers must reduce the light by ca 70-80% using matting or similar material;

---

7. For example the ODA funded Koshi Hills Agricultural Project in the eastern hills.

- temperature: the optimum is 8 - 20 degree but apparently the plants could survive limited periods of 0 - 30 degrees although with reduced survival rates.

- humidity: 80 - 90%

- day length: Dr Rhajbandary had not systematically experimented but thought winter day lengths suitable for potato.

98. Given these technical demands the ability of farmers to achieve high survival rates for the plantlets is likely to be highly correlated with their levels of education, time to experiment, resources to invest in matting, polytunnels etc, and contact with and backup from research and extension personnel. The use of the technology would also be limited to areas which did not experience extremes of temperature in the weeks prior to planting time when the plantlets were being 'hardened off'.

B. Costs and Returns for Seed Enterprises using Sand Rooting Technology

99. If uptake of the sand rooting technology is to operate without subsidy, farmer seed enterprises should be willing to pay the market price for potato plantlets from private micropropagation firms, and be able to sell the derived seed tubers on to local ware potato producers at a profit.

100. At present it appears that the price for a 'jam jar' containing perhaps 50-100 plantlets would be around Rs50 (Shrestha pers comm). Assuming the lower number and an 80% survival rate, 40 plantlets/jar would be successfully planted.

101. The ANSAB project assumes that each farmer would plant 5 ropani (0.25ha) to the micropropagated plantlets. Thus, at a planting density of 5/m^2, farmers would need to purchase 312.5 jars to provide the 12,500 plantlets needed. This would cost US$312.5 @ Rs50/jar.

102. The skilled operative time required to root 12,500 plantlets in sand trays, and later individually repot them, has to be added to these costs, as does the cost of consumables such as the trays, pots, sand etc. Planting out this number of plantlets will also take more time than would planting seed tubers.

103. The additional labour costs are estimated here at 10 man days. Assuming a rate of say $3/day (3 x the local unskilled rate in Kavre District), this would add another $30 to planting costs, bringing the total to $312.5 + $30 = $343. When consumables costs are added, plus capital depreciation on polytunnels and other fixed costs, the total planting costs are estimated at $375 on 0.25ha.

104. Farmers planting five ropani conventionally would normally use about 250Kg of seed tuber, assuming the local practise of cutting the tubers into pieces. This could be purchased for Rs2500, or $50, based on average seed prices reported in the survey (Rs10/Kg - Table 11).

105. Thus, at this stage, the seed enterprises have incurred US$325 additional costs in planting the tissue culture-derived plantlets, compared to planting with conventional material.

106. The ANSAB project assumes that the pre-basic seed derived from the plantlets would be harvested as minitubers weighing as little as 5g each. Farmers in Kavre District are currently used to paying around $200/ha planting costs for conventional seed tubers. In order to match this price the minitubers would need to be sold at Rs0.2 each (@ 5/m2 planting density)[8].

107. If each micropropagated plant produces an average of 40 minitubers, the gross income from 5 ropani (0.25 ha) would be 40 x 12,500 plants x Rs0.2 = Rs100,000 or $2000.

108. The gross income from conventional seed tubers produced on the same land, assuming a yield of say 16mt/ha and a local seed price of Rs10/Kg, would be 4000Kg x Rs10 = Rs40,000 or $800.

109. Under these assumptions the incremental gross income from 5 ropani (0.25 ha) planted to micropropagated plants is:

	$2000	(gross income from minitubers)
less	$800	(gross income from conventional seed tubers)
less	$325	(incremental planting costs)
plus	$25	(estimated saving in fungicide costs)
total	$900[9]	(incremental gross income from 0.25ha)

110. Since the incremental costs were estimated at $325, the benefit:cost ratio to seed entrepreneurs using the sand rooting technology to plant 0.25 ha is estimated at 2.75/1.

---

8 The ability to sell minitubers at a premium price, above the market rate, is questionable. Seed entrepreneurs will face competition from traders bringing in cheaper planting material from India and elsewhere. Farmers may even consider Rs0.2 to be expensive given that this will increase the price by weight of seed tubers by some 400%.

9 This may be a conservative estimate since i) plantlets yield 100 or more minitubers under ideal conditions, ii) storage costs are also likely to be reduced.

