INTSORMIL
Contract No. AID/DSAN-G-0149

Sorghum Production in the Small-Farmer Sector of Sinaloa, Mexico

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Executive Summary

This report presents the findings of a sorghum production study conducted by the University of Kentucky's International Sorghum and Millet project (INTSORMIL) in Sinaloa, Mexico, from 1983 to 1984. There were two major research objectives: (1) to document the agricultural system, particularly the role of sorghum, in the small-farmer sector in a commercial agricultural system; and (2) to identify the agronomic and economic incentives and constraints on sorghum production. Data are reported from both irrigated and rainfed farming systems in which sorghum is a major crop for small farmers. Recommendations for future research that address the current constraints on sorghum production are presented at the end of this report.

Sinaloa is Mexico's primary agricultural state, due to its adoption of modernized agricultural practices. A moderate climate, an irrigation system and government support enable the farmers to produce two or three crops per year. Sorghum, soybeans, wheat and beans are the state's major commercial crops. In 1983, Sinaloa was Mexico's third largest sorghum producing state, with 9% of the national tonnage. Red-seeded sorghum is used in animal feed.

The small farmers in a newly irrigated district in northern Sinaloa have the resources for small-scale commercial production. Their sorghum production is mechanized and uses modern inputs. However, farmers with irrigated land presently face three major constraints on sorghum production that make wheat their first-choice crop. The shortage of tractors is one constraint: this delays sowing for some farmers and exposes the sorghum, at a critical stage, to the summer's heavy rains and pests, reducing crop yields. The second constraint is the midge, Contarinia sorghicola, which is becoming increasingly difficult to control with aerial fumigation. Other pest and disease problems are relatively minor. The third constraint is the delays often encountered in getting the credit needed to plant the crop and official approval for aerial spraying. As a result of these problems, the great majority of the small farmers have switched to a wheat/soybean rotation due to its greater profitability.

Dryland farmers, those outside the irrigation district, are also shifting away from sorghum production but for different reasons. These farmers have very limited agricultural resources for commercial production. Corn and sorghum are the major dryland crops, and sorghum is a preferred cash crop because of its greater productivity under local ecological conditions. The constraints to sorghum production - lack of machinery, pests, and delays in governmental actions - of farmers in irrigation districts are more severe for dryland farmers. Crop losses are extensive because credit does not cover the cost of fumigating for Contarinia sorghicola. Moreover, promised governmental support often is totally lacking. Sometimes sorghum is only useful as forage, since it is not a subsistence crop. Farmers in 1984 switched to corn production because it provided food for household consumption as well as fodder for livestock.

These constraints point to areas of research that could improve the prospect for sorghum production. First, insect-resistant sorghum varieties that adapt to the hot, humid conditions of northern Sinaloa are needed to

increase yields in both the irrigated and dryland districts. Second, dryland farmers need better infrastructural support to improve the timing of planting and pest control operations.

Chapter 1. Introduction

This research report focuses on sorghum production in a commercial agricultural system and is a part of INTSORMIL's project in Mexico. The fieldwork for this study was conducted in Guasave, in the northwestern state of Sinaloa, Mexico, from July 1983 through August 1984. The report is divided into four chapters. This chapter summarizes the development and current status of Mexico's national agricultural system and indicates the research goals. Chapter two provides a general introduction about the state of Sinaloa and its agricultural resources, land tenure patterns, major crops and agricultural infrastructure. Chapter three presents sorghum production data from three farming communities, two with irrigated cropland and one with rainfed cropland, each representing local farming systems. Chapter four provides recommendations for improving sorghum production based on the data from the study.

Mexico's National Agricultural System

Mexico's agricultural modernization is based on the agrarian reforms of the 1910 Revolution, which significantly changed the amount and distribution of the nation's cultivable land. It is estimated that prior to the revolution, 95% of the rural population did not own land (Ecstein, 1978). By 1940, the expropriation of land from the private haciendas and its redistribution to the small farmers, ejidatarios, made 48% of the farmland available to the ejidal sector (Hewitt de Alcantara, 1976). At that time, the modernization of agriculture became a national priority in order to provide foodstuffs for the growing population and to support industrialization. From 1940 to 1970 Mexico's agriculture developed rapidly. It has been described as an "agricultural revolution" - a successful Green Revolution (Wionczek, 1982; Wellhausen, 1976). It was not until the late 1960s that the rate of growth slowed, and the fundamental weaknesses in Mexico's development strategy became apparent.

The rapid development of Mexico's agricultural sector was due to an increase in land under cultivation and permanent irrigation. Government policy supported expansion: from 1940 to 1965 as much as 20% of the federal budget was spent on the agricultural sector (Hewitt de Alcantara, 1976). The amount of cultivated land increased from 7.3 million hectares in 1940 to 12.3 million hectares in 1960, a 68% increase (Hewitt de Alcantara, 1976). Given the country's maldistributed rainfall, developing water resources was a priority for agricultural development. Irrigation projects absorbed 80% of the federal funds allocated to the agricultural sector through 1960 (Wionczek, 1982). The amount of irrigated land increased 72% from 1940 to 1960 and totaled 3.5 million hectares in 1960 (Hewitt de Alcantara, 1976). However, the distribution of this primary resource was unequal: one-half of the government funds were invested in large irrigation projects in the north, that is, Sinaloa, Sonora, Baja California, Tamaulipas. As a result, in 1965, these states contained almost three-fourths of the nation's irrigated land (Hewitt de Alcantara, 1976). In addition to developing the nation's primary agricultural resources, government subsidies during the 1950s made the modern technology of the Green Revolution available, especially to the commercial farmers in the irrigated areas.

Significant increases in agricultural production accompanied this modernization. Production grew at an average annual rate of 8.2% during 1940-1950 and 4.3% during 1950-1960 (Grindle, 1981). The production of basic food grains increased dramatically: wheat yields quadrupled, corn yields doubled, and bean production almost doubled (Wellhausen, 1976). As the population grew at an annual rate of approximately 3.5%, agricultural production easily met national demands of foodstuffs (United Nations, 1982). Mexico was self-sufficient in corn until the late 1960s and in wheat until 1972, and even exported these grains until 1967 (Hall and Price, 1982).

By the early 1970s the growth in production was failing to match the growth in demand. Mexico was importing 20% of its food grains (Wellhausen, 1976). Agriculture's share of the GDP dropped from 11.6% in 1950 to 7.1% in 1970 (Sanderson, 1986). The primary factor that constrained agricultural growth was the Mexican government's focus on industrialization. Food imports were also the result of the disproportionately large investment in the private production of commercial crops. Until the mid 1970s, government policies and three-fourths of the funds for agriculture supported crop production (cotton, tomatoes, sorghum) in irrigated areas of the northwestern states of Sinaloa and Sonora for industry or export (Grindle, 1981). Outside these areas, agricultural modernization and government support for commercial production of domestic food crops were limited.

The second constraint to agricultural growth, especially the production of food grains was the dual policies for, and subsequent dual development in the private and ejidal sectors. The private sector controlled most of Mexico's primary agricultural resources and had become a commercial success by absorbing the technological improvements of the 1950s. By 1970, almost one-half of the private farms were 250 acres or larger while almost one-half of the ejidal farms were only 12.5-25 acres. Thus, the private sector was dominated by large farms while the ejidal sector was composed primarily of small farms. The private sector controlled 44.5% of Mexico's arable land and accounted for approximately 60% of the national agricultural production (Yates, 1981). Because the structure of relative prices favored the production of feed grains and export crops, private farmers used their irrigated land and modern technology to produce such crops as sorghum, tomatoes and strawberries. The ejidal sector, with fewer agricultural resources and limited success in technological improvements, produced the nation's food staples, corn and beans. It is estimated that more than 90% of Mexico's corn, the primary food staple, is still grown without irrigation or modern inputs, including hybrid seed (Elwell and Puleman, 1980). As a result of this dual-sector agricultural system, Mexico's unbalanced production patterns and food grain deficits constitute an agricultural crisis that has persisted since 1970.

The continuing agricultural crisis raises questions regarding the productivity of the private sector versus the ejidal sector, and even whether the latter is a viable system of production. Data from the 1970 agricultural census showed that productivity in the ejidal sector was lower than that in the private sector and it had declined since 1950. Ejidal production averaged 77% of that in the private sector in 1950, but dropped to 67% twenty years later (Yates, 1981). In 1970, private farmers produced twice as much per hectare, on the average, as the ejidatarios (Yates, 1981). The ejidatarios' share of the national agricultural production in 1970 (approximately 38%) thus was not commensurate with their control of the national cropland (56%) (Yates,

1981; Fifth Agricultural, Livestock and Ejido Census, 1970). The bases of this difference are the scale and technology levels of the ejidatarios and the private sector. Private farmers, with more land, were the primary recipients of modern technology provided by government programs. Mexico's goal of increasing agricultural production directed the new inputs toward the farmers having greater agricultural resources, thereby bypassing most of the ejiditarios. Currently it is estimated that only 6% of Mexico's ejidos are modernized (Hardy, 1982). The success of agricultural modernization in the private sector and the need to increase agricultural production generate debate regarding the ejidal system of production. However, due to Mexico's ideological commitment to agrarian reform, converting the ejidos to large-scale, private enterprises is unlikely. Collectivization, an alternative way to take advantage of economies of scale, historically has only limited success. Therefore, modernizing the ejidal sector is politically and practically the most feasible course. It is fundamentally an issue of increasing agricultural resources, including government investment, in the small-farmer sector.

