PN-AAG-603

CORNELL INTERNATIONAL AGRICULTURAL MIMEOGRAPH 71

EC
634.11
E39

APPLE GROWING IN THE CHIMBACHENIPE REGION OF CHIMBORAZO PROVINCE, ECUADOR

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August 1979

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AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY

1. SUBJECT CLASSIFICATION

A. PRIMARY
Food production and nutrition — AF00-0710-G520

B. SECONDARY
Plant production--Fruit crops--Apples--Ecuador

2. TITLE AND SUBTITLE

Apple growing in the Quimiag-Penipe Region of Chimborazo Province, Ecuador

3. AUTHOR(S)

Elfving, D. C.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1979	26p.	ARC EC634.11.E39

7. REFERENCE ORGANIZATION NAME AND ADDRESS

Cornell

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*

(In Cornell int. agriculture mimeograph no. 71)

9. ABSTRACT

10. CONTROL NUMBER

PN-AAG-903

11. PRICE OF DOCUMENT

12. DESCRIPTORS

Apples
Fruit crops
Insect control
Plant diseases
Technological change
Ecuador

13. PROJECT NUMBER

931113700

14. CONTRACT NUMBER

AID/ta-BMA-8

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

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OF
CHIMBORAZO PROVINCE, ECUADOR

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INTRODUCTION

The Quimiag-Penipe (Q-P) region of Chimborazo Province, Republic of Ecuador (lat. 1° 30' S), has been chosen as the site for a joint rural development project sponsored by Cornell University and the Interamerican Institute of Agricultural Science (IICA). This program is being carried out in conjunction with an overall rural development project of the Ecuadorian Ministry of Agriculture and Animal Husbandry (1).

The author's services were requested by the Ecuadorian Ministry of Agriculture and Animal Husbandry (MAG) to evaluate the current status of apple culture within the Q-P region and to recommend strategies for improvements in that production. The duration of the visit to the Q-P region was from August 20 to September 9, 1978. Most of the author's time was spent in the Q-P region, with visits to the MAG fruit tree nurseries at Guaslan and Pillaro and a one-day tour of deciduous-fruit-producing areas near Ambato.

THE QUIMIAG-PENIPE REGION

Location

The Quimiag-Penipe Rural Development Project covers an area of approximately 31,470 hectares (ha.) located in Chimborazo Province, Republic of Ecuador (2). This area is located in the Interandean region, where intense volcanic activity has produced the major geologic and topographic features. The project area is bordered on the west by the Chambo River and extends eastward to a major north-south ridge running southward from Tungurahua volcano. The region is characterized by a predominance of steeply sloping terrain. Changes of elevation within the project area are extreme, creating considerable variation in microclimate within the region. The general range of elevation within the project area extends from approximately 2300 m. at the river up to approximately 4000 m. at the highest points.

Climate

The climate of the region is typical of tropical zones in that mean temperatures fluctuate very little throughout the year. Various climatic

zones are created by differences in elevation, with microclimatic variations within these zones resulting from topographic features which may influence exposure or air movement patterns. Diurnal fluctuations in temperature typically exceed seasonal changes in mean temperature. Rainfall may occur during any month of the year, but is usually greater from November to June. The mean monthly temperature in the principal fruit-growing area of the region ranges between 11 and 13° C all year.

Soils

The soils of the area are derived from the products of volcanic activity. They are composed primarily of volcanic ash, which confers a loose, sandy texture. These soils are generally very low in organic matter, and may be low in water-holding capacity. The scarcity of published information on the physical and chemical characteristics of soils in the region makes an estimate of natural fertility difficult. Such soils are likely to be deficient in nitrogen, however. Erosion can become a serious problem in these soils if not managed carefully.

Fruit Crops

The major deciduous fruit grown in the Q-P region is the apple. Some peaches, pears, and plums are also grown but the apple is by far the predominant fruit and will constitute the primary subject of this report. Fruit growing is not generally distributed throughout the region, although many farms have a few backyard trees. The great majority of the commerical apple production of the region is centered around the village of Bayushig, where about 65% of the trees in the Q-P region are located (1). Other small production areas scattered throughout the region comprise the remaining 35%. The amount of land area devoted to fruit growing in the region is not large, amounting to between 250 and 300 ha. in Bayushig (2, 10) and probably not more than 400 ha. total for the region as a whole. These specific fruit-producing localities have probably developed into fruit areas primarily as a result of soil and climatic conditions which permit successful, though mediocre, fruit growing with a minimum of orchard management technology.

