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# ON-FARM POTATO RESEARCH IN THE PHILIPPINES

Edited by
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# SUMMARIES OF PAPERS

## On-Farm Research for Optimizing Potato Productivity: A Description on CIP's Current Approach

Roger Cortbaoui and Michael J. Potts

An approach is described in which the aim is to improve the transfer of potato technology from the research station to the farmer's field, using agro-economic evaluations of possible alternative production technologies tested under farmer's conditions. Emphasis is placed on determining managerial and qualitative changes that could be introduced into the crop production system in order to generate a change in yields and/or returns that covers costs and risks related to its adoption. The sociological implications of any such changes are borne in mind.

The approach consists of three major phases: the identification of alternatives to the present crop production system, on-farm testing of these alternatives in comparison with the farmer's current practices, and an evaluation of these alternatives in terms of improvements in yield and income derived from the crop. The factors to be considered at each phase are considered in detail and at a practical level in order that all parties involved, scientist, extension worker and farmer, may readily understand the philosophy underlying the approach. Precise guidelines for conducting on-farm potato research are not described.

It is concluded that the approach is a valuable tool that the potato programmes of the developing world could use in order to improve the productivity of the potato crop under their specific conditions.

## Potato Production in Benguet Province, Philippines: An Example of Vegetable Production in South-east Asia

Michael J. Potts

Benguet Province in Northern Luzon, Philippines, is typical of many highland areas throughout South-east Asia; for example, Burma, Thailand, Indonesia and Vietnam. In all areas, vegetable production is usually a major enterprise. The historical development of the enterprise, practices followed and problems encountered are often similar.

This paper traces the social, agricultural and economic aspects of the potato industry in Benguet with the aim of elucidating present day practices and prejudices in order that appropriate development programmes may be undertaken. Much of the information and experiences described will be of value to scientists and administrators in other parts of the region.

# White Potato Yield Survey: Benguet Province

Michael J. Potts, Lito M. Pacuz and Elmo O. Sano

A survey is described in which samples were taken at harvest from potato fields in Benguet Province and an estimate of the yield was made. A total of 419 fields were surveyed during the wet seasons, 1980 and 1981, and the dry seasons, 1980-81 and 1981-82. Respective mean seasonal yields were: 28.2, 17.1, 24.7 and 28.8 tonnes per hectare.

The range of yields varied according to season; being concentrated about the seasonal mean during the wet season, 1980 and the dry season, 1981-82, but showing marked variability during the other two seasons. Weather factors were considered to be primarily responsible for the variability.

During the wet season, the cultivars Conchita, Cosima and Greta were most commonly grown. Cultivar Conchita and cultivar Greta were particularly popular in the more remote localities, where good late blight resistance and a long dormancy period were considered essential. Cultivar Cosima was grown in localities where there was a concentration of co-operators in the local RP/German Seed Potato Programme.

During the dry season availability of seed-pieces dictated the cultivar grown: a preference being shown for cultivar Red Pontiac.

Cultivars showed little difference in yield; except that cultivar Cosima yielded slightly less than average for both the wet season crops, 23.7 and 16.2 tonnes per hectare, respectively; and cultivar Greta yielded below average during each of the dry seasons, 21.8 and 25.4 tonnes per hectare, respectively.

## In-Ground Storage of White Potato: A Preliminary Assessment

Michael J. Potts, Elmo O. Sano and Lito M. Pacuz

A series of trials is described intended to provide basic information about "in-ground" storage of white potato (*Solanum tuberosum L.*) for table use in Benguet Province, Philippines. Particular attention is given to losses in yield and quality, farmer reaction and the role of "in-ground" storage in the farming system.

Losses in yield were minimal (6%) during the three-month period following maturity, thereafter falling markedly to 25% after five months. Quality changes showed a similar pattern with excess sprouting and shrivelling of the tubers being observed after five months. Little pest or disease damage was observed.

Field observations indicate that the practice is probably most suited to smaller farmers on the margins of the production zone. More information is required on farmers' attitudes generally, to the economics of the practice and to any possible alternatives if satisfactory storage recommendations are to be made regarding the increase in potato production proposed by the National Potato Programme.

## Transfer of Technology to Small Farmers: On-farm Research in the Philippines

Michael J. Potts, Amado B. de los Santos and Julia A. Solimen

This is a revised version of a paper presented to the Second Social Science Planning Conference at the International Potato Centre, Lima, Peru. It described the evolution of a programme intended to (a) identify factors currently limiting potato production, (b) suggest and test through the medium of "on-farm trials" alternative practices and (c) evaluate agronomically, economically and socially the implications of the alternative practices. The major philosophical, organizational and practical features experienced in the field are described. The steps taken to overcome difficulties together with a few personal comments of the authors are forwarded.

## An Agro-economic Assessment of Seed-potato Storage Technologies in the Philippines

Michael J. Potts, W. V. D. Albert, Felix R. Rutab,
Elmo O. Sano, Pepito P. Mariano and Robert H. Booth

A series of 14 on-farm trials indicated that improved seed-storage facilities, in the form of additional diffuse light and ventilation, may considerably reduce losses of seed-tubers and result in a better quality product: less weight loss in store, more sprouts per tuber and shorter, more robust, sprouts. This improvement resulted generally in improved emergence, stem number per hill, yield of marketable tubers and economic return. The improved on-farm stores compared favourably with the refrigerated storage available locally in both agronomic and economic aspects.

## An Agro-economic Assessment of White Potato Manuring Trials: Benguet and Mountain Provinces

Michael J. Potts, Amado B. de los Santos,
Elmo O. Sano and Felix R. Rutab

Two sets of manuring trials done on white potato crops, in farmers' fields in Benguet and Mountain Provinces, are described. In the first set the traditional application of chicken manure to the seed-bed was eliminated and in the second set all commercial fertilizer (as a compound: 14.14.14) was applied to the seed-bed instead of as the customary side-dressing.

Agronomic practices and economic costs pertaining to the changes in practices were carefully recorded. A yield increase of at least 15% and an increase of at least 10% in net returns were taken as the minimum that could be regarded as significant under field conditions.

Yield response to the elimination of chicken manure varied considerably according to site. Two sites showed an increase, two a decrease and six no change in yield. In terms of net economic returns, four sites showed an increase, two a decrease and four no change. The beneficial effect of chicken manure was most marked on dry soils or sites consisting of sub-soil. It is suggested that moisture retained by the chicken manure facilitates improved nutrient uptake.

The placement of all commercial fertilizer into the seed-bed increased yield significantly at six sites with no change at the remaining seven sites. Monetary returns were increased at ten sites and decreased at one, due to poor fertilizer incorporation and subsequent crop damage.

# An Agro-economic Assessment of Further On-farm White Potato Production Trials

Michael J. Potts, Amado B. de los Santos and Lito M. Pacuz

A further series of 45 trials is described to investigate aspects of seed quality and manuring practices in the yield and returns from white potato.

The response to the use of certified seed in place of the farmer's own seed of the same variety varied, being primarily dependent on the quality of the farmers' seeds; further investigations were considered necessary. The use of larger seed-pieces (35 to 55 mm) in place of the farmers' small seed gave a positive improvement in yields and monetary returns and was considered worthy of attention by the extension services. The use of whole seed in place of cut seed for the dry season gave no improvement in yields or returns.

The use of alternative organic fertilizers, McLife and Sagana 100, gave no consistent agronomically or economically beneficial effects and their recommendation should be questioned. Commercial fertilizer applied to the seed-bed again showed beneficial agronomic and economic effects as did the use of additional nitrogen and potash as side-dressings at hilling-up. The use of lime gave contradictory results and requires further attention.

There was no consistent improvement arising from the use of lime but it is considered that the practice requires further attention.

## Farmer Acceptance of Improved Potato Storage Practices in Developing Countries

Robert E. Rhoades, Robert H. Booth and Michael J. Potts

The introduction of a new technology to developing country farmers frequently necessitates complementary changes in related traditional practices. This has been particularly true where post-harvest knowledge and technology has lagged behind the rapid acceptance of modern, high-yielding cultivars. This paper describes the diffusion of low-cost potato storage practices among Philippine farmers, a case study which has wider implications for international efforts to reduce post-harvest losses in developing countries.

## Diffuse-light Potato Seed Storage as an Example of Technology Transfer: A Case Study

Michael J. Potts

An example of the adoption of a new technology, namely the storage of potato seed tubers in diffuse-light, is described under conditions typical of many developing countries: lack of financial and technical resources, etc. Progressive stages are shown within one farm. In addition, farmer awareness of seed-tuber quality and confidence in new technologies were increased so that other related technologies have been adopted prior to any apparent data on subsequent yields and economic returns, which have since been shown to be not inconsiderable.

# INTRODUCTION

The potential for agricultural research to alleviate the world's food shortages must clearly be exploited if the world's rapidly increasing population is to be adequately fed. The successes of such institutions as the International Rice Research Institute (IRRI) and the Centro Internacional de Mejoramiento de Maiz y Trigo (CIMMYT), with their new high-yielding varieties of rice and wheat, have demonstrated that traditional farming practices can be substantially improved through the use of new technologies and inputs. However, only rarely do technologies, many of which were developed by the First-world Nations of the temperate zone, have global application: local modification and refinement being necessary if they are to be biologically suited, socially acceptable and economically viable within a particular community.

The potato crop is a particularly good example of this dilemma of developing appropriate technologies. The high yields attained in the developed world and on research stations elsewhere are far in excess of those attained by farmers in most Third-world Countries, even though the expense of production often limits its cultivation to the best and wealthiest farmers. If production of this highly nutritious and productive crop is to be increased, then considerable effort must be expended in identifying appropriate technologies to increase current yields and expand cultivation to those resource-poor farmers who stand to derive most benefit from the higher incomes and improved diet which this crop is capable of giving.

It was in recognition of this "technology gap" that the International Potato Centre (CIP) held a planning conference in December, 1978 intended to review the current state of knowledge regarding the technology transfer process and to serve as a basis for formulating an approach to technology transfer specifically adapted to the potato. This approach was given the title "Optimizing Potato Productivity" (OPP).

The OPP approach is, first and foremost, a team approach in which scientists from various disciplines and local institutions work with farmers in order to fully understand current production practices and, most importantly, the farmers' reasons for these practices. On the basis of this knowledge, alternative practices are suggested. These are then tested in the farmers' own fields using the farmers' current practices as a comparison. Data collection is limited to that essential for the technology to be evaluated agronomically, economically and socially prior to its promotion by the Extension Services, the inauguration of further work on the research station or the formulation of policy by administrators.

Shortly after CIP had outlined its OPP approach, the Philippine government expressed interest in conducting a co-operative project to develop the approach. Potato production in the Philippines was limited to a few highland areas, notably Benguet and Mountain Provinces, and farm yields of approximately 7.5 tonnes per hectare were considered low: particularly in the light of Experimental Station yields of over 20 tonnes per hectare. Furthermore, the potato, due to its high potential yield and nutritional quality, had been identified as a priority crop by the Philippine government and, in order to promote the potato, a national potato programme, the Philippine Potato Programme (PPP), consisting of all those organisations interested in the production and utilization of the potato, had been formed.

In view of the interest shown by the Philippine authorities in developing the approach, a joint three-year, PPP-CIP project was set-up in which Benguet and Mountain Provinces were selected as the test area. CIP assigned a post-doctoral scientist to work in the field with national personnel to develop the approach. This scientist was backed up by frequent visits from headquarters' staff who were also involved in similar projects elsewhere. The experience gained was then fed back to CIP, Lima, where it was collated with information from the other projects, to further develop the approach, particularly at the field level. At the same time, much of the information gathered proved to be of immediate use to the national Extension Services, Research Organisations and Policy-makers within the Philippines.

The experience gained in developing this approach have also proved to be of interest to many other national and international institutions concerned with agricultural development: not least has been the interest shown in the symbiotic relationship between an international centre and a national programme. Facets of the project have been published in appropriate scientific journals but, in order to give a comprehensive view of the project's objectives and development for use elsewhere, it was felt appropriate that they should be collated and published together with a number of hitherto unpublished papers under a single cover.

The papers, which appear under their original titles, have been grouped within sections which describe the outlines of the original approach, the study area and current farming practices, on-farm trial experiences and trials results and farmer acceptance of alternative technologies. A final section has also been added in which some tentative conclusions are drawn. Every effort has been made to keep the content of the papers in the form accepted by the scientific journal concerned except that minor editorial changes have been made to maintain typographical continuity and to reduce repetition.

# SECTION I:

## The Approach

CHAPTER 1

# On-farm Research for Optimizing Potato Productivity: A Description of CIP's Current Approach

Roger Cortbaoui and Michael J. Potts

## Introduction

In its efforts to improve the transfer of potato technology from the research station to the farmer's field or store, the International Potato Centre (CIP) has formulated an approach under the title "Optimizing Potato Productivity." This approach is centered on agro-economic evaluations of possible alternative production technologies carried out under farmer's conditions. The ultimate goal of these evaluations is to identify technological changes that potato farmers could make in their crop production system in order to increase income derived from their crop.

The basic assumption behind this approach is that in order to be potentially adoptable a technology should:

- be appropriate for the needs and resources of the farmer;
- generate a change in yields and/or returns that covers costs and risks related to its adoption and gives some agronomical, economical or sociological benefit.

The purpose of this paper is to describe the current approach in its broad lines and not to give precise guidelines for conducting on-farm potato research. The authors recognize that the approach still contains some problematic aspects that field experience will help clarify and resolve.

## Preliminary Considerations

This approach is meant to be an intermediate step between the generation of technologies at the research station and their dissemination to farmers via the Extension Services. It contributes to the efficiency of both research and extension by:

- testing the relevance of research results for solving production problems faced by farmers
- allowing a better selection of those research results that could be profitably disseminated.

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- acting as demonstrations in farmer's fields of practical research findings

- providing new information (concerning actual production problems) that could stimulate additional research oriented towards solving specific production constraints.

Ideally this type of reseach is conducted by multi-disciplinary teams of social and biological scientists. In reality, these teams seldom exist (especially where developing potato programs are concerned) and the work will often be carried out by production agronomists previously sensitized to the multi-disciplinary aspects of the approach. For this reason socio-economic techniques used should remain simple and accessible to non-specialists but in no case should they be neglected.

Although CIP can play an important role in stimulating on-farm potato research, the leading role in its implementation must be played by national potato workers whose major responsibility is, after all, the identification of improved farming techniques adapted to the ecological and socio-economic environments of their countries.

## The Optimizing Potato Productivity Approach

CIP's optimizing potato productivity approach is the result of various on-farm research activities conducted during the past three years both by regional and source-research scientists. In December, 1978 an International Planning Conference brought the contribution of several "outsiders" to the definition of the strategy.

In its present form, CIP's approach consists of three major phases centered on the achievement of the goals below, whilst at all times taking full note of any sociological consequences arising from the alternative technology:

A. identification of alternatives to the present crop production system

B. on-farm testing of these alternatives in comparison with the farmer's current practices

C. evaluation of the alternatives in terms of improvements in yield and income derived from the potato crop.

The details of each of the three phases can be described as follows:

## *Identification of alternatives to the present crop production system*

By means of a thorough study of the present crop production system of a given area and of the relevant production technology, this first phase of the on-farm research aims at identifying possible ways in which the farmer could improve the yields and income of his potato crop. It includes the following steps:

i) *Delimitation of the area under study:* One of the first decisions to be made during this phase is the choice of the area in which on-farm research is to be conducted. Often this choice is made according to criteria such as proximity to a research or extension centre, location in a priority area of a governmental development program or importance of the potato crop. The areas selected this way do not always present an acceptable degree of homogeneity as far as their ecology, cropping patterns and socio-economic situation are concerned. This is why the actual choice of the area under study will in many cases be followed by a division of this area into sub-areas or agro-ecological zones defined according to pre-selected criteria. These criteria are chosen for their relevance to the potato crop and for the influence they could have on the definition of the technological alternatives that will be suggested in the following stages of the on-farm research.

ii) *Study of the present crop production system:* A thorough knowledge of the present crop production system is an important pre-requisite for on-farm potato research. Although valuable, the perception of the production problems that the local technicians might have, should not be considered as the only source of information. At this stage a conscious effort should be made to set aside any pre-conceived ideas concerning the production problems. Ideally, the technician should be able to "forget" what he already knows of the present situation of the potato crop and to get out to the fields collecting information about "what's really going on?"

The objective of the study is to find out "How are potatoes grown in the area under study?" This includes a qualitative description and an understanding of the crop production system and in some cases a quantification of information in order to determine the relative importance, within the area, of the major production problems.

The techniques used during the information gathering process and the magnitude of the operation will be determined primarily by the complexity of the situation and the human resources available. An "informal survey", which gives a fundamental appreciation of the area and its potato production practices, supplemented by well prepared interviews of

potato producers, is an excellent first step. This informal survey might later be complemented with a "formal survey" designed to quantify specific aspects of the crop production system.

A major outcome of the study of the present crop production system is likely to be the identification of different types of potato producers defined on the basis of major economic characteristics of their farms. Subsequently one or more types of farmers could be chosen as target group(s) for on-farm potato research.

iii) *Diagnosis of the hypothetical limiting factors:* Using the information gathered concerning the present crop production system, the potato specialist can make his diagnosis. This will consist in listing the components of the actual system that could be improved because they are thought to be limiting yields and incomes. These limitations might be identified as low physical yields per unit area, poor quality of the product and/or high production costs.

A certain degree of empiricism is inherent to this step because it relies on the experience and the "flair" of the production specialist. This disadvantage can be minimized by a higher degree of precision in the information gathering process and by a thorough knowledge of the potato crop.

iv) *Identification of the technological alternatives to be tested:* The diagnosis does not always lead to the identification of a possible solution simply because these solutions do not exist or because they require the use of special inputs; material, technological or financial, that are not available to farmers. This will influence heavily the choice of the technological modifications to be introduced in the farmer's current system. The socio-economic knowledge of the area (accumulated during the information gathering process) will help discard unrealistic non-viable solutions. A very important point, not to be overlooked at this stage, is that the advice of the farmer could also help rule out those alternatives that conflict with the socio-economic situations of the target area.

Simple low cost alternatives will be preferred to complex costly ones because they are more likely to be adopted. Several hypothetical limiting factors may be identified, but the trials will test solutions to individual problems except for those factors with high interaction levels. This precaution will allow a better judgment of the technologies tested and will help keep the trials simple, easily manageable and understandable by the farmer.

The basic objective of the trials is a comparison between the farmer's present crop production system and a proposed modification that could increase yields and incomes. Thus the experimental design of the trials will include a "farmer treatment" and the "alternative treat-

ment(s) to be tested. The proposed modification will constitute the only difference between these two treatments, all the other production factors being the same as in the farmer's present crop production system.

## *On-farm trials*

At this stage, the researcher has developed one or more hypothesis concerning the identification of factors that could improve yields and incomes. The on-farm trials phase will test these hypotheses in farmers' fields.

i) *Choice of farmer co-operators and number of trials*: Normally the co-operators are chosen because of their willingness to participate in the research effort. In addition, this choice should ensure:

- several testing sites for each of the alternatives under study
- an even geographical distribution of trials in the study area.

Ideally, the co-operators should be representative of the target group selected. This representativeness is frequently difficult to achieve, but evident biases can easily be avoided by a good awareness of the co-operator's major characteristics (farm size, tenure, relations with the market, cropping patterns, etc.). Whenever possible, the co-operators will be chosen among those who are aware of the production problem that the suggested technology is meant to resolve.

The final number of trials will depend on the human and material facilities dedicated to on-farm research. These facilities will also determine the number of alternatives that could be included in the testing process: if necessary the number of alternatives tested can be reduced so that the number of testing sites dedicated to each alternative could be increased: the objective of this research being the determination of technological alternatives that remain valid across a large number of situations.

ii) *Execution of on-farm trials*: The preparation and execution of the trial *per se* raises the following questions:

a. how to include the farmer's technology as a control in the experiment?

b. how large should the trial be?

c. what experimental designs should be used?

d. where on the farm should the trials be located?

e. which cultural practices should be executed by the technicians and which by the farmers?

Although the answers to these questions will vary with the local situations and the type of technology tested, the following principles can be emphasized.

a. The trial is meant to compare an alternative technology to the farmer's current practice. Thus the "farmer's technology" should be an integral part (a treatment) of the trial and should reflect as closely as possible the current practices. In some cases the farmer might change his current practice copying the "new" proposed technology. This may necessitate the substitution of the "farmer's treatment" by another plot in the field. This risk can be minimized by a very clear definition of the proposed alternative and a greater awareness on the farmer's part. The solution that consists in simulating the farmer's practice is in our eyes more hazardous and harmful than risking to "lose" some of the trials.

b. The size of the trial will be large enough to allow an acceptable degree of security in the interpretation of the results, but at the same time small enough to minimize the risks that the farmer is taking when applying a "new technology" whose good results are not evident for him.

c. When deciding on the type of experimental design the temptation of transposing to the farmer's field the requirements and rules of the experimental station should be avoided. Often a simple design consisting of adjacent plots representing the farmer's treatment and the alternative one(s) will be sufficient. In cases where the topography of the field make it necessary a simple lattice-type design might be used. Complicated statistical designs are not in our opinion adapted to this type of on-farm research: besides, one should not forget that the goal of this research is not to test the validity of a technology at one specific site but its performance over several locations. The error due to the simplicity of the experimental design is compensanted by the diversification of the experimental sites.

d. The location of the trial within the farm might be a delicate decision. The temptation of choosing the best and most secure potato field should be avoided. Ideally the field should be representative of the farm. In reality this representativeness is not easy to secure. Again evident biases can be avoided by a thorough examination of the farm and the elimination of the very obvious atypical fields.

e. Since the ultimate goal of this research is the determination of technological changes that the farmer *could make* in his crop produc-

tion system, the ideal situation would be to have the farmer execute both his technology and the proposed one. This principle might prove to be idealistic when some complicated and precise experimental variables alternative are concerned. In those situations the technicians will execute the cultural practice under consideration.

iii) *Follow-up of the trials and data recording:* Regular follow-up visits are essential for:

- securing the execution of the different cultural practices at the right time and in the right way
- recording the necessary agronomic and economic data
- discussing the performance of the proposed technology with the farmer co-operator.

The determination of the data to be recorded is dictated by the agro-economic evaluation planned. In other words, the researcher will record the data that he will need during the evaluation process, they will consist mainly of agronomic and economic changes related to the application of the proposed technology (yields, quality of harvest, costs and returns). This implies that the evaluation procedure must be defined at the outset together with the choice of technological alternatives and the experimental designs.

The time of data recording is another important aspect and should be decided according to the type of technology tested. This applies not only to the agronomic data but also, and mainly, to the economic data, the recording of which needs as much (or more) care and advance planning.

iv) *Participation of the farmer:* The farmer co-operator plays an active role in the implementation of the trials not only because he lends his land and inputs but also because his "evaluation" of the proposed technological alternative is as important as the one based on agro-economic figures and calculations. For this reason care should be taken to make sure that the farmer understands the trial and its results. Ideally the majority of inputs used in the trial should come from the farmer. The researcher could provide some of the inputs in order to compensate the special efforts that the farmer undertakes when accepting to co-operate. In no case should this compensation be so big as to "buy" the willingness of the farmer regardless of the content of the trials.

## Interpretation and Evaluation of the Trials

At the end of the second phase, the researcher has accumulated a large amount of data concerning the agro-economic performance of his proposed technology in comparison with with farmer's practice. These data have been gathered for all the sites where the alternative has been tested and consist mainly of yields, costs and returns for the prevailing farmer's practice and the alternative tested.

The third phase of the approach concentrates on utilizing the above-mentioned data in drawing conclusions about the relevance of the "modified" technology for the improvement of the marketable yields and incomes derived from the crop.

### *Micro-analysis of the trials*

For each of the experimental sites the following questions need to be answered:

a. Did the alternative technology produce a better yield (quantitatively and/or qualitatively) than the farmer's present practice. If yes, how much better?

b. How big was the change in net returns made possible by the alternative technology in relation to the change in cost necessary for its adoption?

The first question is answered in a relatively easy way by comparing physical yields both in quality and in quantity. Special care should be given to develop uniform qualitative criteria that remain valid across the different experimental sites.

The second question is answered by partial budget analysis of each of the trials. This is done by estimating:

- The change in income that the alternative technology generates. (This will usually take the form of extra income but occasionally a reduction in income may be associated with a lowering of production costs.)

- The change in production costs incurred while replacing the farmer's technology by the proposed alternative.

The two figures estimated above will be used to determine:

- the change in net income generated by the new technology

rate of return on additional money spent while adopting the alternative technology (benefit/cost ratio).

Clear criteria should be used to determine prices of inputs and outputs in the partial budget analysis. These criteria should indicate where and when the prices are collected and should help in reflecting the qualitative differences on these prices.

The estimation of the "change in costs" will include an estimate of the cost of extra capital needed for the application of the alternative technology. Although problematic, the "cost of capital," or interest, should not be forgotten.

## *Macro-analysis of the trials*

The overall evaluation of a series of trials, testing the same alternative to the present crop production system, enables the researcher to judge whether the agro-economic performances of his technology hold across different experimental sites.

This can be done by fixing a minimum increase in yield, and a minimum benefit/cost ratio that the proposed technology should achieve in comparison with the farmer's current practice. The proportion of trials where these minimum have been attained (separately or simultaneously) will indicate:

a. whether the problem that the alternative was supposed to resolve is significant for the area under study, and

b. whether the solution represented by the alternative is relevant to the identified problem.

Not all the alternatives will produce an increase in yield *and* an acceptable benefit/cost ratio or *vice versa*. The overall evaluation described above will help determine whether the technology tested:

- increases yield but is not profitable under the present circumstance, or
- increase profits without affecting significantively the physical yields (cost reduction or quality improvement, or
- increase both yields and profits.

There are no clear-cut criteria for establishing the minimum increase in yields and the minimum benefit/cost ratio that a technology should generate in order to be acceptable in our evaluation. These minima should reflect what is locally acceptable taking into considera-

tion the actual yield levels, the rate of inflation, the other investment possibilities and the risk to the new technology.

### *"Farmer's evaluation"*

The agro-economic evaluation described above will not answer all the questions. The perception and the opinion that the farmer could have of a technology tested in his field are essential and should be sought. This is why the results of the trial he hosted (and if possible those of similar ones) should be presented to the co-operator and discussed with him. His understanding of the proposed technology and his knowledge of the agro-economic results of the trial will help him give an opinion as to the relevance of the trial to the solution of the production problems he is facing. His willingness to adopt the suggested alternative is the best indicator of the success of the on-farm work.

## Utilization of the Results

The results of a series of on-farm trials and the experience and information accumulated during their implementation could lead to the identification of technological improvements that can be disseminated with greater prospects of adoption by potato producers. In some cases they will point out production problems that require more attention from the research agencies. But in all cases they will be used to refine the on-farm research process through a better definition of the problems and a more efficient choice of the improved production technologies that will be tested during subsequent cycles of the evaluation process.

## Prospects and Problems

The approach described requires very careful thought in conceptualizing the trials and their execution if the benefits of its relative simplicity are to be realized. It will be most effective in determining managerial and qualitative changes that could be introduced in the crop production system. It will be of limited use in determining optimum levels of inputs or in defining degrees of interactions between production factors: this is the province of the research worker at the experimental station. It will allow the identification of those improved production technologies, adapted to specific areas, which are likely to be adopted by potato producers. It will rule out those technologies that are not economically significant for the farmers.

For all these reasons but mainly for its simplicity, which allows it to be readily comprehended by the farming community, it constitutes a valuable tool that potato programmes of the developing world could use in order to improve the productivity of the potato under their specific conditions.

# SECTION II:

## The Study Area

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## The Study Area

### Introduction

An essential pre-requisite to any development or extension programme is a fundamental grasp of the current cropping system: agronomic practices, economic and marketing constraints, sociological factors and, above all, the farmer's own understanding of his situation.

Whilst many of the research workers and technicians concerned with potato production in Benguet were native to the area; they had very diverse views of the situation, based on their own personal upbringing and scientific background. Such views were apparently giving rise to unco-ordinated research and extension programmes. It was decided, therefore, that a comprehensive description of potato production should be made. Although much information could be rapidly collated, the study was regarded as a long-term project based upon as many informal discussions with farmers, merchants, extension technicians, research workers and other interested parties as possible. The building-up of a personal relationship with these parties was seen as essential if true and reliable information was to be forthcoming. Formal survey questionnaires were not regarded as an appropriate medium in the first instance, since data collected in previous surveys was known to be erroneous. For example, survey estimates of yields were known to be below those economically viable and also considerably less than the visual estimates made by co-operating parties in the field.

In order to obtain quantitative data in specific areas of doubt surveys or preliminary trials were conducted. This section thus consists of a description of the overall cropping system, based primarily upon the author's experience in the field but also a careful selection of published works, and two papers, a survey of farm yields and some preliminary storage trials, which demonstrate how precise supplementary information may be gathered at little cost in terms of labour and finance.

At the time of writing a small project similar to the yield survey was being planned with a view to obtaining quantitative information on labour and material inputs; an area in which there is much conflicting opinion.

CHAPTER 2

# Potato Production in Benguet Province, Philippines: An Example of Vegetable Production in South-east Asia

Michael J. Potts

## Introduction

Temperate vegetables are grown in many highland areas, above 1200 m, throughout South-east Asia. The patterns of farming, in terms of the crops grown, cultivation methods, etc., and the socio-economic problems encountered by farmers show a remarkable degree of similarity throughout the whole region. However, the urgent need to intensify food production is leading to the rapid abandonment of many of the traditional practices in favour of improved, often "western", methods of production.

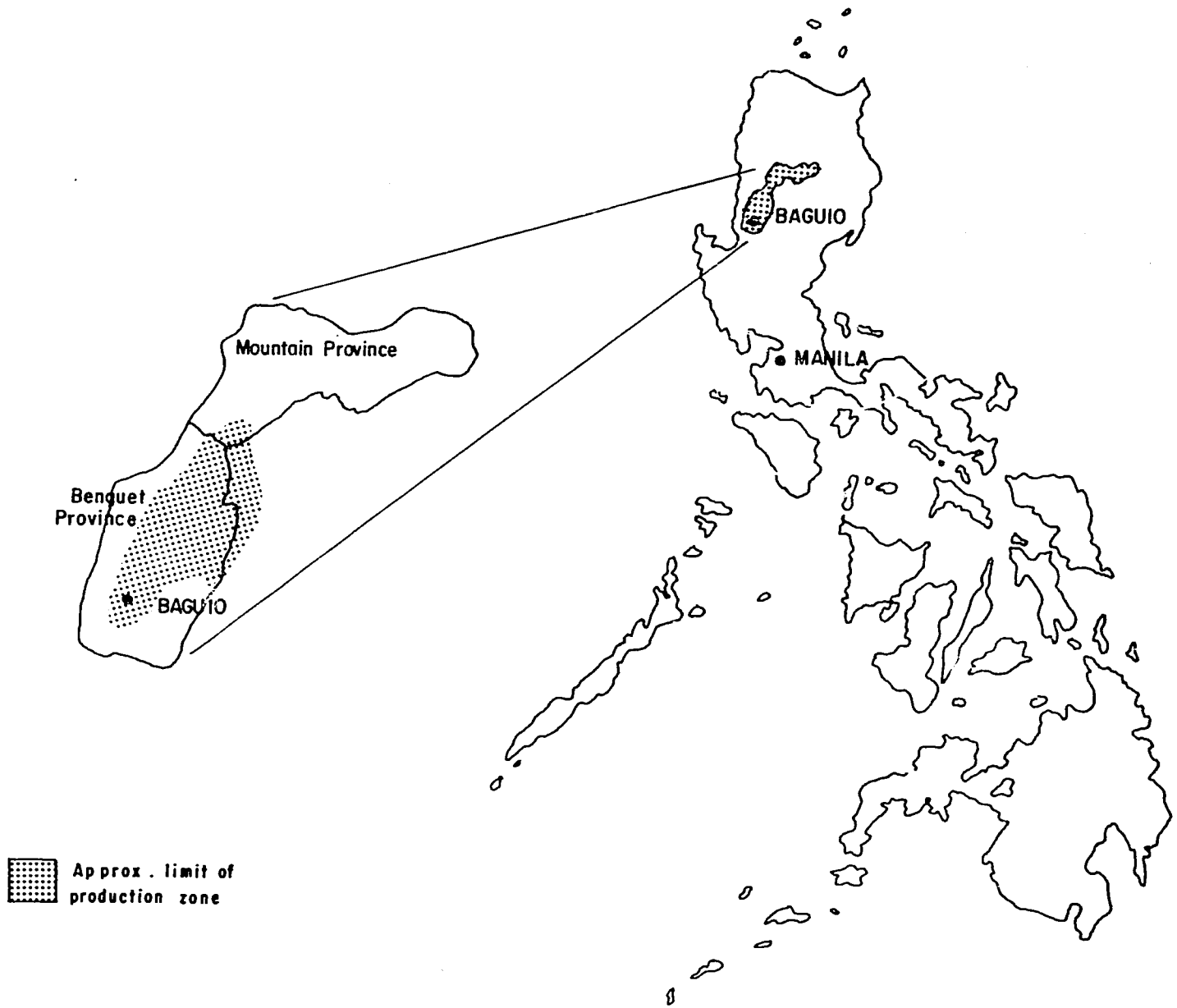
Benguet Province, Philippines, is a typical example of the situation in South-east Asia. Vegetable production has been the principal farming enterprise for most of this century, with little change in the socio-economic status of the farmers or their cultivation practices. However, during the last five to ten years, following strong encouragement by the national government, there has been a rapid change in circumstances and traditional customs and practices are quickly being overlooked. Nonetheless, experience in the field has shown that a thorough knowledge of these traditional circumstances is required if change is to be directed most efficiently (Potts et al, Ch. 5). Nowhere has the change more dramatic than for the potato crop; for which, coincidentally, many of the practices and problems also apply to the other vegetable crops.