Other Factors Influencing Potential Impact of the Sand-Rooting Technology

111. The potential impact of the proposed new technology (tissue culture followed by sand rooting) needs to be assessed in the context of the potato sector and seed supply mechanisms as a whole.

112. The commercial potato market is very volatile; there are no systematic mechanisms in place to introduce stability such as price setting or maintenance of buffer stocks. The price of seed continues to be determined as much by the volume on the market as by quality criteria.

113. Production remains profitable in the majority of years, as demonstrated by the continual expansion in commercial areas under improved varieties, however farmers face a good deal of uncertainty. Thus while they are very likely to be interested in purchasing seed that will return improved yields (the number one varietal criterion expressed by respondents in Kavre and Rasuwa Districts - Table 9), they are likely to be adverse to any significant increase in planting costs.

114. It is significant that these and other factors such as transport costs have constrained significant private sector involvement to date in potato seed supply in Nepal, despite the rapid growth in this sector.

115. Farmers that are specialising in seed production in commercial areas are commonly being subsidised via the support of projects providing improved varieties, technical support, storage facilities, credit etc. The Swiss-funded project in Kavre District also paid farmers in the scheme a 20% premium for potato of seed quality. In the absence of such support, standards in seed production tend to decline because producers tend to cut out some of the activities including positive and negative selection (rogueing) which increase their unit costs.

116. Given this background, prospects for the adoption of the sand-rooting technology by seed entrepreneurs is likely to be very sensitive to the extra initial costs (both fixed and variable) incurred in producing from micropropagated plantlets, as well as by market conditions.

117. Geographically, opportunities to adopt the sand-rooting technology will be spatially limited to sites in the most accessible commercial pockets in warm temperate mid-hill areas due to both agroecological and infrastructural factors.

118. The main markets for the minitubers would be in the same warm temperate commercial pockets, but more so in the sub-tropical and tropical production areas where local seed production and storage is impossible. The impact here could be substantial, provided the price of minitubers was no

greater than alternatives available. Impacts in more remote commercial potato areas would depend on whether there was sufficient incentive for the private sector to take advantage of cheaper transport and storage costs associated with the low comparative weight of minitubers.

119. The scheme is unlikely to have much relevance in non-commercial areas such as those surveyed in Rasuwa District. Agro-ecological and infrastructural constraints will prohibit use of the sand-rooting technology. The state-supported supply of mini-tubers from more suitable areas would be favoured by the low transport and storage costs, but would need to be very carefully assessed against alternative options to strengthen local self-reliance in seed production.

OVERALL CONCLUSIONS

120. The are some inherent difficulties in drawing comparisons between the two case studies. In Vietnam the study considers why the supply of micropropagated plantlets by small enterprise(s) is operating successfully in the present. In Nepal the study looks *ex ante* at the factors that will influence the capacity of seed enterprises to adopt micropropagation technology. Nevertheless some tentative conclusions can be made. Two factors stand out:

121. Firstly the technology is quite different in each case, despite the common use of tissue culture to initially produce and micropropagate disease-free nuclear stock.

122. In Vietnam the small enterprise which was studied undertakes the in-vitro stage 'in-house' and thus gets its disease-free plantlets 'at cost' rather than paying for another private enterprise to supply them.

123. It was initially supplied with in-vitro material of three high yielding clones by the local research station, itself supplied by CIP. It is now able to initiate its own cultures and market new varieties, although the heat treatment required to rid cultured material of viruses must still be undertaken in a more sophisticated laboratory.

124. The enterprise undertakes several generations of multiplication from stem-cuttings to produce hundreds of thousands of plantlets from a few original mother plants. Local climate, reliable services etc create very favourable conditions for this activity. The enterprise is totally dedicated to production of plantlets; economies of scale allow it to reduce the costs of producing each plantlet to between $0.2 - 0.4cents. They are marketed at a decent profit for about $0.6 cents, thereby knocking about 30% of the normal local price of a seed tuber. Farmers purchasing the plantlets harvest their own first generation seed and

can expect to realise consistently high yields through to the third generation before requiring new plantlets.

125. In Nepal it is not proposed that the farmer seed enterprises could manage the in-vitro work. A micropropagation company close to Khatmandu is to undertake this stage. In order to do so profitably it has to sell the product - glass jars of 50-100 micropropagated potato shoots, to the seed enterprises, for around Rs50 or US$1, (substantially more than the Vietnamese enterprise can produce the plantlets for itself).

