FARMERS' PRACTICES, PRODUCTION PROBLEMS AND RESEARCH OPPORTUNITIES IN BARLEY PRODUCTION IN THE CALPULALPAN/APAN VALLEY, MEXICO

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Derek Byerlee
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PREFACE

In cooperation with researchers in many national agricultural research programs, CIMMYT has sought to develop procedures which help to focus agricultural research squarely on the needs of farmers. The process involves collaboration of biological scientists and economists to identify the groups of farmers for whom technologies are to be developed, determining their circumstances and problems, screening this information for research opportunities, and then implementing the resulting research program on experiment stations and on the fields of representative farmers.

CIMMYT's Economics Program has emphasized developing procedures for the first stage of this process, through to establishing research opportunities. The evolution of the procedures, now synthesized in a manual "Planning Technologies Appropriate to Farmers: Concepts and Procedures" has been strongly influenced by collaborative research with many national programs and with CIMMYT's wheat and maize training programs. Our efforts with national programs began in 1974 with Zaire's national maize program, then moved to work in Tunisia, Pakistan, and Egypt. The pace of work accelerated notably in 1976 with assignment of regional economists stimulating similar work in Kenya, Tanzania, Zambia, Ecuador, Peru, Bolivia, Panamá, El Salvador, and India. Cooperation with still other national programs is now underway. We believe that the resulting procedures offer cost effective and robust guidelines to national programs.

We are now preparing reports that illustrate the implementation of these procedures in various national programs. While not all such work can be reported, we take this opportunity to thank all of those who have collaborated with us.

This report is the result of the collaboration of CIMMYT's Economics Program and Wheat Training Program to better understand the circumstances of barley producers in the area where the Wheat Training Program conducts an on-farm experimental program. The information is being used to better focus these experiments on key farmer problems.

Donald L. Winkelmann
Director, Economics Program
1.0 Introduction: Purposes of the Survey

Since 1975, CIMMYT’s Wheat Training Program has conducted experiments on improved barley, wheat and triticale technologies in farmers’ fields in the high valleys of the States of Mexico, Hidalgo and Tlaxcala, Mexico. These experiments have been conducted for the primary purpose of familiarizing participants in the training program with rainfed wheat, barley and triticale agronomy and techniques of on-farm experimentation. The experiments have also served to develop and to some extent, demonstrate improved technologies for wheat and barley production in the area.

The CIMMYT Economics Program has cooperated with the Wheat Training Program since 1975. In that year, a small study was conducted on the circumstances of barley producers in the area, in order to provide information for more closely focusing experimentation on the problems of typical farmers. The study also provided price and cost information for economic evaluation of the experimental results. In 1979, the Economics Program began its own training program, emphasizing the role of economists in agricultural research. A major part of this training consists of field work to design and execute farmer surveys to provide information for agricultural research decision making.

The survey of farmer practices and problems in barley production described here was carried out in 1979 in one highland valley by the Economics Program and the Wheat Training Program, with a number of objectives in mind. These can be summarized as follows:

1. Training: A primary purpose of the survey was to train economists from agricultural research programs in the type of information on farmer circumstances useful in research decision making and in the design and implementation of farmer
surveys to obtain this type of information.

2. Research Decision Making: The surveys was also designed to provide information to the Wheat Training Program on farmer practices and problems in research decision making. A number of different types of information are needed in planning on-farm experimental programs, including:

   a. Information on variation in farmer circumstances (both agronomic and socio-economic) to enable grouping of farmers into fairly homogeneous groups or recommendation domains (RDS) which can be served by the same experimental program and technological recommendations.

   b. Information on production problems and farmer constraints on using potential improved technologies.

   c. Quantitative information on the most common practices followed by farmers as a basis for comparing improved technologies.

   d. Quantitative information on farmers and fields as a basis for selecting representative farmers and fields for experimental work.

   e. Information on input/output coefficients and price relationships faced by farmers that can be used to evaluate improved technologies.

3. Methodology Development: The methodology used by CIMMYT Economics in assessing farmer circumstances is continually being evaluated. In this case we wish to compare information obtained by informal and formal survey methods and to test the value of informal field observations.

   This report focuses on the second objective - that is, the presentation and analysis of information on farmer circumstances for use in designing on-farm experiments. We first outline the methodology employed for obtaining data and then briefly describe the agro-climatic and socio-economic environments in which
farmers make decisions. Variation in these circumstances is used as a basis for stratifying the sampled farmers into tentative recommendation domains (RDs). The farming system and in particular farmers' barley production practices are presented and analysed for each RD. The following sections analyse production, income and risk. This information is synthesized in the final section into implications for experimental research in the area.

2.0 Methodology

2.1 Selection of the Study Area

A highland valley with Calpulalpan, Apan and Sanctorum as the main urban centers was chosen as the area for the study. The farmers sampled are from the Municipios\(^1\) of Mariano Arista, Calpulalpan and Lázaro Cárdenas in the State of Tlaxcala and the Municipios of Emiliano Zapata and Apan in the State of Hidalgo (see the map in Figure 3.1). The area is convenient for CIMMYT - a half-hour drive - as well as a major barley producing area. In the 1970 agricultural census, some 10,500 ha were planted to barley in this valley. It is also an area in which the CIMMYT Wheat Training Program has worked extensively since 1975.\(^2\)

2.2 General Survey Procedures

The survey procedures followed are described in the CIMMYT Economics Manual (Byerlee, Collinson, et al, 1980). These are:

a) Assembly of secondary data, in this case primarily climatological data from the Mexican meteorological service and data from the 1970 agricultural census which are available at the level of the "municipio".

\(^1\)A local government unit.

\(^2\)The Wheat Training Program also works in two other distinct zones but to better achieve the objectives of the survey, we decided to focus on one valley with fairly homogeneous climatic characteristics.
Figure 3.1 Map Showing Location of Study Area
b) An exploratory survey consisting of informal interviews with farmers and institutions that serve them such as the official credit bank (BANRURAL), machinery contractors ("maquiladores") and input suppliers. During the exploratory survey we went in small groups to a different part of the valley each day and talked informally to farmers we met on the way.

c) A formal survey was conducted using trained interviewers to administer a written questionnaire to a randomly chosen sample of farmers. Three interviewers were employed. They were sons of local farmers or farmers in their own right, 18-25 years old with at least primary school education. They were given a one week training course including practice in filling the questionnaire in the field. The questionnaire was designed on the basis of information learned during the exploratory survey and focused on farmers' practices and reasons for these practices.

d) A sample of farmers was chosen by randomly locating coordinates on an aerial photograph of the valley of scale 1:50,000. The point corresponding to a coordinate was located on the ground and the four barley fields nearest to the point chosen. The farmers managing these fields were then identified and interviewed. Only barley fields belonging to distinct farmers that could be identified within 250 meters of the point were selected. As a result less than four farmers were interviewed at many points. This sampling procedure probably led to some bias toward larger farmers who have larger fields and/or larger number of fields. Therefore regional averages presented below do not necessarily represent the true picture for the region as a whole. In most cases, however, we present data disaggregated by subgroups based on farm size or machinery ownership which removes most of the bias.
e) At the time of sampling or on a return visit a senior researcher informally made observations on the sampled fields. These included observations on planting method, stand, weed problems, lodging, frost damage and an "eye ball" estimate of yield.

2.3 Data Analysis

Basic descriptive statistics on farmer practices and problems were extracted by hand tabulations. More indepth analysis involving cross-tabulations was conducted using the FASAP computer program (Hesse de Polanco and Walker (1980)) and the SAS statistical package.

3.0 The Agro-Climatic Environment of Farmers

The agro-climatic environment of farmers not only establishes the potential for crop production but is also the major source of risk in farmer decision making. Rainfall, frosts, soils and topography are the major elements of the agro-climatic environment that influence farmers' decisions in the study area. Disease and pest incidence (except weeds) are often an important element of the natural environment but were not found to be a significant factor in the study area, with the exception of weeds.

3.1 Rainfall

Average annual rainfall for points in the study area is shown by the histograms in Figure 3.2. In general, rainfall decreases as one moves away from the mountains on the southern side of the valley. Apan on the northern side of the valley, with an annual rainfall of about 590mm, is therefore somewhat drier than Calpulalpan and Sanctorum.

Almost all rain falls from April to October with June to September as the wettest months. May rainfall averages 38mm in the driest point, Apan, and is
APAN (1961-75)
Average Annual Rainfall: 588 mm
Average May-Sept Rainfall: 464 mm

CALPULALPAN (1948-1978)
Average Annual Rainfall: 635 mm
Average Rainfall, May-Sept: 506 mm

SANCTORUM (1966-78)
Average Annual Rainfall: 742 mm
Average Rainfall, May-Sept: 625 mm

Figure 3.2 Histogram Showing Monthly Rainfall Distribution for Three Centers in the Calpulalpan Valley

Source: Unpublished rainfall data from Servicio Meteorológico Nacional, Mexico
normally sufficient to allow May planting. However, an early planting does run
the risk of the barley maturing in wet weather in September. However, May rain-
fall is somewhat unreliable as the average rainfall in Apan and Calpulalpan is
only 21mm in the 20 percent driest years (see Figure 3.2). In these years
sowing of barley will be delayed into June, shortening the growing season.
Rainfall from June to September is generally quite reliable averaging over
40mm for each of these months even in the 20 percent driest years.

3.2 Frosts

With an average altitude of about 2600 meters above sea level, the length
of the growing season in the study area is also constrained by the incidence of
frosts in the latter part of the season (September and October). Figure 3.3
shows that these frosts can occur as early as the first week of September but
the probability of a frost (0°C) is not large until the last week of September
and then rises rapidly in October. These data were taken at Calpulalpan near
the center of the valley. Lower lying areas have a higher frost risk while
higher areas on the southern slopes have a much lower risk. This means that
late planted barley (late June) that matures in 120-125 days runs a significant
risk of frost damage in late September and early October. Normally, rainfall
is sufficient to allow earlier planting but farmers who delay planting after
opening rains to control weeds or due to lack of equipment run the risk of
early frosts.