The shift to producing feed crops for livestock is the second factor contributing to Mexico's food grain deficits. Forage crops have expanded at a greater rate than basic grains since 1965 (Table 1). In 1965, when Mexico

Table 1. Mexican Cropland in Major Crops, 1965-1983

Year	Basic Grains*		Corn		Fruit and Vegetables[1]	Forage	
	%[1]	ha's[2] (000)	%[3]	ha's[2] (000)	%	%[1]	ha's[2]
1965	73	N.D.**	52	N.D.	4.6	3.5	N.D
1970	68	10.253	50	7.440	5.7	8.2	1.126
1975	62	9.500	44	6.694	6.7	14.0	1.922
1979	48	7.670	37	5.916	7.5	12.0	1.842
1983[4]	50	10.446	36	7.420	9.0	11.0	2.219

*Basic grains are corn, beans, wheat, rice and oats.

**N.D. = No date.

1 Barkin, 1982.

2 Econotecnica Agricola (Vol. 4, No. 8, 1980).

3 Spalding, 1984.

4 Direccion General de Economia Agricola, 1983.

was exporting basic grains, forage crops occupied 3.5% of the cropland. By 1983, forage crops, including pasture, alfalfa, and sorghum, occupied 11%. Altogether, 28% of Mexico's cropland was used to support livestock (Direccion General de Economia Agricola, 1983). Sorghum has become a major feed crop in Mexico: the area sown in grain sorghum increased 13.1% annually from 1965 to 1979 while forage sorghum increased 14% (Barkin, 1982). During this same period corn acreage dropped 1.8% annually, beans dropped 6.2%, and wheat dropped 2.3 (Barkin, 1982). Cropland in basic grains has not increased since 1970 while that sown in forage crops has doubled; sorghum accounted for 70% of the forage crop area in 1983 (Direccion General de Economia Agricola, 1983). At the same time, Mexico has been a net importer of food since 1979 (Diagram 1). Imports of staple grains (corn, beans, wheat) amounted to 53% of national production in 1984 (U.S. Department of Agriculture, FATUS, 1985; Direccion General de Economia Agricola, 1986).

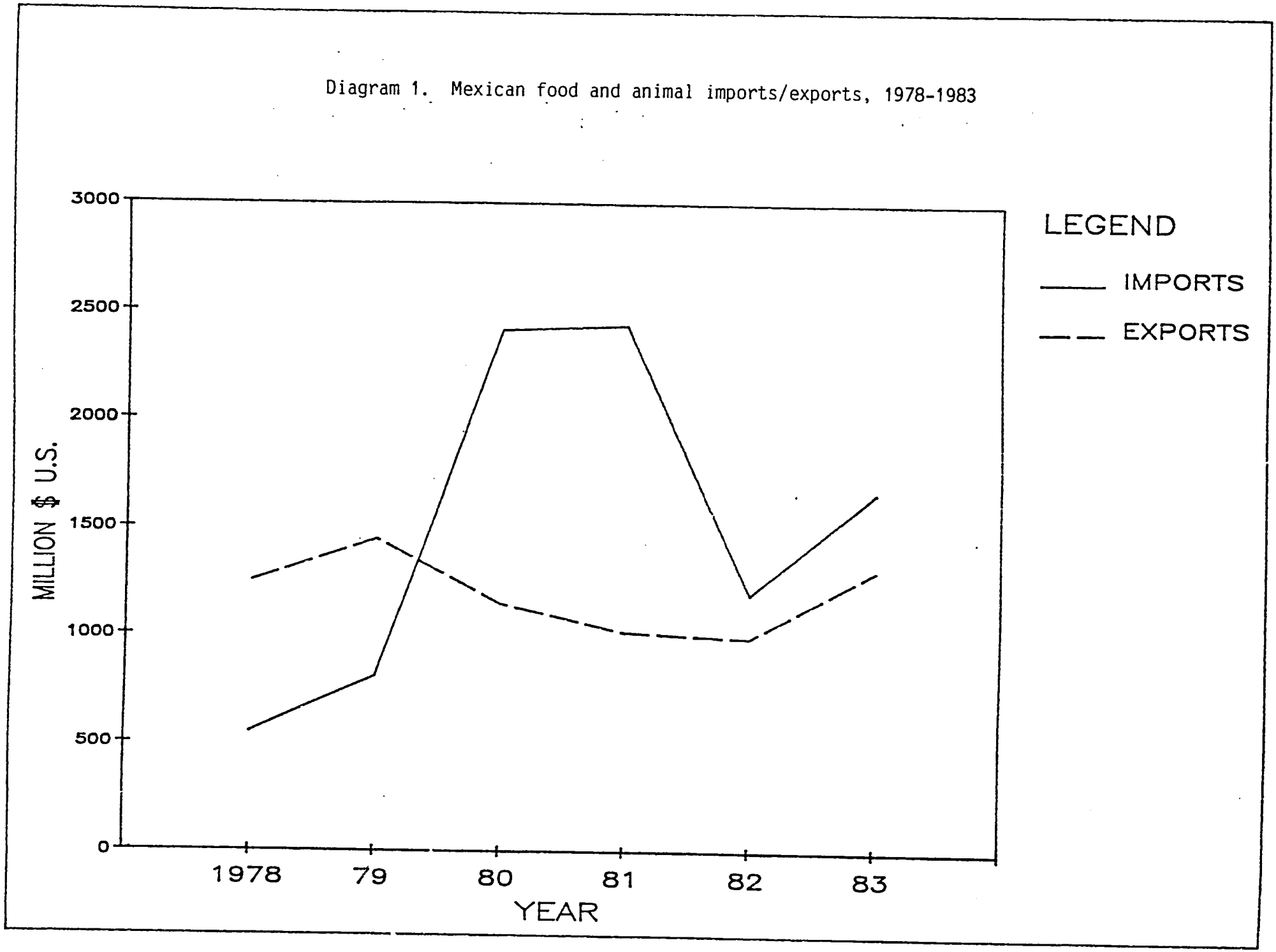
Two major reasons for the growth of sorghum production are sorghum's adaptive characteristics as a crop and the industrialization of livestock production in Mexico. Concerning its characteristics, sorghum spread rapidly through Mexico in the 1960s because the drought-tolerant, high-yielding hybrids were attractive to farmers in a variety of environments. Regarding industrialization of livestock, there is a steady demand for meat from the domestic urban market and the production of sorghum supplies feed for the livestock industry. This is probably the fastest-growing sector of the national agricultural system (DeWalt, 1985).

Government subsidies and guaranteed prices have supported sorghum production since 1965. The technological package for commercial sorghum production includes government credit, hybrid seed, chemical fertilizers, irrigation equipment and technical assistance. AS a result, sorghum has become a major crop for the private farmers. In 1983, 36% of Mexico's sorghum was sown on irrigated land in contrast to only 12% of the corn crop and 11% of the bean crop (Direccion General de Economia Agricola, 1983). Feed grain production clearly is a significant trend in Mexico's modernized, commercial agricultural sector.

Research Goals/Objectives

The project goals are to investigate the status of the ejidal farmers and the role of sorghum in a modern agricultural system. The specific research objectives in Sinaloa are: (1) to determine the ejidatarios' access to agricultural resources in a modernized, commercial agricultural system; (2) to investigate ejidatarios' crop choices and production outcomes, focusing on sorghum; and (3) to evaluate the ejidatarios' agricultural system in terms of household economic and nutritional status. Previous studies (Hewitt de Alcantara, 1976; Sanderson, 1981) have described the poverty of the ejidal sector in Sonora, where irrigation and modern technology have been the basis of successful commercial agriculture, but little research has been performed in northern Sinaloa, where modern agriculture is still developing. The importance of sorghum production to Sinaloa and to the ejidal sector makes Sinaloa a desireable research site. The data from three ejidal farming communities are used to address questions such as: what factors limit ejidal production? and what is the role of feed crops in Mexico's breadbasket?

Diagram 1. Mexican food and animal imports/exports, 1978-1983



Chapter 2. Sinaloa, Mexico's Breadbasket

Development of Commercial Agriculture

Both economic and political factors were responsible for the agricultural modernization of the northwest. In Mexico's drive for industrial development, agriculture was given the dual role of feeding a growing population and supplying capital for industry through agricultural exports. In the north large tracts of potentially productive land were sold to private farmers, ensuring political support and rapid return on government investments.

The northwest received the lion's share of the government's investments through the 1960s. By 1945 half of the irrigated land and paved roads in Mexico were in Sinaloa and Sonora (Hall and Price, 1982). The government also provided inputs for commercial production: the north received more than twice as much credit as other regions as well as technical assistance and subsidized, modern inputs (Hall and Price, 1982). A dual agricultural system was established in the region. The private sector controlled most of the land and produced export crops, using irrigation and modern technology, while the ejidatarios rented out their land or produced subsistence crops with minimal resources. The inequality between the two sectors was greatest in the most fertile areas, such as in Sonora and northern Sinaloa, where the government invested heavily to boost crop production.

By 1970 the contrast between private and ejidal agriculture was glaringly evident. At this time Sinaloa was the most important agricultural state in Mexico, leading the nation in production and export with more than 30 crops (Sanders, 1974). The private sector was composed of 18% of the population, held 43% of the irrigated land and produced 72% of the total value of Sinaloa's agricultural production (Cecena, 1974). Sinaloa primarily had an export economy. In 1973 it produced about 59% of Mexico's agricultural exports (Sanders. 1974). Credit for the private sector's profitable commercial crops such as cotton and tomatoes came mainly from the U.S., and the products were sold north of the border. The Mexican public banks, which funded the ejidal sector, provided credit for only 18% of Sinaloa's farmland in 1973, leaving the ejidatarios largely without credit or technical assistance. Ejidatarios produced the less profitable domestic staples such as sorghum and safflower. One-third of the ejidatarios, including some with irrigated land, worked as laborers, planting and harvesting the export crops for survival. But, by the end of the decade, their often violent political protests forced the government to allocate the state's agricultural resources more equitably.

