Applied Agricultural Research for Small Farms in Asia

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Correction for Book 31, page 27, Table 2.

* Note: column 2 'Area sown' x 100

Year	Area sown (1000 ha)	Production (1000 mt)	Average yield mt/ha
1975	696	1.18	2.27
1976	724	1.28	2.31
1977	830	1.71	2.52
1978	872	1.93	2.61
1979	840	1.96	2.75
1980	845	2.18	2.93
1981	877	1.58	3.00
1982	845	2.20	3.26
1983	825	2.54	3.60
1984	990	2.41	3.07

Source: Department of Census and Statistics, Sri Lanka

PREFACE

The papers on which this Proceedings are based were first presented at an international seminar/workshop on *Applied Agricultural Research and Development for Small Farms*, sponsored jointly by the Food and Fertilizer Technology Center for the Asian and Pacific Region (FFTC), the Southeast Asian Regional Center for Graduate Study and Research (SEARCA), and the Philippine Council for Agriculture and Resources Research and Development (PCARRD). The seminar was held in Los Baños, Philippines, on May 13-18, 1985. I should like to express my warm thanks to the two co-sponsoring organizations, SEARCA and PCARRD, with whom the Center has enjoyed a close and mutually supportive relationship over many years.

There is generally acknowledged to be a considerable problem in transferring technology from the scientific laboratory to the farm. While the world has evolved highly effective means of developing agricultural research, it has been less successful in designing programs to make use of this research. Both on a world scale, and in the Asian and Pacific region, too many new technologies are being developed which do not take sufficient account of the particular problems of the small-scale farmer they are intended to serve.

The Food and Fertilizer Technology Center has always emphasized technology for the small-scale farmer who is the mainstay of the region's agriculture. The papers in this volume discuss technology for small-scale farms, and the problems involved in developing suitable technology, together with a discussion of ways in which these problems might be solved. The book includes a number of case studies of development programs designed specifically for small farms in the region.

It is hoped that this Proceedings will be of benefit to all those who are concerned with small farm development, particularly in the Asian and Pacific Region. The Center is greatly pleased to be able to publish a book on this important topic, and I wish to record my sincere thanks to the participants whose excellent contributions have made it possible.

T. C. Juang

T.C. Juang
Director, FFTC

FOREWORD

The gap between the world of scientific agricultural research, and that of the small-scale farmer with one or two hectares of land, has often been commented on, as has the fact that a great deal of current agricultural research is not producing technology that can be put to practical use by ordinary farmers. The problem is particularly acute in developing countries, since most modern agricultural technology requires a relatively high level of inputs such as fertilizers and chemical pesticides, which the small-scale farmer cannot afford and cannot obtain credit for. Often there is no economic analysis of new technology before it is extended to farmers, so that the level of profits, or even whether there is any profit at all after higher costs are absorbed, is not known.

All that is known is that the technology has done well at the research station, that it is agronomically successful under research station conditions. Whether it is even agronomically successful, let alone economically successful, at a small farm level is generally decided as a result of trial and error in the field, and error in this context means that the small-scale farmer has been convinced to invest resources he can ill afford in the hope of a return which did not materialize. It must be remembered that the small-scale farmer has little margin of error. Especially in developing countries, there is so little surplus production that crop failure or the death of a single animal may be a disastrous loss.

Small farmers in the highly industrialized parts of the region, in Japan, Korea and Taiwan, have higher incomes than those in developing countries, and are thus less constrained by lack of resources. They are also part of a rural structure in which all farms are small and farm incomes relatively equal, while most of the nation's wealth is generated by industry rather than by agriculture, which supports a well developed rural infrastructure. Even in these areas, however, the small size of farms is a constraint on economic development, and is a major factor in determining what kind of technology is economically viable.

For decades, the extension specialists of the region have been struggling to adapt and extend, as best they can, technology which was designed on a research station under very different conditions than local farms. They have been most successful at doing this in areas such as Taiwan and Korea, where research and extension are run by a single organization, or such as Japan where they are very closely linked under a joint administrative Lead (in Japan's case, on a prefectural level). Extension of new technology to small farmers in many other countries in the region has been less successful, in that much of the technology developed by scientists is not being adopted by farmers, and many farmers continue to practice what is still a largely traditional economy.

The papers in this book are all concerned with bridging the gap between the very successful agricultural research being conducted in the Asian and Pacific region, and the small-scale farmer. The two papers of the first section present a general discussion of the problems involved, particularly in developing countries, and discuss the implications of the small-scale farmer's lack of resources for investment into agricultural inputs. The second section presents a series of case studies from developing countries in the region of development programs designed specifically for small farms. The final section contains three papers on technology transfer in Taiwan and Korea, which, with Japan, have had such outstanding success in developing a prosperous modern agricultural economy based entirely on very small farms.

Jan Bay-Petersen
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TECHNOLOGY FOR THE SMALL FARMER

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INTRODUCTION

If present population growth rates continue, there will be roughly twice as many Asians alive in 25 years time as there are today. With the exception of countries such as Indonesia and Malaysia, most of the good arable land in the region is already in use. Therefore, the only possible way to feed this huge population is by intensification of agricultural production. Either more crops per year must be grown, or the yield of existing crops must be increased. Although impressive gains in food production have been registered in the region in the last two decades, these will not be enough to avert a very serious situation by the end of the century if present policies are continued. The United Nations Food and Agriculture Organisation[1] has estimated that unless decisive action is taken, the number of seriously undernourished people in the Far East will rise from about 300 million in 1975 to more than 400 million in 2000. The potential to avert this situation exists in abundance in the region. Production can be increased many times over, but only when water supply and control are improved, and when fertilisers, herbicides and pesticides, and suitable farm machinery, are made available to the average farmer. Both governments and farmers have to invest more money into farming, for this to be made possible: Governments must provide large infrastructure objects such as dams, irrigation and drainage structures, and the farmers must use more inputs such as fertilizer and suitable machinery. However, at the moment, many countries in the region are not helping this to happen, since they are making it virtually impossible for the average farmer to buy the necessary inputs.

AFFORDABLE TECHNOLOGY

Probably no two words in the English language have been so badly misused in the last decade as 'Appropriate Technology'. This has steadily come to mean technology which is simple and in many cases third-rate. I believe that the time has come for a different approach. Let us first see what the farmer can now afford, estimate whether this is adequate for requirements and, if not, what is required to provide him with the necessary technology. The technology in use in the region today varies enormously, ranging from countries such as Japan where agriculture is almost completely mechanized, to countries such as Bangladesh and Nepal where the technology in use is still quite primitive.

When looking at relative costs of agricultural inputs in different parts of the region, one can translate them all into one currency such as U.S. $ and compare them. However this does not give an accurate picture of what the farmer can afford, since the farmer's currency is the crop he grows and which he must sell to obtain the money to make such purchases. Rice is by far the most important crop of the region, indeed is the most important food grain in the world. It is useful, therefore, to cost inputs not in dollars or rupees or pesos or baht, but in how many metric tons of rice a farmer must sell to buy these inputs. Figure 1 shows such a costing for selected countries in the region. Using figures from the Asian Productivity Organisation[2], it shows how many metric tons of paddy a farmer must sell in different countries in order to be able to buy a small power tiller. A huge variation is apparent from country to country. In Japan, a farmer needs to sell only one mt of paddy to buy a power tiller. In Indonesia, the figure shoots up to 28 mt. In practical terms, this means that it is 28 times more difficult for an Indonesian farmer to buy a power tiller than a Japanese farmer. Using figures from Herdt and Palacpac[3], Fig. 2 shows how many kilograms of paddy must be sold by farmers in different countries to buy one kilogram of nitrogen fertiliser. Again a huge variation from country to country is seen. A Japanese farmer has to sell only 0.5 kg of paddy to buy 1 kg of nitrogen fertilizer, while his Thai counterpart has to sell 4½ kg i.e. fertilizer is 9 times more expensive for Thai farmers than it is for Japanese farmers. Small wonder, then, that fertilizer use in Thailand is one of the lowest in Asia.

One can take the calculations one stage further. Again using data from the Asian Productivity Organization[2], Fig. 3 shows, for a farmer in different countries on the average sized farm in that country, with an average paddy yield, how many complete crops of paddy must be sold to purchase a 6 kW power tiller.

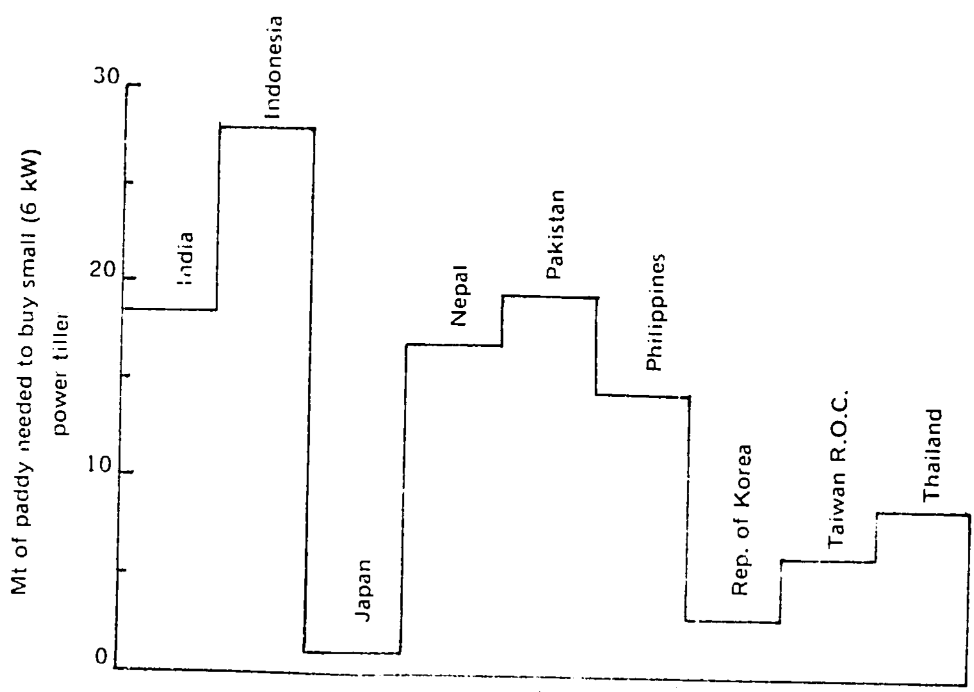

Fig. 1 Mt of paddy which must be sold in different Asian countries to buy a small power tiller

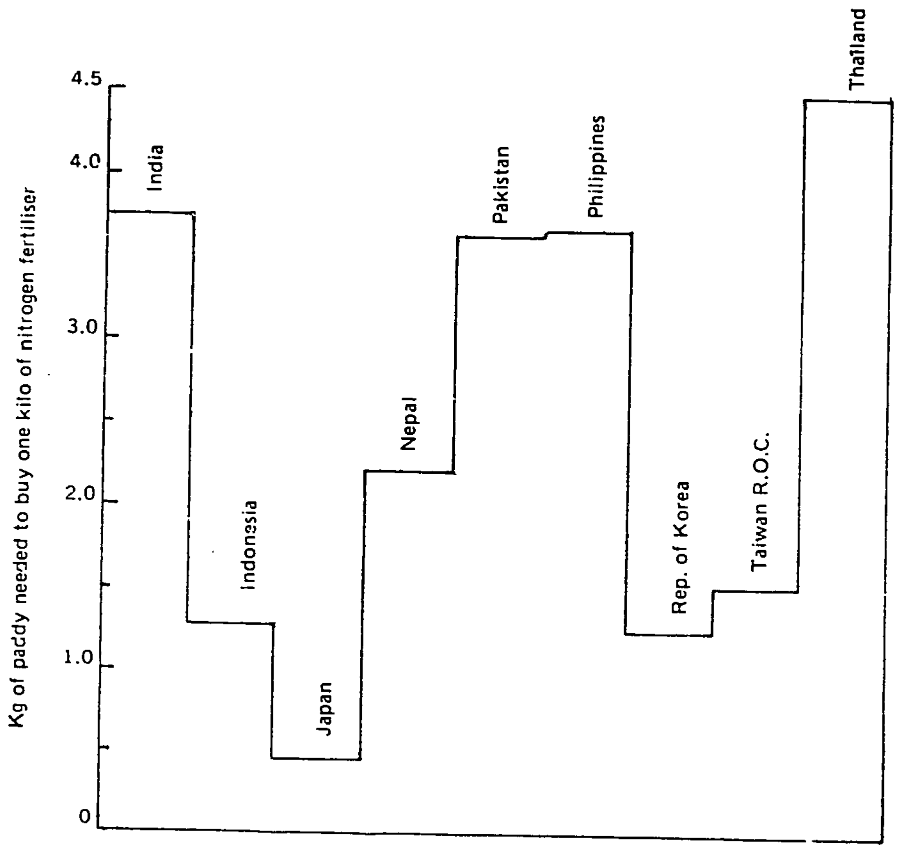

Fig. 2 Kilograms of paddy rice which must be sold to buy one kilogram of nitrogen fertiliser

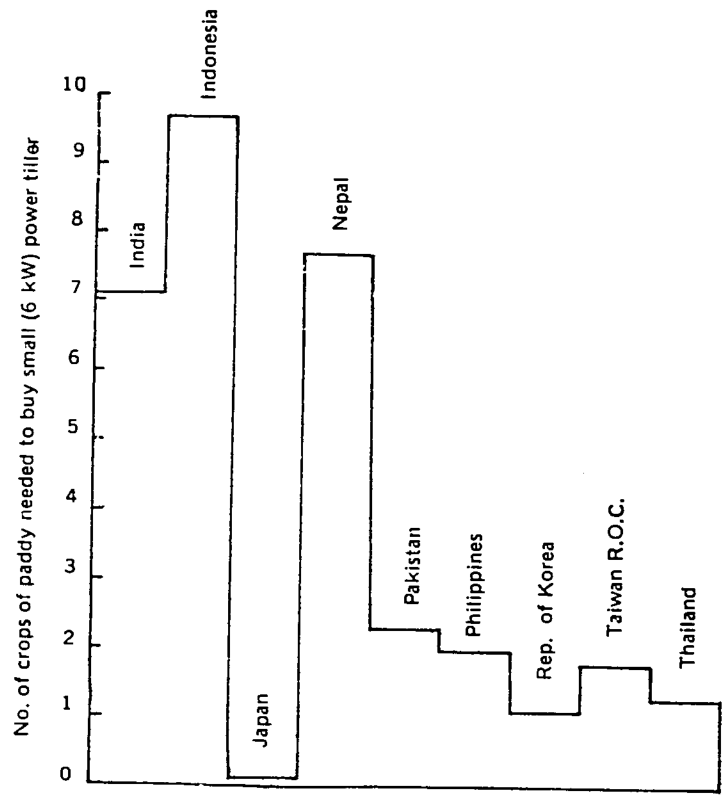

Fig. 3 Number of complete crops of paddy from average sized farm with average yield to buy a small power tiller

In Japan the figure is 0.1. in Indonesia 9.7, in India 7.1, in Nepal 7.7. The consequences of this are shown in Fig. 4. Fig. 4 is virtually an inverse of Fig. 3. In those countries where power tillers are, in real terms to the farmer, affordable, then quite large numbers are in active use. However which farmer, anywhere in the world, can find someone to mortgage him for between 7 and 10 years complete income?

As stated in the Introduction, there is a very strong requirement for increased food production in Asia over the next 25 years. Fig. 5, again using data from Ref. 2, shows the average paddy yield in selected Asian countries as a function of the price paid to farmers. Fig. 5 shows two things; it shows the potential for increased food production in this region, and it also shows that this potential will not be realized unless farmers are given the income, by way of higher food prices, to be able to intensify food production.

Indeed I would go so far as to say that, in many cases, the major problem in agriculture in Asia today is not a technological one at all. A great deal of suitable technology already exists in the region, and is being used in some countries. Some, like the Thai power tillers, the 'Turtle' tillers from the Philippines, and the Chinese reaper-windrowers and rice transplanting machines, have been developed inside the region itself. The main problem is not the technology available, it is that policies of cheap food prices make it impossible for the average farmer in many countries to avail himself of this technology.

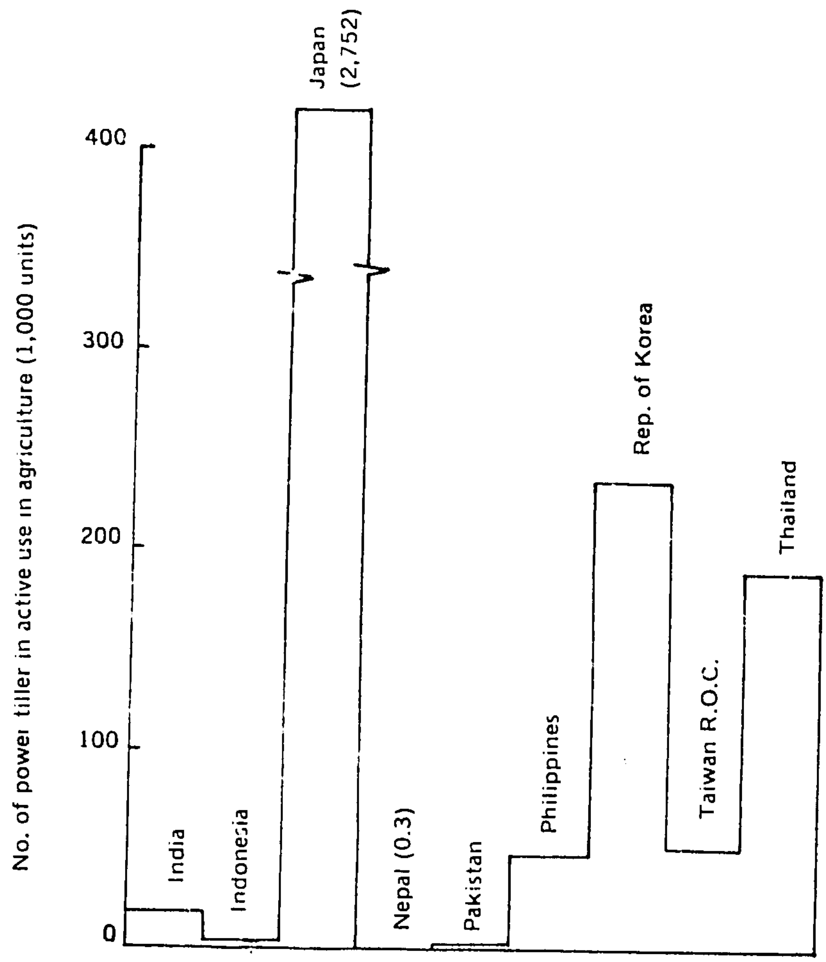

Fig. 4 Number of power tillers in active use in agriculture in different Asian countries

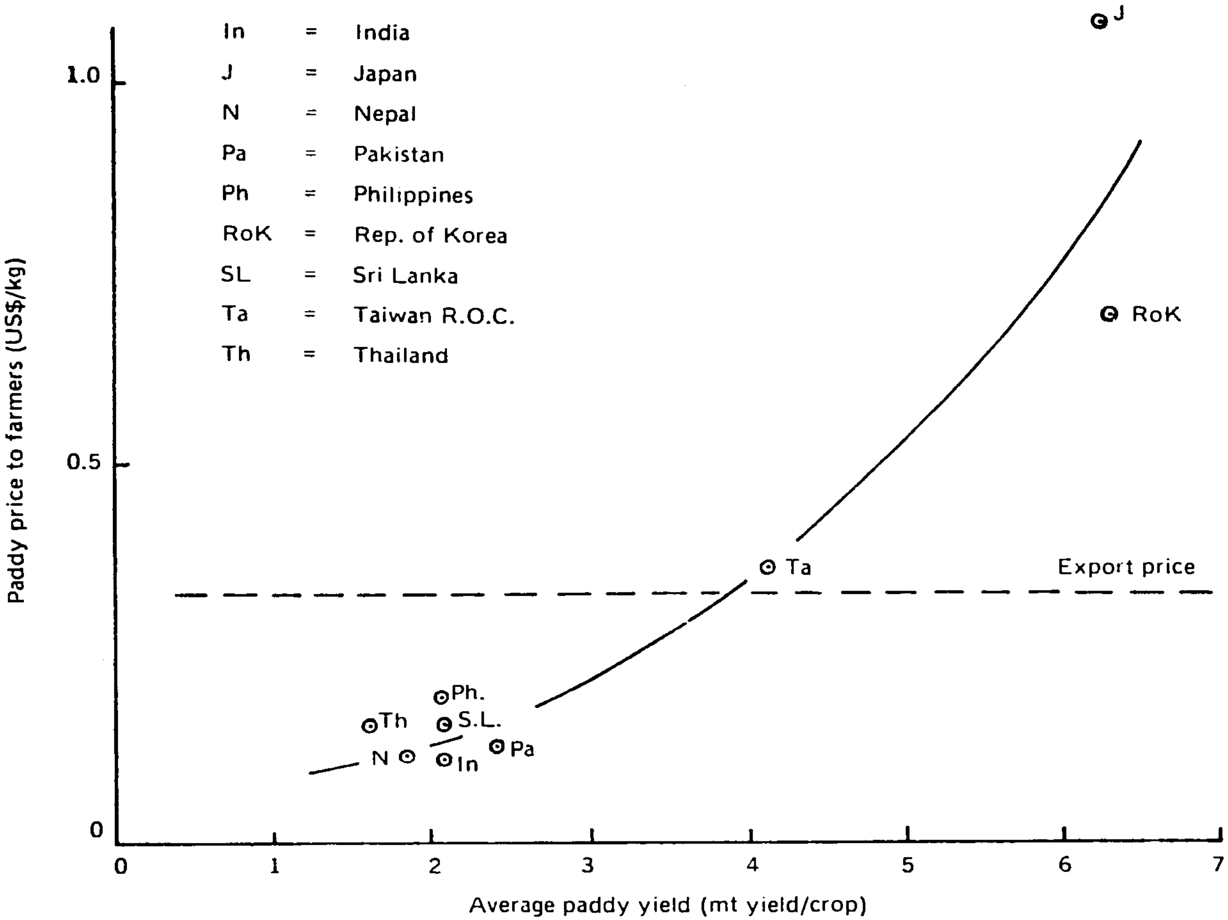

Fig. 5 Average yield of paddy as a function of price paid to farmers (1981 prices)

CONCLUSIONS

Food production in Asia can be increased to meet the projected demand over the next 25 years. However, attitudes to food pricing will have to change if this is to be made possible. This is of course a highly charged political issue. The urban elite in many countries will be strongly opposed to paying more for their food. The alternative, however, is that Asia may be seriously short of food in the near future. The Asian farmer has shown that he is perfectly capable of increasing production up to the required levels. However, he must intensify production to be able to do this. If his income is not large enough to afford the necessary inputs, then all his skill and determination will count for nothing.

More than 60 years ago, when the Soviet Union started its transition from a predominantly rural society to the highly sophisticated society it is today, industrial development was made a top priority and agriculture was made to finance industrial development. The result is that even today, the Soviet Union cannot adequately feed its own population, and most years must import millions of tons of grain to meet its food requirements. It would be foolish for the emerging nations of Asia to repeat that mistake. Indeed it would be more than foolish, it would be tragic.

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DISCUSSION

Q. Thank you for your very clear statement of the problem. What can we do to solve it?

A. Farmers' organizations in Thailand have made many representations to the Government about prices. If farmers' organizations could be strengthened, this would be most effective. In my own country, Great Britain, the National Farmers' Union is a very powerful and effective organization, which lobbies Parliament and influential people to persuade them to the farmers' point of view. As long as five million farmers have five million points of view, nothing can be done. However, if they speak with one voice, they are very influential. Historically, it has been difficult for farmers to organize, but very effective when they do.

Q. With regard to farm mechanization, I should like to ask to what extent farm machinery has displaced farm labor and led to unemployment among rural workers, who as a result have had to leave their farms. Furthermore, in Central Luzon we have found that many farmers who have adopted power tillers would like to go back to ploughing by water buffalo, but find it difficult to do so. They find that the cost of oil and spare parts is now so high that machinery is no longer economical, but often production loans and access to irrigation water depend on the adoption of farm machinery.

A. The question of whether agricultural machinery is labor displacing or not depends on how mechanization is carried out. Some studies indicate that it is labor displacing, others indicate the opposite. In Northern India, for example, mechanization has increased production so much that it has increased the labor demand. The wrong kind of machine, introduced at the wrong time, may have the opposite effect. For example, it would be disastrous to introduce the combine harvester at this time into the Philippines.

The increase in the price of oil in the 1970's did not slow down the growth rate of sales of agricultural machinery in Asia. These sales took place for a reason – farmers must have good reason to buy machinery.

Q. You say that one way of enabling the farmer to buy more farm inputs is to raise food prices. However, if consumers have to pay more for rice, businessmen will have to charge more for inputs.

A. This is the old inflation argument, but if there is a strong demand for increased production, some change has to take place. If there is no price increase, rice yields will stay at their present level of c. 2 mt/ha.

In Europe after the Second World War, there was widespread destruction and fear of famine. The Common Agricultural Policy of the EEC was set up to stimulate agricultural production through pricing policies. This was so successful that there are now big surpluses.

AGRICULTURAL RESEARCH TO HELP THE SMALL-SCALE FARMER IN DEVELOPING COUNTRIES

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INTRODUCTION

After decades of modern agricultural research, the small-scale farmer in most developing countries is still poor, and is still operating a largely traditional technology at little above subsistence level. In nearly every case, this type of farming co-exists side by side with highly capitalized commercial farms, on which wealthier farmers have adopted modern agricultural technology, with considerable success. The modern agricultural technology has not been developed with the wealthier farmer as the specific target, but nor has it been designed specifically with the poorer small-scale farmer in mind. It is always the strong who are best able to take advantage of changing circumstances and new opportunities. On the whole, agricultural research in the developing world is now benefiting those who need it least—those who are well endowed with resources and who are already practising modern, highly productive systems of agriculture.

If agricultural research is to help the small-scale farmer, there must be a selective emphasis on technology appropriate for the typical small-farm situation of scarce financial resources, poor access to information and transport, a scarcity of market outlets both for purchasing agricultural inputs and selling farm produce, and, of course, a limited land holding.

SELECTION OF APPROPRIATE TECHNOLOGY

At the moment, one of the main criterion for evaluating an agricultural innovation under development is whether it is agronomically successful. Typically, a research report concludes with an account of the extent to which the new technology has increased production, compared to the control. To develop technology suitable for the small-scale farmer, this must be only the first step.

The second question must be whether it is cost effective. To answer this adequately is likely to require farm testing under local conditions, in that prices of both inputs and produce vary considerably, depending on the number of suppliers/wholesalers and their distance from population centers. Even a fairly general indication, however, would be a considerable improvement on the present situation, whereby it is left to the individual farmer to test by his own experience whether investment into additional farm inputs is profitable or not.

Provided a new technology proves to be agronomically successful and economically viable, it is then essential to evaluate new technology in its context of use by the small-scale farmer.

Although it is obvious that small-scale farmers in developing countries, particularly in remote rural areas, are unlikely to be able to duplicate the experimental conditions of research stations on their own farms, this aspect is often not given sufficient emphasis. Farm testing of new technology will be discussed in a later section of this paper. On-farm research is a very rewarding approach in developing and testing small farm technology, but it is expensive and time consuming. Furthermore, its very advantage, that technology is tailored to closely fit local requirements, also has the drawback that repeated testing may be necessary in different areas to cover different situations, particularly in countries where small farms follow diverse agricultural patterns in a range of environments. Some preliminary assessment of technology in terms of its suitability for small farms, is needed, not only for new but also for existing technology.

The most obvious general requirements are that it should be simple and cheap. Technology for the small-scale farmer in developing countries should also be assessed in terms of its probable mode of use. It is well known that experimental results obtained in field trials are usually higher than average yields obtained on ordinary farms, because the research plot is given a higher standard of management. Research needs to be assessed in terms of its success or failure when low-cost local materials are substituted for recommended ones, or when inputs applied have a lower quality or quantity than those recommended. Some types of technology are comparatively flexible in their requirements, while others involve a more rigid set of conditions which must be met if the technology is to succeed. The latter type of technology should not be introduced to the small-scale farmer unless there is good infrastructural support to ensure that farm practices reach a sufficiently high level, which is unlikely to be the case in a developing country.

For example, a system of pest control which is effective and economical, but which requires a close match between pesticide and pest species, accurate timing of pesticide application, and strict control over quality and quantity of pesticide, is not likely to be suitable for the small-scale farmer in developing countries. Nor is the high yielding variety which is highly successful only under good management and with a high level of standardized inputs, unless the small farmer has strong government support and a good supply and distribution system. Where the farmer, in spite of subsidies, must operate independently for the most part, according to his own scarce resources, as is usual in developing countries, a less demanding variety, even if less productive, would be preferable.

Varieties or agricultural techniques which are flexible in terms of site and management level are also more likely to be resilient to other factors such as weather and pests, which means a lower level of risk in small-farm investment.

I also wonder whether it would not be useful for farmers and extension specialists if more information were available concerning *minimum* effective rates. It is quite common for the small-scale farmer with a limited knowledge of fertilizers and soil nutrients to apply very small quantities of fertilizer, which are all he feels he can afford, in the belief that some fertilizer is better than none. Below a certain critical level, this is not true: applied fertilizer has no detectable effect on crop yield. Of course, there will be some slight increase in soil fertility, but any slight increase in yield this produces is outweighed by the effect of other factors such as the weather or the extent of crop damage by pests.

Indications of minimum effective rates are not usually part of the standard recommendations to farmers on fertilizer or pesticide rates– perhaps in developing countries they should be. Information on minimum critical levels is implied in fertilizer response curves, but it is fairly rare to find a clear statement of minimum effective level based on these, and such statements tend to be scattered through the litterature in publications on a variety of topics. For example, Dr. Keerati-Kasikorn in a paper on soils and pasture development refers to research indicating that on phosphorus deficient granite soils in northern Thailand, even where phosphorus deficiency was severe no response was seen to applications of 20 kg/ha P or less: if the farmer could not afford to apply effective rates, it was better to apply no phosphorus at all. (Keerati Kasikorn 1984, Gibson 1975).

Although most experienced agricultural extension agents working in the field with small farmers must have a fairly good idea of the level at which fertilizer or pesticide applications are too low to be effective, knowledge based on experience is formed as the result of trial and error. Error in this situation means that the farmer has been convinced to make an investment, out of scarce resources, in the hope of a return which did not materialize. Modern technology has failed him, and made his already difficult situation worse.

It is sobering to realize that we shall never know how many thousands of small-scale farmers have suffered from trying to modernize their production, using means which were ineffective and inappropriate, because they misunderstood the nature of the technology they were dealing with, and because they were constrained by poverty to approximations of the model recommended by the extension specialist.

SMALL FARM INNOVATIONS AND RISK AVERSION

It is widely acknowledged that the risk factor is an important component in determining whether a farmer will adopt technology which is new to him, and that it operates particularly against the poorer farmer, in that he has few reserves to protect him in the event of failure. A number of studies have emphasized the role risk aversion plays in slowing down the adoption of new technology. Small-scale farmers have no margin of error, because there is little or no production surplus. Crop failure or the death of a single animal may be a disastrous loss, 'A poverty ratchet on an irreversible course to greater misery' (Robert Chambers, quoted Roling 1985 p. 17).

Both common sense and several published surveys indicate that small-scale farmers are likely to be slower to adopt new technology when the risk involved is high. However, in practice the risk factor seems to have had a surprisingly small effect on research design or technology recommendations, where small farms are concerned.

In part, this is because it is difficult to evaluate the importance of risk aversion in farmers' response to new technology, and it is difficult to incorporate into research something it is not easy to demonstrate and is impossible to quantify.

The relationship between the adoption or rejection of new technology and risk aversion is not a simple one. As Feder *et al* (1981) have pointed out, innovation entails both a subjective risk, in that lack of familiarity with new technology makes the farmer's yield less certain, and an objective risk, in that the innovation mav be more vulnerable to bad weather or pests than the traditional practice it replaces. The farmer's assessment of the risk involved is a composite of many factors, of which the nature of the technology itself is only one. Others include his faith in the extension worker's competence, previous experience in agricultural innovation, and the amount of information he is given concerning the new technology. (A number of studies have shown a strong relationship between the farmer's decision to adopt new varieties and his access to information about them, whether by extension agents, demonstration plots or the mass media) Furthermore, new technology may in some cases reduce rather than increase risk, as when effective pest control techniques lower the risk of crop damage or failure (Roumasset 1977).

The difficulty involved in isolating or measuring the different variables means that, although risk aversion is assumed to be a component in the behaviour of small-scale farmers (as it is of human beings generally), there is very little certainty as to its relative importance, and as to the extent to which the farmer's perception of risk is a correct one.

There is, however, a growing feeling that in many cases a small-scale farmer's refusal to risk investment in new technology may be justified, in the sense of being a correct assessment of the objective facts. When agricultural scientists and extension specialists first faced the problem a few decades ago of the widespread refusal by small-scale farmers to adopt modern agricultural technology, researchers naturally looked for an explanation by comparing the farmers who did not modernize with those who did. At that time, modernization of agriculture implied a strong value judgement, and it was generally assumed that those who adopted new technology were enterprising and innovative, while the 'laggards' who did not represented the more conservative and passive farmers. Later, it was realized that the innovators were not so much enterprising as comparatively wealthy, while the laggards were generally poor, so that the major cause of non-adoption was believed to be lack of resources with which to do so. In the neat phrases of Capland and Nelson, 'person blame' was replaced by 'system blame' (Capland and Nelson, quoted Roling 1984). The chain of causation was felt to run from wealth to innovation, rather than the reverse, as had been believed earlier (Meyers 1982).

The poverty of the small-scale farmer in developing countries means that, not only does he have few resources to invest, but that any capital investment at all involves a much higher level of risk than it does for the wealthy farmer. It is a tenet of gambling that a rational decision on whether a risk is justified or not depends on an evaluation, not only of potential losses versus potential gains, but of whether those potential losses are manageable (should they occur) in relation to assets already owned. The degree of risk involved in investing $100 depends, not just on the chances of success, but on the proportion between that $100 and the investor's total resources. A $100 investment is a very small risk to a millionaire, whatever the probable outcome, but it is a very big risk to a poor man with an annual income of $200.

Technology for the small-scale farmer, therefore, should carry as little risk as possible, and the level of risk should be defined in terms, not only of the probability of gain versus loss, but in terms of the proportion the maximum possible losses bear to total farm income.

An example of programs for small-scale farmers which have not taken this aspect sufficiently into account can be seen in several livestock programs recently established in this region. These are intended specifically to give the poorer farmer supplementary income. Several of these programs provide the farmer with livestock on credit, the money to be repaid when the animal is sold for meat after being fattened by the farmer, or from the profit from dairy products. However, even when large, very expensive animals such as cattle are involved, there is generally no livestock insurance program. The farmer bears the whole risk of the value of the animal, which may be more than his total annual income.

Low-input Agriculture for the Small-scale Farmer

In view of the lack of resources characteristic of the small-scale farmer in developing countries, in the absence of strong government support both livestock and crop production programs designed for such farmers should emphasize low capital investment and low risk, rather than maximization of production. Modern agricultural research aimed at maximizing production nearly always involves relatively high inputs, since the basic strategy is to breed plant or animal species into varieties which are extremely efficient converters of nutrients to agricultural products, and then manage these improved species in such a way as to maximize their rate of conversion.

A research bias towards capital intensive technology with a high level of inputs always mean a bias towards the large-scale farmer. Research for the small farmer means an emphasis on *the circumstances of the user of the technology*.

Risk Aversion — The Longterm Considerations

A further point to consider in the problem of risk aversion and new agricultural technology is that the scientist tends to evaluate success over rather a short term – two to three years is a common period for farm testing for a particular technology while the farmer's time scale in evaluating success is a very much longer one, continuing indefinitely into the future over the generations.

As Newman *et al.* have pointed out (1980), it is common in studies of farmers at a micro level for researchers to assume a 'point bias' a tendency to consider the farmer at one point in time, and overlook the fact that the farmer today is a product of what happened in the past. To the agricultural scientist, traditional farming practices appear inadequate, almost a failure, since he compares their productivity with the potential yields of new technology. To the farmer, the success of traditional agriculture has been demonstrated by the fact that it enabled his ancestors to survive and give rise to surviving descendants, as he hopes to do himself. The traditional farmer has inherited his farm practices, and the social structure which goes with them, as part of a cultural tradition which has roots in the distant past, but which has been constantly modified to adapt to changing circumstances. It is true that some traditional farming systems, in particular slash and burn farming, are at the point of collapse, but in general terms the traditional farming economy could reasonably be viewed as a composite of successful adaptations and decisions carried out over a long period of time, a system which incorporates the information gained by centuries of farming experience.

It can be assumed that the present day farming system is at least partly geared to survival in the long term, in the face of crises such as drought which may occur only intermittently but are potentially disastrous. It is a basic tenet of biology that the population of a species is determined by the amount of food available at the time of greatest food shortage. Although human beings can use technology to store food reserves more efficiently than any other species, famines are part of the history of every human society. Famines can occur without any substantial change in food availability: what is important is access to food and who is entitled to it. Although there are food exchange relationships in most traditional farming communities, for the most part the farm household operates as an economically independant unit in terms of subsistence, and is dependant on its own efforts for its food. Any shortfall in food production in any one year is likely to mean hunger, and this consideration has been influencing the farm economy since its earliest beginnings.

If we view the traditional agriculture as a longterm survival mechanism, a number of farm practices which seem relatively inefficient at any one point in time may be advantageous in the long term, in terms of increasing the chances of survival. For example, in his analysis of smallholder agriculture in Western Province, Kenya, an area with a seasonal rainfall in which the main rainy season is followed by a very dry one, Oluoch-Kosura found that farmers could obtain the highest yields of maize (the staple crop) if they planted early in the rainy season, so the maize could ripen while soil moisture was relatively high. However, if he planted early, he also ran the risk of a delay in the rainy season and a crop failure from water shortage. 'Farmers tend to forgo the higher yields which result from early planting in favor of a greater certainty that the rains have actually started, and will continue' (Oluoch-Kosura 1983, p. 11).

Of the farm practices which are retained by the farmer in preference to modern agricultural techniques, it is difficult to identify those which have a long-term protective function. However, an effort by researchers to identify long-term survival strategies in the traditional agricultural economy may give a better understanding of the particular local environmental constraints, and how to overcome these with limited resources.

Minimizing Risk — Not Just a Technological Problem

To regard research as the key to development implies that the problems of third world farmers are predominantly technical ones. To a large extent this is not true: the primary problems are organizational ones. Study after study of rural conditions has found that in developing countries there is a marked lack of credit facilities for small-scale farmers, or if government or bank credit is available, complex and lengthy procedures are needed to obtain it. Supplies of inputs such as high quality fertilizers, seeds and pesticides at controlled prices are inadequate. Even where these constraints are overcome and increased production is achieved, local markets are generally incapable of offering price levels high enough to encourage innovation: indeed, increased production is likely to glut local markets and lower prices even further. Higher prices are available at town or city markets, but these are usually paid to the middleman rather than the producer, who is isolated by poor roads, lack of transport, and often, a powerful closed network of dealers. 'Under these conditions, a refusal to adopt innovations in agricultural technology is a rational response to objective conditions'. (Murdoch 1980)

It should also be remembered that the three countries in the region (or indeed in the world) which have been most successful in transforming largely subsistence farming into modern commercial farming by small-scale farmers– Korea, Japan, and Taiwan ROC– did so during the 1950's and 1960's with the technology available at that time. From 1953 to 1962, using the agricultural technology of a generation ago, Taiwan increased its agricultural output by an average of 4.8% per annum, and from 1963 to 1972 production continued to increase by over 4% each year. Two Chinese economic experts, Hsieh and Lee (1966) have argued that the main secret of Taiwan's economic development was her ability to meet the organizational requirements, particularly in terms of providing public goods at socially optimum levels and prices. Thus Taiwan in the early 1950's had an effective supply and distribution system for chemical fertilizers of standardized quality. Land reform achieved social equity in rural areas, and gave the farmer the land he tilled and the profits from his labor. Taiwan has also established a highly efficient production and distribution system for improved seeds and other inputs, and a farm produce marketing system which gives the farmer a high level of marketing information and choice of marketing outlets, along with good rural transport to take produce to market. Agricultural development in Japan and Korea has followed a similar pattern.

Taiwan's policy of decentralized industrial development, which provided rural areas with employment opportunities, also provided farmers with off-farm income to invest in agriculture. By 1980, 91% of Taiwan's farmers were part-time and earned most of their income in the industrial sector. Income generation in rural areas may be an important factor in encouraging agricultural innovation by small-scale farmers. Several studies in Kenya, for example, have suggested that income earned off the farm is a key element in determining farm productivity and output, because of the technological improvements it makes possible. Other studies, however, from the same country indicate that, given the choice, smallholders prefer to earn supplementary income off the farm rather than by cash cropping, largely because off-farm income is more reliable (Meyers 1982).

Probably increased employment opportunities vary in their effect on smallholder agriculture in different areas, and even on different farms in the same area. The smallholder may or may not wish to use the income thus generated to invest in increased agricultural production. However, it is certain that without capital or credit, he is unable to do so even if he wants to.

BRIDGING THE GAP BETWEEN THE SCIENTIST AND THE FARMER

It is now become a commonplace that the farmer's selection and use of agricultural technology is related to a range of socio-economic factors. Of these, economic gain is only one motivating force, and may be less important than social and cultural factors.

Like the world of the farmer, the world of the scientist has its own socioeconomic factors, which govern behavior and influence choices. The scientist in developing countries has much the same career structure as his counterpart in the developed world, in which sucess is rewarded with increased income and prestige -- success in this context meaning scientific success. The practical effectiveness of his work in developing small farm agriculture is not part of the scientific career structure: since this is usually not monitored, it is not usually known, and therefore has no public impact, unlike the conference papers and publications which build a scientist's reputation. In most developing countries there is in fact an organizational barrier between the scientist and the farmer, in that research and extension function independantly of each other, and the extension services regard contact with farmers as their professional territory, to be defended from encroachment by outsiders. Those programs which combine research and extension in a single organization have generally been very successful, as for example the seed development and distribution program in Thailand, which is one of the most successful improved seed programs found in any developing country.

The great advantage of combining research and extension into a single system is that research can incorporate feedback from farmers, so the scientist is able to correct research design where necessary and produce innovations which are acceptable to the small farmer. It also becomes possible for the scientist to find out the research needs of the small farmer; a question which is generally ignored by the world of research.

If the scientist is to develop technology appropriate to the small farm situation, he needs to know if the innovation is compatible with the rest of the present farming system; if the necessary labor and inputs are available to operate it; if it is economically feasibly and gives viable returns; and if it is in accordance with the social and cultural values of the farmer.

> " ... scientists can come closer to understanding their [farmer] clients by trying to 'think like a farmer'. If in the farmer's place, given the circumstances and resources, what would be one's view of the technology being proposed? At this point it is best to remember a simple rule of thumb: the farmer is the teacher, 'the expert' about local farming practices, and much of value can be learned from the farmer". (Rhoades 1984, p. 65).

Increasingly, agricultural research for small-scale farmers in developing countries is being integrated into the extension process, and farm testing of new agricultural technology is now being pioneered by most of the international agricultural centers, as well as a number of national agricultural organizations.

The testing of research at the farm level helps ensure that the technology is appropriate, not only to the farmer's requirements, but to the requirements of the particular local environment, which is likely to have a number of constraints not present in the research station.

FARM TESTING OF NEW TECHNOLOGY

Agricultural research is concerned with isolating major determining factors affecting the success or failure of a particular system of crop production. Thus, it is carried out in such a way as to subject the experiments to strict scientific control, in order to eliminate as far as possible variability caused by external factors in the environment, so that the effect of the factors under study can be measured exactly. What emerges is a model which, under the conditions tested, has proved markedly successful in achieving its stated ends.