Given these agro-climatic constraints, the ideal situation for the farmers
is to plant when rains are quite reliable in late May/early June using a variety
that is mature by the last week in September and that can be harvested in the
drier weather of October.
Figure 3.3 Cumulative Probability of Frost in September/October at Calpulalpan

Source: Unpublish data from Servicio Meteorológico Nacional, Mexico.
3.3 **Topography**

The great majority of fields in the study area are flat or gently sloping with some steeper slopes on the southern side of the valley. Erosion on sloping fields is reduced by planting the perennial cactus, "maguey", on the contour. However, normally there is sufficient space between the maguey rows to allow annual crops to be planted between the row using a tractor for land preparation and planting although machinery efficiency is reduced.

3.4 **Climatic Conditions in 1979**

In 1979, the year in which the survey was conducted, climatic conditions were somewhat abnormal in several respects and may have a bearing on the survey results. First, early rainfall was below average. At Calpulalpan no rain was recorded in May until May 22. Between May 22 and 30, 51mm of rain was received but this was followed by another dry spell in which only 25mm were recorded until June 27. As a result, moisture for planting was sometimes lacking, delaying planting. Also early planted fields were often subject to considerable moisture stress in June. Finally, killing frosts began on September 25 and continued for several days.

4.0 **Socio-Economic Environment**

The socio-economic environment consists of markets for inputs and products, investments in infrastructure, institutions serving agriculture such as banks and general rules and customs placed on resource use such as land tenure. These elements are usually regarded by farmers as fixed in their decision making, although they may have important effects on the practices they follow.

4.1 **Infrastructure**

The study area is generally well served by roads with two main highways
crossing the valley, several paved lateral roads and an extensive network of service roads most of which are motorable during the rainy season.

4.2 Product Markets

Two distinct markets exist for barley - barley for forage and barley for malting. Traditionally, most barley was produced for animal forage, either for the farmers’ own animals or for sale. The 1970 Agricultural Census reports that over 60 percent of barley was produced for forage purposes.

During the 1970's however, the emphasis has switched strongly to production of barley for malting purposes. This reflects a strong increase in demand for beer in Mexico with rising population and incomes. Incomplete statistics indicate that beer production has expanded at an annual growth rate of about 6 percent per annum during the 1970s.

A private organization of major breweries, Impulsora Agrícola, has promoted barley production for malting purposes through distribution of improved varieties of higher malting quality and technical advice, as well as acting as a buying agent. Impulsora Agrícola normally announces a fixed buying price although this is often discounted according to quality. Although this price is often not available at the time farmers make planting decisions, barley prices do not seem to be subject to much seasonal or year to year fluctuation. Prices have risen gradually relative to competing crops. For example, the price of malting barley has increased about 300 percent from 1974-79 compared to a doubling of the guaranteed price of maize.\(^1\)

To sell directly to Impulsora Agrícola, farmers must take their barley to one of its few buying points. Because of this, most farmers sell to intermediaries.

\(^1\)In 1980 farmers are lobbying for a substantial price increase from Impulsora Agrícola. (Excelsior, 29 September, 1980) However the guaranteed price of maize has also increased substantially.
who purchase barley at the farm gate and transport it to a buying point of Impulsora Agrícola. 1/

4.3 Input Markets

Major input suppliers in the area are private stores (the "veterinarias"), Impulsora Agrícola, FERTIMEX and the official bank, BANRURAL. The veterinarias distribute seed and herbicides but fertilizer must be purchased through FERTIMEX outlets or as part of a loan in kind from BANRURAL. FERTIMEX stores are located in most of the larger centers but fertilizer supplies are very erratic and farmers who do not take bank credit often must travel a considerable distance to obtain fertilizer. BANRURAL distributes inputs of seed, fertilizer and herbicide as part of its loan.

4.4 Credit

As just noted, credit in kind and sometimes as cash for machinery expenses is available from BANRURAL at modest interest rates of 14-16 percent per annum on a standard loan of $3000-3500/ha. BANRURAL particularly works with the ejido sector. However, terms of the loans and the type and quality of inputs included in the loans vary with the branch of BANRURAL. In particular, part of the study area is in the state of Tlaxcala and the other in the state of Hidalgo, so that branches of BANRURAL fall into different administrative districts.

4.5 Research and Extension

A primary activity of extension is to provide technical advice to farmers working with the credit program of BANRURAL. They do not have a demonstration program nor is there a research program operating in the area to provide

1/ A more detailed description of the role of Impulsora Agrícola, see Medellin (1980).
recommendations to farmers. Nonetheless the National Agricultural Research Institute (INIA), has established recommendations for barley production in the area which are promoted by Impulsora Agrícola. These are shown in Table 4.1. Extensive experimentation on varieties and agronomic practices as well as demonstration of technological packages has been conducted by the CIMMYT Wheat Training Program. Although the primary purpose of these experiments is training, they have no doubt had some impact on the spread of new technologies.

4.6 Land Tenure

The major land tenure arrangement in the area is that of the ejido with ejidatarios managing their land allotment individually. Private ownership is also common. Many farmers rent additional land on a share or cash basis. Although legally ejido land may not be rented or sold, much of this rented land is probably ejido land. During 1979 the going rental price for land was about $1000/ha.\(^1\)

4.7 Labor Market

The local labor market is strongly influenced by the proximity of the study area to Mexico City as well as by the location of factories in or near the area. The industrial complex, Ciudad Sahagun is only a few kilometers outside the area. As a result, there are strong alternative employment opportunities in the non-agricultural sector. The high wage rate for agricultural labor relative to other rural areas of Mexico ($100/day in 1979) reflects this labor scarcity. The scarcity of labor, reflected in rising wage rates, has been an important factor encouraging mechanization in the area, especially labor intensive activities such as harvesting. (Hesse de Polanco and Byerlee (1981).)

4.8 Machinery Market

An active market for rental of tractor services for land preparation and planting and for combine harvesting exists in the area. Machinery renters,

\(^1\)All monetary units are in Mexican pesos. Approximately $23 Mexican = $US 1.00
<table>
<thead>
<tr>
<th><strong>Land Preparation</strong></th>
<th>Plough and harrow after harvest followed by a second ploughing and harrowing before planting. Alternatively, harrow after harvest, followed by ploughing 6 weeks later and another harrowing before planting.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Variety</strong></td>
<td>Apizaco, Puebla, Cerro Prieto, Chevalier</td>
</tr>
<tr>
<td><strong>Sowing Date</strong></td>
<td>1 May to 15 June. After 15 June plant only Cerro Prieto or Puebla.</td>
</tr>
<tr>
<td><strong>Sowing Rate</strong></td>
<td>100 kg/ha</td>
</tr>
<tr>
<td><strong>Fertilizer</strong></td>
<td>Calpulalpan 60 kg N/ha, 30 kg P/ha</td>
</tr>
<tr>
<td><strong>Herbicide</strong></td>
<td>2 lt/ha of Esteron 47 in 200 lts. water applied 20-30 days after planting. For wild oats 4 lt/ha of Finaven 20-30 days after planting.</td>
</tr>
</tbody>
</table>

Source: Impulsora Agrícola (1977)
commonly known as maquiladores, may be entrepreneurs with their own plant specializing in this activity. Or they may be farmers in their own right who charge-off some of the capital cost of machinery ownership by performing contract work for neighbors after completing work on their own farm. There are also some maquiladores from other regions such as the Bajío with a different agricultural calendar who move machinery (often by train) to the area for planting and harvesting.

According to the 1970 Agricultural Census there was one tractor for every 40 cultivated hectares in the area. This is a relatively favorable ratio although it is not clear if the census figures includes all tractors or only tractors in working order. The ratio is likely to have become even more favorable since 1970.

5.0 Grouping Farmers into Recommendation Domains

One decision that must be made early in a research program is the division of farmers into relatively homogeneous groups or recommendation domains - that is, farmers with similar problems for whom we can make one recommendation. It is necessary to try to make this division early in the program since research might be orientated differently for each group of farmers.

From secondary data and conversations during the exploratory survey we concluded that the study area is quite homogeneous agro-climatically but heterogeneous with respect to socio-economic characteristics of farmers. The only important agro-climatic variation seems to occur on the southern slopes of the valley (e.g. around Nanacamilpa and San Marcos) where rainfall is higher and risk of frost lower than in the valley floor. This subregion therefore has a longer, more certain growing season that favors longer season crops such as maize and wheat, as well as later maturing barley varieties. However, the area
is small relative to the total area studied and we did not deem it worthwhile to consider this variation in defining recommendation domains.\textsuperscript{1/}

Farmers are quite heterogeneous with respect to such interrelated characteristics as farm size, land tenure, machinery ownership and use of credit, although it is not immediately clear that these differences are sufficiently large to warrant different sets of recommendations. One guide is the extent to which farmers' current practices correlate with these characteristics. Analysis showed that many cultural practices, especially land preparation were significantly correlated with these characteristics. Production practices tended to be more cash and machinery intensive with increasing farm size, with a greater proportion of land farmed under individual or share land tenure, and with increasing ownership of farm machinery.

The criterion, tractor ownership, was chosen for tentative stratification. This clearly divided sampled farmers into two groups - those who rented tractors (37 farmers) and those who owned tractors (50 farmers). Some of the former group also used horses for some operations but only one farmer in the sample used horses for all land preparation and planting activities. Tractor ownership is of course highly correlated with farm size but it was hypothesized that the basic characteristic determining practices of large farmers was tractor ownership. That is, farmers who own a tractor can perform land preparation and planting in a more timely manner than those who must await the services of a rented tractor. Moreover, because of the sensitive nature of land tenure in the area, we felt that information on farm size would be less reliable than information on tractor ownership for purposes of stratification.