This paper is an attempt to document the historical development of the potato crop, as an example of a typical vegetable crop in South-east Asia; and to show how this development has affected the cropping practices used today before many practices are superseded and totally forgotten as the older generation of settlers dies out. It also serves to illustrate the importance of this information in formulating development projects and should serve as a basis for the development of other crops, both in the Philippines and elsewhere in South-east Asia, where similar circumstances arise.

## The Location

Benguet Province covers an area of 2,556 square kilometres on the island of Luzon, Philippines (Figure 1) and, together with a small area in neighbouring Mountain Province, it is thought to account for approximately 65% of the land area planted to white potato, *Solanum tuberosum* L., (2,260 hectares) and 85% of the production (An[illegible], 1979a).

Figure 1. THE PHILIPPINES, SHOWING STUDY AREA



Approximately 70% of the population of the Province of Benguet derive subsistence from farming and about 12,000 farmers in the two provinces grow white potato (Balaoing, private communication).

Bisecting the province, north-east to south-west, is a cordillera ranging from 1700 m to 2400 m amsl along which much of the potato production is concentrated (Plates 1a, 1b). From this cordillera run numerous valleys: the most important from an agricultural viewpoint being Loo Valley (1450 m amsl) in the north of the province (Plate 1c) and La Trinidad Valley (1300 m amsl) to the south (Figure 2) which, together account for 0.4% of the land area of Benguet Province (Solimen, 1978).

The terrain may be described as " ough" and is characterised by steep slopes, deep ravines and water s. Gently sloping land is nowhere extensive, being limited to a few ri er banks and ridge tops. Under Philippine law land of more than 18% slope is national forest and cannot be cultivated but nonetheless much of this land has been brought under cultivation. Plates 2a, 2b, 2c show a representative selection of views at three points along the main Cordillera; km 49, km 68 and km 100 (Figure 2).

## *Soils*

Geologically the district is very complex. It comprises of displaced sedimentary rocks mixed with intrusive volcanic and metamorphic rocks. There are small areas of limestone to the north-west and south around La Trinidad Valley. There is much faulting and many of the rock formations are fragmented. There is also a high degree of mineralization (Anon., 1980a).

Over most of the area the soils are free-draining sandy- or silty-loams, which may be very deep especially along ridge tops. They are mainly acidic and liable to erosion (Plate 2b). Along the valley bottoms alluvial soils have been deposited but these are not extensive. Plate 3a shows a typical soil profile found in both the pine- and rain-forest zones.

## *Climate*

The Province of Benguet may be described as having a temperate climate with two distinct seasons: a wet monsoon season extending from late April until November and a dry season from December until April.

Table 1 summarizes the basic meteorological data collected at Baguio City to the south of the province and at an elevation of 1400 m amsl. Although these data are not strictly applicable to the cordillera,

Table 1. Climatic parameters, Baguio City.[1/]

| Parameter | Month | Jan | Feb | Mar | Apr | May | June | July | Aug | Sept | Oct | Nov | Dec | Annual Mean/ Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mean Daily Maximum Temp °C + | | 22.3 | 23.6 | 24.3 | 25.2 | 24.2 | 23.8 | 22.9 | 21.8 | 22.8 | 23.5 | 23.1 | 23.5 | 23.4 |
| Mean Daily Minimum Temp °C+ | | 12.9 | 13.2 | 14.1 | 15.6 | 16.0 | 16.4 | 16.7 | 15.9 | 15.9 | 15.7 | 16.3 | 14.5 | 15.3 |
| Monthly Rainfall (mm)* | | 20 | 19 | 48 | 122 | 352 | 422 | 922 | 1043 | 650 | 362 | 163 | 56 | 4177 |
| No. of Days with Rain* | | 4 | 4 | 6 | 10 | 20 | 23 | 27 | 27 | 25 | 19 | 10 | 6 | 181 |

+ 10-year average, 1970-1979

* 52-year average, 1916-1968

1/ Source: PAGASA, Baguio City

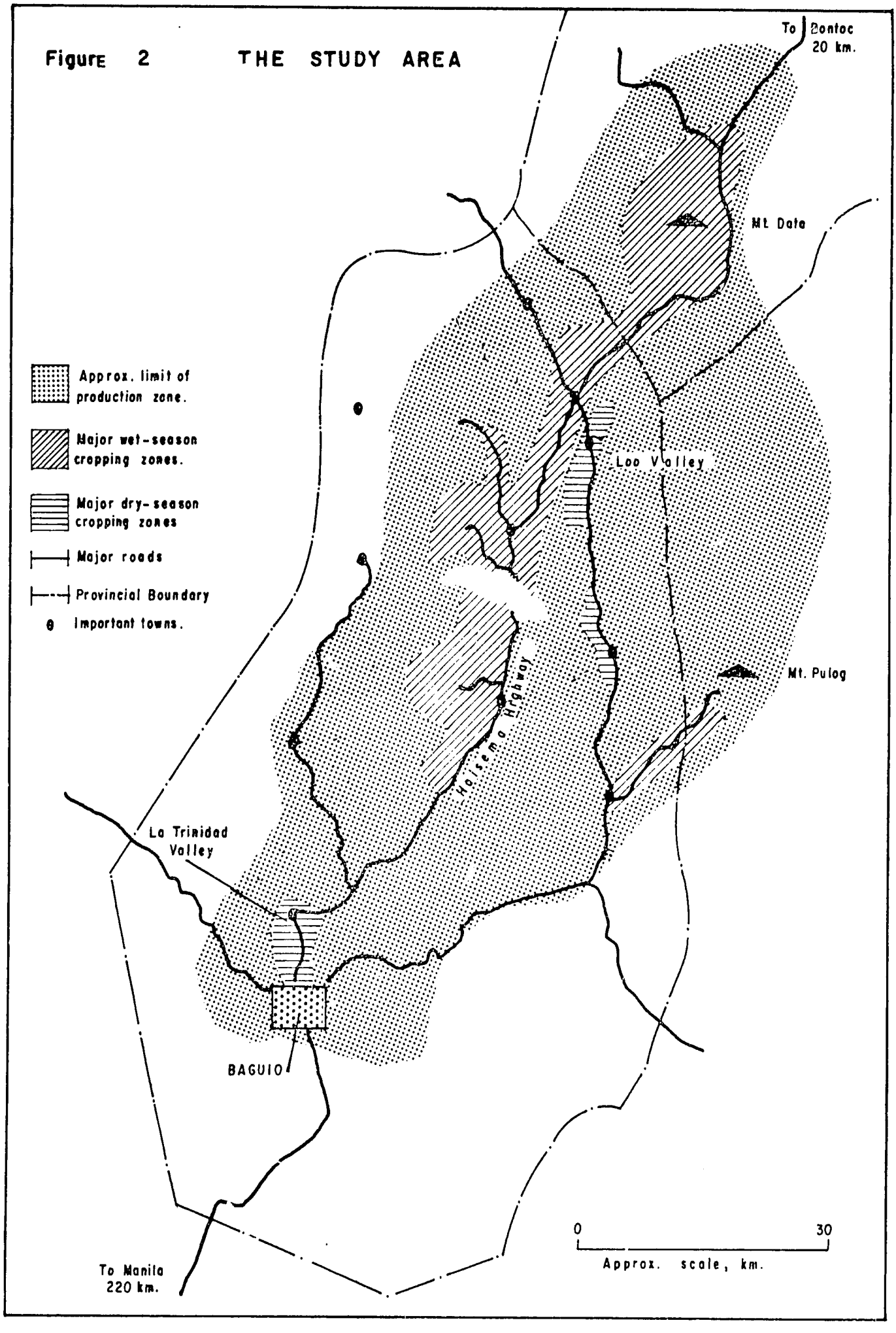
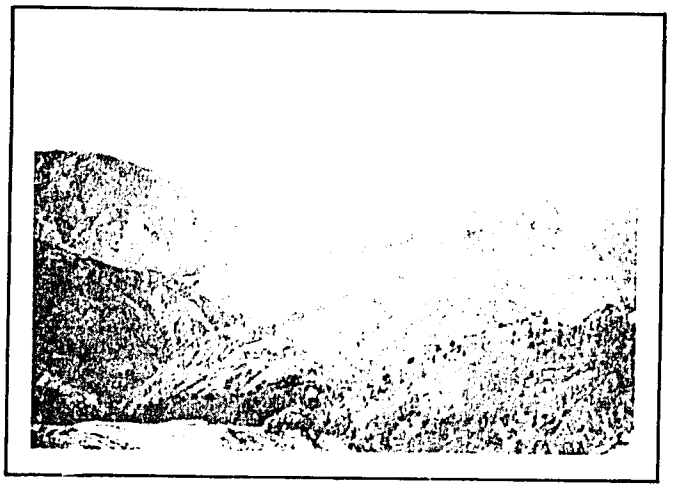


Figure 2 THE STUDY AREA
To Bontoc
20 km.
Mt Data
Approx. limit of production zone.
Major wet-season cropping zones.
Major dry-season cropping zones
Major roads
Provincial Boundary
Important towns.
Loo Valley
Mt. Pulog
Halsema Highway
La Trinidad Valley
BAGUIO
To Manila
220 km.
0
30
Approx. scale, km.

1



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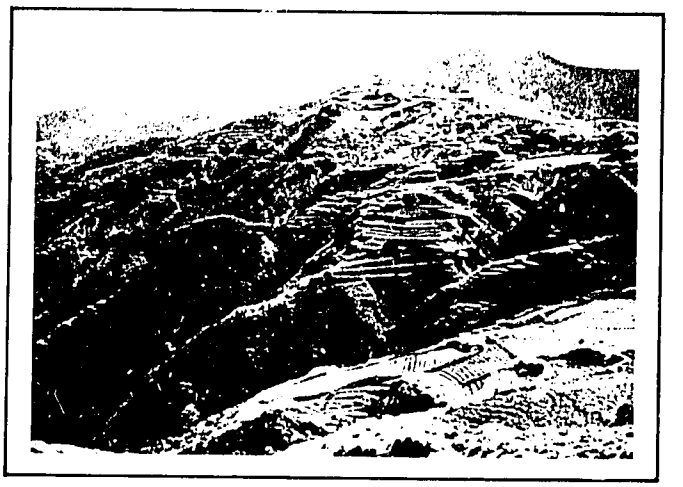

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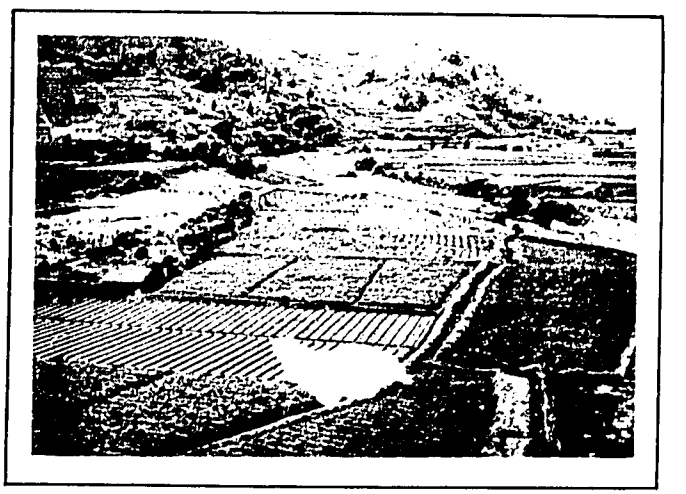
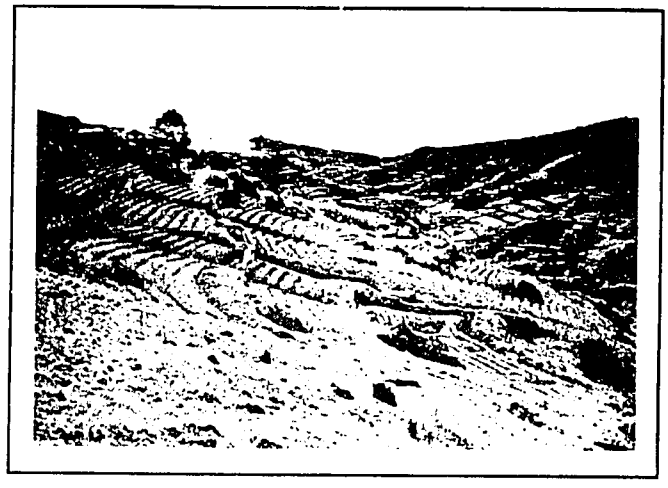


c

Plate 1. The Terrain. (a) View from the main cordillera, km 30. Note: extensive logging, (b) View along the top of the cordillera, km 55. Note: vegetable production concentrated near main highway along top of cordillera, (c) Loo Valley. Note: irrigation canals formerly used for rice production.

2



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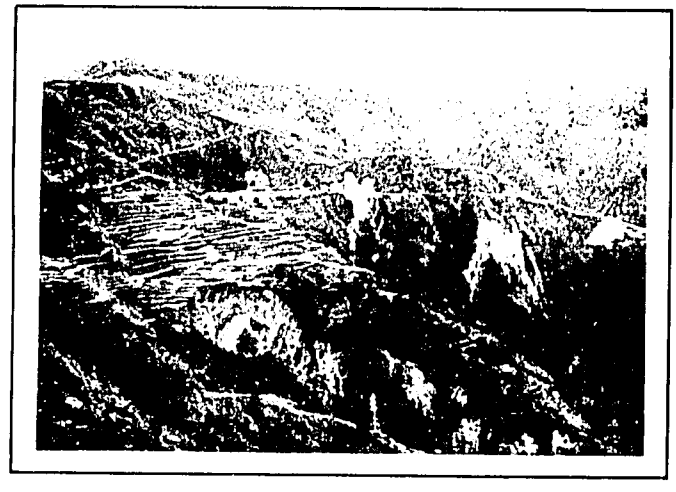

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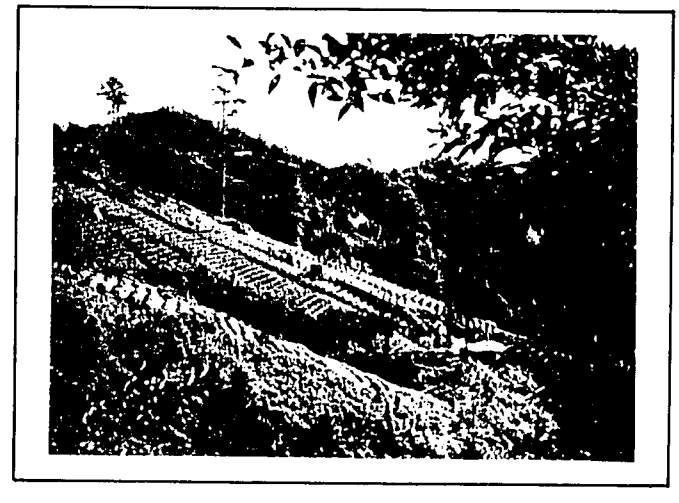

Plate 2. Representative Production Areas. (a) Paoay, km 45. Note: contour farming; complete removal of three cover, (b) Km 68. Note: serious erosion, (c) Km 100. Note: contour farming.

they are the most reliable available and give a good indication of the weather patterns in the area.

Rainfall during the period July to September may be extremely heavy and is frequently associated with strong winds and typhoons (Plate 3b). Cropping during this period is considered risky. Similarly, during the dry months of January and February, frosts may be encountered in exposed areas and basins at night and cropping of sensitive crops is avoided (Plate 3c). Hail damage frequently occurs during May and early June.

### *Vegetation*

The natural vegetation covering the whole of the area up to an altitude of 2100 m amsl is of the pine type, predominantly Benguet Pine (*Pinus kesiva*), which appears to be a natural fire climax (Plate 4a). Benguet Pine is a vigorous pioneer, which regenerates freely where seed is available from nearby trees. Under the pine the vegetation is dominated by grasses, particularly *Andropogon annulatus*, *Themeda triandra* and cogon grass *(Imperata cylindrica)*. These grasses become dominant in cleared or burned areas together with the fern, *Pteridium aquilinum*.

Above 2100 m, where it is frequently cool and shrouded in mist or cloud, a botanically rich, high-mountain forest, locally known as mossy forest, predominates (Plate 4b). It is dominated by trees and climbers reaching heights of approximately 10 m and which belong to many different botanical families. Ferns, grasses, mosses, lichens, liverworts and epiphytes are abundant (Plate 4c). Vegetative decay is slow in these areas and litter and humus accumulate giving rise to deep, rich organic soils favoured by vegetable farmers for cultivation (Steringga, private communication).

## Historical Development

Two major tribes, the Ibalois and the Kankanays, are native to Benguet Province together with a number of smaller tribes, which are generally associated with one of the main tribes both linguistically and culturally. Collectively, these tribes form part of a larger group known as the Igorots.

The Ibalois are traditionally agriculturalists and occupy the valleys to the south and east of the province (Plate 5a). Gabi or taro *(Colocasia esculenta)* and related Genera are thought to have been historically the main cultivated crop; grown using the *kaingin* (slash and burn) system (Plates 5a, b). Following the Spanish conquest in the mid-sixteenth century, camote *(Ipomea batatas)* rapidly assumed the role of

3

a

b

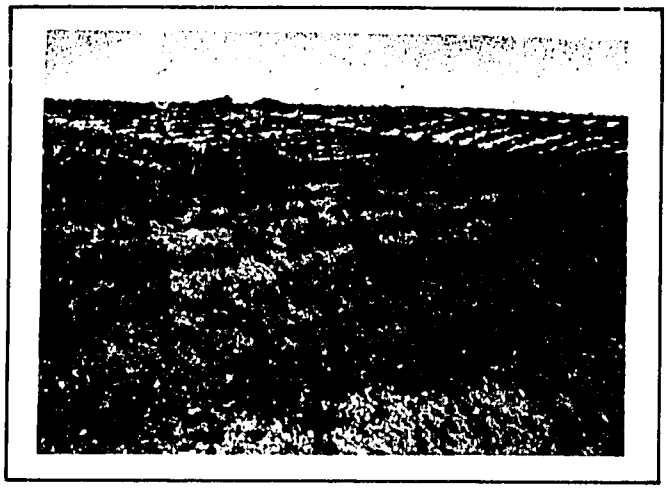

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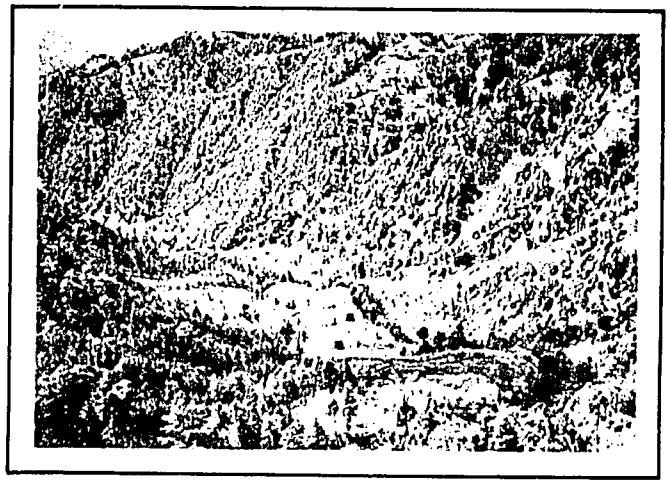
Plate 3. Soil and Weather Conditions. (a) Typical soil profile beneath mossy forest, Buguias. Note: previous erosion due to removal of forest canopy by fire; poor leached subsoil, (b) Typhoon damage, June, 1981. Note: breaking of stems, stripping of leaves, subsequent attack by late blight, (c) Frost damage to cv. Red Pontiac, Paoay, January, 1981.

4



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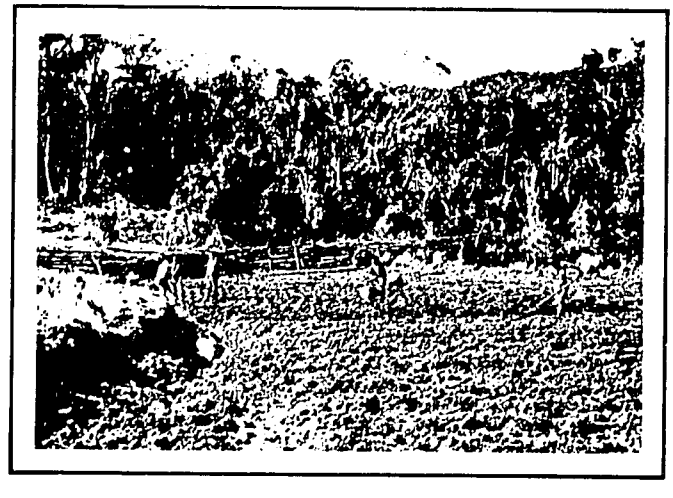

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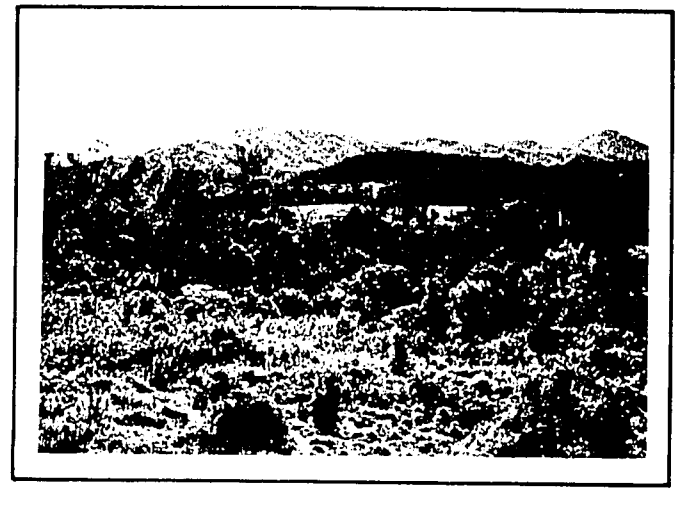
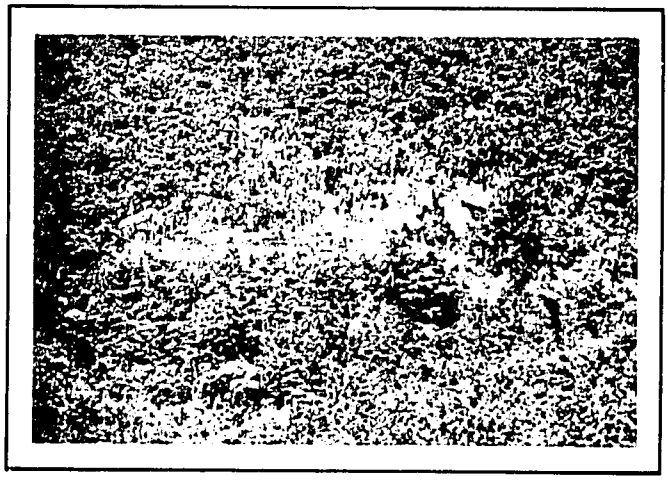


**Plate 4. Natural Vegetation.** (a) Pine forest, km 100, 1800 masl. Note: removal of prime timber, (b) Mossy forest, Kabayan, 2100 masl. Note: dense forest cover; rich organic soil, (c) Mossy forest and natural grassland, Buguias, 2000 masl.

5

a



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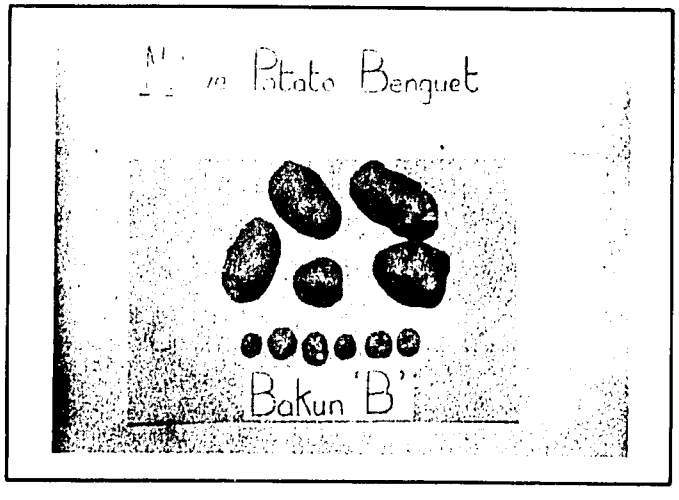


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**Plate 5.** Traditional Agriculture. (a) Ibaloi village, Tenaloab, end of dry season, 1982. Note: permanent settlement, lack of roads, primitive terraces cleared for forthcoming crop, (b) Traditional *kaingin*, near Kabayan. Note: recent burning; current cropping, new grass fallow, forest regeneration, (c) The native potato tuber recovered from within camote grown in *kaingin*, Bakun, December 1981.

staple root crop. Fifteen percent of the mainly Ibaloi farmers are still believed to derive their subsistence from unterraced *kaingin* (Anon., 1980a). Corn grew only poorly but other vegetables such as beans and onions were grown and traded one village to another (Scott, 1977). Formally the swiddens were moved every two or three years but it is more usual now to cultivate the same swidden, allowing it to fallow one year in three.

Although rice was grown in neighbouring areas, particularly to the north, it was not a major food of the Igorots; except perhaps for festive occasions. However, in the nineteenth century, natives came down from the northern areas to construct complex, irrigated terraces, where rice was grown. All peoples now consume rice as their major staple, either grown locally or more usually "imported" from the lowlands of Luzon, since production is insufficient to fulfill local demands and in many instances rice cultivation is being superseded by more profitable vegetable crops. Not all locations suitable for terracing have yet been developed and construction is continuing.

The Kankanays had a more shifting pattern of agriculture, again based on the *kaingin* system. Taro and camote were grown with small areas of beans. Again migrants from the nort-east introduced terracing and irrigated rice culture and rice is now consumed by all peoples. Settlements of any permanency were usually located close to mineral deposits, gold, copper and silver, since the Kankanays were the native miners (Anon., 1970).

Although the Spanish occupied the Philippines for over 350 years, they did not pacify and settle these mountainous regions of Northern Luzon. The first governor of Benguet was appointed only in 1846 and his successor, Don Blas de Baños, is attributed with "distributing a few potatoes among the Igorots who then cultivated them so well that Benguet potatoes were on sale in Manila a few years later. Potatoes from China or Australia, however, are still preferred"(Semper, 1862). During the next 50 years, there was a small migration to the area, particularly La Trinidad Valley where rice and camote were the major crops, but tomatoes, tobacco and "all sorts of European vegetables" (including potatoes) were also grown (Von Drasche, 1876).

Following the Spanish-American War in 1898, there was a rapid increase in migration to this valley area. Predominant amongst the migrants were Japanese, who remained following the completion of a local road building project (Kennon Road), or Chinese who were active traders in the locality. Older informants in the area estimate that even by 1920 as much as 70% of the farming population may have been of Japanese or Chinese descent.

The migrants brought with them a system of vegetable farming which is still strongly in evidence today. Older informants cite cabbage,

carrots, cucurbits and tomatoes as the crops most frequently grown, and their major market was Manila, now readily accessible due to the completion of the Kennon Road in 1903.

The Japanese growers did not move far from the valley floor but local people began clearing the lower slopes and copying their methods of farming. The construction between 1923 and 1932 of the Halsema Highway (Figure 2), as a widened road along the ridge of the cordillera, made accessible the forest lands to the north. The population density of this area was still very low and traditional *kaingin* was still the method of agriculture practiced. However, one reliable informant, whose father first came to the area in 1898 with the American army, said that his father knew of patches of *kaingin* where "native" potatoes were grown as a small patch "in one corner".

Potatoes were grown at this time by planting tubers in the piles of ash resulting from burning grasses: but they appear to have been used principally for domestic consumption. The type of potato grown was generally termed "native." Farmers in the region recall growing considerable areas of "native" potato as recently as the late 1960's but it is no longer to be found. Descriptions of the "native" potato vary but generally fall into one of two broad types:

a. tall luxurious foliage (flower- colour unknown), few elongated irregular tubers, white skinned with deep eyes, yellow waxy flesh and a sweet flavour

b. tall luxurious foliage with white flowers, a long growing season, small round white skinned tubers, yellow waxy flesh with a sweet flavour.

However, intensive efforts by several interested parties have recently (December, 1981) led to discovery of a "native type" of potato filling the former description in an isolated swidden and this is to be grown and multiplied in order that it may be positively identified (Plate 5c).

The exact date on which the potato was introduced to the Philippines is unknown but Camel (1704), a prominent Jesuit naturalist who resided in the Archipelago in the late seventeenth century, records its cultivation in Luzon using the Peruvian term "*papas*". This statement implies that the potato was introduced before the year 1700 and possibly from Peru; although this latter point is not certain, since the term *papa* is also used in parts of Mexico from where the Philippines were governed.

The Augustinian "sphere of influence" in the Philippines was northern Luzon and a monastery was set-up on the nearby coast before the year 1600. Furthermore, the Ibaloi and Kankanay tribesmen continue to use the term *papas* whereas *patatas* is universally used throughout the rest of the country. There would appear to be significant circums-

ancial evidence to suggest that the potato was introduced from South America to Benguet at a very early point in the Spanish occupation. The first documented evidence of its introduction to the Province, however, remains that by Don Blas de Baños in 1846 (Semper, *loc. cit.*) but the seed-source is unknown.

It is interesting to note that the two descriptions of the native potato vary according to location. The first description is most usually given by respondents living near the original Spanish mule trails from the coast to the gold mines whereas the second description is more common in the interior which was not settled by the Spanish until the time of Don Blas de Baños. Thus it is plausible to hypothetize that the original introduction from South America was of the long, irregular-shaped type whereas the round type is a descendant of the introduction by Don Blas de Baños. Attempts are currently being made (wet season 1982) to locate a "native" type filling the latter description. Identification may then help to clarify the situation.

Between 1930 and 1940, a little migration took place from the relatively heavily populated lower valleys; particularly to the Paoay area, where some felling was taking place by licensed lumber companies, and also to Sinipsip where similar operations were taking place. The migrants practiced "plough agriculture" although the burning of grasses, etc., was still very important. The migrants soon adopted commercial cropping and introduced small areas of white cabbage; growing one crop per year, using practices learned from the Japanese. The produce could be sold in Baguio or exchanged for essential items, such as salt, brought to the area by itinerant traders.

Following the last war, 1939 to 1945, there were very few people of Japanese descent remaining in the area. Their place was taken by the Chinese, who soon began to move out of the Trinidad Valley and up into the mountain areas. Dueñas (1954) notes, in his survey of lands registered for classification, "the large number of alien (mainly Chinese) squatters who had applied for land classification." He states also that they "occupied almost all the level and wide areas under cultivation and production." Further, Dueñas notes that it was these people who introduced permanent improvements, including irrigation.

Hitherto, the Chinese had fulfilled the role of trader; supplying inputs, credit and other essential items and organizing the collection and marketing of the produce; frequently to other Chinese merchants in the lowlands. The new Chinese farmers maintained strong links with the trading families and in many cases engaged in trading themselves, either setting-up local stores or engaging in the trucking of produce to Baguio; the principal collection centre. They also financed some of their nearby farmers.

Intermarriage between these Chinese aliens and native Filipinas was common, thus enabling the Chinese to apply (in their wives' names) for cultivation rights or outright land ownership. The Chinese often employed indigenous labour and it is interesting to note that many of the foremen of these early Chinese settlers are recorded as being squatters and as having applied for land classification in the survey of Dueñas (*loc. cit.*). The attitudes and practices of the Chinese were thus being perpetuated.

The new migrants continued to concetrate on cabbage as their main cash crop and it was not until 1948 that farmers began to turn to the potato as cash crop. The cultural practices adopted were similar to those used for cabbage and still predominate today. They will be described fully in succeeding sections.