Population

The Q-P region is made up largely of small farmers employing traditional farming methods. These people are primarily of "mestizo" (mixed Spanish-Indian) ancestry and are fluent in Spanish. A 1971 survey indicated a regional population made up of around 86% mestizo and 14% Indian people, as contrasted with an average for the entire province of approximately 50% Indian population (1). Chronic unemployment is a serious problem, with a level of 42% unemployed cited in one study (1). Many people must leave their farms during a part of the year to seek employment elsewhere.

The "minifundio" or small-farm-size problem in the Q-P region is serious and can be highlighted with a few statistics. While 58% of the cultivated land is owned by 3% of the agricultural producers, with an average of more than 20 ha. per farmer, fully 42% of the agricultural units consists of farms of less than one ha. in size (1). The average farm size among farmers in the Bayushig area is only 1.5 ha. (2). Thus, subsistence farming is a way of life for the majority of the people of this region.

Cropping Systems

Because of the need of subsistence farmers to produce crops for their own consumption as well as for commerce, multiple cropping systems are the rule in the Q-P region. Fruit trees are usually intercropped with one or more of the principal subsistence crops, corn, beans, and/or potatoes. Weeds and/or forage crops for animals may also be grown, depending on need.

CURRENT STATE OF APPLE ORCHARDS IN THE Q-P REGION

History and Background

While basic subsistence crops such as corn, beans, and potatoes have a long history of association with native agriculture, fruit growing is a rather recent development. The first fruit orchards in the Q-P region are reported to date from the last decade of the 19th century; the major apple cultivar, 'Emilia', was apparently introduced to the region sometime around the turn of the century (1). Hence there has not been the evolution of cropping systems for fruit crops analogous to those developed for basic crops. In addition, fruit crops do not represent the primary agricultural production for the vast majority of small farmers; this fact is reflected in the almost complete absence of applied orchard technology.

The average level of orchard productivity is very low, primarily as the consequence of the lack of proper orchard management practices. The few production data which are available give an indication of the current state of the industry. The average apple yield for the Q-P region is quoted as being around 1.2 metric tons (m.t.) per ha. (1), while the country-wide average may reach 1.4 m.t./ha. (1, 8). While not indicated, it is likely that these data do not represent units of land area fully planted to trees. The average productivity per tree is difficult to determine from the meager data available, but probably ranges from as little as a few apples to as much as 40 to 50 kg. per tree in some cases (1, 11). This low level of productivity represents only 5 to 10% of the average per-tree productive capacity of comparable standard trees (seedling rootstock) in New York.

Climate

Probably the primary effect of the prevailing climate on tree behavior occurs between the onset and termination of rest and dormancy. The buds of all deciduous fruit species require exposure to a certain amount of so-called "chilling" temperatures during the dormant period in order to properly initiate growth. Effective chilling temperatures fall within the range between approximately 0° to 15°C, with the most effective temperatures for breaking rest at about 5°C. Because of the lack of pronounced seasonal fluctuations in temperatures typical of tropical climatic zones, the problem of insufficient chilling during the dormant period has been encountered wherever temperate fruit crops have been grown in subtropical or tropical regions. The typical symptoms of insufficient chilling can include:

a. an extended period of budbreak;
b. a prolonged period of bloom without the concentration of flowering characteristic of more temperate areas;
c. poor overlap of bloom periods of different cultivars based on their individual chilling requirements;
d. a tendency for reduced branching and delayed foliation in trees of moderate to high vigor;
e. the death of some buds or their failure to develop.

The effects on tree behavior of limited exposure to chilling temperatures result in extended harvest seasons, with fruit maturation taking place over a long period. The risk of harvesting both overmature and undermature fruit during any picking is greatly increased.

Other climatic effects, particularly the occurrence of frosts, hail, wind, and fog can limit tree growth and/or productivity. Frosts and hail occur from time to time in the Q-P region, varying in intensity and frequency with the microclimatic variation typical of the region. If frequent, these climatic factors can limit production through the killing of blossoms and young fruits by frost or physical damage to leaves and fruit from hail, which if severe, can affect tree growth as well as promoting disease problems.

The Q-P region is frequently subject to heavy winds from the east. Wind damage can take the form of desiccation and subsequent death of leaf and fruit tissues. Wind also promotes physical damage of fruit, leading to losses in fruit quality and to disease problems.

Because of the elevation of the Q-P region, cloudy, foggy periods are frequent, particularly at higher elevations. Such conditions influence the activity of certain pest species, especially of pathogenic fungi, such as apple scab, which require the presence of moisture on susceptible tissue surfaces in order to begin growth. Frequent and extended wet periods increase the likelihood of infection and complicate the problems of disease control.