\textsuperscript{1/}This subregion also consists of smaller farmers so that some of this variation is captured in the subsequent stratification by farm type.
Results showing the different practices of the two hypothesized groups of farmers will be presented in the following sections. In the conclusions we shall summarize these differences and again examine whether two separate recommendation domains (RDs) are justified.

6.0 General Features of the Farming System and Farmers' Resources

6.1 The Farming System and its Evolution

General features of the farming system are summarized in Tables 6.1 and 6.2. Barley is by far the most important farming enterprise in the area. The 1970 Agricultural Census indicates that 73 percent of annual cropped areas was planted to barley. This percentage seems to have increased recently to over 85 percent of annual crop area in the sampled farmers in 1979.

Maize makes up most of the residual area of 10-20 percent planted to other crops. Maize is of course the traditional staple food and over two thirds of farmers continue to plant enough maize for subsistence purposes. Maize area increases only marginally with farm size so that larger farmers are almost entirely specialized in barley production (Table 6.2). It may be, however, that 1979 maize area was below normal because of poor rains in April when maize is normally planted and a frost in June which resulted in some badly damaged maize fields being replanted to barley.

Nonetheless, there is evidence that farmers are slowly reducing the area sown to maize. Compared to five years ago, farmers claim to have reduced maize area by about 16 percent. Half of the farmers claimed to have decreased maize area while another 37 percent were growing the same area of maize. Only 13 percent had increased their area in maize. According to farmers the low price
Table 6.1  Cropping Patterns and Farmers' Resources by Recommendation Domain

<table>
<thead>
<tr>
<th>Recommendation Domain</th>
<th>Tractor Renters</th>
<th>Tractor Owners</th>
<th>Statistical Significance on Differences between RDs b/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Farmers</td>
<td>37</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Average Farm Size (ha)</td>
<td>10.8</td>
<td>50.0</td>
<td>**</td>
</tr>
<tr>
<td>Cropping Pattern</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Area Planted to Barley</td>
<td>79</td>
<td>91</td>
<td></td>
</tr>
<tr>
<td>Percent Area Planted to Maize</td>
<td>17</td>
<td>8</td>
<td>**</td>
</tr>
<tr>
<td>Percent Area Planted to Other Crops a/</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Percent Farmers Plant Maize</td>
<td>65</td>
<td>74</td>
<td>**</td>
</tr>
<tr>
<td>Percent Intercrop with Maguey</td>
<td>41</td>
<td>44</td>
<td></td>
</tr>
<tr>
<td>Rotation Practices</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Planted Barley after Maize</td>
<td>47</td>
<td>27</td>
<td>**</td>
</tr>
<tr>
<td>Percent Continuous Barley for Five Years</td>
<td>33</td>
<td>56</td>
<td>**</td>
</tr>
<tr>
<td>Land Tenure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Ejido Land</td>
<td>68</td>
<td>27</td>
<td>**</td>
</tr>
<tr>
<td>Percent Privately Owned Land</td>
<td>18</td>
<td>31</td>
<td>**</td>
</tr>
<tr>
<td>Percent Rented Land</td>
<td>15</td>
<td>42</td>
<td>**</td>
</tr>
<tr>
<td>Average Number of Fields</td>
<td>2.7</td>
<td>4.7</td>
<td>**</td>
</tr>
<tr>
<td>Average Size of Field (ha)</td>
<td>4.0</td>
<td>14.5</td>
<td>**</td>
</tr>
<tr>
<td>Machinery Ownership</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Own Disc Plough</td>
<td>0</td>
<td>96</td>
<td>**</td>
</tr>
<tr>
<td>Disc Harrow</td>
<td>3</td>
<td>100</td>
<td>**</td>
</tr>
<tr>
<td>Drill</td>
<td>0</td>
<td>48</td>
<td>**</td>
</tr>
<tr>
<td>Combine Harvester</td>
<td>0</td>
<td>40</td>
<td>**</td>
</tr>
<tr>
<td>Truck</td>
<td>8</td>
<td>60</td>
<td>**</td>
</tr>
<tr>
<td>Credit - Percent Receive Credit from Official Bank</td>
<td>16</td>
<td>52</td>
<td>**</td>
</tr>
<tr>
<td>Labor - Percent Hire Labor</td>
<td>69</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>- Percent have Off-Farm Income</td>
<td>50</td>
<td>44</td>
<td></td>
</tr>
</tbody>
</table>

a/ Mostly habas and frijol (broadbeans and beans)

b/ ** Differences between the two groups are significant at 5 percent level using a Chi-squared test for percentages and t-test for means.
Table 6.2  Cropping Patterns and Farmers' Resources by Farm Size Group

<table>
<thead>
<tr>
<th></th>
<th>&lt;5ha</th>
<th>5-10ha</th>
<th>10-20ha</th>
<th>20-40ha</th>
<th>40-100ha</th>
<th>100ha+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distribution of Farmers by Farm Size - Percent</td>
<td>15</td>
<td>26</td>
<td>22</td>
<td>17</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>Cropping Pattern</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Area Planted to Barley</td>
<td>73</td>
<td>74</td>
<td>77</td>
<td>83</td>
<td>82</td>
<td>99</td>
</tr>
<tr>
<td>Land Tenure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent Ejido Land</td>
<td>97</td>
<td>84</td>
<td>60</td>
<td>63</td>
<td>44</td>
<td>2</td>
</tr>
<tr>
<td>Percent Privately Owned Land</td>
<td>3</td>
<td>0</td>
<td>29</td>
<td>9</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td>Percent Rented Land</td>
<td>0</td>
<td>16</td>
<td>11</td>
<td>28</td>
<td>19</td>
<td>61</td>
</tr>
<tr>
<td>Average Number Fields</td>
<td>2.2</td>
<td>2.8</td>
<td>3.1</td>
<td>5.1</td>
<td>5.3</td>
<td>7.7</td>
</tr>
<tr>
<td>Tractors - Percent Own</td>
<td>25</td>
<td>35</td>
<td>53</td>
<td>73</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>- Percent Owners Doing Custom Work</td>
<td>50</td>
<td>50</td>
<td>40</td>
<td>55</td>
<td>27</td>
<td>43</td>
</tr>
<tr>
<td>Credit - Percent Receive Credit from Official Bank</td>
<td>0</td>
<td>22</td>
<td>53</td>
<td>53</td>
<td>55</td>
<td>57</td>
</tr>
</tbody>
</table>
of maize and the high labor requirements were major reasons for reducing maize area although the risk associated with the longer growing season of maize probably also plays a role. Nonetheless, most farmers expressed the intention of growing about the same amount of maize in the future to satisfy subsistence requirements.

As the area of barley increases relative to maize, there is also a tendency toward sowing continuous barley in the same field. Figure 6.1 shows that in the selected fields, a barley-maize or barley-beans rotation is practiced by over half of small farmers but as farm size increases the continuous barley rotation becomes overwhelmingly dominant. This trend toward continuous barley cropping may lead to a build up of weed problems although few farmers seem to observe this.

In addition to annual crops, the perennial cactus, maguey, is widely grown in the area for the extraction of agua-miel which is processed into an alcoholic drink, pulque. Generally maguey is grown in rows 6-12 meters apart on the contour at a density of 250-500 plants/ha. It is usually planted on sloping land as an important means of reducing soil erosion. Annual crops are then sown between the maguey rows.

About 40 percent of farmers were cultivating maguey although, in some cases, maguey has been restricted to the borders of fields. Maguey like maize is widely perceived to be a less profitable and more labor intensive crop than barley. In addition, farmers must wait 8-10 years to harvest a maguey plant. Even more than maize it seems to be declining in importance. Forty percent of maguey producers did not replace a plant when harvested and one-third stated that they expected to stop maguey production completely. This trend is less pronounced
Figure 6.1 Percentage of Farmers Who are Using Two Different Rotations by Farm Size
among smaller farmers, many of whom find the year round secure source of cash income a considerable advantage. Moreover, production risk arising from weather variability is very low or negligible in the case of maguey production. However the general decline in the area planted to maguey does have important implications for long-term soil conservation.

Finally, livestock are of some importance in the area. Many farmers have flocks of a few cows, sheep and goats. Barley straw is fed to these animals by grazing them in the field or, in many cases, the straw is baled and sold.

6.2 Land and Land Tenure

In the sample of farmers, land is quite unequally distributed. As a rough measure the smallest forty percent of farmers (i.e. with less than 10 ha each) farm only 10 percent of the area while the largest 20 percent of farmers (i.e. with over 40 ha each) farm 66 percent of the area (Figure 6.2). However, caution is needed in extrapolating these figures to the region. We have already noted the bias toward larger farmers implied by the sampling method. Furthermore, we believe that because of the sensitive nature of land tenure some farmers substantially understated their area so that the proportion of small farmers is inflated.

Distribution of land within each RD is shown in Figure 6.2. Among tractor renters there is relatively little variation in farm size, with almost all having less than 20 ha. Among tractor owners there is great diversity in farm size. In particular, there was a small group of farmers who farmed over 100 ha and up to 250 ha.

Land tenure status is quite closely related to farm size (see Table 6.2). Small farmers largely farm under the ejido tenure system. As farm size increases,

\[ \text{A common index of inequality, the Gini coefficient, was calculated as a high 0.58 for land distribution among the sampled farmers.} \]
Figure 6.2 Distribution of Farm Size by Tractor Ownership
privately owned land and land rental becomes more important. The largest farmers with over 100 ha particularly have increased farm size through land rental. Most land is rented on a share rental basis with either a two-thirds or a one-half share to the renter being most common. The renter normally pays all production costs except harvest costs which are shared according to the share of output.