During the succeeding two decades clearing and settling continued (Plate 6a, 6b) in a generally northerly direction along the cordillera and outwards into the nearby valleys so that today vegetable production extends for some 120 km north of Baguio. Farms are generally dispersed throughout the area and not concentrated in villages or towns, which are few.

Much of the terrain being settled was very steep and, usually, contour farming was practiced (Plate 7a); but ultimately some form of terracing was necessary. Dueñas (*loc. cit.*) comments on the inadequacy of the terracing at that time and recommends that good terracing should be a prerequisite for land classification as alienable and disposable lands. Even today levelling and terracing is carried out in an effort to bring the remaining very steep slopes into cultivation. Many farmers are building narrow, but very expensive, stone terraces (Plate 7b) whilst a few others are using bulldozers to level their more gently sloping areas: both operations are an indication of the continuing profitability of vegetable production in this area. It is interesting to note that in some instances farmers deliberately bury the top-soil during the construction of these new terraces so that crops are grown in the exposed sub-soil. They claim that potato crops grown in these soils are cleaner and thus command a higher price. Similarly, cabbages grown in these soils are smaller with a tighter head and thus fetch a premium.

Most of the Cordillera in Benguet has now been settled and brought into cultivation but clearing and cultivation (usually illegal) is still taking place in many areas in the north, around Sadsadan, and along the eastern side of the Agno River Valley and on Mount Pulag itself. Many of the settlers are either children of former or farmer workers from along the Cordillera itself. Traditional methods of clearing are still used and constitute an extension of the kaingin practice. Scrub and smaller trees are first felled early in the dry season; tree boles being layed along the contour to reduce subsequent erosion. After firing at the end of the dry season, a wet season crop of preferably potatoes, but sometimes cabbage, is then grown. During the following dry season some of the larger trees may be felled, the first stone terraces built and irrigation installed, if water is available.

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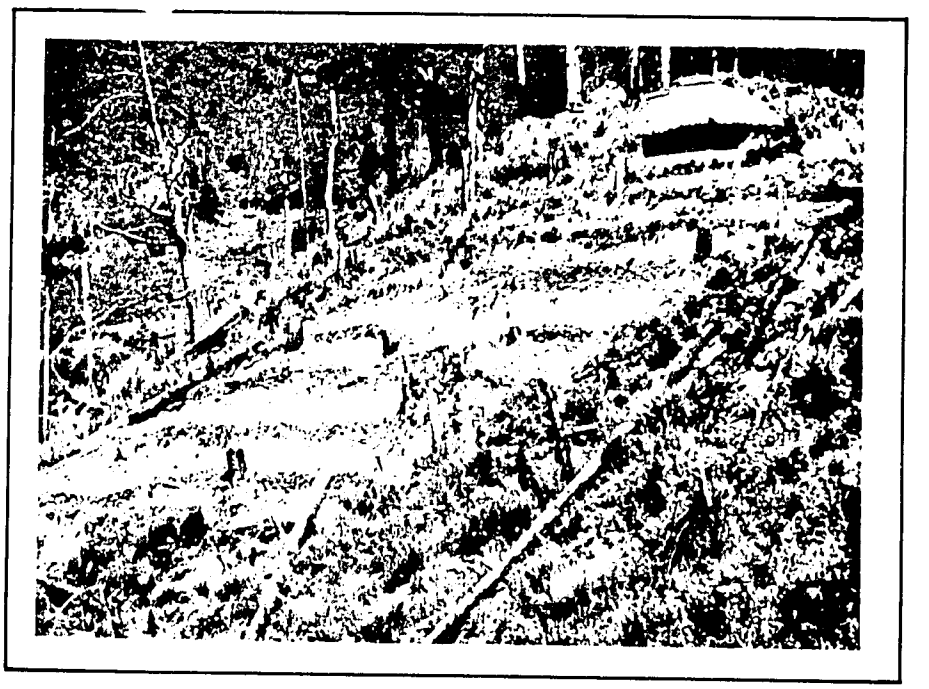

Plate 6. Traditional Agriculture cont. (a) Clearing pine forest, late dry-season, Mount Pulog, March, 1982, (b) Land prepared for first crop following clearing, April, 1982. Note: crude terraces.

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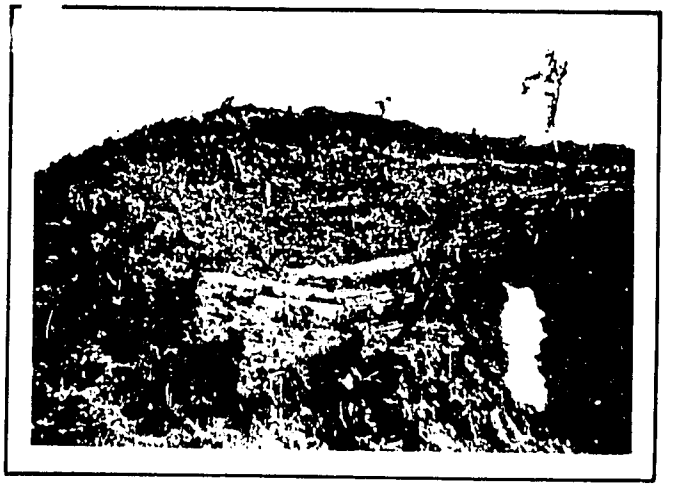

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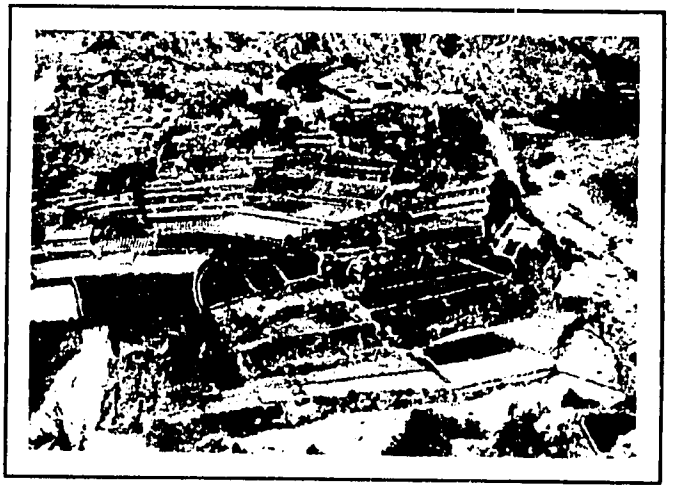

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Plate 7. New Areas. (a) Cabbage crop on recently cleared undulating land, km 102. Note: crop planted along contour, (b) Stone terracing in recently cleared steep land, Mount Pulog. Note: temporary log terraces near summit, (c) Potatoes and other vegetables within traditional rice terraces, Buguias Central, February, 1981.

Potato cultivation is also extending to the irrigated rice paddies (Plate 7c). Following the harvest of the rice crop in December a potato crop is grown during the dry season, January to March. The cool nights and the liberal use of furrow irrigation, which may unknowingly be acting as a coolant, appear to maintain temperatures low enough to allow normal tuber initiation and development. Bacterial wilt *(Pseudomonas solanacearum)*, can be a most serious problem in these crops but flooding of the previous rice crop appears to adequately control this disease: farmers have observed that when potatoes follow irrigated rice, in which paddies are flooded for five or six months, then only a few plants are affected by bacterial wilt but when potatoes follow a non-flooded crop such as vegetables, whether Solanaceous or otherwise, then up to 80% infection can occur and uneconomic yields result.

## The Farming Unit

According to Manto et al (1978), most farms in the area are classified as owner-occupied. However, it is readily apparent that this is not truly the case since this surveys was confined to the municipalities of Atok and Buguias, where vegetable production has been established for many years; a point that should be borne in mind when reference is made to this standard work. Much of the land brought into cultivation in recent years is still classified as government forest lands and many farmers are technically "squatters" with no land rights. Efforts are currently being made by the government to rectify the situation and rights of cultivation or land titles are being granted to certain classes of farmers. The figure of 89% appears only to pertain, therefore, to those established farmers with land rights.

The survey of Manto et al indicated that 11% of farmers lease either all or part of their holding. In many cases the leases extend for only very short periods; often as little as one year and rarely more than five. The area leased depends to a large extent on profitability during the previous season; thus rented land may frequently change hands.

Farm size varies considerably, both between and within localities, but they are usually given as falling in the range 0.3 to 4.0 hectares, mean 1.3 hectares (Ministry of Agriculture, private communication). Some doubt as to the exact size of the holdings arises due to the partial leasing system mentioned above and, more importantly, because many farmers themselves are not aware of their exact areas or alter their response according to what they believe to be the sympathy of the interviewer.

One interesting point to note at this juncture is that the larger farmers usually refer to their field, terrace or paddy by that name

whereas a smaller grower will refer to all three alike as a "garden," reflecting the much greater care and attention given by the small grower.

In many cases it would appear that the farmer and his wife have an equal role to play in policy-making and day-to-day decisions, although this may not always be apparent on the first encounter, when the wife usually defers to the husband. The role of the wife is particularly important where the couple are engaged in other business such as trucking or store-keeping. Most wives also do considerable manual work on the farm despite 83% of them being classified as having no other occupation other than housekeeper (Manto et al, *loc. cit.*). Although communal activities and labour sharing were traditional, particularly in relation to the rice crop in the old centres of population such as Buguias, and are still practiced in the lowlands of Luzon, they are little practiced along the Cordillera.

## Labour

Most farms are family concerns, with the average family consisting of 7 persons (Manto et al, *loc. cit*). Since all operations on the farm are done by hand, adequate labour is crucial.

Outside labour is hired by the larger farmers and those with small or young families. Most outside labour comes from the neighbouring Mountain Province to the north and is often only transitory, that is, they remain for only short periods, often one season, before moving further south to the urban areas of Metro Manila. It is interesting to note at this point that Dueñas (1954) comments that all the labour is male: a situation very different from today where male and female labour is used for all operations.

Labour may be employed on a "contract basis", for example, they are paid a set amount for the job to be done. This system is used particularly for land preparation; but for other operations, where care and supervision are needed, then hired labour is preferred. The majority of hired labours is paid by the day. Despite what farmers regard as the high labour rates and, usually, the necessary provision of accommodation and food in this isolated area, farmers continue to have difficulty in employing sufficient staff. Solimen (1978) reports that some farmers actually take land out of cultivation due to labour shortages and, since few farmers raise animals commercially, it is difficult for them to switch into such less labour-intensive systems.

## Current Cultural Practices

### *Rotation*

Over much of the cordillera, potatoes and cabbage are the main crops. They are usually grown alternately but mono-cropping is not unknown and frequently farmers will grow the same crop for two or even three successive seasons if they believe an increased profit can be made or if they have insufficient seeds to plant the alternate crop. A few minor crops such as carrots, sweet peas (snow peas) or wongbok (Chinese cabbage) are grown in some localities. Whilst almost any temperate vegetable may be grown, crops other than those mentioned are avoided; either because they have a high labour requirement or, more often, because they are perishable and marketing is difficult due to distances from the principal urban markets and poor road conditions.

The main cropping season over the whole of the Cordillera is March to July. Following the relatively recent introduction of irrigation to some areas with limited water supplies, a second cropping season, October or November to February is now possible and this innovation has allowed for both a more constant supply of potatoes to the Baguio and Manila markets and also for an almost doubling of farm incomes, thus greatly enhancing the prosperity of the area. Although, as indicated, early cropping during the typhoon months of August and September is considered risky a few farmers, often favoured with sheltered areas, habitually take these risks in order to benefit from the high December prices. Again, this contributes to evening-out the annual production cycles.

In the intensively cultivated valley areas, where irrigation from former rice cultivation is plentiful, potatoes are usually planted in the dry season: for Loo, October, and for La Trinidad, November or early December, and harvested in December to March, when prices are at their highest. During the rest of the year only a few potatoes are grown in these areas; preference being shown for quick-maturing crops such as wongbok or lettuce.

The considerable variation in production patterns between the mountainous and valley areas of the provinces ensures that there is a constant supply of potatoes to the market throughout the year.

### *Land preparation*

Almost all vegetables are grown on beds, 70 cm to 90 cm wide with a canal of approximately 40 cm between. Most vegetables are then planted in a double row along this bed.

The land may be prepared anytime from two months to one week prior to planting, depending on the season and labour availability. If the land has been recently cropped then the remaining trash is thrown into the old canal and the new bed is formed above it (Plate 8a). One pass with a grub hoe is usually considered sufficient.

In situations where the land has been lying fallow or there is considerable trash, such as at the end of the wet season, then all the debris will be collected first and burned. This work is often carried out by women. In former times the ashes were kept as fertilizer but this custom is now practiced in only a few, often well defined, localities when grasses from nearby banks are added to increase the amount available. The cleared land will then be made into beds, usually by male labour, by one pass with the grub hoe. In such cases the depth of cultivation seldom exceeds ten to fifteen centimetres and restricted root growth in the following crops is readily observed.

Near planting time a second cultivation is carried out in which large clods will be broken and the beds levelled so that they are 10 to 15 cm above the canal bottom. Using the hoe, individual holes will be made for each seed piece (Plate 8b). Holes are usually alternate, with 30 to 35 cm between the rows and a similar distance between seed pieces to give a stand of approximately 55,000 plants per hectare (Plate 8c). However, stands of up to 80,000 plants per hectare are not uncommon, especially where small seed-pieces are used. Into each hole is then placed a handful of well-composed chicken dung

Some farmers, particularly those associated with the recently formed seed potato programme now plant in single rows to facilitate roguing. In this case the rows may be anything from 70 cm (the recommended distance) to 120 cm apart: the latter being the traditional distance between bed centres and fitting well with the traditional cultural practices of other crops. Under this "single-row system" chicken dung is placed in a furrow beneath the seed-piece.

In a few isolated instances, but increasing in popularity due to the saving of labour, is a "hybrid" of the two planting methods described above in which the chicken dung is placed in a furrow under the centre of a bed in which a double row of potatoes will be grown. The potatoes are then planted along the sides of the furrow and the bed levelled. A further modification of this method is to mix the chicken dung with the plant debris thrown into the old canal.

## *Cultivars*

It has already been mentioned that the old "native" types are no longer grown commercially. They have been replaced by successive importations dating from the early 1950's. At that time importations of

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**Plate 8.** Land Preparation. (a) First cultivation following recent cabbage crop, Paoay, May, 1981. Note: all hand labour, burying of cabbage trash in channels between former cabbage beds, (b) Beds prepared for planting at end of the dry season. Note: the double-row beds with individual holes, (c) Planting. Note: spacing the individual holes containing chicken manure but not commercial fertilizer; dark-stored, apically dominant, seed-pieces with long sprouts; the placing of two small seed-pieces in some hills.

cultivars locally known as "Japanese White" and"Japanese Pink" were made from Japan. For the next decade they were grown alongside the "native" types and continued to give acceptable yields, 16 tonnes per hectare in one trial at Baguio (Anon., 1979a), despite their being severely infected with virus; Potato Virus X (PVX), Potato Virus Y (PVY) and Potato Leaf Roll (PLRV). A few farmers continue to grow "Japanese White" in isolated areas.

Sporadic imports of a number of cultivars continued throughout the 1950's from various parts of the world, but it was not until the early 1960's when two cultivars, Conchita and Greta, were imported from Mexico, that any major change in cultivar use took place. These two cultivars were readily adopted and they still account for over 50% of the wet season hectarage (Potts et al, Ch. 3). There have been no further importations so that today they are severely infected with virus. However, they exhibit a high level of tolerance to viruses and symptoms are not severe. Their yields on the farm still compare favourably with new recently introduced cultivars (Potts et al, *loc. cit.*). Farmers also cite good blight and wind and rain resistance as further reasons for continuing to grow these two cultivars and it has been observed that they also have a high level of resistance to *Thrips* spp., an insect which has been a major problem in the dry-season valley crop in recent years. Many farmers, however, dislike them due to their long maturity period (110 to 130 days). The RP/German Seed Potato Programme has now "cleaned" these cultivars of the major virus diseases and is multiplying stocks prior to incorporating them into the seed programme. It will be most interesting to compare the performance of this cleaned seed with the existing stocks and the newly imported cultivars.

Another major cultivar grown in the wet season is Cosima, which accounts for approximately 17% of the crop. Although cv. Cosima is criticised by many farmers on the ground that it is late maturing, susceptible to late blight and subject to growth cracks in dry season, it has continued to be grown because it gives acceptable yields and there has been a steady supply of clean seed; either from the local certification programme or imported.

In the late 1950's, but more particularly in the 1960's and 1970's, regular imports of small quantities of cv. Red Pontiac have been made, particularly from the USA. This cultivar is especially favoured by growers in the lower, warmer and drier valleys, particularly for the irrigated dry-season crop, December to March.

A number of other cultivars, principally of Dutch and German origin, have also been tested on the experimental station and made available to farmers. Some farmers continue to grow small amounts, but they have fallen from favour since a steady flow of imports, for example, clean seed, has not been maintained.

At present non-certified seed cost approximately ₱2.00 per kilo whilst locally certified seed costs ₱4.50 per kilo and imported seed around ₱12.00 per kilo. The continuing use of imported seed is therefore an indication of the value placed by farmers on good seed and the profits to be made from table potato production. The importation of seed into the Philippines is limited to 15% of the total seed requirement. (Ware potato importations have been banned since the early 1950's, but prior to that date regular importations had been made since the American conquest). Sources from the Central Bank of the Philippines indicate, however, that rarely have importations exceeded 5% of the estimated seed requirements. With the formation of the RP/German Seed Potato Programme in 1977, it is hoped to phase out imports as local Farmer Associations produce clean seed. Any further imports would be for foundation stocks only and these would be kept with existing foundation stocks at the newly opened seed farm, Buguias.

*Seed source*

For the wet-season crop most farmers traditionally used their own seed-pieces, saved from the previous crop. Periodically, normally every three to five years, fresh seed would be purchased to "regenerate" their stocks. The new seed-pieces were generally bought from farms at a higher elevation and from growers known to produce good seed-pieces. Thus, an informal rudimentary "seed scheme" has existed for some time. In a few instances, where farmers have access to land at different elevations, then they will alternate their cropping so that seed grown at a high elevation one season will be grown at a low elevation the next and *vice versa*. These farmers believe that yields are improved at both sites using this procedure.

For the dry-season crop grown in the valleys, where aphid populations and thus virus spread is a problem and also where the warmer temperatures have made storage of seed-pieces for more than a few months difficult using traditional methods, seed is normally purchased for each cropping. The seed is usually the produce of the previous wet-season crop grown at a higher elevation. Again an informal seed scheme is thus being operated. A further development within this scheme is to import seed in January or February then multiply it for one, or sometimes two, wet seasons at the higher elevations before using it in the valley. A preference is shown for quick-maturing, early bulking cultivars, which are suited to the intensive farming practices of the lowland valleys. In practice, however, the cultivar chosen depends very much on the availability of seed-pieces, which must have been planted early the previous wet season and have a short dormancy period so that they are sprouted and ready for planting by early October.

Whilst the informal arrangements helped to some extent to provide farmers with better quality seed-pieces it was by no means capable of

providing a sufficient quantity for all the farmers' needs nor was it always of good quality. This fact was readily recognized by farmers, as evidenced by their preference for imported certified seed, and researchers alike who pressed for an official seed-scheme (Balaoing and Lazo, 1967). In 1977 an agreement between the Philippine overnment and that of the Federal Republic of Germany brought into being the RP/German Seed Potato Programme with a primary responsibility to ensure a supply of certified seed to growers. Small quantities of seed are now being made available to growers.

## *Seed-piece preparation*

Traditionally the seed-pieces used were those left over from the previous harvest by reason of being too small to sell. These pieces were then stored underground or, if security was necessary, in sacks beneath the house (Potts, Ch. 10). If long storage periods were involved then the tubers formed elongated white sprouts, which were easily damaged. Seldom was there more than one sprout per seed-piece.

In recent years the method of seed-piece selection, preparation and storage has undergone fundamental changes. Storage methods now vary widely according to the individual needs of the farmer and are all indication of the generally high level of sophistication which these farmers have reached.

An increasing number of farmers is now setting aside specific areas for seed production. In many cases imported or locally certified seed is planted in these areas. Much less common is the practice of setting aside "clean areas" within a table potato crop or the staking of healthy plants for use as seed, commonly known as positive selection. Most farmers are now selecting larger seed-pieces, 30-45 mm in size.

When the seed is to be stored for only a short period, for example, for a March or early April planting following a December harvest, then it is most usually kept in sacks beneath the house; the usual storage place for all equipment and inputs. In order to hasten the breaking of dormancy some smaller farmers ma bring the seeds into their warmer living quarters or place them in their chimneys during this cooler period. A few larger farmers with the necessary facilities, may take their seeds to a warmer environment, for example, their second homes in La Trinidad Valley, where the warmer temperatures hasten the breaking of dormancy. Only a few farmers use chemicals to break dormancy but interest in their use, especially of carbon disulphide, is increasing. Similar practices to hasten the breaking of dormancy are used when seed from the July harvest is to be planted in October.

Storage of seed-pieces for longer than about five months has always caused the farmers concern; but many still find it desirable to store

from January to October/November or from July until the following March. Traditionally, seed-pieces were again stored in the dark in bags or bulk under the house (Plate 9a) and by planting time were dehydrated with long sprouts. Only the more affluent farmers could overcome this problem by sending their seed to cool stores in Manila, more than 300 km away. This was expensive and, due to poor store management, heavy losses were incurred; 70% being mentioned on a number of occasions. Now, less than ten farmers in all are known to use this method.

An alternative method, now increasingly being used, is the use of natural diffuse light in stores. This technology was the subject of a series of demonstrations in 1978/79 by the International Potato Centre and the Philippine Potato Programme (Anon., 1980b; Rhoades et al, 1980) (Plate 9b). Diffuse light was shown to reduce sprout growth to give short sturdy sprouts which were less easily damaged. Also, apical dominance was reduced to give more sprouts, and thus stems, per tuber, so increasing the potential for higher yields (Plate 9c). Weight loss in store and damage due to pests and diseases also appeared to be reduced. Using diffuse light, farmers can now successfully keep their seeds for periods of eight or nine months and also increase substantially their yields (Potts, Ch. 10; Potts et al, Ch. 6).

The degree of acceptance and implementation of the diffuse-light technology varies greatly from the mere removal of window shutters, to allow more light to enter the stores, through the replacement of galvanized iron sheets on the store with transparent plastic sheeting (Plate 10a), to the building of complete new stores (Plate 10b). To facilitate further the exposure of all seed-pieces to diffuse light many of the farmers adopting this technology have built racks within their stores so that the seed may be spread thinly, one to two layers deep, rather than in deep piles as formerly. Alternatively, they may simply spread the seed-pieces thinly over the floor of their store. This technology has been so successful that the local Seed Potato Programme, which was to have built originally six refrigerated stores, has now modified its plans to include six stores of this diffuse light type, with estimated capacities of up to 50 tonnes each (Plate 10c), in place of the planned refrigerated stores.

Coupled with the adoption of this new technology, there has been a growing awareness by farmers of the need to care for their seed. Farmers may now regularly inspect their seed-pieces and remove damaged tubers; the use of chemicals for the control of aphids and tuber moth *(Phthorimaea operculella)* is increasing and many farmers now remove the main sprout in order to encourage multiple sprouting. The use of fungicides in store is not yet commonly practiced.

The practice of cutting seed-pieces is carried out amongst a limited number of growers. It is particularly prevalent amongst farmers who have bought imported seed, which they intend to use for further multiplication,

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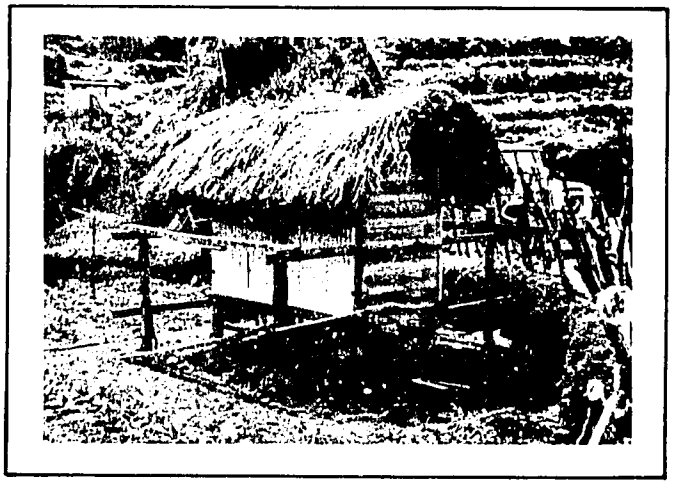

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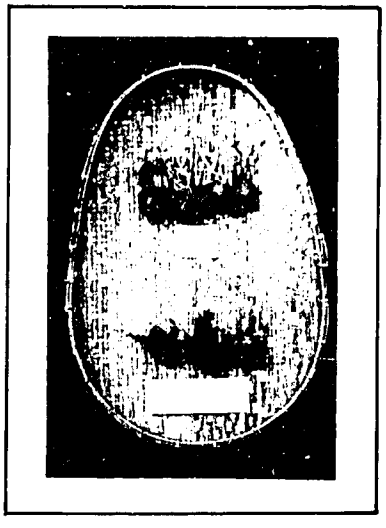

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Plate 9. Seed-piece Storage. (a) Traditional storage below house. Note: multi-purpose nature of storage area; dark, poorly-ventilated conditions, (b) Simple diffuse-light, demonstration store - capacity 1 tonne. Note: use of cheap, readily available, local materials, (c) Seed-pieces of cv. Conchita following eight months in traditional dark store (upper) or simple diffuse-light, demonstration store (lower). Note: apical dominance, long thin sprouts, shrivelled tubers in dark-stored seed; several short sturdy sprouts, firm tubers in light-stored seed.

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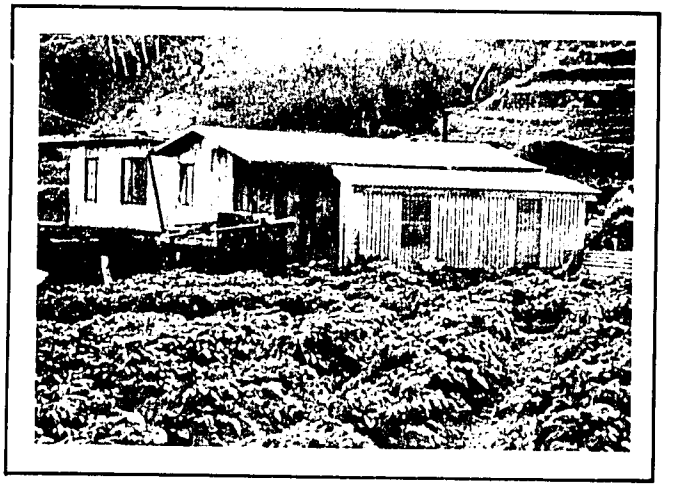

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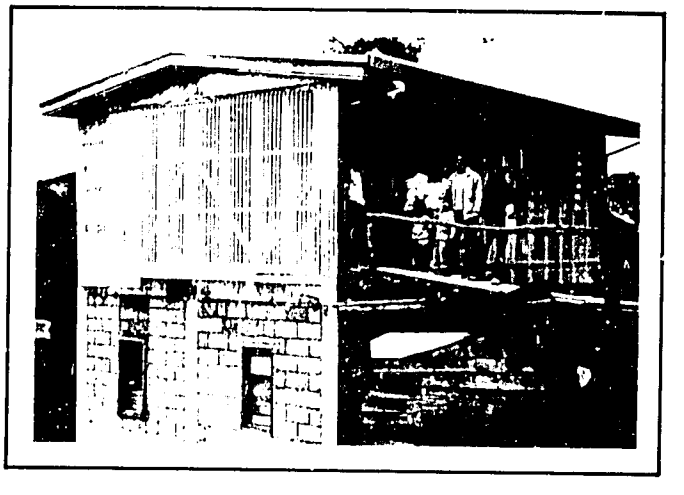

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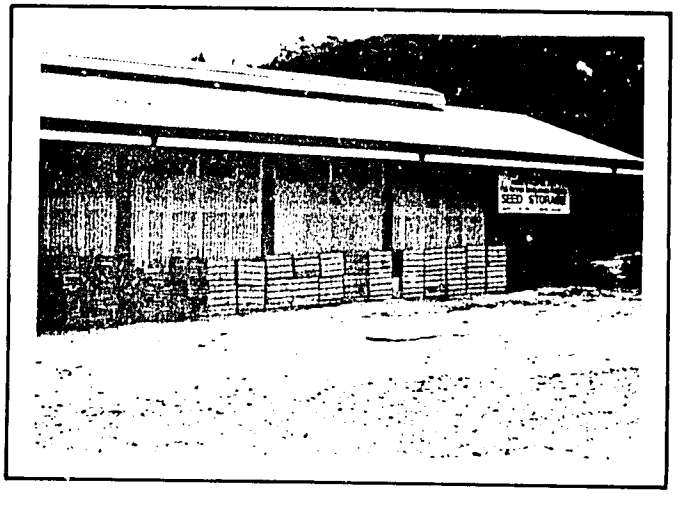


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Plate 10. Seed-piece Storage cont. (a) Modified bodega - capacity 1 1/2 tonnes. Note: replacement of galvanized iron clodding with translucent, yellow corrugated plastic, the provision of shelves within the store, (b) Purpose-built seed store - capacity approx. 20 tonnes. Note: use of corrugated plastic, abundant ventilation under shelves, (c) RP/German Seed Potato Programme/Farmers' Association modified refrigerated store - capacity 50 tonnes. Note: use of corrugated plastic, abundant ventilation.

and amongst farmers who have a limited supply of seed for the dry season crop. The survey by Potts et al. (Ch. 3) indicated that less than 10% of fields were planted with (mainly imported) cut seed for the wet season crop but that over 80% of the dry season crop was planted with cut seed-pieces. Practices vary considerably, but it is not unusual to see tubers being cut into slices containing only one sprout. Seed-pieces are often cut outdoors, in bright sunlight and wind, before the cut pieces are placed in wicker baskets where they will be kept for planting the following day or later. The use of fungicides or bactericides is extremely rare.

### *Planting*

All planting is done by hand. The seed-pieces are usually placed in each prepared hole. The chicken dung and any fertilizer used is then mixed with the soil using the hand or as the hole is deepened and the seed-piece covered (Plate 8c). Depth of planting varies little with planting conditions, and often only one or two cm of soil covers the seed-piece. For dry-season or early-wet season plantings, this frequently leads to drying and rotting of the tubers. Only very seldom, when seed-pieces are small, are two seed-pieces planted per hill as shown in Plate 8c.

### *Manuring*

The old practice of growing potatoes specifically on those sites where grasses and debris had been burned gave way to the practice of collecting of grasses and waste vegetation, burning them and saving the ashes for general application as a fertilizer. Immediately after the war ashes, derived from the burning of rice straw, were hauled-up from the lowlands to augment the local supply, but by the mid-1950's this practice had largely died out; although in a few instances grasses are still collected and burned (Plate 11a).

Ashes were largely replaced as a fertilizer by organic manures. In the first instance bean cake, derived from soya bean, was used but by the mid-1950's chicken dung was the universal organic manure. There are several reasons which can be forwarded for the use of chicken dung and all are of some importance. Many farmers and traders at this time were of Chinese descent and were accustomed to the liberal use of organic manures. Soils in the area naturally had deep top-soils, rich in organic matter; but on the steeps slopes with inadequate terracing erosion was a problem and this layer was rapidly removed and the sub-soil exposed. Farmers found that organic fertilizers gave a marked yield response in such situations and, since at that time chicken dung was available in the neighbouring provinces at little cost and transport was cheap, it was used in increasing quantities. Today, almost without

exception, every farmer uses upwards of five tonnes of chicken dung per hectare; but, due to the cost of the product itself (a function of demand and other uses being found for it) and transport, it is very expensive and in some cases may represent 50% or more of the total input costs. Nevertheless, farmers are extremely reluctant to give up its use for fear of reduced yields, despite increasing evidence that it does not give a significant yield response in many locations, where organic-matter levels are still high. Also, all too frequently, the chicken dung will appear undecomposed at harvest and would thus appear to have contributed few nutrients to the crop. Responses do, however, occur where soils are severely eroded or crops are grown with inadequate irrigation, when the chicken dung appears to retain a modicum of moisture which allows the uptake of essential nutrients (Potts et al, Ch. 7).

The rate at which chicken dung is applied is estimated at around 5 tonnes (one truck load) per hectare (Plate 11b), but the actual rate varies according to finance available and the size of a truck load (the standard measure) relative to the area to be planted: if less than a hectare is to be planted then the rate will be correspondingly increased and *vice versa*. Smaller farmers often buy their manure from agents at the roadside by the basket, sack or even 10-litre oil can.

Composting has hitherto been little practiced but, following its adoption by the Bureau of Plant Industry, who have several research farms in the area, interest in the technique is increasing.