Soils and Water

In the Q-P region rainfall has been recorded every month of the year (6). However, there are only a few months of the year when dependable rainfall (5) exceeds evapotranspiration. Under the soil conditions which prevail in the region, water stress may impose significant restraints on tree growth and productivity, especially where intercropping within the orchard is a common practice. Competition for mineral nutrients, especially nitrogen, among orchard trees and interplanted vegetable or agronomic crops is also likely to be significant.

Orchard Condition and Cultural Practices

a. Tree growth.

The bulk of the trees observed in the Q-P region are of relatively low vigor. While the reasons for this deficiency in vegetative growth are many, it is likely that the major causes can be attributed to lack of or improper fertilization, lack of irrigation, and poor disease and insect control. Since the trees were in the dormant state during the author's visit, no direct observations of growth or flowering were possible. Thus, it is impossible at

this stage to be more precise in evaluating the actual contribution of any one factor to the overall poor state of growth and productivity. The typical effects of insufficient chilling in reducing branching were only observed on a few young trees in the Q-P area. This should not be interpreted to suggest that lack of chilling is not a problem; on the contrary, delayed bud-break, extended bloom, and an extended harvest season all indicate significant effects from insufficient chilling. In trees of higher vegetative vigor observed in Ambato, the typical effects of insufficient chilling on vegetative growth were noted. It is likely that as cultural practices improve in the Q-P region, these effects will likewise become more common.

Little evidence of use of di-nitro products to overcome the effects of lack of chilling was found. The efficacy of these products in stimulating bud development under low chilling conditions has been known for many years (3, 12). One grower in Bayushig reported having used these materials; direct observations of his trees indicated that he has been able to obtain a better tree structure. He also reported stimulation of flower bud growth in spring as a consequence of di-nitro application; this treatment results in better overlap of bloom among cultivars and an earlier harvest.

b. Pruning and Training

Most orchards in the region display both a deficiency of pruning and almost complete absence of proper pruning. Little canopy renewal or thinning out of branches is practiced. The heavy shade produced by the large number of interwoven branches results in the loss of vigor and flower-bud formation in the lower parts of the canopy. Failure to renew the bearing surface results inevitably in reduced production of poorer-quality fruit.

Heading-back of the current season's terminal growth is a common pruning system for deciduous fruit trees in Latin America and was observed in the Ambato area. This practice does not appear to be common in the Q-P area. While this approach may have some limited value in stimulating vegetative growth in trees of low vigor, it is definitely a poor practice under moderate to high vigor conditions. Heading-back tends to stimulate excessive vegetative growth while reducing productivity.

Proper tree training practices appear to be unknown. Failure to practice scaffold selection and training on young trees allows the development of the typical globular canopy structure, which is inefficient in light absorption and which results in fruit production primarily in the outer portions of the

canopy. Pruning practices observed during the visit promote undesirable increases in the height and width of the canopy, thus increasing the difficulty in caring for and harvesting the crop.

c. Irrigation and Fertilization

The majority of apple orchards in the region are unirrigated. This is primarily the result of lack of available water, but even where water is available, orchard irrigation is not a common practice. Fertilizer programs, where fertilizer is used at all, are based mainly on the use of organic fertilizers derived from animal wastes and composted plant materials. The mineral nutrient value of such materials is quite variable, depending upon the nature of the parent materials and the processes of formation, and is therefore unknown. Chemical fertilizers are seldom used, because of both ignorance of the proper methods of use and lack of economic resources to purchase such products. Fertilizer practices are not based on an understanding of the nutritional needs of trees or an awareness of the current nutritional status of the orchard. Observations of tree growth in various orchards suggest a prevalence of nitrogen deficiency. Other possible mineral nutrient deficiencies or excesses could not be evaluated due to the absence of active vegetative growth during the period of the visit.

Due to a scarcity of economic resources, fertilizer practices are often geared to the needs of the principal vegetable or agronomic intercrop. Hence, fertilizer application rarely occurs at the time when the need of the trees, especially for nitrogen, is greatest, that is, at the onset of budbreak and bloom. Even when fertilizer is applied at the proper time, absence of significant rainfall may prevent the mineral nutrients themselves from entering the soil and becoming available for uptake by the trees.