Both the number of fields as well as the size of the field increase with the farm size. Some larger farmers have ten or more scattered fields of varying sizes. This number and distribution of plots means that mechanical operations are somewhat less efficient although the switch from animal power to tractor power has made the management of scattered parcels more practical. Farmers also recognize that the scattering of plots reduces risks from frosts and drought.

6.3 Machinery Ownership

As expected, machinery ownership is dependent on tractor ownership. Almost all tractor owners also own a three-disc plough and an offset disc harrow. Roughly half of tractor owners also own a drill, truck and/or a combine harvester. Tractor ownership is closely related to farm size (Table 6.2). We hypothesized that few small farmers would own tractors and those who did would also contract services to other small farmers. In fact, there is little relationship between farm size and performance of custom work off-farm. About half of tractor owners who claim to farm less than 20 hectares of land do not perform custom work off-farm which leads us to suspect that farm size was understated by this group of farmers. Also, it should be recalled that farmers with surplus machinery capacity can also utilize this capacity by expanded sharecropping.

6.4 Credit

A little over one-third of farmers in the sample received credit from the
official bank in the form of inputs of seed, fertilizer and herbicide. About half of this number, or one-sixth of farmers in the sample, also received credit in cash primarily for machinery hire or operation. Very few tractor renters or farmers with less than 20 hectares of land, received credit (Table 6.2). Therefore, one of the major cash expenses, rental of tractor services, is paid from the farmers' own sources or from credit borrowed from other sources (used by about 12 percent of farmers).

It is not clear why more small farmers are not obtaining credit from the bank. Most credit users seemed to be pleased with services they were receiving although a few complained that inputs were more expensive through bank sources. On the other hand many felt that the agricultural insurance which is mandatory for credit users was an important advantage of working with the official bank.

6.5 Labor

Despite the relatively high level of mechanization in the area, most farmers hire some labor for farm work. A substantial proportion of farmers also have off-farm sources of income such as work on other farms or a business. Some farmers and particularly many farmers' sons are full-time workers in one of the nearby factories. This availability of non-farm employment has reduced the supply of hired labor for farm work.

7.0 Farmers' Barley Production Practices

7.1 Land Preparation

Land preparation practices are summarized in Table 7.1. Except for a very few small farmers on the southern slopes, almost all power is provided by tractors. Many farmers harrow immediately after harvesting (and removal of straw to incorporate the stubble and kill any weeds still growing at the end of the season.
Table 7.1 Land Preparation Practices By Recommendation Domain

<table>
<thead>
<tr>
<th>Recommendation Domain</th>
<th>Tractor Renters</th>
<th>Tractor Owners</th>
<th>Statistical Significance on Differences between RDs a/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent do Pre-Plough Harrow</td>
<td>41</td>
<td>54</td>
<td>**</td>
</tr>
<tr>
<td>Percent Plough in Oct-Dec</td>
<td>17</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Jan-March</td>
<td>49</td>
<td>57</td>
<td>**</td>
</tr>
<tr>
<td>April-June</td>
<td>34</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Percent Consider Best Time to Plough</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oct-Dec</td>
<td>64</td>
<td>69</td>
<td></td>
</tr>
<tr>
<td>Jan-March</td>
<td>17</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>April-June</td>
<td>19</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Percent do Subsoil Ploughing</td>
<td>19</td>
<td>36</td>
<td>**</td>
</tr>
<tr>
<td>Percent Harrow - Zero Times</td>
<td>14</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Once</td>
<td>54</td>
<td>36</td>
<td>**</td>
</tr>
<tr>
<td>Twice</td>
<td>22</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Three Times</td>
<td>11</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Desired Number of Harrowings</td>
<td>2.2</td>
<td>2.4</td>
<td></td>
</tr>
<tr>
<td>Percent Post-Plough Harrow the First Time in Oct-Dec</td>
<td>6</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Jan-March</td>
<td>25</td>
<td>49</td>
<td>**</td>
</tr>
<tr>
<td>April</td>
<td>19</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>May-June</td>
<td>50</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Percent Farmers Expressed Difficulty in Hiring a Tractor in Periods of High Demand</td>
<td>54</td>
<td>n.a.</td>
<td></td>
</tr>
</tbody>
</table>

a/** Differences significant at the 5 percent level based of Chi-squared test.

n.a. Not applicable.
This is followed by a ploughing with a three-disc plough. The date at which this ploughing is done varies by recommendation domain. About two-thirds of all farmers in both RDs consider it is best to plough in November or December, immediately after the previous harvest (see Table 7.1), in order to utilize end of season moisture and allow sufficient time for decomposition of crop residues. In fact only 17 percent of tractor renters and 32 percent of tractor owners ploughed in this period. One-third of tractor renters ploughed after the beginning or the rains in April although very few tractor owners followed this practice. The most common reasons given for not ploughing at the desired time were inability to remove straw from the field and lack of moisture. Tractor renters also cited lack of tractor availability or lack of ready cash as reasons for not ploughing early.

A minority of farmers also practiced subsoil ploughing during the 1979 season, usually after the initial ploughing. However, this does not appear to be a popular practice as two-thirds of farmers who had ever done subsoil ploughing thought they would not do it again.

Intensity of secondary tillage also varies substantially by RD. Tractor renters most commonly harrow once while tractor owners usually harrow twice (Table 6.1). Moreover, most tractor renters do not harrow for the first time until immediately before sowing in May and June. Both the timing and number of harrowings suggests that larger farmers owning tractors are using secondary tillage to control weeds and prepare a better seed bed over the dry season while smaller farmers renting tractors do not begin this process until after the opening rains.

Later informal interviews indicate that some farmers plough twice in cross-wise directions. However, the questionnaire did not specifically ask about this practice.
Again the intensity of secondary tillage is related to tractor availability since both groups of farmers desired at least two harrowings before planting (Table 6.1). After a rain during the dry season there is a relatively short period of time when moisture conditions are suitable for harrowing. However, many farmers who rent tractors stated that they have difficulty obtaining a tractor in periods when there is a high demand for tractor services. When asked to estimate the wait required to obtain tractor services, most farmers estimated that they needed to give one to two weeks notice to a "maquilador". Among small farmers, the need to have cash on hand ($200/ha) at the right time was also felt to be a problem affecting timeliness of operations.

In summary, tractor renters use significantly less intensive land preparation practices than tractor owners. The need for a renter to find a tractor when moisture conditions are right and then find the cash to pay for the service apparently is a severe constraint on more intensive land preparation.

7.2 Planting

Broadcasting seed and covering with a tractor-drawn disc harrow is the common planting method used by farmers in the area although a larger area is probably planted by drills. There is still a relatively limited rental market for drills. Among tractor renters a few farmers are also renting a drill for planting. Almost half of tractor owners, however, planted with a drill.

Drilling does involve some extra cost. As a general rule farmers who use a drill also disc harrow immediately before drilling in order to kill remaining weeds and provide a more even seed bed. This is an operation normally performed when broadcasting in order to cover the seed. Therefore the cost of drilling is the difference between drill rental, about $250/ha, and hand broadcasting
at about $50/ha - that is, an extra cost of about $200/ha.

Most farmers in the informal survey noted that the optimal time for planting, given adequate moisture, was the end of May and the beginning of June. In fact, as shown in Table 7.2 this was the most popular time for planting among farmers in both RDs. Moreover the distribution of planting dates is almost identical for both group of farmers.

Table 7.2 Planting Time and Method by Recommendation Domain

<table>
<thead>
<tr>
<th>Recommendation Domain</th>
<th>Tractor Renters</th>
<th>Tractor Owners</th>
<th>Statistical Significance of Differences between RDs a/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Use Drill</td>
<td>19</td>
<td>46</td>
<td>**</td>
</tr>
<tr>
<td>Percent of Farmers Using Drill who Rent the Drill</td>
<td>100</td>
<td>16</td>
<td>**</td>
</tr>
<tr>
<td>Percent Plant</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before Last Week May</td>
<td>31</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>Last Week May and First Week June</td>
<td>44</td>
<td>39</td>
<td></td>
</tr>
<tr>
<td>After First Week June</td>
<td>25</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Seed Rate (kg/ha)</td>
<td>106</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td>Source of Seed (Percent by Source)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Previous Year's harvest</td>
<td>50</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Official Bank</td>
<td>14</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Impulsora Agrícola</td>
<td>3</td>
<td>20</td>
<td>**</td>
</tr>
<tr>
<td>Neighbors</td>
<td>28</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Special Purchases in the Bajío</td>
<td>3</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

a/** Significant at the 5 percent level using Chi-squared test.
However, a further disaggregation shows that planting date is a function of both farm size and planting method. As shown in Figure 7.1, farmers who drill plant significantly earlier than farmers who broadcast. Moreover, among farmers who broadcast, fields of larger farmers with 20 ha or more were planted significantly later than fields of farmers with less than 20 ha. (Among farmers who drill the distribution of planting dates was almost identical for small and large farmers.) These relationships are of course expected, given that one person can only broadcast about 2-3 ha per day. A large number of workers is needed to complete planting by broadcasting in a short period of time on large farms. At the same time, farmers using a drill plant 10 to 20 ha per day without the use of hired labor.

Figure 7.1 shows that by the end of the first week of June, 90 percent of farmers using a drill had planted the sampled field but only 73 percent of small farmers and 58 percent of large farmers who broadcast had planted. Given that planting after the first week of June significantly increases the risk of frost damage in late September and early October it seems that one of the major advantages of drilling is more timely planting and reduced risk. Drilling may also enable a more even stand by placing seed at a uniform depth.  