Sinaloa's Major Crops

Sinaloa always has been primarily agricultural because of its ecological resources. There are one million hectares of cultivated land in the state, three-fourths of which is in a fertile plain that stretches from the south of Culiacan to Los Mochis, near the border with Sonora (Map 1). Sinaloa's irrigated, commercial farmland is centered in a rectangular plain which is seventy miles across at the northern border and only thirty miles across at the southern. The rainfed farmland lies between that plain and the Sierra Madre mountains that crowd the eastern and southern part of the state.

Map 1. Mexico and Sinaloa

Sinaloa

The crops that have occupied more than 75% of Sinaloa's farmland in the past twenty years are given in Table 2. Corn, beans, wheat, and cotton have been important crops since the Indians cultivated the alluvial soil along the rivers five centuries ago. Cotton remained an important and profitable export crop until the early 1960s. In 1970, Sinaloa was Mexico's primary producer of rice, safflower, sesame and tomatoes and second in the production of sorghum, soybeans, sugarcane and green peppers (Fifth Agricultural, Livestock and Ejido Census, 1970). By 1980, according to the statistics from Secretaria de Agricultural y Recursos Hidraulicos (SARH), Sinaloa was the leading producer of soybeans and export vegetables, second in the production of wheat and beans, and the third in sorghum production. The major crops continue to be soybeans, sorghum, safflower, wheat and export vegetables; in 1983 vegetables occupied 19% of the cropland (Direccion General de Economia Agricola, 1983).

Sorghum has become a major crop in Sinaloa over the past twenty years. In 1961 it occupied only 3% of the land, and that figure rose to 12% by 1971 (Table 2). By 1983, sorghum was second only to soybeans in terms of cultivated area and third in terms of the value of production. Fifteen percent of the farmland was sown in sorghum that year, which was more than that sown in either wheat (11%), beans (10%) or corn (9%). Nationwide, Sinaloa was Mexico's third largest sorghum producer in 1983, producing 9% of the national tonnage (Direccion General de Economia Agricola, 1983).

While the ejidal sector produces most of Sinaloa's sorghum and the other basic grain crops, the more profitable export crops are produced by the private sector. The latter generate a high volume of sales in proportion to the area that they occupy. Export and other vegetables (sesame, cotton and mangos) occupied 19% of the cropland in 1983 and accounted for 59% of the value of Sinaloa's agricultural production (Direccion General de Economia Agricola, 1983). Tomatoes, a major crop in the private sector, were grown on only 11% of the private land in 1982 but accounted for 25% of the value of production in the state (Hogie, 1986). The only export crop that the ejidal sector produces is cotton; in 1982 it occupied only 1% of the ejidal land (Hogie, 1986).

Table 2. Percentage distribution of major crops in Sinaloa, 1961-1981

	Percent Cropland		
	1961	1971	1981
Corn	3	4	3
Beans	9	7	12
Wheat	6	12	19
Rice	7	8	6
Soybeans	0	17	25
Sorghum	3	12	11
Cotton	40	11	1
Sugar	7	3	6
Tomatoes	4	4	2
Other	25	17	15

Northern Sinaloa: Agricultural Resources

Northern Sinaloa is a semi-arid desert, although in many respects its ecology is surprisingly ideal for farming. Twelve hundred square kilometers in this region have been developed for irrigation and constitute Irrigation District 063 of Guasave (Secretaria de Agricultura y Recursos Hidraulicos, 1982a). The district's soil, climate, and water resources make it one of northern Sinaloa's three agricultural oases. Guasave's generally flat topography and chestnut soils are favorable ecological characteristics for farming. The district's land ranges from 3.5 to 60 meters above sea level, with uniform slopes that incline slightly toward the coast (Secetaria de Agricultura y Recursos Hidraulicos, 1982a). The chestnut soils are a mixture of clay and sand and both provide moderate to good drainage and conserve moisture. The topsoil is deep although it tends to lack nitrogen; 41% of the land has low fertility and requires chemical treatment (Secretaria de Agricultura y Recursos Hidraulicos, 1982a). Salinization is the major soil problem that affects at least 10,500 hectares (10%) of the valley (Secretaria de Agricultura y Recursos Hidraulicos, 1982a). Coastal land is particularly susceptible to this problem and overuse of the underground aquifers has salinized some inland areas as well. SARH has an ongoing soil recuperation program for restoring these areas to agricultural use.

Temperature and rainfall patterns in the north result in distinct seasons: a cool, dry winter and a hot, wet summer. The region is considered a desert, especially in the western areas (Secretaria de Agricultura y Recursos Hidraulicos, 1982a). Winter temperatures may be as low as 33° F in January while summer temperatures may reach 117° F in July and August. Overall, however, the climate is considered to be moderate; Guasave's annual temperature averages 76° F (Prontuario Estadistico, 1983). One advantage of this moderate climate is that Sinaloa's fall vegetable crop reaches the American market in the winter when prices are high.

Sinaloa has an intense rainy season during the hot summer months. Annual rainfall averages 17 inches in Guasave, 80% of which falls between July and October (Secretaria de Agricultura y Recursos Hidraulicos, 1982a). Light rains called equipatas fall in December and January. In the past these were only showers, however, in recent years the equipatas' itensity has threatened the fall crops during September, October and November (Secretaria de Agricultura y Recursas Hidraulicas, 1982a). For example, in September of 1982, a cyclone with winds of 117 miles per hour devastated Guasave's crops as well as the town (Prontuario Estadistico, 1983).

Land Tenure

The agrarian reform laws specify that twenty hectares of irrigated land per individual is the legal limit. There are three requirements for ejidal land tenure: the individual must be sixteen years of age or older, reside in a nearby rural village, and depend on the parcel for his livelihood. Ejidal landholdings are inherited, usually by a family member who meets the above requirements, and cannot be sold, rented, or divided. The ejidos in Guasave are individual, meaning that each ejidatario works his parcel independently. Few ejidos have communal land (uncleared) for pasture because ejidatarios do not raise livestock.

Private farmers were allowed to retain the land they owned in the valley before the organization of the modern irrigation district in the early 1970s. Legally, each farmer was also limited to twenty hectares, but excess land generally was not expropriated unless needed for redistribution in the ejidal sector. As long as the private farmer is actively farming his land and the ejidatarios have adequate parcels, the former may own more than twenty hectares of irrigated land. Private land may be sold or divided although its distribution is primarily under the jurisdiction of the local Agrarian Reform office.

There is some inequality in land distribution in Guasave, although this is declining (Secretaria de Agricultura y Recursos Hidraulicos, 1984b). In 1984, ejidatarios comprised 84% of the valley's farmers who held 70% of the land; ejidal parcels averaged 8.8 hectares. In comparison, 16% of the farmers holding 30% of the land made up the private sector; private parcels averaged 19.5 hectares. Actually, the inequality of land distribution is probably greater than SARH's statistics indicate because private farmers use the names of absent family members to combine several parcels into large landholdings. Banrural (government bank) reports that most private parcels consist of 50 hectares, some as large as 600 hectares.

Irrigation District

The haciendas in the Sinaloa River valley have produced both commercial and subsistence crops since the Jesuits arrived in the 1500s. The local economy was a combination of farming, cattle raising and out-migration for four hundred years. Until the Sinaloa River was dammed, its valley remained a primitive, rural district. Throughout the 1960s, most of the valley was still covered in the tough scrub, making it suitable only for raising the hardy local cattle. A few hacendados owned all the land that stretched from the mountains to the sea; they raised large cattle herds and produced commercial crops by sharecropping with the campesinos. The campesinos provided the labor to clear the land, build earthen canals, and farm while the hacendados provided cash, draught animals, equipment and seed. In addition, the campesinos sometimes sharecropped for the hacendados and received one-third of the harvest. Some of the crops they raised included vegetables for export. Campesinos also grew milpas (corn, beans and squash) for their own consumption and raised pigs and cattle. At the turn of the twentieth century, cotton, garbanzo beans, sesame, tomatoes and peas were grown for export and shipped north on the South Pacific railroad.

Hacendados using picks and shovels and mules, built the first irrigation canals in Guasave early in this century. By the 1920s there were 19,000 hectares of irrigated land, including 10,000 hectares of export crops that were irrigated by one canal. In 1948, the National Irrigation Commission built another canal that irrigated an additional 10,000 hectares. The hacendados also had constructed about 370 wells in the valley to tap the underground aquifers. These 29,000 hectares of irrigated land, controlled by the hacendados and nominally by the National Irrigation Commission, delimited Irrigation District 063 in 1948 and became the center of agricultural production for the next thirty years. In the 1930s the campesinos demanded and were given ejidal title to part of the land but this made no change in the

local agricultural system until the late 1970s. Because there were far more campesinos than could possibly farm the cleared land, many people migrated out "looking for a livelihood," until the government was able to clear the land and invest in ejidal agriculture.