126. At this point, rather than further multiplying the potao shoots by the stem cutting method, as in Vietnam, they will be rooted as individual plantlets, hardened off and planted. After three months the first generation seed will be harvested as minitubers and, after an appropriate period of storage, sold on to local ware potato producers.

127. The incremental gross income to seed enterprises from 0.25 ha planted to micropropagated plantlets, as opposed to conventional seed grade tubers, is estimated at around $900. However it is estimated that the incremental cost of planting 0.25 ha to micropropagated plants would be around $325, giving an approximate benefit cost ratio of 2.75/1.

128. A key assumption is that ware potato producers will be willing to purchase the minitubers at a price equivalent to Rs0.2 each. While planting costs would actually be no greater than an average year using conventional tubers, the price by weight would be four times as great. It is noteworthy also that in Vietnam the seed enterprise studied sold potato plantlets at a rate which undercut conventional seed tubers by around 30%, in order to develop a strong market position.

129. Each scheme has arisen in response to locally specific circumstances. For example it is very unlikely that farmer enterprises in Nepal could operate a year round production of plantlets by stem-cuttings as does Mr Ngoc - there is only one well defined planting season in a given production pocket; also in the months prior to planting time, when Mr Ngoc would be multiplying the plantlets, conditions in the mid-hills would be too harsh, requiring electrically heated and lighted area under cover (with prohibitive implications for costs). Thus the scheme provides the enterprises *de novo* with micropropagated plants shortly before the planting season.

130. A second major difference exists between the market conditions and production costs of seed in each case:

131. In the Vietnamese example there exists a strong, stable market for potato from the Dalat City area, both in Ho Chi Minh City and for export. Farmers receive between 2000-3500 Vietnamese dong (ca. $0.18 - $0.32) per Kg. Local yields are around 18mt/ha, giving a gross income of at least $3,200/ha.

Planting costs with conventionally derived seed are around $272/ha - use of cuttings reduces this to around $180/ha.

132. In Kavre District of Nepal both the market price (perhaps Rs5/Kg, or US$10 cents/Kg) and average yield (around 10mt/ha) are lower, giving a gross income of around $1000/ha. Planting costs are proportionately much higher. If farmers planted 2mt/ha it would cost them around $400/ha - the local practise is to cut tubers in to pieces, which cuts planting costs to $200/ha or less. Planting with minitubers produced by 'seed entrepreneurs' would not in this case reduce planting costs, although it could be expected to reduce costs of Late Blight control and raise yields by some 25% as compared to available 'Kufri jyoti' and 'Cardinal' varieties.

133. The lack of any means to regulate or monitor the price and quality of seed brought into commercial production pockets by traders at planting time (eg from India), creates a difficult competitive environment for seed enterprises. The willingness to experiment with new technology may be compromised as a result and the estimated benefit:cost ratio of 2.75:1 may prove to be marginal in these circumstances.

134. One factor that IS common to both case studies is the central part paid by non-government organisations and informal mechanisms in technology transfer. In the Vietnam example the friendship between the local research Director Dr Nguyen and the local farmer, Mr Ngoc, and the willingness of the former to risk aggravating the authorities by 'giving away national secrets' to a private entrepreneur, were essential. In Nepal the NGO ANSAB (Asian Network for Small Scale Agricultural Biotechnologies), with funding from the US NGO Appropriate Technology International, is playing a pivotal role in promoting the scheme as a radical alternative to formal multiplication programmes.

135. The two case studies indicate that the use of tissue culture techniques by small farmers is technically feasible. Seed schemes based around small scale rural micropropagation enterprises can potentially enable rapid dissemination of new varieties, and healthy high yielding seedstock, at comparatively low public cost.

136. However, the success of such schemes is likely to depend on certain prerequisites, which would also be relevant to crops other than potato:

- strong, reliable and effective demand for improved seed;

- publicly supported means to monitor and regulate seed quality;

- technical ability of seed enterprises to consistently supply, and to match or undercut prevalent local seed prices: price stability in seed 'market';

- willingness and ability of local farmers to innovate if offered a different form of planting material (eg plantlets);

- support for seed entrepreneurs from local research and extension institutions; access to credit if required;

- favourable climate for micropropagation with minimum need of additional heat and light;

- favourable fiscal/policy environment for small enterprise development.