Whereas the research station where the model is developed tends to emphasize uniformity as part of the scientific method, small-scale farmers show marked variation in production practices within even fairly small areas, reflecting the heterogeneity of the natural environment. The extent to which the model is successful when applied elsewhere will be mostly related to the degree of similarity between the field conditions at the test site and those where the new technology is being applied.

Heterogeneity in farmers' fields is likely to be more marked in rolling or upland terrain, where differences of slope and altitude produce a variety of microclimates, and is also more likely to be more marked in rainfed areas, in that wetland rice cultivation by its nature has created an artificial, relatively homogeneous, production environment. Small farmers are experienced only in local conditions, but they have spent their lives observing these, and are likely to be very much aware of even slight differences in soil moisture, fertility, micro-climate etc. As mentioned above, long experience is likely to have worked out production practices which are finely tuned to the requirements of the particular environment. Thus one study of farming practices in a mountainous part of Ecuador found more than 100 different cropping patterns within a small district of 3 km^2, all of which incorporated the staple crops of maize and beans in various combinations, using a range of local varieties The authors concluded that

> "It is evident from many conversations that farmers have extensive knowledge about their ecological environment and the effects it has on their crops. While farmers often cannot express or understand such knowledge in scientific terms, we recognize that small farmers have taught us a great deal about the relationships between crops, physical and biotic factors of the environment and the activities of man in the Project area.
>
> A farmer chooses the crop or crop association, the variety and the plant-to-plant spacing according to the characteristics, including potential productivity, of each piece of land. Furthermore he understands the need to adjust these agronomic factors as soil fertility changes ....
>
> Bearing in mind the rationality of many local practices, we do not believe that experiments to determine rotations, associations, or optimal planting densities within the range of crops and varieties presently available in the area would be worthwhile. However, more information about these factors may be needed whenever this would allow the improvement of criteria to be employed in the selection of potential innovations". (Kirkby, Gallegos and Cornick, 1931. p. 18)

Although research centers in the Asian and Pacific region have often in the past carried out field trials in farmer's fields, and extension services have laid out demonstration plots in rural areas which have followed much the same pattern, it is only fairly recently that farm testing has been carried out on a large scale as an integral part of major research projects, using several test sites, a careful delineation of the area under study, and careful selection of test farms to ensure that they constitute a representative sample of the target group. It is usual for this type of testing to be combined with a study of the crop production system already in existance, both as a source of information and for comparative purposes. Assessment of the technology and evaluation of the trial is based, not just on yield, but on the farmer's assessment of the technology under test, and the cost/benefit ration involved. Methodological problems such as sample selection, experimental design, and how to evaluate the traditional technology in terms of effectiveness and yield, are still being worked out.

Because of the difficulty in obtaining precise information, and the lack of control over many variables, farm testing is a difficult type of research to carry out. Some of the major difficulties involved are outlined in the outstanding report of the collaborative research into small-farm potato production in the Philippines, carried out by the International Potato Center (CIP), PCARRD, and the Ministry of Agriculture of the Philippines. (Potts ed. 1983). Initially, they found that farmers tended to cultivate the test plots by the method they considered most useful, rather than the experimental design of the scientists, which made the comparison of plots very difficult: they also found that their original sample of farmers who took part in the farm testing represented wealthier farmers, with larger farms than the target population of ordinary farmers. These problems were later solved by revising the methodology of the trials, including the method of site selection, and by reducing the size of test plots so that small farms could be included.

Data collection, and particularly quantitative data on yields from traditional practices as a comparative base, is a major problem in research carried out in farmers' fields. This is hardly surprising, since it is the data from research carried out under controlled conditions in the experimental station which sets the standards of scientific accuracy.

The effectiveness of on-farm research in the development of technology suitable for the small-scale farmer is already making itself felt. International agricultural research centers are allocating it an increasing level of personnel and funds, and the approach is being adopted by a growing number of national agricultural research organizations. It seems that on-farm testing of new technology will become a major part of all agricultural research in developing countries in which the technology is intended for adoption by the ordinary farmer. On-farm research is a process, not only of technology testing, but of technology generation, as farmers contribute their specialized practical knowledge to the information pool.

CONCLUSION

To feed their growing populations and raise the living standards of their people, developing countries must increase their agricultural production, and it is the agricultural scientists working in these countries who will develop the means to do this. However, in his pursuit of technological improvements, the scientist in developing countries has paid too much attention to the end increased production and too little attention to the means the user of the technology, the ordinary small-scale farmer with limited resources. Much of the technology developed over the last few decades is not appropriate for the poor farmer, but for the comparatively wealthy. It does not use inputs the farmer can produce himself from his own local resources, it uses inputs manufactured outside the local system which the farmer is ill equipped to finance. It is often rigid in terms of the quality and quantity of inputs required and the timing of these, although in general developing countries cannot afford to supply the poor farmer with subsidized inputs and the necessary information to ensure that these technical requirements are met.

In part, this research bias stems from the very success of modern technology, which enables the wealthier farmers who use it to attain very high levels of production, and often supply a major part of the agricultural produce grown for the commercial market and for export. In part, it is because in nearly all societies there are few structural linkages between the farmer and the scientist. Finally, the research bias towards high input agriculture also partly stems from the fact the scientific method in itself, by which strongly controlled experiments test a limited and quantified range of variables, is best fitted for the development of technology which follows a similar pattern highly controlled inputs in controlled environments.

This may be the reason why modern agricultural research in developing countries for small-scale farms has been most successful where the farmer's control over the agricultural environment has traditionally been strongest i.e. wet rice cultivation. This is also the system of traditional agriculture which has the highest level of inputs, both of labor and materials.

Developing technology for the small-scale upland farmer is proving much more difficult. Dryland fields are much more variable than paddy fields, so it is more difficult to develop standard recommendations for new technology. The rainfed farmer has less control than the wet rice farmer over the variables affecting his crop, and in a climate of seasonal rainfall has no control over his most vital input, water.

Since the timing and quantity of rain generally varies from year to year, accurate timing of planting is both essential and very difficult in rainfed farming. Modern inputs such as chemical fertilizers and pesticides do not protect the small-scale rainfed farmer from crop failure due to water stress, and the high level of risk inherent in such farming systems is a disincentive for investment.

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DISCUSSION

Q. In the Philippines, cock-fighting is a very popular sport, and poor farmers often bet relatively large sums on the result of these fights. This involves a 50-50 chance of winning or losing. How can we reconcile this with the reluctance of the small-scale farmer to risk his resources on new technology?

A. The decision as to whether an investment into new agricultural technology is viable or not is usually taken well in advance, and is based on the individual's best knowledge of whether it is likely to lead to economic gain or involve unacceptable loss. In other words, it is a calculated risk. I don't think bets made in cock-fighting are usually of this kind: there is great thrill and excitement involved, and spectators become carried away.

Comment: (Mr. Donal B. Bishop)

In our experience, at the Zamboanga del Sur Development Project, the risk of debt is one of the major factors influencing farmers whether or not to adopt new technology. Although our loans to small farmers in the project had a very good repayment rate of 90% after the first cropping, 50% of the farmers then dropped out of the project, due to their fear of debt.

Q. Who determines the appropriateness of the technology?

A. This is not an objective judgement, but is based on experience of whether the technology does what it is meant to. I suppose the primary judge of this is the farmer himself.

Q. You mention in your paper that technology for the small farmer should be 'simple and cheap'. What level would you consider 'cheap'?

A. This is not an absolute standard, but must be considered in relation to the resources at the farmer's disposal. An investment of US$100 would be relatively cheap for a farmer in Taiwan, for example, but a very expensive one in most developing countries.

SECTION II

TECHNOLOGY FOR THE SMALL-SCALE FARMER IN DEVELOPING COUNTRIES

AN ANALYSIS OF THE PROBLEMS IN THE TRANSFER OF TECHNOLOGY OF HIGH YIELDING RICE VARIETIES IN SRI LANKA

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INTRODUCTION

The last two decades have shown such significant increases in agricultural production in Sri Lanka, particularly in relation to rice, that there is now a certain satisfaction among researchers, policy makers and even consumers that the country is now on the threshold of self sufficiency in rice. From a macro point of view this is probably close to the truth i.e. domestic rice production is now meeting domestic demand.

Successive governments over the last three decades have attempted to increase rice production, with the primary aim of achieving self-sufficiency. This has been done by extending irrigation facilities, developing new high yielding varieties, and providing strong infrastructural support for fertilizer and seed distribution as well as a positive pricing policy. From a research point of view, there has been an emphasis on providing technology that would increase yield per acre, while also attempting to develop varieties that are pest- and disease-resistant.

However, although this technology package has been presented to farmers, national yield levels are still far lower than expected. A 'gap' exists between the potential productivity of the new technology and that actually observed on the farmer's fields. This is most evident in rice production. Such a gap - whether expressed in terms of adoption of the available technology or of on-farm performance -- implies that social gains can be made that could raise output from current input levels, let alone that from a higher level of inputs.

In this presentation, a survey is made of rice production in Sri Lanka over the last two decades. Subsequently, an analysis is made of the gap which exists between potential and actual yields of rice. A hypothesis that explains this gap on a whole farm basis is postulated, and finally, preliminary results from a research study now taking place in Sri Lanka is presented, which look at the problems on a whole farm basis.

Background

An island in the Indian Ocean, Sri Lanka covers an approximate area of 6.6 million ha within the equitorial zone. The population is estimated at 15.1 million[1]. The country's major resources are land and water, and agriculture plays a major role in the economy. The agricultural sector accounts for 42% of the G.D.P. (Gross Domestic Product), 68% of total export earnings and 50% of total employment. While export earnings have increased substantially during the last five years, imports of rice have decreased significantly. (Table 1).

Table 1 Rice imports, Sri Lanka

Year	Quantity imported
1975	461,290
1976	426,888
1977	544,802
1978	169,928
1979	211,518
1980	189,450
1981	157,003
1982	160,931
1983	123,217
1984	26,494

Source: Food Commissioners Department, Sri Lanka

Physiography and Climate

Three distinct physiographic regions within the island can be identified: a lowland peneplain with elevations ranging from sea level to 305 m. above mean sea level (m.s.l.); a highly dissected middle peneplain with an elevation of c. 915 m.; and an upland peneplain rising towards peaks more than 2440 m. high.

The climate is characterized by little variation in temperature and very variable rainfall. The mean temperature ranges from 70-89°F. Precipitation is distinctly bi-modal, and the country receives rainfall from two monsoons, the north-east (November-January), referred to as the 'Maha' season, and the south-west monsoon (May-September), known as the 'Yala' season. During the intermonsoonal periods convectional storms occur, supplemented in October by cyclonic depressions which move in from the east.

Topography plays a major role in determining rainfall distribution. The whole island benefits from the north-east monsoon. The mountains intercept the south-west monsoon, with the result that the highlands and the south-west part of the island receive 190-508 cm of rain per year. This is the wet zone of the country, covering 1.53 million ha. The remaining 75% of the island benefits little from the south-west monsoon, and receives 89-190 cm of rain per annum. This area is divided into a dry and intermediate zone. The dry zone has 4.17 million ha and the intermediate zone 0.8 million ha.

The soils of Sri Lanka have been given a reconnaissance survey and mapped. Nine of the ten soil orders (7th approximation-a comprehensive system of soil classification) are found within the country.

Monthly histograms of rainfall expectancy at the 75% probability levels form the base for identification of individual rainfall regimes in the island. This information has been matched with soil elevation maps, and 24 distinct agroclimatic regions have been identified (See Fig. 1).

Trends in Rice Production

Sri Lanka's contribution to the world's rice production is only a meagre 0.4%. However, the national average yield of 3.5 mt/ha is much higher than the yields found in most countries of Asia and Southeast Asia, which have average yields of around 2.6 mt/ha.

Production trends of rice in Sri Lanka since 1960 are shown in Fig. 2. Overall increase rates have been nearly constant over time, though periodic fluctuations have occurred. During the period 1960-1970, the area planted in rice increased by almost 26%, while during the period 1970-1979 it increased by 17.0%, with a subsequent increase of 18.07%. However, total production increased 55% in 1960-1970, 20% in 1970-1979 and 10% in 1980-1984. Yield per hectare has increased substantially, from 1.9 mt/ha in 1960-1970 to 3.07 mt/ha in 1984. (Table 2). A critical examination of the possible causes for this trend is given below.

REASONS FOR PRODUCTION INCREASES

A number of reasons could be proposed for this relatively high increase in paddy production observed over the past decade. The most probable reasons are the following:

Fig. 1 Agro-ecological regions of Sri Lanka

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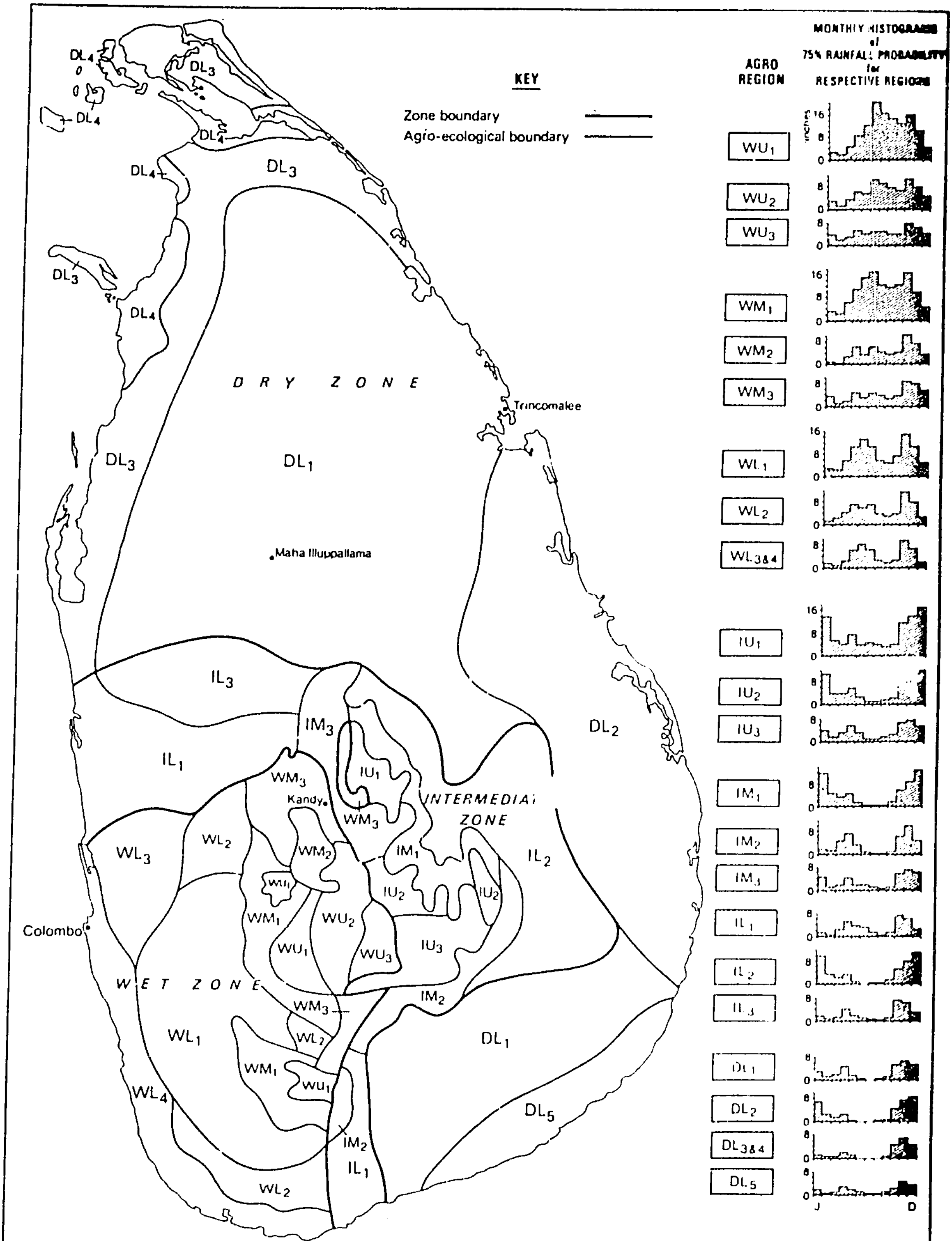


Fig. 2 Area harvested, average yields and total production of rice in Sri Lanka, 1960—84

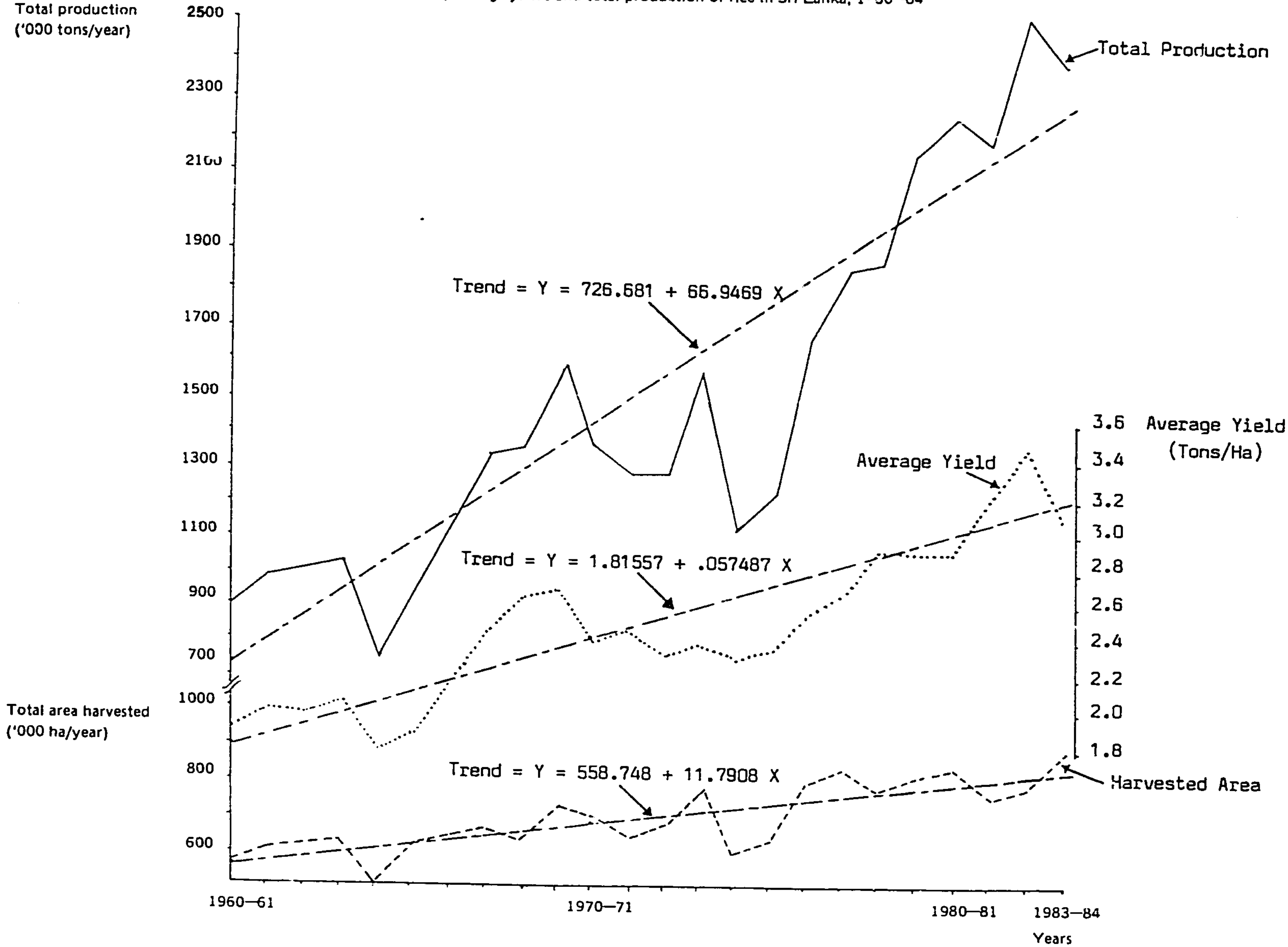


Table 2 Area and production of rice in Sri Lanka

Year	Area sown (1000 ha)	Production (1000 mt)	Average yield mt/ha
1975	6.96	1.18	2.27
1976	7.24	1.28	2.31
1977	8.30	1.71	2.52
1978	8.72	1.93	2.61
1979	8.40	1.96	2.75
1980	8.45	2.18	2.93
1981	8.77	1.58	3.00
1982	8.45	2.20	3.26
1983	8.25	2.54	3.60
1984	9.90	2.41	3.07

Source: Department of Census and Statistics, Sri Lanka

1. Increased area planted in rice
2. Adoption of high yielding varieties (HYV's)
3. Increased use of fertilizer
4. A favourable guaranteed price
5. A broadly based extension service

Increased Area Planted in Rice

The area under rice cultivation in Sri Lanka has increased substantially during the last two decades, due to the increase in the irrigated area, primarily as a result of the Mahaweli Project. (See Fig. 2)

Adoption of High Yielding Varieties (HYV's)

The last two decades have shown a remarkable increase in the use of the high yielding varieties developed by the Department of Agriculture in Sri Lanka. Table 3 indicates the extent of high yielding varieties, both early and late maturing. At present, well over 95% of the area planted in rice is under HYV's.

Increased Use of Fertilizer

The use of fertilizer in rice cultivation has shown a considerable increase over the last decade, as is indicated in Fig. 3. This, combined with the use of high yielding varieties, has definitely contributed to the increase in yield.

Favourable Guaranteed Price

The guaranteed price was established as early as 1948, and has contributed strongly to increased production. The price has, in most instances, been above the world market price, and this has

Table 3 Area planted in high yielding varieties (as % of total rice area)

Year	— Length of cropping season — 3-3½ months (early maturing)	4-4½ months (late maturing)	Total
1975	30	42	72
1976	30	43	73
1977	38	37	75
1978	43	40	83
1979	38	34	72
1980	49	31	80
1981	59	26	85
1982	68	30	98
1983	65	32	97

Source: Department of Agriculture, Sri Lanka

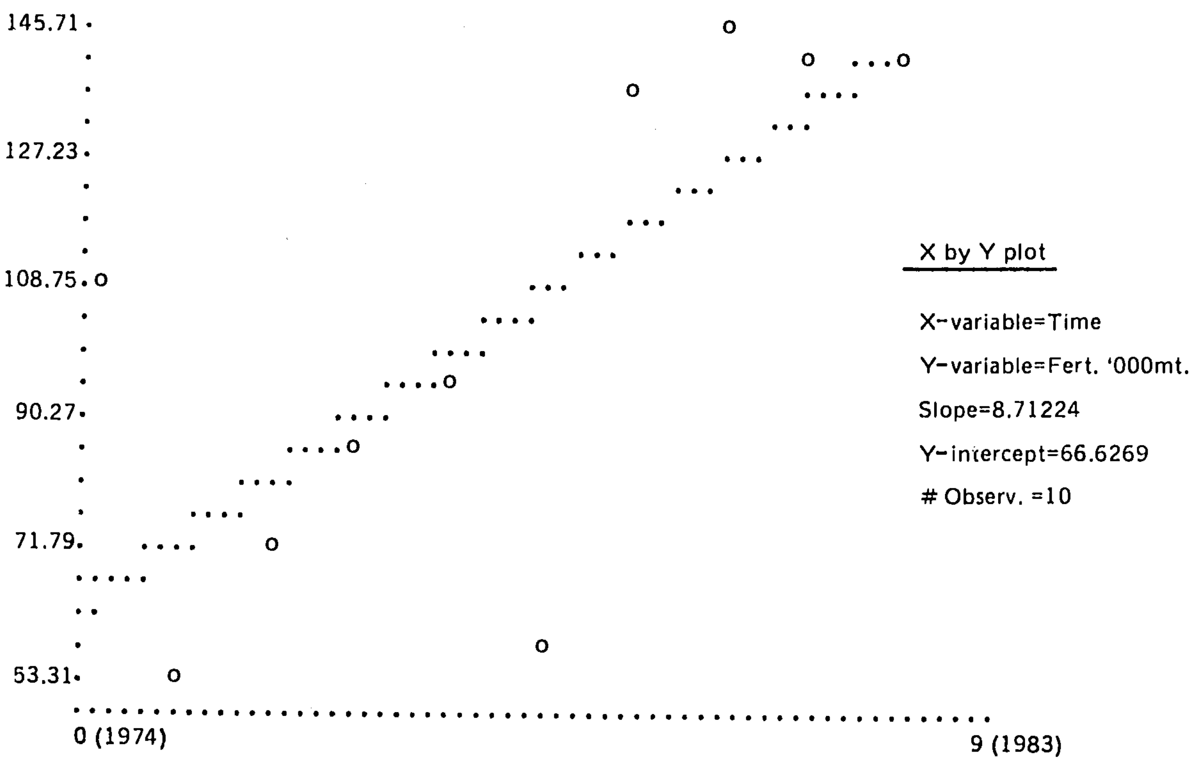


Fig. 3 Annual consumption of paddy fertilizer

acted as an incentive for farmers to cultivate rice as their main crop. Along with the guaranteed price, there has also been a secure marketing system through the Paddy Marketing Board, which has ensured the farmers a market for their rice. The movement of the guaranteed price is indicated in Fig. 4.

Broadly Based Extension Service

The Department of Agriculture in Sri Lanki has a broadly based extension program, and with the adoption of the training and visit system of extension attempts is attempting to cover as many farmers as possible. It is planned for one extension worker to look after approximately 750 farmers. These extension programs have been in operation for the last five years, and have been concentrating particularly on rice production.

. . . .

While it is not clear whether the increased rice production is due to a combination of these factors or any one single factor, it seems likely to be related to both increase in cultivated area and technology. An examination of the contribution of land and technology to increased production in five selected districts is presented in Table 4. It is abundantly clear that in all five instances, the increase in production has been due to the technology package offered.

A production function for the rice production sector can be written as follows:

$\hat{Y} = f(X_1, X_2, X_3, X_4)$ where

Y = Total production

X_1 = Area planted in rice

X_2 = Percent of HYV's

X_3 = Total fertilizer use

X_4 = Guaranteed price per bushel

Using the available seasonwise data, the following equation is obtained for the Maha season.

$$Y = -1299.8 + 0.0027X_1^{***} + 9.99X_2^{**} - 0.0017\dot{X}_3 + 10.69X_4^{***}$$

(0.00029) (3.63) (0.00136) (2.401)

$R^2 = .986$

** = Significant at 5%

*** = Significant at 1%

Numbers in parenthesis are standard errors

According to the above, it is clear that the guaranteed price and the percentage of HYV's also have a highly significant positive effect.

A similar result is obtained for the Yala season as shown below.

$$\bar{Y} = -500.169 + 0.0019X_1^{***} + 3.42X_2 + 0.0016X_3 + 6.09X_4^{**}$$

(0.0004) (2.25) (0.0012) (2.13)

$R^2 = .966$

** = Significant at 5%

*** = Significant at 1%

Numbers in parenthesis are standard errors

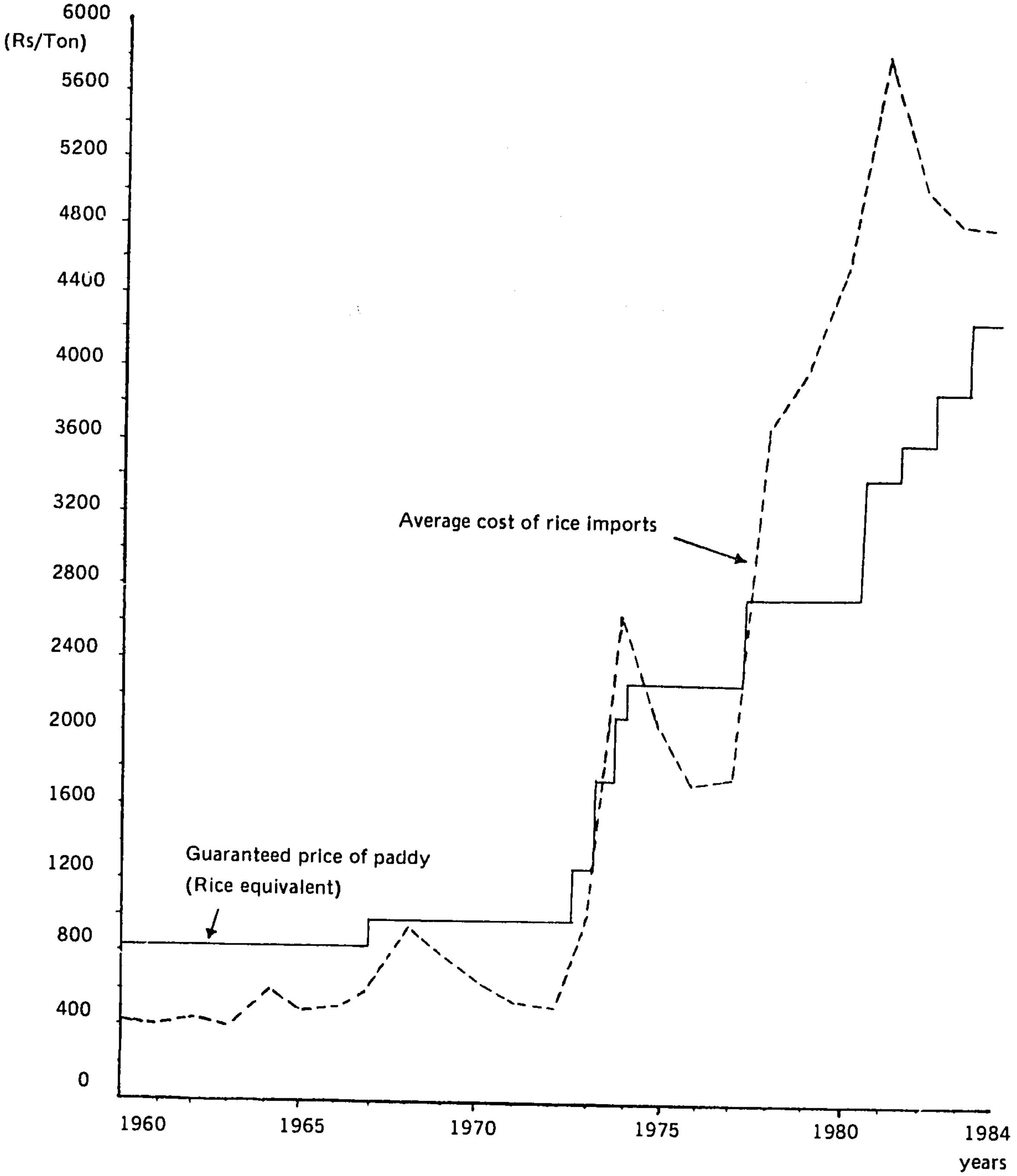


Fig. 4 Guaranteed producer price for paddy and average cost of rice imports

Table 4 Contribution of increased area and improved technology to increased rice production (%)

Season	Kalutara		Kegalle		Kurunegala		Polonnaruwa		Anuradhapura	
	Due to increase in area	Due to increase in Y/Ac	Due to increase in area	Due to increase in Y/Ac	Due to increase in area	Due to increase in Y/Ac	Due to increase in area	Due to increase in Y/Ac	Due to increase in area	Due to increase in Y/Ac
77/78 Maha	13.9	86.1	16.7	83.3	100.0	—	100.0	—	64.8	35.2
78/79 Maha	30.7	69.2	32.9	67.1	58.3	41.7	100.0	—	—	100.0
79/80 Maha	20.6	79.4	-39.5	-60.5	11.6	88.4	41.4	58.6	7.5	92.5
80/81 Maha	11.1	88.9	16.5	83.5	43.4	56.6	100.0	—	-43.7	-56.3
81/82 Maha	—	100.0	9.5	90.5	—	100.0	—	100.0	—	100.0

Source: Division of Agricultural Economics and Projects, Department of Agriculture, Sri Lanka

However, while the achievements listed above are important ones, there has still been quite a substantial gap between the potential represented by the yields obtained at Research Stations, the potential these imply from farmers' fields, and the actual yield. Studies by the International Rice Research Institute, now popularly referred to as the 'constraints project' under the IRAEN program, have attempted to explain these gaps. The analysis focussed on the biophysical constraints operating at a farm level, and the socio-economic factors which contributed to the level and pattern of the farmer's input use[2]. The studies sought to define the economic behavior of the farmers, since the highest yields that were technically possible were unlikely to be economically the most profitable. Another issue was the different yields which could be achieved using similar input levels but with different levels of management of varying technical efficiency.

Results obtained in Sri Lanka under the IRAEN program confirmed the performance gap, as is indicated in Figs 4 and 5. Moreover, as indicated in Table 5, an analysis of district yield data indicated very substantial gaps between the potential and actual yields in selected districts in Sri Lanka. This is further demonstrated in the analysis of Jayawardena *et al*[3] of selected HYV's in Sri Lanka, in Tables 6 and 7. The data shows a significant gap, but also indicates the potential which exists of increasing actual rice production substantially.

The IRAEN study had certain limitations, in that it focussed only on a single crop, rice. Furthermore, it studied only rice grown under gravity irrigation, which provides a stable environment, but did not consider water issues, or the adoption of cultural practises, land use intensity or irrigation patterns. It also assumed that the recommended technology was always the most appropriate for the given environment. The study confirmed the existence of a gap, but failed to explain adequately the contributory causes or the constraints preventing the farmers from choosing to produce at least the economically recoverable portion of this. The failure was partly due to the methodological approach: a proper evaluation of economic efficiency or farm level constraints requires that the actual complexity and the multi-enterprise nature of the Sri Lankan farmer be taken into account. Such an analysis was not possible, given the single crop focus of the study[4].

The problem, then, can be viewed from a different perspective. If high yielding varieties cover over 95% of the rice land area, if fertilizer use is significantly high, and the price support given acts as an incentive to profitable cultivation, and if institutional support for the coordination and supply of inputs and the purchasing of outputs is well established, what then prevents the farmer from maximizing the full potential? Some of the possible causes are:

1. The use of fertilizer below recommended levels.
2. That the extension service is not reaching all farmers.
3. Socio-economic constraints.
4. The general nature of recommendations.
5. That farmers are optimizing use of their limited resources *to maximize whole farm income.*

CONSTRAINTS TO RICE PRODUCTION

Use of Fertilizer Below Recommended Levels

While the national consumption of fertilizer for rice cultivation has risen, it is questionable whether farmers really are using the recommended levels. A number of studies conducted by the

Fig. 5 Actual and potential farm yield from constraints experiments in farmers' fields, Giritale, Sri Lanka, 1975/76

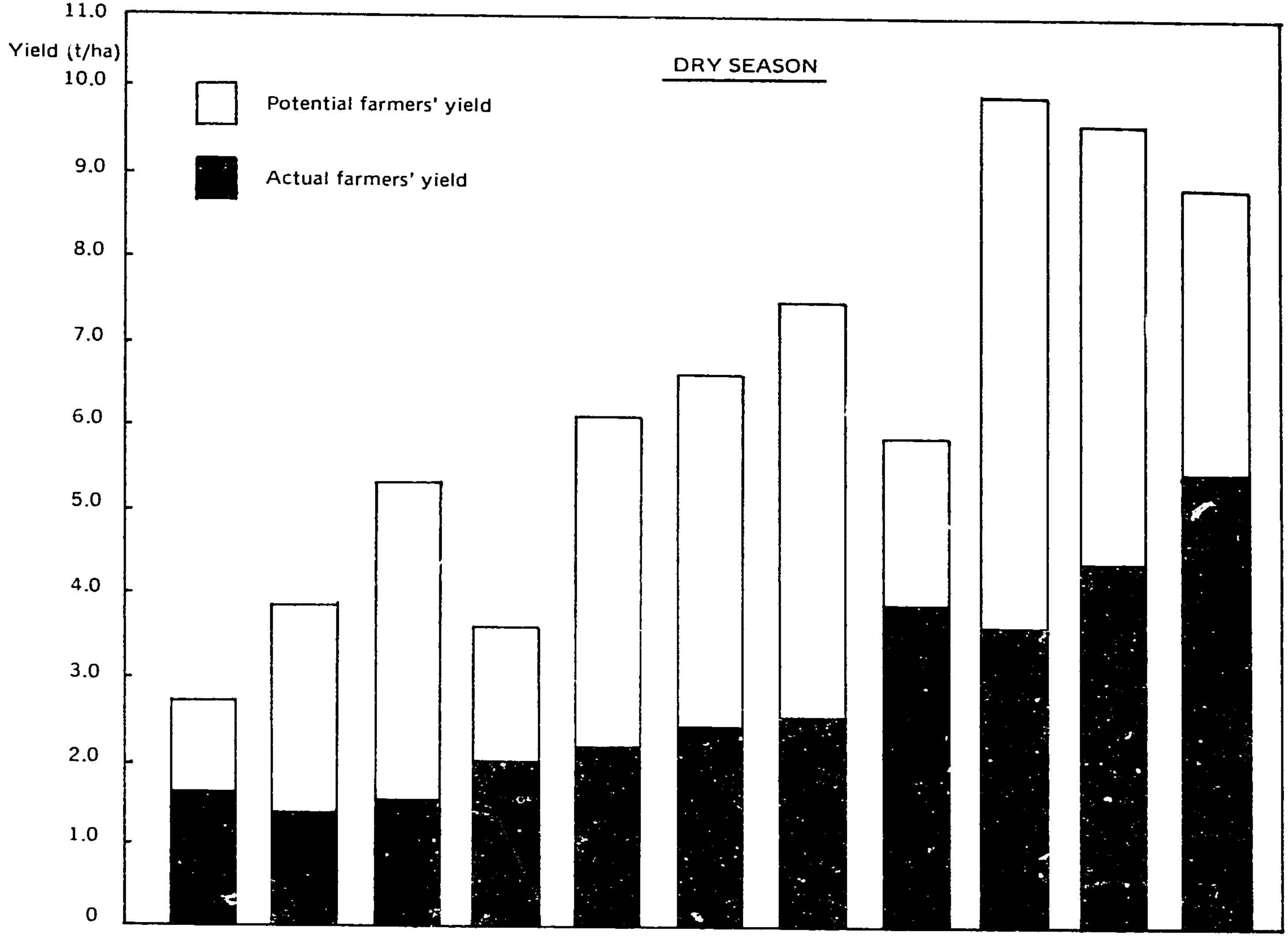
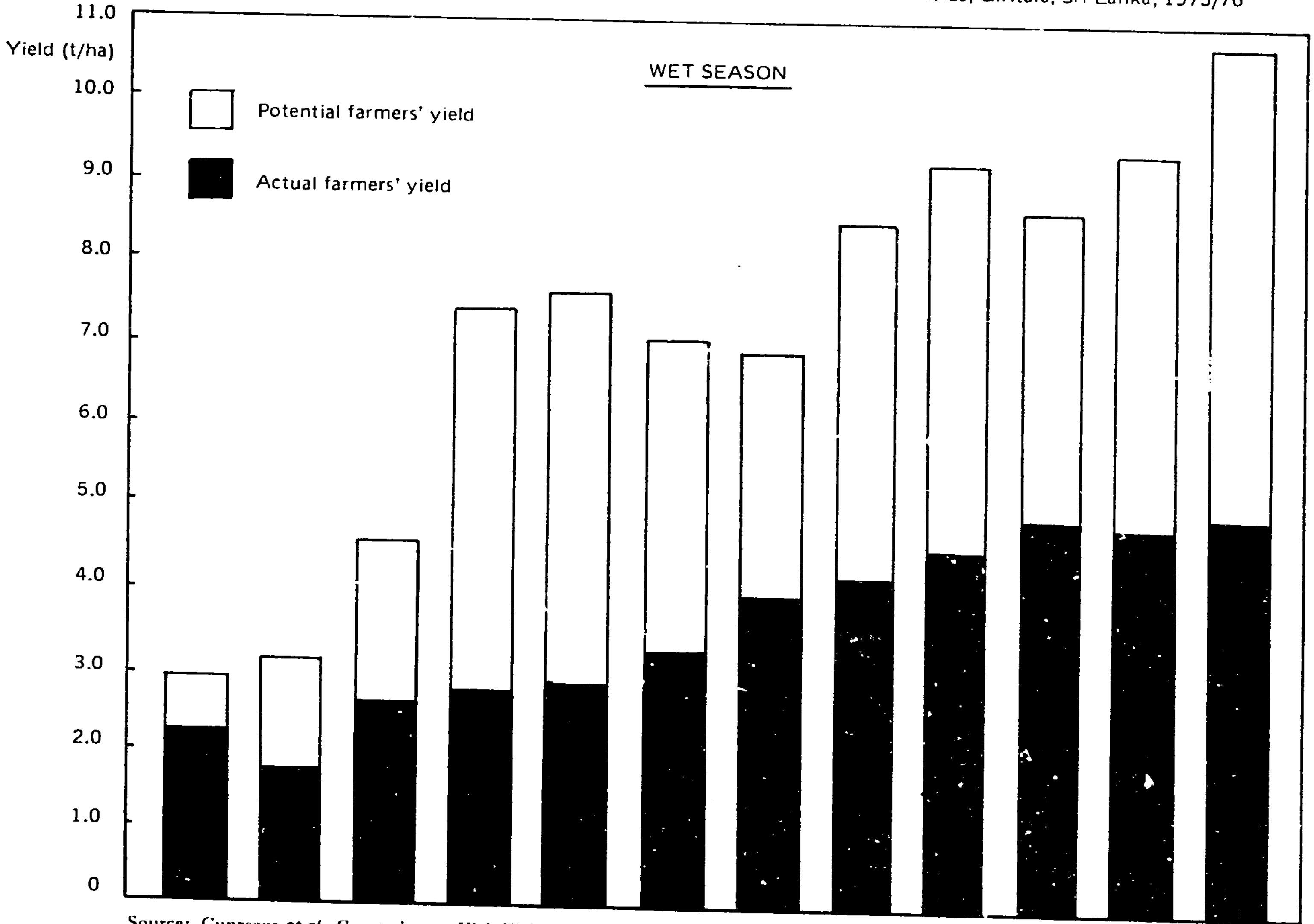


Fig. 6 Actual and potential farm yield from constraints experiments in farmers' fields, Giritale, Sri Lanka, 1975/76



Source: Gunasena *et al.*, Constraints to High Yields on Asian Rice Farms; An Interim Report. IRRI.

Table 5 Potential and actual yield per hectare

District/ Season	Potential yield mt/ha	Actual yield mt/ha	Actual as a % of potential
KALUTARA			
79/80 M (= Maha)	2.57	1.80	70.06
80/81 M	3.16	2.12	67.21
81/82 M	4.18	2.60	62.25
KEGALLE			
79/80 M	5.88	3.00	51.00
80/81 M	6.23	3.43	54.97
81/82 M	6.44	3.58	55.62
KURUNEGALA			
79/80 M	4.70	3.02	64.32
80/81 M	5.10	3.27	64.17
81/82 M	5.36	3.70	69.01
POLONNARUWA			
79/80 M	4.67	3.75	80.18
80/81 M	4.86	3.74	76.86
81/82 M	4.83	4.71	97.50
ANURADHAPURA			
79/80 M	4.89	3.72	76.61
80/81 M	4.21	2.59	61.52
81/82 M	4.68	3.07	65.61
AMPARAI			
79/80 M	6.23	3.60	57.27
80/81 M	6.50	4.25	65.39
81/82 M	6.65	3.89	58.52

Source: Division of Agricultural Economics and Projects, Department of Agriculture, Sri Lanka

Table 6 Rice yield in farmers' fields under different management conditions

(Unit: mt/ha)

Variety	Managed by research personnel	Managed by farmers	Yield gap
B W 272-68	3.49 (4)	3.50 (19)	–
B G 276-5	4.89 (10)	3.19 (20)	1.70
B W 267-3	4.41 (4)	3.63 (19)	0.78
B G 94-1	4.95 (8)	3.54 (8)	1.41

Source: Jayawardena *et al.* 1983[3]

Note : Figures in parentheses indicate the number of experimental sites

Table 7 Yield gap under different management conditions

Rice variety	Growth duration (months)	Yield (mt/ha)					
		Experiments managed by research station in its own fields (I)	Experiments managed by research personnel in farmers' fields (II)	Experiments managed by farmers in their own fields (III)	Average yield in farmers' fields (IV)	Yield gap (A)	Yield gap (B)
B G 400-1	4½	5.0	4.0	3.0	2.6	1.0	2.4
B G 90-2	4	4.5	3.0	2.5	2.5	1.5	2.0
B W 100	4½	4.0	3.0	2.0	1.75	1.0	2.25
B G 94-1	3½	6.0	5.0	3.5	3.0	1.0	3.0
B G 34-6	3½	5.0	4.0	2.5	2.5	1.0	2.5
B G 276-5	3	6.5	4.75	3.0	3.0	1.75	3.5
Herath banda	3½	2.0	1.75	1.5	1.5	0.25	0.5

Source: Jayawardena *et al.* 1983[3]

Department of Agriculture[5] and the National Fertilizer Secretariat[6] indicate a relatively low level of fertilizer use, compared to that recommended. It is difficult to adduce specific reasons for this but a national Benchmark Study[7] has indicated that the relatively high price of fertilizer and the lack of credit at the time it was needed were the main problems.