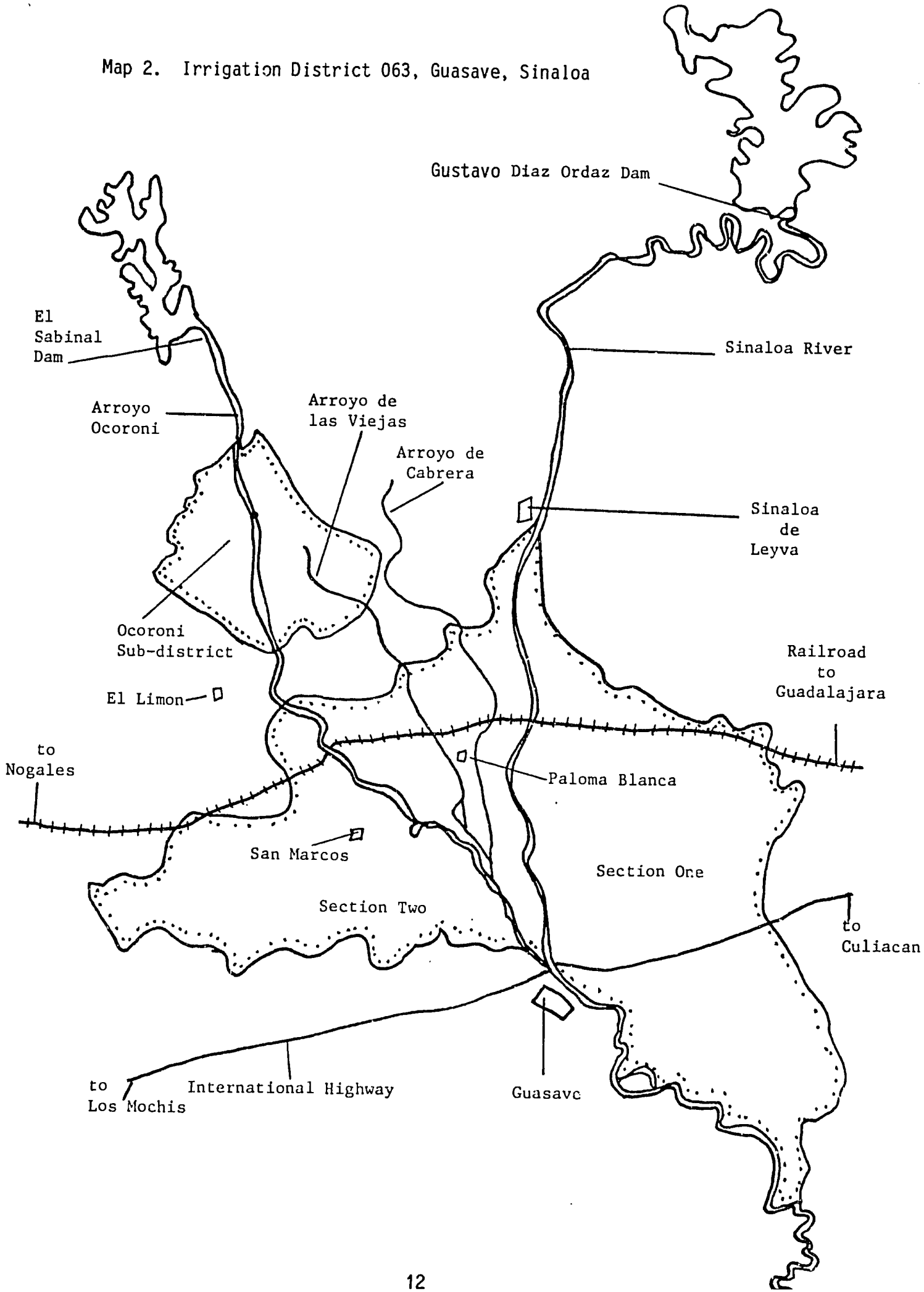
The modern Irrigation District 063 comprises the valley irrigated by the Sinaloa River. The river originates in the Sierra Madre, east of Sinaloa and flows through Guasave to empty into the Gulf (Map 2). The dam, Gustavo Diaz Ordaz, lies in the hills approximately sixty miles east of Guasave. Construction began in 1976 with funds from the World Bank and was completed in 1981. The dam and lake cover an area of 7,917 hectares and irrigate 110,000 hectares in the valley (Secretaria de Agricultura y Recursos Hidraulicos, 1982a). Irrigation water was first available in the fall of 1981 but the project wasn't completed until mid-1986.

In addition to the dam there are two other sources of water in the valley. The underground aquifers still provide water through a system of 444 wells that are regulated by SARH. However, as fuel costs rose the pumps became prohibitively expensive to run, and as soil salinization increases with their use, production drops. The river water source is the El Sabinal Dam on the Arroyo Ocoroni River (Map 2). The Ocoroni area is a subdistrict within District 063 and began operating with 10,000 irrigated hectares in 1985. The irrigation district's total area, therefore, is 120,000 hectares; before the canals were finished in 1984, it also included 16,000 hectares of rainfed land.

The irrigation district and SARH's technical personnel are organized into two sections because the river flows across the valley, dividing it in half (Map 2). Each section has an SARH headquarters located in a major rural town that is staffed by a chief who is responsible for the section and its technical personnel. Section One has 60,000 hectares of land, 6,000 of which are still rainfed. The area is divided into twenty irrigation sections of about 3,000 hectares with one extension agent assigned to each irrigation section. The extension agents and their supervisor provide technical assistance to the farmers. There are also twenty canal agents, five gatekeepers and two supervisors to distribute the irrigation water. Because these administrative sections are bounded by the canals, they cross-cut the ejidos. One ejido thus can have two or three extension agents attending the farmers within its boundaries.

The fieldwork reported below was conducted from 1984 to 1985 in Section Two, which comprises 50,000 hectares, including 10,000 that are still rainfed. Section Two is further divided into fourteen irrigation sections and is somewhat understaffed, having only eleven extension agents, each of whom is responsible for 3,500-4,000 hectares of farmland. According to SARH standards, Section Two should have three more extension agents as well as four more canal agents and one more gatekeeper. In addition to lacking staff, SARH personnel currently have extra work due to construction of an irrigation system. The extension agents are responsible for checking canals, reporting on construction progress, and ordering supplies. Both the farmers and the technical personnel are critical of this work, but SARH is scrambling not only to provide technical assistance but to complete the irrigation system on schedule. Presently, there is no solution for extension agents' dual responsibilities, even though providing start-up assistance to farmers requires extra work from the technical personnel.

Map 2. Irrigation District 063, Guasave, Sinaloa



The Agricultural Infrastructure in Guasave

A complex bureaucracy directs agriculture in Guasave. Several federal agencies formulate offical policies appropriate for local conditions and function as gatekeepers for agricultural resources. This infrastructure is the context for farmers' decisions and actions; it is especially important for the ejidatarios, who have the least power in the system. Ejidatarios have limited control over their own production and are often caught in bureaucratic contradictions in which they have no power to resolve. The next section describes the major agencies in the district that form the infrastructure within which ejidal agriculture operates: SARH, Banco Rural (Banrural, the government bank responsible for ejidal agriculture), ANAGSA (Aseguradora Nacionale de Agricultura y Ganaderia S.A., National Agricultural and Livestock Insurance) and CONASUPO (Compania Nacionale de Subsistencia Populares, National Company of Dietary Staples).

SARH: Secretary of Agriculture and Water Resources (Secretaria de Agricultura y Recursos Hidraulicos). Guasave became SARH's headquarters and the administrative center of the district in the 1970s. SARH's responsibilities are to improve production at both the technical and operative levels, coordinate the different agricultural sectors within the district, maintain the irrigation system, and help the farmers solve their problems (Secretaria de Agricultura y Recursos Hidraulicos, 1982a). SARH is not solely responsible for fulfilling those objectives but serves as the headquarters and coordinator for the numerous federal and private agencies within the valley's agricultural system. For example, its personnel work with representatives from Banrural, ANAGSA, the ejidal sector, the private sector and CONASUPO in planning each year's crops and in organizing the farmers. With personnel from INIA's (National Institute for Agricultural Research) local experiment station, SARH also directs the analysis of the technical aspects of production, sets prices for agricultural labor, and researches local needs for hybrid seed, fertilizers and pesticides (Secretaria de Agricultura y Recursos Hidraulicos, 1982a). Given this broad organizational role and large staff, SARH is the ejidatarios' primary resource for help with production problems.

SARH is also in charge of ejidal agriculture, and its administrative services limit the ejidatarios' freedom to make management decisions. SARH selects seed varieties and other inputs based on recommendations from INIA's agricultural experiment station. Unfortunately, INIA does not use farmers' experiences with crops in recommending seed varieties to SARH. Since SARH controls the valley's water supply it determines the area size and location that each crop can be sown. In 1983 when credit was available, the ejidatarios wanted to sow rice but the limited area available was given to the private farmers.

SARH extension agents also must provide written authorization for all ejidatarios' farming decisions in using farm inputs. The lack of autonomy creates several problems for the ejidatarios. If an ejidatario diagnoses the need for an extra pesticide application on his sorghum, he has a dilemma. The application must be authorized in writing by the extension agent so Banrural will pay for it. The crop could be severely damaged before the extension agent inspects the field and completes the necessary paper work. If the ejidatario decides to treat the crop first and seek authorization later, he risks losing crop insurance. Ejidatarios also often disagree with the recommendations of SARH agents. The ejidatarios contend that the new

extension agents are not sufficiently knowledgeable about local conditions, especially soil deficiencies and pests, to make sound decisions about treatment. The problem is that the agencies that direct and fund farm operations can penalize any deviations from the recommendations, even if the latter are not appropriate.

Bank Credit (Banco Rural). Bank credit has funded local agriculture since 1938, although private, irrigated farming received most of the credit until 1969. There was no credit for dryland farmers until about 1944 and little funding until 1974. Credit was available for the ejidal sector in 1969 although the closest offices were located in Culiacan and Los Mochis, two hours away from Guasave. To improve the availability and administration of agricultural credit, three federal banks were combined into Banrural in 1976 and an office was established in Guasave (Banrural, 1984). Banrural, the government bank responsible for ejidos, provides credit for all types of producers and generally has the lowest interest rates. Because the twelve private banks in Guasave can refuse credit to ejidatarios and rainfed farmers, most of these farmers work with Banrural. In 1982 Banrural provided credit for 69% of the farmers who sowed land in the valley (Secretaria de Agricultura y Recursos Hidraulicos, 1982a). This land included a total of 71,000 irrigated hectares and 25,000 rainfed hectares, 95% of which was ejidal land. Credit is provided only for basic grains: sorghum, beans, corn, wheat, soybeans and safflower. Credit for the more profitable export crops--cotton, tomatoes, melons, and vegetables--is available only for the private farmers.