The only other major source of organic manure is mushroom compost available in Baguio and La Trinidad Valley. This compost is used almost exclusively in La Trinidad Valley. During the decade to the mid-1970's however, there was a thriving mushroom industry in the Atok municipality also, particularly amongst larger farmers, and mushroom compost was then a major source of organic manure.

It is interesting to note at this point that at very little cost; namely the replacement of part of the galvanized iron cladding with transparent plastic coupled with additional ventilation, the old mushroom houses have been converted into very adequate diffuse-light seed stores, capable of holding two to five tonnes of seed using existing shelving.

Inorganic manures, or commercial fertilizers as they are commonly called, were first used in the early 1950's when they were available as igoro (6.10.4) and Corona. Since that time there has been a slow but rogressive increase in the concentration of the elements so that today a 14.14.14 compound fertilizer is used almost exclusively.

The most usual practice is to apply all the commercial fertilizer as a side-dressing at hilling-up: a criminal waste of phosphate and potash (Plate 11c). Until the late 1970's upwards of 1000 kg per hectare

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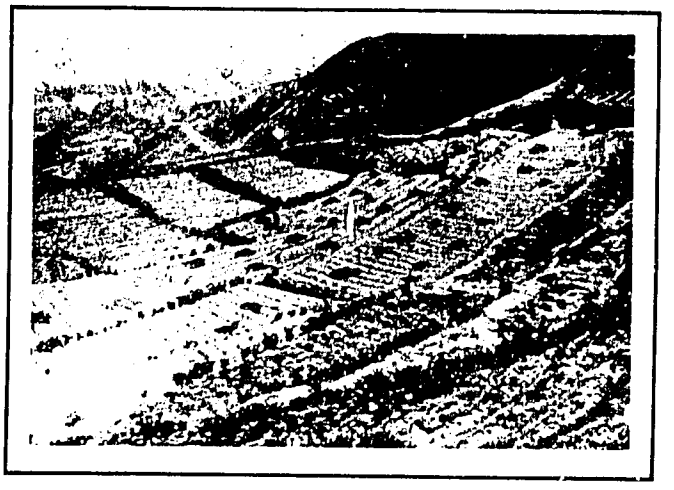

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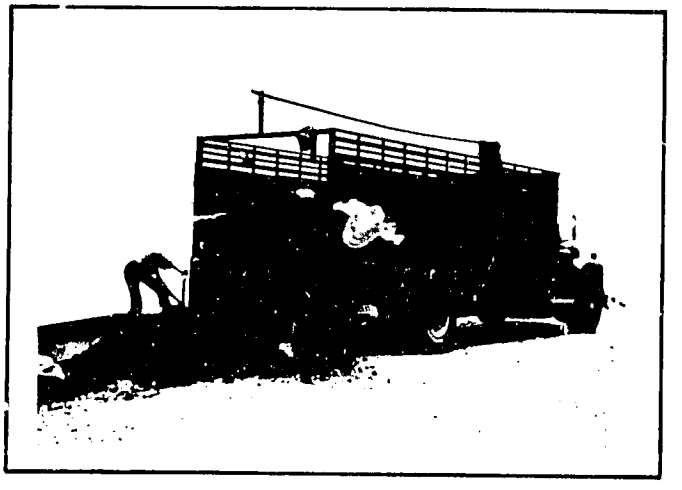

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**Plate 11.** **Manuring.** (a) Burning of grasses for fertilizer, km 73, dry season, 1982, (b) Delivery of chicken manure. Note: one truck holds approx. five tonnes; trucks return to Baguio/Manila with vegetables, (c) Application of chicken manure (right) and commercial fertilizer (left) post-emergence of crop. Note: no manure of any type was applied pre-planting of this crop.

of compound would be applied at this time but, following the strenous efforts by the Extension Services coupled with the increasing cost of commercial fertilizer, application rates have now been reduced generally to 600 to 800 kg per hectare. This trend is particularly prevalent amongst the seed growers, who now almost all apply it to the seedbed, often in conjunction with 100 kg per hectare of muriate of potash (0.0.60). Other growers are following the trend more cautiously and currently split their application between planting and hilling-up.

Few farmers apply lime although many areas are highly acidic, pH 4.0 to 4.5. Liming materials are available on the periphery of the main production areas, for example La Trinidad Valley, but transport costs make its widespread use prohibitive. Trials are being carried out currently by the National Programme to demonstrate the value of this material.

## *Irrigation*

The availability of water for irrigation varies considerably throughout the region. In the old rice producing valleys of Loo and La Trinidad irrigation water is usually available and many farmers practice furrow irrigation techniques (Plate 12a). In the more marginal areas of these valleys water is applied using watering cans, once or twice a day (Plate 12b). Here, the water seldom penetrates deeper than 5 cm and its beneficial effects must be held in question.

Along the cordillera, irrigation water is often not available or only in very limited quantities. Where water is available it is most common for farmers to join together and drill a well or tap a spring. Water is then piped separately to each holding using small bore, often less than 3 cm internal diameter, metal or plastic pipes (Plate 12c). The combined effects of the narrow bore and the not inconsiderable distances, sometimes in excess of 1 km, between the supply and the farm holding causes the pressure to be low and the supply meagre: a particular problem since sprinkler irrigation is the most common system used in these areas.

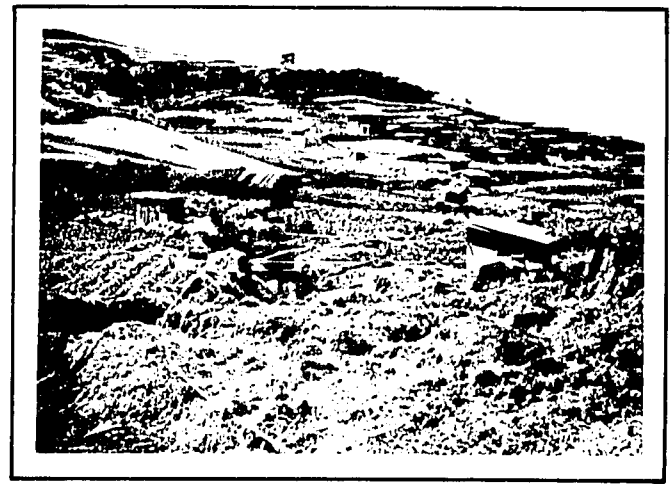
## *Weed control*

The predominant weed species of the area, in their approximate order of importance,are *Galinsoga parviflora* l., *Spergula arvensis* l., *amabilis* l., and *Poa annua* l. All weeds are controlled by hand: chemicals are never used. The first cultivation is usually also the first hilling-up, *circa* four weeks after planting, when the potato plants are approximately 15 cm to 20 cm in height. At this time all or the remaining dose of commercial fertilizer is added, either individually around each plant or along the centre of the bed between the double rows.

12

a

b



c

Plate 12. Irrigation. (a) Furrow irrigation in traditional rice growing area, Loo Valley, (b) Use of watering cans where irrigation facilities are lacking. Note: rapid run-off, caking of soil surface; poor water penetration, (c) Communal irrigation pump-house (behind cows), Paoay. Note: small-bore pipe radiating to individual farms.

For hilling-up the soil is necessarily dug from the between-bed canals. In order to obtain sufficient soil for the operation, deep canals are dug to give prominent, raised beds These deep canals also facilitate good drainage during the frequent periods of torrential rain. For the wet season crop in particular, a second hilling-up operation may take place approximately six weeks after planting. This again helps drainage and also replaces soil washed from the beds by the previous rains.

## *Pests and diseases*

Late blight (*Phytophthora infestans*) is almost universally regarded as the major disease problem of potatoes and this accounts for the continuing popularity of older cultivars of Mexican origin. There is a continuing flow of requests by farmers for new cultivars with blight resistance despite the vast range of chemicals available to control the disease. Farmers may spray (Plate 13a) as often as every three days during the wet season, particularly when European cultivars are grown, giving a total of 10 or more applications. However, the continuous rain associated with the monsoons which may last for seven to ten days, often prevents spraying and thus a rapid build-up of the disease and death of non-resistant cultivars ensues (Plate 13b). Spraying usually ceases at, or shortly after, flowering; although there is much to be gained from continuing application.

A second foliar fungal disease commonly observed is early blight (*Alternaria solani*), but seldom is this regarded as a problem or precautions taken.

Rhizoctonia is a major problem in some areas but the disease is still not understood by most farmers. It would, however, appear to be becoming increasingly common, particularly where the newer European cultivars are being grown: and there is a now visual evidence to suggest that the older Mexican cultivars have some resistance or tolerance to the disease which has, until now, prevented its build-up. Investigations are currently being carried out by the Bureau of Plant Industry into this disease.

Bacterial diseases are not usually a problem in this area except that seed imported from some North European countries may show severe symptoms of blackleg (*Erwinia carotovora*) in the first cropping season: the disease being latent in the country of origin. Bacterial wilt (*Pseudomonas solanacearum*) is only found in isolated patches of the lower valleys (Plate 13b). Nevertheless, there is evidence to support the notion that it is present in a latent form in higher areas; since seed taken from these areas and planted at lower areas has been known to show wilt symptoms, whereas imported seed grown nearby remains free of symptoms.

13

a

b

c

Plate 13. Pests and Diseases. (a) Blight control, cv. Conchita, Paoay, May, 1982, (b) Bacterial wilt, former rice terrace, Kabayan, February 1981, (c) Damage by *Thrips* spp., dry season, 1982. Note: bronzing of underside of leaf of susceptible cv. Isola (left); healthy tissue of cv. Conchita (right), an adjacent plant.

Most crops are infected with a range of viruses but the introduction of cleaner seed through the seed certification scheme should improve this situation.

A number of insect pests are common in the area: potato tuber moth (*Phthorimaea operculella*); aphids, particularly *Myzus persicae* and *Aphis gossypii*; cutworms (*Agrotis epsilon*) and thrips (*Thrips tabaci*) and *Thrips palmi*). All may be adequately controlled using chemicals currently available in conjunction with appropriate cultural practices. However, poor maintenance of spraying equipment, a manually operated back-pack sprayer with a single cone nozzle, together with poor spraying techniques has given rise to difficulty in controlling some of these pests, particularly *Thrips* spp.,which live on the underside of the leaves (Plate 13c).

Nematodes had not been observed until recently. However, an inspection of fields intended for seed production by the Bureau of Plant Industry has shown the golden nematode (*Globodera rostochiensis*) to be present on 18 farms, usually at a low population, but high populations (> 100 cysts per 100 g soil) have been observed on two farms. Investigations are currently being carried out by the Bureau of Plant Industry to determine the extent of the disease and the patho-type involved. It is again interesting to note that infestations appear to be lower on the two cultivars, Conchita and Greta, of Mexican origin.

## Frost

The occurence of frosts and cold winds at higher elevations during January and February has already been mentioned (Plate 3c). In a few steeply sloping areas, notably to the north of the cordillera, the burning of grasses is used to ameliorate the problem. During the day, dried grasses are collected and stacked some 50 to 100 m up the hillside, above the potato field. Just before dawn the winds flowing down the hillside are at their coldest and are most dangerous to the crop. At this time the piles of grasses are fired so that the warm smoke is carried downwards over the crop thus reducing the chilling effect.

## Harvest

Many farmers regard the potato as a "90-day crop" and with some growers this time scale is immutable; irrespective of maturity. In general, potatoes are harvested immature.

When practiced, haulm destruction or removal is usually by cutting, five to eight days before lifting. The tops are normally discarded in the canals and not removed from the field. Haulm removal by pulling is being encouraged amongst the seed growers and is being slowly adopted. Chemical haulm destruction is not practiced.

Almost without exception the potatoes are lifted using a sharpened stick, 30 cm long and 3 cm to 4 cm in diameter. The earth is loosened and lifted, using the stick in the right hand, and the tubers are removed with the left. The produce of three beds is usually stacked along the centre bed ready for grading and sorting or carrying to the *bodega*, which often only takes place when a whole terrace or field has been lifted (Plate 14a).

During the dry months, grading and packing most usually takes place in the field. Tubers are graded into extra-big, big, medium, small, marble and cracked and damaged. The exact size range within any one grade varies from farmer to farmer and also according to what he thinks that the market will bear: if there is a shortage of potatoes then he will lower the base limit to each size grade.

Following grading into piles in the field the potatoes are packed into plastic net bags; traditionally red for red-skinned varieties and orange for white-skinned varieties (Plate 14b). Each bag holds 25 to 32 kg. In many cases, however, farmers still practice a system locally known as *bomba* in which the correct sized tubers are neatly arranged around the outside of the bag but the central space is filled with smaller or damaged tubers. There may be many such damaged tubers due to "pecking" - the piercing of a tuber with the harvesting stick.

Since the practice of *bomba* is still common, many agents set a price for the consignment, irrespective of whether the practice has actually been carried out, thus encouraging the farmers to continue the practice.

In the more remote areas, the dry season harvest will first be carried to the roadside before being graded, packed and sold direct to an agent (Plate 14c).

During the wet season, harvesting usually takes place only in the morning, since the onset of rain will generally occur in early afternoon. In the late morning the potatoes will be carried to the *bodega* or store in the bamboo or wire baskets used at planting time. The potatoes may be graded daily or, more usually, at longer intervals of approximately one week.

## *Storage*

Once harvested, few farmers appear to store their table production for any considerably period of time. Most usually they grade and then store in bags until they have sufficient for a jeepney or truck load. A minority of larger farmers may store part of their wet season crop for

14

a

b

c

**Plate 14. Harvesting.** (a) Harvesting, Paoay, wet season, 1981. Note: use of hired labour on this large farm; the use of a short stick to lift the tubers; the placing of three rows-into-one; crop being removed to *bodega* for grading, (b) Harvesting, Loo Valley, dry season, 1981. Note: crop graded and packed in field, the use of bomba, (c) Grading and packing by roadside, km 102, dry season, 1981.

up to three months in the hope of receiving higher prices in October or November. Storage is not practiced during the dry season when prices are usually near their peak.

The general practice of sending produce to market soon after harvest entails that, contrary to many observers' belief, seed-pieces are set aside from the ware potatoes soon after harvest. Only in the instance where farmers store their produce until October or November are the ware and seed tubers kept together for any appreciable time.

The practice of in-ground storage or "delayed harvest" as it is known locally, is carried out by many farmers for the wet-season crop. In this case farmers, who have well-drained soils, merely leave their matured potatoes in the ground until they are ready to harvest. It is not unusual for crops mature in July to be left until October or even December. The beds may have to be earthed-up two or three more times during this period to cover tubers exposed by rain. Losses during the first three months, at least, appear to be minimal (Potts et al, Ch. 4). This system particularly commends itself to the smaller farmer who has not sufficient labour to lift all his crop at one time; or who has no irrigation facilities and thus cannot plant a dry-season crop and so may wish to keep his produce for the higher October/November prices. Also, it enables the farmer to harvest during the drier periods of this difficult season.

It is supposed by many, and experiments are currently being conducted to test this hypothesis, that losses are actually lower using in-ground storage than from conventional storage practices because many tubers are usually damaged by "pecking" at harvest and, since grading before storage is seldom practiced, these will rot in the conventional store. Using the delayed-harvest technique potatoes are moved from the field to market before any substantial rotting can occur. Delayed harvesting has a major disadvantage in that it might "tie-up" land, which would otherwise be cropped, hence it is seldom practiced during the drier months; a period when many soils may also be too hot and dry and higher prices also prevail.

## Yields

Yields have been thought generally to be low. Balaoing and Lazo (1967) report that average yields in 1963 were approximately 6 tonnes per hectare and statistics from the Bureau of Agro-economics indicate that this had risen to only 7.4 tonnes per hectare by 1978 (Anon., 1979c). However, a recent survey (Potts et al, Ch. 3) of 419 fields during a two year period, 1980-82, revealed average yields in excess of 20 tonnes. There was little difference in mean yields between the wet- and dry-season crops, except that the wet-season crop was more liable to adverse

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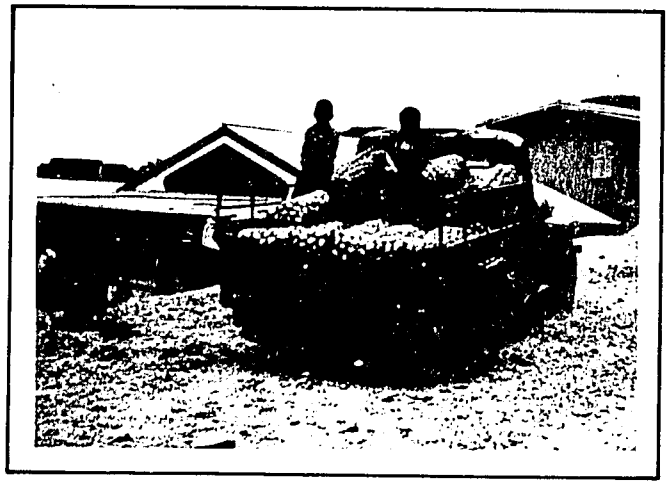

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Plate 15. Marketing. (a) Typical "farmer's own" Transport, (b) Agent (woman second from left) purchasing directly from farmer, (c) Small consignments carried by public transport.

weather conditions such as the delayed onset of rains or an early typhoon, which could completely destroy a crop. There was also little difference in the mean yields between cultivars with the older, Mexican cultivars yielding as well and often better than the newer introductions.

## Marketing

The marketing of the potato crop has now developed into a highly complex and sophisticated system, which is allied closely to the financing of the crop. It has been described in detail by Manto et al (1978) and Vergroesen (1980). An increasing number of farmers now have their own transport, a jeepney or truck (Plate 15a), and take their own produce to market in Baguio or, in the case of larger farmers, by truck to Manila; the ultimate destination for most of the potato crop. Farmers without their own vehicles rely on hired transport to transport their produce to market in La Trinidad or Baguio. Alternatively, buyers may visit the farm, purchase the crop and arrange for transportation, etc. (Plate 15b).

Along the cordillera itself, where transport is readily available, produce is collected directly from the farm; but in more remote areas it first has to be carried to a main road, usually by hired labourers known as "convoy labourers" or "*kargadores*". It is then usually taken to Baguio, by bus (Plate 15c) or jeepney for small consignments or by truck for larger loads. In some cases trucks will take the produce direct to Manila.

Buyers of the crop may conveniently be divided into six main groups, although considerable overlap occurs:

a. Agents - buyers working for large merchants or wholesalers

b. Wholesalers - who may be based either in Baguio or Manila

c. Assembler-wholesalers - wholesalers based in Baguio who collect produce from a number of sources before sending it to Manila

d. Financier-wholesalers - wholesalers often based in Manila where they may work through an agent, who also finance farmers in return for their produce

e. Wholesale-retailer - usually a smaller wholesaler based in Baguio but occasionally Manila-based, who has a limited number of retail outlets

f. Retailer - most commonly Baguio based.

Despite several attempts marketing through farmers co-operatives has been singularly ineffective (Vergroesen, *loc. cit.*) and virtually no produce is sold directly to the consumer.

The marketing of the crop by a farmer is closely allied to its financing: farmers who have obtained credit from a merchant usually being committed to selling their entire crop through him. Figure 3 shows the marketing channels and the percentage by volume for a one-week period in 1978 (Manto et al, *loc. cit.*)

## Financing

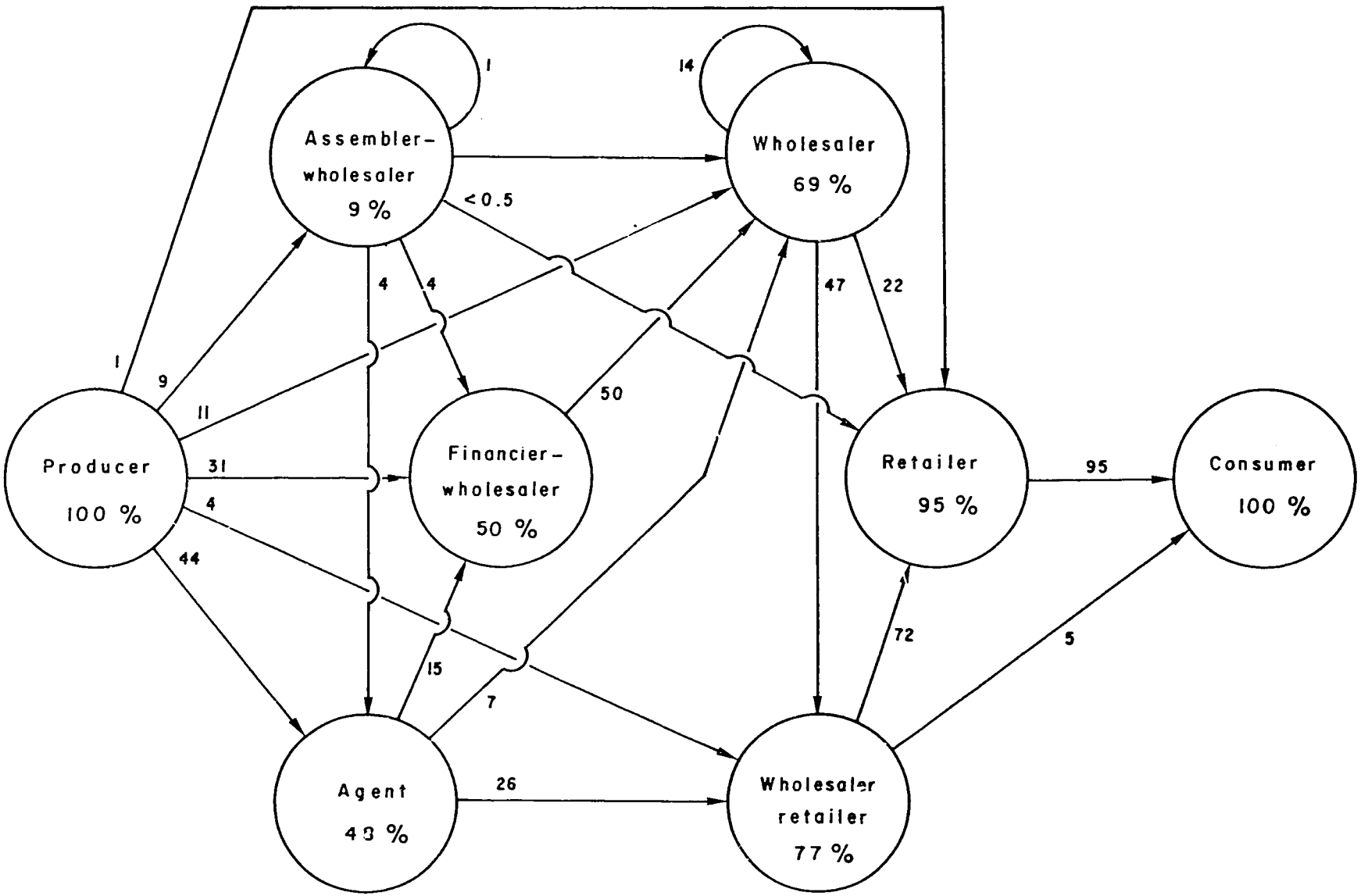
A large proportion of growers receive credit but rarely does a farmer borrow from a bank, despite considerable government effort to encourage this practice, because they either do not have collateral, since many are technically squatters, or they mistrust the paperwork involved; fearing that returns, etc. may be revealed to the Revenue authorities. Also, they resent the time taken to travel to the larger town and to complete the formalities: often three or four days. It is more simple to raise credit from a merchant, or more occasionally, from a larger neighbouring farmer. An agreement on terms can often be agreed in a matter of minutes, although the price may be high with interest rates equivalent to 60% per annum not being uncommon; as opposed to the 15 to 21%, depending upon the size of the loan, currently being charged by local banks (March, 1982).

Farmers who have received credit from a merchant usually hand over all the produce to the agent or financier-wholesaler, when he will either be paid the agreed price or the trader sells the produce, removes from this sum the original loan, interest and handling charges, and returns the balance to the farmer a week or two later. Should a loss be made on the crop the farmer is, of course, indebted to the financier for a further season.

The relationship between a farmer and a merchant is highly personal and based upon trust and there is a great reluctance amongst the parties to discuss details of any business transations. In many instances, it is a continuing relationship passing on from season to season or even father to son. It is generally known by the Chinese term *suki*. The merchants gives credit; either in the form of cash or, more usually, in the form of "kind", when he provides part or all of the inputs, plus a living allowance until harvest if necessary. Exact details of the agreement vary but in all cases the farmer pledges all of his produce to the merchant.

In some cases the merchant may dictate to the farmer production details such as planting and harvesting dates or the products to be used,

Figure 3. MARKETING CHANNELS




* After Manto et al (1978)
Figures indicate percent by volume passing through each channel.

their rates and their timing. Thus, the farmer becomes little more than a labourer on his own farm. Such a relationship is sometimes preferred by the farmer, since it removes a large degree of risk and decision making from their lives. Indeed, some farmers will even let their land to a merchant and then work on it as a labourer, thus guaranteeing themselves two sources of income, rent plus wage, with no risk worries. A similar attitude of mind regarding risk prevails when farmers continue to borrow from merchants although they have sufficient funds of their own. By continuing the *suki* relationship they are assured that if their financial sitatuion should worsen in the future then they will always be guaranteed credit.

The *suki* relationship, whilst benefitting both the farmer and the merchant does introduce a degree of inflexibility into the farming system. For example, the merchant may have an interest in advising certain products, which may not even be necessary. In particular, the use of chicken dung is requested by almost all merchants despite there being little evidence of its beneficial effect under some situations. However, chicken dung is the major commodity transported from the lowlands back to the production areas and it helps to cover the cost of transport. If this product was not necessary then transport costs would be almost doubled. For the farmers part; he is reluctant to substantially alter practices or take risks when neither the inputs or the costs are his own.

The *suki* system may also operate between merchants. For example, an agent in Baguio may act as a *suki* to a wholesaler in Manila, in which case he would be supplied with credit to purchase potatoes directly from the farmers and then consign them to Manila.

In exceptional circumstances the *suki* system may be developed into an even closer relationship in which there are often family ties. In such cases the *suki* or *compadre*, as he is generally known, is allowed more credit; sometimes for non-farming purposes. Such a relationship often develops between a merchant and a leading farmer, agent or municipal official in a locality.

## Economics

Estimates of the cost of production vary widely since no field work has been carried out to measure labour requirements and actual inputs: all estimates are based, therefore, upon farmer responses to questionnaires or researchers' own judgments. A field survey is currently being conducted by the Philippine Potato Programme to rectify this. Furthermore, labour requirements and supplies will vary very much from farm to farm. The estimates shown in Table 2 were compiled by members of the Programme and are the best currently available: they

Table 2. Estimated cost of production one hectare of table potatoes during the wet season using Certified Seed tubers.*

| Activity/Input | Mandays | Value, ₱+ |
|---|---|---|
| Labour: | | |
| Land preparation: includes clearing, 1st and 2nd hoeing, bed preparation, application of chicken dung | 260 | 3,900 |
| Planting: includes seed-piece preparation, seed treatment, hauling and planting | 40 | 600 |
| Weeding and hilling-up | 60 | 900 |
| Spraying | 50 | 750 |
| Harvesting: includes sorting, grading and hauling | 60 | 900 |
| Sub-total for labour | 470 | 7,050 |
| Supplies: | | |
| 2000 kg certified seed at ₱4.50 per kg | | 9,000 |
| 5 tonnes chicken manure at ₱5,500 per truck | | 5.500 |
| 750 kg commercial fertilizer at ₱115 per 50 kg bag | | 1,725 |
| Fungicides/insecticides | | 5,000 |
| 750 net bags at ₱1.40 each | | 1,050 |
| Sub-total for supplies | | 22,275 |
| Total for labour and supplies | | 29,325 |

* Modified from Benguet Technoguide for Potato (Anon., 1979a)

+ Labour is calculated at ₱15.00 per man-day

£ 1 Sterling is equivalent to ₱15.75, March, 1982.

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Plate 16. Consumption. (a) A well-laid Filipino table. Note: abundance of rice; potato only used as *bayan* a) and fruit salad b).

serve to show the major costs but no estimation is made here of rent, loan and interest charges and depreciation which again vary considerably from farm to farm. It will be noted from Table 2 that the major input costs are seed (particularly if certified seed is used), non-certified seed costing approximately ₱4,000.00 per hectare and certified ₱9,000.00 per hectare, organic fertilizer (chicken dung) and labour. The total labour requirement for one hectare is estimated at less than 500 manhours so that a one-hectare crop can be managed by a small family, assuming some extra help is available at harvest.

Prices vary considerably during the year and may even fluctuate markedly during a single day. In general, they are at their lowest at the end of the wet-season crop and at their highest in December. Assuming a yield of 20 tonnes per hectare and a farm gate price, of ₱2.00 per kilo, both conservative estimates, for a crop marketed in early August then a net return of ₱10,675.00 may be expected. A December marketed crop may be expected to yield twice this return.

Returns from the principal alternative crop, cabbage, are also difficult to assess due to widely fluctuating farm gate prices, for example ¢30 in December, 1979 but ₱2.40 in December, 1980 (Vergroessen, private communication). In general, however, it would appear that cabbages are usually of equal or slightly less profitability than potatoes.

## Consumption

The staple for almost all groups in the potato producing area of Benguet is rice, which is consumed at least three times per day and often as many as five times. Camote is still the staple for a few small groups. Meat and fish, often with a vegetable such as cabbage or carrot, are consumed in varying amounts according to the financial position of the family, but seldom more than once per day.

Potatoes are not eaten as a staple. Most people claim that they are not "filling", that is, they feel hungry again within a few hours of eating potatoes. Also, they claim that they encounter stomach disorders if they eat potatoes in a number of consecutive meals. Most importantly, potatoes are regarded as a source of income, thus generally all marketable potatoes are sold and only the damaged and small tubers are kept and eaten, up to three or four times per week, until supplies are finished. Most usually, they are sliced and boiled before being fried with lard and added to side-dish of meat, known as *bayan*. Sometimes they may be added to another vegetable dish.

One section of the population which does appear to eat potato on a regular basis is that of Chinese origin. Here, the potato is again

usually prepared as *bayan* although it may be fried and eaten with rice (and sometimes eggs) for breakfast.

Due to the potato being almost a "by-product" to these farming families and due to the way in which it is prepared; little preference is shown for cultivar, skin or flesh colour, texture, etc. The notable exception being that many older people state a preference for a meally potato which is sweet, that is, their recollection of the old "native" potato.

Even on festive occasions is the potato only rarely consumed in this producing area, preference being given to camote or, if available, gabi (taro); both of which are regarded as being sweeter and more "filling."

The Kankanays and Ibalois of Benguet traditionally eat the foliage of many plants and it is interesting to note that a number of farmers report eating potato leaves, particularly from young volunteer plants. These are boiled and then fried in lard (Poats et al, 1981), in much the same fashion as camote tops are prepared. These groups may also eat potatoes roasted in the field whilst they are working their patches of *kaingin*.

## Future Development

Although the potato accounted for less than 0.04% of the food crop hectarage in 1978, the Philippine authoritieis have put great emphasis on the crop because of this high nutritive value. Consequently, in 1977, a seed potato programme was set up in conjunction with the Federal Republic of Germany and in 1978 the Philippine Potato Programme was inaugurated.

The Philippine Potato Programme is inter-agency, inter-disciplinary body consisting of ten agencies actively concerned with potato research, production, extension and training. Through this body and its technical sub-committees research, extension and training is guided.

Most of the potatoes produced in Benguet are presently consumed by the hotel and catering trade in Manila and other tourists resorts with a much smaller quantity being consumed by wealthier families. Very few potatoes are consumed by the general public, due to both its high price and, in many instances, apparent preferences for other foods, although it is consumed widely as a salad in festive occasions in many lowland houses (Poats et al, 1981) (Plates 16a, b). The recent introduction of chains of fast-food restaurants by several overseas companies has greatly increased the demand for potatoes. This development has had several far-reaching consequences. It has, in the short term, greatly increased the price of potatoes, particularly those in the larger-size categories

suitable for French-fries; this will decrease further the possibility of the general public eating potatoes regularly. The high prices and general poor processing quality of the potatoes presently being produced has led to an intensification of research into the crop, in particular the varieties being grown. It has also led to possible new production areas being explored. In the medium to long term, it is possible that through these new restaurants more people will become accustomed to the potato and, through the intensified research and expanded hectarage, prices will be lowered thus bringing it within the "means" of a larger section of the population.

CHAPTER 3

# White Potato Yield Survey: Benguet Province

Michael J. Potts, Lito M. Pacuz and Elmo O. Sano

## Introduction

The white potato (*Solanum tuberosum* L.) is a priority crop in the Philippines (Anon. 1979a) and is the object of considerable research and extension effort. Yields, however, are generally thought to be low, even in Benguet and Mountain Provinces; the major producing areas of the country, where it may account for up to half the cropped hectarage (Manto et al, 1978). According to figures from the Bureau of Agro-economics for 1978 (Anon. 1979c) average farm yield (for all seasons) in the provinces was 7.4 tonnes per hectare, little more than the 6 tonnes per hectare estimated for 1963 (Balaoing and Lazo, 1967). This figure is supported by the survey of Manto et al,(1978), which showed an average yield of 6.8 tonnes per hectare but a considerable range from 3.1 to 14.7 tonnes per hectare.