The Extension Service Is Not Reaching All Farmers

While the extension efforts of the Department of Agriculture are widespread, the extension service has not yet achieved adequate overall coverage. The T & V (Training and Visit) System is conceptually very efficient, and given all the necessary mobility and access can be an extremely useful tool for increasing production. In reality, however, certain difficulties arise, which to some degree prevent all the desired visits to farmers from taking place. Some indicators from an evaluation study of the T & V System in selected districts are presented in Table 8. It is clear that contact farmers are more exposed to visits and technology messages than the follower farmers. This could have serious drawbacks in overall production, as the majority of farmers are follower farmers.

Socio-Economic Constraints

A number of constraints can be included under this heading, such as the lack of credit, unavailability of inputs, and inadequate markets. However, one important aspect is also the inability of farmers to meet the present high costs of cultivation.

Table 8 Contact between farmers and extension system in four districts of Sri Lanka — 1983

% Farmers reporting

District	Indicator 1		Indicator 2		Indicator 3	
	CF	FF	CF	FF	CF	FF
Polonnaruwa	85	65	90	8	80	23
Amparai	85	33	75	28	58	16
Gampaha	84	30	80	15	55	20
Kurunegala	75	15	20	13	15	—

CF : Contact farmers
FF : Follower farmers
Indicator 1 : Frequency of more than one visit/month
2 : Know about the functioning of the Extension System
3 : Received advice on fertilizer use
Source: Division of Agricultural Economics and Projects, Department of Agriculture, Sri Lanka

A major problem in the small farm sector in Sri Lanka is chronic indebtedness, and the inability of most farmers to afford new technology. This has been highlighted in a number of studies. The average cost of cultivation of one hectare of wet rice, using standard modern inputs,is US$120* under

*25 Rs (Sri Lanka Rupees) = 1 US$

irrigated conditions and US$92.00 under rainfed conditions. The average income per hectare of rice varies from c. US$120.00 to c. US$200.00. It is clear that, given that the average farm income is lower than the cost of cultivation, farmers have to resort to credit[8] facilities in order to be able to cultivate a successful crop of rice. Regional differences in this aspect can be identified. An attempt to ascertain the average income from farming in two selected districts is given in Tables 9 and 10, which show the percentage of annual gross income needed to cultivate rice. Almost 69% of a farmer's annual income is required for this, which is quite a high proportion. By and large, costs have remained high, and unless farmers are backed by institutional or non-institutional credit, most are unable to afford the technology needed for good yields. This is reflected in the fact that farmers tend to use a lower level of inputs than that recommended, which, particularly in terms of fertilizer use, may have serious effects on crop growth.

General Nature of Recommendations

The recommendations made by the Department of Agriculture for cultivating rice are in most instances related to the particular variety, but have little relationship to the local environment. It is true that some varieties are environmental specific, such as those developed for rainfed areas in the north and the poorly drained land in the southwestern part of Sri Lanka. However, in every instance, improved rice varieties have been bred for major irrigation schemes with an assured supply of irrigation water. These varieties are too often cultivated under water stress conditions, particularly in the rainfed areas of the dry zone. Under these circumstances, it is not possible to maximize the potential yield of the varieties, because the water requirements are often not adequately met.

Table 9 Average farm income model for Amparai district 1982/83

Maha season, 1982/83	Lowland	Upland
Average cultivated area:	1 ha	0.4 ha
Income from 1 ha rice		= US$495.47
Income from 0.2 ha peanut		= US$ 20.71
Income from 0.2 ha maize		= US$ 23.19
Total income		= US$539.37
Yala season, 1983	**Lowland**	**Upland**
Average cultivated area:	0.4 ha	0.2 ha
Income from 0.4 ha rice		= US$231.20
Income from 0.2 ha cowpeas		= US$ 41.07
Total income		= US$272.27
Total income for the year		= US$811.64
Cost of rice cultivation, Maha season	1 ha	= US$399.34
Cost of rice cultivation, Yala season	0.4 ha	= US$158.63
		US$557.97
% of annual income utilized for paddy cultivation		= 68.7%

Source: Division of Agricultural Economics and Projects, Department of Agriculture, Sri Lanka

Table 10 Average farm income model for Anuradhapura district 1982/83

Maha season, 1982/83	Lowland	Upland
Average cultivated area:	1 ha	0.4 ha
Income from 1 ha rice		= US$407.93
Income from 0.16 ha Chillies		= US$ 20.96
Income from 0.16 ha cowpeas		= US$ 19.34
Income from 0.08 ha maize		= US$ 5.24
Total income		= US$453.47
Yala season, 1983	**Lowland**	**Upland**
Average cultivated area:	0.4 ha	0.2 ha
Income from 0.4 ha rice		= US$197.74
Income from 0.3 ha sesame		= US$ 2.56
Income from 0.06 ha Chillies		= US$ 71.27
Total income		= US$271.57
Total income for the year		= US$725.04
Maha cost of rice cultivation		= US$297.63
Yala cost of rice cultivation		= US$132.27
Total cost of rice cultivation		= US$429.90
% of annual income utilized for rice production		= 59.3%

Source: Division of Agricultural Economics and Projects, Department of Agriculture, Sri Lanka

FARMERS OPTIMIZE USE OF THEIR LIMITED RESOURCES TO MAXIMIZE WHOLE FARM INCOME

In Sri Lanka, small-scale farmers typically grow a number of crops, as well as engage in various off-farm activities. It is important to recognize this, as it has important policy implications. The whole farm should be considered as the unit of the analysis rather than a single crop enterprise. In this context, in addition to the question of whether farmers are using the best available technology in the most efficient manner, there are other issues related to the whole farm.

1. Given the resource base and the available technology, is the farm operating at its economic optimum?
2. Are the observed yield gaps influenced by other farm, and non-farm, activities?

Ranaweera (1979) argued that even though these questions are often raised by researchers, few vigorous empirical attempts have been made to view problems from a whole-farm perspective[9].

The emphasis in the past, even in cropping systems studies, has been on introducing new technology to change the cropping pattern, rather than looking at farm practices on a whole-farm basis. The lack of a whole-farm approach could in the long term cause research to follow a path which may may not benefit the small farmer.

PRESENT RESEARCH STUDY

A study was undertaken in Sri Lanka in two selected districts under different irrigation conditions, to try and overcome some of the shortcomings of previous research. Specifically, the following hypothesis was offered for this study. (Shand *et al.*).

1. In a whole farm context, a farmer optimizes overall enterprises (subject to his resource endowments), without necessarily maximizing output or income from any one individual enterprise.
2. In the long run, the farmer will maximize his income by efficiently deploying his resources over both on-farm and non-farm (other farm and off-farm) activities.
3. Farmers' performance will be specific to agro-ecological environments: hence, technology and policies should also be tailored to these different environments.

It is also recognized that adequate attention should be paid to variations in technology and performance within the farming population. If some of these inter-farm variations are associated with factors that can be manipulated by policy variables, this would provide valuable insights for the formulation of agricultural policies for overcoming productivity differences. Another important aspect is the stability of performance in environments subject to erratic rainfall, and the related issue of risk and uncertainty that guides farmers' practices.

Methodology

This study comprises a number of agronomic trials and socio-economic surveys, and the close monitoring of selected farmers. It is believed that researchers engaged in the development and dissemination of technology should be closely associated with farmers, testing new technology in actual farm environments. The following procedure was adopted.

1. A number of representative and cooperative farmers who were considered to be fairly typical of the farming community, in terms of their resources and type of farm land, were selected.
2. A trial was conducted on a plot of manageable size of the desired land type, under research management, using the recommended technology to grow the same crop as the farmer.
3. The activities of the farmer and his family, including their other farm and off-farm activities, were monitored.
4. The results from the research managed plot were compared to those from adjacent, similar farmers' plots.

This procedure was followed for the farmer's major farming enterprise in both upland and irrigated land. The home garden was not included in the trials. However, a close monitoring was done of the farmer's labor and input use from all activities related to his farm. In addition, socio-economic studies consisting of a survey of approximately 350 randomly selected farmers in and around the trial sites were conducted, facilitating the comparison of the research managed trials and the cooperating farmers with other farmers in the district. These are referred to in the text below as 'Survey Farmers'.

Project Areas

Project areas were in the dry zone district of Anuradhapura and the intermediate zone district of Kurunegala. These areas too were selected because of the potential they represented for improved rice production. The dry zone offers greatest potential for agricultural development in Sri Lanka. Anuradhapura district is representative of this zone, and the Regional Research Centre of Maha Illuppallama is also located within the district. In Anuradhapura district there were 12 agronomic trials.

Kurunegala is typical of the intermediate zone. In fact all three zones, (dry, intermediate and wet) are found in this district, with the intermediate zone predominating. The research site was close to the Central Rice Breeding Station at Batalagoda, and this enabled officers responsible for the development of new technology to actually test it in the fields under farm conditions at 12 sites.

RESULTS*

The results presented here are restricted to the Maha 1982/83 season at Kurunegala.

Table 11 sets out the yields of Research Managed (R-M) and Farmer Managed (F-M) trials in the three areas, while Table 12 presents the yields obtained by survey farmers in these same areas. A comparison of these Tables shows that, in the rainfed area, the R-M trial average yield was more than double that of the average farmer yield. (The F-M yield of the cooperators was roughly the same as that obtained by farmers in the survey). Indeed, only one farmer recorded a yield higher than the R-M average. Two-thirds recorded yields of less than half the R-M average.

Under major tank irrigation** conditions, the average R-M trial yield was 78% higher than the survey average of 3.25 mt/ha. The F-M average yield, of 4.9 mt/ha, was substantially higher than the survey average of 3.25 mt/ha. In the minor tank area, R-M average yield was 65% above the survey average, while 42% of survey farmers had yields less than half the F-M average. Thus in each area there was a substantial gap between average yields of R-M trials and those of survey farmers, but this gap was widest in the rainfed areas.

ECONOMIC COMPARISON OF TRIALS AND FARMER PERFORMANCE

Profit Margins

There was little variation in the prices received by survey farmers for rice. The average of US$0.13/kg was used to value the output of R-M trials. Consequently, the differences between farmers' gross revenues and average income from R-M trials in each of the three areas reflect the underlying yield differences.

* This section draws heavily from Shand *et al.* 1985

** Major tank irrigation: From large-scale reservoir and coordinated water management system
Minor tank irrigation: Small-scale (sometimes single farm) reservoir. Ed.

Table 11 Paddy yields from research-managed and farmer-managed fields in Kurunegala district *Maha* season, 1983/84 (mt/ha)

Trial No.	Crop duration (months)	Yields (mt/ha)		Yield difference
		Research-managed (R-M)	Farmer-managed (F-M)	
Major tank irrigation				
1	3	4.5	3.6	0.9
8	3	5.3	4.8	0.5
9	3½	5.8	5.4	0.4
10	3½	6.2	4.4	1.8
11	3½	6.2	5.3	0.9
12	3½	5.2	4.4	0.8
2	4	7.1	6.1	1.0
	Mean yield	5.8	4.9	0.9
Minor tank irrigation				
3	3	4.6	3.3	1.3
4	3	4.6	4.3	0.3
6	3	4.2	1.5	2.7
	Mean yield	4.4	3.1	1.3
Rainfed				
5	3	5.5	2.9	2.6
7	3	4.5	1.4	3.1
	Mean yield	5.0	2.2	2.8

Source: SL/ANU Project, Department of Agriculture, Sri Lanka

Table 12 Distribution of yields of sample farmers in Kurunegala district, *Maha* season, 1983/84 (mt/ha)

Yields (mt/ha)	Major tank		Minor tank		Rainfed	
	% Farmers	Cumulative %	% Farmers	Cumulative %	% Farmers	Cumulative %
Up to 1.00	4	4	—	—	10	10
1.01 – 1.50	5	9	23	23	16	26
1.51 – 2.00	7	16	13	36	15	41
2.01 – 2.50	13	29	12	48	22	63
2.51 – 3.00	12	51	13	61	17	80
3.01 – 3.50	13	64	23	84	8	88
3.51 – 4.00	13	77	6	90	5	93
4.01 – 4.50	7	84	—	90	3	96
4.51 – 5.00	7	91	4	94	3	99
5.01 – 6.00	4	95	3	97	1	100
6.01 – 7.00	2	97	3	100	—	—
over 7.00	3	100	—	—	—	—
Mean	3.25		2.66		2.26	

Source: SL/ANU Project, Department of Agriculture, Sri Lanka

The average total variable costs per hectare were remarkably similar in the three survey areas. Labor was the most important item (51-60%). Of this, family labor was predominant (up to 50% of average total costs in the rainfed area), though in the minor tank area there was a considerably greater proportion of hired labor (19% of total costs) than in the other areas (11 and 10% respectively). Costs of power (mainly from bullocks) were next in importance, and materials (mainly fertilizer) were third. The cost of materials was lowest in rainfed areas.

Despite the increase in variable costs with the use of recommended practises in the R-M trials, the large increase in gross revenues gave substantial average profit margins in each area (Table 13). In the rainfed area, the average difference of US$151.92/ha between the net profits of Research Managed fields and those of Survey Farmers was 127% greater than the FM average. In the major tank irrigated area, there was a 64% increase, while in the minor tank area the increase was 156%, principally because of the relatively small average profit margin recorded by Survey Farmers in the latter area.

Benefit Cost Ratios

Benefit cost ratios were estimated, first for individual farmers in each of the three area samples, and then for the groups as a whole (Table 14). The group means were all greater than unity. The mean ratio in major tank irrigated areas was highest (at 1.40), as might be expected, and the rainfed ratio (1.11) was slightly above that for the minor tank irrigated sample (1.09). In the major tank irrigated area, the majority (68%) of farmers showed ratios of more than unity, while in the other two samples, 50% or more had benefit cost ratios below unity.

Potential Incremental Benefit Cost Ratios (IBCRs)

Potential IBCR's are given by the ratios of the differences in gross revenues to the differences in total costs of research-managed trials and farmer performance[1/]. They assume that average research-managed trial performance can be repeated throughout the survey area.

There are four basic combinations possible for an IBCR:

Type 1: $GR_{R\text{-}M} > GR_F$ and $TC_{R\text{-}M} > TC_F$

Typically, it might be expected that gross revenue from an R-M trial would exceed that of a farmer, and also that R-M costs would do the same, and thus the ratio would be positive.

Type 2: $GR_{R\text{-}M} > GR_F$ and $TC_{R\text{-}M} < TC_F$

In this case, not only is R-M trial gross revenue the larger but its cost is lower than that of the farmer. The trial technology is unambiguously superior, since by adopting it the farmer can raise his revenue and lower costs. The term is, however, negative, owing to a negative denominator.

1/ Potential IBCR = $\dfrac{GR_{R\text{-}M} - GR_F}{TC_{R\text{-}M} - TC_F}$ where :

$GR_{R\text{-}M}$ = Average gross revenue of research-managed trials

GR_F = Gross revenue of individual survey farmers

$TC_{R\text{-}M}$ = Average total variable costs of research-managed trials

TC_F = Average total cost of individual survey farmers

Table 13 Average gross revenues, costs and gross profits SL/ANU project, Kurunegala, Maha season, 1983/84

(Unit: US$)

Item	Major tank irrigation			Minor tank irrigation			Rainfed		
	Research managed	Farmer-managed	Survey farmer	Research managed	Farmer-managed	Survey farmer	Research managed	Farmer-managed	Survey farmer
Gross revenue	693.84	583.08	423.48	532.12	366.96	318.92	603.80	261.72	7387
Labor & Power	(238.16)	(236.76)	(131.92)	(244.48)	(226.36)	(171.84)	(209.32)	(185.84)	(131.76)
Materials	(84.40)	(54.44)	(64.60)	(100.84)	(46.84)	(74.00)	(123.12)	(52.84)	(44.28)
Total costs	322.56	291.20	196.52	345.32	273.20	245.84	332.44	238.68	176.04
Net profit	371.28	291.72	226.16	186.76	93.76	73.08	271.36	23.04	119.44

Survey farmer costs exclude family labor costs

1 US$ = Rs (Sri Lanka) 25

Type 3: $GR_{R\text{-}M} < GR_F$ and $TC_{R\text{-}M} > TC_F$

In this situation the farmer's performance is superior, since he can achieve a higher gros revenue at lower cost than in the trial. The term becomes negative, owing to a negative numerato

Type 4: $GR_{R\text{-}M} < GR_F$ and $TC_{R\text{-}M} < TC_F$

In this fourth case, both the gross revenue and total costs of the research-managed trial ar smaller than those of the farmer. The sign of the term will be positive. If the ratio is less than unity it would benefit the farmer to adopt the new technology, as he would save more in costs than he woulc lose in reduced revenue. A ratio greater than unity would mean the reverse, i.e. adoption would reduce a farmer's revenue by an amount greater than it would save in costs.

Table 14 Benefit cost ratios for Kurunegala district, Maha season, 1983/84 (per ha)

Benefit/Cost range	Major tank		Minor tank		Rainfed	
	% Farmers	Cumulative %	% Farmers	Cumulative %	% Farmers	Cumulative %
0.01 – 0.05	4	4	17	17	14	14
0.51 – 1.00	28	32	33	50	38	52
1.01 – 1.50	35	67	31	81	26	78
1.51 – 1.75	10	77	5	84	10	88
1.76 – 2.00	6	83	8	94	1	89
2.01 – 2.50	9	92	—	94	5	94
2.51 – 3.00	4	96	3	97	4	98
3.01 – 4.00	2	98	3	100	2	100
4.01 – 5.00	2	100	—	—	—	-7
over 5.00	—	—	—	—	—	—
Mean	1.40		1.09		1.11	

Source: SL/ANU Project, Department of Agriculture, Sri Lanka

The distribution of survey farmers according to these IBCR types (Table 15) showed, firstly, that the great majority belonged to Type 1 where R-M revenue and cost exceeded those of the farmers, though to a lesser extent in the minor tank irrigated area than in the other two areas. A small number belonged to Type 2, for whom the trial technology would be superior. These were most numerous in the minor tank irrigated area (17%). Farmer superiority in performance was recorded by small numbers in each area (3, 8 and 2% in major and minor tank and rainfed areas, respectively).

Table 15 IBCR sub-types of farmers SL/ANU Project, Kurunegala, Maha 1983/84

IBCR Sub-Types	Major tank		Minor tank		Rainfed	
	No.	%	No.	%	No.	%
1	93	92	26	72	118	92
2	2	2	6	17	7	5
3	3	3	3	8	2	2
4	3	3	1	3	1	1

INPUT CONSTRAINTS ON FARMER PERFORMANCE

This section explores constraints on farmer performance in the major tank, minor tank and rainfed areas in Kurunegala district in the Maha season of 1983/84. It complements the first section, in which the economic performance of farmers was compared with average performance in research-managed (R-M) trials over the same cropping season. It is based on two socio-economic surveys in three areas of Kurunegala district. A summary of the highlights is presented.

Labor Availability

Relatively few farmers in the major and minor tank and rainfed areas worked solely on their own farm (7, 16 and 12%, respectively). A large proportion combined work on their own farm with work on other farms, especially in the major tank sample. A small but significant number combined work on their own farm with non-farm work, but more engaged in all three activities (farm, other farm and non-farm).

Some conflict for available labor that could affect paddy cultivation may exist between rice and upland crop cultivation on the farm, and between rice production and non-farm work. Proportions of farmers reporting a rice/upland crop conflict in major and minor tank and rainfed areas were 26, 28 and 21% respectively (Tables 16 and 17). Farmers response to questions concerning conflicting labor demands showed that extra labor was usually obtained to meet the need, either by hiring it, by exchanging labor with friends or relatives, by working longer hours or by maximizing family labor participation. There was some variation between the three areas in the mix of these solutions. Most important, very few farmers delayed operations for either rice or upland crops, but where they did, the rice crop was given preference.

There were fewer farmers with conflicts between rice cultivation and non-farm activities (12, 20 and 17% respectively in each area). Amongst these farmers, the most common reaction was to suspend or reduce off-farm work temporarily, but some worked longer hours, some hired labor for farm work and some used exchange labor for this.

In both situations, it is notable that neither work on highland crops nor non-farm work prevented rice production operations being accomplished. However, competing demands on labor did affect the timing of work in paddy fields, so rice output was affected to some extent.

Table 16 Incidence of conflicting labor demands for rice vs upland crops SL/ANU Project, Kurunegala, Maha season, 1983/84

	Major tank	Minor tank	Rainfed
Rice/Upland crops	%	%	%
Farmers reporting conflict	26	28	21
Adjustments	(100)	(100)	(100)
Hire labor	(30)	(86)	(26)
Work longer hours	(22)	—	(9)
Maximize family participation	(7)	—	(4)
Use exchange labor	(26)	(14)	(48)
Delay upland cultivation	(11)	—	(9)
Other	—	—	(4)

Table 17 Incidence of conflicting labor demands for rice cultivation vs non-farm activities SL/ANU Project, Kurunegala, Maha season, 1983/84

	Major tank	Minor tank	Rainfed
Rice/Non-farm	%	%	%
Farmers reporting conflict	12	20	17
Adjustments	(100)	(100)	(100)
Suspend/reduce off-farm			
Work temporarily	(45)	(40)	(67)
Work longer hours	(27)	—	(10)
Hire labor for farm work	(9)	(60)	(10)
Use exchange labor	(9)	—	(13)
Other	(9)	—	—

Seed Supply

With few exceptions, farmers used New Improved Varieties (NIV's), regardless of water availability. The high yield potential and suitable crop duration of these NIV's was given as the main reason for use. In the major tank area, there was a relatively wide spread of crop duration, from three to four months.

Seed supplies of preferred varieties were not reported to be a problem in any of the three areas sampled. The same varieties were recommended for all three areas, the only obvious difference being longer duration types for the major irrigation areas, where water was available over a longer period. The varieties recommended were bred for well-irrigated conditions: whether these are the most appropriate varieties under rainfed conditions is a matter of particular concern to this project.

Crop Establishment

Methods adopted for crop establishment differed in the three survey sub-areas. A basic difference was that most of the farmers in the major tank irrigation areas transplanted, while in the other two areas broadcasting was the norm. The main reason given by farmers in the major tank area for their choice was the 'convenience' of the method, with high yield as a secondary but related reason. Nearly all the farmers in the minor tank area broadcast seed, but some transplanted randomly and a few row transplanted. 'Convenience' was again the main deciding factor, but water availability was another significant factor. This pattern was even more apparent in the rainfed area, where 84% broadcast, and lack of water was almost as important as 'convenience' in deciding what method to use for crop establishment.

Credit

Very few farmers in either the major tank, the minor tank or the rainfed areas used credit during the cropping season (8, 1 and 1% respectively) in 1983/84, despite the fact that institutional credit was available for almost all of them. Of the few farmers denied credit, lack of security for loans was an important reason in the tank areas, while defaults and the lack of a crop credit scheme were important in the rainfed sample. Those farmers who did borrow did so from the Government Bank or an agricultural credit scheme, or from friends and relatives.

Table 18 Credit use by farmers SL/ANU Project, Kurunegala, Maha season, 1983/84

	Proportion of farmers		
	Major tank %	Minor tank %	Rainfed %
Borrowed credit for farming, Maha	8	0	1
Sources:			
Availability of Institutional Credit (Yes)	92	92	85
Reasons for not using IC:			
Interest too high	6	5	7
Difficult procedures/red tape	32	32	40
Repayment conditions too strict	20	14	16
Insufficient security	—	—	6
Not necessary	42	50	32

SUMMARY

The data presented above needs to be treated cautiously, as it deals with only one cropping season and one specific area while the analysis itself is preliminary. However, it suggests a number of possible constraints, and their relative importance, in the three areas.

The supply of labor for rice production appears to be adequate, with the possible exception of a few farms, particularly in the rainfed areas, where off-farm work may interfere with the timing of the application of some inputs.

Virtually all farmers use recommended New Improved Varieties, which require an assured water supply for best performance. Supply of seed was not a problem. The question, however, still arises as to whether the high yielding, short statured varieties bred for irrigated conditions suit rainfed situations, or the quasi-rainfed conditions found in areas irrigated from minor tanks. If weed infestation becomes a problem under rainfed conditions, fertilizer response is greatly diminished, and yields decline accordingly. At present, farmers apply expensive herbicides or engage in heavy manual labor, or a combination of these, to control weeds.

The use of fertilizer appears to be lower than that recommended. The lower yields obtained by farmers could be attributed to this.

The above data at least offers some indications of the reasons for the 'gap', and also signifies the importance of the interaction between farm and off-farm activities.

The study justifies the need for further research in this area of economic analysis. It is clear that examination of constraints on a single crop basis does not adequately explain the reasons for the extent of a yield 'gap' in a single crop. A complete understanding of the interactions between farm, off-farm and non-farm activities, as well as the interactions within the different components of the farm, will lead to better policies in small farm development. Up until now, the emphasis has been on increasing the cropping area and production of selected individual crops. While this has made a contribution, particularly in terms of projected production on a macro level, it has not adequately explained why Sri Lanka still has to import substantial quantities of other crops.

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DISCUSSION

Q. What are the implications of the fact that research-managed production realized higher profits than farmer-managed production?

A. It implies that the use of improved technology by farmers may have only a limited result, unless this is combined with a high standard of management. Farmers need to be made aware of the importance of this, and of the profits to be expected from improved management, through the mass media and other channels of communication.

Q. Would it not seem that the gap between farmer-managed and research-managed production might be a spur to the multinational corporations who control the world's fertilizer supply, since they are always eager to encourage increased production?

A. All I can say is that money invested by farmers in fertilizer does increase production and yield a profit. I think we have to tell the farmer all the relevant facts, and let him make his own decision.

Q. How do you operationalize the extension system in your country?

A. The extension worker in Sri Lanka has to take care of as many farmers as is possible, although obviously this number must also be a manageable one. With regard to the dissemination of rice technology the extension services have done well, but they have been much less successful with regard to other crops.

Q. I feel that any attempt to set a proper ratio between applied and basic research is to take a very short-sighted view. Some participants at this seminar have claimed that as much as 50% of the public funds spent on research is being wasted, in that it does not produce directly usable technology. I feel that this is not true– history can show numerous cases in which enormous time and energy have been spent on endeavours which in the short term gave no direct benefit, but in the long term resulted in an important breakthough.

If we consider the funds spent on agricultural research as a proportion of G.N.P., it is very small.

A. The issue is not whether research which only yields results in the long term is valid or not– I would agree that it frequently is. The work of Thomas Eddison is a case in point.

The issue is what effect the present agricultural research is having, and in general, it is a case of the rich getting richer and the poor getting poorer. While an increasing sum is being spent on research, the general public are losing confidence. To give agricultural research the practical meaning it should have, we must consider the farmers' conditions, what they do, how much they can afford, and other such considerations.

TRANSFER OF APPROPRIATE TECHNOLOGY TO RUBBER SMALLHOLDERS IN MALAYSIA

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Rubber smallholdings in Malaysia can generally be divided into two categories – the organised smallholding and the unorganised (individual) ones. Organised smallholdings are those developed by agencies such as the Federal Land Development Authority (FELDA) and the Federal Land Consolidation and Rehabilitation Authority (FELCRA), while the unorganised smallholdings are those developed by the smallholders themselves, with the aid of replanting grants from the Rubber Industry Smallholders Development Authority (RISDA). Both categories are important to the Malaysian rubber industry, in terms both of area and production. In 1983, the total planted area of all smallholdings was about 2.01 million ha, accounting for about 73% of the total area planted in rubber. The output of 961,503 mt in the same year contributed 63% of total production (Table 1). It is estimated that there are about 500,000 smallholders in the Malaysian rubber industry.

Like most small farmers in other developing countries, Malaysian smallholders face problems of small land holdings of uneconomic size, low productivity, backwardness and capital deficiency. The majority of smallholdings are scattered and unorganised, and thus cannot be integrated to achieve economies of scale when farmers are trying to develop their holdings, and purchase inputs and market their produce (Yahil, 1983). Approximately 80% of the land owned by smallholders was in holdings of not more than 4 ha. Of these, 50% were less than 2 ha, and 3.6% smaller than 1.5 ha (Table 2). Low productivity stems from poor uptake of technology, resulting in poor and inefficient allocation of resources. Backwardness is associated with the low educational level of the older generation of smallholders. With a poorly educated workforce, the rate of technological diffusion is low. The situation in the smallholder sector is further aggravated by the problem of labor shortage, because of the growing trend among rural youths to seek jobs in the urban industrial sector. Consequently, the smallholder sector today no longer enjoys the advantage it once had of cheap and readily available labor.

Table 1 Rubber hectarage and production in Malaysia 1982 – 1983

Regions and sectors	Area under rubber (ha)			Rubber productions (mt)		
	1982	1983	%(1983)	1982	1983	%(1983)
Total Malaysia	2,010,135	2,009,900	100	1,516,585	1,561,992	100
Peninsular Malaysia	1,700,700	1,702,400	85	1,478,982	1,521,717	97
Sabah and Sarawak	309,435	307,500	15	27,603	40,375	3
Estates	473,200	464,000	27	576,721	560,114	37
Smallholdings	1,227,500	1,238,400	73	902,261	961,503	63

Source: (Raja Badrul Shah Kobat 1984)

Table 2 Distribution of size of farm holdings among smallholders, 1977

Size (ha)	No.	%	Area	%
0.01 – 0.49	24,234	4.9	8,263	0.6
0.50 – 0.99	68,641	14.0	52,105	4.0
1.00 – 1.49	84,810	17.3	104,006	8.0
1.50 – 1.99	61,871	12.6	105,913	8.1
2.00 – 2.99	126.092	25.7	300,193	23.1
3.00 – 3.99	55,855	11.4	190.664	14.7
4.00 +	68,957	14.1	539,497	41.5
Total	490,460	100.0	1,300,641	100.0

Source: (Shamsul Bahrin, 1983)

In view of the valuable contribution the smallholders make to rubber production, and also in view of the problems they face, the need to improve their situation is obvious. It is important therefore to accelerate the pace of technology transfer to the smallholder sector, in order to lift farmers from their technological backwardness and remove the constraints affecting their productivity. This paper discusses some of the technological advances aimed at improving the production and income of the rubber smallholders, and the transfer of these technologies.

ORGANIZATIONAL PROBLEMS IN TRANSFER OF TECHNOLOGY

The government instituted a number of organizational changes in the late 1960's and early 1970's in an effort to accelerate development in the smallholder sector. The Malaysian Rubber Development Corporation (MARDEC) was established in 1969 to buy, process and sell smallholders' rubber. In 1972, RISDA was formed from a reorganisation of the Rubber Industry Replanting Board (RIRB), to solve the socio-economic problems of smallholders. It subsequently took over the extension function of RRIM, leaving the latter to concentrate on research. Soon after, a Technical Coordination Committee (TCC) was formed. This committee, comprising RRIM, RISDA, the Malaysian Agriculture Research Institute (MARDI), and the Department of Agriculture, was intended to ensure the smooth flow of research findings to the smallholder sector.

Despite these changes, the smallholders, through their association claimed that they were not receiving the technology that was being developed. Their claim was to some extent valid, because of the lack of coordination between research institutes and the implementing agencies. In addition, there was no effective system of transfering the technology to the smallholder sector. The TCC was active only for a short period, and has had little effect since 1975 (Abdul Halim, 1980).

THE NATIONAL COMMITTEE ON TRANSFER OF TECHNOLOGY

Although the need for an effective system of technology transfer has long been recognised by planners and implementors, it was only in 1981 that a clear effort was made toward the formation of a national committee for the transfer of technology. This committee, comprised of members from the National Smallholders' Association (NASH), RRIM and RISDA, adopted a system approach in planning and implementing development projects (Ani Arope, 1983). There appear to be two major thrusts in the national committee's program -- the development of smallholdings to enhance production through proper management and education of the smallholders, to equip them with skill and new knowledge, and at the same time an attempt to motivate them to adopt new technology.

At the RRIM, the Smallholders Extension and Development Department is responsible for planning and implementing technology transfer programs, covering all aspects of rubber planting, production and processing. At the same time, the Department is also involved in the implementation of adaptive research, and monitoring and evaluating of projects. It also provides training in relevant technologies to field workers and supervising staff.

TYPES OF TECHNOLOGY

Planting Material

Recommendation of High Yielding Cultivars

It has normally taken about 30 years before a *Hevea* cultivar is recommended to the industry as Class 1 material, after a long process of breeding, selection and large-scale trials. The advent of new propagation and planting techniques has helped solve the problems of breeding and selection, and has shortened the time needed to assess the merits of each new cultivar.

Before 1968, planting material recommendations were general in nature, based on the potential yield and the probability of getting the expected yield in commercial planting. Environmental factors affecting yield were not adequately considered. However, in 1974 a new concept, designated as the Environmax Planting Recommendation, was introduced to the industry. Underlying this concept is the principal of 'maximizing yield potential of a clone in a particular locality, subject to the inhibitory influence of the environmental factors' (Ho, C.Y. *et al*, 1974). Thus, more weight was given to environmental factors such as weather conditions, disease, and soil conditions, in the choice of planting material for any given locality.

The primary objectives in the current clonal recommendations are to select clones which give high, early and sustained yields (Table 3). Clones selected for smallholders should have the following characteristics:

- High average yield over their economic life
- High yield during the early years of tapping
- Good response to yield stimulation

Table 3 Mean yield[a] of recommended clones[b] (Classes I and II) and seedlings[c] (Class I)

Clones/ seedlings[c]	Year of Tapping 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Class I															
RRIM 600	720	1210	1600	1860	2310	2320	2350	2470	2700	2360	2190	2040	2660	2940	3260
PR 255	1170	1500	1850	2250	1920	2070	2300	2140	2110	2050	2380	2210	2140	2100	2120
PR 261	860	1290	1610	1840	1830	2240	2360	2420	2260	2120	1860	1600	1690	1870	1720
PB 217	570	1050	1380	1520	1580	2200	2200	2270	1950	2020	2110	2210	2050	—	—
GT 1	700	1180	1410	1640	1570	1960	2280	2340	2310	1880	2040	1700	1530	1670	1640
RRIM 712	690	1490	2010	2330	2230	2290	2610	2290	2560	2760	2250	—	—	—	—
Class II															
PB 235	1370	1870	2280	2300	2000	2060	3230	2530	2560	2530	2170	3290*	—	—	—
PB 255	1180	1750	2230	2250	2120	2600	2850	2640	2540	2390*	—	—	—	—	—
PB 260	1180	1820	2220	2220	1960	2370	2760	2530	2390	2230*	—	—	—	—	—
PB 28/59	770	1450	2110	2220	2350	2570	2120	2040	1860	2370	2490	1930	—	—	—
RRIM 701	550	1100	1520	1720	1680	2050	2200	1850	1790	1990	2130	2160	2340	—	—
RRIM 628	830	1410	1780	2030	2010	2250	2010	1870	1880	1700	1970	2050	1880	1800	2510
RRIM 725	630	1310	1800	1840	1690	2010	2090	1700	1690	1860*	—	—	—	—	—
RRIM 703	830	1660	2360	2230	2060	2690	2310	1650	1190	1360	1610	1370	1120	—	—
AVROS 2037	440	730	1170	1760	1770	1680	1970	2090	2220	2180	1930	1790	1880	1950	2020
RRIM 527	630	1100	1530	1730	1910	2070	2000	1940	1860	1650	1870	1790	—	—	—
RRIM 623	1000	1290	1470	1630	1640	1880	2100	2100	2000	1900	1670	1440	1380	1320	1510
RRIM 728	880	1380	1900	1830	1970	2110	—	—	—	—	—	—	—	—	—
RRIM 729	800	1360	1920	2030	2210	2090	—	—	—	—	—	—	—	—	—
PB 280	1090	1500	1890	2180	2240	2160	—	—	—	—	—	—	—	—	—

a In kilogram per hectare per year
b Data from large-scale slones trials
c Data from Prang Besar Research Station
* Yields from panel B and C

- Good response to frequent tapping
- Vigorous growth

The above characteristic ensure a high income per unit area or per tapper, and a short period to wait before returns begin.

Reduction of the Immature Period

A shorter period of immaturity is of great economic significance to the smallholder, in terms of early income and reduction of maintenance costs. Conventional planting techniques adopted by smallholders in the past were mainly planting seed-at-stake planting seedlings in baskets or polythene bags. These techniques normally require c. 7-8 years before the trees can be tapped. A study on the use of advanced planting materials, such as budded stumps, stumped buddings and clonal stumps, by RRIM has shown that the period of immaturity can be reduced to c. 4-5 years (Table 4).

The superiority of advanced planting material over conventional planting techniques considerably lessens the reluctance felt by smallholders to replant their low yielding trees. The establishment of local and regional nurseries by RISDA to provide advanced planting material further facilitated the adoption of this technology by smallholders.

Improved Agronomic Practices

Legume Cover

Establishing and maintaining legume cover crops, such as *Calopogonium caeruleum*, *Centrosema pubescens* and *Pueraria phaseloides*, is now a common agronomic practice among smallholders. Since 1976, RISDA has made it mandatory that legume cover be established in all replantings where no intercrops are planted. Using good quality seed, it normally takes about 180 days to establish full ground cover. With good maintenance, the cover may last 4-5 years.

The many benefits of maintaining a pure legume ground cover in rubber smallholdings has been well documented over the years. Its rapid growth helps to control weeds, and provides nitrogen for the rubber trees. RRIM trials have shown that, in areas where legume covers were planted, budded rubber trees come into tapping earlier than in non-legume areas (Chin, S.L. 1977).

The main problem associated with the successful establishment of a legume cover in rubber smallholdings is the lack of enough good quality seed. Seeds tested from 1979 until 1981 were found to be only 30% viable: 29% were dead seeds and 41% were hard seeds. (Chee, Y.K. 1982). Therefore, to ensure continuous adoption of this technology, it is important that good viable seeds are available to smallholders.

Discriminatory Fertilizer Usage

The discriminatory use of fertilizer applications has been used by RRIM since the late 1960's. It is now being widely practised by the industry. In this approach, the amount and type of fertilizer to be applied in a particular smallholding is based on an analysis of both soil and leaves. Other associated factors, such as soil type, exploitation methods and presence of cover crops, are also considered.

Poor yields from smallholdings have been attributed to, among other factors, inadequate or non-usage of fertilizer, and poor agronomic management of holdings. The situation has gradually changed in recent years. Smallholders are beginning to show greater appreciation of the value of fertilizer, as is shown by their increasing demand for it.

Weed Control

Herbicides are now being widely used by rubber smallholders to control weeds. Two popular chemicals are paraquat and ghyphosate. Studies have shown that, when the weedicide is used at the recommended rate in nurseries, chemical methods of weed control are more effective and economical than manual weeding, and had no adverse effect on seedlings and buddings (Yeoh *et al.* 1980).

Research is currently being conducted on the use of an Ultra Low Volume (ULV) applicator for weed control. This has several advantages over the conventional knapsack sprayer, and has been shown to have great potential for use by rubber smallholders because it is lightweight and requires less water.

Tapping System and Ethepon Stimulation

Research on the best direction for tapping cuts, and intensity and frequency of tapping, is well established. However, trials are still in progress on latex stimulation, to determine how this can be more effectively applied, with modified tapping systems, to obtain maximum productivity with minimum exploitation of the tree at minimum labor cost. Stimulation can increase the yield and give an immediate return, and is particularly suitable for use by smallholders.

Table 4 Variation in period of immaturity with different planting materials

Planting material	Mean immature period (years)	Longest immature period (years)	Shortest immature period (years)
Conventional			
Seed-at-stake	6.6	7.8	5.6
Basket/polybag Seedlings	6.0	6.8	5.3
Advanced			
Budded stumps	5.7	6.6	5.0
Stumped buddings	4.6	6.1	3.9
Clonal stumps	4.4	4.7	4.1

Source: (Loh, Y.Y. 1982)

It has been recognised that smallholders practice an intensive form of tapping. Their method of daily tapping results in high bark losses and extensive damage. This in turn leads to poor yields, a high incidence of dryness, and poor bark renewal. Therefore, it is necessary to develop a new tapping system suitable for smallholdings.

Short-Cut Tapping. Tapping with shorter cuts S/3 and S/4 has been introduced to smallholdings. In trials recorded over a period of 6-36 months for Panels A, B and C, it was found that short cuts of S/3 and S/4 respond better to ethephon stimulation. The increase in yield using this system over half spiral (S/2 D/2) control ranged from 6-24% for Panel A, 1-19% for Panel B, 82-108% for Panel C. Using double quarter cuts (2S/4) without stimulation, Panel B and Panel C gave a yield increase of 20% over the half spiral control (B. Manikam and P.D. Abraham, 1977).

Upward Tapping. When the lower tapping panels have been completely used up or badly tapped, resulting in poor bark renewal, smallholders can still sustain production from their trees by exploiting the upper virgin bark. Most of the upper bark is still healthy and productive. Table 5 shows the results of trials conducted in smallholdings, in which 69% of the holdings involved obtained a yield increase of more than 50%. (J.L. Anthony and P.D. Abraham, 1980). Although higher tapping is uncomfortable for the tapper, and requires special skill, this system provides an effective mean of upgrading uneconomic smallholdings.

Mixed Farming

At both the immature and mature phases of rubber growth, smallholders can supplement their incomes by adopting a mixed farming system. The following combinations can be used:

(a) Cash crop + rubber,
(b) Sheep + rubber,
(c) Poultry + rubber, and
(d) Poultry + sheep + rubber.

Table 5 Percentage response over pretreatment yield with upward tapping

Yield increase	No. of smallholdings			
	Budding	Seedling	Total	%
No response	26	7	33	6
Below 50%	118	20	138	25
51% — 100%	229	47	276	49
101% — 150%	62	10	72	13
151% — 200%	12	8	20	4
Above 200%	13	4	17	3
Total	460	96	556	100

Source: (*Planter's Bulletin,* June 1981)

Cash Crops

Rubber smallholders often plant cash crops between the rows of rubber trees. However, their disorganised method of planting and poor choice of crops results in a low return from such crops. Groundnut, maize and soybean, planted in rotation as intercrops in rubber rows, have been shown to generate a substantial income for smallholders (Wan Mohammad and Chee, 1976). Table 6 shows the various crops and varieties planted, planting distance and seed rates. Where soil conditions and terrain are not suitable for short-term crops, bananas, pineapples and sugarcane can be profitably grown. Table 7 indicates the yield and return from these crops. Returns are higher when family labor is used.