Banrural's credit is based on SARH's production cost estimates for each crop. Interest rates to ejidatarios for basic grains were 27% for the 1983 fall crops and 28.5% for the 1984 summer crops. The Bank of Mexico serves as collateral for the ejidal sector by guaranteeing 80% of their loans. If the ejidatarios cannot repay their loans for four consecutive years, they are denied crop insurance, a prerequisite for bank credit, and thus lose their funding. In 1984 one major problem with bank credit was the difference in estimated production costs between Banrural and ANAGSA, as is explained in the next section.

Credit to buy tractors is available through Banrural as well as the private banks in Guasave. The interest rates on machinery depend on the type of producer, ejidal or private, and are slightly lower for the former. An ejidal work sector must have 75 hectares under cultivation and produce two crops per year to obtain Banrural backing to buy a small tractor (such as a John Deere 2535, 72 h.p. or a Massey Ferguson 285, 80 h.p.). Through SARH's 1981 mechanization program, some ejidatarios purchased tractors, mainly the large International Harvester 1486, but there were persistent mechanical problems, and the agency later left town. In 1985 the ejidal sector began to purchase combines with bank credit; in Paloma Blanca, ejidatarios formed groups of 20 members and bought new combines through Banrural.

The district's lack of machinery, especially small and medium tractors, is recognized as a problem by SARH and the banks. In Guasave in 1981, there were 1,069 tractors, 439 seeders and 60 combines to work 107,529 hectares of farmland (Secretaria de Agricultura y Recursos Hidraulicos, 1982a). The private sector owns approximately 70% of the tractors. The ejidal sector has one tractor per 220 hectares of farmland, and the farms that make up this area are not necessarily contiguous. The shortage of machinery is a major constraint on ejidal production, as the data in Chapter Three will show.

National Agricultural and Livestock Insurance (ANAGSA). As the offical insurance agency, ANAGSA has an essential role in the local agricultural system. Crop insurance is obligatory for the ejidatarios and the cost is included in their bank credit. Natural phenomena that farmers cannot control--drought, flood, frost, hail, pests, diseases, high winds and fire--are covered by ANAGSA. Only the crops certified by INIA's agricultural experiment station are insurable. Insurance rates are determined by the crop, the type of farmer (ejidal vs. private; irrigated vs. dryland) and the type of irrigation used (gravity vs. wells). For example, in 1984 the insurance rate for sorghum was 5.84% of the cost of production per hectare, for both ejidal and private farmers. The rate for wheat, less prone to insect and weed damage, was only 2.63%. The dryland farmers pay the highest rates because their crops are at the greatest risk. In the case of total crop losses, ANAGSA's policy is to reimburse the farmers for 100% of their labor and bank interest. Payments on partial losses are variable; ANAGSA's extension agents estimate the percent of loss and the farmers are reimbursed accordingly. Before 1981 ANAGSA was responsible only for the principal. Since then it also has covered the bank interest.

Insurability is based on the farmers' adherence to the agricultural experiment station's official recommendations, through SARH. For example, SARH sets the date for sowing sorghum, and if the farmers do not conform they lose their crop insurance. The coordination of the banks, SARH and the machinists' unions in setting prices on agricultural inputs and services theoretically enables ANAGSA to make correct reimbursements. Production-cost estimates vary by agency and ANAGSA tends to make the lowest estimates of cost, which creates administrative disagreements about repayments when crop losses occur. These interagency differences in production costs for sorghum in 1983 illustrate this problem. ANAGSA calculated a production cost of 25,208 pesos per hectare; SARH, 32,528; Banrural, 30,950; and Banoro, a private bank, 38,512. This large variation in production-cost estimates, especially between the first three institutions, clearly sets the stage for conflicts when there are crop losses.

When ANAGSA does not repay the banks promptly, farmers are charged interest on the outstanding principal. If insurance payments are delayed because of disagreements over differences in production costs, a common occurrence, the interest accrues. Theoretically, ANAGSA is responsible for that interest but actually it becomes the ejidatarios' debt. In 1983, when soybean losses were extensive, ANAGSA was unable to make reimbursements promptly and some ejidatarios waited more than a year for financial compensation. By 1984, ejidatarios owed the bank substantial sums and were negotiating with ANAGSA to pay at least part of the debt.

Because ANAGSA and the banks control ejidal finances they also control the farmers' decisions, to a large extent. By midsummer 1984, heavy rains ruined much of the ejidal soybean crop, so ANAGSA and Banrural decided to have the ejidatarios in Paloma Blanca sow corn in August, followed by sorghum in the spring. The ejidatarios said that August was too late to sow corn and preferred to accept the soybean loss, leave their land fallow over the summer, and sow wheat in the fall, as it is a more profitable crop than sorghum. But Banrural and ANAGSA planned to recoup some of the soybean losses with the corn

rather than lose the summer cycle entirely. If the ejidatarios refused to sow corn, the bank demanded immediate payment of their soybean costs and ANAGSA refused to pay. The ejidatarios, although they disagree strongly with the decision that had been made, had no say in the matter.

National Company of Dietary Staples (CONASUPO). CONASUPO is the government agency responsible for the purchase of crops of official prices. Farmers who use bank credit are obliged to sell their harvests to that agency. Unfortunately, CONASUPO has had difficulties making payments on time and some farmers sell their crops to private buyers, who pay less than the offical price, but pay immediately. Some unofficial buyers, however, have decamped without making any payments. Official prices customarily increase several times after harvest and farmers have to repeatedly return to CONASUPO to collect each monetary increment. These partial payments delay the time it takes for farmers to receive their full harvest payments. Part of CONASUPO's inefficiency, as with the rest of the infrastructure, reflects the fact that the entire system is still developing. Hopefully, in time, its organization will improve.

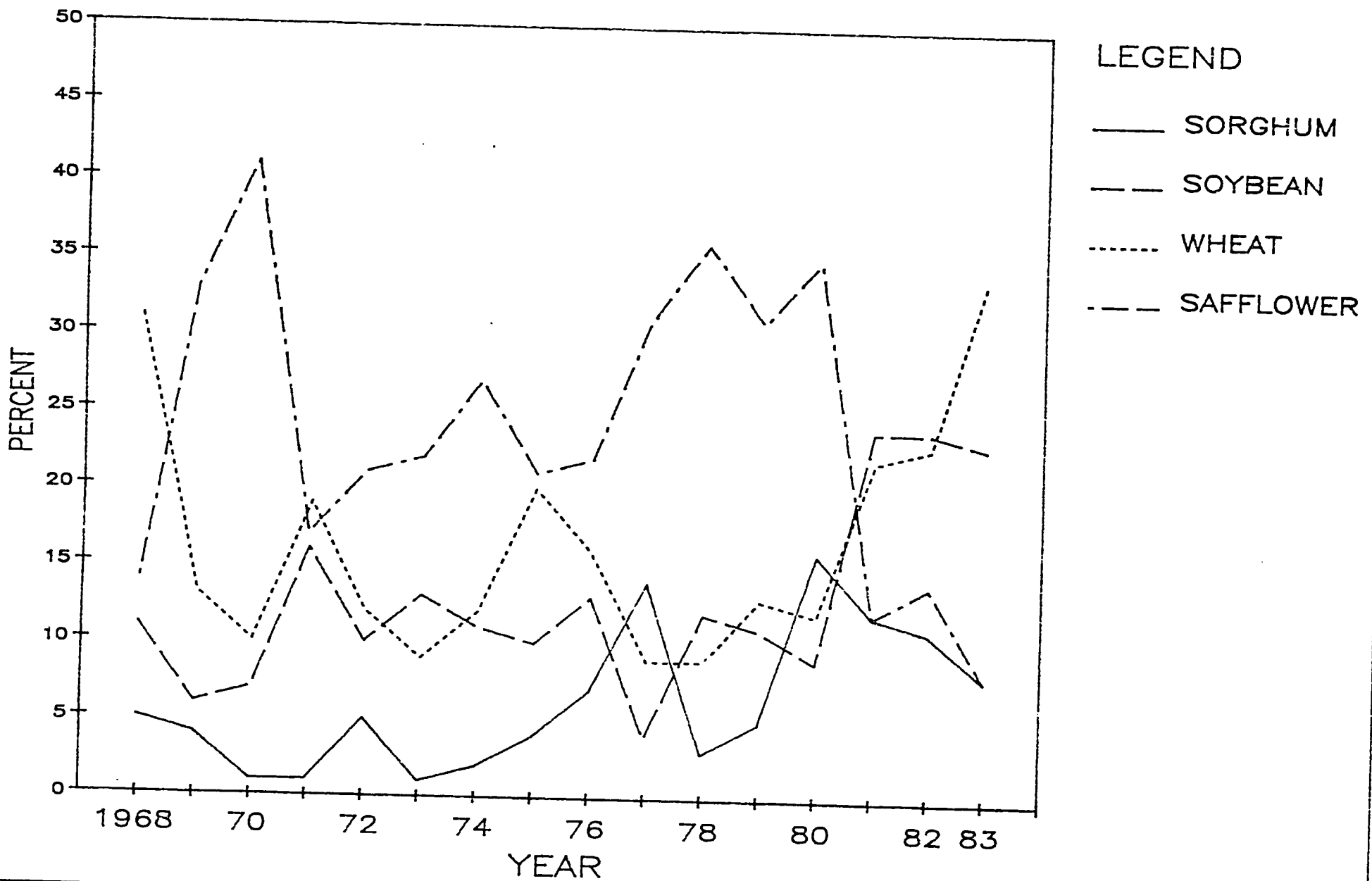
Favoritism. Favors are an important mechanism in the local agricultural system. Social status and cash cut through formal bureaucratic organization for access to local resources, especially when they are scarce. Some SARH personnel rent land in the district and receive payments for distributing water to the private farmers. Cash determines the distribution of agricultural goods and services, which are always limited in the new district, and the ejidatarios have comparatively little of that resource. Ejidatarios thus are at a disadvantage in the competition for local resources. They are the targets for those in positions of authority who can extract some profit from them even on a small scale. This system of favors enables the private sector to aggrandize local resources and maintains the ejidal sector's low status.