Recently, a few workers in the locality have concluded that average yields may be substantially higher: 12.5 tonnes per hectare (Baniqued, 1980), 6.4 to 16.0 tonnes per hectare (Weibel, 1981) and 15 tonnes per hectare (Anon. 1982). Such estimates appear to be supported by results from recent "on-farm" trials in which the mean yield of the farmers' control plots in the years 1980 to 1982 ranged from 12.3 to 19.6 tonnes per hectare according to the experimental series (Potts et al, Chs. 6, 7,8). These revised estimates appear more probable since estimated production costs indicate that a yield of at least 10 tonnes per hectare (Anon. 1979a) to 13 tonnes per hectare (Anon. 1982) is necessary to cover these costs, assuming average farm gate prices for the produce.

To date, almost all data regarding potato yields has been qualitative, having been gathered by survey techniques or from visual observations, and may be subject to considerable misunderstanding and sampling error. This paper describes an attempt to obtain quantitative data, through the use of field-sampling techniques, on potato yields. Such quantitative information must be regarded as necessary to form a reliable "base-line" on which to place future production strategy and research.

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## Materials and Methods

In each of the main harvest periods; wet season - June to August, 1980 and 1981 and dry season - January and February 1981 and 1982, visits were made to farmers' fields for sampling purposes. During the wet season samples were taken from throughout the highland areas of Benguet Province and during the dry seasons from Loo and La Trinidad Valleys: the respective seasonal production areas. No pre-determined sampling plan was used, visits were made during the course of other duties in the area and sampling was limited to fields where harvesting was observed to be taking place.

At each site, three samples, each 5 m to 8 m long and one plot wide, were marked-out at random from within the field. The plants were harvested and the tubers were classified as saleable and unsaleable (cracked, rotten, etc.). The weight of saleable produce was recorded together with exact plot dimensions and used as bases for estimating crop yield in tonnes per hectare.

Notes were made regarding crop condition at harvest and any further data that could be obtained through informal consultations in the field was recorded.

## Results

A total of 419 fields were surveyed and the mean yields by season and cultivar are shown in Table 3, together with cultivar as a percent of the fields sampled in each season.

In the wet season 1980, 184 fields were sampled and eleven cultivars including mixtures were identified, the principal cultivars grown were Conchita, 42% of fields; Cosima, 16% and Greta, 14%. The mean overall yield was 28.2 tonnes per hectare with little difference between cultivars except that the small number of samples of cv. Alpha showed a lightly higher mean yield, 34.8 tonnes per hectare and cv. Cosima had a lower mean yield, 23.7 tonnes per hectare.

In the wet season 1981, the overall mean yield of the 105 fields sampled was 17.1 tonnes per hectare. Seven cultivars, including mixtures were identified: the principal cultivars being Conchita, 38% of fields; Greta, 23% and Cosima, 17%; again cv. Cosima yielded slightly below average, 16.2 tonnes per hectare and the two farms growing cv. Fina had a slightly higher yield, 21.5 tonnes per hectare.

The number of fields sampled in each municipality and the percentage of fields in which each cultivar was identified is shown in Table 4;

Table 3. Overall average yield (tonnes per hectare), number of fields sampled, average yield of each cultivar and percent of total sample planted to each cultivar by cropping season.

| Cropping Season | Average Yield (t/ha) | Number of fields sampled | Cultivars | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Alpha | | Conchita | | Cosima | | Fina | | Greta | | Isola | | Red Pontiac | | Other/Mixtures | |
| | | | y | % | y | % | y | % | y | % | y | % | y | % | y | % | y | % |
| Wet Season 1980 | 28.2 | 184 | 34.8 | 4 | 31.0 | 42 | 23.7 | 16 | 29.6 | 4 | 29.2 | 14 | 32.2 | 4 | 29.8 | 8 | 26.5 | 7 |
| Wet Season 1981 | 17.1 | 105 | 0 | 0 | 17.6 | 38 | 16.2 | 17 | 21.5 | 2 | 16.6 | 23 | 9.4 | 4 | 16.9 | 6 | 18.5 | 10 |
| Dry Season 1980-81 | 24.7 | 56 | 0 | 0 | 0 | 1 | 22.9 | 14 | 31.5 | 16 | 21.8 | 14 | 0 | 0 | 23.9 | 55 | 0 | 0 |
| Dry Season 1981-82 | 28.8 | 74 | 0 | 0 | 0 | 0 | 29.1 | 69 | 30.4 | 5 | 25.4 | 5 | 0 | 0 | 29.8 | 18 | 17.5 | 3 |

Table 4. Number of fields sampled and percent distribution (by Municipality) of cultivars (wet seasons 1980 and 1981).

| Municipality | Year | Number fields sampled | Percent of fields planted to each cultivar | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Alpha | Conchita | Cosima | Fina | Greta | Isola | Red Pontiac | Other Mixtures |
| Atok | 1980 | 45 | - | 40 | 20 | 16 | - | 9 | 16 | - |
| | 1981 | 9 | - | 22 | 33 | - | 11 | 22 | - | 11 |
| Bakun | 1980 | 7 | - | - | 43 | - | 14 | - | 14 | 29 |
| | 1981 | 15 | - | 7 | 20 | - | 47 | - | - | 27 |
| Buguias (Abatan, Bayoyo) | 1980 | 38 | - | - | 47 | 3 | 32 | 8 | 3 | 8 |
| | 1981 | 25 | - | 12 | 44 | - | 32 | - | 8 | 4 |
| Buguias (Natubleng) | 1980 | 8 | - | 62 | - | - | 13 | 13 | - | 13 |
| | 1981 | 8 | - | 50 | - | - | 25 | - | 13 | 13 |
| Kabayan | 1980 | 41 | 20 | 56 | - | - | 20 | - | 2 | 2 |
| Madaymen | 1980 | 43 | - | 74 | - | - | 9 | - | 9 | 7 |
| | 1981 | 33 | - | 82 | - | 3 | 6 | - | 6 | 3 |
| Mankayan | 1980 | 2 | - | - | - | - | - | - | - | 100 |
| | 1981 | 15 | - | 20 | 7 | 7 | 27 | 13 | 7 | 20 |

except that for convenience, the data for the municipality of Buguias has been divided into the two distinct geographical and agricultural zones: Abatan and Bayoyo; and Natubleng.

Most cultivars were grown in each municipality except that cv. Alpha was only found in Kabayan, where it accounted for 20% of the 41 fields sampled in 1980, the only season in which samples could be taken from that municipality. Cv. Conchita was especially common in Madaymen where, over the two seasons it was grown in 78% of fields sampled and the neighbouring area of Buguias (Natubleng), 56% of fields sampled; Kabayan, 56% of fields sampled and the more distant parts of Atok, where overall it accounted for 39% of fields sampled. Cv. Greta followed generally the same pattern except that it was also grown in 32% of fields in Buguias (Abatan and Bayoyo). Cv. Cosima accounted for 46% of fields in Buguias (Abatan and Bayoyo).

In the dry season 1980-81, 56 fields were sampled and only four cultivars were identified: cv. Cosima, Fina, Greta and Red Pontiac. The cv. Red Pontiac accounted for 55% of fields surveyed. Cv. Fina had a markedly higher than average yield at 31.5 tonnes per hectare and cv. Greta a marginally lower yield at 21.8 tonnes per hectare. In the dry season 1981-82, 74 fields were sampled with an overall mean yield of 28.8 tonnes per hectare. Cv. Red Pontiac accounted for 18% of fields sampled and cv. Cosima 69%. Again cv. Fina, which was grown in only 5% of fields, had a marginally higher yield than the mean, 30.4 tonnes per hectare, and cv. Greta had a lower yield, 25.4 tonnes per hectare. At the two sites where mixtures were grown, yields were markedly lower, 17.5 tonnes per hectare.

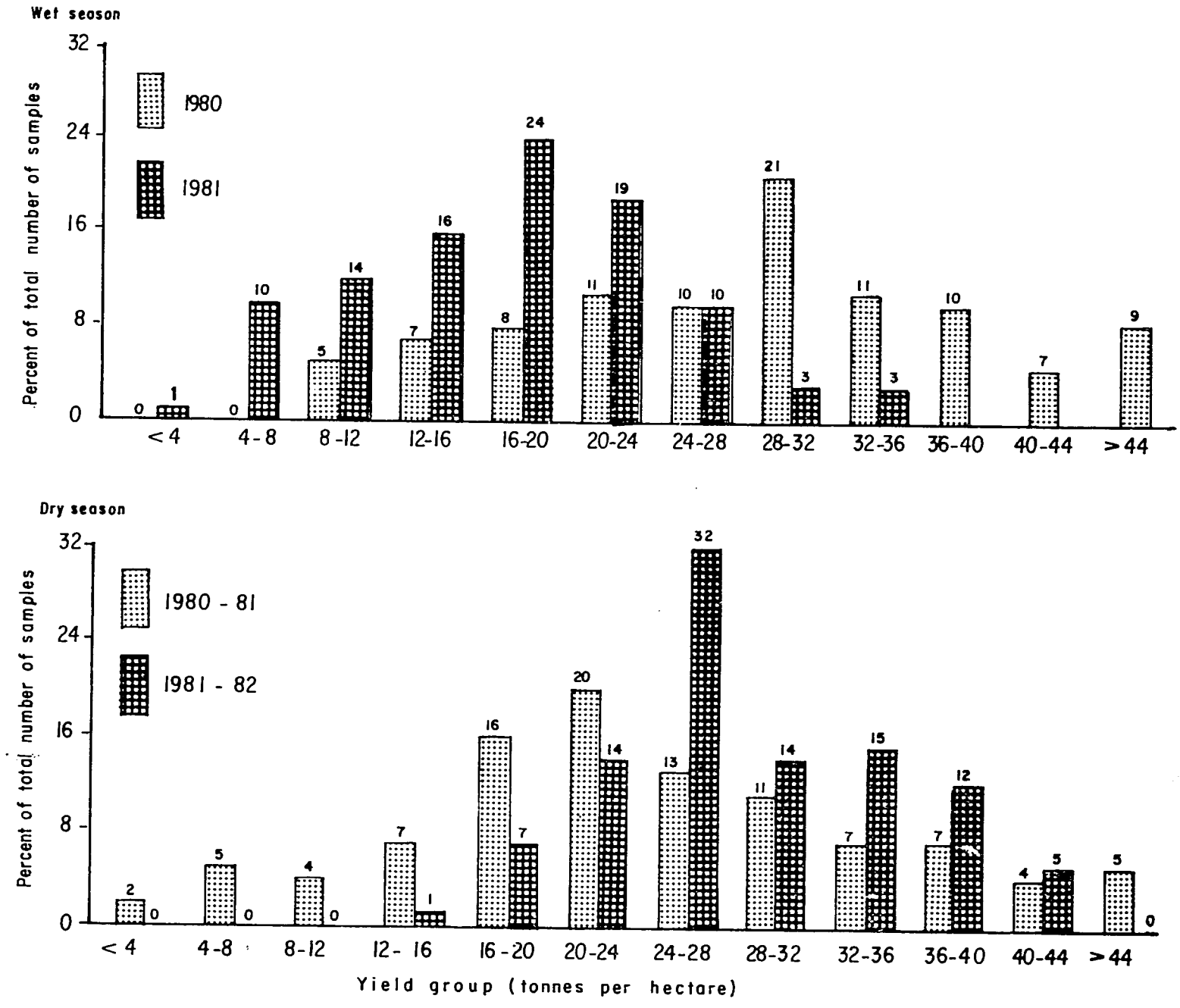
The distribution of yield, over all cultivars, was concentrated about the seasonal mean in the wet season crop, 1981 and the dry season crop, 1981-82 but for the other seasons a wide range of yields were obtained; 8.0 tonnes per hectare to more than 44.0 tonnes per hectare in the wet season 1980, and less than 4.0 tonnes per hectare to more than 44.0 tonnes per hectare in the dry season 1980-81 (Figure 4).

## Discussion

### *Wet season*

Although the onset of rains for the wet season 1980 was delayed until mid-April, the remainder of the growing season may be regarded as good and thus yields were near optimum: this is reflected by the relatively few samples, 12% with yields less than 16 tonnes per hectare. In 1981, the onset of rain was delayed until late April and a typhoon severely damaged most crops in early June, thus the overall mean yield

Figure 4 YIELD DISTRIBUTION, AS PERCENT OF TOTAL FOR EACH CROPPING SEASON.



was lower with many more crops giving poor yields: 41% of farms recording yields of less than 16 tonnes per hectare. Seasonal factors would, therefore appear to be a major determinant of yield.

The large number of cultivars observed during the wet season is a reflection of the increasing number of importations that have been made in recent years, particularly from Holland and Germany. However, in both seasons, more than half the samples were of the established cultivars Conchita and Greta. These two cultivars of Mexican origin were introduced in the early 1960's. There have been no subsequent importations and almost all crops contain some admixtures and are severely infected by virus. Nonetheless, they exhibit a high degree of tolerance and continue to yield well. The informal discussions with farmers indicated that the high level of resistance to late blight (*Phytophthora infestans*), was a further reason for their continued popularity. Also, they have a longer dormancy period than the more recent introductions, thus farmers could keep them in store for eight to nine months without undue losses due to excessive sprouting and disease; an essential prerequisite in those areas where only one crop per year may be grown, for example, Madaymen, Kabayan and the more distant parts of Atok. The survey confirmed the popularity of these two cultivars in these localities. Discussion with farmers in Kabayan indicated that cv. Alpha was popular because of its moderate late blight resistance in this more isolated area, where chemicals are considered expensive and are often not available. The popularity of cv. Greta in Buguias (Abatan and Bayoyo) was explained by farmers to be due to its use as a seed crop for the subsequent dry-season crop in nearby Loo Valley.

The cultivar Cosima presently accounts for a large proportion of the seed being produced by the local RP/German Seed Potato Programme and the popularity of this cultivar in Buguias (Abatan and Bayoyo) is a reflection of the high concentration of seed producers in this area, who inevitably passed-on seed to neighbouring farmers. The relatively poor performance of this cultivar may be due to the observed presence of virus, in particular Potato Leaf Roll (PLRV) and Potato Virus X (PVX). No explanation can be forwarded for the marked difference in the relative yield of cv. Isola between the 1980 and 1981 seasons.

## *Dry season*

The dry-season crop is produced principally under irrigation in the warmer irrigated valleys of Loo and La Trinidad, where intensive vegetable farming is practiced. It was readily noticeable during the sampling process that yields were markedly affected by the efficacy of the irrigation practiced and this explains a major part of the wide range of yields obtained, particularly during the season 1980-81. In 1981, the rains continued late into December and thus soil moisture was less of a limiting factor and the yield distribution of the early 1982 harvest was more concentrated about the seasonal mean.

In the valley areas intensive farming practices often result in crops being harvested at only 75 days from planting. An early bulking cultivar, such as Red Pontiac or Fina, is thus preferred. It was interesting to note, however, that where even these early bulking crops had been allowed to reach full maturity, up to 120 days, then yields were very high with several farms recording more than 40 tonnes per hectare in both seasons.

To obtain seed-pieces, which have broken dormancy and are ready for the dry-season planting, is often very difficult. They must be planted and harvested early in the preceding wet season and have an inherently short dormancy. This frequent shortfall in seed availability results in many valley farmers not being able to plant the cultivars of their choice. The shortfall was also forwarded by many farmers as the reason for the common practice of cutting seed-pieces during the dry season; again the informal questionning indicated that more than 80% of farmers cut their seed for the dry-season crop whereas less than 10% cut their seed for the wet-season crop. The effect of seed-piece cutting on breaking dormancy was also forwarded by a few farmers as a reason for this practice. The savings in seed costs due to cutting was, surprisingly, mentioned only by a few farmers.

The cultivar preferred by many farmers for the dry season crop is Red Pontiac, which has a relatively short dormancy and is moderately heat tolerant; a favorable characteristic for the lower valleys, even during this cooler time of the year. However, it is customary for farmers in these valleys not to produce their own seed, due to the high aphid populations in the valleys and the consequent spread of virus diseases; but to purchase seed from higher elevations nearby. Informal supplementary questioning of a limited number of farmers indicated that fewer than 30% of farmers claimed to plant their own seed during the dry season, and the majority of these were on the slightly elevated margins of the valley, whereas over 75% of farmers claimed to save their own seed for the wet-season crop.

In February, 1980 quantities of seed of cv. Red Pontiac were imported and planted during the wet season. Since this cultivar has a relatively short dormancy period, considerable quantities of seed were available for the following 1980-81, dry-season planting and this is reflected by the number of fields where this cultivar was recorded. In January and February, 1981 importations of cv. Red Pontiac were limited but there were considerable importations of cv. Cosima; hence the significant increase in the number of farmers planting this latter cultivar during the dry season, 1981-82 : 14%, 1980-81 : 69%, 1981-82. The significant fall in the number of farmers planting cv. Fina in the dry season, 1981-82, was due to many crops of this cultivar being completely destroyed during the preceding wet season, 1981 by a typhoon and a subsequent late blight attack; thus, few seeds were available for the following dry-season crop. Much of the shortfall was made up by using cv. Cosima,

which was readily available but which is not normally preferred due to its longer dormancy period and hence later planting and longer growing season.

## Conclusions

Whilst care must always be taken in extrapolating "small-plot yields" to a "per hectare basis" the results obtained from these surveys indicate that yields are markedly higher than those thought generally to be obtained. Whilst seasonal variations are highly significant, a yield of not less than 20 tonnes per hectare in a good season, wet or dry, might be regarded as a conservative average and 30 tonnes per hectare may be regarded as a reasonable production target for the National Programme.

Farmer preference for cultivar depends upon cropping season. For the wet-season crop the traditional cultivars resistant to late blight are preferred and for the dry-season crop an early maturing cultivar which also has a short dormancy is preferred. It would seem appropriate, therefore, to place considerable emphasis on these factors when new introductions are being considered.

CHAPTER 4

# In-Ground Storage of White Potato
## A Preliminary Assessment

Michael J. Potts, Elmo O. Sano and Lito M. Pacuz

## Introduction

The white or Irish potato (*Solanum tuberosum* L.) has been identified as a priority crop by national authorities in the Philippines (Anon. 1979a). In 1978 a total of 3170 hectares was devoted to the crop within the country as a whole, of which 2370 hectares were located in Benguet and Mountain Provinces, Northern Luzon which accounted for 87% of the national production (Anon. 1979c).

Climatic factors favour two distinct cropping seasons: a wet season crop in March to July or August and a short, 70-to 90-day dry-season crop between late October and March. Cropping between these periods is considered risky due to a typhoon season in August and September and a dry season with frosts in some areas in late January and February. Production is therefore seasonal and if a regular supply of table potato to the market is to be achieved a method of storage would be necessary.

At present little is known or documented about the storage practices of farmers and before any major expansion in production takes place, a thorough study is necessary for appropriate recommendations. However, it is apparent to the authors that one method of storage known to all farmers and practiced by many is that of "in-ground storage" or "delayed harvest". In this system, which is used almost exclusively for the wet season crop and particularly on higher land with good soil drainage, the tubers are allowed to remain undisturbed in the ground, following haulm death and maturity, for periods of up to six months. Although this apparently low-capital requiring practice is well known and has been used for many years, there is scant information on storage losses and quality changes pertaining to it or of the farmers' own perception of the practice, its limitations and problems. This study was designed to look into these changes and act as a focal point for discussion with farmers to provide a basis for recommends in table-potato storage and for further experimentation.

## Materials and Methods

Six sites were located on light to medium, well-drained soils in two areas of Benguet Province in June, 1981. At each site 25 contiguous beds, at least 10 m long and comprising a double-row of plants, were identified. On five sites the Mexican cv. Greta was grown on the sixth

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the German cv. Cosima. During the first seven days of each of the months August to December, five beds were harvested. Any sprouts were removed and discarded before the produce was bulked and graded by size: extra big, big, medium, small, marble and reject. Each grade was weighed and visual observations were made of tuber condition.

Informal discussions were held with a limited number of farmers and merchants in the area to determine their attitudes to the practice.

## Results and Discussion

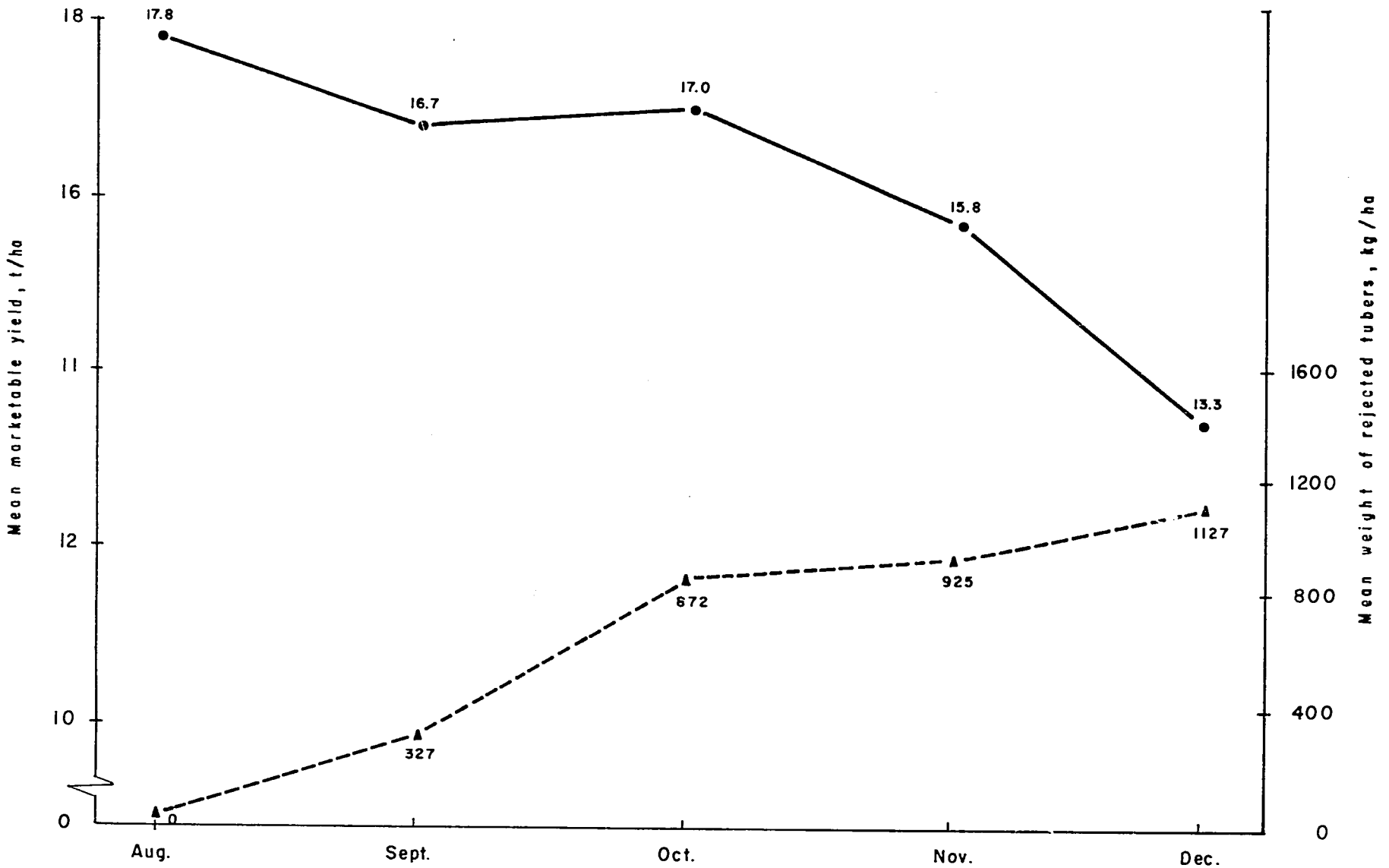
Four sites at which cv. Greta was grown and one site where cv. Cosima was grown were successfully harvested in all months. Figure 5 shows the mean yield per hectare of marketable produce and the weight of rejected tubers. Due to the large variation between sites no statistical analyses were done. At the sixth site no data were available for the August harvest and, due to large variation in yields between sites, this site has not been included in the overall means. Data for the remaining four months, however, followed the pattern shown.

The mean yield of marketable produce in August was 17.8 tonnes per hectare with an insignificant proportion being rejected at all sites (Plate 17a). The small reductions in yield in September and October, to 16.7 and 17.0 tonnes per hectare, respectively, were probably a result of sampling errors; although a small number of tubers were rejected in each month, 327 and 872 kg per hectare, respectively, due to "greening". Little pest or disease damage was noted (Plate 17b).

Yield of marketable produce fell markedly in November and December, to 15.8 and 13.3 tonnes per hectare, respectively, but there was little increase in the weight of rejected tubers, 925 and 1187 kg per hectare, respectively. By this time growth from the tubers was taking place, reaching 150 mm above the soil surface by the December harvest (Plate 17c) and many tubers had lost their initial turgidity. Isolated instances of bacterial soft rots were noted at this time.

The results have shown that under conditions at the study site, the practice of in-ground storage may be used successfully to store potatoes for up to three months with little loss in yield (approximately 6%) or quality. After that time dormancy had broken and vegetative growth rapidly ensued with the consequential breakdown of starch to sugars within the tubers and its transference to the growing regions. By two months after breaking dormancy, the young plants were well established and the tubers had become soft and poor in quality. Yield losses amounted to approximately 25% by weight at this time.

Figure 5. MEAN MARKETABLE YIELD (—) AND WEIGHT OF REJECTED TUBERS (---). AUGUST TO DECEMBER



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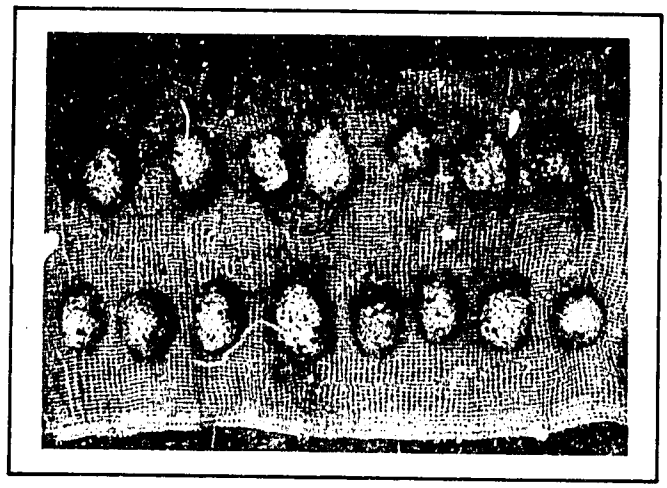
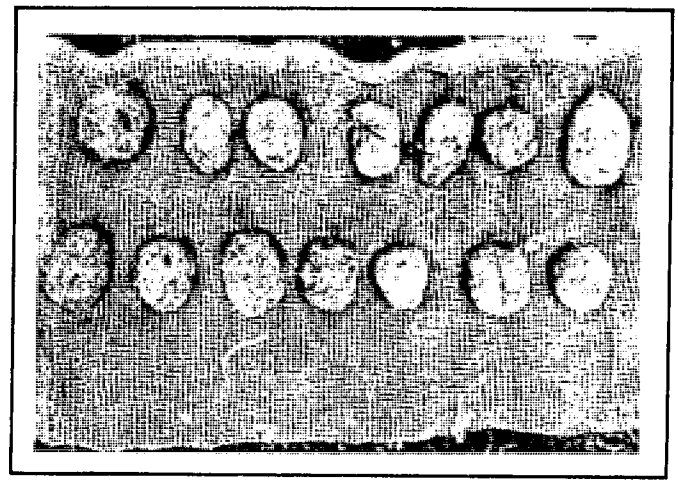


a



b

c

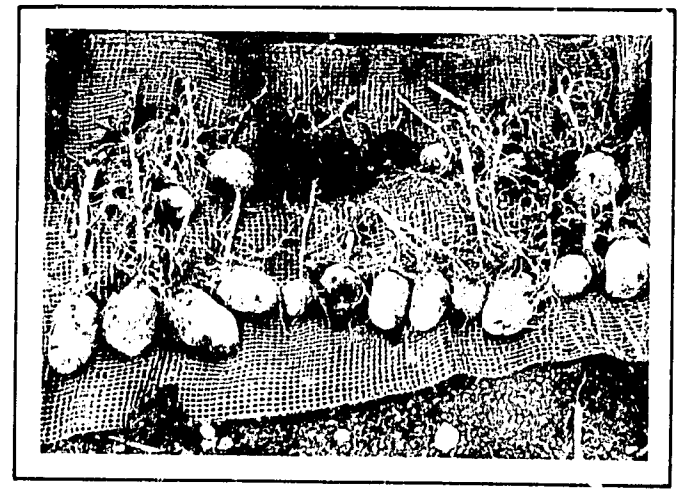


Plate 17. In-ground Storage. (a) Crop of cv. Conchita two months after maturity, September, 1981, (b) Above crop lifted three months after maturity, October, 1981. Note: occasional sprouts *a*), (c) Above crop lifted five months after maturity, December, 1981.

The three-month storage period coincides with the current cropping systems. The majority of crops grown during the wet season reach maturity in mid- to late-July. Due to the heavy rains and typhoons, planting of any crop even in the most favoured areas cannot being again until late August and is delayed most usually until early October. Consequently, land during this period may be regarded by farmers as "idle" and so the "stored" potatoes are not replacing another revenue-earning crop.

Harvesting, sorting and handling are estimated to require 35 man-days per hectare and account for a considerable part (16%) of the labour input into the crop (Anon. 1979a). Thus, if harvesting can be done over an extended period, it may be more easily managed by the family unit and the need for hired labour is reduced. By extending the harvesting period, any permanent family or hired labour may be gainfully employed during otherwise slack periods: covering of exposed tubers to prevent greening and harvesting taking place during dry-periods; and sorting and packing being done in the *bodega* during wet spells.

Since fresh or new potatoes are not available until early December, and then only in limited quantities even from a late August planting, there is a period of at least five months during which potatoes must be stored if a constant supply is to be available to the major markets of Manila; assuming production in other areas is strictly limited. Apparently the practice of in-ground storage will only adequately provide for the first three months of this period, with losses in yield, quality and an alternative crop probably making further storage unattractive to the farmer. Field observations confirm the above discussions: most farmers were observed to have completed their harvest in mid- to late-October. This is a period of festivity in the Filipino calendar and the potato, being used for several festive dishes, commands a high price. After this time, prices fall again to their mid-October levels and then continue to rise steadily until the major festive season in December.

The length of this storage period could be extended by careful management practices. Both the cultivars used in the trials are considered to be of medium maturity (Rasco, 1980) with a corresponding dormancy period. Selection of cultivars with a longer dormancy period, for example, the cultivar Conchita, which accounts for a large proportion of the wet-season crop (Potts et al, Ch. 4), would delay the onset of growth. Site selection is also important because in cooler locations with lower temperatures, dormancy will be extended. Late planting of the crop will also delay the time at which re-growth starts but, because it also delays the maturity of the crop, there is a risk that it will be seriously damaged by monsoon rains and wind before it reaches maturity. Informal discussions by the authors with many farmers have shown that the latter are in fact aware of these possible practices and bear them in mind when planning the cropping season. The farmers tend to choose well-drained sites, since any water-logging causes rapid rotting of the

tubers, and they also adjust cultural practices accordingly; for example, they prepare the beds higher than is commonly practiced to improve drainage.

Farmers on the periphery of the major production zone would appear to practice in-ground storage to a greater extent than elsewhere in the area and to adjust their cropping system accordingly. These farms are characterized as being smaller than average and worked as a family unit. They are often at higher and thus cooler elevations with a well-drained soil. Irrigation facilities may be limited, thus limiting production during the dry-season, so that in some areas only on wet-season crop is grown each year and in-ground storage does not therefore render land idle. Farmers in the more intensive production areas with available irrigation were observed to use the practice only to a limited extent. Emphasis in this latter situation appeared to be on harvesting and selling or storing the crop by other methods and planting a successional crop as soon as practicable. Further investigations into their motives and actual practices are needed for a full appreciation and understanding of in-ground storage.

A precise economic evaluation of the trials was not made but several general observations were possible. In-ground storage requires little capital costs. Prices in July and August are usually low and then rise steadily until the end of the year with the major "festive" peak in December. Thus storage up to this time will give some increase in gross income.