137. These circumstances are epitomised in the Vietnamese case, where the technical, economic, and policy environment, combine with entrepreneurial flair to create a particularly favourable set of circumstances. This degree of success may not be easy to recreate elsewhere.

138. Successful schemes based on small micropropagation enterprises will usually be limited to seed supply for high value cash cropping systems. There is no reason why such an approach should not be well suited to the needs of geographically limited small-scale production areas: by minimising the expensive *in-vitro* phase of micropropagation and employing family labour in the (labour intensive) multiplication phase, the seed enterprises can be highly productive on a small scale.

139. This indicates a particular niche role for such enterprises in provision of improved seed in small scale cash cropping systems which are not adequately provided by larger scale private or government schemes for reasons of geography, high costs of conventional seed production, or limited volume of seed market.

140. An interdisciplinary approach is essential in assessing such opportunities. Both technical and socio-economic factors will critically affect viability, including diagnosis and impact of disease constraints, other factors influencing demand for improved seed, dynamics of existing seed supplies, analysis of markets, benefits and costs to seed enterprises and local farmers.

References

BIOTECHNOLOGY AND DEVELOPMENT MONITOR (1992) 'Potatoes: improving disease resistance and quality'. Number 12, September 1992, pp3-5.

BUTTEL, F. (1990) 'Sociological Impact'. in Persley, G.J. (ed.), Agricultural Biotechnology: Opportunities for International Development. CAB International, Wallingford, UK.

COMMISSION OF THE EUROPEAN COMMUNITIES (1987) 'The Potato'. Green Europe, Newsletter on the Common Agricultural Policy, no 222, 6/87.

CROMWELL, E. (ed) (1990) 'Seed Diffusion Mechanisms in Small Farmer Communities: lessons from Asia, Africa and Latin America'. ODA Agricultural Administration (Research and Extension) Network, Network Paper 21.

DODDS, J., HORTON, D. (1990) 'Impact of Biotechnology on Potato Production in Developing Countries'. Agbiotech News and Information, vol 2, no 3, pp 397-400.

FERCHAK, J., RIBEIRO, S. (eds) (1992) 'Lab to Land: Biotechnology for Sustainable Agriculture in Asia'. Proceedings of the first ANSAB (Asian Network for Small-Scale Agricultural Biotechnology) Workshop, March 29 - April 1, 1992.

HO, TRUONG VAN., TUYET, LE THI., TUNG, PHAM XUAN., VANDER ZAAG, P. 'Potato Research and Development in Vietnam in Recent Years'. International Potato Centre Circular, vol 15, no 3, September 1987.

HMG NEPAL (1988) National Agricultural Research and Services Centre Annual Report 1987/88, p104.

HMG NEPAL (1991) Agricultural Marketing, Information Bulletin, Special Issue - 2048. Ministry of Agriculture, Food and Agricultural Marketing Services Department.

HMG NEPAL, MIN. OF AG. (1991) Master Plan for Horticulture Development. Vol 5 - Vegetable, Potato and Spice Development in Nepal. Pacific Management Resources Inc, USA, in association with East Consult (P) LTD, Nepal.

JOFFE, S., GREELEY, M. (1987) 'The New Plant Biotechnologies and Rural Poverty in the Third World'. Appropriate Technology International, Washington D.C., USA.

MUREITHI, L.P. and MAKAU, B.F. (1989) 'Biotechnology and Farm Size in Kenya'. ILO Technology and Employment Programme, Research Working paper WEP 2-22/WP.194.

NATURAL RESOURCES INSTITUTE (1989) Report on a visit to Kenya to review biotechnology R&D activities and discuss case studies. Internal report.

RHOADES, R.E., (1985) 'Traditional potato production and farmers' selection of varieties in eastern Nepal'. Potatoes in Food Systems Research Series, report no 2. International Potato Centre (CIP). Lima Peru.

SINGH, R.B. (1989) 'Current status and future prospects of plant biotechnologies in developing countries in Asia'. in Plant Biotechnologies for Developing Countries: proceedings of an international symposium jointly organised by the Technical centre for Agricultural and Rural Cooperation (CTA) and the FAO, and held in Luxembourg, 26-30 June 1989.