Some growers are using only commercially-prepared foliar fertilizer formulations applied to the trees as the sole means of fertilization. This approach is not only expensive but ineffective when such materials are applied to dormant trees, as was observed during the visit. Sprays of foliar fertilizers applied to leaves without any applications of fertilizer materials to the soil can lead to a condition of nitrogen sufficiency in leaves of apple trees with a simultaneous deficiency of nitrogen in woody tissues. This condition can lead to significant yield loss.

d. Planting Systems

Fruit trees are not usually considered as the principal crop by small

farmers. Thus it is common to see orchards in which the trees are distributed in a more or less haphazard manner in the orchard area. Where trees are planted in rows, a large open space is left between rows to provide space for the intercrop. Some orchards were observed in which a single apple cultivar alone was being grown. It was not possible to determine the extent to which this practice is followed. A large fraction of the current orchard area is made up of older trees. There is little new planting or renovation of older orchards taking place in the area at the present time. Land use efficiency and total production may suffer without careful attention to orchard design.

e. Pollination

Apples, pears, plums, and some peach cultivars require cross-pollination (one cultivar can only be effectively pollinated by another cultivar) to obtain proper fruit set and development. When cross-pollination is poor or absent, fruit set is greatly reduced, and the few fruits which may develop are often undersize or misshapen. It is quite probable that insufficient cross-pollination is a serious problem in orchard productivity in the Q-P region. No honeybees were observed in any orchards visited. Although many peach trees were in bloom at this time, the only insect activity observed around them consisted of various wild species. Fruit trees require insect activity for pollination, and honeybees are very efficient in pollen transfer, especially between cultivars. Absence of honeybees from orchards during bloom greatly reduces the chances for good cross-pollination, even when other factors are favorable.

Under climatic conditions of reduced chilling, different scion cultivars often exhibit distinct periods of budbreak and bloom. Limited bloom overlap in orchards can be a serious impediment to cross-pollination, due to reduced availability of suitable pollen when any one cultivar is in flower. Extended bloom periods also make satisfactory pest control without serious risk of significant loss of bees very difficult. Single-cultivar orchards almost without exception experience reduced productivity due to deficient cross-pollination.

There is little or no understanding of pollination requirements of fruit crops on the part of growers. Many of them believe that honeybees in fact induce fruit-set problems. This belief has led to efforts by some growers

presence. The origin of this concept is unclear, but it no doubt will represent a significant problem in grower education as a program of improved pollination is undertaken.

f. Disease and Insect Control

Satisfactory control for the various diseases and pests of apple present in the region appears to be almost nonexistent. Although none of the insect or fungal pest problems described as being of importance is difficult to control with modern methods, the capital investment requirements for equipment and materials and the almost total lack of knowledge of pest life cycles and control practices restrict effective application of these techniques. Uncontrolled pests and diseases contribute to poor tree vigor and productivity. Fruit quality and storage life are also affected by uncontrolled pest problems.

Most of the orchard trees in the Q-P region carry heavy incrustations of lichens and mosses. More than anything else these epiphytes are indicative of the total lack of proper pest control practices. In other areas where pest control practices are more effectively carried out, these organisms do not develop. Their association with trees of poor vigor has led to the belief that they are in some way connected in a causal manner with poor tree growth. In fact both lichens and low vigor are indications of poor cultural practices.

Major pests of the apple in the Q-P region include, but are probably not limited to, the following (4):

1. Fungal Pests
   a. Apple scab (*Venturia inaequalis*)
   b. Powdery mildew (*Podosphaera leucotricha*)
   c. Fruit rots and spots (various sp.)
2. Insect and Mite Pests
   a. Woolly apple aphid (*Eriosoma lanigera*)
   b. Codling moth (*Laspeyresia pomonella*)
   c. Fruit worms (various sp.)
   d. Mites (probably various sp.)

The timing of the visit prevented direct evaluation of the distribution and severity of these and other pest problems. Interviews with growers suggest that many of these problems are quite serious.

The principal characteristics of pest control practices which contribute to the overall state of pest control previously described include:

1. A small number of pesticide applications; often only once per year or less;
2. Inadequate coverage of susceptible tissues, especially in the upper parts of the canopy;
3. Improper timing of applications in relation to tree and/or pest developmental stages;
4. Use of improper spray materials or incorrect dosages.

Growers depend largely on hand-operated spray equipment for their chemical control programs. Effective coverage of leaf and fruit surfaces with such equipment is seriously limited by tree height and spread and by the volumes of spray material required to properly spray an orchard. Effectiveness of orchard pest control programs could be increased significantly with the use of improved spray equipment, such as small, motorized back-pack sprayers. Improved orchard management practices, which maintain the productive canopy nearer the ground, help develop a more open canopy to facilitate penetration of applied spray materials. Tree size control with appropriate rootstocks would also serve to improve the efficiency of any pest control program.