The overall result is that tractor owners who consist of both large farmers who use a drill and large farmers who broadcast do not plant any earlier on average than tractor renters. However, variation in planting dates among tractor owners is much higher as a result of different methods of planting.

1/ However we have observed farmers obtaining excellent stands by broadcasting on a well prepared seed bed. Some farmers also claim that scattering of seed throughout the soil profile at varying depth increases the probability of obtaining early emergence when soil moisture is limiting.
Figure 7.1 Cumulative Distribution of Planting Dates in Selected Fields by Planting Method and Farm Size
The seeding rate varies between 90 and 130 kg/ha with an average of 115 kg/ha. We hypothesized that farmers broadcasting would use a higher seeding rate than farmers who drill but average rates are almost identical for each group. The source of seed does however vary substantially between the two recommendation domains. Farmers renting tractors largely planted seed saved from the previous year while farmers owning tractors generally purchased seed, usually through the Rural Credit Bank. A few of the larger farmers make special trips to the Bajío each year to obtain new supplies of seed from barley grown under irrigation in that region during the winter. Purchased seed was generally priced at $5.0-5.5/kg or about twice the selling price of commercial barley.

7.3 Varieties

Year of release and days to maturity of varieties planted by sampled farmers over the last three years are shown in Table 7.3. A total of six varieties were encountered in the survey. There is very little difference in the varieties planted between the two groups of farmers.

Commum a tall "local" variety introduced to Mexico by the Spanish in the XVI Century is now only planted by a few small farmers in the area. It is highly regarded for its forage value but it has low malting quality and does not respond well to improved management, particularly the application of nitrogen which causes it to lodge severely. Commum has been replaced by improved varieties released by INIA since the early 1960's. One of the earliest of these INIA varieties was Apizaco which became the major variety planted in the area. Apizaco is still widely grown but a newer and earlier variety, Cerro Prieto, is now equally common. Moreover, a comparison across the years 1977 to 1979 shows that Cerro Prieto has been rapidly replacing Apizaco during this period.
<table>
<thead>
<tr>
<th>Variety Planted</th>
<th>Variety to Maturity</th>
<th>Approx. Years РФ</th>
<th>Approx. Days</th>
<th>Percent</th>
<th>Percent</th>
<th>Percent</th>
<th>Percent</th>
<th>Percent</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puebla</td>
<td>105</td>
<td>107</td>
<td>107</td>
<td>107</td>
<td>107</td>
<td>107</td>
<td>107</td>
<td>107</td>
<td>107</td>
</tr>
<tr>
<td>Celaya</td>
<td>107</td>
<td>107</td>
<td>107</td>
<td>107</td>
<td>107</td>
<td>107</td>
<td>107</td>
<td>107</td>
<td>107</td>
</tr>
<tr>
<td>Centinela</td>
<td>105</td>
<td>107</td>
<td>107</td>
<td>107</td>
<td>107</td>
<td>107</td>
<td>107</td>
<td>107</td>
<td>107</td>
</tr>
</tbody>
</table>
| *Information from Riojas, Guadiana (1976) and personal observations.*
Interestingly this trend is strongest among the smaller farmers (i.e. tractor renters). Celaya is another older variety of lower malting quality whose use is declining. Puebla and Centinela are newer varieties of yet earlier maturity which have recently increased in importance, although they are still only sown by a relatively small number of farmers. The sowing of Puebla may have peaked because of difficulties farmers experience in selling it for malting purposes.

Farmers also tend to plant late maturing varieties earlier. Figure 7.2 shows that there is a clear preference towards planting Apizaco up to the third week of May, after which Cerro Prieto is more commonly planted.

It is clear that farmers in the region have wide knowledge of varieties in the area and are continually experimenting with new varieties. In fact, only Centinela, the latest variety released, was not widely known in the area. Some two-thirds of farmers changed varieties over the period 1977-79.

Farmers were also asked to name, from the varieties they knew, the "best" variety for their needs and to rank these varieties with respect to certain characteristics (see Table 7.3). Apizaco emerged as the most popular single variety largely because of its proven yield and quality characteristics and because it exhibits few problems of lodging and shattering. Nonetheless, farmers consider earliness as an important characteristic and many preferred one of the newer earlier varieties, Cerro Prieto, Puebla and Centinela. Although Cerro Prieto is sown by almost one-third of farmers, it is preferred by only 20 percent of farmers. Farmers consider that Cerro Prieto has more problems of lodging and especially of shattering if harvesting is not completed soon after maturity. On the other hand, Celaya was equally preferred to Cerro
Figure 7.2 Relationship Between Date of Planting and Variety Planted
Prieto although grown by less than 10 percent of farmers. The lower preference for Puebla and Centinela probably reflects the fact that these varieties are less well known.

The fact that farmers sometimes plant a variety other than the preferred variety seems to reflect several factors. Seed availability was mentioned by many farmers. For example, Cerro Prieto seed was widely available in 1979. Moreover, farmers who worked with the bank often did not plant their preferred variety because they were constrained to use the seed provided by the bank. Only 41 percent of farmers receiving official credit planted their preferred variety compared to 70 percent of farmers working independently. The late start to the rainy season in 1979 may have caused some farmers to switch to an earlier variety such as Cerro Prieto although, as we have seen, the trend away from Apizaco and Celaya toward Cerro Prieto has occurred consistently over the last three years. Finally, farmers may simply be expressing a preference for the older varieties with which they have had more experience.

7.4 Fertilizer

Although most farmers have had experience using fertilizer on barley we found it quite difficult to obtain reliable information on fertilizer use during the interviews. A number of different fertilizers are used by farmers, but farmers often did not know the name or nutrient composition of the fertilizer they used. Most often it was distinguished by color - black or white - or by referring to the bag in which fertilizer came. The following data on fertilizer should therefore be interpreted cautiously.

In 1979 a little over a half of farmers in RDI (tractor renters) and almost all farmers in RDII (tractor owners) used fertilizer (Table 7.4).
Table 7.4 Farmers Practices By Recommendation Domain for Use of Fertilizer and Herbicide

<table>
<thead>
<tr>
<th></th>
<th>Recommendation Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tractor Renters</td>
</tr>
<tr>
<td><strong>Fertilizer</strong></td>
<td></td>
</tr>
<tr>
<td>Percent Farmers Ever Used Fertilizer on Barley</td>
<td>73</td>
</tr>
<tr>
<td>Percent Farmers Applied Fertilizer in 1979</td>
<td>57</td>
</tr>
<tr>
<td>Percent Fertilizer Users Applied Nitrogen</td>
<td>93</td>
</tr>
<tr>
<td>Percent Fertilizer Users Applied Phosphorous</td>
<td>56</td>
</tr>
<tr>
<td>Percent Fertilizer Users Applied Potassium</td>
<td>12</td>
</tr>
<tr>
<td>Average Dose of Nitrogen for Fertilizer Users (kg/ha)</td>
<td>49</td>
</tr>
<tr>
<td>Average Dose of Phosphorous for Fertilizer Users (kg/ha)</td>
<td>20</td>
</tr>
<tr>
<td>Percent Users Apply by Hand</td>
<td>19</td>
</tr>
<tr>
<td>Percent Users who Split Application</td>
<td>14</td>
</tr>
<tr>
<td><strong>Herbicide</strong></td>
<td></td>
</tr>
<tr>
<td>Percent Farmers who Ever Used Herbicide on Barley</td>
<td>86</td>
</tr>
<tr>
<td>Percent Applied Herbicide in 1979</td>
<td>75</td>
</tr>
<tr>
<td>Average Dose Esteron 47 (lt/ha) - users</td>
<td>0.65</td>
</tr>
<tr>
<td>Percent Farmers Applied with Back Pack Sprayer - users</td>
<td>100</td>
</tr>
</tbody>
</table>
Fertilizer users applied nitrogen at an average dosage of 50-60 kg/ha. Phosphorus was applied at a rate of about 40 kg/ha P$_{2}$O$_{5}$ if used, but only about half of fertilizer users in RDL used phosphorous. Most tractor renters broadcast the fertilizer by hand but machine application was common among tractor owners.

These average figures, however, obscure a great deal of variability in fertilizer use among sampled farmers. As shown in Figure 7.3 this variability is less in the case of nitrogen where most farmers apply between 40 and 60 kg/ha of nutrient. In the case of phosphorous, the most common application is around 23 kg/ha (one 50 kg bag of triple superphosphate or 18-46-0 per hectare) but the variation in dosage is much greater. Over half the farmers claimed to have applied nitrogen and phosphorous at a ratio of less than 1.7:1 which indicates a rather high rate of phosphorous use relative to nitrogen.

The official bank has had a substantial impact on fertilizer use by giving loans in kind. Table 7.5 shows that all farmers working with the official bank applied fertilizer but only a little over one-third of small farmers, not receiving credit, applied fertilizer. To a large extent this reflects problems of fertilizer availability in the area. Most of the larger farmers not working with the bank applied fertilizer but they often journeyed 50 km or more to points outside the area to obtain the fertilizer. Note that there is little difference in the levels of fertilizer used between fertilizer users who work with the bank and those who work independently.