Sheep Rearing

RRIM has been investigating the feasibility of integrating sheep with rubber since the mid-1970's. The economic benefits of rearing sheep in smallholdings include low-cost weed control, as well as profit from the sale of the animals (Wan Mohammad and Hamidy, 1983).

Crossbreeding programs carried out by mating pure Dorset Horn (DH) rams with local ewes produced crossbreds that were of significantly better quality than the local animals in terms of performance and live weight (Table 8).

60-70% of the natural ground vegetation found in rubber smallholdings has high nutritional value, comparable to that of cultivated grasses. Since sheep eat nearly all types of natural vegetation, a smallholding with extensive undergrowth can support several head of sheep. The recommended stocking rate in smallholdings is 8 sheep per hectare.

A comprehensive economic analysis on one of the RRIM sheep rearing projects involving smallholders found that profits over a 25 month period came to US$1285.71, or about 10% of the total investment. The net present value (NPV) and internal rate of return (IRR) was calculated to be US$854.98 and 44%, respectively. The extra income received by each participant was US$17.14 per month. In addition, the analysis also showed a reduction in weeding costs of about 21% per year (K.H. Tan and P.D. Abraham, 1981).

Table 6 Planting of groundnut, maize and soybean in immature rubber plantation

Intercrop	Variety	Distance from rubber trees (m)	Planting distance (cm)	Seed rate (kg/ha)
Groundnut	CES 101 V 13 Nam Gai	0.9	31 x 10	123 – 134
Maize	Sg. Buloh 11 Sg. Buloh 12	1.4	17 x 23	13 – 16
Soybean	Palmetto Acadian	0.9	30 x 10	43 – 45

Source: (Wan Mohammad and Chee, 1976)

Table 7 Production and income per hectare from different types of crop (US$)

Type of crop	Production	Farm price	Gross income	Net income (hired labor)	Net income (family labor)	Net income (hired labor)
Pineapple	64,500 fruits	$ 0.10/frt	$6,980.51	$2,676.62	$5,400.00	$161.90
Banana	18,500 kg	0.13/kg	2,402.60	1,173.59	1,510.39	50.22
Sugarcane	70,000 kg	0.05/kg	3,636.36	2,706.06	3,020.78	96.54
Papaya	17,000 kg	0.08/kg	6,060.61	4,177.05	4,743.29	158.00
Groundnut	3,500 kg	0.43/kg	1,515.15	817.32	1,144.59	381.39
Soybean	1,200 kg	0.48/kg	571.43	75.76	310.82	88.74
Maize	25,000 cobs	0.05/cob	1,298.70	654.54	896.10	358.44

Source: (Abdul Ghani Ibrahim, 1984)

Table 8 Comparison of liveweight of local sheep and crossbreeds at different ages

Cross	Cumulative weight gain (kg)			
	9 months		12 months	
	Female	Male	Female	Male
Local	14.14	14.23	17.25	16.31
25% DH	19.86	25.26	24.26	29.50
50% DH	25.85	29.49	30.17	36.35

Source: (Wan Mohammad and Hamidy, 1983)

Poultry Rearing

As well as sheep rearing and intercropping, poultry rearing is also an economically viable project on rubber smallholdings. Broiler production is more suitable than that of layers, because the return is fast and there are fewer management problems. An untrained smallholder will need to raise at least 2-3 batches of chickens before he can grasp the technical and management aspects of broiler production. An experienced smallholder with a family of three or four can effectively raise about 1000 birds per batch.

The production cost of broilers raised on smallholdings ranges from US$ 1.02 to US$1.04 per kilogram, while a broiler chicken consumes about 5 kg of feed over a period of 8 weeks. Table 9 shows the production costs and income of broiler projects carried out by smallholders who received credit and advice from RRIM. Variations in income are related to the number of chickens produced, the time of the year they were produced, and current market prices. The most important factors affecting income from broiler production are:

- Availability of day-old chicks when needed

- Supply of high quality feed
- Timing of production
- Cost of day-old chicks and feed
- Mortality rate, and
- Market outlets and price of chicken

Table 9 Production and average income from smallholder broiler production

No. of chickens reared	No. of batches per year	Total production (kg)	Average income per year (US$)
150 – 300	5	4,800	$ 229.43
500	4	5,950	$ 861.47
500 – 1000	6	11,940	$1030.30

Source: (Raja Badrul Shah Kobat, 1984)

INTEGRATED DEVELOPMENT PROJECT

The RRIM integrated development project (IDP) concept is essentially a group farming system, in which a group of rubber smallholders work cooperatively to replant and manage their land, using the best available technology at every stage of tree growth.

The main objectives of the IDP concept of technology transfer are:

- To enhance smallholder' development through 'package-deal' technologies, to enable them to realise short- and long-terms benefits from their limited plots of land by applying new technologies available from research and development in RRIM
- To raise general farm productivity, by increasing farm productivity and family income in a more continuous and efficient way
- To enable a group of farms serve as a demonstration plot to show nearby smallholders the benefits of adopting new technology on an organised group basis

Implementation and Progress of IDP

The RRIM initiated the IDP concept in 1982 on 22 hectares of land at Sg. Taling, Negeri Sembilan. The area was replanted with rubber, financed by RISDA replanting grants. The rubber rows were intercropped with maize, papaya and banana, covering a total area of 6.3 hectares. Five poultry sheds were constructed for rearing 500 broiler chickens per batch per shed on a rotational system. A 2.0 hectare interrow nursery was also established, to produce and sell planting materials.

Broiler Production. The project was started in December 1982. Table 10 shows the income obtained by each family. The average income received by each smallholder was US$419.76 for 3 batches, or US$139.92 per batch. This is before deducting the fixed costs of shed and equipment from loans payable only when participants made more than a certain profit. However, the income was still considered substantial.

In 1984, the project sufferred a temporary set-back because of the low price of chickens. Table 11 illustrates the production and income of one of the participating smallholders. Even with a small loss on four batches, the overall income shows a profit of US$252.19.

Table 10 Income from poultry-rearing on a rotational system

Smallholders	No. of batches	Gross family income (US$)	Credit repayment (US$)	Net income (US$)
Haji Yusof	3	422.77	170.37	275.78
Nunaidah	3	505.94	145.48	360.46
Ibrahim	3	982.97	368.70	609.94
Khalid	3	806.67	325.84	480.84
Sulaiman	3	665.26	297.77	367.49
Mean	3	676.73	256.96	419.77

Source: (RRIM Annual Report, 1983)

Table 11 Production and income for 1984

Batch	Production cost US$/kg	Market price US$/kg	Total production kg	Gross income US$	Net income US$
1	1.00	1.13	2181.30	1029.91	85.61
2	1.04	0.95	2335.40	923.81	-87.19
3	1.02	1.39	2404.80	1410.22	367.49
4	1.04	1.00	2256.00	933.44	-42.58
5	1.00	0.93	249.50	1009.48	-69.09
6	1.08	1.08	2236.50	966.23	- 1.95

Source: (Sulaiman Ahmad *et al*, 1984)

Intercropping. The intercrops planted included maize (0.8 ha), banana (3.8 ha) and papaya (1.7 ha). Table 12 shows the income and production from intercropping in 1984. A single crop of maize on a 0.8 ha plot gave a net income of US$131.21. From the production of banana and papaya, a smallholder made an average income per ha per month of US$34.29 and US$59.82 , respectively. These profits were made possible because of readily available markets for these products.

Interrow Nursery. The interrow nursery project was begun on a 2.0 hectare plot, and it was planned to produce 100,000 budded stumps. By the end of 1984, 80,000 stumps had been produced and a profit of US$1,731.60 realised by the smallholders. A further 3% of the material are stil remaining for sale.

Table 12 Production and income of intercrops in 1984

Crop	Area (ha)	Total production (kg)	Total income (US$)	Average Income/month/ha (US$)
Maize	0.8	3791 cobs	23.25	181.21
Banana	3.8	15358.5	1563.54	34.29
Papaya	1.7	9434.3	1220.63	59.82

The group replanting carried out on the 22.0 ha has been shown to be successful, in terms of the healthy growth of the rubber trees and performance of the IDP projects. The whole area was planted with seedlings, with a planting density of 445 tree per hectare and 22' x 11' planting distance. The whole area was successfully budded in July 1983, 84% in RRIM 600 clones. The remaining 16% was budded with new clones of RRIM 712, PB 217 and PB 255. After 2 years, with regular maintenance, fertilizer applications and good weed control, the trees have performed well in spite of poor soils in the area.

In terms of credit recovery, the intercropping and interrow nursery project have recovered almost 100% of the credits given at the end of 1984. However, broiler production had recovered only 34% of the credits given for the construction of the chicken sheds and the purchase of equipment. The success of replanting and associated projects indicated that the IDP concept is a workable system for adoption by rubber smallholders.

DISCUSSION AND CONCLUSION

Smallholdings in Malaysia, considered collectively, are impressive in terms of the volume of rubber they produce in a given year. This is largely because of the vast acreage of rubber plantation owned by a large number of smallholders. However, it is an acknowledged fact that the yield and income from individual smallholdings are low. Appropriate technology is available for smallholders to adopt on an individual or on a group basis. The use of high-yielding and advanced planting materials, along with improved agronomic practices, will ensure that their trees can be tapped early, and an overall increase in yield from their holdings. Smallholders who planted intercrops, reared sheep and raised broiler chicken have been shown to benefit from these enterprises by being able to earn supplementary income while their rubber trees were immature. The transfer of appropriate technology to the smallholder sector, however, will only be effective if

(1) there is an efficient system for providing various services, modern farm inputs and delivery of recommended techniques, and
(2) there is willingness and motivation among smallholders to work hard and utilize all the facilities and opportunities available to them.

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DISCUSSION

Q. What assistance do you give your rubber farmers who are not organized?

A. There are quite a lot of rubber planters who are not members of a smallholder organization: either they are not aware of, or see no benefit in membership. They are still entitled to extension help from RISDA, which informs farmers of research developed by the RRIM. The government also extends loans to unorganized smallholders, at a fixed amount per hectare, to help them in the development of their farms.

Q. What is the land tenure situation of your rubber smallholders?

A. The majority of our rubber plantations are owned by the farmers themselves.

Q. Rubber is a longterm crop. How does the rate of return compare with that from other crops?

A. In terms of income, one hectare of rubber would normally give a smallholder a net profit of c. M$200 (US$86.58) per month. However, this varies according to the age of the trees and the price of rubber.

Q. How many hectares of rubber would be considered an ideal plantation size for smallscale planters?

A. It has been found that about 10 acres (4½ hectares) is ideal.

Q. How do profits from rubber compare with those from palm oil?

A. At present in Malaysia the planting of oil palm is more popular among farmers than rubber, due to the fall in the price of rubber.

SMALL FARM RESEARCH AND DEVELOPMENT AT KHON KAEN UNIVERSITY, THAILAND

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The Northeast region of Thailand, with 17 million people and 17 million hectares of land, is the largest region, in terms of both area and population. Most of the people live in rural areas, and are engaged in small-scale rainfed agriculture – mainly monocropping of rice, cassava, and kenaf. The average farm family consists of 7 persons, earning a living from a farm approximately 3.3 ha in size. The Northeast is the poorest region in the country, with an annual per capita income (1983) of US$265, only 38% of the national average. This very low income is due primarily to low agricultural productivity. The major problems are poor soils and erratic rainfall. The soils are mostly light and sandy, with low fertility and low moisture holding capacity. The average annual rainfall is more than 1,100 mm, but it occurs at irregular intervals, and varies greatly in intensity. Droughts and floods are common occurrences. At present, only 5% of the cultivated land is under controlled irrigation, while the maximum potential for irrigation is less than 15% of the total arable land. Detailed information on the agroecosystem of the Northeast may be found in the KKU-Ford Cropping System Project Workshop Report, *An Agroecosystem Analysis of Northeast Thailand* (KKU-FORD 1982).

Khon Kaen University (KKU) situated in Khon Kaen province – the regional center of the Northeast – is the major university in the area. The Faculty of Agriculture is one of the 12 faculties established since 1964. In addition there is one Graduate School offering master's degree programs in Agriculture, Education, and Engineering.

Research Activities

KKU is one of the major research institutions in Thailand, and is actively engaged in both agricultural and rural development research. To coordinate and extend research, the KKU Research and Development Institute was established in 1979. A formal linkage of research activities in the Faculty of Agriculture and those in the Ministry of Agriculture and Cooperatives started in 1984, when the Agricultural Development Research Center for the Northeast was completed, with aid of a grant from Japan. This Agricultural Development Research Center is a tri-partite project, involving the Government of Thailand, USAID, and the Government of Japan. A Research Annex, consisting of 5 main laboratories (Agriclimatology, Crop Physiology, Microbiology, Chemical Analysis, and Physical Analysis), has been constructed at the Faculty of Agriculture to provide modern research facilities.

In terms of research, the Faculty of Agriculture is the most active faculty at KKU. The Faculty is involved, not only in basic and applied research, but also in interdisciplinary research to integrate component technology, and to find appropriate technology for small farmers in the rainfed area, using the farming systems approach. Most of the research budget (80-85%) comes from foreign sources, such as the Australia Centre for International Agricultural Research (ACIAR), Asian Vegetable Research and Development Center (AVRDC), the European Economic Community (EEC), the Ford

Foundation, the International Atomic Energy Agency (IAEA), the International Development Research Centre (IDRC), the Japanese Society for the Promotion of Science (JSPS) and the United States Agency for International Development (USAID).

Current research projects which receive foreign assistance are:

1. ACIAR – Development of Legumes for Farming Systems in Northeast Thailand (1983-85)
2. ACIAR – Ecological Studies of Root Nodule Bacteria and Use of Legume Inoculants (1984-86)
3. ACIAR – Micronutrient Requirements for Biological Nitrogen Fixation and Growth of Legumes (1984-86)
4. ACIAR – Utilization of Fibrous Agricultural Residues as Ruminant Feeds (1984-86)
5. AUSTRALIA – Crops Research for the Northeast (1983-87)
6. AVRDC – Development of Vegetable Crops for Small Farmers (1984-87)
7. *EEC - Improvement of Cowpea and Kenaf Production to Partly Replace Cassava Growing in Northeast Thailand (1985-87)
8. *EEC – Oilseed Crops Development (1985-87)
9. FORD – Rural Systems Research (1985-87)
10. *IAEA – Improving Food and Agricultural Production with the Aid of Nuclear and Related Technology (1985-89)
11. IDRC – Groundnut Improvement (1982-85)
12. JSPS – Soil Salinity (1982-85)
13. JAPAN – Agricultural Development Research (1984-88)
14. *NETHERLANDS – Ley Farming (1985-88)
15. USAID – Integrated Farming Systems Research (1984-89)

(*Projects under negotiation)

In addition to the above projects there are about 20 small-scale projects supported by the KKU-RDI, the National Research Council of Thailand (NRCT), and local agencies.

Small Farm Research

Located in the middle of the Northeast region, and surrounded by almost 2 million farm families, most of them living on small farms, KKU cannot avoid having a strong interest in small farm research and development. Many of the KKU staff gained experience in rural research from involvement with the Social Laboratory which the Faculty started in 1973, with the cooperation of SEARCA. In 1975, the Cropping Systems Project was initiated, with the support of the Ford Foundation. The Project uses the systems approach, to examine how limited available resources can be utilized to increase the income of small rainfed farmers through crop intensification. From several years of testing, on both the University farm and farmers' fields with the farmer's participation, the Project has identified several promising cropping patterns (Charoenwatana, 1984). Some examples are:

- Intercropping of cassava with peanut or mungbean.
- Peanut-mungbean or mungbean-peanut double cropping in upland areas.
- Growing peanut or mungbean before rice in higher paddy fields.

The rate of adoption of these new cropping patterns varies greatly among farmers, due to social factors. Because of this, the Project has expanded its activities to include social aspects, utilizing the concepts of human ecology (Rambo, 1983) and agroecosystem analysis (Conway, 1982) to promote integration and interaction among natural and social scientists.

Since the rainfed farmers in the Northeast receive a considerable part of their income from livestock and fish, the Project has now integrated animal components into the cropping system research program. The farming systems approach (Norman, 1980, Shaner *et al* 1982) which focuses on the farm household and views the entire farm in a holistic manner, is used to develop technology suitable for small farmers in the Northeast. The Cropping Systems Project finally evolved as the Integrated Farming Systems Research Project in 1984, with financial support from USAID. An interdisciplinary team of about 40 natural and social scientists from 5 faculties are involved in the present Project. The specific objectives of the Project are

1. To develop and test farming technology, and define the type of farming and environments where it will be most suitable and beneficial.
2. To derive classificatory information on agroecosystems and farming systems, their environments, the types of problems they are likely to have, and how they allow or constrain various types of technological solution.
3. To develop and test methodologies for carrying out these first two objectives, and develop these in a form which can be applied in the field.
4. To promote training and communication with action agencies, so that all three of the above objectives are met in Northeast Thailand and throughout the country.

At present, Ford Foundation assistance is encouraging closer interdisciplinary cooperation between biophysical and social scientists in research on rural resource problems in the Northeast. During the past two years, KKU researchers have been very active in the development, testing, and application of rapid rural appraisal (RRA) methodologies. To date, 21 Rapid Rural Appraisals have been conducted throughout the Northeast. These center on the semi-structured interviewing of villagers by in a multi-disciplinary team of at least two persons from at least two disciplines, on a subject relating to rural resources issues (Beebe 1985, Chambers 1983).

Because of the rapid success gained by the use of adapted Rapid Rural Appraisals in Farming Systems Research, a Rural Systems Research Project has been proposed for Ford Foundation assistance for 1985-87. In this Project, patterns of agricultural, demographic, economic and environmental change will be identified, and their interrelationship assessed in order to define appropriate policies and programs. Rapid Rural Appradisal will be related to other research methods and to rural development acti[illegible]. KKU farming systems research will be broadened from the analysis of micro-level data to macro analysis, and a socio-physical resource analysis of the Northeast region.

Small-Scale Farmers' Development

KKU interest in small-scale farmers' development began in the early 1970's. The involvement of the Faculty of Agriculture in the Social Laboratory Project, partially supported by SEARCA, has helped create awareness of small farmers' problems among the faculty staff, and provide much needed direct working experience in the villages. The Social Laboratory at KKU concentrates mainly on group dynamics, leadership development, and on monitoring developmental changes in the 10 villages within the Khon Kaen area.

In 1977, the Faculty of Agriculture began the Intensive Farm Training Project (Walker, 1983) on the KKU campus with assistance from the Asia Foundation. The basic aim of this Project was to demonstrate that a small labor-intensive farm with appropriate inputs and technology could provide a sufficient income for the farm family. A small village was set up for ten families next to the University Farm. Each family has a farm plot of approximately 0.3 ha, and a typical village hut. In principle, the village is a mini Moshav, or smallholders' cooperative settlement. The trainees' qualifications are:

1. They should be small-scale farmers from an area where intensive farming is feasible.
2. They should have completed compulsory education, and have leadership potential.
3. They should be young farmers, less than 35 years old, with no more than two children.
4. They should have good working habits, good moral character and good health.

The final selection of trainees is made by Project personnel, usually based on recommendations from the village committee.

The trainees are required to live and work in the Project for at least ten months. Various aspects of intensive farming are taught, especially vegetable production. In addition to agricultural technology, trainees receive basic instruction in food preparation, food preservation, nutrition and hygiene. Cooperative principles are emphasized – each trainee has to take turns to manage for one month a small cooperative store, which belongs to all of them. The buying of inputs and selling of outputs are done cooperatively. Training procedures are very flexible and practical, and are based on the actual needs of the trainees, relying heavily on learning by doing and problem-solving. Knowledge flows in all direction – from staff to farmer, farmer to farmer and even farmer to staff. Decision-making concerning management of the farmer's plot is left to each family to decide, after discussing the alternatives with the staff of the Intensive Farm Training Project.

For production and living expenses, trainees may borrow from the Project's revolving fund. At the end of training, all revenues from each plot, after deducting production and living expenses, are given to the trainee, together with dividends from the cooperative store. Todate, five groups of trainees, or 50 families, have completed their training. The average net savings of each group are as follows:

Group	Average annual net savings (USS)	Range (USS)
1.	194	–70 to 912
2.	557	105 to 793
3.	313	–303 to 1016
4.	334	–157 to 1043
5.	406	234 to 729

The average net savings for all five groups was US$361 (ranging from – US$303 to US$1043). Results so far indicate that it is possible to train most farmers to practice intensive farming on a 0.3 ha. plot, and that the better farmers can produce impressive net savings. The success or failure of the trainees depends very much on their working habits, skill in management, and especially their moral character (Kovityakorn 1982, Kovityakorn and Taepong-sorut 1982).

The Ley Farming Project, which commenced in 1979 as an agronomic research project funded by the Netherlands Government, identified viable farming systems based on ley rotation and low-input dairying. This was extended to upland farmers in the Ubolratana Settlement, approximately 75 km. from KKU (Gibson 1984). A total of eleven farmers joined this Project. There were no major problems encountered in the adoption of dairying on ley pasture and in the production of farm-grown feed during the project period, because of strong project support and the strong incentive of being able to earn a regular daily income from milk. It will be interesting to see whether the farmers will permanently adopt the new technology after support from the project is discontinued.

KKU is involved in two other small-scale dairying projects. One of these is Sumjarn Project, under the Office of Land Reform, which started in 1979 and is only 12 km. from KKU campus. The other is the Ban Huai Rai Project, about 100 km from Khon Kaen, which began in 1981 by the villagers themselves. Rapid Rural Appraisal was used to study these three projects (Simaraks 1984). In general, it was found that the Ban Huai Rai group was the most successful of the three. The unity and cooperation of the farmers are excellent, because of strong leadership from the leader of the group, who is also the headmaster of the local school. The physical environment is also better, especially in providing water all year round. In contrast to the other two groups, which were set up largely by government authorities, the Ban Huai Rai group organized itself, so the level of interest in the project is very strong. KKU will continue its support for these three projects, and will follow their development.

With the assistance of the International Cooperative Alliance, KKU Faculty staff cooperated in a study of Cooperatives for Small Farmers (Prapertchob *et al*, 1982) during 1980-81, in order to identify how to help small farmers through cooperative organizations. In this study, it was found that the present farmers' cooperative organization is too big to allow participation by small farmers. They would feel more at home in a smaller group with a specific purpose, preferably involving 10-20 members. To promote the formation of an effective and functional group, a Group promoter would need to make an extended stay of at least six months. As a follow-up to this study, KKU is now cooperating with the Thai Department of Agricultural Extension, the Netherlands Government, and FAO, in a Small Farmers' Development Project in the Northeast region.

Another current project on small-scale farmer development is the Program for Employment and Income Generation among Rural Workers of Khon Kaen, Northeastern Thailand, supported by the International Labor Organization. The objectives of this project are:

1. To develop a system of integrated farming.
2. To develop suitable training methods for rural workers.
3. To form small groups of rural workers for cooperative action in villages.
4. To increase the *per capita* income of rural workers.

Twenty-five families in five villages within a 50 km_4 radius of KKU are involved. Essentially, the integrated farming method being promoted is one of integrated fish-swine production. The project is now in its final year.

CONCLUSION

A university can have a considerable role in small farm research and development, if it has a strong committment to agricultural and rural development. Experiences at Khon Kaen University have indicated that the farming systems research approach, together with rapid rural appraisal, is very useful in identifying appropriate technology for small-scale farmers.

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DISCUSSION

Q. How does Khon Kaen University integrate its efforts with those of the existing extension services?

A. We selected areas where the Department of Extension was not working actively since we didn't want to overlap. Usually we concentrate on finding methodology or technology. We are now being consulted by the extension department concerning the use of a farming systems approach, and have been able to be of some help to them, especially in finding appropriate technology – for example, in growing groundnuts after rice, farmers were formerly urged to hurry their planting as much as possible. We found out, however, that successful farmers delayed their planting until the rains stop completely, but stressed very good land preparation, to provide the necessary soil mulch. We work together with the extension services and try to give them something they can use, rather than committees or formal meetings. We tend to keep a low profile. It is easy for our university since it is new, being established only in 1964. We feel that the Ministry of Agriculture must take the leading role, and should take most of the credit for development, since it is their direct responsibility. The university should take a secondary role in terms of extension.

Q. I wonder why you emphasize the wholesale rather than the retail disposal of crops distributed by farmers? Many farmers have complained of the profits taken by middlemen – if farmers have the time to sell their own produce, wouldn't this be best?

A. We thought this at first, but found that middlemen did not take a very big profit, and in fact performed a useful service quite cheaply. We feel now that the farmer's time is best spent in production.

Comment (Dr. Aida Librero)

I agree with you on this, and hope that Khon Kaen University has documented this information. Many people assume that middlemen exploit the farmer, and we need documentation of cases in which their profits are reasonable and they offer a good service. In other cases, they do take excessive profits. Some documentation would be of great help to policy makers.

A. The problem is that research and development often are not much in contact. The people who like to work with farmers are not generally very interested in research and documentation – they tend to evaluate their progress subjectively. I feel we may even have to establish another group to work in the middle, and document what happens.

SOCIO-ECONOMIC IMPACT OF TECHNOLOGY TRANSFER ON A PHILIPPINE VILLAGE

– Some Lessons from Technical Cooperation with Japan –

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INTRODUCTION

The Green Revolution has made a great contribution to the development of agriculture in Asia since the 1960's. We are now at the stage of considering its effects. The transfer of innovative technologies, mainly concerned with seeds and fertilizers, enabled many countries to achieve rapid growth in their rice production. On the other hand, it has been widely recognized that the effectiveness of new technology differs from region to region and from nation to nation, because it is restricted by local agro-environmental and socio-economic conditions. Recently, it has also been noted that the gap between depressed and developed areas has grown, in terms of economic viability and social justice.

The Cagayan Valley in northern Luzon, Philippines, is one such region where development has been slow (Fig. 1). Since the majority of arable land is rainfed, the average yield of unhulled rice (palay) was only 1.7 mt/ha in the mid- 1970's, while in Central Luzon it was more than 2.5 mt/ha. In this connection, the Cagayan Integrated Agriculture Development Project (CIADP), one of the core national development programs[1], was initiated in 1977 to raise the region's socio-economic status by increasing food production.

In response to a request by the government of the Philippines at the time of CIADP's establishment, JICA (Japan International Co-operation Agency) has provided funds and technical assistance. In particular, special emphasis had been laid on establishing an agricultural experiment facility that can disseminate research findings directly to small farmers through demonstration farms, extension and training activities (JICA, 1980). For this purpose, the Agricultural Pilot Center (APC) was established at Iguig in Cagayan province. During the period 1977-1984, a joint Philippine – Japanese research program examined various methods of making rice-based farming more productive in a way that was acceptable to small rainfed farmers in the area.

The author conducted a socio-economic survey in 1982/83, to evaluate the impact of technology transfer by APC on a rural community (APC, 1977 and JICA, 1984). Based on a comparative study between conditions in 1977 and those in 1982, the main purpose of this paper is to provide data on changes in the socio-economic structure observed at Minanga Norte, a rice-growing village (Barangay), in the project area near the town of Iguig (Fig. 2).

* Author has recently joined the ESCAP CGPRT Centre, Bogor, Indonesia, as an Agricultural Economist

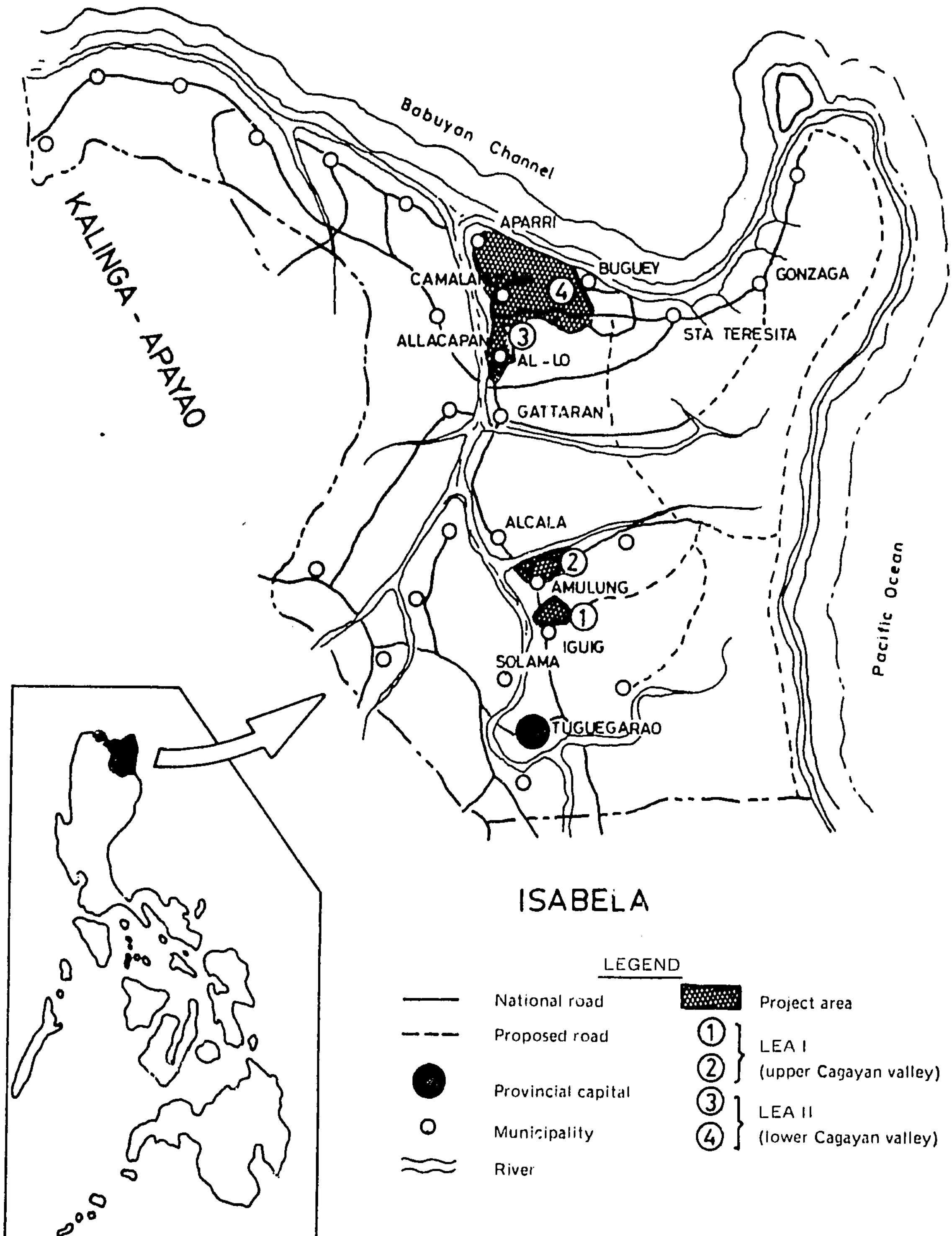

Fig. 1 Map of Cagayan province and location of project areas

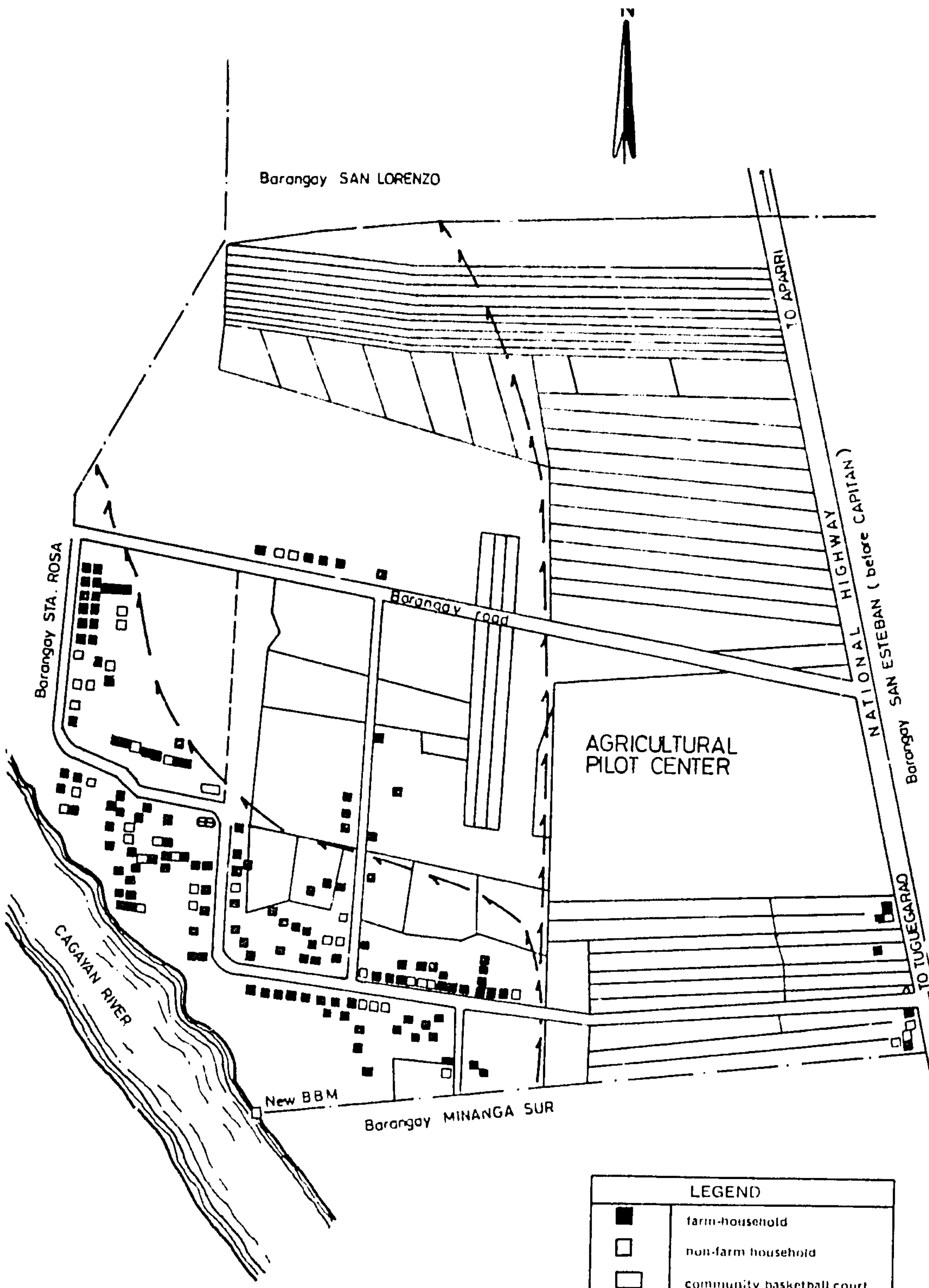

Fig. 2 Spot map of Minanga Norte, Iguig, Cagayan

Outline of Technical Co-Operation

The APC project, the principal aim of which is to spread improved rice cultivation techniques, was initiated in conjunction with two other projects, irrigation and social development (electrification). While irrigation facilities were built by the National Irrigation Administration (NIA), electrification was assigned to the Cagayan Electric Cooperative (CAGELCO). These two projects were directly concerned with the basic infrastructure, as a pre-requisite for the effective dissemination of improved technology[2]. The APC joint research project was established to develop appropriate farm technology through applied research, and by verification of the suitability of technology at specific locations.

Since the extension program aims to encourage farmers to adopt the improved technology recommended by APC, activities include the establishment of pilot farms, training programs and support communication. Pilot farms set up in Iguig, Alcala-Amulung, Lal-lo and Buguey, serve as *Leading Extension Areas* (LEA) to demonstrate improved agricultural technology to farmers under the guidance and support of APC. LEA refers to the area covered by the pilot farm, where irrigation facilities and technical guidance are provided to cultivators. *Outside Leading Extension Area* (OLEA) refers to villages near the LEA where rainfed rice technology is being practiced but which will eventually be provided with irrigation water when facilities are completed.

As of 1982, LEA was extended to 4 areas covering an aggregate area of about 200 ha (Fig. 1). The Iguig Pilot Farm (60 ha) and Alcala-Amulung Pilot Farm (75 ha) at LEA I in the upper Cagayan started in 1978 and 1979 respectively. At LEA II in the lower Cagayan, Lal-lo Pilot Farm (32 ha) was set up in 1980 and Buguey Pilot Farm (42 ha) was launched in November 1981. It is expected that the target area in the upper Cagayan will cover a total area of approximately 3,125 ha, while that in the lower Cagayan is about 10,875 ha.

A package of improved technology, which was based mainly on modified IRRI research findings, has been extended to the farmers within the designated LEA where conditions are similar to other CIADP areas. Any potential problem identified in the LEA during the course of operation is then fed back to APC for in-depth analysis and appropriate action.

Setting of Research Site

This paper does not aim at evaluating the effectiveness of the APC project itself, but will provide an example of the impact of technology transfer on rural society. Using the results of two socio-economic surveys conducted by APC in 1977 and 1982 for all households in the village of Minanga Norte, I shall present a profile of the village and its rice-based agriculture. The survey results are summarized in Table 1, together with data obtained in 1982 at the village of Antiporda near the Buguey Pilot Farm in the northern part of Cagayan.

Ethnic Groups and Population

Like people in other barangays near Iguig, the villagers of Minanga Norte are predominantly Itawes, one of the major ethnic groups of the province. The major dialect spoken in this village is thus Itawes. The Ilocano and the Ibanags comprise the minority groups in the area.

Table 1 Summary of household surveys at Minanga Norte and Antiporda, Cagayan

	Minanga Norte		Antiporda
	1977	1982	1982
Total area (ha)	152	152	200
Area harvested (ha)			
Rainfed	35.6	34.7	159.3
Irrigated	33.2	37.4	18.2
Upland (outside village)	94.6	96.6	0.5
Rice yield (mt/ha)			
Rainfed (OLEA)	1.6	1.7	1.5
Irrigated (LEA)	—	3 ~ 4	2.5 ~ 3
Population	689	781	636
Annual growth rate (%)	—	2.5	1.6
No. of households	136	170	108
Farmer	101	109	80
Landless worker (LW)	10	29	15
Non-farmer	25	32	13
% of farm households (%)	74	64	74
(including LW)	82	81	88
No. LEA farmers	35	38	13
Land distribution per farmer	0.28	0.34	0.47
Gini ratio	~ 0.35	~ 0.48	~ 0.55
Labor input (workdays/ha)			
Rainfed	56	59	75
Irrigated	—	96	
Farm equipment			
Tractor		0	4
Spray equipment		16	8
Rotary weeder		4	0
Plow		231	154
Water buffalo		126	65

There were 170 households in Minanga Norte in 1982 (Table 2). This is 25% higher than the number of households enumerated in 1977. The number of people in 1977 was 689, and had risen to 781 in 1982. This means that the annual growth rate was 2.54% over the five year period. This is lower than the national rate (2.64%), but higher than the rate for Cagayan province (2.03%) for 1975-1980. About 38% of the population were less than 15 years old, and 47% were less than 20. Assuming that 15-64 are the economically productive ages, the potential labor force in Minanga Norte was 450. The ratio of productive to non-productive people was 1.36.

Table 2 Occupation of household heads, Minanga Norte, Iguig, Cagayan, 1977—82

Occupation	No. of household heads 1977	1982	Occupation	No. of household heads 1977	1982
Farmers			**Non-farmers**		
LEA Farmers			Laborers	4	10
Owners	5	7	Fishermen	2	5
Part-owners	16	23	Carpenters	2	5
Tenants	13	8	Technicians	1	3
Lessee	1	—	Businessmen	1	2
OLEA Farmers			Epidemic Aides	1	—
Owners	13	11	Housekeepers	1	2
Part-owners	18	22	Weavers	1	—
Tenants	33	38	Conductors	—	1
Lessee	2	0	Drivers	—	1
Landless Agricultural Workers	10	29	Janitors	—	1
			Driver of *Calesa* (house-drawn rig)	—	1
			Housemaid	—	1
			Retired	4	—
			Unemployed	8	—
Sub-total	111	138		25	32

Occupation by Household

Farming is the main occupation of the majority of household heads (80%). Out of 109 farm household heads, 38 had paddy fields covered by the APC project (LEA), while the remaining 71 were OLEA farmers. In addition, there were 29 households classified as landless agricultural workers. These laborers work on farms but do not possess rights to any land (Ledesma, 1982). The number of landless workers almost tripled between 1977 and 1982. The number of non-farm households increased by 28% during the same period.

Rice Yields

The average yield of (unhulled) rice in 1977 was 1.0 mt/ha. This was less than the 1975 national average of 1.75 mt/ha. The low yield was attributed to drought and to flood damage by the Cagayan river. In addition, most farmers practiced traditional farming techniques. After the temporary irrigation system became operational in the LEA in 1978 and technical guidance to the farmers was initiated, there was a drastic change in the agricultural situation, including the yield per unit area. The majority of farmers now plant HYVs (High Yielding Varieties), use fertilizer, and have also adopted recommended crop protection practices.

Under partly irrigated conditions, the target yield of 3.5 mt/ha has been attained since 1979 (Fig. 3). However, the average yield of LEA in 1982 was lower than in previous cropping seasons. This was due to limitations in the water supply, especially during the dry season, as a result of pump breakdown, and to damage from a typhoon that hit the area in 1982.

Use of Fertilizers and Chemical Pesticides

The use of fertilizers and chemical pesticides was not common in the area before 1978. Lack of capital and a limited water supply were the major constraints to the adoption of improved technology. In 1982, more than 90% of the LEA farmers applied fertilizer during both dry and wet seasons, while 90% and 70% respectively used insecticides in each of the two seasons. On the other hand, only 30% and 17% of the OLEA farmers applied fertilizers and insecticides on their farms during the dry and wet seasons, respectively.

APC recommended LEA farmers to apply 6 bags (300 kg/ha) of ammonium sulfate or 3 bags (150 kg/ha) of urea during the wet season, and 8 bags of ammonium sulfate or 4 bags of urea during the dry season. However, the majority of farmers who used fertilizers and insecticides applied the minimum doses recommended by technicians, or even less than this.

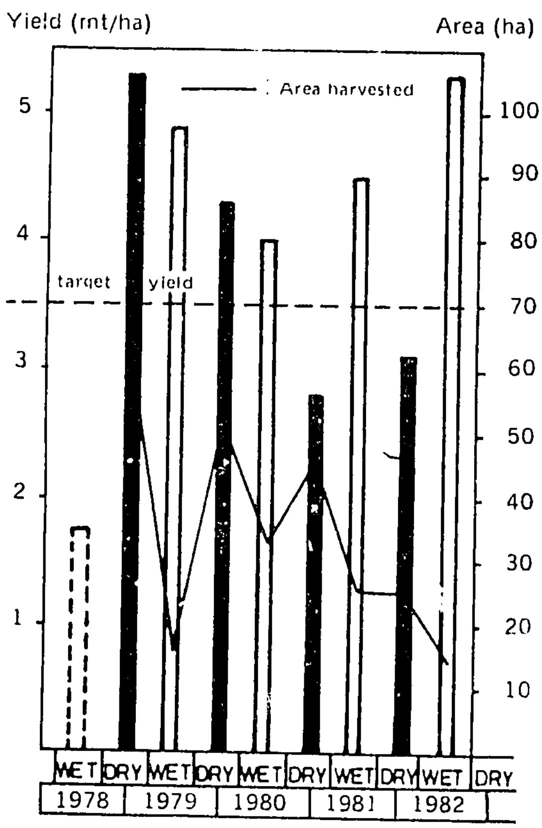

Fig. 3 Changes of yield and area irrigated at the Iguig Pilot Farm, Cagayan, 1978–82

Farm Equipment

The wooden plow, steel plow and harrow are the main land preparation equipment, and are all owned and used by the farmers themselves. This equipment is drawn by draught animals. Only 16 of the 109 farm households owned a sprayer. Out of these, 12 belonged to the LEA, and the other two to the OLEA. The average amount of labor used for rice production was 96 workdays (wd)/ha for LEA and 59 wd/ha for OLEA. The data shows that rice cultivation at the LEA is more labor intensive than that of the OLEA.