Traders appeared to show no preferences between tubers stored in a *bodega* and tubers stored "in-ground". providing the latter were harvested under dry conditions and were free from excessive dirt. Towards the end of the trial period, however, merchants stated a preference for potatoes stored in the *bodega* although some sprouting and loss of turgidity had occured because their quality was generally better than that of in-ground stored potatoes which showed considerable growth. Due to typhoon damage earlier in the season potatoes in late 1981 were scarce and all produce was bought at high prices. When the first produce of the new crop became available in December, it commanded a high market price because of its lighter colour, thin and often scuffed skin and turgidity with no evidence of sprouting. In 1981 the difference in farm price between in-ground stored and freshly harvested potatoes amounted to ₱3.50 by mid-December: new ₱11.00, old ₱7.50. In a more normal season merchants would expect a difference of approximately ₱1.00 at this time: new ₱3.20, old ₱2.25.

This preliminary trial series would appear to indicate that the technique of in-ground storage is an appropriate technology for some farmers in Benguet Province. Capital costs are low, tubers may be satisfactorily stored and harvested periodically, with little loss in yield and quality, over a three-month period when there is little other

activity on the farm and when prices are initially low but rise steadily. If the practice is to be fully appreciated, however, further trials paying particular attention to quality during the later stages of the storage period and to economic returns are necessary. A survey and descriptive documentation and evaluation of alternative practices, which the authors have observed, is also urgently required if satisfactory and appropriate recommendations regarding storage of the projected increase in production are to be made and a constant supply to the market is to be achieved.

# SECTION III:

The On-farm Trial Experience and Results

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## SECTION III

## The On-farm Trial Experience and Results

### Introduction

The first of the four papers describes the evolution of the OPP approach during the course of the three- ear Philippine project. Many problems, philosophical, administrative and practical, were encountered and the paper summarises the steps taken to overcome them. Most of the steps would be applicable to other locations; but when considering a similar approach in other areas flexibility in approach is essential, since farmers' own situations and attitudes, extension and research practices and above all administrative procedures all vary. However, the basic concepts and approach do appear to hold good under a wide range of circumstances.

The last three papers in this section report the results of the major experimental thrusts. The trials reported by no means constitute all the trials carried out by the project. A number of other preliminary trials were carried out, either to demonstrate the approach to technicians, farmers and administrators or as a prelude to a more detailed study.

CHAPTER 5

# Transfer of Technology to Small Farmers: On-farm Research in the Philippines

Michael J. Potts, Amado B. de los Santos and Julia A. Solimen

## Introduction

In the Philippines the potato is a small-farm crop, confined to the highland regions. The crop seldom accounts for more than one hectare, *circa* 50% of the cropped area (Manto et al, 1978), and yields have been thought generally to be low, *circa* 6.6 tonnes per hectare (Anon. 1979c) but production costs are high, thus it is regarded as a luxury food limited to the catering trade, wealthier classes and perhaps festive occasions.

Research stations results have indicated that yields in excess of 20 tonnes per hectare may be readily achieved (Bureau of Plant Industry, 1978, 1979, 1980; Sano and Hermano, 1977), thus the potato was identified by the National Authorities as a crop which can serve as a model to demonstrate the flow of technology from research to utilisation in an effort to improve yields whilst maintaining or lowering production costs (Anon. 1979d).

The model adopted by the Philippine Potato Programme (PPP), an association, chaired by the Ministry of Agriculture, of institutions interested in the production and utilisation of the potato crop, was based on the International Potato Centre's (CIP) approach of Optimizing Potato Productivity (OPP) (Anon. 1978), which forms an integral part of their "farmer-back-to-farmer" strategy of technology transfer (Rhoades and Booth, 1982). Initial trials were begun in late 1979 and the following paper summarises the major philosophical, organisational and practical features experienced in the field since the senior author joined the project in February, 1980. Many of the points are likely to be encountered, both in the Philippines and other developing countries, when similar projects are initiated. The steps taken to overcome difficulties and a few personal comments of the authors are forwarded.

## Initial Approach

The initial scheme was to develop a package of technology incorporating the best technology available. This package was to be tested on farms and evaluated agronomically and economically before being promoted by the Extension Services. As new technology became available it would be incorporated into the package, tested on farms and, if successful, a revised package would be promoted (Anon. 1979d).

Organization of the project and the field practices were as follows:

i. The PPP set up a sub-committee of field coordinators comprising a senior extension worker, a socioeconomist, an agronomist and a post-harvest specialist. All were employed by institutions based in the production area.

ii. The sub-committee drew up a detailed agro-economic survey questionnaire aimed at identifying current practices and problems.

iii. The sub-committee formulated a low cost, high-income package of production technology which consisted of 22 steps.

iv. Field extension technicians conducted the agroeconomic survey and identified farmer cooperators.

v. Two packages were tested from December, 1979 to April 1980 and a further six from March, 1980 to July 1980. Each trial was the responsibility of one technician and covered an area of approximately one hectare; but had no direct comparison with the farmers' own practice: reliance being placed on farmers' estimates of yield in previous seasons, as gathered from the agroeconomic survey.

vi. All material and labour costs were borne by the farmer cooperator, although assistance was offered in negotiating a loan with one of the banking institutions associated with the PPP.

## Evaluation

At the end of each trial series an evaluation meeting was held comprising members of the Management Committee of the PPP, the field coordinators and the extension technicians. These meetings were valuable in that they allowed for the free flow of information, particularly from the technicians to the Programme leaders. Many useful discussions took place, problems elucidated and solutions aired. The more notable points were:

### *Philosophy*

i. The trials were complex and difficult to carry out in the field. Farmers did not appear to appreciate the philosophy and principles involved and all farmers selected those technologies which they considered most appropriate to their situation, thus forming their "own package". Comparison between trials was therefore not possible.

ii. Reliance on survey data to estimate farmers' inputs and yields was not practical. Both vary considerably from season to season, for example, according to the incidence of pests and diseases.

iii. The complete package was considered by many farmers to involve considerable financial risk, especially when the areas involved in the trials was taken into account. Trials were thus limited to the larger, financially-secure farmers, which were unrepresentative of the provinces as a whole.

The offer of help to negotiate a bank loan was generally not accepted by farmers: firstly, many farmers were squatters or tenants and had no collateral in terms of land rights; secondly, farmers considered the risks too high, particularly when such large areas and thus investment was involved; thirdly, many farmers had their own source of finance, for example, a neighbour or merchant, and they did not want to disrupt this often long-standing relationship by borrowing from another source for one season only.

iv. The economic costing was difficult, many estimates being necessary.

*Administration*

i. The extension technicians were scattered geographically with no transport of their own; thus, it was difficult to coordinate activities and make rapid decisions.

ii. The field technicians carried out the trials in addition to their normal duties and they were unable to give the trials the close attention required. This insufficient contact and supervision was partially responsible for the lack of understanding and involvement by the farmers.

*Data collection*

i. The preliminary survey was drawn-up by the sub-committee without the aid of professional advice. The survey was complex and its execution beyond the scope of most extension workers, who had no knowledge of survey practices.

ii. Interpretation of the mass of data collected was difficult. Also, only those farmers who had already been located as cooperators were surveyed. Thus the sample was biased and the numbers too small to draw any general conclusions.

iii. The field technicians had not chosen the farmer cooperators at random, preferring to visit those that were readily accessible and with whom they were acquainted. Their farms tended to be the larger, they were more progressive farmers and not representative. They were, furthermore, the subject of many surveys and demonstrations and the continuing use of these farmers is probably the source of several misunderstandings and fallacies concerning production practices.

iv. Farmers' estimates of previous yield were often unreliable, as were their estimates of farm area. Reliance could not, therefore, be placed on comparisons between farmers' estimates of yield per unit area and those obtained from trials.

v. Whilst regularly travelling through the area it became apparent to the authors that many of the responses in the initial survey were inaccurate; for example, visual estimates indicated that yields were in fact, considerably more than the previously assumed 6.6 tonnes per hectare.

*Field practice*

i. Each trial covered approximately one hectare. This effictivity restricted trials to large farms; the average holding being only around one hectare (De la Cruz, private communication), and even this area may have comprised many fragmented terraces.

ii. All field work was carried out by Ministry extension technicians: a group which should have had close contact with the farmers.

*Training and extension*

i. Some extension technicians had little experience with the potato crop, due in part to a reorganisation of the Ministry of Agriculture.

ii. None of the technicians had any practical experience in conducting field trials.

## Remedies and Comments

In order to overcome the problems several steps were taken:

*Philosophy*

i. Demonstrations were carried out at ten locations, from March to July, 1980, of the CIP's OPP approach (Anon. 1978), in which only one or

several interrelated variables were compared directly in the field with the farmers' own practice; thus allowing a true comparison between the current farmer technology and improved practice (Cortbaoui and Potts, Ch. 1). A change to this approach was made beginning October, 1980.

ii. The simplified approach allowed for the size of each trial to be reduced to 500 $m^2$, thus the average and small farmer could be included. Reduction in trial size does not appear to have had any effect on the level of accuracy of the results.

iii. The reduction in trial size reduced the financial risks incurred by the farmer aiding the incorporation of smaller farms into the project. For the season October, 1980 to March, 1981, a small financial subsidy was offered to farmers participating in trials involving certified seed, because a considerable increase in input costs was envisioned. Whether such subsidies were of much practical value in aiding the trial programme is not known at this point, but several technicians have suggested that if a cash inducement is needed to encourage a farmer then he will have little interest in the trial and will probably not look after it as well as a fully committed cooperator.

iv. A simplified approach to economic costing was used in which a partial budget analysis was used in place of the full economic costing (Horton, 1980).

## *Administration*

i. A senior Filipino field technician (de los Santos) was appointed as a field coordinator and together with the senior author was empowered to take all day-to-day decisions. Transport, an essential for any coordinator, was also available, thus frequent visits could be made to all trials sites and decisions made rapidly. Errors in the field have been greatly reduced. Unfortunately, the field coordinator, like the field technicians, is involved in the project in addition to his normal duties, thus only limited time is available for his activities. A full-time field "leader" would be the ideal goal for the project if it is to continue at its present size and form.

ii. To limit the workload for any one technician a ceiling of two trials each was set. This has resulted in the involvement of many technicians with little experience with the potato crop.

## *Data collection*

i. The technicians were thoroughly briefed on basic survey principles and on the information required from the questionnaire, the questionnaire was radically simplified and the survey carried out prior

to identification of the farmer cooperators. However, the existing workload of the technicians still restricted the number of farms could be surveyed and reliance had to be placed on field experience in order to obtain a representative sample.

ii. Briefing of the technicians and simplification of the questionnaire allowed for the more important points to be identified, but much basic information was still missed. For instance, this small survey allowed for the identification of those groups of farmers requiring assistance and gave valuable information about their geographical distribution, economic status and the overall production pattern, but some essential information, in particular relating to social factors and the quality of the field practices, was lacking. For example, no information was collected regarding the role of the wife or foreman in making day-to-day decisions. Similarly, whilst much data was obtained regarding the frequency of pesticide application and the products and quantities used, there was no information on the quality of application; that is, the technique used in the field. This problem is likely to be encountered by any quick survey of naturally cautious farmers, whether it is formal or informal and the sample large or small, particularly when it is carried out by untrained personnel.

The only apparent practical way to gain such information is for a non-biased, trained scientist, conversant with the local dialects and with interests in agronomy, economics and anthropology, to spend the full cropping season in the field observing and talking to farmers: the quality of the field practices, the real problems as the farmer sees them and his reasons for acting as he does should then become evident. Ideally, the scientist, if not a native speaker, should be thoroughly trained in the appropriate languages since experience has shown that working through a translator often leads to misunderstandings, particularly if he tries to put his own interpretation on the question or answer.

iii. In addition to the Preliminary Survey supplementary yield data were obtained through a yield survey in which sample yields were taken, in the field, from a total of 419 farms during the harvests of July to August, 1980 and 1981 and January to Feburary, 1981 and 1982. Average yield per hectare was computed at 28.2, 17.1, 24.7 and 28.8 tonnes per hectare, respectively (Potts et al, Ch. 3), figures which were not disputed by the farmers concerned and which agreed with their own private estimates of "more than 20 tonnes." Obtaining such basic information is essential and further similar supplementary surveys may be necessary if a meaningful project is to develop and the National Programme to direct scarce resources and funds to those areas most likely to benefit the farmer and the nation as a whole.

*Field practice*

i. For the first series of trials, beginning October, 1980, four main variables were selected. Selection was based partly on the preliminary survey but also on the observations and experience of the authors during the previous six months. For example, the use of chicken manure was selected as a variable because the initial survey showed it accounted for 25% of the input costs but, more importantly, observations showed that, for the dry season at least, it was often undecomposed at harvest and thus of little apparent benefit to that crop.

Each selected variable was compared with the farmers' current practice and was considered to be most likely to be accepted by the farmers and to increase their monetary returns. They also acted as examples of the general classes of variables that may be expected:

a. A reduction in variable costs: the elimination of expensive organic manure.

b. No change in variable costs, merely a minor change in husbandry practices: a change in the timing of phosphate fertilizer application.

c. An increase in variable costs: the use of improved (certified) seed.

d. A change in capital costs: the use of improved seed storage techniques. This series of trials formed part of a larger project reported elsewhere (Potts et al, Ch. 6).

ii. The use of only one variable enabled the farmer to understand and more readily identify himself with the trial. Farmer participation and regular visits by extension workers allowed a rapport to be built-up between them and much additional information was gained.

iii. Farmer selection was critical to success since it was the farmer who finally bore the financial risks and the brunt of the day-to-day cultural practices. Thus,whilst ensuring that farmers were selected from within the designated group, preference was given to those most likely to actively participate as one of the team.

Once again, a thorough season-long initial survey would have been most likely to identify suitable cooperators; since the opportunity should have arisen to strike a personal relationship and also to discover who was responsible for the daily decisions and management of the farm because this would be the person in most frequent contact with the technicians and who would have to be encouraged. For example, in this project it was noted that the farmer's wife often made most day-to-day decisions, thus it was she who had to be sought-out and encouraged: an exercise made easier by ensuring that women were included in the field team.

Other personal information regarding the candidate cooperator also affected his suitability; in particular, his relationship with his creditors. For example, several trials were lost in this project because the creditor visited the farm and insisted that, due to market prices, the crop, although very immature, be harvested immediately, leaving no time for the field technician to be notified. Such possible situation, must be identified at an early stage.

iv. To reduce error to a minimum and to ensure that all the necessary information was gathered, a very simple step-by-step guide was made-up for each experiment together with the necessary data-recording sheets. This approach plus regular visits by the field coordinators maintained uniformity across the trials and few errors in either the field techniques or data recording appear to have occured.

v. To spread the trials geographically and within the target groups, two trials were located in each of the 13 municipalities. Increasing the number of trials (target, fifteen per variable) reduced the risk of a series being invalidated due to the loss of too many trials. Experience to date would seem to indicate that under Philippine conditions 15-20% of trials may be lost through unavoidable circumstances, particularly weather.

## *Training and extension*

i. The inexperienced technicians attended a national course on "Potato Production Technology" in which considerable time was devoted to "Technology Transfer". In future it is intended to invite leading farmers to this course, thus further expounding the philosophy. More important, however, was the practice of the authors of regularly visiting each trial in the presence of the technician concerned. This enabled enthusiasm to be maintained and, indeed, technicians and farmers are now requesting help with their own additional trials, aimed at local or farm-specific problems. Also, it served as an ideal form of in-service training; thus the project is also enhancing the competence of the field technicians.

ii. Whilst no formal programme was set up in which the trials were used as demonstration sites, they were always a focus of interest amongst neighbouring farmers.

The more enterprising field technicians encouraged neighbouring farmers to visit the sites and discuss the trials and in so doing they gained much supplementary information whilst serving a useful extension function.

could consistently perceive in the field during the harvesting process. Differences in quality were not included but were uppermost in many farmers' minds; however, quality differences are reflected in the economic analysis.

## *Economic evaluation*

The economic evaluation consisted of a partial budget analysis to determine either the net Benefit/Cost (B/C) ratio (Horton, 1980) or, where there was no change or a reduction in costs, merely the percentage change in returns. To date, it has not been possible to place a definitive figure for the minimum B/C ratio at which a technology is likely to be accepted. This minimum reflects changes in agronomic yield, actual production costs, the rate of inflation, other investment opportunities and, most importantly, the farmer's perception of risk involved in the new technology. Pending further follow-up studies on this aspect, an arbitrary figure of 0.65 for the net B/C ratio or a change in economic returns of 10% has been used.

Economic interpretation of the results has been relatively straightforward for those trials involving a simple change in variable costs or merely in agronomic practices. Some considerable difficulty, however, has been experienced in obtaining accurate data on the manhours required for an operation and its subsequent computation to a meaningful per hectare basis, since relatively small areas have been used for the trials. Fortunately, since the yield differences and economic returns have been so marked, slight errors in this particular computation have little effect on the overall picture.

A problem of far greater importance with respect to the economic analysis has been estimating the capital costs involved in constructing diffuse-light seed stores. The degree of complexity involved ranged from very minor modification to existing structures to the erection of very complex stores, some of which had been more elaborate and expensively constructed than necessary from a technological viewpoint and thus unfavourably influenced the economic evaluation of the technology. Further, many stores were built from unused materials already on the holding and constructed during hours when labour would not otherwise have been usefully employed. Thus, there is a conflict between the true economic cost of adopting the technology and the farmers' perception of the cost: and probably neither reflect the optimum cost of producing good quality seed. Such a conflict may be envisioned for the adoption of other technologies involving capital investments.

## Dissemination of Results

The technologies tested have been shown to be agronomically and economically sound and of likely benefit to farmers in the area. The process has now begun of disseminating the information throughout the locality. In addition to the normal arms of the extension services (farmers' meetings, municipal notice boards and the media) a "blueprint" or "technoguide" (Anon., 1982) has been written. This technoguide has incorporated the same principles as the original "package of technology"; but this package would be location specific, applicable to only a small area such as a province, with specific recommendations for each municipality or *barangay* (village) where necessary. Ultimately it is intended to translate the technoguide into the local dialects of the area. Each package is to be compared, as a single entity in the field, with farmers' current practices in that area. Similar problems of acceptance, particularly of expense, to those encountered in the original trials are likely to be encountered but, since each major item in the package has been tested under representative conditions, it is felt that farmers can choose those technologies which they regard as most appropriate to their own personal circumstances, in the knowledge that they have been thoroughly tested and positive benefits may be expected.

The path chosen by other similar projects will obviously depend very much on the ability of the extension services and their usual practices. However, experience has shown that attention should be given to this aspect at the outset and that the extension services, the ultimate educational arm, should be consulted and involved throughout. Success or failure of the whole process depends ultimately on their ability to get the message across.

## General Conclusions

In order for a programme of on-farm trials to be successful a logical stepwise approach, from the understanding of the farming system to the evaluation of results, must be adopted. Each step must be thoroughly explained and discussed by all participating persons and institutions, including a selection of potential farmer cooperators - the central pivot of any programme. Lack of understanding by any participator results in a lack of enthusiasm and frequent errors which may undermine the whole programme. The promotion of complex packages, therefore, is to be avoided.

Before embarking on the trials programme *per se* a thorough understanding of the current farming systems must be held by all concerned. Survey questionnaires are no substitute for the stationing, in the field, over an extended period, of a scientist trained in the social,

*Motivation*

i. Motivation of the technicians was of prime importance to the success of the project since much depended upon their diligent execution of the field work. The problems are not inconsiderable, particularly as the technicians are very busy: the creation of a "feeling of involvement" by means of a careful explanation of the philosophy behind the project; regular meetings, in which senior members of the PPP enthusiastically participated; group participation in such activities as planting and harvesting; and finally, constant contact and encouragement in the field, appear to have overcome most of these difficulties.

Unenthusiastic technicians, who have not adequate supervised their trials, have been dropped from the project since they contributed little to the project or to the farming community at large and cause a considerable drain on time and resources that could be better allocated elsewhere.

ii. Enthusiasm and cooperation on the part of the farmer was also of paramount importance since it was he who was bearing the financial risks and the brunt of the day-to-day field practices. Through their regular visits and patience, the technicians have built up an enviable rapport with the farmers and maintained considerable enthusiasm.

iii. Finally, the enthusiasm and encouragement of the PPP hierarchy should not be forgotten; since unless leadership is given by these administrators, members in the field will feel that their efforts are held only in low esteem. The regular meetings and visits to the field by senior members of the PPP have avoided this pitfall.

## Interpretation of Results

In the period to December, 1981, 41 of the "simple" trials were successfully harvested and a further nine were lost mainly to adverse weather. Trials were evaluated individually and collectively for each grouping.

Interpretation of individual trials consisted of two interrelated phases: an agronomic phase and an economic phase:

*Agronomic evaluation*

In general it was considered that an increase in yield of at least 15% was required before a farmer would be likely to adopt a technology: this is an arbitrary figure based on farmer consultations and demonstrations, which indicated that this difference was the minimum that farmers

*Group evaluation*

Results within any one group of trials were often very variable; thus to assess the appropriateness of each technology to the Mountain Province area as a whole, each variable was considered as a grouping, for example, the fertilizer placement trials shown in Table 5. This format acted as a guide to enable both farmers and extension workers to obtain an overall qualitative assessment of the technology, bearing in mind individual circumstances and risk. Detailed accounts of the trial procedures and results are to be published elsewhere (Potts et al, Chs. 6, 7, 8).

Table 5. Fertilizer Placement Trials: No. trials showing >15% increase or decrease in agronomic yield or >10% increase or decrease in economic returns.

| Factor | Increase | Decrease | No Change |
|---|---|---|---|
| Agronomic yield | 6 | 0 | 7 |
| Economic return | 10 | 1 | 2 |

*Farmer evaluation*

It has already been indicated that the agroeconomic evaluation described above may only act as a guide, as may the farmers' own comments made during the enthusiasm of the trials. A brief follow-up survey immediately following the above series of trials indicated that the farmers concerned and their immediate neighbours, who had been closely involved and consulted throughout, all stated categorically that they would adopt the new technology, even after only one season's results. However, it is becoming apparent as farmers plant successional crops that not all farmers have adopted the practices. This is in part due to natural conservatism but it would appear that other socioeconomic factor are involved. For example, many farmers are financed by merchants, who sometimes provide the necessary inputs in kind during the cropping season. A proposed change in practice on the part of the farmer may not suit the merchant therefore, and thus he may discourage the farmer. Only intimate knowledge of the farming system and a close relationship with all parties involved enables the researcher to identify and evaluate these other factors and to suggest methods of overcoming any problems.

economic and agricultural sciences. Such a scientist is then more able to understand the more personal motives involved in the farmer's decision-making, for example, the true role of the wife in decision making or the relationship of the farm o the creditors, merchants, etc. Field-oriented surveys, however, may be valuable means of confirming visual observations and obtaining necessary additional data; for example, in this project it was used to obtain a true estimation of yields, which had been consistently underestimated by previous survey questionnaires.

Even in areas already achieving average yields, there may be groups of farmers for whom alternative technologies would be beneficial. These technologies may not necessarily involve an increase in costs and may not even result in an increase in agronomic yield, but can still result in improved monetary returns. Such technologies appear most likely to be accepted.

Enthusiasm on the part of all involved is an essential prerequisite of a successful on-farm trials programme. Such a programme is by its nature a dynamic, long-term approach, which is constantly changing as new technologies become available. Planners and administrators, therefore, have a duty to maintain enthusiasm through active participation at all levels. Such participation will also enable the administrators to consider the appropriate methods of disseminating the accumulated information, so that the trials programme will be of lasting benefit and not merely an end in itself.

CHAPTER 6

# An Agro-economic Assessment of Seed-potato Storage Technologies in the Philippines

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## Introduction

A major constraint to potato production in many areas of the tropical zone is an adequate supply of good quality seed tubers at planting time. The problem is particularly troublesome in situations where seed must be kept in a warm climate for long periods; well beyond the end of natural dormancy. High storage losses occur frequently due to attack by pests and diseases and excessive sprouting and moisture loss, thus the cost of the remaining planting material is expensive. Furthermore, the resulting poor quality seed can only give rise to low yields.

Benguet and Mountain Provinces, the major potato production area of the Philippines, are a good example of this problem of seed storage. There are two main cropping seasons each year: the wet-season crop, March to July or August, and the dry-season crop, October to January or February. It is a general custom to store seed from a wet-season crop to plant the following wet season, and a similar situation pertains to the dry season; thus in both instances the seed must be stored for approximately nine months. Seed is usually stored, in net bags or in bulk, in darkness under the house, where ambient minimum temperatures may range from approximately 9°C in January to 16°C in July. A few farmers used to store under refrigeration at Manila, 300 km away; but high transport and storage costs and heavy losses have discouraged the practice.

To some degree, exposure of tubers to diffuse light has similar physiological effects as low temperatures; resulting in reduced sprout growth and a reduction in apical dominance. Such techniques are commonly used in developed countries for green-sprouting seed prior to planting (Dinkel, 1963).

In an attempt to demonstrate in the field that this technique of storing seed exposed continuously to natural diffuse light, under conditions of adequate ventilation, is a practical means of storing seed-tubers beyond their natural dormancy period, thereby reducing storage losses and improving seed quality, a series of demonstrations was set-up jointly by the Philippine Potato Programme and the International Potato Centre. The first demonstrations were set up in 1978, when a number of purpose-built rustic stores were constructed within the potato producing area (Anon. 1980b) (Plate 9b).

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Within 14 months of commencing the project at least 43 farmers had adopted the technique, with a greater or lesser degree of modification and sophistication, to suit their own situations (Rhoades et al, 1980).

This paper describes a series of trials aimed at estimating, in the farmer's field and under his everyday conditions, the influence of adoption on his agronomic yields and economic returns. The trial series formed part of a wider project, described by Potts et al (Ch. 5), in which very simple on-farm trials are used to verify results already developed, under the controlled conditions of the research station prior to their promotion by the extension services. Precise data was, therefore, not the primary aim; rather a number of trials were conducted throughout the production zone in order to obtain an overall evaluation of the capacity of the technology to improve the economic and social status of the farming community.

## Materials and Methods

### *Field trials*

Thirteen (13) trials were laid down during September, 1980 on farms located throughout the potato growing area, following harvest of the wet season crop in July to September, 1980. The seed tubers were obtained from this harvest. At one further site seed from the dry-season crop was harvested on 18 April, 1980 and placed into store on 28 July, 1980. Four treatments were used.

a. Farmer's *dark* store (Plate 9a) which corresponds to farmer's traditional practices.

b. Farmer's *improved* store (Plate 10a), reflecting varying degrees of acceptance of the use of the diffuse-light technology by farmers. Store modification ranged from the removal of shutters from small windows, to allow a little light penetration, to the replacement of whole walls of the store with transparent plastic sheeting, coupled with improved ventilation (Plate 10a).

c. The *simple* rustic store (Plate 9b) used in the original demonstrations (Anon. 1980) and which corresponds to near optimum diffuse-light storage conditions. Each store measured approximately 2.0 m by 1.2 m, had an overhanging thickly-thatched roof, transparent plastic sides and insect proof mesh ends; thus light was able to penetrate from all sides. The seed was stored in single layers on racks approximately 30 cm above each other (Anon. 1980).

d. *Refrigerated* store, a practice formerly used by a limited number of growers.

Table 6. Site and treatment details.

| Trial Code | Site | Variety | Date planted '81 | Date harvested '81 | No. tubers per treatment | Storage technology | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Dark | Improved | Simple | Refrigerated |
| A | La Trinidad | Isola | 3 April | 30 June | 1000 | + | + | + | + |
| B | Lengaoan | " | 24 March | 13 July | 1000 | + | + | + | + |
| C | Madaymen | " | 2 May | 10 Aug | 1000 | + | + | + | + |
| D | Sinto | " | 13 April | 22 July | 1000 | + | + | + | + |
| E | Loo | " | 23 March | 28 June | 1000 | + | + | + | + |
| F | Paoay | " | 30 March | 30 June | 1000 | | | + | + |
| G | Kalasipan | Conchita | 3 April | 15 July | 500 | + | + | | |
| H | Madaymen | " | 4 May | 5 Aug | 1000 | + | + | + | |
| I | Madaymen | " | 6 May | 6 July | 500 | + | + | | |
| J | Natubleng | " | 17 March | 9 July | 500 | + | + | | |
| K | Bayoyo | Cosima | 19 March | 14 July | 500 | + | + | | |
| L | Sinto | " | 13 April | 22 July | 1000 | + | + | + | |
| M | Paoay | Fina | 11 March | 16 June | 500 | + | + | | |
| N | La Trinidad | Arka | 18 Dec | 27 March | 200 | + | | + | |

Whilst the farms were not selected at random they were considered to reflect a representative cross-section of farmer ability and acceptance of the practice.

Tubers were selected for each treatment at random from the farmer's own seed supply and placed in store. The source of seed in each case was the farmer's own seed and varied in terms of cultivar and quality; except for sites A to F where the seed was all from the same harvest at the same source, that is, farmer "D." The number of tubers per treatment was the same at any one site (Table 6). Samples were also adjusted to ensure that the weight of each sample and the size of the seed-tubers within each sample were the same at any one site. The weight of tubers per treatment was recorded at the outset of the trial.

The dark-store treatment was placed in net bags under the farmer's house; the simple rustic-store treatment was displayed one layer deep in the rustic store; the farmer-improved treatment was stored in a manner exactly similar to that currently being practiced by the farmer, usually a single or double layer on racks or spread on the store floor; and the refrigerated treatment was stored at the University of the Philippines, Los Baños, 400 km south of the area, these samples were brought back to the farms on 20 March, 1981 and displayed in diffuse light in the farmer's store until planted.

Immediately before planting the number and weight of healthy tubers remaining in store was recorded, the number of sprouts on 100 randomly selected tubers counted and the length of the apical sprout measured: at one site only (site N) was the apical sprout removed prior to planting and the length of the longest remaining sprout was recorded.

The trials were not replicated. Treatments were planted, as whole tubers, in single blocks alongside each other within one field. All cultural practices were those normally used by the farmer concerned and thus varied from site to site.

Approximately six weeks after planting the number of plants per treatment that had emerged were counted. Ten sub-plots, randomly distributed within each block except for the outer rows, which were regarded as border rows, were then marked out and the number of main stems per hills within each sub-plot counted. Date of harvest was recorded before each sub-plot was harvested and the produce graded according to size and quality, using the farmer's own criteria, before weighing.

An attempt was made to keep a complete record of all costs, including capital costs, for each site throughout the course of the trials in order that an economic assessment of the treatments could be made as described by Cortbaoui and Booth (1980).

Sites were visited regularly during the storage and growing periods and notes made of farmer's observations and comments.

## Results and Discussions

The optimum amount of light required within a store is dependent upon a number of other factors, including the length of the storage period, cultivar, ambient air temperature and available ventilation: a long storage period, a cultivar with an inherently short dormancy period and high temperatures requiring more light. Thus it is exceedingly difficult to quantify the light requirement.

The quantity of light in the farmer-improved stores varied considerably between sites according to the degree of modification made to the store. In general it was felt from visual observations, that taking into account the long storage period involved and the cultivars used, there was probably insufficient light available in these stores, whereas the simple-rustic stores allowed almost the maximum available. In the same manner, the simple stores had good ventilation whilst many of the improved stores were considered to still lack adequate ventilation.

All trials were carried successfully through to harvest except at two sites, A and E, where the farmers-improved store treatment was lost due to premature planting by the farmer. No data is therefore available for these treatments.

Losses in seed-tuber number varied considerably between sites and are thus shown in full in Table 7. There was no common disease or pest factor to which losses could be attributed except that dry rot (*Fusarium* spp.) was observed in all the field stores, sites A to F, which had used seed of cv. Isola from the same single source: dry rot was not observed to any appreciable extent in seed from the refrigerated store treatment.

It would appear from the improved-store treatment (Table 7) that diffuse light and ventilation considerably reduced losses. The overall mean losses for the dark and improved store being 17% and 8% respectively by seed number and 33% and 28% respectively on a weight basis. However, this is not reflected by the simple-store treatment, where the mean loss in seed number and weight was similar to that for the dark store. This apparent high rate of loss was mainly attributed to dry rot, which was particularly noticeable in both the farmer's dark store and the simple-store treatment at two of the sites, A and E. These sites were at a lower elevation, 1300 and 1440 m amsl respectively, than the remaining sites, 1800-2200 m amsl, and were thus considerably warmer, a factor favouring the development of the disease (Hooker, 1980). Since seed

at both of these sites was from the same source it would appear that losses were due to combined effect of seed source and site location. It was these two sites that the improved store treatment was lost and no recordings were taken, thus the overall mean values shown in Table 7 are misleading since no account was taken of the effect of dry rot on seed-tuber loss in the mean values shown. If all treatments from these sites are omitted together with site F, where there was considerable damage due to vermin, then the overall mean loss in seed number and weight was dark 9% and 33%; improved 8% and 23%; simple 3% and 21% and refrigerated 13% and 27% respectively. Losses in the simple store would therefore appear to be generally minimal. The high losses in seed weight but not seed number in the farmer's dark store at site C was probably attributable to poor ventilation and thus high temperatures and respiration and water losses in this store.