A 1972 crop protection survey reported the occurrence of many phytopathogenic nematode species on numerous crops grown in the Ecuadorian highlands (4). While no surveys have been made of pathogenic nematodes on apples in Ecuador, such problems may be significant, and may become especially visible if orchard replanting becomes more common.

g. Harvesting, Handling and Storage

None of these activities was observed during the visit to Ecuador. Nonetheless, certain observations can be made about this aspect of fruit production. Extended bloom periods caused largely by problems of insufficient chilling result in an extended harvest period, generally beginning in February and running into or through May. The risk of nonselective harvest of both mature and immature fruit is increased, thus affecting final product quality and appearance. Transport of perishable commodities such as fresh fruit is difficult over the steep slopes and poor roads characteristic of the area. Lack of storage facilities dictates immediate movement of harvested fruit to market. The majority of growers has little opportunity to take advantage of improved prices much later in the season, and locally-grown deciduous fruit in general remains a very seasonal commodity. Opportunities for loss of quality and attractiveness between harvest and the consumer are numerous.

While little data are available, reports of growers in the Ambato area indicate that the demand for deciduous fruit far outstrips the supply. A ready market is available if fruit products can be brought to the market in saleable condition.

h. Scion and Rootstock Cultivars

The principal apple cultivar in the Q-P region is 'Emilia', reportedly introduced from the province of Tungarahua. Other common cultivars include 'Balsosa', 'Tortera' or 'Pasposa', 'Carmelita', 'Rayada'and 'Flor de Mayo'. The origin of these cultivars is unclear, but at least some of them may represent introductions originally for rootstock uses. Other cultivars of more or less common occurrence include 'Jonathan', 'Rome Beauty', 'Winter Banana' and various strains of 'Delicious'. Rootstocks are represented by a large number of genetically distinct types; seedlings as well as vegetatively propagated materials have been used. There is little evidence of the use of size-controlling rootstocks although clonal material of various size-controlling rootstock cultivars has been introduced into Ecuador at various times (10). Rootstock cultivar identity is almost impossible to assure at this point in time.

i. Nursery Operations

Most fruit tree nurseries in the country are under the control of MAG (7). Propagation of apple trees as well as of all deciduous fruit trees in MAG nurseries appears to lag far behind demand. Because of unstable seed sources for rootstock use, apple tree production has been shifted from the use of seedling rootstocks to the use of rootstock suckers sold to nurseries by apple growers. While this product serves as another source of income to growers, it is an unreliable source of rootstocks for the nursery, making it more difficult to plan an organized tree-propagation program. In addition it tends to foster suboptimum production practices in that apple suckers, when allowed to develop, serve both to divert tree vigor from the scion cultivar and as an excellent host for diseases and pests.

Methods of propagation in the nursery are time-consuming and inefficient Where the cleft graft is used as the preferred propagation method, one propagator can graft between 200 and 250 trees per day. In contrast, with modern budding techniques, a skilled fruit-tree propagator in the United States can easily bud up to five times as many trees per day. Methods of rootstock cul-

initiation of rootstock development and the final product ready for sale to the fruit grower. The use of improved methods of rootstock cultivation and propagation should materially shorten the nursery period, thereby facilitating a significant improvement in nursery production of trees.

j. Marketing

Availability of marketing options to small farmers in the Q-P region is restricted by both economic and legal factors. Few growers have the economic means to own vehicles and equipment suitable for the timely and efficient handling and transport of fruit crops to market. Fees and permits at restrictive costs to small farmers must be paid or obtained to participate in direct producer-to-consumer marketing in towns such as Riobamba. The fee and permit structure does not allow adjustments for short-term seasonal sales or small volumes of produce. For access to larger markets the small farmers rely principally on intermediaries, who purchase fruit from growers and in turn transport and market the fruit elsewhere. The on-farm price for fruit is relatively low in comparison to the potential price at retail in these larger markets. It is not clear how the cooperative structure which has developed in the Bayushig area has worked toward serving as a marketing medium for member growers. Restriction of market alternatives limits the incentive of small farmers to increase their efforts to produce and market more and better fruit.

k. Potential Fruit Area

Many climatic and edaphic factors influence the suitability of a particular region for fruit growing. The application of specific cultural practices can serve to offset certain natural limits such that an otherwise nonadapted location can become available for the cultivation of fruit crops. An assessment of the potential of any area should take these factors into consideration. The dearth of detailed information on soil and climatic characteristics within the Quimiag-Penipe region make a precise estimate of the potential fruit area impossible. Nevertheless, a rough estimate of the possibilities can be obtained from the following analysis.