We shall now turn to the socio-economic impact of technology transfer on the village during the period 1977-1982.

LAND AND VILLAGER UNDER TECHNOLOGY TRANSFER

Tenure Status of Arable Land

In general, the land tenure system in rainfed areas is more complex than in irrigated areas, because land ownership or the right of cultivation among tenants has traditionally been transferable. Farmers' plots are scattered over a wide area, and tenants hold rights to cultivate small plots of lowland and/or upland. This pattern may be attributed to two reasons. One is low productivity, even though the man/land ratio is quite high. The other is the custom of inheritance by which all children have the same rights of succession.

According to the Barangay Index Control Map, which was approved by the Ministry of Agrarian Reform in 1977, the total area of Minanga Norte was estimated at 152 ha. Of this area, about 80 ha was occupied by rainfed rice fields cultivated by 122 tenants. The average area per tenant was 0.65 ha.

A survey conducted by the APC in the same year found that only 65 tenants actually resided in this village. Therefore, almost half the tenants who held rights to cultivate village land resided elsewhere. In addition to the area tenanted, it was estimated that less than 20 ha was farmed by the land owners. The remaining portion consisted of roads, house sites, and upland crops.

In October 1982, 77 Minanga Norte farmers cultivated 59 ha of rice. (Table 3). Twenty farmers also cultivated rice on 14 ha of land located outside the village. In total therefore, 97 village residents planted rice on 72 ha of paddy fields. Of this, 81% of the land belonging to the village and 19% of the land outside the village was rainfed. In addition, 18 farmers cultivated corn on 12 ha of upland belonging to the village, while 72 farmers planted corn on 84 ha of upland outside the village area. These data show that the majority of farmers cultivated both rice and corn, either inside or outside their own village.

Table 4 shows the number of farm households and the land tenure status in 1977 and 1982. The 1977 data show that 31 out of 35 LEA farmers cultivated rice on 33.2 ha of rainfed land, while the rest of the land was used for corn cultivation. In addition, 48 OLEA farmers tilled 35.6 ha. The total rainfed area inside and outside the village was thus 68.8 ha. There was also 94.6 ha of upland.

Table 3 No. of farmers, and area of rainfed/upland cultivated by LEA and OLEA farmers, within and outside Minanga Norte, Iguig, Cagayan, 1982

Items	Rainfed (rice)			Upland (corn)		
	No. of farm households	Area (ha)	%	No. of farm households	Area (ha)	%
Within village area						
LEA	38	33.4	—	7	4.6	—
OLEA	39	25.2	—	11	7.7	—
Sub-total	77	58.6	81.3	18	12.3	12.7
Outside village						
LEA	5	3.6	—	25	29.5	—
OLEA	15	9.9	—	47	54.8	—
Sub-total	20	13.5	18.7	72	84.3	87.3
Total	97	72.1	100.0	90	96.6	100.0

Table 4 Changes in tenure of arable land between 1977 and 1982, in Minanga Norte, Iguig, Cagayan

Type of farm	1977				1982			
	Lowland		Upland		Lowland		Upland	
	No. of farmers	Area (ha)	No. of farmers	Area (ha)	No. of farmers	Area (ha)	No. of farmers	Area (ha)
LEA								
Owner	5	6.5	4	1.8	7	6.0	5	3.9
Part-owner	15	15.5	16	19.2	23	26.0	19	25.0
Share tenant	10	10.7	12	14.4	8	5.4	7	5.3
Lessee	1	0.5	1	1.0	—	—	—	—
Sub-total	31	33.2	33	36.4	38	37.4	31	34.2
OLEA								
Owner	9	6.1	10	6.4	7	4.1	6	5.3
Part-owner	16	12.2	17	18.7	20	15.4	20	24.8
Share tenant	22	16.8	30	32.1	24	15.2	32	32.2
Lessee	1	0.5	1	1.0	—	—	—	—
Sub-total	48	35.6	58	58.2	51	34.7	58	62.3
Total*	79	68.8	91	94.6	89	72.1	89	96.6

* Grand total area: 1977 = 163.4 ha; 1982 = 169.7 ha

where mainly corn was cultivated, making the total cultivated area 163.4 ha. In comparison, the total area in 1982 was estimated at 168.7 ha. Thus, although the population grew by 2.5% per year, the total arable area remained almost the same. This suggests that the population pressure on land has risen rapidly in Minanga Norte.

Changes in Land Ownership

Table 5 shows the changes in tenure/household status between 1977 and 1982. Of the 136 households residing in Minanga Norte in 1977, 106 were still living there in 1982. The remaining 30 households had been dissolved or had moved out (because of the death of the household head, his retirement, or for other reasons). As of 1982, 64 new households had moved into the village. The Table shows numbers of households of different status in 1977 and in 1982.

Figs 4 and 5 illustrate the dramatic changes in land tenure status of LEA farmers. Changes occurred, not only in the number, but also in the membership, of each group. In the case of LEA farmers (Fig. 4), there were five owner-cultivators in 1977. After five years, one of these had changed his status to part-owner, and three new owner-cultivators had joined the group. One of the new owner-cultivators had been a part-owner in 1977, but had transfered the right of cultivation to others. The other farmers had purchased and/or inherited irrigated land at the LEA, and moved into the village.

In 1977, 16 part-owners had resided in this village. Eleven of these households retained the same status after five years. Four other farmers became either owner-cultivators (one farmer) or tenants (three farmers). One part-owner moved out of the village for family reasons. However, the number of farmers in this class had increased to 23 in 1982. The number of tenants fell from 13 in 1977 to eight in 1982. Six of the original 13 tenants became part-owners, four retained their original status as tenants, and the other three were part-owners in 1977. One man who had not been a farmer in 1977 changed his status to tenant.

Fig. 5 illustrates the change in the number of landless agricultural workers. These have neither ownership of the land, nor tenancy rights to it, and their income is earned principally by their own toil. In 1977, there were ten landless workers. One of these became an owner-cultivator, and two became tenants. Another two moved out of agriculture to become non-farm households, and two more moved out of the village. As a result, only three households remained with the same status in 1982. However, the number of landless agricultural workers increased to 29, because one LEA tenant, one OLEA owner cultivator, three non-farm householders and 20 immigrants joined this class during this period.

Repercussions on the Social Structure

Changes in equity, with regard to the distribution of landholdings in the village, were also studied. A Lorenz curve indicates which percentage of the population holds which percentage of the land area. The diagonal line intersecting the square box represents the line of perfect equality. Similarly, the Gini ratio indicates this degree of equitable distribution in number i.e. the closer to 0, the more equitable; the nearer to 1.0, the greater the inequality.

Fig. 6 shows the distribution of landholdings in 1977. At that time, the village's 163 ha of arable land were cultivated by 101 Minanga Norte farmers with a Gini ratio of 0.289. However, if

Table 5 Changes in type of household between 1977 and 1982 in Minanga Norte, Iguig

	Items	1982 LEA Owner	LEA P-owner	LEA Tenant	OLEA Owner	OLEA P-owner	OLEA Tenant	Landless worker	Non-farmer	Emigrant*	Sub-total	Total
1977 LEA	Owner	4	1	—	—	—	—	—	—	—	5	136
	Part-owner	1	11	3	—	—	—	—	—	1	16	
	Tenant	—	6	4	—	—	—	1	1	1	13	
	Lessee	—	1	—	—	—	—	—	—	—	1	
OLEA	Owner	—	—	—	1	4	2	—	1	5	13	
	Part-owner	—	—	—	5	4	2	1	—	6	18	
	Tenant	—	—	—	2	7	18	—	2	4	33	
	Lessee	—	—	—	—	—	—	—	—	2	2	
	Landless worker	—	—	—	1	—	2	3	2	2	10	
	Non-farmer	—	1	—	—	3	—	4	8	9	25	
	Immigrant*	2	3	1	2	4	14	20	18	—	64	
	Sub-total	7	23	8	11	22	38	29	32	30		
	Total	170										

* Emigrant means household resided in Minanga Norte in 1979 but had moved out or disappeared by 1982

Immigrant means household settled in this village after 1977

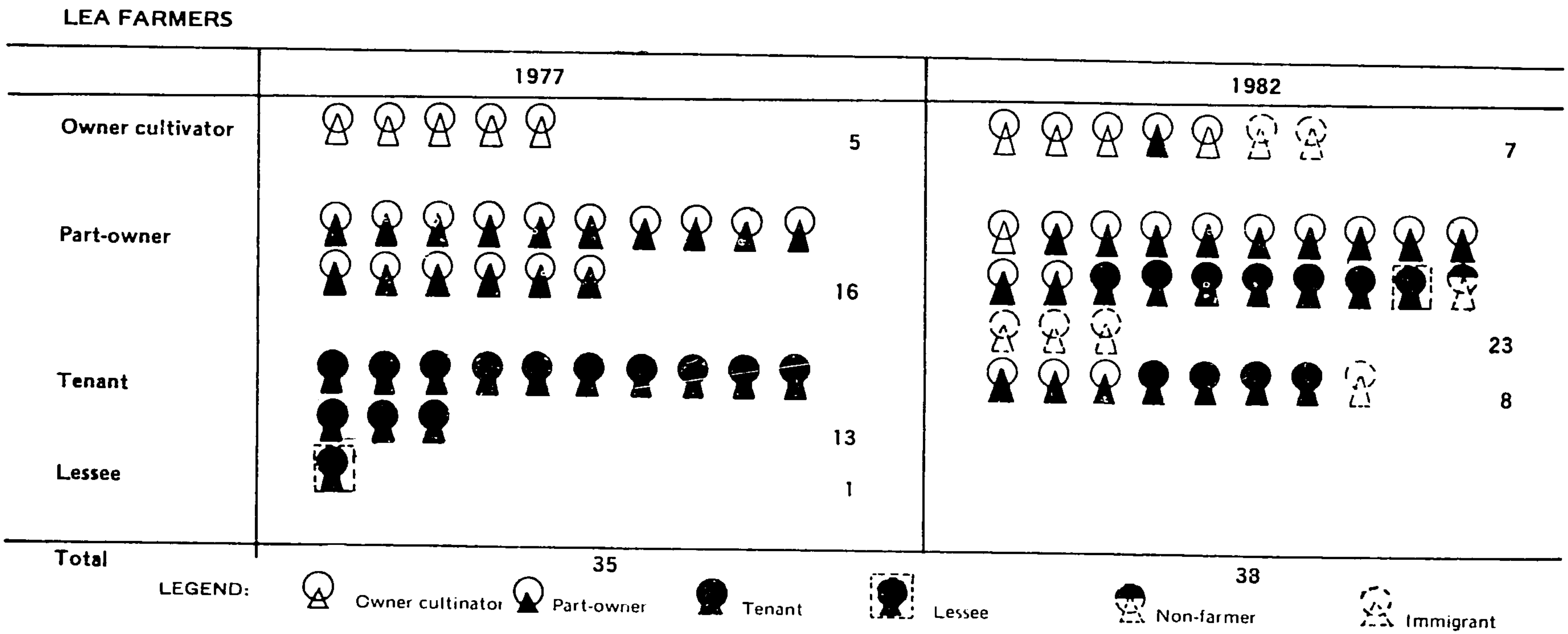

Fig. 4 Changes in classification of LEA farmers from 1977 to 1982, Minanga Norte, Iguig, Cagayan

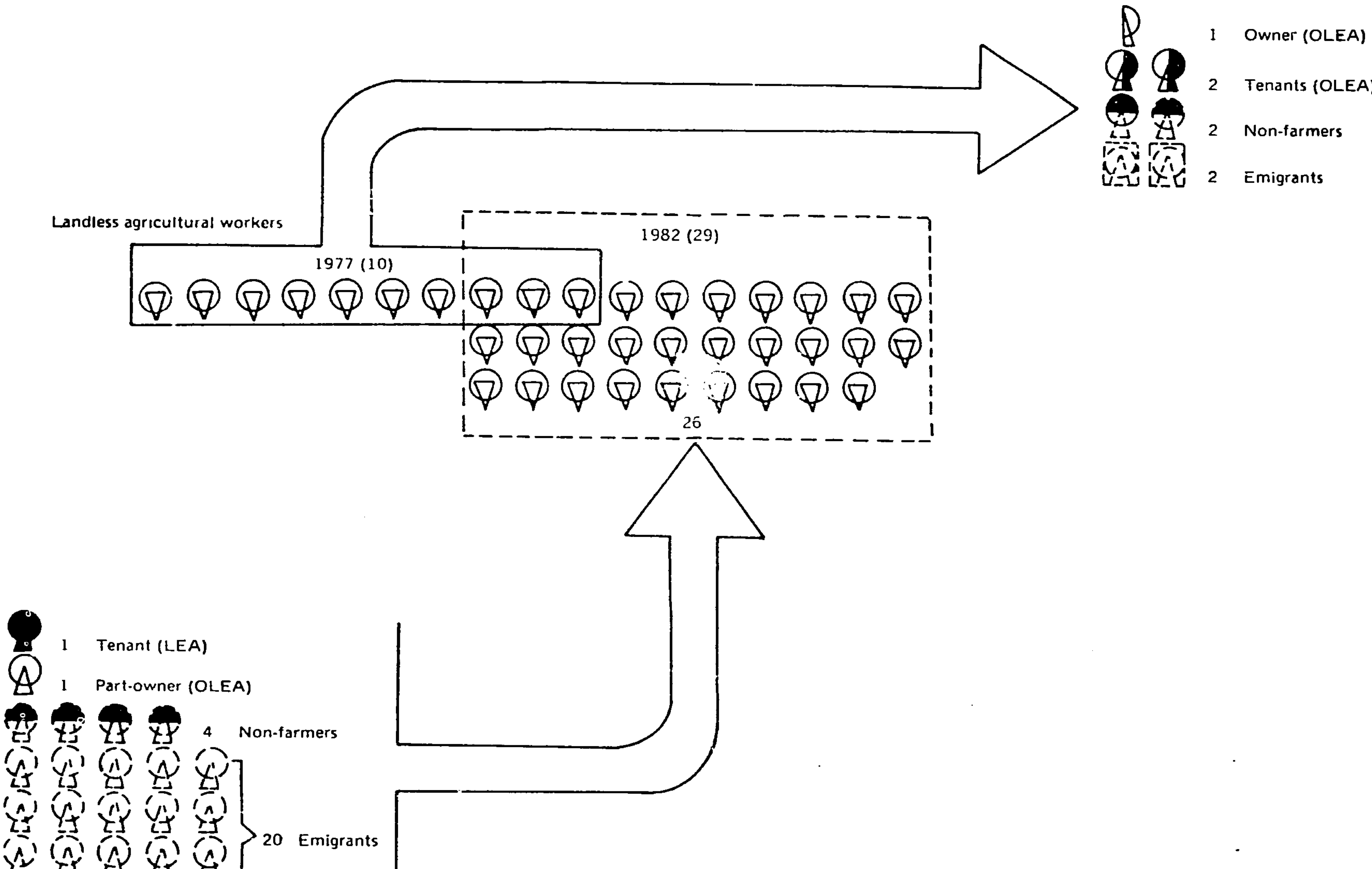

Fig. 5 Changes in classification of landless agricultural workers from 1977 to 1982, Minanga Norte, Iguig, Cagayan

the definition of farm work is extended to include the 10 landless farm workers, the curve produces a more inequitable ratio of 0.351. This means that 50% of the arable land area was tilled by 70% of the cultivators.

As shown in Fig. 6, the distribution of landholdings had become less equitable in 1982. The Gini ratio of 0.477 (which included landless workers) reveals the most inequitable distribution of landholdings of all four Lorenz curves shown.- This means that 20% of the tillers had neither tenant's nor owner's rights to the land. Conversely, the top 20% of tillers held tenancy or ownership titles to 50% of the rice and corn land.

The land reform program has been gradually introduced to several villages in Iguig[3]. In the case of Minanga Norte, however, it seems that the program has not yet been adopted because the rice and corn fields are owned by small landlords who are exempt from OLT (Operation Land Transfer). As of 1982, Certificates of Land Transfer had been distributed to only five farmers for six parcels of rice land. In addition, the majority of tenants stated that they are still practicing the traditional share-cropping.

Irrigation facilities are not yet completed, nor can we assume that all LEA farmers have successfully adopted the new rice technology. This survey has noted only the changes which have taken place between 1977 and 1982. However, because of unknown factors such as farmer's behavior concerning land ownership, the picture may be more complicated than it seems, at first sight. The various changes among Minanga Norte farmers imply that they may hold very high expectations concerning APC activities.

TECHNOLOGY TRANSFER AND RURAL DEVELOPMENT

This section reviews the effects of the introduction of improved rice-growing technologies by APC into the village. In many cases, when a major modernization effort is made in a traditional farming village, it initially has a marked impact on the area. Thus, it was necessary to make a detailed survey of the continuity of these effects, in terms of their impact on social and economic problems. The infrastructure was inadequate when double cropping techniques were first introduced to Minanga Norte. This made it difficult to observe the effects of new technology within a short period of time.

When an advanced rice cultivation technology is introduced into a traditional society, how does the technique spread in the society and what sort of advantages does it give both farmers and the society as a whole? The experience of Minanga Norte seems to indicate that agricultural change included the following steps:

Changes in Land Productivity:

In Minanga Norte, rainwater was traditionally used to grow rice. Because of the poor water supply and low level of technology, rice production in this village was very low, at around 1.5 mt/ha of unhulled rice for traditional varieties and 2 mt/ha for improved ones. The construction of irrigation facilities and other infrastructure improvements made it possible to grow two rice crops each year. As

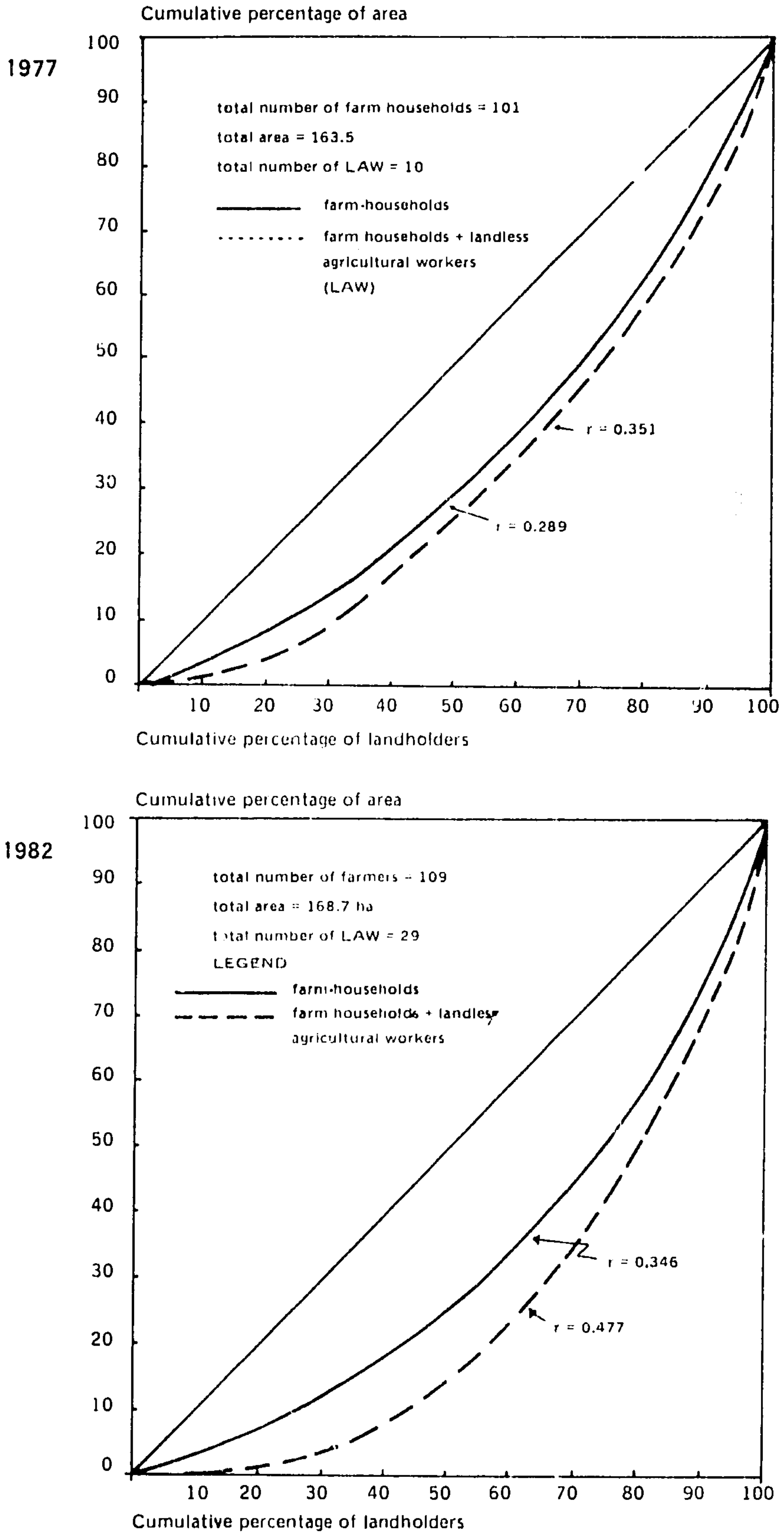

Fig. 6 Area cultivated by farmers at Minanga Norte, Iguig, Cagayan 1977–1982

improved technology spread among farmers, the yield of rice per unit area began to increase. During the 1982 survey, the output of LEA farmers in Minanga Norte exceeded 3.5 mt/ha.

The production capacity in a rainfed village is raised when the infrastructure is improved and appropriate farming techniques are introduced. The completion of the Magat dam as a source of electricity will transform the APC pilot farms and other parts of the CIADP area, and also the floodplain of the Cagayan River, into a rice granary.

Increase in Population:

As the rice yield increases so will the capacity of the village to support population, and at a higher rate than in nearby traditional villages. The present rate of population growth in the Philippines as a whole is 2.64%. While that in the province of Cagayan stands at 2.03%, the rate for Minanga Norte was estimated at 2.5%.

Changes in Household Composition:

Population growth does not always mean an increase in the number of households. Unless there is also an increase in accomodation and other necessities, the emigration of entire households is likely. If conditions are favorable, an inflow of people along with natural increase will push up the total number of households. In Minanga Norte, the number of households increased from 136 in 1977 to 170 in 1982, representing a gain of 25%.

Creation of Job Opportunities:

The existence of employment opportunities within the scope of commutation is necessary for the formation and maintenance of a village. The town of Iguig is only about 20 km from Tuguegarao, the provincial capital, a journey which takes 20 minutes' by jeepney. The members of all 32 non-farming families in Minanga Norte in 1982 were employed in Iguig.

The number of farm households in Minanga Norte increased from 101 in 1977 to 109 in 1982. As the increase in the total number of households was faster, the ratio of farm families declined from 74% to 64% during this period. On the other hand, the number of landless agricultural workers increased, from 10 to 29 (7% to 17%). These workers make a living by helping nearby farmers, and might thus be included in the category of farm households. When these families are added, the percentage of farm households remained at 80% in both years.

Limitations on Increasing the Area of Arable Land:

As population increases and the number of households relying on agriculture grows, there will be pressure to expand the cultivated area. As noted earlier, the total area of rainfed and upland fields cultivated by Minanga Norte farmers in 1977 was about 160 ha, and remained virtually the same in 1982. Population pressure on the land thus rose rapidly.

The study of cultivated land in Minanga Norte also revealed that farmers in the village own a similar acreage of upland and rainfed rice fields. For these farmers, growing corn on upland is a source of income during the dry season. The dry season is the off-season for rice, and corn is also a means of hedging the risk of fluctuations in rice yield.

Aggravation of Social Competition:

When the area of cultivated land does not expand, in spite of an increase in the number of farm households dependent upon agriculture, competition for the right of cultivation among these families becomes more serious. When rainfed rice farming prevails, land prices are generally low, due to low productivity. In addition, farmland is divided into small lots because of the equal inheritance system.

However, in recent years, the basis of production has improved and the possibility of higher productivity has emerged. Consequently, there has been an increasing tendency toward social competition, reflected in changes in the composition of classes of both LEA and OLEA farmers.

Appearance of Landless Workers:

What has happened to those farming households which have failed in the competition for the right to cultivate land? Their fate is evident from the example of Minanga Norte, where the landless households increased from 10 in 1977 to 29 in 1982. These households work in other farmers' rice fields to earn their daily wage. They prefer to reside in areas where irrigation conditions are good and rice is harvested twice a year. It has been reported that these workers account for as much as 40% of the total population in some villages (Ledesma, 1982).

Economic Mechanisms for Sharing Production:

The difference in unhulled rice yields between the LEA and OLEA farmers suggests that there would be a gradual widening of the income gap between the two[4]. However, the village economy seems to be based on customary mechanisms of redistribution, which minimize any expansion in income gap and resultant frictions (Hayami & Kikuchi, 1981).

One example of such mechanisms is when one farmer helps another in harvesting. The second farmer in return helps the first in his harvesting work[5], each receiving a share of the other's harvest as payment in kind. The survey confirmed that this custom prevails even in rainfed villages.

Social Friction and Institutional Changes:

As noted above, differences in the yield of unhulled rice between LEA and OLEA farmers have become greater. However, the gross returns of LEA farmers involve expensive irrigation costs (150 kg of unhulled rice/ha for pump irrigation). There also is a need to use more farm inputs such as fertilizer and agricultural chemicals, which similarly results in higher expenses. For this reason, the traditional sharing of the harvest is too burdensome for the employer-farmer Reducing the share of the harvest given to workers helps lighten the burden.

In Minanga Norte, the harvest share between employee and employer-farmer in LEA gradually changed from 1:7 to 1:6. In OLEA, 1:7 is still popular among farmers The harvest share in the LEA area has gradually been reduced in consideration of the yield level, the costs involved, the number of workers employed for harvesting, and other factors.

The survey showed these developments since the introduction of the improved technology for growing rice. Land reform and improved technology represent two major factors influencing village society in the Philippines. In view of the present situation of villages in Cagayan, more time will be needed for completion of land reform, improvement of irrigation facilities and dissemination of improved technology.

CONCLUSION

As described above, the establishment of APC and its extension activities have had a variety of socio-economic effects on rice farmers in the sample villages. However, many unsolved problems remain.

Stability of Production per Unit Area

As indicated in Table 1, rice yields obtained by LEA farmers improved during the first five years of APC. However, as Fig. 3 indicates, even LEA farmers are likely to find it difficult to ensure a stable yield of rice. On the pilot farm of Iguig, for instance, the target of 3.5 mt/ha in the wet season has almost been attained, but the rice yield during the dry season decreased to 3 mt/ha in 1981 and 1982[6].

This instability of rice yield arises partly because LEA farmers are unable to ensure a sufficient water supply. Another reason is the fact that farmers in Minanga Norte have a low level of technology in irrigated rice farming, because they are traditionally engaged in both rainfed and upland cultivation. This factor should be considered before efforts to disseminate advanced techniques are made. Measures to solve problems must be given top priority.

Perspectives for Future Rice Production

From the viewpoint of the villagers, the problem of irrigation also presents farmers with a serious question in terms of their relation to agricultural policies. This problem originates in the fluctuation in the supply and demand for rice in the Philippines which occurred in the 1970's and 1980's. The country's rice production is now approaching a balance between supply and demand, and rice yields have stabilized in the highly productive Central Luzon and Southern Tagalog regions. In consequence, optimistic views about rice growing are gaining ground, at least on a village level. As rice production stabilizes, the pace of improving irrigation facilities has become slower, especially in areas in which development has been delayed.

Development of Appropriate Technology for Rainfed Farmers

The previous paragraphs discuss the principal problems involved in APC's activities at a village level. We shall now discuss matters which can be tackled successfully by APC.

1) A higher yield of unhulled rice is not always guaranteed by irrigation. The improvement of fertilization techniques under various soil conditions should become an important item of study. There is not yet sufficient research on this in rainfed/upland areas.

2) In addition to improving artificial fertilization techniques, there is a need to stimulate farmers' interest in applying organic substances to the soil. The continued production of twice-yearly rice crops means that the study of the soil productivity is important.

3) Farmers' interest should be stimulated in techniques of controlling plant diseases and harmful insects. At present, the area planted in two rice crops each year is not very large, and stemborers are the only major harmful insect. When the same variety of rice is planted over a wider area all year round, plant diseases and harmful insects will become a primary problem. Considering this, there is a need to begin now to collect data on this situation.

4) With regard to the improvement of agricultural tools, most farmers do not own even a rotary weeder, although most are very interested in the use of herbicides. APC's technical guidance puts a heavy emphasis on savings in land and capital and on labor-intensive techniques. Considering this, the use of weeding by hand and hand-driven weeders should not be overlooked.

A RECONSIDERATION OF TECHNOLOGY TRANSFER

A cost-return analysis shows that an evident difference has begun to emerge between the profitability of LEA farmers and that of OLEA farmers in Minanga Norte. Among LEA farmers, substantial differences in income have appeared between owners, part-owners and tenants. In the past, in villages where productivity has been low and stagnant, a balanced state was created in accordance with the stage of development. Emergence from this type of traditional society is now beginning. If the pace of change is too fast, social frictions will naturally result between the beneficiaries and non-beneficiaries of APC's projects.

This aspect was not fully considered when the technical cooperation project was first promoted. To avoid these frictions, specific proposals should be made to include OLEA farmers in the dissemination of useful techniques, rather than limiting contact to farmer-beneficiaries on pilot farms. The majority of OLEA farmers and landless workers in the village still experience the same cultivation conditions as those of five years ago.

Footnotes

1) CIADP was created under PD (Presidential Decree) in 1189 on August 30, 1977 to accelerate the balanced and integrated development of the province, through the implementation of a carefully laid program for the simultaneous delivery of a range of agricultural infrastructure and social services. As of 1982, this is the third of the eight integrated area development projects in the Philippines.

The project serves, not only to increase production of traditional crops such as rice, corn and tobacco (without necessarily increasing the production area), but also seeks to make full use of all land resources through the introduction of industrial and cash crops, including the development of livestock, dairy and fisheries. Supporting CIADP's effort to develop the province's agricultural and natural resources is its allied infrastructure development program, jointly sponsored by the Philippine and Japanese governments.

2) The irrigation component is closely related to the completion of the Magat Dam as a source of electric

power for the whole Cagayan Valley area. The Magat river, a tributary of the Cagayan river, located in Isabela province, is the source of power generated by the Magat Dam.

As part of the Magat Dam Project, it was planned to construct two to three permanent pumping stations along the Cagayan river within Cagayan province. However, the construction of irrigation facilities had to be delayed, because of natural disasters and other causes. A temporary pumping station was established at the town of Iguig for supplying water to LEA farms.

Improved technologies developed at APC were greatly affected by irrigation conditions. In this respect, APC's activities for agricultural extension were carried out under many restrictions, as a result of the delay in the irrigation project.

3) In 1972, the Philippine Agrarian Reform program was extended to all tenants in rice and corn growing areas. Share-cropping tenancy was officially abolished. Operation Land Transfer was initiated to distribute Certificates of Land Transfer to eligible rice and corn tenant farmers. These tenants became formally amortizing owners under the program. By 1974, Operational Leasehold started fixing leasehold status for share tenants of small landlords. This program covered those who owner 7 ha or more of tenanted rice and maize growing lands.

4) The average gross income from rice farming by OLEA ranges from ₱ 2,000 to ₱ 3,000 (US$111.00 – 166.60) per hectare per year depending on tenure status. At the LEA, the average gross income is 5 to 7 times higher than OLEA. On a per farm basis, LEA part-owners received the highest gross income, with an average of 15,000 (US$833.30), and OLEA part-owners received the lowest at only ₱ 1,500 (US$83.30).

5) In carrying out farm practices in the Philippines, hired workers account for 60% to 80% of the total working hours (about 100 workdays per hectare) (Morooka *et al*, 1979). This is very different from rice cultivation in Japan, where the farm family provides the principal source of labor. Several reasons can be considered for this dependence in Philippine villages on hired labor.

First, natural conditions allow farmers to plant rice at any time of the year if water is sufficient. The second reason is an economic one: there are often great differences in yield between individual farmers, and farmers need to help one another in rice growing to reduce the risks involved.. The third reason is a social one, relating to the traditional share tenancy system, which means that an increase in yield is not always reflected in the income of the tenant. These and other factors combined to create a social pattern based on 'a economy of sharing'.

6) It should perhaps be noted that the average rice yield at Tubuan Village in Laguna in 1974 was 3.4 mt/ha. Productivity in this village has increased rapidly by means of the 'Green Revolution' (Hayami, 1978). Production in Abangay Village, also in Iloilo, was reported to be 3 mt/ha in 1976 (Ledesma, 1982). In addition, data from a random sample of local records at the Department of Agrarian Reform shows that the average rice yield at Rajal Sur Village in Nueva Ecija in 1964 was roughly estimated to be 1.7 mt/ha.

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DISCUSSION

Q. How would you evaluate the relative proportion of functional compared to dysfunctional consequences of the project you describe?

A. I do not have enough data to answer this question, particularly since assessment of this would be largely subjective.

Q. What do you feel is the main benefit from the project?

A. The introduction of new, high yielding rice varieties to the farmers.

Q. Do you think the law and order situation in the district may have influenced the rate of technology adoption?

A. Yes, I think it may have had some effect. Certainly it has had the effect, at least in the short term, of producing greater inequalities in rural income. Since only LEA farmers were covered by the project, the gap in farm income between LEA and OLEA farmers has become wider. In addition, the number of landless workers has increased rapidly as the project continued. There has also been an increase in the pressure of population on available land resources in the village.

TURNING CONVENTIONAL AGRICULTURAL RESEARCH AND DEVELOPMENT ON ITS HEAD: THE FARMER-BACK-TO-FARMER APPROACH

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INTRODUCTION

Most scientists who work in agricultural research today believe in farmer involvement, even if it is little more than lip service to the idea that farmers are the ultimate clients who decide the appropriateness of a technology or program. However, policy-makers, research scientists and development specialists differ significantly on exactly what should be the role of farmers and when should they be involved in the research process. This paper discusses the two main approaches followed today by agricultural researchers: the *top-down* and *feed-back models* of development. It concludes by rejecting both of these models in favor of a third, the *farmer-back-to-farmer approach* which has as its central theme the involvement of farmers as colleagues and advisors in the research and transfer process. The validity of this approach will be illustrated by two case studies:

(1) the successful generation of post-harvest technology and its use by farmers in over 20 developing countries, and
(2) a recent project of adapting potato production to lowland areas of the Philippines.

THREE RESEARCH MODELS

Top-down Model

Adherents of the top-down approach are generally scientists or policymakers who believe the building blocks of agricultural development do not involve rural traditions or even farmer wisdom but only science, the process of generating new knowledge and technology in a laboratory or on an experiment station. While farmers and consumers are said to be the ultimate beneficiaries, farmers remain largely passive recepients of newly generated knowledge and are not considered to have anything to contribute to technology development. Likewise, social scientists are generally not seen as having a role in generating appropriate technology, only in after-the-fact evaluations.

In a somewhat sarcastic, but often true portrayal, A.H. Bunting has described this top-down model:

> The conventional model of agricultural extension as communication, in the minds of many technical and administrate people, represents the research worker, BIG BROTHER, guided by SCIENCE and Von Liebig, producing new technology which he transmits through an arrow to the extension service which in turn fires it off through another arrow at the expectant and grateful producer.

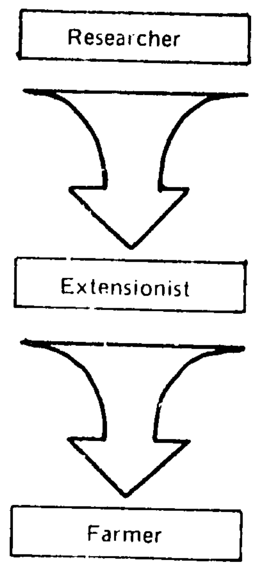


Fig. 1 Top-down model

In the top-down model, decisions as to what are the relevant problems and testable hypotheses are made largely by researchers and policymakers. They believe they know best what farmers need. The orientation of research largely grows from the scientist's background training and a general reading of the situation based on experiences in other circumstances. Under the top-down, vertical model, researchers conduct research on the experiment station, analyze these data, compile them into a report which become recommendations, if extended at all, for extensionists working with farmers. The well-known approach developed in India known as 'Lab to Land' exemplifies the top-down model.

Feedback Model

The feedback model of applied agricultural research represents a communication improvement over the top-down approach in that a 'feedback' mechanism between research-extension-farmers is provided. Researchers on the station should be able to understand better how farmers are reacting to their technologies, largely through the go-between roles of field agronomists, social scientists, and extensionists who work directly with farmers. This model has become popular with the growth of Farming Systems Research (FSR) and incorporation of on-farm experimentation into agricultural research methodology. On the extension side, the Training and Visit (T and V) system promoted by the World Bank is an example of the horizontal, feedback model (Benor and Harrison, 1977).

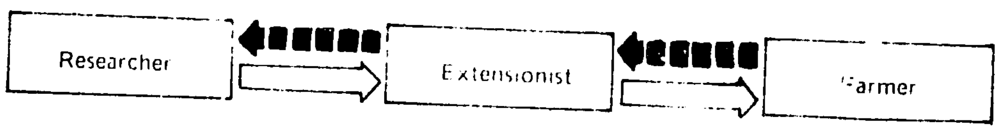


Fig. 2 Feedback model

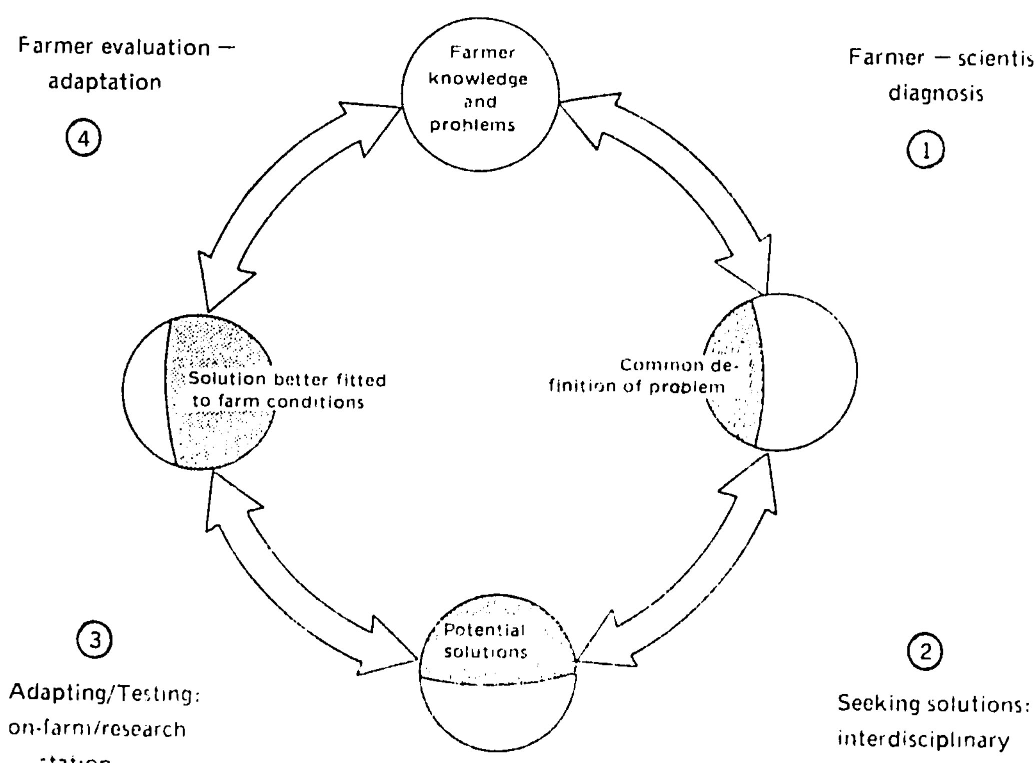
Despite a communication improvement in the feedback model, however, this model shares the following characteristics with the top-down approach:

(1) decisions as to the relevant research questions and the fountain of technologies still come from scientists,
(2) farmers remain passive receipients of technology, and
(3) interaction between farmers and scientists remains superficial, especially when extensionists pass information about farmers to biological scientists who remain out of touch with actual farm conditions.

Farmer-Back-to-Farmer Model

An alternative to the above two models is the 'Farmer-back-to-Farmer' model (Rhoades and Booth 1982). The underlying assumption of this model is that research must *begin* and *end* with the *farmer.* In fact, it turns the top-down model completely on its head by starting with the farmer, not on an experiment station or with a planning committee out of touch with farm reality. This means that farmers must be incorporated as fully active members of the problem-solving team. Farmers with their long-term understanding of local conditions, soil types, socioeconomic reality, crops, markets assume the status of experts in their own right. It also assumes farmers have technological problems for which they want solutions. The Farmer-back-to-Farmer model involves a circular flow of activities, with each activity aiming to accomplish a goal (Fig. 3).

Fig. 3 Farmer-back-to-Farmer



The farmer-back-to-farmer model begins and ends with the farmer. It involves four major activities each with a goal. The hatched areas in the circles indicate an increasing understanding of the technological problem area as research progresses. Note that research may constantly recycle.

	Activities	Goals
1	Diagnosis	Common definition of problem by farmers and scientists
2	Interdisciplinary team research	Identify and develop a potential solution to the problem
3	On-farm testing and adaptation	Better adapt the proposed solution to farmer's conditions
4	Farmer evaluation/adaptation	Modify technology to fit local conditions; understand farmer response; monitoring adoption

Adapted from Rhoades and Booth (1982)

The model does not imply a 'cookbook' approach as is the case in Farming Systems Research in which one is confined to rigidity sticking a step-wise methodology. Farmer-Back-to-Farmer research, for example, may begin with a simple experiment and end with a survey. The key is flexibility and gearing research to locally available resources. The organization of research is centered around a continuous dialogue between farm and experiment station and between farmers, technologists, extensionists and (if available) social scientists. It may be necessary to recycle a technology when it is rejected, or in some cases it may be necessary to terminate projects altogether and return to the stage of a more precise definition of the problem.

TWO CASE STUDIES ILLUSTRATING THE FARMER-BACK-TO-FARMER APPROACH

The 'Farmer-Back-to-Farmer' is best illustrated by two recent cases of farmer-guided design and transfer of technology. One of these technologies, rustic potato seed stores, is now used by several thousands of Third World potato farmers in 21 countries. The second case describes the introduction of potatoes into lowland areas of the Philippines where potatoes had never been grown before.

CASE 1: Diffused Light Potato Storage for Developing Countries

When post-harvest research at the International Potato Center (CIP) began in the early 1970's, the objective was to design storage structures and systems superior to those which existed in developing countries. Initial specific interest centered on farmers living in Peru's Mantaro Valley near the main highland research station. Storage problems were first thought to grow from inadequacies of traditional farm storage practices, which caused 'losses' due to rotting, insect attack, shrinkage, and pathogens. Many projects to solve storage problem of Andean farmers had been launched earlier but without success (Rhoades 1983).

By *beginning* with the farmers and heeding their advice, however, it became clear that scientists and farmers perceived the storage problem differently. When the post-harvest team asked farmers about storage 'losses', farmers responded they had no 'losses'. Farmers claimed that potatoes that shrank or suffered insect attack were simply selected out and fed to pigs. These potatoes, already the poorest of the harvest, were considered necessary as feed for their livestock. Additionally, some wives claimed that small, shrivelled potatoes tasted sweeter and were sometimes desired for their culinary quality.