Guasave's Agricultural Development and Major Crops

The ejidal agriculture that developed in the late 1970s changed the form of production more than the type of crops grown. The custom of mixed subsistence and commercial farming continued, with emphasis on commercial production. Before the water and credit systems were dependable, the ejidatarios sowed corn, beans and squash--especially corn--to feed themselves and to sell in the local market. As the irrigation district and credit stabilized they planted more crops for the national market: wheat, soybeans, safflower, rice, corn, cotton, sorghum, and beans (Secretaria de Agricultura y Recursos Hidraulicos, 1982a). Because of the ejidals' advantageous geographical location and the political climate in Mexico during this time the ejidatarios began farming as commercial producers.

Although the ejidatarios have become commercial farmers, a dual agricultural system still exists in Guasave. Private farmers with extensive landholdings have access to bank credit for profitable export crops. Ejidatarios, on the other hand, are funded to produce only basic grain crops. Both the dryland farmers next to the district and ejidatarios provide hand labor in the private farmers' fields and packing plants. In 1983 it was still cheaper to plant and harvest vegetable and cotton by hand in Guasave than to import American machinery. For the ejidatarios, private farmers are always

Diagram 2. Major grain crops, D.R. 063, 1968-1984, % Cropland



available as an alternative to bank credit--to rent ejidal land, sharecrop or finance ejidal ventures in vegetable production. Private farmers own combines to harvest ejidal crops and trucks to transport them to storehouses. Their social status ensures preferential treatment when they need technical assistance, agricultural supplies or any agricultural resource that is in limited supply. This also is true in the SARH office where irrigation water arrives on private farms at the time and in the quantity requested, often at the expense of ejidal crops.

The valley's major crops since 1968 have been wheat, cotton, safflower and soybeans. These crops plus rice, corn, sorghum and beans are the valley's staples although the relative importance of each has changed markedly over the past sixteen years. In addition to those major crops, a small area of the valley (2-6%) is used to grow a variety of other crops: sesame, garlic, onion, chile, garbanzos, potatoes, lettuce, cabbage, watermelons, sunflowers, peanuts, barley, oats and arigolds (Secretaria de Agricultura y Recursos Hidraulicos, 1982a). Three perennial crops also occupy a small amount of land in the district: pasture grass, alfalfa and fruit trees (mainly mango and oranges). And a variety of export crops--tomatoes, peas, cucumbers, broccoli, cauliflower, zucchini, and melons--is sown in another 1-11% of the valley (Secretaria de Agricultura y Recursos Hidraulicos, 1982a). However, wheat, cotton, safflower, soybeans, rice, corn, sorghum and beans have accounted for the greatest hectarage and value of production since 1968.

The agricultural trends since 1968 are shown by the changes in area occupied by Guasave's staple crops. Safflower and rice were the staple crops from 1968 to 1979. Safflower, both dryland and irrigated, has occupied as much as 41% of the land and averaged 26% during these years. Wheat and soybeans, one rotation in the agricultural year, occupied less land than safflower and rice since 1980 to 1981 when irrigation was first available in the district. The next year, the area sown in wheat and soybeans increased sharply and continued to rise through 1984, so that currently they are Guasave's major crops (Diagram 2). The valley's other principal rotation, sorghum and beans, has always occupied less area than does the wheat and soybeans' rotation; this area has decreased since 1981.

Sorghum and safflower have been the principal crops for dryland farmers and those with limited water resources. Sorghum was first sown in the El Fuerte district north of Guasave in 1956, on less than 1% of the land in the district; by 1983 it occupied 10% (Secretaria de Agricultura y Recursos Hidraulicos, 1984a). In Guasave, sorghum was grown on an average of 4% of the land from 1968 to 1979 (Secretaria de Agricultura y Recursos Hidraulicos, 1979). In 1981 the area sown increased to 16% of the district, but by 1983 it declined to 8% or 9,554 hectares (Secretaria de Agricultura y Recursos Hidraulicos, 1984a). This decline reflected the farmers' preference for the wheat and soybean rotation rather than the sorghum and beans rotation because the former was more profitable. This trend will be explained more fully with research data.

Sorghum always has been produced primarily by the ejidal sector. In 1975 the ejidatarios sowed 54% of Guasave's sorghum and this increased to 79% in 1981 (Secretaria de Agricultura y Recursos Hidraulicos, 1981). The private sector produced most of the soybeans, an alternative to sorghum in the summer cycle, until 1980, when 58% of the crop was sown on ejidal land (Secretaria de Agricultura y Recursos Hidraulicos, 1980). The ejidatarios preferred the

soybeans' crop, and therefore the ejidal sector's access to local agricultural resources--water and crops with a higher profit potential--was clearly secondary.

Sorghum production in Guasave has averaged 4 tons per hectare since 1968. The lowest yield since then was 2.9 tons per hectare and the highest was 5.5. Local production was 3.7 tons per hectare in 1983, compared to the national average of 3.2 (Direccion General de Economia Agricola, 1986). For the three years that ejidal and private production can be compared, 1980-82, the ejidatarios were slightly less productive: 4.1 vs. 4.5 tons per hectare. Ejidal productivity also was lower than that in the private sector for wheat, soybeans, beans and corn.

There are a number of insect pests that attack the sorghum in Guasave. Both the farmers and CIAPAN (AGricultural Research Center for the Pacific North) report that the worst pests are the midge, Contarinia sorghicola, and the fall army worm, Spodoptera frugiperda. Other local pests are Agrotis sp., Grillo gryllus sp., Schizaphis graminum, Rhopalosiphum maldis and Nezara viridulla (Centro de Investigaciones Agricolas del Pacifico Norte, 1983). The two most common diseases that the farmers report are panicle smut, Sphaceloteca sorghi, and "tizon de la panoja," Fusarium moniliform, but these are minor problems. Weeds are not a major problem because they are controlled by cultivation with tractors and by hand with machetes. Johnson grass is not a problem on irrigated land, but it is a problem in dryland areas. Crop losses from migratory doves and other birds are also minimal at present.

SARH recommends control of the midge with Lorsban 480, Malthion 1000, Folimat 1200 (Bayer) and Gusation ethyl 50 (Bayer). Other insecticides recommended by CIAPAN are Salvadrin, Diazinon 25, Sevin and Dimetone (Roxion by Union Carbide) (Centro de Investigaciones Agricolas del Pacifico Norte, 1983). Decamine (2-4-D) and 2-4D-A are commonly used against broad-leaf weeds and Faena (Monsanto) against Johnson grass. SARH bases its production costs on three insecticide applications while Banrural allows for five. The farmers interviewed for this study performed at most, three aerial fumigations. Control of the midge is difficult because extensive areas in the valley are sown in sorghum and because many farmers do not fumigate. Compounding this problem, sorghum is not planted at a uniform time due to credit problems and access to machinery. Thus, those least likely to afford crop loss (the late planters) are the most susceptible to the build-up midge population.

Methodology: Selecting Two Research Sites

The field study of the small farmers is conducted in the Second Section of District 063 (Map 2). Two ejidos were chosen on the bases of sorghum production, overall agricultural productivity and availability of agricultural resources (land, water, credit). The first ejido, Paloma Blanca, was larger than average in both population and land area, and was one of the valley's better ejidal producers. The second ejido, San Marcos, was also larger than average in population and land area but representative of a typical ejido in the district in terms of organizational and production problems. Agricultural production was affected by several factors. Paloma Blanca was a compact community, had had irrigation for the past three years and had no bank debts.

San Marcos was a dispersed community that had used wells for three years, had sown only one crop cycle with irrigation water, and consequently was indebted to Banrural.

One out of five farmers was drawn at random from a complete list of ejido members, producing a sample of 60 households in Paloma Blanca and 34 in San Marcos. Both male and female heads of the households were interviewed. In addition, community leaders and key informants were interviewed to collect information on the ejidos' histories, the farmers' evaluations of constraints and incentives on agricultural production, and the farmers' experience with and evaluation of sorghum in particular. Bank officials, and ANAGSA and SARH personnel were also interviewed to obtain data on the valley's agricultural system and, in particular, sorghum production.

As described above, the ejidatarios in Guasave were commercial farmers. Before they began farming their own land most ejidatorics had migrated out of the valley for a period of time, some as far as the U.S., working as wage laborers. Very few had stayed in Guasave as subsistence farmers. Therefore, this population was not one that made a transition from subsistence to commercial farming. Many farmers sowed half a hectare of corn or milpas for household consumption, but they primarily produced cash crops for the commercial market.

Chapter 3. Ejidal Sorghum Production in Northern Sinaloa

Ejido Paloma Blanca

Paloma Blanca is a prosperous rural community with many modern services. About 5,000 people live in brick houses surrounded by fruit trees and flowers, especially roses, which flourish in Guasave's climate. All the ejidatarios paid to bring electricity and piped water to the ejido in 1975; television antennas on top of tile roofs and household vegetable gardens are common. There is a primary school for the children. A second school offers one year of education as well. A new church is under construction and the ejido has its own tortilleria and a few cafes. The roads in the ejido are unpaved and become nearly impassable during the rainy season, but they are graded each year.