UYEN, NGUYEN VAN., VANDER ZAAG, P. (1984) 'Vietnamese Farmers use Tissue Culture for Commercial Potato Production'. American Potato Journal, Vol 60, pp873-879.

UYEN, NGUYEN VAN., VANDER ZAAG, P. (1985) 'Potato Production using Tissue Culture in Vietnam: The Status after Four Years'. American Potato Journal, Vol 62, pp237-242.

Appendix 1: Protocol Developed by CIP and the Vietnamese Centre for Experimental Biology for Rapid Micropropagation of Potato.

The following is extracted from Nguyen and Vander Zaag 1983: "Two or three test tube plantlets of a desired cultivar are obtained from the (research) station. These are multiplied *in-vitro* monthly and maintained in the farmer's house. After 1 month the *in-vitro* plantlets are cut into single node units and either re-rooted *in-vitro* or, when the basic stock is large enough, are rooted in sand 'mother' beds at a density of 1000 cuttings/m2. The use of sand results in lower incidence of fungal and bacterial infection. Plantlets form roots in 5 days. At 14 days, the first harvest of apical cuttings is taken when the leaves are still in the juvenile stage (having round leaves), followed by weekly harvests for up to 3 months. Cuttings are taken at a very young stage to ensure vigorous rootings and to obtain physiologically young plants. Sand, being poor in nutrients, tends to keep the plantlets small and not too competitive and is thus ideal for repeated harvests.

The apical and axillary bud cuttings from the mother bed are rooted in beds of well aggregated sub-soil and manure at a 50:50 ratio, also at a density of 1000/m2. After these are rooted, weekly harvests of apical and axillary cuttings are taken for 2 months. These are then potted in a similar sub-soil and manure mixture contained in 3x5 cm banana leaf pots with open bottoms. In 15 days they are rooted and sold to farmers, who directly transplant them to the field. Based on present farming practices, three *in-vitro* plants can produce enough planting material for 1 ha based on the multiplication rates outlined above".

Appendix 2: Rapid Rural Appraisal Methodology used in Nepal.

Field Survey - Sampling Frame
Following initial team discussions and secondary data analysis the sampling frame was based on a purposive selection in three stages: i) the District, ii) the VDC (Village Development Committee) and component village(s) iii) individual and group respondents. The sample was stratified according to:

- degree of market orientation
- elevation/cropping systems
- wealth ranking

Market Orientation
Interviews were conducted in both commercial potato pockets, and remote areas; the opportunities for seed potato enterprise development and adoption of new technology were thought likely to be very different in each. The choice of Districts was pre-determined to some extent as three - Kavre, Nuwakot and Rasuwa Districts had already been selected by the New Era/ATI project and field trials of MS42.3 were underway. Kavre and Rasuwa were selected for the RRA as these represented the two extremes of market orientation. Locations within Districts were selected at various distances from a motorable road. The two chosen locations in Kavre District - Panchkhaal and Nala VDCs and surrounding villages - were all within 4 Km of a road. Locations in Rasuwa were up to 10 Km from the road.

Elevation/Cropping Systems
The sample frame spanned the range of agroclimates for potato production in the hills of Nepal - from subtropical (<1000m) to high hill (>2500m) elevations. The cropping systems, potato planting time, pest complexes and particularly options for seed storage change radically in Nepal according to elevation.

Wealth Status
Wealth status indicators varied according to where interviews were being held. On the basis of such indicators care was taken to interview farmers across a range of socio-economic circumstances.

Distance from roadside was often a good wealth indicator - in Rasuwa District a four day trek was made to two remote villages at some 9000ft elevation. In Kavre District farmers with a high proportion of irrigated fields were generally wealthier than those with rainfed fields as they could grow dry season cash crops including potato and other vegetables - those with tin-roofed houses were also relatively wealthy. In both Districts farmers with large (eg > 1 Ha) and small (eg 0.1-0.5 Ha) holdings were included.

In Rasuwa District the small village size made it possible to construct, with the help of village headmen, a list of

the households and their land holdings - from this information, and discussion of locally specific wealth indicators such as ownership of livestock, caste etc, a cross section of wealthier and poorer farmers were selected.