Continued dialogue with the farmers, however, revealed that storage problems existed but not in a way that either the anthropologist or the biological scientists had originally perceived. Farmers claimed nothing was wrong with their traditional stores, but that the fault lay rather with improved varieties they had adopted during the previous decade. The problem, in their view, was that stored seed potatoes of new varieties produced extremely long sprouts and lost considerable weight under traditional storage management. The long sprouts of seed potatoes had to be pulled off at planting time. This was considered to be costly in labor and time. Farmers expressed less concern with problems in storage of consumer potatoes, the focus of most projects in prior years. Thus, on-station research shifted emphasis toward solving problems of storage of improved seed potatoes, a problem emphasized by farmers themselves.

Fortunately, some scientific findings already existed that storage of seed potatoes in diffused light (not direct sunlight) reduces sprout length, improves seed quality, and gives higher stem density which leads to higher yields. Most small farmers in developing countries store in darkness. However, it was not known how widely acceptable the diffused light principle was to farmers or how it could be adapted to local conditions.

The team intensified on-station experiments with diffused light while simultaneously planning on-farm trials to test and adapt the technology. The process which followed was one of continuous reduction of both the cost and the complexity of the diffused light stores. This involves stage 3 of the 'Farmer-back-to-Farmer' model: on-farm and on-station research and testing. When farmers tested the storage technology with scientists but under farm conditions, results were similar to those of the experiment station. However, the seed trays in which the experiments were conducted were still considered costly. By this point, interaction with farmers had taught the team that a storage structure separate from the family farm dwelling was not possible, that the new storage system – for reasons of convenience and security – had to be incorporated into local architecture. If the team had followed the top-down model they could still be pushing free standing structures. If the team had relied on feedback through a contracted social science study, the idea could have been lost in a report which was never read.

The testing stage was followed by farmer evaluation, and adaptation, in which farmers themselves began to experiment with and modify the use of diffused light. The results were indeed surprising. Scientists quickly discovered in a follow-up study that farmers were not adopting a storage technology *per se* but adapting the *principle* of using diffused light to their own unique cultural conditions. It was not a 'technological package' which was being transferred, but rather an idea. Farmers as researchers were experimenting with ways of fitting the technology into their reality. The diverse forms of storage techniques using diffused light created by farmers was surprising to scientists, and illustrates why farmers must assume the role of partner researcher.

Instead of adopting a model store, separate from their dwelling, some farmers simply spread potatoes out under a veranda where indirect light falls naturally. Other, however, followed the same idea but built simple shelves for better ventilation. A few converted old buildings, and some cooperatives built large stores. Throughout other developing countries where the technology was introduced, farmers also created their own unique adaptation. Farmers were enthusiastic about participating in this final stage of research adaptation and were proud of changes personally made in their own stores. Later, the International Potato Center research team working with national programs around the world seized on the farmer adaptation cases to recommend to extension programs that demonstrations be as varied as possible. Instead of a model store separate from a building, demonstration stores were established within compounds or blended into local buildings. In consequence, farmers during field days related more quickly to the principle of using diffused light.

Follow-up by the CIP scientific team corresponds to the final evaluation stage by the farmer when the technology is totally under the farmers' management. This stage is necessary to understand farmer response, so the technology might be improved, recycled to earlier stages (adapting/testing stage), or if rejection has occurred, to begin once again with the farmer to go around the research cycle again. The crucial point is that research must *begin* with the farmer, *end* with the farmer, and that research is a continuous, interactive, and cyclical process. Figure 4 illustrates the number of adoptions of this technology up until 1983.

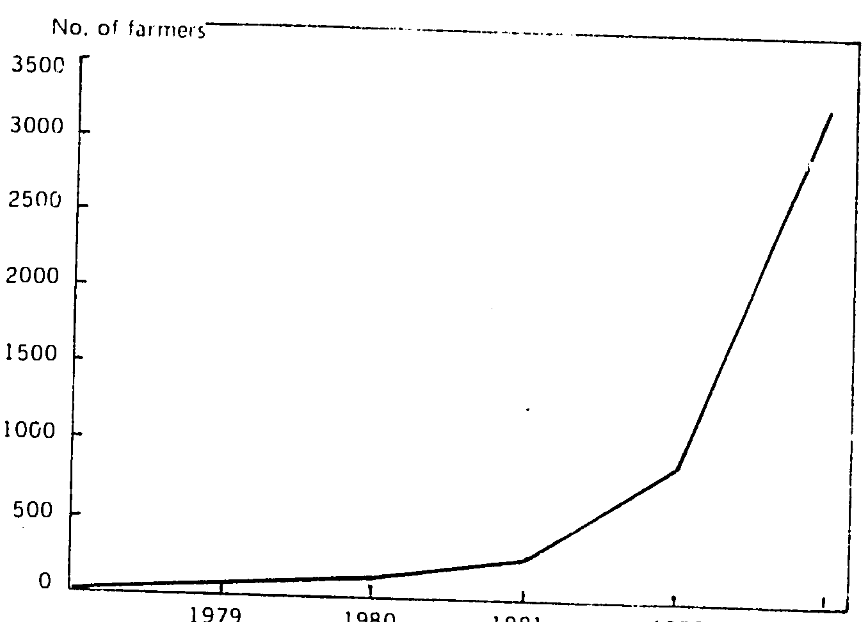


Fig. 4 Known farmer adopters of diffused light seed storage

Case 2: Tropical Potatoes for the Lowland Philippines

The Philippines presents a challenge to scientists involved in improving the efficiency and output of food production and utilization. Most of its rapidly growing population (3% per annum) of 50 million lives in the lowlands, especially those ecological zones between the ocean and highlands. The potato is a nutritious, high-priced commodity which is now produced only in the highlands above 1500 meters. However, potato production costs are high in the mountain zones due to high labor and transportation costs, and the need for special inputs (e.g., chicken manure) which must be trucked in from the lowlands. Furthermore, further expansion of agricultural activity in the highlands might increase erosion and stimulate further environmental depredation in the ecologically fragile highland areas. If consumption potatoes could be successfully produced in the lowlands, while the highlands concentrated its efforts on producing quality seeds for lowland production, the welfare of the populations in both areas could be improved. Highland farmers should be able to maintain income levels through seed production, while small farmers in the lowlands could add a new cash crop. Low income consumers in lowland consumption centers should be able to purchase more food, in the form of potatoes, due to a reduction in prices brought about by the expansion of lowland production.

With the above challenge in mind, SAPPRAD adopted the Farmer-Back-to-Farmer approach in 1984, in an effort to introduce the tropical potato to lowland farmers. This implied, that first the problems from the farmers' point of view must be carefully identified, and then adaptive research conducted involving farmers as research colleagues. Despite the potential for expansion of potato production in lowland areas, farmers' lack of knowledge of potato production, and three major constraints (water management, bacterial wilt, and insect pests) had prevented any successful attempts to produce potatoes in lowland areas.

Following earlier basic research by CIP (Vander Zaag *et al.* 1984) and other institutions, it was determined that success with the lowland potato could be enhanced by avoiding bacterial wilt through planting

(1) after irrigated rice,
(2) after sugar cane, or interplanted with young sugar cane,
(3) along riverine flood plains.

Furthermore, the coolest time of the year, when Siberian winds help lower temperatures in Luzon, was selected for the first season.

A farming systems survey conducted in key areas in 1984 (October) included information on:

(1) socioeconomic profile,
(2) land availability,
(3) crops and rotation patterns,
(4) farmer innovativeness, and
(5) family labor utilization and role of women.

Working through the 'Technology Packaging for Countryside Development Project' of PCARRD, 39 farmers in 6 communities agreed to grow, for the first time, potatoes. (See Fig. 5 for the institutional linkages). In each community, the SAPPRAD teams worked with established community leaders, generally mayors, who were asked to help select 'experimenters' on the tropical potato. Research trials were also conducted on experiment stations near where farmers were already experimenting. The basic idea is for institutions, basic research, and on-farm research with farmers to work through the process of technology transfer together, all at the same time. This, in essence, is the farmer-back-to-farmer (and community-back-to-community) idea, applied to a completely new crop for Filipino farmers.

Three weeks after the first national technology transfer meeting of SAPPRAD (October 9), 37 farmers and 8 technicians were trained in lowland potato production at MSAC (Oct 21-25). The basic information on tropical potato agronomy was taught to farmers simultaneously in the Illocano and Visayan dialects. Initial technoguides in the local languages were also developed. The farmers and technicians returned to their communities for the first planting in November, 1984.

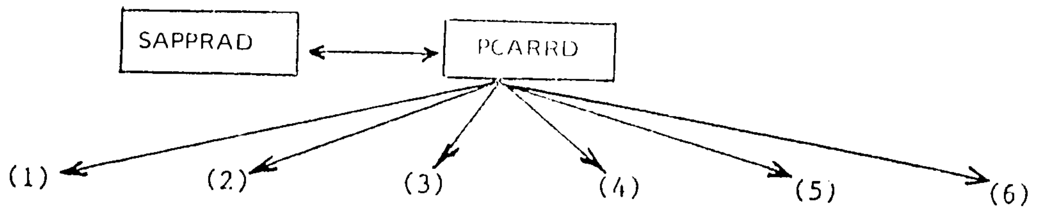


Fig. 5 SAPPRAD 1984-85 lowland potato on-farm research locations and institutions

(1) *Sto. Niño Cagayan* (7 farmers)
- Ministry of Agriculture and (MAF)
- Cagayan Integrated Agric. Dev. Proj. (CIADP)
- Sto. Niño Farmers Association
- Municipal Government
- Farmers Community Development Foundation

(2) *Batac/Laoag Ilocos Norte* (7 farmers)
- Philippine Tobacco Res. & Training Center (PTRTC)
- Ministry of Agriculture

(3) Bacnotan — *La Union* (7 farmers)
- Don Mariano Marcos State University
- Ministry of Agriculture & Food
- Municipal Council
- Provincial Governor

(4) Tubao — *La Union* (15 farmers)
- MSAC
- Phil. Bus. for Social Progress
- Barangay Council
- Municipal Council

(5) *Villasis, Pangasinan* (5 farmers)
- Municipal Council
- Ministry of Agriculture & Food

(6) *Bungabong, Nueva Ecija* (3 farmers)
- UPLB Inst. of Plant Breeding
- MSAC

Some basic rules were established for the first round of farmer trials were as follows:
(1) Farmers were to plant small plots, generally no larger than 500 m^2.
(2) There were no 'handouts', that is, farmers took all the risk on their own, and were expected to pay back the costs of the inputs advanced by the local project.
(3) All labor was to be provided by the farmers.
(4) SAPPRAD and PCARRD would provide technical support.

(5) Farmers could make modifications in the experiment design from the beginning, if they so wished.*

The SAPPRAD group wished to create an atmosphere of friendly competition, to maintain enthusiasm. It was announced that an award would be given to

(1) the best farmer,

(2) the best technician, and

(3) the best potato-producing community.

It is hoped that the best farmer will receive a plaque from the Ministry of Agriculture, and that he will be asked to deliver a lecture, to use in a future technoguide. Wherever appropriate, farmers will be listed as authors of relevant publications.

During the growing season from November to March, technicians in the local area visited farmers on a regular basis. Farmers themselves kept daily farm records, noting when they sprayed, hilled up, weeded, etc. (see attached copy of farm record sheet). Participating farmers in each community also kept in close contact with each other, as they experienced for the first time the difficult job of producing potatoes. Monitoring of pests and diseases was done by local technicians, as well as by SAPPRAD senior scientists on a national level. In February, both farmers and technicians carried out a tour of the experiments. By mid-February, harvesting of the trials had begun. The Table below gives some basic results from the various sites.

Table 1 Yields and return on investment (ROI) of outstanding farmers

Name	Municipality/Province	Yield (mt/ha)	ROI (%)
Valentin Verdadero	Sto. Nino, Cagayan	25.1	298
Kogelio Agustin	Sto. Nino, Cagayan	24.1	290
Juan Tangonan	Laoag City, Ilocos Norte	7.5	105
Raymundo Hermosa	Bacnotan, La Union	10.5	124
Artemio Marzan	Tubao, La Union	12.9	280
Alberto Mones	Villasis, Pangasinan	9.5	65

* A good example of this was when farmers decided to plant single rows instead of double rows, due to plowing patterns using bullocks. In the highlands, double rows are made by manual labor. In another case, farmers decided to apply mulch after hilling up

Farmer Response to the New Tropical Potato Technology

In March 1985, an informal exploratory survey was conducted by the monitoring team of the new potato-producing communities of Batac/Laoag, Villasis, Tubao and Bacnotan, at the time when the first harvest began. Both farmers and technicians were asked for their opinions on producing this new crop.

It should be repeated that the participating farmers had never grown potatoes before in their lives. In fact, they had previously had no idea that it was even possible to produce potatoes under local conditions.

The excellent yields and potential profits from producing potatoes has fired a kind of 'potato fever' among the farmers. It does not take an unusually clever farmer to realize that if he can get 15 mt/ha, he will have a return of over 250%, yielding a cash net income of some $3,000 dollars or more per hectare, far superior to any other crop, including tobacco. Every farmer interviewed said he would plant again in the following season, and virtually all wished to expand their cropping area to at least 1,000 m^2. There is in fact some worry that farmers will in the foreseable future overexpand their production, and lose heavily if natural disasters or market gluts occur. Farmers in this area are wary of 'get rich, quick' crops, and for this reason are taking a cautious but obviously enthusiastic view of potato production. We encountered no farmer, for example, who said he was going to put all of his arable land into potatoes.

While high profits are an obvious motivation to plant again, other important considerations from the farmer's point of view should be noted. First, in the areas visited, land often lies fallow during the dry winter months. Irrigation water is available, but it is costly. The production of rice, maize, and watermelon is possible but not profitable given the high cost of irrigation. However, potatoes give such excellent returns that irrigation costs can be easily recovered. Second, the winter period is a slack labor time in the agricultural cycle. Labor was not mentioned by any farmer as a problem.

Even farmers who did not reach the goal set by the technicians were enthusiastic to plant potatoes in the following season. Since farmers covered their own costs even in the first year, we can assume they are not misleading the survey team. Most of the farmers made mistakes in water management, often flooding the potatoes as if they were rice. Several, when asked why they overwatered, simply responded by saying 'I forgot'. Many farmers in this area are tobacco farmers, and several informed us they felt potatoes would be an easy crop compared to tobacco.

Farmers have already started adapting tropical potato production to local conditions. It was discovered that it was better to strip crop potatoes with corn, than to crop between single corn rows. One farmer had problems with chickens scratching in the rice straw mulch for grain. He will use dried banana leaves as a mulch next year. Several farmers said they intended to move their potato plots to better soil and to cooler locations. Farmers want to move back the planting date to October instead of November, although technicians say there is a greater risk of loss due to typhoons at this time. Debate between farmers, technicians, and scientists is lively. This also is important in a participatory farmer-back-to-farmer approach.

Appropriate technology alone will not carry the tropical potato project to a successful conclusion. SAPPRAD was able to establish the pilot potato community project by linking up with many local and national institutions. Twenty-one organizations were mobilized to facilitate the process (Fig. 5). In the future, organization and management, along with credit and marketing aspects, will be crucial to the expansion of potato production in the lowlands.

While it is too early to determine how successful the Philippine tropical potato experiment will be, it is clear that a new, previously unknown production system and crop has been introduced and adapted quickly and efficiently. This is due to following, not a top-down or vertical feedback approach, but the circular, farmer-centered, farmer-back-to-farmer model. Additionally, the linking in with local institutions has been an important element in this case, as it was with the diffused light storage technology.

CONCLUSION

Three approaches to working with farmers have been outlined. Each approach aims to involve the farmer, but in a different way. The first is a top-down, vertical model, in which scientific researchers assume the farmer has difficulties or problems for which solutions already exist or can be developed through science. It is a matter of simply developing the technology, and then exposing it to farmers who will either accept or reject it. Farmers, however, have little role in the technology design and generation process.

The second, the feedback horizontal model, involves the farmer, but only as a source of information useful to the design of technology. Mechanisms for the feedback are generally surveys by socio-economists and on-farm trials organized by agronomists. One problem is that feedback between the three blocks (biological scientist – social scientist – farmer) is frequently weak. It often ends up that scientists pass back and forth reports that are not read, and that much of the farmer's viewpoint is lost in academic interpretation. When social scientists also claim to be technologists, polarization occurs and communication breaks down. The farmer's viewpoint disappears in inter-disciplinary aggression.

The final model, 'Farmer-back-to-Farmer', offers suggestions on how the three points of view (of biological scientists, social scientists, and farmers) can be combined to generate acceptable technology. It assumes neither that any one single discipline has a corner on the truch, or that the farmer has all of the answers. In fact, for a single problem area (e.g. post-harvest technology) many questions related to the problem still remain unanswered, the subject of continuing research.

The Andean potato storage example, in particular, illustrates that when an attempt was made to combine viewpoints and fully involve farmers, twenty-five years of failure in potato storage work came to an end. While not all Andean potato farmers have adopted the practice, many have. This indicates to us that a farmer involved approach has a better chance of succeeding than one in which the farmer is not involved. We predict the same outcome in the generation and transfer of tropical potato agronomy to lowland farmers in the Philippines.

Appendix: Farm Record Sheet

Date	Time	Specific description of farm activities actually performed	Remarks
Dec. 20, 1984	8:00 — 9:00 a.m.	Watering	
26, "	2:30 — 3:30 p.m.	Spraying mesurol for thrips	
29, "	whole day	Weeding and removing of worm	
Jan. 1, 1985	whole day	— do —	
3, "	2:30 — 3:00 p.m.	Spraying insecticides, fungicides and for thrips	
4, "	10:30 — 11:00 a.m.	Hilling up was done thru the assistance of Dr. P.A. Batugal and research personnel of DMMMSU	
5, "	4:30 — 5:30 p.m.	Watering	Mulching lost 1/3 of the area done on January 7, 1985
9, "	2:30 — 3:00 p.m.	Thrips control spraying	
11,	7:00 — 9:00 p.m.	Watering	
	4:30 — 5:00 p.m.	Thrips control spraying	
16,	7:00 — 8:00 a.m.	Watering	
	3:30 — 4:30 p.m.	Thrips control spraying	
17,	8:00 — 12:00 p.m.	Side dressing with urea fertilizer and hilling up	
18,	10:00 — 11:00 a.m.	Spraying insecticides and fungicides	(30 kg) 21-0-0 for whole area
19,	7:00 — 8:00 a.m.	Removing of worm was done	
22,	7:00 — 8:30 a.m.	Watering	
	4:00 — 5:00 p.m.	Thrips control spraying	
28,	6:30 — 8:00 a.m.	Watering	
29,	4:00 — 5:00 p.m.	Thrips control spraying	

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DISCUSSION

Q. Since the farmer-back-to-farmer model begins and ends with the farmer in direct contact with the researchers, will this approach eliminate totally the presence of extension workers?

A. No, the extension workers will still be very much involved in spreading technology to farmers. However, the farmers participated in the planning of the technology, and were allowed to modify it to suit their needs.

Q. Would you expect to achieve the same results if technology testing were carried out on a larger scale?

A. In terms of developing technology for small-scale farmers, if resources are limited, interreaction between research and farmers is absolutely necessary. Even if there are enough resources, the more this is done the better.

Comment: (Dr. Li Tong)

I have a very strong belief in the farming systems approach, and the need to involve farmers in technological development. After hearing the success stories you have presented, I feel this even more strongly. If we are to follow this approach, we seem likely to save a lot of money, since we shall see what is being adopted, and what is not. Probably 50% of the technology now developed for farm use will not in fact be used, but will end up in a library gathering dust.

A. I agree with this. Our testing cost only ₱64,000 (US$3,500). Another advantage in involving research scientists in work in farmers' fields is the effect on local technicians, who benefit very much from the contact and experience. A third advantage is simply the effect on production – we didn't tell the farmers this, but our main objective in the potato production program was simply to get plenty of low-cost potatoes onto the market. The farmers should of course continue to make a profit, but not as much as in these early stages.

MANAGEMENT ISSUES IN RESEARCH-EXTENSION LINKAGE IN THE PHILIPPINES

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INTRODUCTION

Research and extension linkage, or the lack of it, has been blamed as the culprit responsible for the failure of research to reach the farmers. Extensionists claim that there are not enough worthwhile research results to extend to farmers, while researchers contend that extension is not fast enough in delivering new technology to farmers. There is a grain of truth in both contentions, because of the immense yield gap that exists between research results and farmers' yields. For example, in the Philippines, the national average rice yield per hectare is only 2,500 kg (Philippine Bureau of Agricultural Economics, 1985). This is relatively low compared to the potential yield of 4,000 kg per hectare, even without the use of fertilizers (Chang, 1975).

In the past, there was little conscious effort in the Philippines to establish a closer link between research and extension. Any attempts to link research and extension were on an *ad hoc* basis, rather than as a permanent part of the structure of the development process. This situation is best exemplified by the Masagana 99 Rice Production Program.

The original package of technology used for Masagana 99 was developed by a team of researchers and extension agents of the International Rice Research Institute (IRRI) and the Ministry of Agriculture and Food (MAF). This technology was widely adopted by the farmers who joined the program, because of the massive infusion of credit on favorable terms and fertilizer subsidies. As many studies have pointed out, Masagana 99 enabled the Philippines to became self-sufficient in rice, and even a rice exporter for some time. However, when the rice crisis had been overcome, government support for the program waned. These early attempts to bring research and extension closer together were, to use a cliché, nipped in the bud.

The Agusan-Bukidnon-Capiz (ABC) Settlement Project, funded by the World Bank, also had the research and extension forces working together, but as in Masagana 99 this linkage became relatively weak at the end of the project.

At present, the Philippine Ministry of Agriculture and Food has a number of research and development projects which involve the fusion and strengthening of research and extension. These include the RADOS program (Rainfed Agricultural Development Out-reach Sites) under the KABSAKA Rainfed Project in Iloilo, the Farming Systems Development Project in Regions V and VIII, and the RIARS (Regional Integrated Agricultural Research System) technology verification program under the Agricultural Support Services Project (ASSP). This paper will discuss the many concerns that we face, and the problems and contradictions we have to resolve in organizing a viable research-extension linkage vis-a-vis these projects. Discussions will, however, largely center on the RIARS project, since its network involves the whole of the Philippines, with one research site in each province.

THE MAJOR ISSUES

The topic of this paper is quite a complex one. We are not experts in this field, but we feel that what we are presently doing to address the research-extension linkage problem would be of interest to many of those involved in small farm research and development.

There is an endless stream of management issues surrounding research-extension linkage. For example, how do we establish linkage? Who is responsible for this linkage? What does it cost? How do we sustain this linkage? In this maze of interlocking questions, we have defined four major issues:
(1) structure and responsibility for research and extension
(2) roles of various groups, and the mechanisms needed to coordinate these roles;
(3) constraints that impede research-extension linkages from functioning effectively, *and*
(4) institutional arrangements for research and extension linkages.

Structure and Responsibility

In many developing countries, research and extension are largely a function of the government, through the agricultural ministries, agricultural universities and national research councils. Private companies also conduct their own research and extension work, but we cannot rely on this, as the motivation of such companies is generally company profits rather than the welfare of the small farmer.

In the Philippines, agricultural research and extension are functions shared by the Ministry of Agriculture and Food, the Philippine Council for Agriculture and Resources Research and Development (PCARRD), and state colleges and universities. However, basic research is given more emphasis by the universities and specialized commodity research centers, while applied research is more the concern of the Ministry.

In the Ministry, we view research-extension linkage from two perspectives: linkage within the Ministry, and linkage with local and international research institutions.

Linkage within the Ministry

In the Ministry, much effort is still needed to link research and extension at both national and local levels. In 1980, we decentralized the MAF so that the management of all agricultural services in the regions will emanate from the Office of the MAF Regional Director. Previously, five bureaus (i.e. Agricultural Economics, Soils, Plant Industry, Animal Industry and Extension) had all functioned independently, through their own regional directors. On a regional level, the regional staffs of the five bureaus were placed under one MAF regional director. This new organization, however, did not automatically link research and extension, because of the traditional commodity approach in both services. Moreover, the staff bureaus still operated in isolation from each other, with each bureau planning and implementing its own program. Coordination was mostly on a personal rather than on an institutional basis. This kind of linkage may work for some time, but is unstable, because when the staff members concerned move to a different post, whatever cooperative efforts they have started may cease to function.

The creation of the Agricultural Research Office (ARO) in August 1981 was a giant step linking research with extension. Where before there was no body in the MAF to integrate and coordinate the research activities of the bureaus, ARO now performs this role. On the other hand, the Bureau of Agricultural Extension had the mandate to coordinate the extension programs of the various regions, but had difficulty performing this function because it was uncertain how to relate to the regional offices and the other bureaus. (This issue is still very current at the MAF, and is now being addressed by a task force organized to clarify the roles and responsibilities of MAF bureaus and regional offices.)

The ARO serves as the secretariat of the Research Coordinating Committee, the policy-making body research in the MAF. It is organized in such a way that all the staff bureaus, through the Assistant Directors for Research, are represented in the ARO's Advisory Committee (PCARRD's Assistant Director for Research is also a member of this committee.)

There are a number of ways to integrate research and extension. It may be done through existing systems, or by establishing new integrating systems, such as joint research and extension bodies, headed by a director who has control over both services; by establishing field research centers where these services formally work togethr (Quisumbing in Delz. ed., 1982), and by organizing research activities along a farming systems approach.

Merging research and extension into a single office should be the answer, but due to the existing political processes in the Philippines we doubt if this will be effected. We have therefore opted to effect linkage by establishing a technology verification program organized along a farming systems approach in 76 outreach sites, instead of the usual commodity approach. Along with this, we are upgrading and improving 12 existing commodity (crop) experiment stations, to become regional integrated agricultural research stations.

The technology verification program is designed to develop location-specific and cost-effective production technologies for small farmers, utilizing the farmers themselves in the process. It involves the on-farm verification of cropping patterns and component technologies, under actual farm conditions. The program is carried out through the RIARS in each region.

The RIARS is the regional program for agricultural research, integrating all activities in crops, soils, livestock, extension and socio-economics. It is managed by a RIARS manager, who is assisted by five core staff representing each of the fields previously mentioned. Also, each region has a research coordinator, who plans and coordinates all research activities within or outside the Ministry. Both report to the regional director.

The RIARS, with its farming systems approach, provide a mechanism through which research and extension work together. This proceeds from the identification of useful research areas, based on signals coming from the farmers, to selection of sites, and the implementation and monitoring of research projects. Farm trials which are replicated in a number of farmers' fields are conducted by extension workers, who are trained in farming systems research methodology. These extension workers, or what we call the Provincial Technology Verification Teams, provide us with a direct linkage with the farmers.

The RIARS activities are funded by the World Bank-assisted Agricultural Support Services Project. When the technology verification program began, there were already a number of national and regional programs (whose funding come from other sources) doing verification research, both researcher- and farmer-managed in nature. We are now attempting to integrate all these projects under the management of RIARS, although in some cases we are meeting resistance at a national level. In Regions V, VI and XI we have already integrated all on-farm research projects (Region VIII will soon follow) and we are watching them very closely, particularly since there were a number of research personnel who were displaced as a result of the integration. We are positive, though, that we will become more efficient by having one single management of such research in each region.

Also, our staff from the Ministry meet four times a year with the research coordinators, RIARS managers and regional directors to discuss technical as well as administrative matters. We usually invite representatives from IRRI, UPLB and PCARRD to this conference, to ensure that they know what we are doing at the Ministry.

Linkage with other research institutions.

Since technology is also generated and validated by other institutions outside the Ministry, it is imperative to maintain close contact and coordination with them.

Since 1982, we have been holding a bi-annual Technology Transfer Workershop with IRRI. At this forum, Ministry staff from national and regional offices are given the opportunity to discuss with IRRI researchers the problems in rice production requiring immediate research attention. In return, IRRI scientists provide MAF with information on what technology is available or is in the process of being developed, with regard to the problems identified. If there is a need to work cooperatively on a common problem, IRRI and MAF then proceed to do so.

This relationship with IRRI has yielded a number of positive results. We feel that we have been successful in breaking down the great awe that MAF researchers and extensionists had for the IRRI researchers. Now we are really talking to each other. In fact, we now have a number of joint projects which enable us to maximize our resources and complement each other's work. In Claveria, Misamis Oriental, and three other locations, for example, we are now testing the use of deep placement fertilizer applicators that IRRI has developed. Recently, IRRI has requested the participation of all RIARS in its small farm equipment testing program.

Similarly, we conduct dialogues with PCARRD, University at the Philippines at Los Baños, the Visayas State College of Agriculture, and the University of Southern Mindanao, to exchange technical information. Furthermore, this year CIMMYT has been providing us with assistance on the economic analysis of our technology trials through an agricultural economist based in Bangkok.

We also recognize the importance of linking with the outside world. This contact comes in the form of our membership in the CGIAR, and with the technical publications that we regularly receive from international research institutions and agricultural universities.

The Roles of Various Groups in the Generation and Application of Research

The development of a technology is generally regarded as a four step process: technology generation – technology testing – technology validation – technology dissemination. This poses the questions on how linkage can be achieved at each stage of the process, who should perform which aspects of the activities, and what structures and linkages would make the process function as a whole (Delz ed., 1982).

The popular belief that extension is the research link with the farmers is now under fire.

This is because this concept dichotomizes research and extension into two mutually exclusive processes, instead of treating them as an adjunct to each other. It negates the importance of jointly determining the needs of farmers by involving farmers in the decision-making process. Indeed, because of our failure to view technology transfer as a continuum, the ideal double-arrowed technology information flow which is Research ⇌ Extension ⇌ Farmers has been reduced to single arrows in the direction of the farmers (Palmer, *et. al.* 1982).

In the Ministry, we believe that research and extension should work together at all stages of the technology verification program, in order to produce technologies that reflect the real needs of farmers. In the RIARS, we have involved extension workers and farmers in identifying and ranking in importance research needs, and in the selection of sites and farmer cooperators. This is in keeping with the farming systems concept of involving extension with researchers, national decision-makers, production program personnel and farmers, throughout the farming systems research and development process.

The degree of involvement of extension personnel in the research process varies for each stage. Shaner *et al* (1982) suggest that in target area selection and problem identification, extension's paticipation is about 20%. In planning and implementing on-farm research, extension's involvement drops, since these are largely the researchers' concern. In multiple farm testing and in pilot production programs, the responsibility of extension is about 60% and 25%, respectively.

In the RIARS, the extension agents assist the RIARS staff in identifying research areas and farmer-cooperators, for we believe that they have a better understanding of the area than the researchers. We are just starting our multiple farm testing, and pilot production programs, and we shall involve extension workers and farmers very closely in planning and implementing these undertakings.

Subject matter specialists have not yet been utilized in the RIARS program. However, we are now finding means of integrating them in the technology verification programs. At present, the RIARS core staff fill the role of the subject matter specialist.

Constraints that impede the functioning of research and extension linkages

Problems in recruiting and keeping good staff. Like many other countries, the Philippines has a problem in recruiting agricultural researchers and extension workers who are willing to be assigned to remote areas. However, such personnel can be encouraged to work in these areas by giving them incentives such as better pay, an honorarium, free housing and educational advantages. The RIARS provides staff housing although only for the RIARS manager and his core staff. We also give honoraria, but this has to be done through PCARRD, because under existing auditing rules we are not allowed to give such payments. We also provide training and educational tours. In spite of these incentives, however, we cannot be sure that we will be able to prevent a rapid turnover of staff. We already have a few cases of RIARS managers and core staff members who have transferred to better paid jobs.

Many of our researchers and extension workers are diverted from their primary functions of developing and transferring technologies because they are usually required to carry out both regulatory and administrative functions. We have therefore requested the regional directors to allow the RIARS staff to work full-time on the technology verification program.

Inadequate government support. We often do not receive enough funds from the government to carry out our research activities smoothly. The administrative and budgetary structures generally discourage rather than encourage communication, cooperation, and integration of the activities of research and extension (Palmer *et al* 1982). What we are doing at ARO is to give a quarterly lump sum budget to the regions, and leave the management of these funds to them, so that they can make the necessary adjustments in their budget in response to changing priorities in the region. Also, we try to look for additional funding sources other than the World Bank and USAID. In fact, we have been able to get grants from the Australian Centre for International Agricultural Research (ACIAR) and the International Development Research Centre (IDRC) to finance projects that are complementary to the technology verification program. We also expect to get another grant from the IDRC for a study on how to institutionalize R & D projects, using the Agusan-Bukidnon-Capiz Settlement Project as a case study.

Professional attitudes.

Extension workers are generally considered inferior to researchers, while extensionists feel that researchers do not value their contribution to technology transfer (See Asian Regional Workshop on the T & V System, Thailand). We hope that, through the involvement of extension personnel in the Ministry's technology verification program, extension workers and researchers will come to realize that they are both equally important in the development process.

Institutional Arrangements for Research and Extension Linkage

Theoretically, it should be easy for us to forge a research-extension linkage because the funding support that we get from the World Bank and the USAID for this purpose are being coordinated by a single office. We know that it would have been a different story had we initiated this move solely with our own government funds, since funding would then have been distributed to numerous offices in the Ministry. In three years time, this external funding support will cease, so we are now taking steps to make this linkage between research and extension a necessary part of the Ministry's overall agricultural development effort.

As was mentioned earlier, the RIARS recieves financial assistance from the World Bank: its budget is not part of the MAF's regular budget. We have therefore proposed to the Budget Ministry that it should create a Field Operations Service in the MAF, to oversee the implementation of the Ministry's field programs, particularly research and extension, and to serve as a point of reference for the regional directors. The Service would have three divisions, namely, (1) Research and Extension (this will replace ARO); (2) Inputs Supply, Credit and Marketing; and (3) Farmers' Organizations.

We are hopeful that the proposed Service will be approved, and that the arrangements we have started in order to foster a stronger research-extension linkage will be sustained, even if the World Bank and USAID funding terminate.

CONCLUSION

Although we recognize the importance that a research-extension linkage plays in facilitating technology transfer, we also recognize its limitations. We know it is no panacea. It cannot alone promote the adoption of technology without the necessary infrastructural and policy support. Research and extension should not be limited to generating, verifying and promoting technology. We believe that their roles should go beyond this. Although the perceived goal of research and extension is to increase the farmers' income through the development of location-specific and cost-effective technologies, there will still be the problem of how farmers can obtain production capital. Research and extension should therefore be able to inform farmers on alternative sources of credit They should be able to identify markets for their produce, and, as much as possible, should help farmers to market and get a good price for their produce. And finally, research should be able to influence government policies, and propose alternatives which are more beneficial to farmers and the agricultural sector in general.

There must be strong leadership in research and extension, which extension agents and farmers can trust. We should also define the mission of these services, as a basis on which to direct, monitor and evaluate programs. But most important, we should always seek the participation of the farmers in all stages of the technology generation and transfer process, if we are to develop technologies that are truly relevant to their needs.

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DISCUSSION

Q. A study of development projects is being conducted by MAF at the moment. Could you tell us about this?

A. We are studying the Aguran-Bukidnon-Capiz development projects that have been terminated. We are looking at the sustainability of foreign fund-supported development projects where the fundings have been terminated — how they are functioning, the level of services they are extending, etc.

Q. How are your verification trials going?

A. This is our second year. The first year was a disaster, maybe because it was still a learning process. Our extension workers, for instance, had never done any research. This year will be better, with the improved relationships we have developed with the farmers. Verification trials are not really concerned with getting the farmers to adopt technologies we recommend. The main objective is to develop the farmer's capability to compare his practices with those we recommend. Both farmer and researcher have developed a respect for each other.

Q. You mentioned that for technology to be truly appropriate, the farmer should be involved from technology generation to adoption. How do you involve farmers in technology generation? What in practice seems to be happening is that technology is regarded as the province of research and extension, and farmers are ignored. What happen if you do group together farmers, extension and research?

A. The degree of involvement by farmers varies, and it is true that the involvement of farmers at technology generation is not as great as at adoption. However, the Technical Advisory Committee of PCARRD (Philippine Council for Agricultural and Resources Research and Development) has farmer representatives, but their contribution is relatively small, and it is difficult to find representative farmers. Once a very good rice farmer was asked to join the committee. He participated very well where rice was concerned, but the TAC structure makes it difficult to have a single-commodity representative, and the farmer had nothing to contribute on such topics as forestry or livestock.

We are still intending to have farmer representatives, possibly not at a PCARRD-TAC level, but at the commodity team level.

Q. Do you think we are paying sufficient attention to outstanding farmers? Every year we give them awards, but perhaps we should take more notice of their advice and experience.

A. I know of cases in which the best farmers are always the first stop for training groups, and they are often used as consultants. However, they are so far ahead of the others that what they are doing has little relevance to the situation of ordinary farmers. Possibly mechanisms should be developed to involve outstanding farmers in a more significant way.

ON-FARM TECHNOLOGY TESTING OF THE PHILIPPINES' MINISTRY OF AGRICULTURE AND FOOD

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INTRODUCTION

On the assumption that the best technology in the experiment station is also the best in the farmer's fields, the testing of agricultural technology has traditionally been conducted in experiment stations, where research facilities are adequate and environmental control is excellent. Recent findings, however, consistently show that experiment station yields are well above those obtained by farmers – (Gomez, K.A. 1977; Gomez, A.A. 1979 and Mercado, A.C. 1980). These results put in doubt the assumption of a consistent performance in experiment stations and the farmer's fields and thus whether research station findings can be directly applied to actual farms. Because of this, the Ministry of Agriculture and Food (MAF) of the Philippines established in 1983 a nationwide network of on-farm trials, designed to verify the applicability of experiment station results to actual farms. In the succeeding sections we shall describe:

(1) the role the MAF's on-farm trials, with respect to the total research network of the Philippines
(2) the procedure for implementing these trials, and
(3) some significant findings.

ROLE OF ON-FARM TRIALS IN THE PHILIPPINE RESEARCH SYSTEM

Agricultural research in the Philippines begins with the development of new technology and ends with the adoption by farmers of this new technology. Shown in Figure 1 are the four major steps involved.

Step 1 is carried out primarily by agricultural universities and colleges; step 2, jointly by the universities and the Ministry of Agriculture and Food (MAF); while responsibility for steps 3 and 4 mainly resides with the MAF.

The on-farm technology verification trials of the MAF (primarily step 3) picks out the best practices from technology generation trials, combines these with the best farmers' practices, and develops what might be called an 'improved technology package'. The new package is compared to the existing farm practices in an actual farm environment. With this trial, it is possible to verify whether the station results are in fact applicable to actual farms, and whether the best research station technology is actually better than the existing practice.

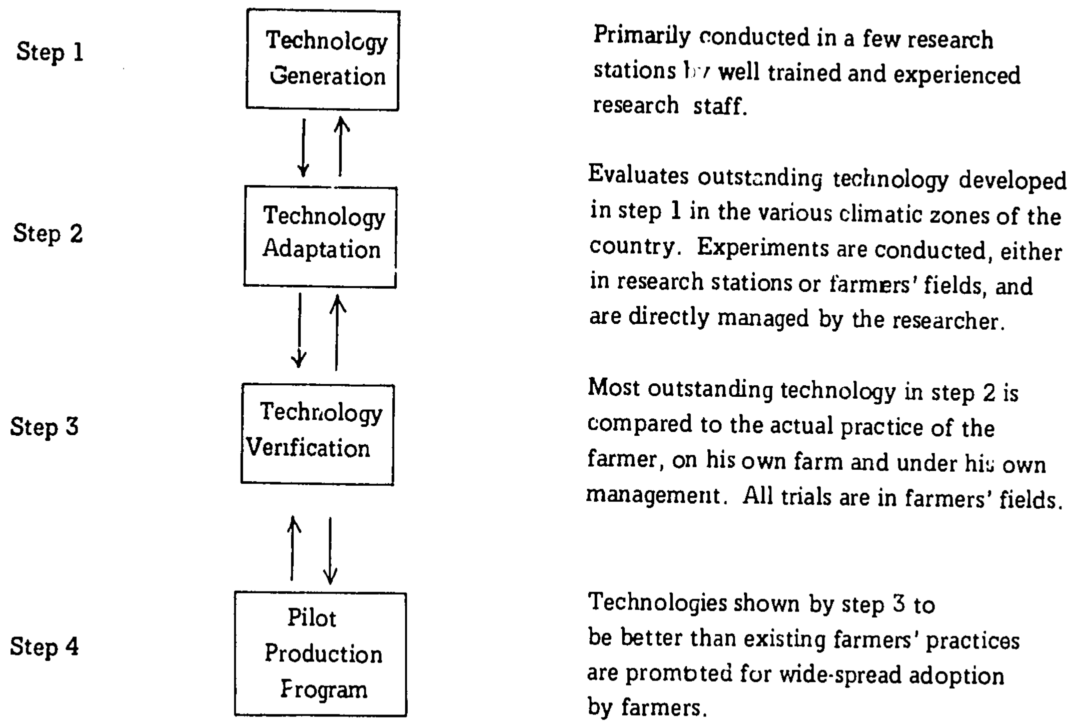

Fig. 1. Agricultural research in the Philippines.

Clearly, the role of the MAF on-farm trials is not to re-invent or compete with the experiment station trials but to verify and ensure that only appropriate findings from the research station are actually brought out for use by farmers. Furthermore, actual and potential defects of new technology can be readily identified, further tested in research stations then finally modified and further improved. Thus, on-farm trials are a logical and necessary companion of research station trials.

IMPLEMENTATION PROCEDURES

The on-farm technology verification trials of the Ministry of Agricultural and Food (MAF) basically consist of the following steps:

Selection of Target Area

The area that is expected to benefit from the results of the verification trial is termed the 'target area.' Ideally, a single target area should have an environment that is uniform enough to allow a common set of technical recommendations. For the present program at least, one target area was selected from each of the 72 provinces in the country.

Site Description

A research site, usually consisting of at least one barangay (village) was selected to represent the target area.

Design of the Technology

On the basis of the survey and available research findings, alternative cropping patterns with corresponding management practices were designed for each test site. The cropping patterns designed usually involve an extra crop added to the existing practice and/or a change or modification in up to three or four components (e.g. variety, fertilizer level, pest management, etc.) for each crop.

Testing and Evaluation

Each alternative cropping pattern so designed is compared to existing farm practices at a selected cooperator farm. The cropping pattern is established in a 1000 m^2 plot, surrounded by the farmer's own crop. By monitoring how the farmer cooperator manages his crop, and by harvesting some of the crop from both the farmer's and the alternative pattern, productivity and profitability of the two patterns can be compared.

Pilot Production Program

After two years, alternative patterns that satisfy the minimum requirements for superiority against that of the farmers are promoted for adoption by all farmers at the test site.

Responsibility for field implementation of the verification trials rests primarily with the regional offices of the Ministry of Agriculture and Food. An on-farm trial manager is appointed in each region, and two or three field researchers are assigned to each test site. In view of the number of field researchers required, and the need for these reseachers to reside at or near the test site, the program opted for training existing extension personnel already assigned to the municipality where the test site is located.

Technical supervision for the whole network is carried out by the Agricultural Research Office at the Ministry of Agriculture and Food. This office initiates periodic review of the research findings, and helps the region decide on the program of work for the coming cropping season or year.

SOME SIGNIFICANT FINDINGS

There are two types of useful information that have so far been generated by the on-farm verification trials. Firstly, our familiarity and understanding of the existing farm practices have greatly improved. Secondly, we have come to realize that only a small fraction of the alternative technology we design can be considered substantially better than existing farm practices.

Current practices

The cropping patterns shown in Table 1 are those most commonly used at the selected test sites. A single rice crop is the most common pattern in irrigated rice paddies, while a sequence of two rice crops is found in rainfed rice paddies, a sequence of two corn crops is found in upland areas and coconut in perennial crop areas. In terms of crop management, existing farm practices are characterized by a fairly low level of input use. Fertilizer application is less than half the recommended level, while hardly any pesticides are applied. Consequently, the cost of production for the existing cropping pattern is lower than that of the alternative patterns (Table 2).