About one-fifth of the surveyed farmers had applied organic fertilizer in 1978 or 1979. In particular, about half of the farmers who applied no chemical fertilizer used organic fertilizer. Most organic fertilizer was from the farmers' own animals and was spread by hand. In most cases, the quantities applied were quite low in terms of nutrient value.
Figure 7.3 Distribution of Rates of Nitrogen and Phosphorous Application Among Fertilizer Users

Table 7.5 Fertilizer Use by Farm Size and Use of Official Credit

<table>
<thead>
<tr>
<th></th>
<th>Farmers Less than 20 ha</th>
<th>Farmers Over 20 ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percent Farmers Use Fertilizer</td>
<td>Independent, Official Bank</td>
<td>38 ( ^a ) / 100 ( ^a )</td>
</tr>
<tr>
<td>Average Dose of Nitrogen of Users (kg/ha)</td>
<td>Independent, Official Bank</td>
<td>47 / 51</td>
</tr>
<tr>
<td>Average Dose of Phosphorous of Users (kg/ha)</td>
<td>Independent, Official Bank</td>
<td>18 / 29</td>
</tr>
</tbody>
</table>

\( ^a \) Farmers who do not receive credit from the official bank
Finally we asked farmers about their perceived yield increase from using chemical fertilizer. Prices paid by farmers for chemical fertilizer in 1979 were approximately $3.2/kg for Urea (46 percent N) and $3.1/kg for Triple Superphosphate (46 percent P). With a transport charge of $10 per 50 kg bag, application labor of 0.5 mandays/ha and capital costs of 25 percent, an average dose of 60 kg/ha N and 35 kg/ha P would require a 350 kg/ha increase in yields to cover costs. In fact farmers estimated average yield increases of about 1.0 ton/ha - well above the breakeven level. Moreover, farmers did not perceive fertilizer as a risky investment. Over two-thirds of farmers estimated yield increases above the breakeven level even in the worst years.

7.5 Weed Control

Weed control in the area is achieved through secondary tillage operations, herbicide application and, on a limited scale, rotation and selective manual control. Secondary tillage has been discussed under land preparation and here we document other weed control methods, especially herbicide use.

Use of the 2-4, D product, Esteron 47, has become almost universal in the area with some 94 percent of farmers having used this product. The number of farmers applying herbicide during 1979 was somewhat lower, possibly due to the dry weather after planting.

Farmers apply 2-4, D at a rate considerable below the recommended dosage of 2 lt/ha of commercial product (1 lt/ha active ingredient). The modal dosages was in fact only 0.75 lt/ha of commercial product and many farmers applied only 0.5 lt/ha and some as little as 0.3 lt/ha. In fact, no farmers in the sample applied the recommended dose. Nonetheless, most farmers achieved good broadleaf weed control with these dosages.
On average in normal weather conditions farmers estimated that application of 2-4, D increases yields by about 500 kg/ha, substantially above the 85 kg/ha needed to cover the cost of application. Furthermore, farmers probably benefit from reduced impurities in their grain sample and hence lower discounts on prices received for barley.

Back-pack sprayers are used by 94 percent of farmers in the sample to apply herbicides. Even most of the largest farmers, with 100 ha or more of barley, use back-pack sprayers by employing teams of several workers, each with a sprayer. Farmers estimate that 2 to 4 ha of barley can be sprayed by one worker in a day so that a team of 5 workers might be able to spray 100 ha in a week. Given prices of labor of $100/day in 1979, the cost of manual application is $25-50/ha for labor plus cost of the sprayer. Since sprayers rent for $30-40/day or $15-20/ha the cost of manual application is from $40-70/ha. It is unlikely that a tractor and boom sprayer could compete with the cost of back-pack sprayer application although the tractor would probably provide more even application over the field.

Farmers generally felt that Esteron 47 gave good control of broadleaf weeds except for "calabacilla", from the curcubita family. However, the widespread use of 2-4, D does not mean that there are no broadleaf weed problems in the area. As shown in Table 7.6, our own observations in farmers' fields subjectively rated only one-half of fields as clean of broadleaf weeds and nearly one quarter of fields as badly infested. Many of the badly infested fields had not been sprayed during 1979. However, most of those fields in the moderately infested category had been sprayed but the level of control achieved was quite low even for weeds

\[\text{Cost of application, calculated as 0.75 } \text{lt/ha of Esteron 47 at $160/lt, 0.5 manday/ha for application, $20/ha for rent of the hand sprayer and 25 percent capital cost. Additional harvesting costs are assumed to be negligible and the price of barley at the farm gate is taken as $2.75/kg.}\]
normally controlled by 2-4, D. This might arise from the low dosage, unsuitable climate conditions at the time of spraying or late application. Climatic conditions probably played some part since earlier planted fields were suffering considerable drought stress at the normal time for 2-4, D application. Many weeds recovered or new seeds germinated with heavy rains following the dry period. Nonetheless, we have also observed a considerable variation in the time of application in relation to crop growth. Figure 7.4 shows the distribution of weeks after planting in which 2-4, D was applied by sampled farmers. Assuming that the optimal time for 2-4, D application in the area is 4-5 weeks after planting, over half of the farmers applied 2-4, D outside this period - mostly later. Moreover, there was some association between weed problems and date of application. Sixty-three percent of fields sprayed 4-5 weeks after planting were weed free compared to 50 percent of fields sprayed six weeks or later after planting.

The lack of good weed control on many fields sprayed with herbicide probably reflects farmers’ management in choosing the right time and dose of application. Since use of chemical weed control is a relatively new practice in the area, we hypothesize that farmers are still adjusting their management practices as they gain more experience.

Most farmers also were aware that 2-4, D does not kill grassy weeds, especially wild oats, the main grassy weed in the area. As shown in Table 7.6 our field observations indicate that wild oats is not yet a major problem weed although subjectively we estimated that it was causing substantial yield losses in 15 percent of fields inspected. Another 29 percent of fields had many plants with the potential to build-up to a serious problem.

Most farmers were aware of the potential problem of wild oat infestation and felt that tillage methods were the most efficient control mechanism. In fact,
Table 7.6  Ratings of Weed Problems Based on Field Observations

<table>
<thead>
<tr>
<th>Rating of Weed Problem</th>
<th>Broadleaf Weeds</th>
<th>Wild Oats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serious</td>
<td>23</td>
<td>15</td>
</tr>
<tr>
<td>Moderate</td>
<td>28</td>
<td>29</td>
</tr>
<tr>
<td>Little or None</td>
<td>49</td>
<td>56</td>
</tr>
<tr>
<td>(Percent)</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

*Based on authors' observations in the farmers' fields selected by the sampling technique. As a rough guide "serious weed problems" represent at least a 10 percent yield loss on a 2 ton/ha crop and "moderate weed problems" a 5-10 percent yield loss.

Figure 7.4 Histogram Showing the Distribution of Weeks after Planting of the Application of the Herbicide, Esteron 47
fields of tractor owners who have greater flexibility in timing and number of secondary tillage operations showed somewhat less problems with wild oats than tractor renters. Some farmers also try to rotate with a row-crop such as maize or beans when they notice a wild oat built up. Use of such a rotation for wild oat control requires excellent weed control in the row-crop which is not the case for many farmers. Also rotation is not a feasible strategy for large farmers who grow very little maize. A few farmers also selectively weed wild oat plants by hand as a control measure. Finally, a few farmers are aware of the herbicide Finaven for the control of wild oats but none are using it. They consider that, at present, the cost of Finaven use of about $750/ha would not be repaid.

With a tendency toward cultivation of continuous barley and better control of broadleaf weeds, an increase in wild oats as a serious weed problem is expected. However, this trend is probably being counteracted at present by improvements in land preparation, particularly the increased number and improved timing of secondary tillage operations.

7.6 Harvesting and Crop Disposal

In recent years, combine harvesting has replaced hand harvesting for most farmers in the area. Only 5 percent of the sampled farmers — all small farmers — now harvest by hand.\footnote{Hand harvesting is usually only performed where maguey rows are sown too close to allow entry of a combine. In wet weather, smaller farmers may also harvest by hand rather than await dry weather for combine harvesting.} The average cost of combine harvesting in the previous season 1978 was $600/ha or equivalent to six days labor. This is substantially cheaper than could be expected for hand harvesting and machine threshing. The main disadvantage of machine harvesting is the shortage of machines during the peak harvesting period so that those who rent combines usually have to wait two to three weeks or more to obtain the services of a contractor. Machine harvesting might also be delayed if the rainy season extends into October.
After harvesting about half of the farmers also use a mechanical baler to cut and bale the straw for sale. This is practiced especially by larger farmers who do not have animals to graze off the straw in time to prepare the land for the next crop cycle. In 1978, farmers estimated that about 100 bales/ha of 18 kg each of straw could be sold at $2-3/bale. (This price is net of the baling cost.)

The remaining stubble can also be rented for grazing purposes at $100-200/ha.

We also asked farmers about grain disposal after the 1978 harvest. Because of the substantial time lapse of almost a year between crop disposal and the interviews and because many farmers are reluctant to reveal crop sales we do not have much confidence in the data obtained.

However, some general observation can be made. A good deal of barley is used for animal feed. About half of all farmers stored one ton or more for feeding domestic animals. Small farmers also usually save seed for the following season. A few farmers - all small farmers - stored their entire production for animals. Some barley is also sold for animal feed but it is difficult to estimate the proportion since farmers who sell to intermediaries sometimes do not know the final destination of their product.

The marketing channels for barley are closely associated with farm size. Larger farmers with their own trucks usually sell directly to Impulsora Agrícola buying points in Apan or Mexico City. The price is determined by the fixed price announced by Impulsora Agrícola less discounts for quality.1/ Smaller

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1/ In 1977, Impulsora Agrícola had the following quality standards. Germination not less than 85 percent. Moisture - maximum of 13.5 percent except in factories with driers in which case grain with up to 16.5 percent moisture is allowed but $125/ton is charged for drying and weights were adjusted to 13.5 percent moisture content. Utilizable grain - no discounts with over 85 percent, thereafter discounted 10 kg for each percentage point decrease in utilizable grain with a limit of 65 percent. Floating grain - limit 10 percent. Broken or hulled grain - acceptable up to 5 percent then discounting 10 kg for each one percentage point up to a limit of 10 percent. Impurities - acceptable up to 2 percent then 10 kg discount for each one percentage point up to a limit of 6 percent. Mixtures with other varieties - acceptable up to 10 percent.
farmers usually sell to "acaparadores", intermediaries who buy directly in the field or at the farmers' house. The price received is lower than direct sales to Impulsora Agrícola but the cost of contracting transport services is also saved. On average, farmers received a price of $2.75/kg for the 1978 harvest.