Choice of respondents and form of interviews

In each area the first point of contact would be the local ADO officials who would mediate contacts in the village. Usually the first contact would be with the village chief or other locally important individual such as the school teacher. These discussions provided an insight into the social structures of the village and helped select respondents and facilitate necessary introductions. At other times, eg when trekking, interviews were undertaken on a more ad hoc basis.

Most interviews were on a one to one basis, over around half an hour, undertaken by one of the two Nepali interviewers in local language. They would write down information in English on a standard form. I or my Nepali agronomist counterpart would interject with further queries or requests for amplification during the interviews.

At least one group discussions was held in all villages visited. Effort was always taken to include women in group discussions and as individual respondents. This was made easier by the inclusion of a Nepali women interviewer in the team, nonetheless the sample is heavily skewed towards male respondents.

The interviews were informal and semi-structured, along a previously defined check-list of points to be raised and discussed. These started from the general - what sorts of crops do you grow here?, what are the main problems you face? to the more specific - what potato varieties do you grow? - why?

Appendix 3: Kavre and Rasuwa Districts: Potato Production and other Background Data

Area & Population (1981)

District	Population	Area (sq km)	Density
Kavre	307,150	1396	220
Rasuwa	30,241	1544	19.6

Education (1981)

District	literacy
Kavrepalanchok	25%
Rasuwa	9%

Irrigation (1981)

District	% area irrigated
Kavre	17%
Rasuwa	5%

Potato Production

	Year	
Kavre	78/9	87/8
Area	1010	1550
Prodn	6060	14100
Av Yield	6t/ha	9.1t/ha

	Year	
Rasuwa	78/9	87/8
Area	600	2500
Prodn	3300	18750
Av Yield	5.5t/ha	7.5t/ha

Kavre District

Kavre District is adjacent to the Khatmandu valley and is transected by the major [] Highway. It lies within the 'mid-hill' zone of Nepal with cultivation in both sub-tropical (<1000m) and warm temperate (1000m-2000m) areas.

The most intensive production takes place in irrigated river valley basins. According to information from the District ADO about one quarter of the total cultivated area in Kavre was in irrigated production for at least 6 months in 1992.

In lowland production rice predominates, in rotation with: potato, wheat, maize, tomato, or brassica.

In upland production maize predominates' in rotation with: wheat, potato millet, brassica, barley, pulses, beans, or buckweat.

The ADO estimates that total potato land was 3000 Ha in 1991; one third of which was lowland where only improved varieties (from the NPDP) were grown. In the upland just over half the area was sown to improved varieties.

The district has several major potato producing areas. Two of the most important are Panchkhal (sub-tropical) and Nala (warm temperate) where production is primarily for the Khatmandu market; surveys were undertaken in both areas.

In both the surveyed areas intensive cultivation began around the same time as the road came about 15-18 years ago, opening up the Khatmandu market - potato quickly displaced wheat in the lowland fields and is now a very profitable and popular crop; its cultivation is felt to have improved the local economic situation in recent times.

Yields were reported as fairly stable in Kavre/Nala VDC but declining in Kavre/Panchkaal VDC. This latter appears to be associated with the continuing use of infected, degenerated seed stock.

In general the lowland potato farmers were doing rather well, with incomes of Rs50,000/annum (ca $1,200) or more being quite common. The strong impression received, backed up by figures given by respondents, was that income dropped quite quickly with distance from road and that upland farmers, especially those some kilometres away from the road, were much worse off.

Rasuwa District

It was not possible to obtain statistical information on this District from the ADO.

Rasuwa District lie to the north-west of Khatmandu and borders Tibet. It can be reached by road from Khatmandu in a day, however the first area surveyed, Goljhung VDC, lies a further day down a good motorable road as far as Dunche, followed by several hours on roads passable by landrover. From there the team walked to a maximum distance of about 10km from the road, as far as Paragung village, in Chilime VDC.

Dunche is the nearest market town, which the local villagers can walk to in a day. It lies on a historical trading route with Tibet.

Agroecology in the surveyed villages was cool temperate mid and high hill upland production, with some very limited lowland river valley. 1800-2800m elevation.

In the mid hill areas 2-2.5 crops per year are possible (mainly wheat, maize, potato, radish, bean, pea).