The reduced losses in both light-store treatments were due in part to the effect of light *per se*, which caused a marked greening and toughening of the tuber skin and markedly reduced sprout growth (Table 8) (Plate 9c) and thus respiration and moisture losses, and also to improved ventilation, which lowered temperature in the store thus further lowering respiration and moisture losses: as reflected by the less shrivelled tubers. With the exception of site L, where the seed was obtained from the same source as the Isola and where the loss of 38% in the improved store was mainly attributable to dry rot also, losses in the improved-store treatment were similar to those in the simple store.

There was a mean loss of 15% in seed number from the refrigerated store, primarily due to physical damage in transit, which allowed secondary rots to enter the seed. No explanation can be forwarded for the low levels of loss for the refrigerated treatment at sites D and E. The reduction in respiration and thus moisture loss, due to the low temperature in the refrigerated store, was reflected by the more turgid tubers and thus losses in seed weight were reduced and partly compensated for the losses in seed number, when compared with the dark-stored seed.

The cultivars used in these trials were of medium or late maturity and, with the exception of site N, there was little visual difference in the length of the apical sprout from the three farm stored treatments at six weeks prior to planting. However, at planting both light-stored treatments had slightly shorter apical shoots; improved 22 mm, simple 20 mm, than the dark stored treatment, 27 mm (Table 8) and these differences were becoming increasingly more marked with time.

At site N the differences in sprout length were very marked with dark-stored seed having an average length of the longest remaining sprout of 147 mm (the apical sprout having been removed seven weeks prior to planting), whereas that from the simple store was only 16 mm. The exceptional sprout lengths recorded at this site reflected the

Table 7. Percent loss in number and weight of seed between commencement and end of storage phase.

| Site Code | % loss in seed number (weight) | | | |
|---|---|---|---|---|
| | Dark | Improved | Simple | Refrigerated |
| A | 36 (53) | - ( -) | 22 (42) | 21 (13) |
| B | 20 (47) | 2 (30) | 4 (17) | 16 (17) |
| C | 0 (50) | 9 (58) | 3 (26) | 16 (39) |
| D | 17 (42) | 6 (21) | 3 (21) | 8 (28) |
| E | 63 (74) | - ( -) | 77 (82) | 5 ( 5) |
| F | - ( -) | - ( -) | 21 (48) | 21 (29) |
| G | 7 (38) | 1 (38) | - ( -) | - ( -) |
| H | 0 (10) | 0 (24) | 0 ( 8) | - ( -) |
| I | 6 (29) | 3 (36) | - ( -) | - ( -) |
| J | 4 (25) | 2 (21) | - ( -) | - ( -) |
| K | 0 ( 7) | 1 (11) | - ( -) | - ( -) |
| L | 21 (39) | 38 (32) | 6 (31) | - ( -) |
| M | 1 (11) | 0 (11) | - ( -) | - ( -) |
| N | 8 (36) | - ( -) | 8 (28) | - ( -) |
| Overall Mean | 17 (35) | 8 (28) | 17 (34) | 15 (22) |
| Mean (Omitting sites A, E and F) | 9 (33) | 8 (23) | 3 (21) | 13 (27) |

Table 8. Length of apical sprout and number of sprouts at planting; emergence and number of main stems per hill at six weeks from planting.

| Variable | Storage technology | | | |
|---|---|---|---|---|
| | Dark | Improved | Simple | Refrigerated |
| No. sites at which storage method practices | 13 | 11 | 9 | 6 |
| Length (mm) apical sprout at planting | 27 | 22 | 20 | 2 |
| No. sprouts per tuber at planting | 3.0 | 3.1 | 3.9 | 4.7 |
| No. main stems per hill | 3.0 | 3.2 | 3.8 | 3,8 |
| % emergence six weeks after planting | 78 | 82 | 84 | 86 |

warmer seasons over which the tubers were stored combined with the lower and warmer elevation involved. They illustrate dramatically the difference of light and temperature on sprout growth.

At all sites, the light-stored tubers had green, robust sprouts whereas the dark stored seed had thinner, white sprouts, which were easily damaged. Interestingly, it was observed that there was a noticeable difference between cultivars in the degree of robustness of the greened sprouts, with those of the cv. Isola being rather more easily removed. The difference in sprout length and form would be expected (Dinkel, 1963) and trials have shown that where early maturing cultivars are used the differences markedly more pronounced (Sano, private communication). The tubers held in the refrigerated store showed negligible sprout growth due to reduced physiological actvity.

There was no difference in the number of sprouts per tuber at planting between seed from the dark store and from the improved store, mean 3.0 and 3.1 respectively (Table 8). Seed from the simple store had a mean sprout number of 3.9 per tuber. The cooler temperatures experienced in the refrigerated store resulted in a correspondingly higher number of sprouts per tuber, mean 4.7. At site N, where the apical sprout was removed seven weeks before planting, there was a marked increase in the number of sprouts per tuber, which were of a similar size to those used in the other trials, 6.0 and 7.4 sprouts per tuber for the dark and simple stores, respectively.

The number of main stems per hill were dark 3.0, improved 3.2, simple 3.8 and refrigerated 3.8. This pattern is similar to that for the number of sprouts per tuber (Table 8), an effect observed also by Goodwin et al (1969) except that those from the refrigerated store had proportionately fewer main stems. The proportionately lower number of main stems in this latter treatment may have been due to many of the sprouts being less than 1mm in length and thus undergoing a re-imposition of apical dominance following planting (Goodwin et al, *loc. cit.*; Morris, 1967).

The wide geographical spread of the trials made it impractical to accurately record the rate of emergence of the various treatments. Visual observations would indicate that the refrigerated treatment was later than the other treatments in emerging and that the two light treatments were slightly earlier than the dark-store treatment; particularly the simple-store treatment, where at all sites small rootlets were clearly visible at planting.

At several sites, however, the dark-store treatment was observed to emerge first. This may have been due to seed from this treatment being "physiologically older" than that from the other treatments, but it is considered more likely that this treatment, which had not been

desprouted, merely had marginally longer sprouts at planting and there was thus a *de facto* difference in planting depth since although the tubers of all treatments were placed at the same depth, the tips of the longer sprouts of the dark treatment were actually nearer to the soil surface.

The percentage of plants which had emerged six weeks after planting was least in the dark-store treatment (78%) and increased progressively in the order, improved store (82%), simple store (84%) and refrigerated store (86%). This pattern follows the degree of robustness in the sprouts and is probably a reflection of the varying degrees of sprout damage at planting and subsequent disease attack, particularly by *Fusarium* spp. and *Rhizoctonia solani*, which was observed in some of the crops of cv. Isola and cv. Cosima.

## *Marketable yield*

Planting was considerably delayed at many sites due to drought. Also, a typhoon in mid-June damaged all but one of the trials; site H. Date of maturity could therefore not be realistically assessed; no treatments were able to fully express their potential and yields are correspondingly low. Furthermore, trials tended, by change, to be planted in groups; for example, all those including the dark store, farmer's store and simple store were generally planted late, whereas those including the dark and farmer's store only were, in general, planted early (Table 6); thus it is not feasible to present data in terms of overall means, as for the other agronomic data, since mean yields from treatments which were in the main planted late would be unduly low due to the influence of planting date rather than by storage technology *per se*. The mean yield of marketable tubers expressed as tonnes per planted hectare has therefore been grouped by trial design for presentation in Table 9.

In the ten trials in which there was a direct comparison between the dark store and the improved store there was a mean increase in yield of marketable tubers from 13.3 to 14.3 tonnes per hectare (Table 9). This small increase in yield of only 6% is due mainly to there being at two sites, C and G, an unexplained but marked decrease in yield from the improved-store treatment. The effect of store improvement is shown more markedly in the means from the five trials in which the simple-store treatment can be included in the above comparison; the respective mean yields were darkstore 11.7 tonnes per hectare, improved store 13.6 tonnes per hectare and simple store 14.5 tonnes per hectare.

The apparent anomalies between the above two comparisons in terms of both absolute yields and yield increase due to storage treatment is partially due to the omission of the anomalous site G from the comparison but also to the, by change, use of different cultivars in each group. In the former group cv. Conchita predominated and, since this cultivar

Table 9. Yield of salable tubers.

| Variable | Storage Technology | | | |
|---|---|---|---|---|
| | Dark | Improved | Simple | Refrigerated |
| Mean yield salable tubers (t/ha) from trials comparing Dark and Improved | 13.5 | 14.3 | - | - |
| Mean yield salable tubers (t/ha) from trials comparing Dark, Improved & Simple | 11.7 | 13.6 | 14.5 | - |
| Mean yield salable tubers (t/ha) from trials comparing all treatments | 11.4 | 13.5 | 14.2 | 13.7 |

has a long dormancy period the benefit of diffuse light was not fully expressed in terms of seed-tuber condition at planting. Also, this cultivar is late maturing and the cessation of growth due to the typhoon would favour the earlier bulking "physiologically old" seed stored in the dark and warmer farmer's stores. Seed stored in the light stores, which were also cooler, may be expected to be "physiologically younger" and thus their potential yield, had the season progressed normally, could have been greater. In the latter group cv. Isola, which has a shorter dormancy period, predominated and thus, despite early typhoon damage, the benefits of improved storage techniques on seed-tuber condition were more apparent. Also, in this earlier maturing cultivar, the effect of physiological age may be expected to be less marked. In the comparison in which all four treatments could be compared cv. Isola was again used and hence the similarity to the previous comparison in the mean yields obtained; with overall mean yields of dark store 11.4 tonnes per hectare, improved store 13.5 tonnes per hectare, simple store 14.2 tonnes per hectare and refrigerated store 13.7 tonnes per hectare (Table 9). Yields from the refrigerated treatment were approximately equal to the improved-store treatment but slightly less (4%) than those from the simple store; due possibly to the effects of "physiological age" and the later emergence of the refrigerated treatment combined with the early cessation of growth due to typhoon damage preventing the potential of this treatment from being fully expressed. It was unfortunate that a trial at the Baguio Experimental Station to investigate further this possible effect of "physiological age" was completely destroyed by the typhoon.

Storage method had no consistent effect on tuber size at harvest.

## *Economic evaluation*

Precise economic data for the field trials was difficult to obtain; in particular those data relating to capital costs, since many stores had been modified over a considerable period of time prior to commencement of the trial series and frequently materials already available on the holding had been used. Precise records of material costs and the labour required were thus not available. However, following extensive interviews with the farmers and using the best information available a comparison was made between the traditional dark-store technology and each of the "improved technologies" using the procedure outlined by Cortbaoui and Booth (1980), (Table 10).

In ten trials a comparison was made between the traditional dark store and the farmer's improved store. In seven cases, there was a "significant" increase in net income, arbitrarily set at being equivalent in monetary terms to at least 500 kg of marketable produce, derived from the store improvement. In all seven cases this increase was due to an increase in agronomic yields and in five cases it was also due to a

Table 10. Comparison of net income from improved storage technologies compared with the traditional farm store.

| Comparison | No. of comparisons | No. trials with increase in net income | No. trials with equal net income | No. trials with reduction in net income |
|---|---|---|---|---|
| Dark vs Improved farmer's store | 10 | 7 | 2 | 1 |
| Dark vs Simple store | 8 | 6 | 0 | 2 |
| Dark vs Refrigerated store | 5 | 2 | 2 | 1 |

*de facto* reduction in costs. The lower in-store losses in the improved treatments necessitates less seed, and thus less capital, being placed in store to plant a given area. At two of the remaining three sites, the net return from each treatment was approximately the same: the difference amounting to less than 30 kg (site M) and 200 kg (site J) per hectare of ware potatoes at the current market price. At the final site (site K) there was a marked reduction in net return due to the lower yield from the improved store.

At six of the eight sites at which the simple store could be compared with the dark store there was an increase in net income due to store improvement. At one site (E) there was a marked decrease in returns due to dry rot and subsequent loss of seed tubers. The lower net income at the final site (C) was due to a slightly lower yield from the simple-store treatment and a reduction in tuber size giving a lower market price.

A comparison between the refrigerated storage and the traditional dark store was only possible at five sites. At two sites there was a marked increase in net income arising from refrigerated storage. At two further sites there was an insignificant increase/decrease in net returns due to there being only a marginal increase in agronomic yield which did not compensate for the high costs of refrigerated storage. At the final site (D) there was a decrease in net returns due to a slight (2%) decrease in agronomic yield but a large increase in storage costs.

## Conclusions

Although the trials design precludes the use of statistical analyses and there is a considerable variation within the data due to range of conditions pertaining at each site, it is apparent from the general improvement in agronomic yield and economic returns that the use of adequate diffuse light and ventilation is an appropriate approach to the problems of storing seed-potato tubers on the farm under developing country conditions. Such seed is capable of giving agronomic yields and a net income similar to, or better than, refrigerated storage, particularly where haulage over long distances to and from the latter is involved. Further, the technology considerably reduces risk on the part of the farmer, due to less storage losses and more healthy seed at planting time. These results are confirmed by the adoption of the practice by many farmers in the area (Rhoades et al, 1980).

CHAPTER 7

# An Agro-economic Assessment of White Potato Manuring Trials: Benguet and Mountain Provinces

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Elmo O. Sano and Felix R. Ru[illegible]

## Introduction

The white potato (*Solanum tuberosum* L.) is a major crop in the vegetable producing areas of Benguet and Mountain Provinces, frequently accounting for more than 50% of the cropped area in any one season (Manto et al, 1978). Production costs are high, particularly the cost of chicken manure and commercial fertilizer.

The surveys of Manto et al (*loc. cit.*) and Weibel (198[illegible]) indicate that 5.0 to 5.5 tonnes per hectare of chicken manure is norm[illegible] used and 130 to 140 kg per hectare of each of the major nutrients, nit[illegible]gen (N), phosphate ($P_2O_5$) and potash ($K_2O$), are applied as commercial fertilizer, usually as a complete compound formulation (14:14:14). At such levels manuring is considered to account for 35% of all production costs (Manto et al, 1978).

Visual observations and farmer consultations by the authors suggest that the quantity of chicken manure applied, which is considerably more than the 2.3 tonnes per hectare currently recommended (Anon. 1979a), is governed primarily by tradition and finance available at planting and bears little relationship to present soil condition, nutrient status, cropping pattern, etc. Further, it was observed at harvest, particularly for the dry-season crop, that often much of the manure remained undecomposed, thereby, raising some doubt as to its nutrient and economic value.

It has also been observed that commercial fertilizer, which is applied essentially at the rates recommmended (Anon., 1979a), is applied at the time of first hilling up and not at planting. This is contrary to the practice recommended (Anon., *loc. cit.*) and also to most research findings which indicate that $P_2O_5$ and $K_2O$ are required in large quantities by the potato crop but both are only slightly soluble (Burton, 1966).

The traditional practice of applying commercial fertilizer would, therefore, appear to make inefficient and uneconomic use of these elements since, if these elements are to be readily available to the plant, they should be placed directly in the rooting zone because it is unlikely that they will be leached to this zone when applied to the soil surface at hilling-up.

The following series of trials formed part of the Philippine Potato Programme's strategy of Optiming Potato Productivity (Potts et al, Ch. 5)

and were designed to investigate the response of the potato crop to chicken manure applied under a range of conditions and to quantify the benefits that may be expected from applying all the commercial fertilizer at planting.

## Materials and Methods

Twenty-three trials were conducted from March, 1980 to February, 1982 at sites throughout the major production areas of Benguet and Mountain Provinces. The location of the trials is shown in Tables 11 and 12, only one trial being conducted on any one farm. Each trial covered a minimum area of 500 $m^2$, divided into two treatments: the "farmer" treatment and the "alternative" treatment. The trials were not replicated at any one site, being planted as single blocks, side by side.

In the "farmer" treatment, the farmer was asked to carry out all procedures from land preparation to harvest and marketing according to his normal customs. Thus some agronomic factors varied from site to site; for example, cultivar, absolute level of fertilizer inputs, the use of single or double row bed, plant population and disease control practices; but they were consistent within the two treatments planted.

In the "alternative" treatments, the farmer did all procedures as before except that:

a. in ten trials no chicken manure was applied, or

b. in the remaining 13 trials all the commercial fertilizer was applied at planting; ensuring that the same rate per hectare was applied in both the "farmer" and "alternative" treatments.

At harvest, ten samples (10 m long and one bed wide) were taken from each treatment at each site. The produce was graded according to size and quality by the farmer himself; and thus varied according to his own standards and those which he thought the market would bear. Each grade was then weighed. All costs and labour requirements relating to the use of the alternative treatment, its harvesting and marketing were recorded using the "farm-gate" prices obtained by the farmer. Informal discussions and demonstrations were done throughout the trial programme to obtain the farmer's reactions to the practices (Potts et al, *loc. cit.*).

## Results and Discussions

The effect of eliminating chicken manure varied considerably according to site (Table 11). Both yield increases, of up to 3.7 tonnes per hectare, and yield reductions, of up to 11.3 tonnes per hectare, were obtained with an overall mean reduction in yield of 1.7 tonnes per hectare or 9%. Changes in net monetary returns to the farmer also varied, ranging from a decrease of 30% to an increase of 42%, with an overall mean decrease of 2%.

Application of the commercial fertilizer to the seed-bed instead of as a side-dressing gave an increase in yield at 11 of the 13 sites: mean, 2.9 tonnes per hectare or 15% (Table 12). At one site, Bosleng, there was a slight reduction in yield of 1.0 tonnes per hectare due to the change of practice and at the remaining site, Loo (i), there was no change in yield. Similarly, there was an increase in net monetary returns at the eleven sites showing a yield increase: mean 21%. At the two remaining sites there was a small decrease in returns.

Marked difference between treatments in the size range of tubers produced were observed for both group of trials, but these differences did not vary consistently with treatments, although they did in some instances affect the net monetary returns.

Informal discussions and demonstrations conducted with the farmers suggested that a yield difference of at least 15% was required if it was to be perceived by the farmer in the field. Similarly, a change in net monetary returns of approximately 10% was generally thought necessary before being regarded as significant by the farmer. Although opinions differed beween farmers in this latter respect there was no obvious association with farm size, socio-economic circumstances, etc. These figures have, therefore, been regarded as "significant guidelines" in the remainder of this discussion.

No consistent patterns were discernable, in either group of trials, regarding the effect of the uncontrolled agronomic factors, such as cultivar or plant density, on the "alternative" treatment. Thus it was concluded that such factors had an insignificant effect, if any, on the treatments being studied and therefore could be disregarded in the following discussion.

### *Organic manuring*

Using the above criteria, the elimination of chicken manure gave a significant increase in yield at two sites, a decrease at two sites and no practical change at the remaining six sites (Table 13).

Table 11. Agronomic yield at each site, with or without chicken manure (CM) and change in net income, pesos (₱),due to the elimination of CM.

| Site | Yield (tonnes per hectare) With CM | Without CM | Change in net income (₱) |
|---|---|---|---|
| La Trinidad | 11.6 | 13.6 | + 6296 |
| Lengaoan | 18.5 | 22.2 | + 11647 |
| Loo (i) | 9.3 | 8.3 | 0 |
| Loo (ii) | 29.3 | 26.3 | + 2318 |
| Paoay (i) | 4.1 | 3.8 | + 2584 |
| Paoay (ii) | 29.5 | 26.2 | + 479 |
| Sadsadan | 27.7 | 17.8 | - 4913 |
| Sayangan (i) | 32.5 | 30.4 | - 2134 |
| Sayangan (ii) | 33.3 | 23.0 | - 20660 |
| Sinipsip | 6.4 | 6.4 | + 2913 |
| Mean | 19.6 | 17.9 | - 97 |

Table 12. Agronomic yield at each site, side dressing or basal application of commercial fertilizer, and change in net income, pesos (₱), due to basal application.

| Site | Yield (tonnes per hectare) | | Change in net income (₱) |
|---|---|---|---|
| | Side dressing | Basal appl. | |
| Abatan | 10.6 | 23.1 | + 30400 |
| Bakun | 14.3 | 17.5 | + 3651 |
| Bosleng | 24.5 | 23.5 | - 2466 |
| Cot-cot (i) | 21.4 | 24.0 | + 6848 |
| Cot-cot (ii) | 20.5 | 24.1 | + 5812 |
| Loo (i) | 16.0 | 16.0 | - 3758 |
| Loo (ii) | 18.3 | 20.0 | + 4853 |
| Masala | 29.5 | 30.6 | + 3108 |
| Natubleng (i) | 10.7 | 12.6 | + 4808 |
| Natubleng (ii) | 21.4 | 24.6 | + 7310 |
| Natubleng (iii) | 21.7 | 25.0 | + 11030 |
| Suokan | 9.2 | 14.0 | + 9250 |
| Tulodan | 29.7 | 31.3 | + 6373 |
| Mean | 19.1 | 22.0 | + 6709 |

In economic terms, however, there was a significant increase in net monetary returns at four sites where chicken manure was eliminated. At two sites, Loo (ii) and Paoay (i), this was due to the saving in costs of the chicken manure outweighing a slight decrease in yield. At the other two sites, La Trinidad and Lengaoan, the chicken manure probably depressed yields because it had not been sufficiently composted and then was not thoroughly incorporated into the seed-bed: scorching of the sprouts and poor, delayed emergence resulted. Such practices are frequently observed in the area. At four sites there was no change in net returns but at the remaining two sites, Sadsadan and Sayangan (ii), the yield reduction far outweighed any saving in costs to give a decrease in net monetary returns.

Dried poultry manure is considered to contain 5% total nitrogen (N), 3.0% total phosphorus ($P_2O_5$) and 1.5% total potassium ($K_2O$); as well as a number of minor nutrients and trace elements; in particular calcium, 4.0% CaO (Anon., 1979b). Thus, if chicken manure is applied at the 5.0 tonnes per hectare recorded by Manto et al (1978) and Weibel (1981), then a total of 250 kg of N, 150 kg of $P_2O_5$ and 75 kg $K_2O$ is being applied per hectare. The reduction in yield arising from the elimination in chicken manure observed at some sites may therefore be expected due to its contribution of nutrients to the crop.

Although no soil analyses were made prior to the trial series, visual observations indicated that there was s relationship between soil type and yield response to chicken manure application. Sub-soils and soils low in organic matter, for example at Paoay (ii) and Sayangan (i) and (ii), gave consistently marked yield increases as a result of chicken manure application. This may be due to the organic matter providing essential nutrients since analyses have shown that chicken manure concontains not only N, $P_2O_5$ and $K_2O$ but substantial quantities of other nutrients also, in particular calcium, magnesium and copper. No explanation can be readily forwarded to account for the substantial yield response to chicken manure application at Sadsadan, an area recently cleared from forest and with soils rich in organic matter. However, soil pH in this area is known to be low, less than 4.5 and often below pH 4.0 (Bureau of Plant Industry, private communication) and it is possible that the chicken manure (pH *circa* 7.5, is supplying nutrients which would otherwise be "fixed" at these low pH's. Experiments are currently being carried out by the Bureau of Plant Industry to investigate this effect.

The effect of chicken manure was particularly noticeable also at two sites where the irrigation facilities were considered inadequate, Loo (ii) and Sayangan (ii); suggesting that the organic matter was aiding the conservation of moisture. Due to the generally small quantities of irrigation water being applied and the dry nature of the soil in both treatments at these two sites it is unlikely that the beneficial effect of chicken manure was due to its influence on water uptake *per se*: a

conclusion supported by Holliday et al (1965). Harris (1960) suggests that small lumps or pieces of organic matter, for which he introduced the term "nodules", that were incorporated below the seed-piece were capable of retaining sufficient moisture to permit the potato roots to absorb nitrogen and other nutrients from within their structures at a time when the moisture in the surrounding soil was insufficient to permit the uptake of nutrients from commercial fertilizer. Further supportive evidence for this hypothesis is given by Holliday (1970).

No assessment has been made in this trial series of the long-term effect of the use of chicken manure on soil structure, micro-element status, etc., but the rapid breakdown of organic matter during the hot, moist wet season would suggest that there is little long term effect on soil structure. The evidence from these trials would indicate that, at sites with an adequate soil pH and inherently high organic matter contents in particular, careful attention should be given to the frequency of use of chicken manure and to the quantities used: considerable monetary savings could be made in view of the rapidly increasing cost of organic manures.

## *Commercial fertilizer*

The change in the timing of application of commercial fertilizer, from a side-dressing to a basal application, gave a significant increase in yield at six of the thirteen sites: yield changes being only small at the remaining seven sites (Table 14). However, in terms of net monetary returns a significant increase was obtained at ten sites: due in part to increased yield but also in some instances a slightly larger average tuber size where the fertilizer was applied basally, thus giving a higher market price. At two sites, Loo (i) and Masala, the yield differences were insufficient to affect the monetary return. At the remaining site, Bosleng, the slight yield decrease was associated with smaller tubers, which had a correspondingly lower market value, to give a significant reduction in net monetary returns.

The slight decrease in yield recorded at Bosleng was almost certainly due to the commercial fertilizer not being thoroughly incorporated into the seed-bed before planting and thus scorching of the shoots and delayed and erratic emergence ensued. Similarly, scorching and delayed and erratic emergence was observed at the one site at Loo (i) where no yield change was observed. Careful attention should be paid by the farmer to the thorough incorporation of the commercial fertilizer if this change in practice is to be consistently successful.

The results would appear to confirm the premise that in order to make efficient use of commercial fertilizer it should be placed directly in the rooting zone where the less soluble $P_2O_5$ and $K_2O$ components are readily available to the plant.

Table 13. Number of trials (n = 10) showing > 15% increase, decrease or no difference in agronomic yield and > 10% increase, decrease or no difference in net monetary return due to the elimination of chicken manure.

| Factor | Increase | Decrease | No difference |
|---|---|---|---|
| Agronomic yield | 2 | 2 | 6 |
| Monetary return | 4 | 2 | 4 |

Table 14. Number of trials (n = 13) showing > 15% increase, decrease or no difference in agronomic yield and > 10% increase, decrease or no difference in net monetary return due to the basal application of commercial fertilizer.

| Factor | Increase | Decrease | No difference |
|---|---|---|---|
| Agronomic yield | 6 | 0 | 7 |
| Monetary return | 10 | 1 | 2 |

The application of commercial fertilizer at planting instead of at hilling-up involved no increase in input costs; although it admittedly requires an increased labour input during this peak period. However, the yield and monetary benefits accruing from this change of practice are considerable and it would appear to be a more economic method of utilizing this expensive resource.

## Conclusion

In view of the increasing costs of both organic and commercial fertilizer, careful attention should be paid to their use if crops are to be profitable. This trial series has indicated that the use of organic manures, in particular chicken manure, may possibly be reduced with little, if any, loss in monetary returns: possible methods would include a reduction in the quantity used in each season or a limitation of its use to, say, alternate seasons. Long term trials, however, are needed to verify this.

More immediately, these trials have shown that the correct application of commercial fertilizer at planting instead of as a side-dressing may be expected to result in a direct and substantial improvement in yield and monetary returns. Such an improvement may be expected for many other crops where a complete fertilizer is applied as a side-dressing; for example, the use of this practice has been observed by the authors in Benguet on rice, cabbage, carrot and beans. A similar programme of trials with these crops could be used to verify this and be used as the basis for an extension exercise.

CHAPTER 8

# An Agro-economic Assessment of Further On-farm White Potato Production Trials

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## Introduction

The availability and high cost of seed-pieces at planting time and the cost of fertilizers, especially chicken manure, are continually cited by farmers as being major constraints to white potato production, both in the traditional producing areas of Benguet and Mountain Provinces (Manto et al, 1978; Vergroesen,1980; Weibel, 1981) and also new production areas such as Mindanao (Acasio et al, 1980; Balanay, private communication).

Whilst seed from the RP/German Seed Potato Programme should in future ensure a continuous supply of good quality seed, estimates (derived from an updated version of Anon., 1982) indicate that its cost will still be a major factor in potato production: 50% of production July, 1982 prices. Fertilizers may be expected to account for at least a further 25% of production costs.

Potts et al (Ch. 5) have described an approach to technology transfer in which "on-farm" trials form the central pivot. Early trials (Potts et al, Ch. 6) indicated that improved seed-storage practices could substantially reduce seed-piece losses while at the same time increasing yields. Similarly, Potts et al (Ch. 7) showed that in many instances fertilizer inputs may be reduced and that by different application techniques more efficient use could be made of them.

This note describes further trials, based on a preliminary informal survey, which are intended to identify further improved practices, with a view either to more detailed research effort or to their immediate implementation by the Extension Services.

## Materials and Methods

Forty-five trials were carried out according to the approach described in details by Potts et al (Chs. 5, 7). In each case on alternative technology was compared with the farmers current practice. Other than for the particular technology being tested all rates, time of application, etc. were the same for both treatments. Agronomic and economic data pertaining to the change in practice were carefully recorded together with the farmer's reactions.

Three facets relating to seed quality were compared: the use of locally certified seed, larger seed-pieces (35-55 mm) and cut-seed pieces.

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Four aspects of manuring were also studied: the use of organic fertilizers (McLife or Sagana 100) in place of chicken manure; the application of all commercial fertilizer to the seed-bed instead of the more usual side-dressing; the use of side-dressings (Potash, $K_2O$ and nitrogen, N); and the use of lime. The number of test sites are shown in Tables 15 and 16.

## Results and Discussion

### *Seed quality trials*

The results of the seed quality trials are summarised in Table 15, where a yield increase of more than 15% and a *net* benefit/cost ratio (B/C) more than 0.65 have been regarded as significant improvements (Potts et al, Ch. 5).

Certified seed improved yields and monetary returns at two of the four sites. Certified seed is presently only of European cultivars, which have been only recently introduced to the Philippines in any significant quantities. Thus, much of the farmers' own seed of these cultivars is still of good quality, being only a few generations removed from importation. It is not surprising, therefore, that certified seed did not always give an improvement in yield. It was not possible to determine the number of multiplications that farmers' seed had undergone since importation, but field observations of the degree of virus infection and the significant number of "off-type" plants, for example, other cultivars, would indicate that the farmers' seed in those trials where certified seed gave an improved yield had been multiplied for several generations in this country. As time progresses and these cultivars become more generally available differences are likely to be more marked. Production of certified seed of the older cultivars, Conchita and Greta, which were imported 1961-1963 and are still preferred by many farmers for the wet season crop, has now been initiated and differences between certified seed and farmers' seed may be expected. A programme of "on-farm" evaluation over a number of seasons is thus required if the value of certified seed and its effects on farmers' seed is to be understood.

The six trials in which larger seed-pieces, 35-55 mm, were used in place of the farmers own small seed demonstrated conclusively the benefit in agronomic terms of this practice and also showed that in most instances, five trials out of six, a substantial improvement in monetary return may also be expected. Based on even the limited number of trials conducted, it would appear that this practice is ready for promotion by the Extension Services. However, further trials to look at plant spacing would seem appropriate since observations by the authors have indicated

Table 15. Seed quality trials: Number of trials showing > 15% increase, decrease or no difference in agronomic yield and a net benefit/cost ratio of < 1, > 1, or no difference.

| Change in practice | No. Sites | No. trials giving > or < 15% change in agronomic yield | | | Trials giving net b/c ratio 1.0 | | |
|---|---|---|---|---|---|---|---|
| | | > 15% | < 15% | No change | > 1.0 | < 1.0 | No change |
| 1. Certified seed vs. Farmers' Own | 4 | 2 | 0 | 2 | 2 | 0 | 2 |
| 2. Seed-pieces of 35-55 mm vs. Farmers' own small seed | 6 | 6 | 0 | 0 | 5 | 0 | 1 |
| 3. Whole seed vs. Farmers' cut seed | 5 | 0 | 0 | 5 | 0 | 0 | 5 |

that where farmers' small seed is planted at close spacing substantial yields may be obtained; similarly, unnecessarily high seed rates seem to be being used where farmers are planting large seed-pieces at close spacings.

No improvement in either yields or economic returns were obtained when using whole seed in place of cut seed for this dry-season planting. The use of cut seed-pieces by farmers for the dry-season crop is a common practice (Potts, Ch. 2) and these trials indicate that despite comments to the contrary by many workers in this area, this practice is wholely acceptable; all five trials giving an significant improvement in agronomic and monetary returns. A possible explanation for the misunderstanding by research workers is that for the dry-season crop, the seed-pieces are usually cut under the warm moist conditions pertaining at the end of the monsoon season and then placed soon after cutting into a warm and moist, but not excessively wet, seed-bed. Thus suberization of the cut surface proceeds rapidly and seed-piece decay is minimized. Where the technique is, infrequently, practiced for the wet-season crop, however, the seed-pieces are often cut outdoors under hot, dry conditions so that the cut surface rapidly dries and adequate suberization is prevented. When such seed-pieces are placed in a hot, dry soil prior to the onset of the rains seed-piece decay is rapid. Thus, if farmers show sufficient demand for cut seed at this time,on-farm trials and extension practices to evaluate improved cutting practices are needed.