Climatic and soil factors of major significance in the suitability of a locality for fruit growing include rainfall, the quantity of chilling temperatures, occurrence of frost and hail, exposure to wind, soil depth, soil drainage, hard-pan if present, soil water-holding capacity, and fertility. Some of these limits can be overcome with cultural practices.

Irrigation can be used to offset insufficient rainfall or low soil water-holding capacity. Use of di-nitro sprays can substitute for insufficient chilling temperatures. Fertilization can overcome low natural soil fertility. Techniques for moderating the effects of soil drainage, wind damage, and frost are available.

While some of these approaches are obviously too expensive for consideration by small farmers themselves, it should be clear that any evaluation of the fruit-producing potential of an area should take such factors into account. The Ecuadorian Institute of Water Resources (INERHI) has planned a system of irrigation canals for the Q-P region. When this project is completed it will certainly result both in improved crop production as well as the opportunity to cultivate crops on otherwise unsuitable soils. Almost certainly, fruit crops will be affected by this development.

A country-wide survey of potential crop areas for 15 fruit and 12 vegetable crops was completed in 1975 (9). In this survey climatic and soil limits established for the various crops were used to define the potentially available land area estimated to be suitable for agricultural development. It was estimated that in Ecuador there are approximately 700,000 ha. suitable for the cultivation of deciduous fruit crops. In one irrigation project in Chimborazo Province (location unspecified in this same report) almost 5000 ha. were identified as suitable for deciduous fruits. Considering the conservative climatic and edaphic limits used in this study, it would appear that the potential area for fruit crops in Ecuador and in Chimborazo Province may be quite extensive.

Economic Factors

a. Technical Assistance

At this time no organized form of technical assistance for fruit growers exists in the Q-P region. Ecuador has no formally-sponsored applied research program in deciduous fruit growing, although one is being planned under the direction of the National Institute for Agricultural Research (INIAP). University agricultural training programs offer only the standard broad range of agricultural topics without the specialization necessary to provide effective service to an industry in dire need of technological assistance. Without both an organized research program to adapt current technology to the needs of small farmers and an effective training program to prepare the

specialists necessary to conduct research and disseminate that information, improvements in fruit production should remain slight. Such an effort will require people trained at the advanced-degree level to carry out the necessary research as well as people well-versed in tree behavior and cultural practices of fruit growing to assist farmers in improving cultural practices.

b. Economic Limitations

The small farmers who constitute the target group of this rural development project operate almost exclusively as subsistence farmers of very limited means. Many of them must spend a portion of the year working in employment outside the area in order to supplement their incomes. Some of the problems of orchard management discussed here can be traced directly to the limited resources of the small farmer, and interesting strategies have been developed by them in an effort to compromise perceived needs for cultural inputs with the limits imposed by available capital. The best illustration of the impact of limited resources on orchard management technology can be observed in the pest control program. Hand-operated hydraulic spray equipment and a wide variety of agricultural chemicals are readily available to fruit growers in the Q-P region. Yet the effective use of chemical pest control on apples appears to be almost nonexistent. For instance, growers were observed in the process of making a single annual spray application which was composed of a mixture of several chemical materials, including insecticides, fungicides, and even a foliar fertilizer. For many growers such an application, though largely ineffective, would represent their total available capital investment in pest control for the year. In interviews with growers, the point was repeatedly made that many of them simply did not have the means to purchase such materials for use in their orchards, notwithstanding whether or not they had sufficient knowledge to use them effectively. A similar argument applies to the use of chemical fertilizers and other technology. In order for improved orchard management practices to become more widely employed by small farmers, effective technology must be developed or adapted to their needs, and their ability to purchase that technology must be improved.

c. Government-Supported Farm Credit Programs

Formal production credit is available to small farmers through programs such as that of the National Production Bank (Banco Nacional de Fomento). These credit programs suffer from procedural features which tend to dis-

courage their use by small farmers. The delay between the time of application and final receipt of the loan can be excessive. For a fruit grower, who must carry out his program of cultural practices according to a schedule established by nature, the timely receipt of a loan may be essential to the proper conduct of the orchard operation. The amount of paperwork required to complete a credit application constitutes a barrier to persons unfamiliar with bureaucratic procedure and located at considerable distance from the various offices where these transactions take place. The time required to complete the application process may represent a significant loss to an individual occupied with the sustenance of himself and his family. For instance, to qualify for credit the small farmer must show official title to his land. Yet lands are often distributed among heirs of a farmer without benefit of legal documentation. Various permits and titles are a necessary part of the credit loan process; some effort has been started by the Government to facilitate the acquisition of necessary documents and these efforts should be increased. It is such problems as those outlined above which reduce interest among small farmers in formal credit programs, and force them to use the informal street credit readily available from loan sharks, but for short terms and at exorbitant interest rates.