In the high hills only 1 is usually possible (usually wheat, millet, potato, 'naked' barley).

Potato production in Rasuwa takes place in pockets of limited sub-tropical river basin, plus mid hill and high hill locations; commercially oriented production is principally in the river basin areas. By far the most production is for on-farm consumption in remote mid and high hill locations.

Potato planting time in the hills is generally March/April after the worst of the frosts have subsided

The distinction between upland and lowland fields as a socio-economic indicator was less useful in the remote villages visited; lowland fields were pretty rare and usually full of stones. More important are the land holding size, distance of cultivated field from house, and ownership of livestock. For inter-village stratification, motorable road distance is very important.

Goljhung VDC: Goljhung Village

This is a village of some 170 households; the population is generally very poor and run into food deficit for several months per year. Apart from agriculture, livestock are also important.

The village is the site of an Asian Development Bank (ADB) funded small farmer project which provides credit for fertiliser, seed and for livestock.

A road constructed some 7-8 years ago passes within 0.5 km and has brought limited market access (to Dhunche); the village as a whole sold some Rs 70,000 of peas last season; this seems to be the main cash income source, along with earnings from local porterage. Some 1000 apple trees planted a few years ago by the local ADO are expected to bring a further cash source in time.

At about the same time as the road was constructed, 'Kufri jyoti' improved variety was introduced by the ADO and is now almost universally preferred by the villagers for its greater yields (local varieties are acknowledged as being of greater consumption quality, but production criteria are paramount - see survey results).

The Kufri jyoti variety is said locally to have increased food availability by around two months per year. Typically the entire crop is consumed, although there may be some pressure selling or exchange for maize or millet.

Generally technical know-how is limited; potato is a fairly new addition to the cropping system; there is little understanding of optimum crop husbandry, inputs management etc, and little evidence of innovative activity/crop improvement.

Chilime VDC:

i) Paragang Village

This is a small village of 25 households some 10km (half a day) away from the nearest road. Market access is therefore very restricted.

The ranking of food sources determined by a village group discussion is i) wheat, ii) maize, iii) potato, iv) barley. Livestock production provides occasional meat; radish is grown as a vegetable.

These people are very poor; most of the households run into food deficit.

A recent severe land slip has removed some 20 ropani (1 HA) of land close to the village.

Cash sources are from the (apparently illegal but tolerated) production and sale of bamboo mats from a local forest and from porterage. Some of the villagers have sheep and goats which also provide limited cash.

There seems to be more potential from livestock as abundant suitable grazing lands exist, however these appear to be monopolised to some extent by Goljhung villagers.

There are also abundant forests and a year round water source, including a locally popular hot spring, close by.

The agricultural situation is similar in many respects to Goljhung except:

- no millet is produced
- no cash crop is produced;
- potato production is very recent; in some cases just the last year or two; interest by villagers is high;
- virtually zero use of purchased inputs;

ii) Gongang Village

A brief visit to this village showed a very similar picture to that in Paragang.

iii) Thambuchet and Chilime Villages

These villages are in the river valley and somewhat closer to the local road at around 2km. Some cash cropping is done (pea, bean), otherwise the picture is again similar to that presented above.

Appendix 4: Background Statistics on Nepal

Area = 147,181 sq km
Length = 885 km (East to West)
Width = 193km (mean) North to South

Topography: South to North:

- Fertile southern plains, 'Terai' (bordering India)
- Mid-hills (ca 1000m-2500m)
- High hills (bordering Tibet).

Population estimated at ca 19 million in 1990, growing at about 2% per year - apprx 95% Hindu; 5% Buddhist.

Nepal is one of the poorest countries in the world; per capita GDP was estimated at $160 in 1986.

Approximately 17% of Nepal's land is cultivable;
The Terai plains account for 57% of total cultivable area on one third of the land area.

The average land holding in Nepal according to the 1981 census was 1.13 ha. Most subsistence production in the hill areas takes place on much smaller holdings.

Only 14% of total cultivable areas was irrigated in 1985. Agricultural production is highly dependant on the summer monsoon, between June and September, which accounts for 60-80% of the total rainfall.

Agriculture accounted for 53% of GDP at current prices in 1987/8; when the trend was gradually down.

In the same year agriculture accounted for 75% of export value and more than 90% of employment.