The lifestyle in Paloma Blanca reflects the farmers' general agricultural success. Off-farm income is not a necessity for either men or women. Only two men have full-time jobs in nearby cities, although more than half the sample worked occasionally within the ejido doing construction, plumbing or wage labor in the fields. The houses have one or two bedrooms, separate living rooms and indoor kitchens with modern gas stoves. Inside the homes there are televisions, refrigerators and large electric fans for tempering the summer heat. Unlike most of Mexico's rural population, the ejidatarios in Paloma Blanca eat meat and wheat products frequently. The average household member consumes 100% of its calorie requirements each day. Clearly, ejidal agriculture in Paloma Blanca provides an adequate livelihood (Adelski, 1987:194).

Agricultural Resources. Paloma Blanca's rapid transformation into a community of commercial farmers began in the mid 1970s when the ejido's 4,000 hectares were cleared through a combination of government funds, bank loans and rental agreements with the local haciendados. By 1980, the 327 ejidatarios had access to land, water and bank credit for commercial production. Most of them had been farming for three years before this field research was done.

The ejido's farmland is divided into parcels of 10.5 hectares. Seventy percent of the farmers have 10-10.5 hectares of land, and 75% have their land in one plot, which is advantageous for mechanized production. Eight farmers (14%) have access to more land (11.5-21 hectares) through inheritance or sharecropping. Sharecropping or loaning land is a common practice in Paloma Blanca when the parcel owners are female, elderly, or live permanently outside the ejido. The sharecroppers are entirely responsible for the parcel and a share of the harvest.

Although the irrigation system is still under construction, 94% of the farmers have access to water: 72% are using irrigation water alone, 15% are using wells and 7% a combination of the two. Only two farmers (3%) have no water and two others (3%) have land that is partly dryland and partly irrigated with pumps. The irrigation water became available to a few farmers in the ejido in 1981 and to most in 1982. When SARH had not finished the major canal for Paloma Blanca by 1982, the farmers borrowed machinery and made two provisional canals, totaling 14 kilometers, to irrigate 1,700 hectares. These canals have limited capacity so the water often arrives late and

irrigation takes twice as long as expected, but they have been used successfully for more than four years.

The farmers are organized into work sectors to receive bank credit for crops and machinery. These sectors average nine members and 60% consist entirely of relatives; farmers report that this eliminates cheating and facilitates decision making. Within each sector, farmers manage their parcels independently, maintain their own bank accounts and collect their own harvest profits. Sixty percent of the sectors work with Banrural, the government bank primarily responsible for ejidal agriculture. The sector chief arranges the group's credit with the bank and keeps the accounts. By 1984, 93% of the farmers were using bank credit, which allowed them to receive crop insurance to cover losses. The farmers in Paloma Blanca are known as hard-working and successful and have no problems with obtaining or repaying their bank credit.

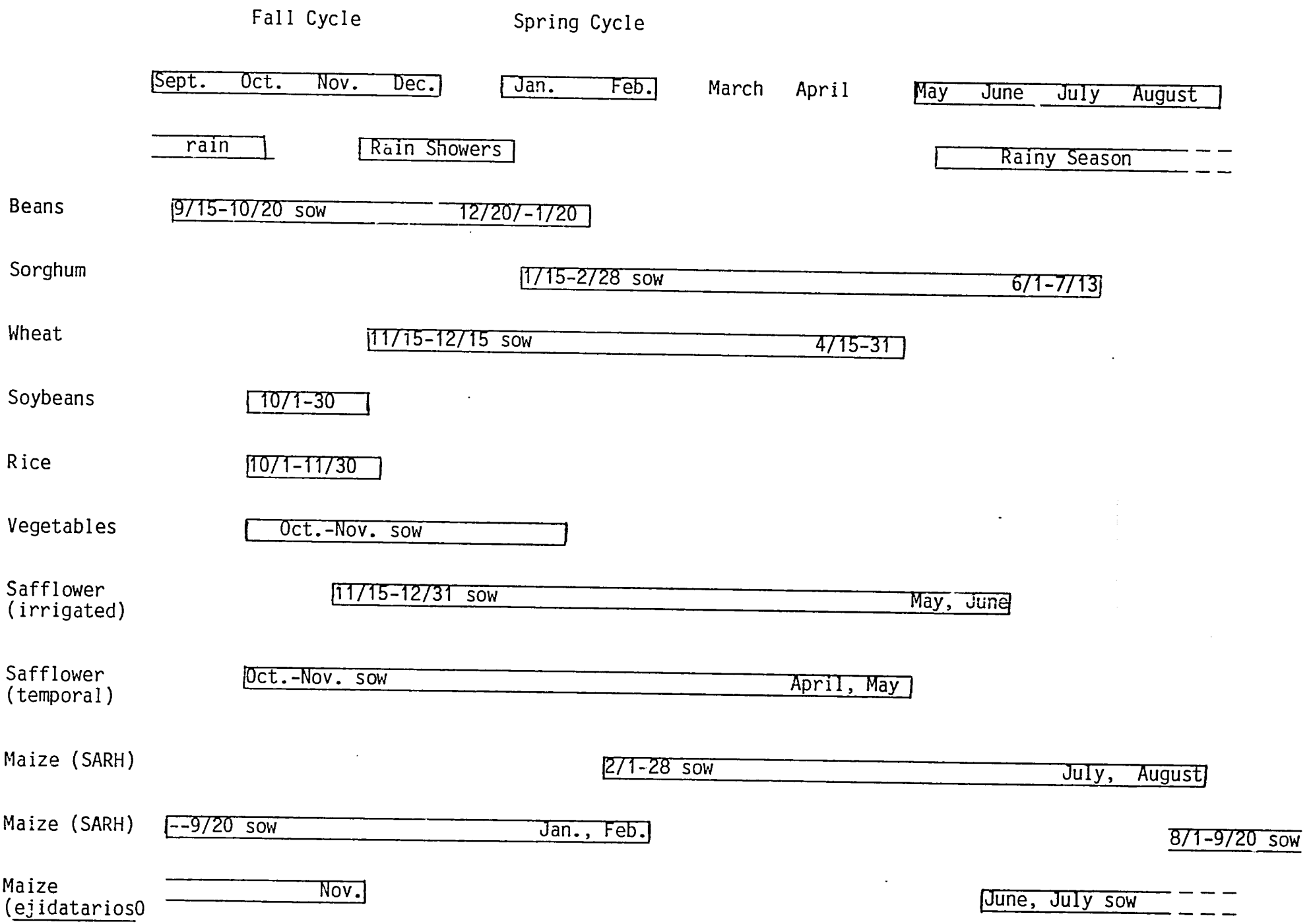
Machinery for agricultural work and transportation is an essential resource in Paloma Blanca. Fifty-two percent of the farmers own vehicles, mainly pickup trucks. Tractors are owned privately and collectively by the work sectors. Only 12 farmers (20%) own tractors, which are small (60-80 h.p.) and were generally purchased second-hand. In addition, 13 work sectors used bank credit to buy 21 tractors, twelve of which are large (140-155 h.p.). There is a complete set of equipment for both the privately-owned and collectively-owned tractors, with two exceptions. The number of tractors in the sample totals 36, twenty-four small and twelve large, to work approximately 700 hectares of farmland. Tractors are rented within the ejido, but the shortage of machinery creates a major bottleneck at sowing time, putting many farmers behind schedule at the beginning of the crop cycle. Since none of the farmers own combines, this creates another bottleneck at harvest.

Livestock are not a significant resource in Paloma Blanca. They are decreasing in number as more land in the ejido is brought under cultivation, eliminating the scrub that has provided pasture. Cattle are a liability because they stray into the crops, spread weeds and return less profit than crops. The ten farmers who raise cattle also sow alfalfa rather than forage sorghum. Not many people sell their crop stubble to cattle-owners as forage because the cattle brought in to graze compact the soil and spread weeds. However, most farmers raise pigs and chickens; sorghum is used for feed.

Technical assistance is available for Paloma Blanca from SARH. Two agricultural extension agents and one canal supervisor are responsible for the ejido. The extension agents make regular weekly visits and the canal operator can be found on the canals every day. Farmers also can consult these specialists in SARH's field office, a thirty-minute drive from the ejido. The main reasons farmers need to contact these persons are to certify crop losses and fumigations. Many farmers report that extension agents often do not keep their appointments and by the time fumigations are authorized, the crop is not worth the treatment expenditure. This appears to be a chronic problem, but farmers feel they can do little about it.

Agricultural knowledge is an intangible resource of farmers. As children they helped their fathers sow seed and harvest crops by hand in some of the same land that they now work with machines. Farmers have also worked with commercial growers and learned about modern agricultural technology--machinery, irrigation systems, and pesticides. However, what farmers call

Diagram 3. Irrigated cropping cycles, Guasave



their own "practical technology" does not always coincide with SARH's policies. For example, sorghum furrows are spaced 50 centimeters apart rather than 70, as recommended by SARH. Farmers report that with proper irrigation and fertilization this spacing does not adversely affect yields. Some work sectors have performed their own field trials with sorghum, growing DeKalb 50a and 55 in the same parcel to determine the best producer (yields were approximately equal). Farmers involved with field test plots are familiar with modern agricultural technology and local conditions; lack of expertise is not one of the factors that hinders crop production.

Use of Agricultural Resources. The agricultural year in Guasave is divided into two cycles: fall and spring. The major fall crops are wheat, beans (Phaseola vulgaris) and safflower; the spring crops are sorghum, soybeans and corn (Diagram 3). Corn and safflower can be sown in both cycles, as Diagram 3 shows. The ejidatarios' two major crop rotations are beans as a fall crop, followed by sorghum in the spring, and wheat in the fall, followed by soybeans in the spring. These crop rotations account for 75% of all the farmers in the spring and 80% in the fall. The fall cycle is dry and cool and crops grown in this cycle are more productive than those grown in other cycles. Problems with insects and operating tractors in the fields for cultivation and spraying are minimal. Fallow land is therefore more common in the summer cycle when the farmers with additional disadvantages--wells, unleveled parcels, flooding from the provisional canals--skip that crop cycle altogether. As Table 3 shows, a few other crops also are grown in Paloma Blanca--alfalfa, vegetables, sesame, watermelons, garbanzo beans--but these are limited in hectarage.