MAG has proposed a credit program of long-term, low interest loans for orchard renovation and replanting (2). In this project, which is currently awaiting approval, the deficiency in technical assistance available to growers in the area is recognized and plans have been included to rectify the problem. Such activities specifically shaped to the needs of the intended recipients should be encouraged.

SUMMARY

The fundamental cause of the low productivity of apple orchards in the Q-P region can be attributed to the almost total lack of application of proper orchard management practices during the life of an orchard. Although the currently popular scion cultivars and rootstocks as well as the nature of the environment add their own dimensions to the problems of production, the lack of suitable orchard management technology is still the major limiting factor.

As long as orchard management practices are not improved, productivity will remain low. Little change in fruit quality can be expected. Changes in scion cultivars or rootstocks will not overcome the dominant influence of poor orchard management practices. Modest production increases can be expected as improvements in such areas as pest control methods, fertilization, pruning, planting system design, and irrigation are realized. Much of the technology necessary to improve production is already available; the major difficulties remaining involve adaptation of this technology to the conditions of Ecuador and the needs and economic limits of small farmers. This process will require applied research to identify those cultural practice deficiencies with major impact on production and to adapt or develop low-cost technology to overcome them. The success of such programs in increasing productivity will also depend on effective transmission of this information to growers and the availability of marketing and credit structures which can help create the incentive to use it.

RECOMMENDATIONS

Technology

1. Development of a stronger apple and overall deciduous fruit industry in the Q-P region as well as in the rest of Ecuador will be impossible without a strong program of research oriented toward adaptation and development or orchard technology designed for small farming systems. Reliance on imported technology alone will not provide the answers to many of the specific problems to be overcome.
2. INIAP has recently received support funds to initiate a research program in fruit and vegetable crops. Cooperative efforts on the part of MAG and any other agencies involved in regional development should be started with INIAP to establish lines of communication with the personnel responsible for this program, to confer on research needs, and to develop relevant research programs.

3. Where possible, cooperative research with growers should be encouraged. This approach allows the evaluation of practices under grower conditions, at the same time developing the direct grower contact which fosters the credibility of the governmental

agencies involved. Research programs should both explore the full potential for deciduous fruit production under the conditions found in the production area and develop recommendations suitable for small farmers of limited financial means.

4. Pressure from responsible agencies should be applied to stimulate progress on developments such as the proposed irrigation project of INERHI. Development of research data on tree performance (see next section) can be of great value in justifying the needs for and the benefits to be derived from such developments.

5. A suggested program of important researchable problem areas is outlined below:

   a. Short-term Research (1-5 years)

      1. Effects of irrigation and fertilization starting before bloom on tree growth, bloom period, fruit set, fruit growth, and fruit quality.

      2. Effects of rest-breaking spray treatments alone and in combination with water and fertilizer management techniques for overcoming lack of chilling and stimulating budbreak.

      3. Survey of orchards to identify and determine the extent of mineral nutrient deficiencies and excesses in apple trees. A foliar analysis service for fertilizer recommendations to growers ultimately could be developed as part of such a program.

      4. Effects of improved training and pruning methods on stimulation of branching, development of better tree structure, encouragement of flowering and fruiting, and renewal of bearing wood.

      5. Effects of improved cross-pollination on fruit set, fruit size, fruit shape, and fruit quality.

      6. Entomological and phytopathological surveys to identify the principal pest problems of apples, determine their life cycles under prevailing climatic conditions, and develop recommendations for control.

      7. Improved procedures for propagation and growth of rootstocks and improvements in methods for propagating scion cultivars to increase nursery productivity.

8. Studies of fruit development and maturity, and indices to aid in harvesting only properly mature fruit at any one picking.

9. Effective and economical fruit handling methods which maximize preservation of fruit quality from harvest to final sale to the consumer.

10. Management strategies for intercropping systems which minimize detrimental effects on fruit tree growth and development.

b. Long-term Research (longer than 5 years)

1. Evaluate local and introduced scion cultivars for adaptation, productivity, and fruit quality attributed of value to the apple industry of the area. Trials of selected cultivars from low-chilling breeding programs in other parts of the world should be initiated.