8.0 Production, Profits and Risks

8.1 Yields and Factors Affecting Yields

Barley yields for 1979 were estimated by the authors by inspecting the farmers' fields. While this is quite subjective, we feel that we were able to categorize the yield of a given field quite accurately to the nearest 0.5 ton/ha. Two estimates of yields were obtained for fields that had been damaged by frosts in late September. The first estimate was based on stand, ear size, etc., and assumed there was no damage from frosts. The second estimate took into account any grain damage resulting from the frost.

Estimated yields are shown for each group of farmers in Table 8.1. Yields in RD1 (tractor renters) are somewhat lower than in RDII (tractor owners). Frost reduced yields by an average of about 300 kg/ha but the incidence of frost damage was quite variable. Many farmers escaped frost damage while others had their entire crop destroyed.

<table>
<thead>
<tr>
<th>Recommendation Domain</th>
<th>Tractor Renters (t/ha)</th>
<th>Tractor Owners (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Yields Assuming No Frost Damage</td>
<td>1.73</td>
<td>1.95</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>.67</td>
<td>.66</td>
</tr>
<tr>
<td>Average Yield with Frost Damage</td>
<td>1.39</td>
<td>1.83</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>1.68</td>
<td>.66</td>
</tr>
</tbody>
</table>
A simple linear regression was fitted to attempt to explain variation in yields in terms of cultural practices such as date of ploughing, number of harrowings, planting date, variety, planting method, nitrogen application, phosphorous application, herbicide application and variables for location to reflect variation in weather patterns in the study area in 1979.

Of course, yield is often a complex interaction of these cultural practices as well as timing of the practices in relation to local weather conditions which is not easily captured in a regression equation. Excluding variables with minor and insignificant effects, and considering only first order linear interactions the final form of the equation chosen was:

\[ Y = 1640 + 281L + 483VT - 598F + 497FH - 274A_2 + 580A_3 - 440A_5 - 507FA_6 \]  
\[ (222) \quad (91) \quad (199) \quad (256) \quad (240) \quad (181) \quad (238) \quad (297) \quad (381) \]

\[ R^2 = 0.44 \quad n = 67 \]

where \( Y \) is yield in kg/ha, \( L \) is number of harrowings, \( V \) is a dummy variable for early variety (Centinela, Puebla or Cerro Prieto), \( T \) is a dummy variable for planting in the second week of June or later, \( F \) is a dummy variable if fertilizer was applied, \( H \) is a dummy variable if herbicide was applied and \( A_i \) are dummy variables representing each of the six areas into which the study area was divided. Standard errors of the coefficients are given in parentheses.

The number of post-ploughing harrowings significantly affected yields. It was estimated that one additional harrow increased yields by 280 kg/ha. Variety and time of planting independently had little effect but when planting was performed in the second week of June or later, an earlier variety significantly increased yields by 480 kg/ha. Fertilizer application generally had
a negative yield effect especially in area A6. In this areas in the north­
east part of the valley (centered on the ejido of Benito Juárez) a severe
drought occurred early in the season and in fact CIMMYT's Wheat Training
Program also lost experiments in this area in 1979. However, fertilizer
and herbicide together significantly increased yields by 500 kg/ha, providing
further evidence that fertilizer is not usually profitable in the absence
of better weed control. Finally the various dummy variables for location
confirm the substantial variability in weather conditions across the area in
1979. Overall the equation explained less than half of yield variation
with cultural practices and location being equally important in the expla­
nation.

8.2 Production Costs and Breakeven Yields

A breakdown in costs shows major expenditures which might offer
potential for reducing production costs through experimentation. Average
costs of production for each group of farmers are shown in Table 8.2 Costs
of machinery have been calculated for tractor owners as equivalent to rental
prices since use of machinery on the owner's farm does incur an opportunity
cost equal to the rental price. The major difference in costs for tractor
renters and tractor owners occurs not in higher machinery costs but in higher
expenditures on seed and fertilizer. Tractor owners spend more than double
the outlay of tractor renters for these inputs. Assuming that land is owned,
and cash costs are machinery, labor and input costs, the tractor renters
needs only a yield of about 800 kg/ha to pay cash costs while a tractor
owner must obtain 1150 kg/ha (see Table 8.3). These figures are relevant for
Table 8.2 Production Costs for Barley Production by Recommendation Domain, 1979

<table>
<thead>
<tr>
<th></th>
<th>Tractor Renters ($/ha)</th>
<th>Tractor Owners ($/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Machinery Costs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ploughing ($350/ha)</td>
<td>350</td>
<td>350</td>
</tr>
<tr>
<td>Harrowing ($200/ha each)(^a/)</td>
<td>200</td>
<td>400</td>
</tr>
<tr>
<td>Covering Seed ($200/ha)</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>Drilling ($270/ha)</td>
<td></td>
<td>270</td>
</tr>
<tr>
<td>Back Pack Sprayer for Herbicides (Rental $40/day or $20/ha)</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Harvesting ($600/ha)</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td><strong>Total Machinery Costs</strong></td>
<td>1370</td>
<td>1640</td>
</tr>
<tr>
<td><strong>Labor</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Broadcasting Seed (.5 manday/ha)</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Broadcasting Fertilizer (.5 manday/ha)</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Spraying Herbicide (.5 manday/ha)</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td><strong>Total Labor Costs</strong></td>
<td>150</td>
<td>100</td>
</tr>
<tr>
<td><strong>Inputs</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seed(^b/) (Own seed - $2.75/kg, Purchased Seed - $5.25/kg)</td>
<td>290</td>
<td>600</td>
</tr>
<tr>
<td>Fertilizer(^c/) (Price of N $7.6/kg, Price of P $7.3/kg)</td>
<td>250</td>
<td>690</td>
</tr>
<tr>
<td>Herbicide(^d/) (Esteron 47 at $150/lt)</td>
<td>100</td>
<td>120</td>
</tr>
<tr>
<td><strong>Total Input Costs</strong></td>
<td>640</td>
<td>1410</td>
</tr>
<tr>
<td><strong>Land</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cash Rental</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>Share Rental</td>
<td>One-Third of Yield</td>
<td></td>
</tr>
</tbody>
</table>

\(^a/\) One harrowing for tractor renters, two harrowings for tractor owners.

\(^b/\) Tractor renters use 105 kg/ha of own seed, tractor renters use 115 kg/ha of purchased seed.

\(^c/\) Tractor renters use on average 23 kg/ha N, 10 kg/ha P. Tractor owners use on average 57 kg/ha N, 35 kg/ha P. Fertilizer prices include $0.20/kg transportation cost to field.

\(^d/\) 0.65 lt/ha and 0.80 lt/ha for tractor renters and owners, respectively.
Table 8.3  Break-even Yields and Return on Capital for Barley Production by Recommendation Domain, 1979

<table>
<thead>
<tr>
<th>Break-even Yields</th>
<th>Tractor Renters (kg/ha)</th>
<th>Tractor Owners (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakeven Yield to Cover Cash Cost of Machinery, Labor and Inputs(^a)/</td>
<td>785</td>
<td>1150</td>
</tr>
<tr>
<td>Breakeven Yield to Cover All Costs Including Cash Land Rental and 25 Percent Return on Capital and Management(^b)/</td>
<td>1380</td>
<td>1830</td>
</tr>
<tr>
<td>Breakeven Yield to Cover All Costs Including One-Third Share Land Rental and 25 Percent Return to Capital and Management(^c)/</td>
<td>na.</td>
<td>2070</td>
</tr>
<tr>
<td>Implicit Land Rent Under Share Rental(^c)/</td>
<td>na.</td>
<td>1500</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Return on Capital(^d)/</th>
<th>(percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate of Return on Capital Assuming No Frost Damage (%)</td>
<td>62</td>
</tr>
<tr>
<td>Rate of Return on Capital with Frost Damage (%)</td>
<td>26</td>
</tr>
</tbody>
</table>

\(^a\)/ Assumess price of barley of $2.75 in farmers' fields.

\(^b\)/ Rate of return on capital calculated for all inputs except hire of combine harvester. In the case of share rental, renter pays two-thirds of harvest costs.

\(^c\)/ Calculated as one-third of the breakeven yield multiplied by the price of barley and reduced by 25% capital cost to be comparable with cash land rental which is paid at the beginning of the season.

\(^d\)/ Calculated as \(\text{yield} \times \text{price} / (\text{machinery costs} + \text{labor costs} + \text{input cost} + \text{cash land rental}) - 1\).

na - not applicable because few tractor renters rent land.
assessing risk (see Section 8.3) since we assume that farmers will want at least to cover cash costs, even in a poor year. But for barley production to be profitable over all years, yields of about 1400 kg/ha and 1800 kg/ha for tractor renters and owners respectively are needed to pay all costs, including those of capital and land.

If land is rented on a one-third share basis, then tractor owners would need a yield of 2070 kg/ha to cover all costs including the third share going to the land owner.1/ (Tractor renters rent very little land.) This gives an implicit price of $1500/ha for land rental on one-third shares, substantially above the rate of $1000/ha for cash land rental. Of course we expect the share rental costs to be somewhat higher than the cash rental cost because the land owner assumes some risk under the yield-sharing arrangement.