## *Fertilizer trials*

The results of the fertilizer trials are shown in Table 16. The same agronomic criteria have been used as for the seed quality trials but for the economic evaluation a change in *net* returns of more than 10% has been regarded as significant since many of these trials involved no change in costs and a meaninful *net* benefit/cost ratio cannot be calculated.

The trials to evaluate the value of the alternative organic fertilisers, McLife and Sagana 100, in place of chicken manure indicated that at the rates recommended, neither was capable of giving increased yields over chicken manure: seven of the ten trials giving no significant improvement in yield. The one trial in which McLife gave an increased agronomic yield was probably due to the chicken manure being insufficiently composted and thus causing damage to the young sprouts prior to emergence, resulting in delayed, uneven emergence. An explanation for the reduction in yield at two sites where these alternative fertilizers were used cannot be forwarded. In monetary terms, the use of these alternative fertilizers is also of doubtful value: Sagana 100 being less economic than chicken manure in each of the three trials and

Table 16. Manuring trials: Number of trials showing > 15% increase, decrease or no difference in agronomic yield and > 10% increase, decrease or no difference in net monetary returns.

| Change in practice | No. sites | No. trials giving > or < 15% change in agronomic yield | | | No. trials giving > or <10% change in economic returns | | |
|---|---|---|---|---|---|---|---|
| | | > 15% | <15% | No change | > 10% | <10% | No change |
| 1. Use of McLife vs. Farmers' use of chicken manure | 7 | 1 | 1 | 5 | 1 | 1 | 5 |
| 2. Use of S100 vs. Farmers' use of chicken manure | 3 | 0 | 1 | 2 | 0 | 3 | 0 |
| 3. All commercial fertilizer applied as basal vs. Farmers' side-dressing | 8 | 4 | 2 | 2 | 4 | 2 | 2 |
| 4. Use of potash as a side-dressing vs. Farmers' use of 14:14:14 alone | 4 | 2 | 0 | 2 | 3 | 0 | 1 |
| 5. Use of nitrogen as a side-dressing vs. Farmers' use of 14:14:14 alone | 2 | 1 | 0 | 1 | 1 | 1 | 0 |
| 6. Use of lime vs. Farmers' non-use | 3 | 1 | 0 | 2 | 1 | 0 | 2 |
| 7. Use of lime plus half rate chicken manure vs. Farmers' use of chicken manure alone | 3 | 1 | 1 | 1 | 2 | 1 | 0 |

McLife showing no benefit in five trials, an increase in one and a decrease in one; all reflecting the changes in agronomic yield. Further trials with these products should possibly be limited, therefore, unless there is a marked worsening of the availability of chicken manure, an increase in its price or a change in the recommended application rate of the alternative products.

In the eight trials involving the placement of inorganic fertilizer, as 14:14:14 ($N:P_2O_5:K_2O$), four gave a significant increase in agronomic yield, two no change and two a decrease: a pattern reflected by the changes in monetary returns. These results are in accord with those already reported by Potts et al (Ch. 7).

Both nitrogen and potash fertilizers, applied as side-dressings at hilling -up, have been used by some farmers. In view of the high solubility of nitrogen fertilizers the practice would appear to have some merit, particularly during the wet season. In the two preliminary nitrogen trials, in which 40 kg per hectare of nitrogen, applied in the form of ammonium sulphate as a side-dressing at hilling-up, one trial gave an increase in agronomic yield with a corresponding increase in monetary returns whilst the other trial gave no increase in yield and a decrease in returns due to there being a higher proportion of small, and thus less valuable, tubers. Further trials, possibly at the research station level initially, into rates of nitrogen application and its timing would, therefore, appear necessary.

The use of potash, as 60 kg per hectare $K_2O$ applied as muriate of potash, would appear to be worthy of further investigation. Two of the four trials gave a significant increase in agronomic yield and two no change. However, in monetary terms three of the trials gave a significant increase in returns, since at one site where there was no difference in agronomic yield there was, for some reason which cannot be readily explained, a high proportion of large tubers which commanded a correspondingly higher price in the market.

As of 31 August two trials involving the application of lime alone, at a rate of five tonnes per hectare, had been harvested. In neither trial was there a significant change in agronomic yield or monetary returns. However, one of the two trials involving the use of a similar rate of lime application but with a concurrent reduction in chicken manure, from 6 to 3 tonnes per hectare, gave a significant reduction in both agronomic yield (15.9%) and monetary return (15.9%). The remaining trial gave no change in agronomic yield by a significant increase (10.7%) in monetary return.

The lack of any positive response to the application of lime can be explained by the unfortunate choice of sites. Due to the delay in obtaining pH analyses trials had to be planted before pH results were

obtained. In practice only one site had a pH of < 5.0 (pH 4.9): that being the one which gave a small increase (5%) in agronomic yield and a significant increase in monetary returns. The remaining sites had a pH in the range 5.1 to 5.6. Potatoes are known to be tolerant to low soil pH's and thus it was not altogether surprising that lime had no significant effect in these trials. However, a review of 556 samples of soil from Benguet Province submitted for analysis during the dry season 1981/82 showed that 161 (29%) had a pH below 5.0, a level of which some response to lime application may be expected; thus it would appear that a further series of trials is necessary using more carefully selected sites.

The biological role of chicken manure is far from clear (Potts et al, Ch.7 ) but the authors felt that it may be ameliorating soil pH in the immediate vicinity of the roots. It was felt, therefore, that use of this expensive commodity could be reduced by substituting an application of lime. Such a practice would be of longer lasting benefit than the use of chicken manure and at the rates used would not alter total input costs. The trials give tentative supporting evidence to this hypothesis in that there was no significant change in yield whilst the marginal reduction in inputs costs resulted in a slight increase in returns. Further trials would thus appear to be desirable. However, as stated by Potts et al (Ch.7 ) a full analysis of chicken manure followed by comprehensive laboratory and experimental station trials is necessary if the role of this commodity is to be understood.

## Conclusions

The trial series have indicated ways in which the use of two expensive inputs, seeds and manures, may be more effectively used. Two recommendations may be promoted immediately by extension specialists: the use of larger seed-pieces and the placement of all commercial fertilizer to the seed-bed. Other practices which could be profitably investigated through further on-farm trials [illegible] value of certified seed, the use of potash as a side-dressing and [illegible] use of lime. At the research station level investigations are required into the role of chicken manure and the rate and time of nitrogenous fertilizer application.

# SECTION IV:

Farmer Acceptance

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# SECTION IV

## Farmer Acceptance

### Introduction

Demonstration that a practice is agronomically and economically viable over a number of seasons and in various situations is still not axiomatic with acceptance by farmers: many other, particularly social, factors being included in his decision-making process. Too little time has passed since these trials were carried out for acceptance to be reliably assessed and arrangements are in hand for acceptance to be monitored during forthcoming seasons. However, two aspects are worth noting at this juncture: the apparent acceptance of diffuse-light seed potato storage practices and the refusal by farmers to consider a reduction in the use of organic manures.

The acceptance of new seed-storage practices by Benguet farmers are still being monitored by CIP scientists as the concept spreads from the original demonstration sites. The two papers in this section describe the situation to date.

The high cost of organic manures, particularly chicken manure, is to the fore of most farmers' minds,as indicated by their constant requests for alternatives. Whilst it is readily acknowledged that the trials concerning the use of organic manures were generally inconclusive, it is interesting to note that even on farms where it was demonstrated that considerable savings could be made in their use farmers and their neighbours were reluctant to do so. Reasons varied, both between farmers and with the occasion on which they were interviewed. In essence, risk appears to be a major factor since farmers having been using chicken manure for many years and would prefer to use chicken manure as a form of insurance policy rather than see yields drop to their former levels when other factors, particularly seed quality,were anyway responsible for the low yields.

Again farmer attitude to the use of chicken manure is to be studied in more detail,together with the apparently ready acceptance of the placement of organic fertilizers into the seed-bed rather than as a side-dressing at hilling-up, in the near future.

CHAPTER 9

# Farmer Acceptance of Improved Potato Storage Practices in Developing Countries

Robert E. Rhoades, Robert H. Booth and Michael J. Potts

## Introduction

Central to the success of the "Green Revolution" has been the acceptance by Third-World farmers of new high-yielding, rapid-maturing cultivars. This technological development, however, has often led to unforseen problems. A change in cultivars frequently means that a host of related practices have to be altered as well. Amongst these new consequences facing applied agriculturalists has been the need to adapt traditional storage systems to preserve not only the bumper crops from the improved cultivars but also the seed required for the next planting.

Post-harvest problems are especially paramount with the potato, a highly perishable but economically and nutritionally important vegetable in developing countries. Traditional potato-storage practices found in most Third-World areas have evolved over relatively long spans of time. They have developed in relation to environmental, climatological, and social conditions as well as to the specific characteristics of the cultivars grown. "Local" or "native" cultivars that have been grown in many countries for decades are often considered by farmers to have excellent "keeping quality". However, the recent introduction of new, "improved" potato cultivars with vastly different growth and storage characteristics has led to the urgent need for an appraisal of traditional storage practices.

The International Potato Centre (CIP), headquartered in Lima, Peru, has recognized the importance of potato storage in developing countries by establishing a major research thrust devoted to post-harvest problems. The approach adopted by this thrust is that research must begin and end with the farmer. This necessitates an understanding of farmer practices and perceptions before workable technical solutions can be proposed (Rhoades and Booth, 1982). This "farmer-back-to-farmer" approach has been utilized successfully in several Asian and South American countries.

This paper discusses a technology transfer case involving the post-harvest thrust: the adaptation of diffused-light potato seed-stores to local conditions in the main vegetable growing provinces of the Philippines and its subsequent acceptance by local farmers. It illustrates, also, similar processes of adoption of new storage practices in several other countries where the same technology has been introduced. An understanding of these processes can be highly relevant to international efforts aimed at reducing post-harvest losses in developing countries.

## Traditional Storage Practices: The Philippines

As in many developing countries, Philippine potato farmers customarily piled seed potatoes on the floor of houses and provided no ventilation or light, except that which incidentally came through windows and doors. According to these farmers, losses due to excessive sprouting and disease, were considerable but the innate good keeping quality of traditional cultivars enabled some tubers, at least, to be kept in acceptable condition for the next planting.

The increased demand for vegetables (from the Manila metropolitan complex) during the 1960s and '70s boosted the potato from essentially a local subsistence vegetable to one of the major commercial crops for mountain farmers. One response to this situation was the replacement of traditional cultivars with new higher yielding imported cultivars: a trend that has continued to accelerate.

However, while the cultivars changed rapidly, storage practices and knowledge lagged behind. Losses with the new cultivars were acknowledged to be very high and were sufficient to encourage some of the larger, more affluent farmers to select-out their seed potatoes and send them to cool stores in Manila, 350 kms away. However, the increasing expense and excessive transportation losses have discouraged even these farmers from continui the practice.

## Farmer Need and Response

It was in the context of these traditional practices and changes that the government's Philippine Potato Programme identified the problem of effective storage of expensive improved potato seed as a key issue. This awareness was tied to the formation of a government sponsored seed program assisted by German Federal Republic technical aid.

Representatives from the International Potato Centre and Philippine Potato Programme held intensive discussions with farmers regarding their storage practices and needs. It became apparent that the use of diffused-light rustic stores might be appropriate to Philippine conditions. This technology utilizes the scientific principle that indirect light reduces sprout growth, increases sprout number and at the same time causes a greening and toughening of the tuber skin. A seed-piece with several short sturdy sprouts, which is capable of producing numerous main stems and consequently high yields and which shows considerable resistance to storage rots thus results.

Farmers at first showed reluctance to experiment with the new technology. However, at one Municipality, the mayor agreed at a farmers'

meeting to allocate municipal funds for a simple test-demonstration dif sed-light store, which was built by the farmers in October, 1978. Du. .ng the course of pıanning and constructing the store every attempt was made to involve the farmers to ensure that the store was both simple and inexpensive and yet appropriate to their needs.

During the 1979 another five simple rustic stores were built throughout the production area. After observing these demonstration stores a few farmers began altering their practices. Adaptation varied: some growers simply removed covers from their store windows to allow more light to penetrate, others replac one or two of the traditional galvanized-iron cladding with inexpens e translucent plastic sheeting and, in a few instances, farmers conve ed derelict mushroom houses to make potato stores capable of holding up to eight tonnes of seed. Moreover, many farmers introduced shelving into their stores to ensure that each tuber was exposed equally to the light. A survey at the end of that year revealed that at least 43 farmers, probably more, had modified their stores in some way (Rhoades et al, 1979).

## Evaluation

Simultaneously as these modifications were being made to stores, 14 on-farm trials were conducted by the Philippine Potato Programme in an attempt to quantify the agro-economic benefits of the new storage practices (Potts et al, Ch. 5). These trials showed that seed stored for nine months under good diffused light conditions in simple demonstrations stores was capable of a 23% increase in yield over comparable seed stored by traditional methods. Seed stored in the farmer improved stores gave an average of 16% increase in yield, although these stores were unknown to be still far from ideal. These increases were similar to those obtained when seed was stored in a cool-store near Manila. In 12 of the 14 cases, crops from the improved stores gave a marked increase (> 10%) in net monetary returns to the farmers (Potts et al, Ch. 6).

By early 1982, a total of at least 160 farmers were known to have made alterations to their storage practices. The degree of alteration or acceptance continued to vary considerably. With the exception of three cases, farmers did not copy the prototype demonstration store. Instead, most accepted the principle of using indirect light and adapted it to their conditions. The variations of these adaptations ranged from simply spreading potatoes in front of a window to the new construction by a cooperative of a 100 tonne capacity natural diffused-light potato store. The success of this new technology has led farmers to consider other "improved" practices and has boosted farmers confidence in the extensionists and scientists who promoted the diffused-light principle.

## General Conditions

The same diffused-light storage principle has been introduced into 21 developing countries through CIP's regional research and training programs. A follow-up study of storage activities in selected countries illustrates the importance of tailoring research and use of the technology to actual conditions faced by farmers. The stores in these countries have a similar structural appearance although each nationality develops its own unique design and adaptation to local conditions.

While new varieties or even a pesticide can be accepted as an unaltered technology, most post-harvest practices must be blended with or grafted onto traditional practices if they are to be successful. This requires that those involved in the generation and transfer of post-harvest technology in developing countries must not only be technically competent but knowledgeable of local architecture, food customs, security needs, and social conditions faced by farmers.

Data collected from 300 adopters of the rustic storage technology, primarily in the Philippines, Peru and Colombia, point to common patterns of acceptance. Adoption begins by either a few individuals or the community as a unit taking the initial risks of experimenting with the new technology. Farmers rarely accepted blindly technicians judgement on the technology. Experimentation was at first on a small scale involving a small proportion of their seed. If the farmers own experimentation proved positive, they often increased the use of the technology. Simultaneously, other community members began adopting in their own cautious way.

Farmers rarely copied demonstration designs precisely, but modified the store to meet their own circumstance. In fact, this has meant in the majority of cases that new stores were not built but that existing farm dwellings or outbuildings were modified. Even when new structures were built, farmers altered the design to meet their own preferences.

The primary lesson for agricultural development offered by this case is that while general principles of post-harvest technology and management are relevant to a wide range of conditions, the application of these principles must be location specific. Farmers and scientists must work together in this adaptive process, but in the end farmers will fine-tune the technology. Agricultural scientists in attempting to solve local problems should constantly remind themselves that the successful application of a technology in one location does not mean that it will automatically work in another apparently similar location. The existence of numerous unused but technically sound potato stores in developing countries testify to the need for an integrated approach which involves carefully defining farmers needs, and adapting scientific principles to their unique circumstances.

CHAPTER 10

# Diffuse-light Potato Seed Storage as an Example of Technology Transfer: A Case Study

Michael J. Potts

## Introduction

### *The Location*

Benguet Province, a mountainous area in Northern Luzon, Philippines, produces more than two-thirds of the country's potatoes, principally destined for the catering and luxury market in Manila, 350 km to the south. Much of the production area is at an altitude of between 1500 and 2000 m.a.s.l. There is a monsoon season, July to October, and a dry season, January to March. Planting during these times is considered risky; consequently, there are two distinct cropping seasons: March to July and October to January or February, where irrigation is available. Temperatures fluctuate little: averaging 22°C (day) and 16°C (night) in July and 18°C (day) and 9°C (night) in January.

The main crop rotation is presently alternate potato and cabbage, with small areas of carrots, sweet peas and wongbok (Chinese cabbage), where availability of labour and soil conditions allow.

### *The Problem*

Due to the nature of the cropping pattern seed pieces frequently have to be kept for a period of up to nine months; from the July harvest for planting the following March, with a smaller quantity being kept from January/February to October. Maintaining seed well beyond the end of its natural dormancy frequently resulted in high storage losses due to attack by pests and diseases and excessive sprouting and moisture loss. This problem was being further accentuated by the use of new cultivars of European or North American origin, which were early maturing and had a short dormancy period. The resulting planting material was thus expensive and the often poor-quality seed pieces gave rise to low yields.

### *The Solution*

The introduction in 1977, by the Philippine Government in conjunction with the Federal Republic of Germany, of a seed potato programme served to heighten awareness of the value of potato seed and also the attributes applicable to good seed. In 1978 and 1979, the Philippine

Potato Programme in conjunction with the International Potato Centre set up within the province six small rustic seed stores (Plate 9b) to demonstrate the principles of diffuse-light storage; a technique widely practised in developed countries for green-sprouting prior to planting (Dinkel, 1963). These small stores had a capacity of approximately one tonne and were built entirely from materials available locally. The principles of diffuse-light storage were readily accepted in the localities of the original six stores and farmers promptly started adapting their own stores (Rhoades et al, 1980).

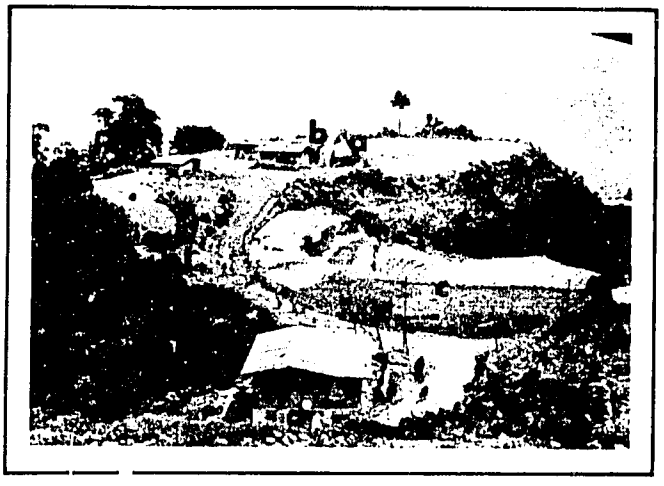
## A Case Study

In order to extend the demonstration, one of the original stores was moved in September, 1980 to a new location: the Depaysos' farm. The Depaysos at that time were, coincidentally, in the process of renovating and enlarging their house. The remainder of this paper describes the stages of adoption of diffuse-light seed storage on the Depaysos' farm, which is typical of many farms in the locality. The layout of the farm building is shown in Plate 18a).

Mr. Depayso's grandfather settled in the area in 1938 and grew mainly camote. In 1948, his father and grandfather began planting potatoes and cabbage. Mr. Depayso and his wife now farm, with their family and four paid labourers, the original two hectares plus a further three hectares, inherited from Mrs. Depayso's father, in a neighbouring municipality and where they now reside (Plate 18a). Potatoes and cabbage continue to be the main crops. The principal cultivars grown are cv. Conchita, cv. Greta and cv. Cosima, with a medium or long dormancy and growing season for the wet-season crop, and cv. Red Pontiac and cv. Fina, with a short dormancy and growing season for the dry-season crop.

Traditionally, the Depaysos used as seed the small and damaged tubers of the previous crop. These were stored in pits underground (Plate 18b) and excessive sprouting and disease resulted from this dark, humid environment. Losses were substantial and the remaining tubers were of poor quality. The Depaysos still store some of the small tubers in this manner, mainly for use as animal feed.

The increasing monetary value of seed encouraged many farmers to store in bulk or in net bags under their house, where theft was less likely. Latterly, some farmers have adopted the practice of storing their seed in specially constructed *bodegas* or stores, such as that built by the Depaysos in 1975 (Plate 18c). These are still the predominant storage methods used, but almost invariably these stores are kept nearly totally dark, are not insulated and are inadequately ventilated; thus seed-piece loss and poor-quality tubers remain the major production constraint.



a

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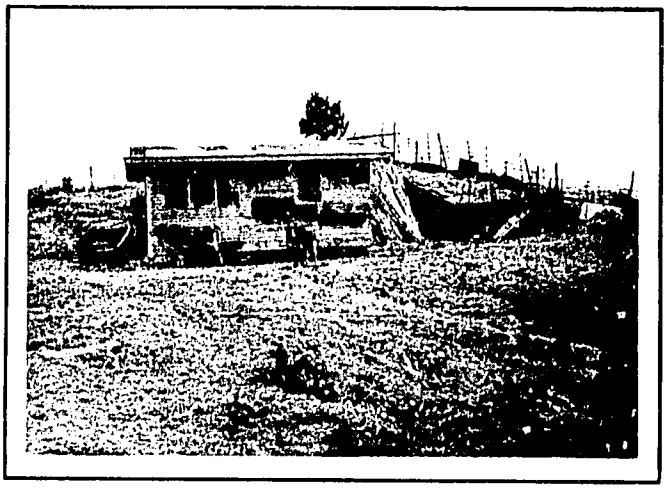

c

Plate 18. Seed-potato Storage: The Depaysos. (a) Overall view of steading. Note: a) traditional underground pit store, b) traditional bodega, c) simple rustic demonstration store, d) purpose-built store below dwelling house, (b) Traditional underground pit store. Note: small tubers, sprouting, (c) Traditional *bodega*. Note: pit store to right.

Following the construction of the demonstration rustic-store on the Depaysos' farm, a small trial was set-up. Tubers from a number of cultivars were placed in the rustic store in mid-September, just as they were beginning to break dormancy. By mid-November, they were beginning to develop numberous short, sturdy green sprouts, whilst the bulk of the Depaysos's seed, which was stored in net bags under the house or in bulk in the bodega, had the commonly observed elongated white sprouts (Plate 19a). The visual improvement in quality and the message learned from seminars conducted by the Seed Potato Programme convinced the Depaysos that they could store good seed successfully for a full nine months, instead of only for three or four as previously. Consequently, they decided to modify their house renovation plans so as to include a purpose-built seed store under the house (Plate 19b).

The store, which was constructed according to Mr. Depayso's own design, measures 4.0 m x 4.5 m. The floor is cement. Some light is provided through the original windows with extra light being derived by replacing some of the galvanized iron sheets of the original dwelling with translucent, yellow, plastic sheeting. Additional ventilation was provided by means of vents above and below the existing doors and windows. The potatoes are stored on two sets of racks 4.5 m long by 80 cm wide, with a central set 4.5 m long by 1.20 m wide; each set consisting of four racks above each other 60 cm apart (Plate 19c), giving a total capacity of approximately two tonnes. Total cost of the store (materials plus labour) was ₱4,000.00 (US $500); approximately the equivalent of one tonne of locally certified seed. Seed was immediately placed into the store upon its completion in late January 1981.

Plans are now well advanced to improve the old bodega in a similar manner through increased light penetration, ventilation and the provision of racks. The Depaysos envisage that they will then have sufficient storage space for all of the three to four tonnes required for each cropping season.

## *Additional Benefits*

The improved quality of the Depaysos' seed is not due to diffuse light alone. The financial investment tied-up in the store coupled with a greater confidence in "new" technology has encouraged them to adopt other forms of improved practices. Thus, instead of only the small tubers being used for seed, larger tubers are now selected for size and quality; they are displayed only one layer deep with their rose ends uppermost; apical dominant cultivars are desprouted six weeks before planting; regular inspections are made and diseased tubers removed and regular sprayings are made to control pests such as aphids and tuber moth.

19

a

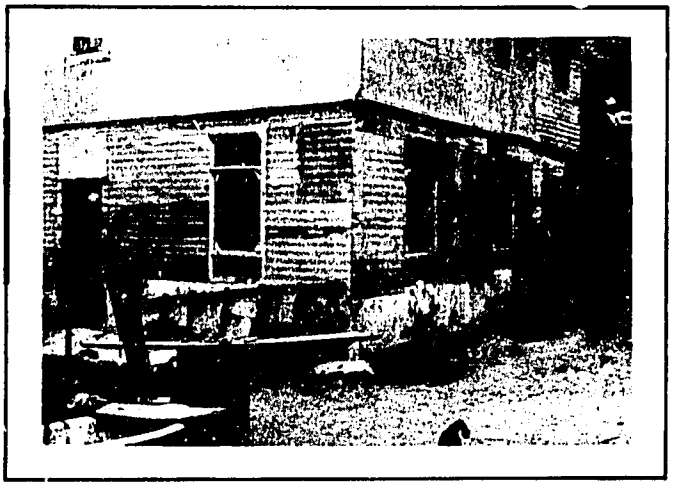

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Plate 19. Seed-potato Storage at Depaysos. (a) Seed-pieces of cv. Conchita following eight months in traditional dark store below house (upper) or simple diffuse-light demonstration store (lower). Note: apical dominance, long thin sprouts, shrivelled tubers in dark-stored seed; several short sturdy sprouts, firm tubers in light-stored seed, (b) Purpose-built store below dwelling house. Note: *a*) insertion of windows, *b*) replacement of galvanized iron sheets with translucent yellow plastic shee *c*) improved ventilation, (c) Racks within purpose-built store. Note: *a*) ıslucent plastic sheeting, *b*) ventilation, *c*) tubers displayed rose-end uppermost, with numerous short sturdy sprouts at 5 months following harvest.

## *Evaluation*

An attempt by members of the Philippine Potato Programme to evaluate agronomicaly and economically the improved storage practice were, unfortunately, only partially successful due to a severe typhoon destroying the crop in mid-season. Trials were carried out on a total of 14 farms and are reported elsewhere (Potts et al, Ch. 6).

On the Depaysos' farm, one set of tubers of cv. Conchita was placed in the old *bodega* and a further set in the rustic store in September, 1980. The tubers were planted in single plots the following May and harvested in August. A summary of the more interesting findings is shown in Table 17.

It can be seen that with this cultivar, which has a long dormancy period, the use of diffuse light had no effect on losses during storage (contrary to findings with some of the cultivars with a short dormancy period /Potts et al, *loc. cit.*7). However, the number of sprouts per tuber was significantly increased: this was reflected by the number of main stems per hill, which greatly affects the yield potential of the crop as a whole. The length of the apical sprout was greatly reduced by diffuse-light storage and, furthermore, this sprout was short, green and sturdy as opposed to the long, white and easily damaged sprouts on the tubers from the bodega (Plate 9b). Emergence from both treatments was good.

As already mentioned yields were greatly reduced due to a typhoon in mid-June. Nevertheless, the diffuse-light stored tubers showed a 12% increase in yield over the traditionally stored seed, and a net return on investment in building the simple store (after allowing for depreciation over 5 years) of over 800%. In a more favourable season, the difference in yield between the two storage methods may be expected to be more marked.

## Adoption

In addition to the remarkable rapidity and commitment with which the new technology of diffuse-light storage and its related aspects were adapted by both the Depaysos and neighbouring farmers, it is interesting to note that at that time there was no detailed information on the increase in yield and monetary returns which may be expected from their adoption. This serves to highlight the reality that, in many circumstances, farmers are only too aware of their problems and the ideal end-results; but what is often lacking is for the appropriate means to attain these ends to be explained and demonstrated at the farm level.

Table 17. Summary of trial results.

| Store | % loss in seed weight in store | Mean No. sprouts/ tuber at planting | Mean length apical sprout at planting(mm) | % emergence at six weeks | No. main stems/ hill | Marketable yield tonnes per hectare | Net B/C ratio |
|---|---|---|---|---|---|---|---|
| Bodega | 10 | 2.9 | 54 | 96 | 3.8 | 16.4 | - |
| Rustic store | 8 | 3.8 | 28 | 99 | 5.0 | 18.3 | 8.3 |

# SECTION V:

Conclusions

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## Concluding Comments on the OPP Methodology

1. The farmer is the central pivot to the whole philosophy of OPP. He must be intimately involved and consulted at all stages if the project is to ultimately benefit him.

2. An "on-farm" trials programme is by its nature a dynamic, long-term approach, which is constantly changing as new technologies arise. Planners and administrators, therefore, have a duty to maintain enthusiasm through active participation at all levels.

3. All participants in the project must be intimately involved and briefed. Lack of understanding by any participator results in a lack of enthusiasm and frequent errors which may undermine the whole programme.

4. Enthusiasm on the part of all involved is an essential prerequisite to a successful "on-farm" trials programme.

5. Understanding is best fostered through simplicity and a logical stepwise approach from the understanding of the farming system to the evaluation of the results. The promotion of complex packages is therefore to be avoided.

6. Before embarking on a trials programme *per se* a thorough understanding of current farming systems must be neld by all concerned.

7. Survey questionnaires are no substitute for stationing in the field over an extended period, of a scientist trained in the social, economic and agricultural sciences.

8. Field-oriented surveys may be a valuable means of confirming visual observations and obtaining additional data.

9. Appropriate alternative technologies need not involve additional costs or even give higher yields provided they result in improved monetary returns.

10. Appropriate methods of disseminating the accumulated information must be developed if an on-farm trials programme is to be of lasting benefit and not merely an end in itself.

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## Concluding Comments on the Field Trials

1. Yields in Benguet and Mountain Provinces were considerably higher than previously believed: *circa* 20 tonnes per hectare as opposed to *circa* 7 tonnes per hecatare.

2. Certified seed may give improved agronomic and economic returns depending upon the condition of the farmers' own seed. Many factors are involved and further experimental station investigations into seed-piece quality are required; particularly with regard to virus content, seed size and storage conditions.

3. Larger seed, 35-55 mm, give improved agronomic and economic returns when planted according to the farmers' traditional practices.

4. For the dry-season crop the cutting of seed-pieces results in no significant decrease in yield or monetary returns.

5. The elimination of organic manures, in the form of chicken manure, gave variable results apparently a reflection of soil conditions and moisture status. The practice should not be recommended generally at present. More research station investigations are urgently required into the factors of a beneficial nature in chicken dung.

6. Alternative organic manures currently available, McLife and Sagana 100, are little different agronomically or economically from chicken manure.

7. Placement of commercial fertilizer to the seed-bed instead of as a side-dressing at hilling-up significantly increases yields and incomes.

8. Application of potash as a side-dressing would appear to enhance yields and monetary returns and the technique requres further investigation.

9. Storage of seed-pieces under adequate conditions of diffuse light and ventilation for periods of up to nine months is comparable to refrigerated storage and may give much improved agronomic and economic returns.

10. Storage of table potatoes requires further investigation: both for its need and appropriate practices. In-ground storage would appear to be an appropriate method,for farmers,in less intensive areas and with well-drained soils for periods of up to three months.

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# APPENDIX

## Supervising Technicians

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Cipriano Bayangan
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Mariano Canuto
Perfecto Cayat
Pepito Mariano
Tyller Ngaosi
Lito Pacuz
Thomas Palileng
Carlito Paulino
Felix Rutab
Paulino Santos
Amado de los Santos
Crispulo Tandoc
Balao Vicente
Basanio Wasing
Antero William
Jefferd Zambrano

## Co-operating Farmers

Mario Aban
Cornelia Alawas
Felix Aliping
Calixto Anno
Victor Awal
Juanito Backian
Mr. Balangbang
Eleon Bangsoyao
Kenio Baoidang
Paul Bay-an
Tirso Bayawa
Juan Catagan
Edward Depayso
Mendoza Depayso
Sacli Diwas
Mariano Dominguez
Felipe Duyot
Fernando Edico
Santos Fianza
Nemisio Faustino
Reynaldo Gabol
Emelio Gabul
Fernanda Gayanan
Cabatan Gatab
Caliag Guinguino
James Guanso
James Guines
John Haight
Belingen Kid-Kid
Mauro Lamenta
Taynan Lacay
George Lesino
Mr. Magante
Jacinto Maliones
Luis Manis
Tolito Marares
Isabello Martin
Petra Mayos
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Mr. Nagayan
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Mike Olo-an
Abellion Olsim
Romeo Ong
Johnny Uy
Murphy Paayas
Mario Pakito
Menio Palasi
Na-ag Palcong
Francisco Paleng
Pedlin Palileng
Manuel Pasigon
Patricio Pongsayan
Julius Simeon
Orlando Smith
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