2. Evaluate locally-used rootstocks for superior types. Comparative trials of Malling, Malling-Merton, seedling, and other apple rootstocks should be started to evaluate their performance under controlled cultural practice conditions.

3. Studies of soil conservation practices designed to minimize erosion and improve soil structure, fertility, and water-holding capacity.

4. Evaluation of planting systems which maximize usage of land area for crops while optimizing the relation between fruit trees and interplanted basic crops. Develop cultivar intermixture recommendations which favor cross-pollination and maximize returns to the grower.

c. A breeding program for development of new cultivars should not be initiated at this time. Local selections, cultivars presently available in Ecuador or elsewhere, and selections from other breeding programs should provide a wealth of scion and rootstock cultivars for testing under Ecuadorian conditions. The resources required for a breeding program are large and results require many years. Specific breeding programs for low-chilling cultivars have been or are under way in several locations, such as Israel, Florida, Texas, and California.

Education

1. For a fruit production improvement program to be successful in the Q-P area, a long-term commitment of personnel in both research and extension roles is necessary. Such positions should be established at a level at which the responsibilities and remuneration attract individuals competent to properly carry out those responsibilities. At the outset it will be very important to provide specialized training to a nucleus of one or two people in MAG who can then begin to carry out extension duties as well as provide contact and coordination with INIAP research programs as they are developed.
2. There is a strong need for improved training for MAG personnel currently involved in various activities related to fruit growing. The typical lack of specialization in agricultural programs at the college level makes it difficult to prepare people for the kinds of responsibilities involved in carrying out specific programs as outlined here. The possibility should be explored of a cooperative arrangement with the Agricultural Faculty of the Polytechnic College of Chimborazo (Escuela Superior Politecnica de Chimborazo), in which students interested in the area of fruit crops might carry out their thesis research work on practical problems related to fruit culture in the region. In this manner much of the initial basic research work recommended in this report could be carried out by students. A trained pomologist should be available to assist in helping to structure thesis programs and evaluate the results. This approach has several possible advantages:
   a. With sufficient student interest it would be possible to develop several projects covering the major areas of need in a reasonably short period of time.
   b. Initial research results could be obtained at relatively low cost with Ecuadorian students, working in conjunction with MAG personnel assigned to such a program. Transportation to the fruit area would not represent a serious problem if the current level of MAG-IICA transportation support is maintained.
   c. This approach would provide an opportunity to help identify and train individuals who might show promise for future

specialization in fruit research and/or extension work.

d. It would give students a direct exposure to the problems of small farming systems through conducting their research work in the area with local fruit growers.

e. It would provide an opportunity to stimulate development of greater depth in the fruit training program at the school through cooperative efforts of the school and various Ecuadorian agencies, as well as IICA and Cornell.

f. The research plots developed under this program could also serve as part of an extension program to demonstrate improved techniques in orchard management to growers.

Resources

1. Improvements in orchard technology will only have significant impact on production if the economic resources of farmers permit their use. Since improved technology is unavoidably more expensive where cultural practices are almost totally lacking, efforts should be made to improve the farmers' ability to purchase that technology.

2. Credit programs designed for deciduous fruit crops should be long-term, low-interest-rate loans to minimize the accumulation of debts by small farmers. Long-term loans are needed to take into account the time required from planting or the start of orchard renovation until commercial production begins or resumes. For new orchard plantings a credit plan of no less than seven years in length should be established; for orchard renovation the term should be at least five years, due to the difficulty generally encountered in successfully renovating old trees. Because satisfactory orchard renovation is often difficult to achieve, any credit loan for orchard renovation should include a stipulated percentage specifically designated for investment in replanting a portion of the orchard. In this manner replanting of orchards can be stimulated.

3. The involved procedures and inherent delays in the credit-granting process should be reduced as much as possible to facilitate access by small farmers unfamiliar with bureaucracy. Easier access to credit also can facilitate the planning of an expanded program of improved cultural practices.

4. Efforts should be undertaken to evaluate the current structure and operating effectiveness of the fruit-grower cooperative in Bayushig. The operating strategy of Ecuadorian agencies involved in rural credit and development is such that functional grower cooperatives can facilitate procurement of financial assistance (See reference 2). Formation should be encouraged of cooperatives which have the structure and support necessary to serve not only in matters related to production, but as agents for member growers with regard to problems of financial aid, land tenure and documentation, etc.

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