Using the yield figures presented in section 8.1 and assuming that the yield (if the crop were undamaged by frost) is a normal yield, we calculated the rate of return on capital as 62% for tractor renters (mostly small farmers) and 33% for tractor owners (mostly large farmers). The larger return for tractor renters reflects the lower level of inputs employed and the relative capital scarcity of this group of mostly small farmers. Moreover, a majority of the tractor owners obtain credit from the official bank at low rates of interest as well as agricultural insurance to protect against crop losses.

1/ If share farmers use lower levels of inputs, the breakeven yield would be lower. However, there is no evidence that share farmers in the sample used lower levels of inputs than land owners.
8.3 Production Risks

Farmers were asked about the seriousness of a number of natural hazards - late start to rains, early finish to rains, early frosts, wet harvest weather, hail, floods, diseases and insects. From this list, early frost emerged as the major hazard followed by hail and late start to rains. Sixty four percent of farmers ranked early frosts as the major climatic hazard. To some extent these results may reflect the fact that frosts were earlier and more severe in 1979 than normal and also rains began later than normal. Nonetheless, when asked about the number of years in the last ten in which early frosts had damaged their crops, farmers frequently mentioned 3 years (see Figure 8.1) which represents a considerable risk to farmers. Hail was also frequently mentioned as a hazard but apparently the risk of hail damage is somewhat less frequent (Figure 8.1).

9.0 Implications for Agricultural Research to Improve Early Barley Production

9.1 Recommendation Domains

Although we have noted important differences in the area with respect to topography and machinery ownership, we conclude that these differences are not large enough to warrant separate RDs for the purpose of planning experiments. On the sloping land on the side of the valley current farmer practices tend to be similar to those on flat land. However, the experiments on wheat described below might emphasize sloping land since length of growing season will be a major factor in the success of wheat production. We did note substantial differences in practices between tractor renters and owners. However, we
Figure 8.1 Histograms of Farmers' Estimates of the Number of Years in Ten that Barley Yields are Reduced by Natural Hazards - Frost, Hail and Late Start to Rains.
present evidence elsewhere (Hesse de Polanco and Byerlee (1981)) that these differences appear to be narrowing as more tractors become available and use of newer varieties, herbicides and fertilizer becomes more widespread among smaller farmers. Therefore rather than considering different recommendation domains, we recommend that in the selection of fields for on-farm experiments particular attention is given to obtaining a representative sampling of cropping history, date of ploughing and timing and intensity of secondary tillage. If in the experimentation stage, important interactions are discovered between these practices and say fertilizer and weed control recommendations, then two separate recommendation domains may be justified.

9.2 Short Run Research Opportunities

From our own observations and experiences working in the area and the results of the survey there are a number of opportunities for increasing barley production and farmer incomes which should be included in an on-farm experimental program. We have divided these into short-run opportunities which offer immediate pay-off in one to three years and longer run research opportunities which will require a somewhat longer period to develop and have less certainty of success.

The major problems facing farmers that offer short-run solution are: a) an uncertain growing season due to unreliable rains at the beginning of the season and frost risk toward the end of the season, b) high cash cost of production especially for seed and fertilizer, and c) weed infestation - both broadleaf and wild oats. Each of the following experiments addresses one or more of these problems.
Variety/Crop x Time of Planting: The survey has clearly shown that farmers use a wide range of planting dates. These result from variation in earlier rains across the region as well as differences in access to machinery. Farmers tend to sow late varieties earlier in order to avoid frost risks at the end of the cycle.

The management flexibility and incomes of farmers could be increased by the availability of varieties with a wider range of maturities. For farmers who can plant earlier, especially those with fields on the slope in the higher rainfall areas where frost risks are lower, wheat seems to be a feasible alternative to planting late varieties of barley. The guaranteed price of wheat is now $4500/ton somewhat above the price received for barley. Also wheat has a higher yield potential. The major difficulty in wheat production at the moment is the lack of an established market outlet in the area.¹/

Farmers also lack an early maturing variety, with satisfactory malting quality. (Currently available early varieties, Centinela and Puebla, suffer from price discounts due to malting quality.) An early maturing variety would be particularly appropriate for sowing later after the first week of June. It would complement the current varieties of satisfactory malting quality - Apizaco of late maturity, and Cerro Prieto of intermediate maturity.

Selection of varieties should also consider resistance to disease such as scald, helminthosporium and rusts which are becoming more common with increased barley area. Finally, ability of a variety to hold grain after maturity is important in years when weather delays machine harvesting.

¹/ In recent informal interviews, however, we have noted some farmers growing wheat and successfully marketing it in Puebla or Mexico City.
We therefore recommend a crop variety by time of planting trial as follows:

<table>
<thead>
<tr>
<th>Date of Sowing</th>
<th>Crop/Variety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early May</td>
<td>Wheat and late barley variety</td>
</tr>
<tr>
<td>Late May/Early June</td>
<td>Cerro Prieto as check variety and other intermediate maturing varieties.</td>
</tr>
<tr>
<td>Mid to Late June</td>
<td>Early varieties</td>
</tr>
</tbody>
</table>

All barley varieties should be screened for satisfactory malting characteristics.

Weed Control: Despite the use of 2-4 D, herbicide there are considerable yield losses in the area due to broadleaf weeds. Moreover, grassy weeds, particularly wild oats tend to be increasing due to continuous barley cropping and higher fertility. Experiments should test the following methods of establishing better weed control.

a) Additional secondary tillage prior to planting especially if a suitable early variety is available to enable delayed planting without risks.

b) Improved stand establishment through better seed bed preparation and perhaps drilling.

c) Testing of broadleaf herbicides such as a Brominol that can be applied earlier than 2-4, D and reduce early weed damage.

d) Verification and demonstration of the optimal time and dosage for 2-4, D. application for given conditions of early weed growth and weather.

e) Testing and establishment of economic doses for wild-oat herbicides such as Finaven. This should be done on fields selected for wild oat infestation.
**Fertilizer:** Although chemical fertilizer is now widely used in the area, there is substantial variation in application rates and ignorance of nutrient composition of various fertilizers. Moreover, fertilizers are a major cash cost in barley production. Experiments should seek to establish most efficient use of money invested in chemical fertilizers by:

a) Identifying areas of phosphorous deficiency and management of phosphorous application over years.

b) Testing method of application of nitrogen (e.g. broadcast, banded).

c) Exploring the interaction between initial moisture conditions and level of nitrogen applied and the split application of nitrogen.

d) Testing the use of a cheaper source of nitrogen such as Anhydrous Ammonia.

9.3 **Longer Term Research Opportunities**

For the long term a number of opportunities exists for reducing costs, especially through reduced tillage, as well as establishing cultural practices and rotations for controlling erosion and weed infestation.

**Tillage:** Possibilities of developing a less costly tillage system for land preparation include:

a) Ploughing after harvest leaving a clean fallow with a mulch cover over the dry season and then use of a deep drill to seed into conserved moisture.
b) Investigation of the cost-effectiveness of subsoiling which is practiced by a significant number of farmers usually with bank support. This would require observation over more than one season after the subsoiling is done.

c) Investigation of the possibility of reduced tillage or no-tillage using herbicides to control weeds prior to seeding.

d) On sloping land, the use of tillage methods and banking to control erosion especially in areas where maguey has been removed.

Rotations: Rotation with a row crop such as maize which was the traditional rotation system has potential advantages for weed control, soil structure, etc. Restoration of this rotation requires a more efficient maize technology especially for weed control and harvesting which are the major factors contributing to maize's high cost of production. Experiments on maize, especially chemical weed control should seek to find a more efficient maize technology for rotation with barley.

Harvesting Techniques: Finally, methods used elsewhere to windrow barley just prior to maturity to speed drying, reduce lodging and improved malting quality warrant testing. An added advantage of this method in the study area would be a shorter production cycle and hence reduced risk of frost.

9.4 Further Implications for Farm Survey Work

The current survey has established a descriptive profile of farmers and their production practices. To complement the proposed experimental work a number of specialized surveys are recommended. These include:

a) Informal interviews with farmers who have begun to grow wheat in the area to determine potential marketing outlets and agronomic problems experienced in order to better assess the potential of wheat versus
barley in the area.

b) In-depth but informal interviews with both small and large farmers who have developed effective weed control techniques to use their experiences to design an effective combination of rotations, tillage techniques and herbicide use to improve weed control in the area.

c) Extension of both the informal and formal survey work to the drier areas of the state of Hidalgo where barley is important but adoption of improved barley technologies has been much slower (Hesse de Polanco and Byerlee (1981).

9.5 Other Issues in Improved Barley Production

The present study has focused on circumstances of barley producers which have implications for research to develop improved varieties and agronomic practices for barley in the area. In the course of this research a number of other issues related to the institutional environment of the farmers were identified as constraints on increased barley production and incomes of farmers.

These included:

a) Difficulty of obtaining the desired fertilizer, especially for farmers who don't work with the official bank. Although FERTIMEX, the official fertilizer distributor has several distribution points in the area, they often lack sufficient supplies.

b) Limited number of buying points of Impulsora Agricola in the area so that most small farmers sell to intermediaries who judge quality without the use of testing equipment. The number of buying points has however increased in 1980.

c) Release and promotion of varieties which in fact have unsatisfactory malting characteristics and lead to price discounts to farmers growing these varieties.
d) Lack of seed cleaning and grading facilities to enable farmers to save quality seed from year to year. At present, annual purchase of seed represents a substantial cash cost to many farmers.

e) Apparent cash shortages on the part of many small farmers, leading to lower intensity and poorer timing of tillage operations and inputs. This suggests potential for future expansion of official credit operations in the area.

These constraints were identified by interviews with farmers. A more detailed understanding of the nature of these constraints as well as recommendations to overcome the constraints will require more in-depth studies of the performances and policies of the agricultural institutions serving farmers in the study area.
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