Table 1. Existing and alternative cropping patterns in the on-farm technology verification trials of the Ministry of Agriculture and Food, Philippines

Existing Cropping Pattern	No. of Sites Reporting	Alternative Cropping Pattern	No. of Test Sites
Rice + Fallow	22	Rice + Legumes	6
Rice + Rice	38	Rice + Rice + Legumes	20
		Rice + Rice	
Upland Rice + Corn	3	Upland Rice + Corn/Legumes	5
Corn + Corn	14	Corn + Corn + Legumes	7
		Corn + Legumes/Corn + Legumes	3
Corn + Corn (Hilly land)	5	Leucaena + Fruit trees + Corn-Corn/Legumes	4
Coconut	9	Coconut + Other perennial + Annual crops	9

Table 2. Cost of production of some existing and alternative cropping patterns* (in US$)

Cropping Pattern	Labor Cost	Cost of Material Inputs	Total
Rice + Fallow	133.33	50.56	183.89
Rice + Legumes	168.89	108.89	277.78
Difference	35.55	58.33	93.89
Rice + Rice	206.66	97.78	304.44
Rice + Rice + Legumes	263.89	195.56	459.44
Difference	57.22	97.78	155.00
Upland Rice + Corn	83.33	31.68	115.00
Upland Rice + Corn/Legumes	168.33	151.11	319.44
Difference	85.00	119.44	204.44
Corn + Corn	132.78	38.33	171.11
Corn + (Corn + Legumes)	153.33	132.22	285.56
Difference	20.55	93.89	114.44
Corn + Corn	89.44	27.22	116.67
Leucaena + (Corn + Legumes)	152.78	156.67	309.44
Difference	63.33	129.44	192.78

*Average of 3-5 sites; US$1 = ₱18 (pesos)

Improved practices

The improved practices were designed by identifying the constraints in existing practices, and remedying these with technology shown to be adequate according to existing research findings. The most common areas of modification were as follows:

1) The addition of an upland annual crop, either before or after the main crop.
2) Changing one component crop,
3) The addition of an intercrop, and/or
4) Improvements in the management of an existing crop, for example improved crop establishment, the use of an improved variety, or additional inputs.

Promising Croppping Patterns

After two years of testing, a total of 27 promising cropping patterns have been identified. These can be grouped into six major cropping patterns, as shown in Table 3. The promising cropping patterns were evaluated according to productivity (measured in terms of agronomic performance) and profitablility (measured in terms of economic performance). Economic performance is expressed in terms of net return and marginal benefit-cost ratio (MBCR). A promising pattern must have a net return that is at least 30% higher than that of the farmer's pattern, and an MBCR of at least 2.0.

The net return (but not the MBCR) of the six major cropping patterns is presented in Table 3. Other features under evaluation are the stability of the technology in varying environments, and the ease of adoption.

It can be seen from Table 3 that the promising patterns have the following features:

1. More intensive land use – added income usually comes from the growing of an additional crop. In the rice areas, for example, a sequence of two or three crops is grown instead of only one or two.

2. Use of improved management – MV and increased use of fertilizers are two management practices, in particular, which usually gave a significant improvement over the existing farm practice.

Table 3. Promising cropping patterns* identified from the on-farm trials of the Ministry of Agriculture and Food, Philippines

Cropping Pattern	No. of Sites where technology is applicable	YIELD (mt/ha)			NET RETURN (US$/ha)		
		1st Crop	2nd Crop	3rd Crop	Alternative	Farmers'	Difference
Rice + Legumes	4	5.43	0.77		667.22	289.44	377.78
Rice + Rice	3	5.98	4.60		786.67	613.33	173.33
Rice + Rice + Legumes	4	5.10	5.11	0.32	708.89	251.11	457.78
Upland Rice + (Corn + Legumes)	2	3.85	2.60+1.25		570.56	268.89	301.67
Corn + (Corn + Legumes)	1	2.91	2.58+2.05		1474.44	1066.11	408.33
Coconut + Banana + (Legumes + Corn)	1	1.18	1.70		763.89	188.89	575.00

*Preliminary data

DISCUSSION

Q. In your farm trials, new cropping patterns are grown on 1000 m^2, and compared to adjacent crops. Is it justified to accept the results from a 1000 m^2 plot as a basis for recommending farmers to follow a new cropping practice? 1000 m^2 is a fairly small area, and is likely to receive better care and management than a plot of one hectare or more. Are you sure that production per unit area in a small plot would be the same as if the same crop was grown in a large one, or does the small plot receive more intensive land care?

A. The plot of 1000 m^2 is managed in the same way as the rest of the farm. Many aspects of farm practice are not changed at all: for example where a rice-fallow cropping pattern is compared to a rice-legume one, only the land use from fallow to legumes is changed: the rice crop is grown in exactly the same way for both.

Yes, I do feel that the comparisons are valid. However, I should add that success is judged by observation, not by statistics. If any improvement is obvious only in a statistical diagram, it is not considered to be useful. To be considered useful, an improvement must be visible straight away. We are also very concerned with *consistency:* if there are ten farms in the community, and the new cropping pattern is consistently better on all ten farms, this is a more important indication than detailed statistical data.

Comment: (Dr. Ly Tung)

In our experience at VisCA (Visayas State College of Agriculture), we found that trial plots even smaller than 1000 m^2 still gave valid results. We found that farmers can judge from quite a small area whether, for example, a new variety is better or not. At first we insisted that plots should be 1000 m^2, but many farms are small and fragmented, and many parcels of farmland are smaller than this. If we had insisted, it would have been difficult to find farmer cooperators.

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TECHNOLOGY NEEDS FOR SMALL-SCALE FILIPINO FARMERS: THE EXTENSION POINT OF VIEW

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INTRODUCTION

The Philippine economy has always been predominantly agricultural. At present, the agricultural sector employs about 55% of the labor force, while it contributes about 60% of exports and about 33% of the Gross National Product. Expenditure for food in the average farm family budget is about 60% of the total income. Accordingly, since 65% of the Filippinos are dependent on agriculture for their livelihood, it can be said that where agriculture goes, there goes the country.

The Philippines has opted for a development strategy proceeding from a balanced agro-industrial development, and consequently, the Philippine Agenda for Action in Agriculture has been oriented toward the attainment of increased and stabilized real incomes from appropriate faming systems, improved quality nutrition, and more savings for reinvestment in complementary income-generating projects. This agricultural development strategy calls for policy adjustments and organizational reforms with regard to credit marketing and de-regulation of prices. There also needs to be improved organization of technology transfer/exchange, and an effective extension service.

In developing countries such as the Philippines, the predominance of small-scale farms, averaging two to three hectares, calls for an organized service delivery system in the agriculture sector, which should reach an equally organized receiving client system (farm families) through a responsive and supportive delivery channel – the local government unit.

From the point of view of the extension service, the following approaches should he followed, to ensure that the technology needs of the farmers are met effectively.

1. Search for the farming system (crops, livestock, other income-generating projects) which will give the highest net income, in terms of existing resources such as soil type, agro-climatic zone, etc.
2. Assessment of the level of human resources development, to determine capability, as well as education and training support needs, in preparation for effective technology transfer.
3. Inventory of the existing institutions which could be developed into self-reliant, self-maintaining community-based organizations, which will ultimately take charge of their own community development.

Moreover, agricultural extension planning and budgeting should be undertaken only through consultation with the farming community. The process proceeds as follows:

Step I. *Situation Analysis.* A program planning and implementation worksheet is used as a guide.

Step II. *Problem Identification and Analysis.* To be done by the assembled community, with the assistance of the extension worker.

Step III. *Goal Setting* by the community, to include the target, measure of performance, time frame, achievability, relevance to probiems identified, etc.

Step IV. *Evaluation of Alternative Solutions* to determine the best and most cost-effective means of attaining the goal.

Step V. *Making the Decision.* To go ahead or not.

Step VI. *Preparing the Work Plan* To include activity scheduling, personnel assignment, resources needed and budgeting.

This planning and budgeting process should be reviewed and approved by the village assembly. It serves as the basis, not only of determing the technology needs of the community, but also of the supervisory work plan of the extension agent assisting the village community.

THE TECHNOLOGY NEEDS OF THE SMALL-SCALE FILIPINO FARMERS: THE EXTENSION POINT OF VIEW.

The agricultural extension service is a continuing non-formal education system, designed for farm families interested in developing farming systems which can increase productivity and stabilize real income. The aim is to enable farm families to attain quality nutrition, and generate savings for reinvestment into complementary income-generating projects.

While information on technology to meet the needs of small-scale farmers can either be obtained free (from reading, seminars, extension teaching) or bought (pamphlets, technical consultants), it is always necessary that consultation take place with the farm family, in to help the family decide what combination of projects and activities it will undertake. This type of applied communication process should also ensure that any projects and activities the family undertakes are brought to a successful conclusion.

Basically, in the small-scale farming systems approach, the Filipino farmer should have the technology for:

1. Knowing the soil type of his farm, its soil pH, organic matter, water-holding capacity, fertility (N-P-K) (including nutrient deficiencies), agro-climatic conditions, and other bio-physical characteristics. This will guide him on his farm management decisions as *what, when, how much, why, how* to raise crops, livestock, fish, etc. on the farm.
2. Determining what technology is available and usable – crops, livestock, fish etc -- as well as any combination of these (production mix) during a given season.
3. Determining cost, and obtaining available credit in time for the needs of his farming system.
4. Assessing periodically the prices of commodities, and supply and demand trends, in marketing centers a favorable distance from the farm.
5. Forecasting cycles of pests and diseases, for effective and economical prevention and control.
6. Farm-level processing and preservation of farm products, in order to escape market gluts and add extra value to his produce.
7. Agricultural cooperation within the community, particularly with regard to *purchase of inputs* and *output marketing.*
8. Knowing sources of technology information, if needed data is not available in the com-

munity.

9. Having access to education and training centers where the farmer can attend seminars and workshops to update his technical knowledge, especially with regard to low-cost technology.
10. Preparing his farm plan and budget, using community production programming to ensure that production matches effective market demand.
11. Developing leadership through continuous study, continuous savings, and discipline and cooperation with other farm families and available technology resource centers.

CONCLUSION

1. The technology needs of small-scale Filipino farmers are dynamic, since they are heavily influenced by the market, family/community values, price policies, the cost of credit, and various interventions, both local and foreign.
2. The ultimate goal of meeting the technology needs of small-scale Filipino farmers is to develop their range of choice, both as individuals, and as members of a community which should strive to become self-reliant, and self-actualizing. Such community organizations must be able to develop their own Community Management System, to determine the technology needs of their farm family members.

DISCUSSION

Q. How do you decided what type of farming system is to be used by the farmers covered by the program?

A. Farm families differ in their values and needs. We cannot and do not propose a uniform farming system for them all. In the situation analysis, the extension worker will list all the problems, and then find out with the farmers how to solve them. In our experience, 80-90% of problems can be solved in the village. The remainder are brought for assistance at a municipal level, and possibly 1% can only be solved at a provincial or national level.

The farming systems approach assesses the capabilities of the village, and finds out how much can be done with this capability. In earlier times, we were very project-oriented. We were in a hurry, and told the farmers what they should do. In fact, the farmers must be the ones to decide. If they are forced into a program, they will have no motivation, and will not participate. If technology is difficult to understand, or is not cost effective, it will not be adopted by many farmers. Whether technology is 'appropriate' or not must be spelled out by the people who use it.

Q. What if the technological requirements of the small farmer are not in concurrence with national priorities?

A. Ideally, since the power of choice is given by God, we should respect the choice of the farmer. We talk of development- for whom? For the people? We must remember that most of them are farmers. I feel that the person is more important than the output of technology.

There are two basic steps in the extension process, whether we call it dialogue or applied communications. The first is that the farm family must decide what projects it will undertake.

The second is that, having made that decision, they should be helped to bring their projects to a successful conclusion.

Comment (Dr. Kavi Chutikul)

It should not just be appropriate technology we offer, but alternative technologies, so the farmer can make a chocie.

Q. In several programs, such as Masagana 99, packages of appropriate technology were given to farmers and resulted in increased production. The results of these increases were not always favorable for example in Mindanao, we have poor rice storage facilities and pricing problems. What is the best solution?

A. As I mentioned in my paper, if technology transfer to small-scale farms is to be meaningful, it has to be supported by organizational reforms. In terms of the deregulation of prices, we must co-ordinate the price of inputs with that received by the farmer for staple products, so that, for example, 1 kg urea can be purchased by 2 kg (unpolished) rice. This will give the small-scale farmer the capability to make technological improvements, but it must be left to him to decide whether he wants to or not. The figures given by Dr. Gee-Clough in his paper are very significant (see p. 1).

SECTION III

TECHNOLOGY FOR THE SMALL-SCALE FARMER IN HIGHLY INDUSTRIALIZED COUNTRIES IN ASIA

THE TRANSFER OF NEW TECHNOLOGY TO SMALL FARMS IN TAIWAN R.O.C.

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INTRODUCTION

Agriculture in Taiwan has changed dramatically during the past four decades; improved crop varieties, chemical fertilizers, pesticides and other new technologies have all contributed to yield increases ranging from 80% to more than 300%. Technological breakthroughs even made possible the increased production of some crops from virtually nil to substantial. Those crops are of major economic importance today. I should like to give a few examples. Remarkable success has been achieved in mushroom production. There were no mushrooms produced in Taiwan until 1953. As soon as rice straw compost came into use, and improved mushroom strains were developed, the mushroom yield increased significantly and the mushroom industry became a booming business. The highest production, in 1978, reached 119,460 mt, with a value of US$58.9 million. Another example is asparagus production. This began in 1955 on a very small scale. The marked increase in production was due to the discovery by research workers that reserving some of the stems to overwinter as mother stalks supplied nutrients to support vigorous growth by new shoots the following year. Research was also important in the production of onions, which are long-day plants which thrive in a cool dry climate. When onions were first planted in Taiwan, only vigorous vegetative growth took place, while no or very small bulbs formed. The successful production of bulbs of economic value was also due to research work, which found that younger seed sets 35 days old should be used, instead of the conventional 60-day old sets generally used in countries in higher latitudes.

All these technologies transferred to the growers increased production. However, general acceptance varied according to the type of crop and technology. With regard to the two examples given above, the technology for mushroom production was the more difficult to transfer, because it included the choice of the right mushroom strains, and the complex processes involved in the cultural practices. In the case of onion the transfer was much easier, because the technology is low site specific (Swindale, 1981).

The official channel of agricultural technology transfer in Taiwan is through the District Agricultural Improvement Stations (DAIS) and Farmers' Associations. At present, there are six DAIS's and 269 Township Farmers Associations. The transfer of new scientific knowledge and technology is achieved through field demonstrations, special gatherings, extension leaflets, radio and TV programs, etc.

This paper describes some cases of new technology transfer that have occurred recently, each with its special features. Factors favoring technology transfer are also discussed. Since the average farm size in Taiwan in 1984 was only 1.10 ha, any technology transfer described in this paper refers to small family farms.

Table 1 The yield of major crops in 1952 and 1983 in Taiwan (kg/ha)

Crop	1952	1983	Index
Rice	1,998	3,850	193
Sugarcane	52,513	79,464	151
Sweet potato	8,953	25,514	173
Peanut	741	1,361	184
Soybean	602	1,536	255
Corn	1,365	3,289	241
Tea	305	923	303
Tobacco	1,621	2,497	154
Banana	6,811	22,287	327
Pineapple	10,731	29,982	279
Citrus	6,022	10,536	175
Mango	6,912	8,680	126
Pear	6,516 (1964)	12,749	196
Grape	3,106	21,625	696
Papaya	9,395	29,988	319
Asparagus	2,280 (1964)	4,808	211
Onion	10,850 (1956)	23,615	218
Tomato	8,178	39,389	482
Mushroom (kg/m^2).	4.8 (1963)	13.5	281

RAPID ACREAGE EXPANSION OF THE RICE CULTIVAR, TAINUNG 67

The unofficial release and widespread cultivation of the rice breeding line Tainung yuh A-6, later registered as Tainung 67, is very unusual and interesting. This variety has also given a tremendous impetus to rice production since its official release. Tainung yuh A-6 was a selection of Taichung 187 (line 138)/Tainung 61//Tainung 61. After a series of tests, it was submitted to the relevant authority to be tested in the official regional yield trial. However, the evaluation committee initially rejected the request, because of the fact that Tainung yuh A-6 is not resistant [illegible] disease, and this resistance is a prerequisite before a new rice cultivar can be officially registered.

The spread of Tainung yuh A-6 began in the Hsinchu area, where there were strong seasonal winds while the second rice crop was growing. Farmers in this area needed a cultivar resistant to lodging, to reduce losses from wind damage. Tainung yuh A-6 was then tested in a regional yield trial in that area. Its good stand attracted the farmer's attention, while agronomic performance in other respects was also excellent, in particular its high yielding ability and the ease of culture (wide adaptability). One farmer then asked a friend at TARI to give him some seeds to test on his own farm. From then on, Tainung yuh A-6 spread out from that locality to be grown commercially over virtually the whole island. Three years later, 100,000 ha had been planted in Tainung yuh A-6, under different names, through the farmers' own seed dissemination. Seed impurity was obvious, as a result of mechanical mixing during seed multiplication by farmers. Consequently, Tainung yuh A-6 had to be officially registered under the name Tainung 67 in 1978.

Since the official release of Tainung 67, the area growing this variety has increased so rapidly that Tainung 67 occupied 70.3% of the total rice area in Taiwan in 1982. This was the first time such a rapid expansion of a newly released cultivar has been seen in the history of rice production in Taiwan. Five years after its release, Huang (1984), the breeder, estimated that Tainung 67 had had the following significant effects on rice production:

1. Rice production has increased by about 10% (based on a five-year average 1977-1981).
2. The mechanization of harvesting has been accelerated by six years, because the lodging-resistant Tainung 67 can be harvested by machine.
3. Damage caused by lodging has been greatly reduced.
4. Its wide adaptability enabled this cultivar to be grown in any cropping seasons and in any region.
5. The chemical control of rice blast is largely effective. Thus, the blast susceptibility of Tainung 67 has never been considered a serious disadventage by farmers since its release.

This story indicates that technology transfer can sometimes be achieved without any effort, if the new technology is fitted to farmers' needs, and assuming that the farmers are knowledgeable and very skillful. Another point I would like to mention, is that the reason for the delay entering Tainung yuh A-6 for the regional yield trials, that the authority in question was trying to prevent an outbreak of rice blast disease, is surely adequate. Although blast disease is well under control by chemical means five years after the release of Tainung 67, this is a special case, and should not be followed as an example.

SINGLE CROSS HYBRID CORN, TAINUNG 351

Rice is the major staple food for the Chinese people in Taiwan. For food self-sufficiency, the government previously encouraged farmers to grow rice, and established a guaranteed price system in

1974 to ensure rice growers' profit. Since then, annual rice production has been maintained at 2.4 million mt, in spite of a gradual reduction in acreage. On the other hand, rice consumption is decreasing, as a result of dietary change to more bread and meat. The excess rice purchased by the government through the guaranteed price system has caused considerable financial losses, and also created pressure on storage facilities. Thus, the government in 1983 announced the beginning of a six-year rice field conversion project, in order to reduce rice production.

In the rice conversion program, farmers are encouraged to grow corn as a substitute for the second rice crop in paddy fields. There is no problem in marketing corn, regardless of how much is produced. Incentives include a guaranteed price of NT$15 (US$.37) per kilogram, with an additional subsidy of one ton of paddy rice for each hectare of land diverted to corn (equivalent to US$370/ha). However, the available hybrid corn cultivars are in general adapted to late fall or winter planting, after the second rice crop is over, and are early maturing with low yields. Thus, the development of a late maturing, high yielding corn cultivar was urgently needed, in order to make the profit from growing corn comparable to, or higher than, that from growing rice. For this purpose, TARI developed a single cross hybrid corn, Tainung 351, which yielded an average of 6 mt/ha of grain in province-wide demonstration trials. This per hectare yield is almost double that obtained from the old commercial early maturing hybrid cultivars. Some of the better farmers may even produce as much as 9-10 mt/ha. The growth period is 105-115 days in the spring, and 115-130 days for the fall crop. This cultivar is also resistant to common rust disease, sugarcane mosaic virus and leaf blight, and is highly responsive to fertilizers. The high yields and other agronomic characteristics of Tainung 351 seemed to meet the requirements for the rice conversion program, so that we were confident that this new corn cultivar would be widely accepted by farmers when released in 1984. A large quantity of hybrid seeds was produced, and was ready for use for the 1984 fall planting. The projected acreage of Tainung 351 was 20,000 ha. Great efforts were made to persuade farmers to achieve this goal, but the result was only 9,000 ha of rice fields converted to corn. Farmers hesitated to grow corn as a substitute for the second rice crop, for the following reasons:

1. Farmers are familiar with growing rice, but not with the cultivation of corn, so that an immediate change to growing corn causes some difficulties in cultural operations.
2. The current labor shortage and high labor costs have caused rice production to become highly mechanized. Apart from land preparation and planting, corn production is not mechanized, particularly the tedious and costly process of harvesting. A corn harvester adapted to local environmental conditions is still being developed.
3. The present cropping system allows farmers to grow two crops of rice and a third winter crop each year. When corn is used as a second crop, it is planted in August – September while the first rice crop is harvested in May – June. Farmers with only a small farm are inclined to use their land as intensively as possible, and are unwilling to leave land fallow for a period of three months. At present, we are still not able to find any cash crop that can be adequately fitted into the gap.
4. Although there is a guaranteed price for corn, the purchasing system was not well organized at the beginning of the project. Most farmers sold their grain on the market at a much lower price. Thus, farmers doubted whether the purchasing system could be operated properly in the next cropping season. Their enthusiasm for participating in the rice conversion program thus became less.
5. Climatic conditions, such as high temperatures, abundant rainfall and sufficient irrigation water, are favorable for growing a second rice crop but are disadvantageous for growing

corn. It is even more risky to plant corn early in August to obtain higher yields.

6. The major corn growing area is in a region with a three-year rotation system, which allows farmers to grow rice two years out of three. Therefore, farmers in this area do not want to give up their privilege when it is their turn to grow rice.

NEW CULTIVARS OF PEAR AND JUICY PEACH FOR TROPICAL LOWLANDS

The pear and juicy peach are both temperate zone fruits. However in Taiwan, the pear cultivar 'Hungshan' can be grown in tropical lowlands, because it does not require low temperatures and is highly adaptable. However, production is limited, because the fruit is of poor quality. Furthermore, Japanese pear cultivars have been introduced to Taiwan, and have been successfully grown on farms along the Central East-West Cross Highway since 1958. Although Japanese pear cultivars have fruit with a more appealing appearance and of better quality than 'Hungshan' pears, their requirement for low temperatures for chilling has limited their production to areas 1,600 m or more above the sea level. TARI scientists saw the problem, and began a cross breeding program in 1975 to improve the quality of Hungshan pears.

The cultivar 'Hungshan' was crossed with Japanese cultivars at both high elevations and in lowland orchards. Hybrid seeds were incubated at 5°C soon after being extracted from the fruit and sterilized with fungicide. About 90% of seeds germinated during the 2-3 months' incubation. All germinated seeds were transferred to small polythene bags, and kept in a shade house for a period of one month. Young plants were then transplanted to the breeding orchard, with spacing of 4 x 1 m. The TARI breeding orchard is located at 24°N, 100 m above sea level. Liquid fertilizer at a low concentration was supplied periodically, to stimulate continuous and rapid growth of the young plants, and thus shorten the juvenile period from 7 years to 4 years.

A preliminary selection was made as soon as the trees started to bloom and set fruit. Hybrid progenies of good quality and adaptability were reserved for further observation and selection. The particularly promising selections were finally grafted onto local 'Hungshan' cultivars, in order to evaluate their climatic adaptability, fruit quality and yield. Currently, three promising selections, SH-29, SH-33 and SH-78, all Shinseiki/Hungshan crosses, have performed well in contract farmers' orchards at an elevation of 100-400 m above sea level. The farmers concerned are confident of the performance of the selections, and have begun to multiply the trees themselves to establish new plantings. There are a number of other farmers also interested in testing these new selections.

The same story is true of peach. The fruit of native peach cultivars grown in the tropical lowland area are small in size, and poor in shape and quality, with hard flesh. The temperate juicy peach cultivars, which need chilling at low temperatures, can be grown only in areas 1,500-2,000 m above sea level, but produce large free-stone fruit of good quality. TARI scientists selected seven high quality peach cultivars which needed little chilling from more than 50 introductions. The seven selected cultivars were Flordagold, Flordaking, Flordared, Cristal, Tutu, Premier and Talisman. All were grafted onto bearing native peach trees, for quick evaluation of their performance in farmers' lowland orchards. After only one year of testing, farmers quickly judged with confidence that these juicy peach cultivars could be successfully grown for a good profit, so they began to propagate them themselves for commercial planting. Requests are now coming into TARI for seedlings. We can only supply a limited number of seedlings, although continuous propagation in TARI's nursery has been accelerated.

BIOLOGICAL CONTROL OF COCONUT LEAF BEETLE, *BRONTISPA LONGISSIMA*

The coconut palm, *Cocos nucifera*, is grown on the east coast and southwest areas of Taiwan. The number of coconut trees planted in 1984 was estimated to be 600,000.

The coconut leaf beetle, *Brontispa longissima* Gestro, was first found in Pingtung in 1975. Later, it spread north and east to Hualien and Taitung, and has since become a serious pest to coconut palms. Since coconut trees are tall, and usually planted along highways and around fishponds, the use of chemical pesticides to control this pest is economically impractical and environmentally unsafe. Therefore, biological control was considered to be the best approach to solving this pest problem.

TARI scientists (Chiu *et al.* 1985) searched for effective biological control agents, and found that the larval and pupal parasite, *Tetrastichus brontispae* (Fern.) was effective in the Pacific region. We then introduced the species from Guam in 1983. After careful study and propagation in the quarantine laboratory at TARI, field releases of T. *brontispae* were carried out at Chen-chin-hu (Kaohsiung)(10 releases of 11,456 adults) and Lin-bien (Pingtung)(seven releases of 4,881 adults) in 1984. The percentage of parasitism recorded from field recoveries made in Chen-chin-hu and Lin-bien were 21.2-79.2% and 9.3-36.2%, respectively.

The population dynamics of the coconut leaf beetle, based on a comparison of the pre- and post-release data, showed that the population densities of the coconut leaf beetle in Chen-chin-hu decreased from 60-100 larvae per tree to less than 30 larvae/tree. A similar trend of population fluctuations at a much lower level was also observed for adults. However, the parasite was less effective in Lin-bien (Figs. 1 and 2).

The ability of *T. brontispae* to disperse under field conditions was demonstrated when it was repeatedly recorded on coconut trees in neighbouring townships 2-8 km away from the release site in Chen-chin-hu. It was also observed that new leaves are growing out from the injured trees. All these facts indicate that *T. brontispae* is now well established in Taiwan, and is gradually dispersing on its own accord into coconut growing areas. It also indicates that *T. brontispae* is an effective biological control agent of coconut leaf beetle.

The program on the biological control of coconut leaf beetle by the parasite *T. brontispae* is still going on at TARI. The most interesting feature is that farmers in the coconut growing areas also kept constant watch on the effectiveness of the control measure. When they found it to be useful, they wrote to TARI asking for more parasites to be released over a wider area, and have also promised to give any necessary assistance to TARI scientists for the release.

FACTORS CONTRIBUTING TO TECHNOLOGY TRANSFER

New technology developed by agricultural research does not always benefit farmers. This is true even in developed countries with larger farms, and is particularly true in countries in the Asian and Pacific region, with small family farms. We are fortunate that in Taiwan, the gap between research and

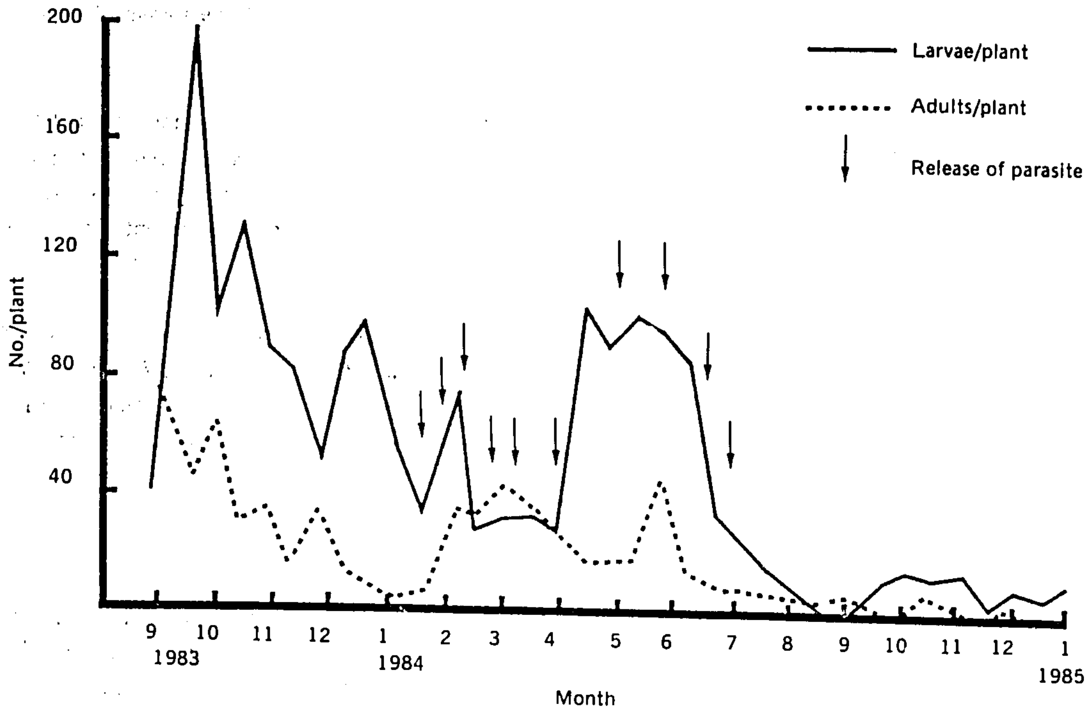

Fig. 1: Fluctuations in population densities of coconut beetles in Chen-chin-hu

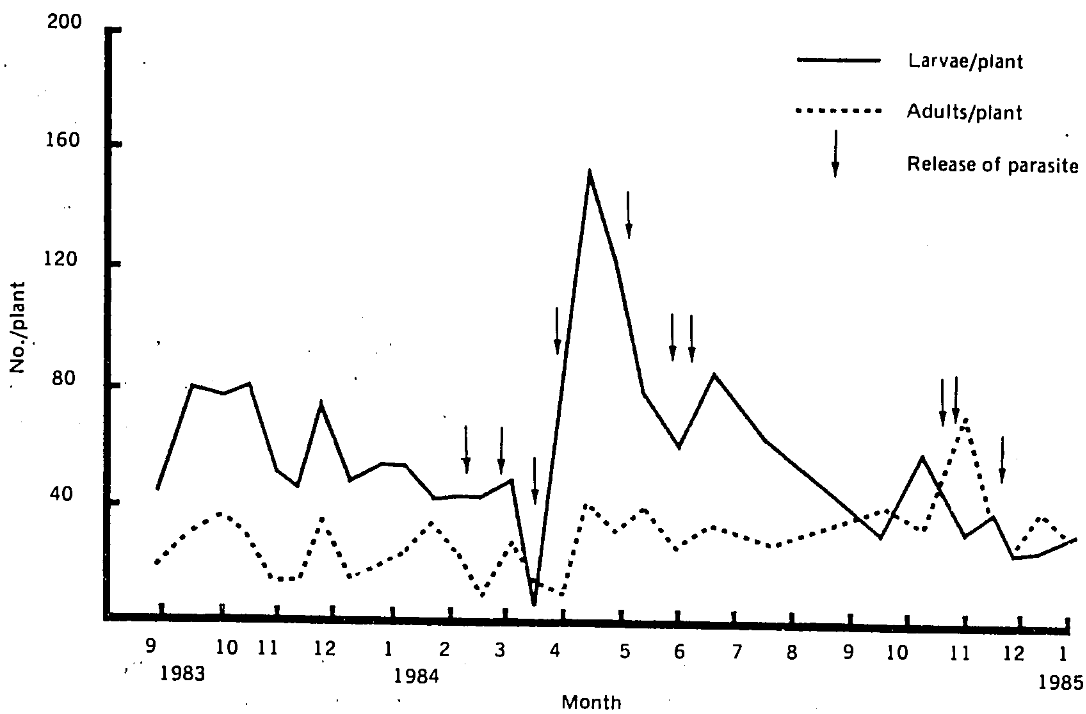

Fig. 2: Fluctuations in population densities of coconut beetles in Lin-bien

farms is relatively narrow. Sometimes, intelligent farmers even generate a demand for new technology The four examples given in this paper clearly indicate that there was not much difficulty in transferring most technology, except for the change in cropping systems involving the use of new corn cultivar Tainung 351. The success, in my personal view, can be attributed to the following factors:

1. Institutions, Policies and Incentives Advantageous for Technology Transfer

Technology will not transfer itself from the research laboratory to farmers. It must be accompanied by suitable institutions, policies and incentives, which make it advantageous for technology to be adopted. The guaranteed rice price system in Taiwan is a government policy which acts as an incentive to encourage farmers to grow more rice. This system, along with the recommended technology, is very effective in increasing rice production, while the poor operation of purchasing system of corn run by the Farmers' Association affected the rice conversion project, and is an example of institutional failure.

2. Farmers' Education and Skills

New technology is becoming more and more complex to use. For instance, the operation of farm machine equipment, and the use of modern machinery and pesticides to control insects and diseases, all require a high level of education and considerable skill. The widespread adoption of rice cultivar Tainung 67 was mainly because of its resistance to lodging, which made it suitable for mechanical harvesting. This would be impossible if farmers were not able to operate rice combines.

3. No Immediate Risk Perceived

Farmers are generally conservative. New technology which enhances production but also involves risk is not likely to be accepted by farmers. The growing of corn as a substitute for the second rice crop increases the risk of natural hazards, so that farmers hesitated to accept the substitution regardless of incentives.

4. Impact of Changing Farming Systems on Farm Profitability

The rice conversion program is a government policy. Although its implementation was discussed at length in order for the program to be accepted by farmers, the change in cropping system from rice-rice-winter-crop to rice-corn, without considering the three month fallow after the first rice crop, greatly affected the farmer's profit from any one piece of land. This oversight became the major constraint to the program.

5. Farming as an Agri-business

In Taiwan, farming is no longer just for subsistence, but has become an agri-business. Farmers are constantly seeking for new technology, from which higher profit can be generated. They consider the economic inputs, the type of output, and whether they can market their produce. The easy acceptance of the new heat-tolerant pear and juicy peach was simply because these two fruits were expected to bring good prices when introduced into the market as new products.

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DISCUSSION

Q. What do you mean by a 'Guaranteed Price'? How is this imposed on middlemen, and how is it implemented?

A. The guaranteed price is the price paid by the government when it purchases produce through the farmers' associations. No middlemen are involved.

Q. How do you market your agricultural produce? Is it all bought directly by the government?

A. No, not all products are purchased by the government, only a few selected crops such as soybeans, rice and corn. The government has its own marketing outlets, both for domestic consumption and for export. If there is no markets for the products in question, the farmers are encouraged to diversify production.

Q. Now that your government is attempting to reduce rice production, will you discontinue the guaranteed price for rice?

A. No, the government will continue with the guaranteed price for rice, to avoid any increase in price.

Q. It seems that farmers' associations in Taiwan are effective channels of technology transfer. How does Taiwan keep them viable?

A. Farmers' associations in Taiwan have several departments, to cover e.g. credit, purchase of farm inputs, extension etc. The farmers' associations through its normal operations, particularly credit, make money which the farmers' association uses to maintain and improve its services. Farmers' associations are financially self-supporting, funded by their own revenues: they obtain only a nominal funding from the government.

Q. Please tell us more about your agricultural financing and credit system?

A. The government does not generally provide agricultural financing. Nearly all the money invested into agriculture comes from the farmers' associations.

Q. What is the average income of farmers in Taiwan?

A. About NT$255,000 per annum, or US$6,375. However, about 90% of farmers are part-time and earn money off the farm, hence their higher incomes.

Q. How did you produce the parasite used against coconut beetle?

A. We reared them in the laboratory. There was no artificial medium used for rearing the coconut beetles.

EVALUATION OF AGRICULTURAL SCIENCE AND TECHNOLOGY DEVELOPMENTS FOR SMALL FARMS IN TAIWAN R.O.C.

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INTRODUCTION

Taiwan is an island with a total area of 35,981 km^2, which supported a population of 19 million in 1985. Over two-thirds of the Island is hilly slopeland more than 100m above sea level. Less than one-third, or 10,800 km^2, is flat land: this is intensively used for agricultural and industrial purposes. There is around 895,000 ha of cultivated land, of which about 500,000 ha, (56%) is irrigated. The agricultural population is 4.28 million, 22.88% of the total population. The average farm size in Taiwan is only 1.1 ha, which means that typically farm operations are on a very small scale.

Over the past decade, of the many factors contributing to the development of Taiwan's agriculture, technological research and extension programs have played a particularly important role. However, the phenomenal growth of industry and commerce has caused serious problems for agriculture, in particular the shortage of rural labor and the relative decline of farm incomes. To cope with this situation, intensive efforts have been made to develop labor-saving cultivation methods, promote farm mechanization and the use of integrated farming techniques, and breed higher-value crop varieties. Since technical improvement and innovation are essential for achieving increased agricultural production, the government has been paying close attention to technological research and development. The focus of research has now turned from labor-intensive to capital-intensive production methods. The cultivation of many new crops, introduced from abroad or developed locally, has been made possible through an extensive research and experiment program.

Technical innovation is a prime mover in the agricultural development of Taiwan. Since Taiwan's agricultural resources are limited, and farm operations on so small a scale, further development will depend heavily upon increasing land productivity through intensive and well-managed technological research.

MAJOR RESEARCH ACHIEVEMENTS FOR SMALL FARMS

Food Crop Production

Improvement of rice varieties:

Rice is the most important food crop in Taiwan. Since 1975, a total of 17 *japonica* varieties and 11 *indica* varieties have been registered and released for commercial production. The variety Tainung 67, a *japonica* type released in 1978, has become the predominant rice. Over 70% of *japonica* rice fields are planted in this variety. This heavy dependance on a single variety might potentially encourage the rapid spread of blast disease, but heavy applications of fungicide have reduced damage from this disease to very minor proportions. The popularity of Tainung 67 is mainly due to its outstanding agronomic characteristics of vigorous growth and lodging resistance, which mean that the ripe crop stands upright in dry paddy fields without lodging and can be harvested by machine, in particular by the combine harvester. Otherwise, a lodged crop could only be cut by hand, which would cost a lot more than harvesting by machine.

Improvement of upland food crops:

A considerable number of improved varieties of upland food crops, such as high-yielding single-cross hybrid corn, short-statured high-yielding hybrid sorghum, sweet potatoes rich in vitamin A, seed-dormant peanuts and high-quality sunflower, have been developed and released to farmers for commercial production.

Quality control for rice:

Since the Taiwan market now demands high-quality rice, research is being conducted to classify rice quality according to a number of physical traits and chemical components identified in the laboratory. Since table quality can only be classified in terms of taste palatability, a taste panel was organized to verify this. Preliminary results revealed that rice grains with a transparent texture and an amylose content of less than 24% are very likely to have good cooking and table quality.

Development of multiple cropping systems:

Rice is the staple crop in Taiwan. Two crops of rice are harvested each year, one in early summer and one in late fall. A short-term inter-crop can be grown in the c. 90 days between the two rice crops, in late winter and early spring. A sophisticated system of multiple cropping has thus been developed on the island. With Taiwan's rapid industrialization, this has been extended to include a fully mechanized system of production, to solve the problem of the farm labor shortage, as well as reducing the costs of production.

Rice diversification program:

Since less rice is now being consumed in Taiwan than ever before, a rice surplus has become a problem, and more than 1,500,000 mt of surplus rice has accumulated in warehouses. A reduction in rice production has thus become a major objective, which means that the cropping system has to be changed. The immediate goal is to grow rice once a year in only some regions of the island, and to diversify the rice fields not needed for this to other crops. A series of experiments have been conducted throughout the island to discover the best time for growing rice in association with various combinations of upland crops.

Rice ratoon culture:

Rice ratoon culture has been studied for more than ten years, but without success, because of variable sprouting from the stubble left over after harvest. A new variety, Tainung sen 18 (*indica* type), registered in 1984, is highly suitable for ratoon culture, since the crop grown from ratoons in the second cropping season has even more panicles per plant than those transplanted in the first, so that the ratoon crop may have a higher yield than its parental crop. A successful ratoon crop would require less capital investment, labor and time, than a transplanted crop. The practice of ratooning is now being extended to farmers in the Hualien area of Eastern Taiwan.

Improved cultural practices:

Improved cultural practices, such as seed treatment, more appropriate timing of planting, proper plant spacing in and between rows, and adequate fertilizer applications, have been recommended for general adoption by farmers.

No-tillage cultivation:

In order to cut down on the cost of crop production, no-tillage cultural practices have been widely adopted by farmers in the production of soybean, azuki bean and corn, after the second crop of rice has been harvested. Commercial machinery for no-tillage cultivation has now been developed, and recommended to farmers.

Production of Horticultural Crops

Through the introduction and breeding of new varieties, Taiwan has moved from importing onions, grapes, Irish potatoes, mushrooms and asparagus to exporting them in large quantities. Furthermore, by the careful selection of high-quality strains of pineapple, mango, passion fruit, guava, litchi, chrysanthemum, gladiolus and day-lily, production has increased considerably to meet the demands of both domestic and foreign markets. Deciduous fruit crops, including apples, pears and peaches, have been successfully developed for commercial production in mountainous areas, while seedless watermelons have been successfully developed for domestic consumption and for export to Southeast Asia.

Using appropriate horticultural techniques and plant growth regulators, the harvest season of grapes, pears, wax apples, carambola, sweet sop, guavas, Indian jujube and shiitake mushrooms can now be lengthened, and more than one crop successfully produced each year.

Virus-free nucellar lines of citrus have been propogated for the replanting of orchards abandoned due to infection by citrus Likubin. Heat-tolerant tomato varieties which are resistant to bacterial wilt have been developed for summer planting.

Production of Special Crops

Tea:

Four small-leaved varieties of tea (*Camellia sinensis var. sinensis L.*) – Taichia Nos. 14, 15, 16 and 17 – were released in 1984. They have very hairy buds, are generally rich in catechins, and have a low level of anthocyanin and leucoanthocyanins in mature leaves – all very advantageous factors for the manufacture of semi-fermented tea.

Taichia No's. 14 and 15 sprout comparatively late in the spring, and are adapted to the mountain areas of central Taiwan. Taichia No's. 16 and 17 are early budding and drought-resistant, and thus suitable for use in the lowlands of northern Taiwan. According to processing tests, Taichia No's. 14 and 15 are good for manufacturing Pouchong tea, while No. 17 is very suitable for making Oolong, and No. 16 for green tea.

Sericulture:

A new bivoltine* silkworm strain, Taizarn No. 7, was released in the autumn of 1984. This

*Producing two broods per season. Ed.

double-cross hybrid produced more than 32 kg of marketable cocoons per egg case (20,000 eggs), 8% higher in yield than the current commercial variety. It is suitable for all three rearing seasons in Taiwan. Its thread is 1,320 m in length: 24.1% of the cocoon is shell and 18.5% raw silk. In addition the egg-yielding potential of this silkworm strain is 17% greater than that of Taizarn No. 6, which means a considerable improvement in the production of silkworm eggs.

Plant Protection

Major rice pests such as rice blast, sheath blight, virus diseases, borers, leafhoppers and plant-hoppers are now under effective control in Taiwan, largely through the implementation of a cooperative pest control program. An island-wide pest forecasting system, established in 1965, gives advance information on pest outbreaks, both to the program and to selected individual farmers. Sampling techniques for crop surveillance have been developed for both the rice brown planthopper and the tarsonemid mite on rice, and for some major species of caterpillars and aphids on cabbages and cauli-flowers. A system for testing pesticide residues has been established for food crops and vegetables. This has contributed greatly to the safe and efficient use of pesticides.

Effective measures have been developed for the control of many major diseases and insect pests attacking fruit crops, such as bananas sigatoka, citrus black spot, mango and grape anthracnose, lac insects, and mango leafhoppers. These control measures are based mainly on knowledge of pest ecology and epidemiology, and the use of chemicals, and have made possible the production of high-quality crops for export.

Meristem culture has also been successfully used to free some vegetatively propagated crops such as Irish potato, sweet potato and garlic from virus infection, and also as a means of mass-producing disease-free banana seedlings for commercial growing.

Sustained research on citrus Likubin over the past 15 years has led to the recognition of a mycoplasma-like organism as the sole etiological agent, and to the discovery that the citrus psylla *Diaphorina citri* has a vector role in this extremely destructive disease, believed to be responsible for the relatively short life span of Taiwan's citrus trees. Techniques of injecting diseased citrus trees, with tetracyclines, to lengthen their productive life, have also been developed and extended to growers for adoption.

Biological Control of Plant Pests

Sex pheromone has been sythesized and used for mass-trapping the tobacco armyworm, *Spodoptera litura*, in 6,200 ha of upland crops and vegetable fields. Results indicate that the use of sex phermones can reduce significantly the frequency of pesticidal applications.

Various species of sugarcane borers have been successfully controlled by the mass release of the egg parasite, *Trichogramma chilonis*, while the Asian corn borer has been similarly controlled by releases of *T. ostriniae*.

The Oriental fruit fly (*Dacus dorsalis*) has been effectively controlled by trapping males with methyleugenol. As a result, Japan and Korea have permitted higher imports of fruit from Taiwan. A further successful example of biological pest control is the integrated use of the microbial agent *Bacillus thuringiensis* and chemical pesticides pesticides against caterpillars on cruciferous crops.

The major pine defoliater, *Dendrolimus punctatus*, has been kept at a very low population level in Taiwan since 1969, since the integrated use of three microbial agents (the white muscardine (*Isaria* sp.), *Bacillus thuringiensis* and the cytoplasmic polyhedrosis virus) came into use.

A cheap and effective biological control measure has been developed against papaya ringspot, a virus disease which was first noticed in 1975 and which soon virtually destroyed papaya cultivation throughout the whole island. The intercropping of papaya orchards with corn is a highly effective control measure for reducing ringspot incidence, and has been widely accepted by papaya growers in diseased areas. Studies are now under way to exploit mild strains of the virus to protect papaya seedlings against attack by severe strains. Two such strains of papaya ringspot virus have been obtained from Cornell University, and have been found to be effective in field tests. A demonstration field control program, to integrate the intercropping method and the use of mild virus strains, is now being carried out.

Soils and Fertilizers

Soil Amendments

Suitable analytical methods and rating standards for measuring available soil P and K have been established for various crops, by correlating test values with that of field fertilizer response. An island-wide survey of agricultural soil fertility was completed in 1967. Current fertility tests include those for micronutrients.

An investigation of fertility factors in relation to the yield potential of rice on 120 representative paddy soils has revealed that shortage of silica is a major limiting factor on the further increase of rice yield in many areas. Applications of slag as a source of silica may improve the growth of rice plants, make then more resistant to diseases and lodging, and increase their yield. The repeated use of slag has proved not to cause any deterioration in the soil or decrease the yield effect

About one-third of the total area in agricultural use in Taiwan is strongly acid, with a pH of less than 5.5. Field tests have shown the importance of liming for the improved production of vegetables, sugarcane, legumes, corn, millet and other dryland crops, as well as of fruit.

The extensive occurrence of brown leaf spot in rice in eastern Taiwan and other hilly areas has been found to be associated with deficiencies of silica, managanese and potassium in soils, while the major factors responsible for low yields in the second rice crop have proved to be a low percolation rate, and a high Ca and bicarbonate content in the soil.

Improved use of Fertilizers

Extensive field trials have been conducted on the timing of applications of fertilizers on various important crops. Various methods of fertilizer use are being tested in relation to different cropping systems, minimum tillage and moisture management. In the 1970's, the use of slow-release fertilizers and deep placement techniques were studied to ensure high efficiency in fertilization. Recently, deep placement by machinery has proved successful.

The optimum rates of fertilizer use for more than 50 crops, including rice, sugarcane, tobacco, sweet potato, soybean, corn, sorghum, peanut, citrus, tea, banana, pineapple, mulberry and vegetables, have been determined through comprehensive field studies. Further field trials are now being conducted for new crop varieties and newly introduced crops, with an emphasis on high-yield corn, oil crops and fruit trees.

Physical and chemical criteria for the classification of soil fertility capability have been established, and a tentative classification system for paddy land has been proposed. The NPK fertilizer requirements and potential yield of rice have been investigated for each individual classification unit.

Farm Machinery

Mechanization of rice production

Major farm machines for rice production, such as power tillers, transplanters, power sprayers, combines and dryers, have been either developed or improved, and have been widely adopted by local farmers in recent years. Machinery for leveling paddy pields, soil pulverizers, nursery implements and fertilizer deep-dressing applicators have also been developed and are now ready for extension. A multi-purpose combine for the harvesting of paddy rice and sorghum has been developed, and adopted by local farmers.

Machinery for other crops

Two types of multi-purpose solar energy dryer have been developed. One with a stationary bed has already been made available to farmers, while the other, a rotary drum type, is still under field testing. In addition, a two-way aeration system for flat-bed dryers has been developed.

A planter for corn, peanuts, sorghum and soybeans has been developed and made available to farmers, as has a machine for havesting corn, while various kinds of harvesters for sweet potatoes, peanuts and soybeans are now being developed and tested.

Improvements have been made to the pipeline spraying system, to ensure efficient automatic spray irrigation under slopeland conditions. A rotary spraying head has been introduced which sprays an extensive area under semi-automatic or automatic control A mobile fruit-picker's platform and three types of tree shaker have been developed. Of these, the shaker mounted on a small 4-hydrostatic-driven mobile drawn by rope is particularly convenient for use on slopeland. A parallel-line and a revolving-disc fruit sorting machine, both of which are simple in structure and high in efficiency, have also been developed. A small tractor for use on slopeland is now available to farmers in Taiwan. It is intended for multiple purposes, and has an attachment for digging holes, as well as a hammer-knife mower, a rotary tiller, and a mist-blower sprayer. This tractor has a hydrostatic drive, providing flexible speed control, and is easy to operate and very stable on slopelands.

Fish Culture

Aquaculture is an important source of income for many small-scale farmers in Taiwan, and many technological improvements have been made, particularly with regard to breeding and the production of fish fry. Induced spawning techniques have been established for *Paneaus* shrimp and fresh-water prawn: the successful artificial propagation of finfish such as the most important varieties of Chinese carp, as well as catfish, mullet, red seabream, black porgy, and milkfish, etc., has been achieved, as has the breeding of improved hybrid varieties of tilapia.

Fish culture in cages has been developed in reservoirs and coastal waters, as have methods of culturing oysters on rafts and long-lines. Fish feeds have been formulated for eel, shrimp, tilapia, milkfish and bass.

Livestock

Livestock Breeding Program

Swine are the most important livestock for small farmers in Taiwan. A swine breeding system, using two national nucleus herds, has been established, and a number of superior breeding sows and boars have been selected. Extensive experiments have been carried out on artificial insemination (A.I.) for both swine and cattle. Approximately 10% of sows and 95% of dairy cows in Taiwan are now artificially inseminated.

Livestock Management

Studies on swine management, including a model pigsty design using a biogas plant for manure disposal, have been of great practical value to Taiwan's hog farmers.

The use of slotted floors in pig units for better sanitation and management has been developed and widely adopted. For cattle production, an extension handbook of ruminant balance rations on various agricultural by-products has been published, and is widely used by farmers under a new dairy extension program.

Disease Control

Veterinary research, particularly on the control of serious epizootics, has been very successful. Taiwan is now free of rinderpest, foot-and-mouth disease, pleuropenumonia of cattle, anthrax, rabies, hog cholera, and swine erysipelas.

RELATIONSHIP BETWEEN RESEARCH AND EXTENSION

Organization of Extension

An island-wide extension network has been established in Taiwan. This includes farmers' associations, and also fishermen's associations, both of which operate with technical and financial support from government agencies. Through the network of farmers' associations, research findings are effectively extended to farmers. The number of farmers' associations in Taiwan is shown below:

Provincial farmers' association 1

↓

County/city farmers' associations 21

↓

Township farmers' associations 269

↓

Small agricultural units 4,536

↓

Farmer-members 822,797

It is expected that a new Agricultural Extension Law will be enacted in the near future, to further strengthen the organization of extension.

Support for Agricultural Extension Agencies

Increase in Number and Standing of Extension Workers

Recently, considerable effort has been made to increase the number of agricultural (including fishery) extension workers, and upgrade their level of professional expertise. Since July 1977, a total of 483 new extension workers have been employed by township farmers' associations. Of these, 174 are paid by the government and the remainder by the township farmers' association. All the newly employed extension workers were recruited as a result of competitive examinations conducted by the Taiwan Provincial Farmers' Association. They then had to undergo two weeks of induction training and a six-month probation period, before they were formall Happointed.

More technical assistance to township farmers' associations:

Beginning in September 1981, 3-6 extension professors have been assigned by each of Taiwan's four agricultural colleges to work part-time in selected technical fields as members of the college agricultural extension committee, and also in close cooperation with the specialists at District Agricultural Improvement Stations.

Improved training and guidance for young farmers

The following measures have been taken in the past three years to improve the educational standing of young farmers in Taiwan 58 short courses have been held for 2,769 young farmers; scholarships have been awarded by township farmers' associations to 2,103 graduates of junior high schools, to enable them to attend senior agricultural vocational schools; and long-term, low-interest loans have been provided for 3,225 rural youths, to finance the development of their agricultural careers and various improvements on their family farms.

CURRENT PROBLEMS

The main problems facing small-scale farmers in Taiwan are the low productivity of arable land already under intensive cultivation, the small size of their farms, and the shortage of farm labor, associated with an increase in farm wages.

Other important problems are the poor post-harvest handling, packaging, and processing of agricultural produce, and the relatively low prices paid for farm products, resulting in low farm incomes and little investment by farmers into agricultural production.

Changing consumer demand has led to strict requirements for higher quality in farm products, and the need to adapt production to meet the growing demand for meat, vegetables and fruit. Conservation of the environment is becoming an increasingly important consideration in Taiwan, and pesticide residues, and soil and water pollution as a consequence of pesticide applications, are an important problem, as is disposal of the manure from an expanded animal industry. All these changes mean that there is a growing need among farmers' associations for more agricultural extension workers and more technical assistance.

MEETING FUTURE NEEDS FOR AGRICULTURAL DEVELOPMENT

Planned integrated land use and development

This will help ensure the suitable use of good farmland and prevent further fragmentation, as well as enabling farmers to expand the scale of farm management and operations. It will also accelerate the development of specialized agricultural production areas, and facilitate the implementation of custom farming and more flexible tenancy systems.

More economical use of water and soil resources

This will involve closer coordination of planning for soil, water and crops, and the construction of irrigation facilities at sites of highest economic potential. Irrigation will also be improved, by the development of modern irrigation equipment, better techniques, and improved management to utilize the return flow for irrigation and prevent water pollution.

Other needs

Studies on labor efficiency and manpower are needed, to make the best possable use of the limited rural labor force, while farmers must have access to agricultural information and data. Labor-saving techniques are particularly needed for horticultural crops, animal husbandry, fisheries, and slopeland cultivation.

Needed improvements in production techniques to boost land productivity include a higher yield for the second rice crop and *indica* rice; adequate irrigation systems for dryland crops, to permit a larger acreage of feed crops and more suitable cropping systems; and the development or introduction of new species and breeds, better fertilization and pesticides, and modern farm machinery.

Maketing and grading systems must he improved, along with the packaging, storage and transportation of agricultural produce.

Other planned improvements in the rural infrastructure include improved designs for standard farm houses, the strengthening of rural medical and public health services, the construction of more rural roads and the urbanization of rural areas.

An agricultural extension law should be enacted, to ensure more effective extension activities, since farmers' associations, like those of fishermen, are not government agencies. The staff of agricultural organizations, at a lower level as well as at a higher, should be well trained, to enable then to perform their tasks competently and etticiently.

DISCUSSION

Q. Obviously, agricultural development has a lot to do with total economic development. I understand that with industrialization and the farm labor shortage, Taiwan is now developing custom farming and group farming. How do these operate?

A. Custom farming is mainly found in association with rice production, although it is also used for the planting and harvesting of upland food crops. A rice service center will own a rice transplanter, a combine harvester, and all the other necessary equipment for mechanized rice production. The farmer will pay the service center to carry out these operations for him. Since 90% of Taiwan's farmers are now part-time, if they do not have enough time to carry out their farm operations, they can hire others to do this. There are also a growing number of specialist farmers, who may grow nothing but e.g. rice seedlings for other farmers, or operate a combine to service the surrounding area.

Q. What is the income of farmers, compared to that of the urban sector?

A. The average income of farm households in 1983 was US$6,185; income for non-farm families was US$8,248. 70% of farmers' incomes are earned off the farm. We have only 80,000 full-time farmers, whom we regard as the 'nucleus farmers' of the future.

Q. I should like to know more about the organization of the agricultural research system in Taiwan.

Q. On a provincial level, we have the Taiwan Agricultural Research Institute, which is the leading agricultural research center in Taiwan. We also have six district agricultural research stations. All these coordinate and cooperate in their agricultural research activities. We also have similar institutes for research into fisheries and forestry.

SMALL FARMERS' PROBLEMS IN NEW TECHNOLOGY ADOPTION: THE CASE OF KOREA

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INTRODUCTION

To provide brief background information on the Korean agricultural structure, one can say that it has one of the highest population densities and population-to-arable-land ratios in the world, with 404 persons per square kilometer and approximately one hectare of cultivated land per farm. This reflects both the very mountainous nature of the Korean peninsula and the country's high population density. Apart from relatively steep hillsides, most of the arable land is intensively cultivated.

The Korean winter is a harsh one: citrus crops are grown only on the subtropical island of Cheju, and most double cropping is confined to the southern half of the country. Korean agriculture consists largely of small owner-operated family farms.

The average one hectare farm has 0.66 ha of paddy land. 67% of all farms are no more than 1 ha in size, and only 5% are larger than 2 ha. Farmland is often scattered in a number of small plots, although much consolidation of holdings has taken place as a result of government programs.

Rice is the main crop, accounting for about 41.7% of value added in agriculture, 66.3% of cropland use, and more than half of all grain production. Vegetables and fruit account for another 5-11% of value added in agriculture, while livestock contributes 24%. The government is actively encouraging crop diversification, and the number of households engaged in the production of fruit, vegetables, industrial crops, and animal husbandry has been growing steadily.

Since the land is so intensively farmed, yields obtained per hectare are high. Korea's annual rice crop is planted in June and harvested in late October and early November. About one-half of the rice farmers (those in the southern part of the country) now grow a second crop on their paddy land, either barley, other winter grains, spring vegetables or forage grasses.

Between 1974 and 1983, agricultural production grew by 3.4% per year, partly because of increased double cropping. Rice production increased by 11% in 1982, and by a further 18.5% in 1983: however this was still less than the production record of 1977, of 6138 kg/ha.

Per capita GNP and (probably) personal income grew somewhat more rapidly in the non-agricultural than in the agricultural sectors between 1974 and 1983, reflecting the fact that industrial production grew more rapidly than agriculture. In spite of the fact that the prices received by farmers rose by 16% more than prices paid, the farm population has continued to decline since 1967. The daily wages of hired agricultural laborers are a little lower than those of manufacturing production workers, and farm labor is in short supply at peak demand seasons.

Korean farmers are mostly literate, and relatively quick to adopt new practices. Fertilizer use in Korea is about 300 kg of nutrient per hectare, or about three times as high as that in any other Asian country, with the exception of Japan and Taiwan. Rice yields per hectare are between double and triple those of any other Asian countries, apart from Japan and Taiwan.

Korean farmers use nearly as much nitrogen as Japanese ones do, but only about 40% of the phosphorus and 30% of the potassium (potash). During the reasonably representative years of 1974-1983, Korea's average production was 5.2 mt of rough rice per hectare.

SMALL-SCALE FARMERS IN KOREA—A DEFINITION

The small-scale farmer can be defined, either in terms of the absolute size of his farm, or the relative size of his farm enterprise. However, the most meaningful definition would seem to be in terms of the farm income (in relation to the particular stage of economic development and agricultural structure within which he operates).

Farm size is often defined in terms of area of cultivated land, but this definition is a useful one for comparison only if farms are homogeneous in terms of type of farming and capital intensity. In fact, the majority of the two million farms in Korea are small-scale grain producers based on family labor, except for a small number of fruit, dairy and cash crop farms. Thus, the Korean rural sector is characterized by its unimodel structure, in contrast to the bimodelly structured rural societies in Latin America and Southeast Asia, where a small number of modern large-scale farms operate side by side with a large number of small subsistence farmers.

Nonetheless, there are significant differences in income and efficiency between farms of different size in Korea. 31% of Korean farms have less than 0.5 ha of arable land, while another 35% have 0.5-1.0 ha. The household income of farms less than 0.5 ha is US$1708.75, which is only 36.8% of the income level of 1.0-1.5 ha farms, and 38.3% of that earned by farms of 2 ha and more.

Usually, however, vegetable producers or livestock farms operating on less than 1 ha earn much higher incomes than grain producers on larger holdings. Thus, the level of income, rather than the area of cultivated land, seems to be a more meaningful basis for defining small farmers in need of special attention from policy-makers. The average farm household income in 1983 was estimated to be US$6410. This is very close to the US$55502.50 which is the average household income of the 0.5-1.0 ha farm group, and the US$6598.75 which is the average income of the 1.0-1.5 ha class. If we define small farmers as those who earn less income from a combination of farming and off-farm employment than that earned by their counterparts in the non-agricultural sector, roughly 78% of Korean farmers will fall into this category.

From a development policy point of view, I define small farmers in the Korean context as those who

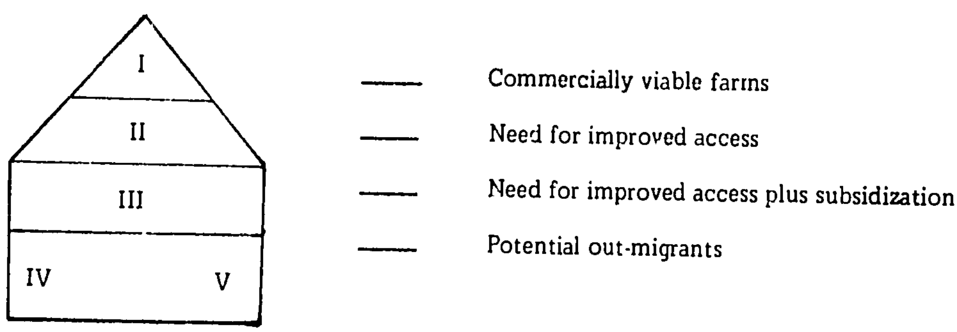
(1) operate on less than 1 ha of cultivated land, and
(2) earn less than US$5500 in a year (the national average household income of a 0.5-1.0 ha farm in 1983).

Growth for Small Farms

Small-scale farmers can be classified into four or five groups, in terms of economic viability.

- Group I : farms operating as commercial enterprises, earning the average income found in other sectors.
- Group II : farms with the potential to become profitable, when access to markets, and modern farm inputs, (including technology) are provided and market prices are adequate.
- Group III : farms which are capable of becoming profitable if special incentives, such as subsidized interest rates, are provided over a certain period of time, in addition to technology, inputs, and good markets.
- Group IV : farms which have a very small land base and are unlikely to be economically viable farm units, even if improved access to technology, markets and subsidized prices were provided.
- Group V : landless farm laborers.

Potentially commercially viable farms are represented in groups II and III. Group IV and Group V farmers should change to non-farm employment in order to earn a good income.



Development for Small Farms

For small farmers' development, there are three approaches to attain higher income, namely a full-time or part-time farm with an emphasis on farm enterprises, a part-time farm with an emphasis on off-farm business, or leaving farming. Which of these farmers choose will depend on a number of factors, including individual preferences, but from the viewpoint of farm efficiency, it is desirable if those who have the potential to be good farmers are given opportunities to climb up the ladder step by step, while those who have very limited abilities to be good farmers are provided with better job opportunities in the non-agricultural sector.

In view of the particular man-land ratio, resource endowment and stage of economic development in Korea, transformation of full-time farmers to part-time ones needs to be included as a means of development for the small farmer, since otherwise the growing income gap between small farmers and city people will never be reduced.

Thus, the organization and management policies in the agricultural sector become very important in solving the conflicting aims of higher productivity, and the transformation of small farmers to part-time producers in agriculture in order to increase their incomes. This requires an integrated approach to rural development, and also policies programmed to coordinate with related sectors.

The central question of small farmer development is undoubtedly how to help farmers to increase their incomes. As well as increased income from off-farm sources, this can be attained by increasing the actual farm income. The means of achieving this can be grouped under eight headings, as in Table 1.

Table 1 Means of increasing farm household income

Classification		Means	Task agent*			
			1	2	3	4
Farm income	(1) Yield increase	Better varieties		X		X
		Irrigation & drainage facilities		X	X	
		Fertilizer & chemicals	X	X		X
		Improved cultural methods		X		X
	(2) Change in cropping system	Profitable crop mix		X	X	X
	(3) Reduction of production costs	Reduced waste of material inputs			X	X
		Reduced labor inputs	X	X	X	X
		Lower interest rates				
		Increased yield	X	X	X	
	(4) Improved marketing	Reduced losses & waste		X	X	X
		Reduced marketing costs	X	X	X	
		Timely deliveries of produce to market			X	X
	(5) Expansion of farm size	Reduced number of farm households	X	X		
		Enlarged area of arable land		X		X
	(6) High prices for farm products	Price support programs	X	X		
	(7) Increased off-farm job opportunities	Decentralization of industrial plants	X	X		
	(8) Increased income transfer	Social security systems	X	X		

* 1. National economic growth
2. Government investment programs and policies
3. Group action by farmers
4. Individual farmers

Items 5-8 in Table 1 rely almost entirely on the growth of the national economy, or on industrial development, and government programs. Of course, the four other items also require active government support and institutional reforms, in addition to the initiative of individual farmers.

As technology develops and the commercialization of farming increases, so does the need for investment, to improve facilities in production and marketing. Not only does the demand for credit by farmers increase, but also the size of public investment required, resulting in the need for a higher social investment into the agricultural infrastructure development. Nevertheless, the key factor for successful programs remains the human resources invested in these efforts, and especially the quality of the farm operators.

SPECIAL FEATURES IN THE DISSEMINATION OF NEW TECHNOLOGY IN KOREA

The organization of the extension service in Korea can best be understood by examining the relationship between the extension program and the following:

(a) agricultural research and experimentation,
(b) the general administrative agencies, primarily provincial and local governments, and
(c) other relevant public and non-public organizations.

Relationship with Research and Experimentation

The Rural Development Administration (RDA)* is the national rural development agency, with the two basic functions of agricultural extension, and research and development. It is an independent part of the extension and research branch of the Ministry of Agriculture and Fisheries (MAF).

Under the RDA, research results can effectively and efficiently be translated into suitable technology, and diffused to farmers through the extension network. The integration of both functions of the RDA, research and extension, into a single organization, certainly has clearcut advantages for both services.

Relationship with the General Administrative Agencies

RDA comes under Korea's Ministry of Agriculture and Fisheries, and the Administrator of RDA assists the Minister of MAF in technical and extension problems related to the nation's rural development policy. He is also responsible for the planning of research and extension in Korea. The nine Provincial Offices of Rural Development (PORD), represent the provincial organization of the RDA.

They come under the Provincial Governments which administer them. The 179 City/County Extension Offices are administratively and technically under the control of PORD, but at the same time, each extension office serves its respective City/County Government. Finally, there are the 1,461 grass-roots extension organizations. These are placed under the jurisdiction of the county extension offices. Each branch office is responsible for extension programs within its geographical area.

* Formerly Office of Rural Development (ORD). Ed.

Relationship with Other Related Agencies and Organizations

In Korea today, there are three major categories of agencies significently concerned with rural development. These are

(a) government administrative organizations
(b) agricultural extension
(c) agricultural cooperatives

These are all more or less independent of each other, but work together on coordinated programs.

The administrative organizations plan and execute short-term aspects of long-term development programs, along with general administration. The agricultural extension agencies of RDA contribute to rural development primarily by means of informal education in social, technical and economic spheres. The agricultural cooperative system is primarily responsible for agricultural inputs and credit, and for the marketing of farm producuts.

Therefore, rural development programs in Korea may be described as being planned and implemented cooperatively and harmoniously in terms of 'administration, technology and capital' by the three major agencies of rural development.

Finally, institutional cooperation between the agricultural extension services and the formal agricultural educational system is ensured by such means as joint research programs, and reciprocal utilization of facilities and equipment.

NEW TECHNOLOGY AND DEVELOPMENT FOR SMALL FARMERS

Development of New High-Yielding Varieties

The present high level of technology in rice farming has been achieved by joint research programs on the breeding of high yielding rice varieties (HYV) carried out by RDA and IRRI since the 1970's. In 1977, Korea had the highest national average yield in the world, of 4940 kg/ha. Current research in rice production indicates that further increases are possible: for example, seed improvement resulted in a yield of 5470 kg/ha, compared to 5050 kg/ha in 1970. This is equivalent to an 8% increase (See Table 2). Analysis of average farm income from rice production in 1982 is shown in Table 5. We can see that production, farm management costs and income have all been increasing over the last decade.

Early season transplanting on May 26 (Suweon area) gave the highest yield of 5740 kg/ha, compared to the yield of 5570 kg/ha from rice transplanted on May 11, and 5110 kg/ha from rice transplanted on June 10: an increase of 12% and 3%, respectively. Using early transplanting, an optimum planting density of 73-81 hills per 3.3 m^2 is recommended, because the yield from 81 hills, of 6320 kg/ha is 5% higher than that from 73 hills per 3.3 m^2.

In water management, intermittent irrigation brought a 9% increase over continuous irrigation, while deep placement of fertilizer produced yields higher by 9-10 %. Table 3 shows the additional income from the use of new technology in rice production. The increase in yield of other important crops is shown in Table 6.

Table 2 Major factors in increased rice production

Major factors		Yield using new technology		Contrast	Increase ratio
Seed improvement	(1980)	5470 kg/ha	(1970)	5050 kg/ha	8%
Earlier cultivation	(transplanted May 26)	5470 kg/ha	(transplanted May 11)	5570 kg/ha	3%
			(transplanted June 10)	5110 kg/ha	12%
Dense planting	(81 hills/ 3.3 m)	6320 kg/ha	(73 hills/ 3.3 m)	6020 kg/ha	5%
Water management	(Intermittent irrigation)	5420 kg/ha	(continuous irrigation)	4970 kg/ha	9%
Deep placement of fertilizer	(HYV)	9-10%			9%

Source: Office of Rural Development, 1981

Table 3 Additional income from new technology

Factors	Increase ratio	Additional yield x crop value (US$)	Additional income (US$)
Seed improvement	8%	2920 x 0.08	230
Earlier cultivation			
— Transpl. on May 26 (contrast May 11)	3	2920 x 0.03	90
— Transpl. on May 26 (contrast June 10)	12	2920 x 0.12	350
Dense planting (81 hills)	5	2920 x 0.05	150
Water management (intermittent)	9	2920 x 0.09	260
Deep placement of fertilizer	9	2920 x 0.09	260

Source: Office of Rural Development, 1981

Table 5 Analysis of average farm income from rice (US$ per hectare)

Items			1970	1975	1980	1982	Remarks
Gross income		Main products (kg) · by-products	4.44	5.2	4.01	5.9	Based on polished rice
		Sub total (A)	415.75	1048.98	2191.45	3861.46	
Production cost	Management cost / Intermediate cost	Seed & Seedling	3.89	9.96	25.13	38.27	
		Government fertilizer	10.20	32.26	74.76	126.44	
		Farm manure	4.44	13.15	32.86	48.43	
		Disease prevention	4.89	22.38	66.56	65.79	
		Lightening power	—	—	—	—	
		Irrigation	9.49	13.61	45.60	77.36	
		Other materials	1.81	8.34	39.55	59.28	
		Small tools	0.71	1.05	2.91	3.83	
		Large agricultural implement	6.10	22.18	90.91	152.89	
		Agricultural building	1.45	4.89	9.00	12.10	
		Agricultural facilities	—	—	—	—	
		Repair cost	—	—	—	—	
		Initial expenses	—	—	—	—	
		Charge & fee	5.25	12.94	71.61	97.93	
		Total (B)	48.23	140.63	460.69	682.30	
		Hired labor	16.59	41.59	121.55	150.54	
		Hired draft	3.29	5.51	11.80	12.06	
		Total (C)	68.10	187.73	594.04	844.90	
		Family labor	66.33	16.63	439.24	567.35	
		Family draft	5.36	8.88	19.66	18.33	
		Operating capital service	9.79	18.44	83.04	121.21	
		Fixed capital service Land service (Rent)	225.53	284.69	660.93	948.13	
		Total (D)	375.10	666.03	1796.90	2499.91	
		Net profit (A-D)	40.65	382.95	394.55	1361.55	
		Income (A-C)	347.65	861.25	1597.41	3016.56	
		Added value (A-B)	367.53	908.35	1730.76	3179.16	
		Net income Rate (%) (A-D) /A	10	37	18	35	
		Income (%) rate (A-C) /A	84	82	73	78	

Source: Year Book of Agriculture & Forestry, MAF, 1983

Table 6 Yield of rice and other important crops in Korea

(Unit: 10a)

Crops	1955	1960	1965	1970	1975	1980	1982
Rice	269	269	311	355	416	321	472
Barley	139	174	263	291	323	359	306
Soybeans	55	47	57	79	113	115	127
Corn	57	59	81	145	172	436	412
Apples	—	694	878	1,008 1/	906	889	1,233
Pears	—	753	764	777	532	650	993
Peaches	—	591	512	660	669	870	940
Oranges	—	155	188	87 2/	728	1,323	2,045
Radishes	—	1,295	1,411	1,152	3,755	4,064	4,096
Chinese cabbage	—	1,199	1,230	1,117	5,773	6,356	7,049

Source: Year Book of Agriculture and Forestry Statistics, MAF 1962–1983

1/: Farmers planted a lot of dwarf-apple trees

2/: Losses from too dense planting of orange trees

Current Labor-saving Technology—Use of Farm Machinery

Small farmers can save labor inputs in rice farming by utilizing farm machinery; by mechanizy other types of production, they can spend more time in off-farm seasonal or part-time labor or make more intensive use of their land, thus increasing their productivity and incomes.

According to RDA survey data, 1965 rice farming required 163.7 labor hours per hectare, while in 1981 it required only 130.5[2] labor hours per hectare. This average decrease of 33.2 labor hours ha was a result of new rice farming technology, including the use of herbicides and farm machinery.

Compared to traditional cultivation methods, the use of farm machinery reduced labor costs by the following amount: tractor, used for plowing and discing, 27%; transplanter used with seedling box, 42%; harvest used for cutting and binding, 15%; dryer, 27%. (Table 4).

Technical Training for Small Farmers

In the early 1960's, when Korea's extension program was still at a fledgling stage, two or three days' technical training for farmers was conducted sporadically, using demonstration plots at research stations or in the field. However, as farmers gradually became aware of the need to apply more diversified and more specialized techniques in their farming, conventional short-term courses and the T & V approach could no longer meet their increased demand for technical knowledge. Formal institutional training was then initiated, and from the mid 1960's, extension agencies provided accomodation facilities for farmers during longer training courses. Equipment and the cost of training, including food, lodging and transportation, were all covered by the national and local extension budget. As farm earnings

[2] ORD (= RDA) 1983. *Study of labor input hours by working order for farm enterprises*

continued to grow, farmers have paid a fee for some training programs in the winter off-season. Technical training is generally divided into two different types, technical agricultural training and training in farm machinery. Both these are conducted at the national, provincial and county level. (Table 10).

Table 4 Utilization of farm machinery and its effect

(hr/10a)

Type of machine	Mechanized labor cost (from Farm Mechanization Institute)	Traditional labor cost	Labor saving (A/B)
Tractor (plowing, discing)	1.83	6.80	26.9%
Transplanter (use of seeding box and transplanting)	13.50	32.06	42.1%
Harvester (cutting, binding)	2.36	15.30	15.4%
Dryer (drying)	1.89	7.13	26.5%

Source: Office of Rural Development, 1982

Training Small Farmers in Advanced Agricultural Techniques

Farm technical training covers such topics as specialized training on producing a particular crop or product, the training of farmers' leaders, and teaching farmers how to make productive use of the winter off-season. (Table 7)

The specialized technical training for a particular crop has been conducted since 1974 for advanced farmers, to teach the special techniques required to produce diversified, high-quality food. This type of training is conducted intensively, and lasts for three to six weeks. It is conducted at the relevant national experiment stations, and there is an emphasis on practical knowledge.

Training participants are selected from amongst the advanced farmers living within the area covered by a farmers' cooperative. Training courses are available in dairy, beef, hog, chicken, hot-house vegetable, fruit, flower and mushroom production, and are now in increasing demand. After the course is completed, trainees take a qualifying test in their particular field. Those who pass the test are given a certificate of qualification, and are given first preference as far as farm credit and loans are concerned. Thus, they play a leading role in the use and dissemination of technical information.

The training of farmers' leaders was previously conducted intermittently at the Extension Office, where it took the form of a table discussion with leading farmers. Since 1975, a one-week course in the leadership and management of farmers' organizations has been held regularly at the Provincial Farmers' Training Institutes. Since 1977, farmers have been trained on three day courses in cooperative techniques of improved production.

From the first beginnings of the extension program in Korea, there had been occasional off-

Table 10 No. of extension specialists attending training courses

Year	Officer course	Professional officer course	Special training courses									Total
			Rice	Upland crops	Horticulture	Livestock	Sericulture	Crop protection	Rural society	Farm machinery	Subtotal	
1976	622	42	317	175	—	79	81	79	—	—	731	1,395
1977	615	58	207	99	—	56	47	221	182	—	821	1,485
1978	583	59	311	172	140	46	67	169	64	—	969	1,611
1979	588	59	224	119	178	276	105	103	232	119	1,356	2,003
1980	469	60	406	180	219	238	60	50	119	75	1,347	1,876
1981	350	60	297	118	119	119	56	119	120	77	1,025	1,435
1982	358	50	197	50	50	48	50	97	179	78	749	1,157
Total	3,585	388	1,959	913	706	862	466	838	896	349	6,989	10,962

Source: Report on Rural Extension Programs, ORD. 1983

Table 7 No. of farmers given technical training in Korea

Type/ Training	Length/ Training	Trainees	Place	Results by year (No. of trainees)						
				1970	1972	1974	1975	1977	1980	1982
Specialized technical training by crop	3—6 weeks	Farmers from cooperative productions zone and other advanced farmers	Experiment Station and ORD Training Center	—	—	282	309	343	365	379
Farmer's leaders training	1 week	Leaders from cooperative production zone and voluntary leaders	FORD Training Center				2,041	4,708	6,749	—
Farmer Training	2—3 days	Farmers from cooperative production zone and leaders of study organizations	City/ County Farmers Training Center					80,537		48,912
Winter off-season training	1—2 days	All farmers	Local School & community Center	2,979,285	2,982,853	2,463,252	2,356,204	2,860,454	2,478,750	1,8

Source: ORD, 'Rural Guidance Manual'. 1981. p. 81

season training courses for farmers during the winter. Since 1970, however, these have systematically been expanded to cover the whole nation, and are held between December and the following March every year. In the early stages, classes for illiterate farmers were important: now the courses focus on technical training, with an emphasis on farm planning and management.

Instructors are selected from Country Extension Offices, and given special courses which last several months. Their curriculum generally includes both cash crops and grain production.

Once the trainee has been chosen for a training course, the training is carried out on a village or higher level, often with the support of local schools or community centers which provide facilities. The administrative office is responsible for planning the course, arranging for the transport of trainees and organizing them into classes, while the extension office prepares training materials and instructors, and reports on the results after the course is completed. Farmers' cooperatives cover other necessary costs of the training course, including meals and accomodation.

Farm Machinery Training

The farm machinery training course began with the establishment of a 4-H Farm Engineering Training Center in the compound of RDA in 1960. This center conducted elementary courses, such as a 4-H vocational training in carpentry, blacksmith skills and masonry, for the improvement of houses and livestock barns.

The training also included courses on the use of improved farm tools. In 1963, thirteen such farm engineering training centers were opened at a provincial level, and in 1968, 23 additional centers were set up at a county level. The farm engineering training for senior 4-H members was conducted until 1969, when a specialized training program in mechanized farm operations was initiated.

As rural manpower grew short, it became increasingly necessary to use farm machinery, and and the maintenance of machinery. This training course was reorganized into a farm machinery training course in 1969.

At first, trainees were selected from senior 4-H members, but since 1972, farmers in possession of farm machinery have also participated in the courses. The continued decline in the rural labor force has meant that farmers' wives play an increasing role in farm work, and they have participed in the farm machinery training courses since 1975. County level training is conducted on a short-term basis dealing with small machinery: Provincial level training is conducted for three to four days with heavier machinery, such as hand-tillers, tractors and transplanters.

Table 8 No. of trainees of attending the 4-H farm engineering training course annually

Year	1960–1969	1970	1973	1975	1978	1982	Total
At both national and local level	2,174	2,267	1,940	1,739	2,202	2,594	30,732

Source: ORD, Rural Extension Bureau, 1983

Farmers' Problems in Adoption of New Technology, and Solutions to These:

Problems	Solution
1. *Limitations on expanding farm size:* The potential for reclaiming upland areas for farming is extremely limited. Very few land-owners wish to sell their land, because not only does land mean security for their families, but also a high rate of appreciation in value is expected in the foreseeable future.	• The effort to increase the land use intensity (labor intensity, capital intensity, etc.) are shown in Table 11: those to increase the yield of rice and other important crops appear in Table 6.
2. *Limitations on increasing land use intensity:* As farmers turn to non-farm work to earn higher incomes, it is not economical to keep a high intensity of land use.	• Part-time jobs to increase farm household income: Tables 12, 13 and 14 show developments in the processing of farm products, and rural manufacturing.
3. *Constraints to adopting cost-effective technology:* – high yielding varieties – chemical fertilizers – insecticides and – pesticides – irrigation water – farm machinery	Organizing small farms into group farming • For major factors in the increase of rice production, see Tables 2 and 5. • For utilization and effects of farm machinery, see Table 4. • For training in the use of farm machinery, see Table 9. • For training of extension specialists, see Table 10. • For technical training for farmers, see Table 7.
4. *Constraints to raising farm incomes* Farmers can increase farm production by using more inputs, but they are unable to influence the market price with their small marketable surplus. Unless the government intervenes, farm prices will remain low, because any significant increase in farm prices will affect the cost of living of urban people.	• Establishing sound government policy for small farms – Providing long-term low-interest loans. – Providing a good agricultural marketing system for small farmers: government purchase of some commodities. – Guaranteed prices (sometimes higher than the retail price, as in the case of rice).

Table 11 Utilization of cultivated land in Korea

(Unit: 1000 ha)

	Area of cultivated land	Total area of utilized land (includes pasture etc.)	%	Food crops	Special crops	Vegetables	Permanent crops	Fruit	Others
1974	2,238	3,122	139.5	2,503	107	274	—	75	163
1975	2,240	3,165	141.4	2,541	100	276	—	88	160
1976	2,238	3,093	138.2	2,492	93	269	—	95	144
1977	2,231	2,914	130.6	2,299	98	285	—	96	136
1978	2,222	3,001	134.5	2,272	136	276	14	94	209
1979	2,207	2,909	130.9	2,129	133	339	11	96	201
1980	2,196	2,765	125.3	1,982	118	359	10	99	197
1981	2,188	2,774	126.3	2,002	100	365	15	100	192
1982	2,180	2,678	122.4	1,908	124	343	13	101	189
1983	2,167	2,698	123.8	1,926	138	322	15	105	192

Source: MAF, Statistical Yearbook of Agriculture, Forestry and Fisheries, 1984

Table 12 No. of farmers attending training courses on additional farm income

Topic of training course	No. of groups	No. of trainees			
		Total (A)	M	F(B)	B/A
Mushrooms	58	2,030	1,731	303	15%
Bees	29	627	558	70	11
Korean cattle	10	688	606	82	12
Swine	4	267	224	43	—
Dairying	1	50	50	—	16
Slieep	2	61	46	15	25
Poultry	17	205	173	32	16
Horticulture under structures	1	113	110	3	3
Fish	1	30	30	—	—
Drawing & flowers	22	308	226	82	27
Ginseng	1	197	197	—	—
Wangool (crop from which matting etc. is made)	1	58	49	9	16
Total	132	4,527	3,903	624	14

Source: Office of Rural Development, 1982

Table 13 No. of farmers attending training courses in the processing of farm products

Course	No. of groups	No. of trainees			
		Total (A)	M	F(B)	B/A
Hulling of red peppers	2	183	147	36	20%
Bamboo processing	4	127	81	46	36
Wallpaper manufacture	4	172	98	74	43
Window paper manufacture	3	78	48	30	38
	7	176	127	49	28
Medical plants—production and use	1	57	54	3	5
Salting of radish	3	108	79	29	27
Drying of persimmon	5	144	195	49	34
Canning	3	86	6	80	93
Drying of radish	1	41	22	19	46
Mandarin orange—production and processing	1	40	—	40	100
Leaf	1	50	25	25	50
Making paper bags to protect fruit	2	92	1	91	99
Manufacture of straw goods					
Manufacture of mats	2	31	19	12	39
	1	46	28	18	39
15	40	1,531	930	601	39

Source: Office of Rural Developmen., 1982

Table 14 No. of farmers attending training courses in rural manufacturing

	No. of groups	No. of trainees			
		Total (A)	M	(B)	B/A
Handmade silk	3	100	5	95	95%
Knitting	25	280	48	232	83
Variegation work	—	120	—	120	100
Embroidery	—	30	—	30	100
4	28	530	53	477	90
Porcelain	1	36	28	8	22
Artificial pearls	1	52	52	—	—
Candles	8	35	—	35	100
3	10	123	80	43	35

Source: Office of Rural Development, 1982

Table 9 Number of farmers attending the farm machinery training course annually

Type/ training	Trainees	Length/ training	Number/training recipients						
			1969	1971	1973	1975	1977	1980	1982
County Training	4-H members	3 days	2,070	2,070	—	—	—	—	—
	Owners of tiller	"	—	—	32,886	42,081	91,185	70,501	64,836
	Housewives	"	—	—	—	—	4,536	14,477	9,927
Provincial Training	Senior 4-H members	3—4 weeks	45	358	1,811	1,739	1,696	2,168	3,114
	Housewives	"	—	—	—	738	785	—	—
	County instructors	"	—	—	—	—	780	—	—
	Owners of machinery	"	—	—	—	—	—	—	—
National Training	Senior 4-H members	4—6 weeks	59	178	129	—	—	—	—
	Provincial, county instructors	"	—	31	101	353	198	57	128
	Owners of machinery	"	—	—	—	218	198	456	2,000
	Advisers from other agencies	"	—	—	—	—	—	120	116

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DISCUSSION

Q. Do the factors increasing rice yield shown in Table 1 have an additive or a cumulative effect?

A. The effect is an additive one.

Comment: This means a 46% increase in yield.

Q. What is the current interest rate for agricultural loans in Korea?

A. The basic interest rate for agricultural loans is 8%.