Sorghum production is standardized and mechanized throughout the Gusave valley. All of the sorghum grown is red-seeded, which is used for animal feed and not for human consumption. Preparing the earth involves one deep plowing, 25 centimeters, and two or three cross plowings before sowing. The crop is sown from January 15 to February 28, the earlier the better, and harvested from May to June. In 1983, farmers used 18 kilograms of seed per hectare. CIAPAN currently is conducting local field trials with two varieties from Rio Bravo, Tamaulipas: RB-30-30 and RB-30-06. Banrural authorized three varieties in 1983: Asgrow Dorado M, Double TX and Northrup King 180. Since 1980, farmers have sown a number of varieties: Oromex 94; DeKalb D-55 and 58; Master 911 and Golden; Asgrow Dorado E and Double T; Northrup King 180, 233, 285 and 2575. The most commonly used varieties in 1983 were DeKalb D-55 and Northrup King 233.

Irrigation and fertilization are standard inputs for sorghum production in Guasave. SARH includes five irrigation applications in its production costs; farmers report that they irrigate the crop 4 to 5 times. Because the irrigation system is still being constructed, the water supply is often insufficient, erratic or late. Farmers, however, report that erratic irrigation does not affect sorghum yields, although production does decline when fertilization is delayed. Anhydrous ammonia, containing 82% nitrogen, is the fertilizer used for irrigated sorghum. Farmers apply 200 kilograms/hectare, preferably after the parcels are irrigated and just before sowing. A tank containing the fertilizer is transported to the field, where it is emptied into the main irrigation ditch. Fertilizer is sometimes applied after the sorghum is sown, especially when farmers have inadequate time to prepare fields: 100 kilograms of anhydrous ammonia per hectare are applied with both the first and second irrigations.

Table 3. Crop history, Paloma Blanca, 1982-1984

	Summer 1982			Fall 1982-1983			Summer 1983			Fall 1983-1984		
	Farmers		Area	Farmers		Area	Farmers		Area	Farmers		Area
	N*	%	ha's**	N	%	ha's	N	%	ha's	N	%	ha's
Sorghum	30	51	280				22	37	239	1	2	.5
Beans				23	38	211				22	37	126
Wheat				28	47	275				46	77	463
Soybeans	15	25	151				22	37	214			
Corn/Milpas	11	18	31	5	8	5	13	22	27	9	15	5.5
Safflower	2	3	20	8	13	54	5	8	31	1	2	10.5
Alfalfa	2	3	6	2	3	6				2	3	3
Vegetables	1	2	10	4	7	12				1	2	10.5
Sesame							1	2	5			
Watermelon										2	3	12.5
Garbanzo										1	2	.5
Fallow Land	7	12	66	4	7	50	9	15	85	2	3	13.5

*N = Number of farmers growing a particular crop
**Ha's = Hectares

Banrural's cost of production of one hectare of irrigated sorghum in 1983 totaled $186, excluding $18 of bank interest. Dollar amounts are based on an average exchange rate for the 1983-1984 peso of $U.S. 1.00 = 166 pesos. The operations and itemized costs are given in Table 4. Cost reductions can be obtained by eliminating certain operations that require machinery and doing the work manually. Farmers report that the 25 centimeter deep-plowing before sorghum sowing is not necessary and therefore do not do it. Several other operations are also generally not performed: leveling the furrows after plowing, leveling the borders from the previous crop and making new borders (1.5 foot borders are made at intervals in the parcel to compensate for each 5 centimeters of slope), cleaning the canals, scaring the birds, and aerial fumigation. Farmers who do not own factors must obtain credit to rent machinery.

Part of the bank credit customarily is spent on household needs rather than on agricultural production. Some farmers take money for operations (e.g., scaring birds off the sorghum) that are not performed and use it as income. Although farmers pay interest on borrowed money, bank credit is a dependable source of income, especially if profits from the previous harvest were small. In fact, many farmers report that they sow certain crops that typically incur losses, such as soybeans, in order to obtain bank credit. Another means of maintaining income before harvest is for the farmer to do his own manual labor (irrigating, weeding) rather than using credit money to hire workers. The amount of credit money spent on household necessities and the amount of manual labor done by the farmer depend on the household's overall economic status, especially on the profits from the previous harvest. At harvest, farmers seldom obtain credit to rent combines and transport the crop to CONASUPO. Instead, they pay cash for these operating expenses to avoid interest charges.

The farmers' actual production costs for sorghum in 1983 ranged from $83 to $167 per hectare. One farmer who owned a tractor spent only $83 per hectare. The itemized cost of production for the farmer who spent $167 hectare is given in Table 5. This farmer saved money by eliminating some operations and paying for the harvest costs in cash. However, even with a production cost 18% below that of Banrural and a yield of 5 tons per hectare, the gross profit per hectare of sorghum was only $126.30.

The current trend in Paloma Blanca is replacement of the beans/sorghum rotation with the wheat/soybeans rotation. In the spring of 1982, 62% of the farmers sowed sorghum, but only 44% continued the rotation with beans in the fall (Table 6). The following year the number of sorghum producers decreased by 11% to 51% while soybean producers increased by 11% to 49%. Only 8 farmers (15%) planted beans in the fall of 1983; the great majority (85%) sowed wheat instead, which was followed by soybeans in the spring. This change of rotations virtually eliminated sorghum as a spring crop in 1984. The change in the amount of land used to grow crops clearly demonstrates the switch from sorghum/beans to wheat/soybeans; sorghum land area decreased 15% from 1982 to 1983 and soybeans increased 54%. Beans have become mainly a crop for household consumption. Except for eight farmers who sowed beans as a major fall crop in 1983, only fourteen people planted a total of only 27 hectares for household use. From 1982 to 1983, there was a 54% decrease in the number of hectares in bean production, clearly showing that beans were no longer a preferred commercial crop. Wheat, on the other hand, has become the farmer's first crop choice, evidenced by a 68% increase in crop area from 1982 to 1983.

Table 4. Banrural's estimated cost of producing one hectare of irrigated sorghum, 1983

Operation	Cost in $U.S.*
Deep plowing (once)	12.95
Harrowing (three times)	16.27
Leveling (once)	3.92
Making furrows (once)	3.31
Irrigation canal and border construction (once)	3.31
Leveling previous borders (once)	1.66
[1]	
Seeding	15.06
Sowing	5.12
SARH's sowing fees	.30
[2]	
Fertilizer	12.53
Application of fertilizer	3.92
Manual labor in fertilizer application	.90
Cultivating weeds mechanically	10.24
Manual weeding	5.42
Fees for irrigation water	2.92
Cleaning irrigation canals (once)	2.56
Harrowing for irrigation (once)	1.66
Irrigation pipes	1.66
Irrigation (six times)	15.81
[3]	
Insecticides	9.07
Aerial application of insecticides (three times)	11.45
Rat poison (once)	.30
Bird scaring (once)	1.81
Combine rental for harvesting	24.10
Transport crop to granary	12.05
Agricultural insurance	8.13
Bank interest	18.33
TOTAL COST	$204.79

*$1 U.S. = 166 pesos
1 Seed: 20 kgs/hectare
2 Fertilizer: Aquamonia 20.5, 800 kgs/hectare
3 Insecticides: Salvadrin, 10 kgs/ hectare, Diazinon, 1 liter/hectare, Dimethoato, 1 liter/hectare, Sevin, 1.5 kgs/hectare
Source: Banco Rural, Guasave, Sinaloa

Table 5. Farmer's cost of producing one hectare of irrigated sorghum, 1983

Operation	Cost in $U.S.*
Sorghum D-55 (198.5 kgs. at $.70/kg)	14.00
Harrowing (three times)	12.65
Irrigation border construction	2.41
Sowing	3.92
Irrigation canal development	1.66
Fees for irrigation water	8.77
SARH's sowing fees	.30
Anhydrous ammonia (1,600 kgs.)	14.46
Fertilizer application	2.71
Irrigation (four times)	8.89
Leveling	3.01
Weeding (twice)	4.52
Agricultural insurance	11.16
Fees for work sector chief	1.51
Furrowing	3.01
Amino-d (herbicide; 1 liter)	.24
Bank interest	10.56
Combine rental for harvesting **	24.20
Transportation to granary **	39.16
TOTAL COST	$167.14

*$1 U.S. = 166 pesos
**Expense was paid with cash
Source: Interview with work sector chief

Table 6. Major crops by agricultural cycle, Paloma Blanca, 1982-1983

	1982			1983			
	Farmers		Area	Farmers		Area	% Change
	N	%	ha's	N	%	ha's	in ha's
Spring Crops							
Sorghum	28	62	277	23	51	235	-15
Soybeans	17	38	181	22	49	278	+54
Fall Crops							
Beans	21	44	214	8	15	99	-54
Wheat	27	56	272	45	85	457	+68

Table 7. Sorghum and wheat yields, Paloma Blanca, 1983-1984

	Sorghum, tons/ha*		
	3.0-4.0	4.1-4.9	5.0-6.1
Number of farmers	7	7	8
Percent	32	32	36

*SARH's expected yield: 5.0 tons/ha

	Wheat, tons/ha*			
	0.6-0.3	3.1-4.1	4.2-5.0	5.1-6.6
Number of farmers	5	11	14	13
Percent	12	25	33	30

*SARH's expected yield: 4.2 tons/ha

One reason why farmers have shifted crops in Paloma Blanca is that sorghum yields have been only acceptable while wheat yields have been excellent. In 1983, 36% of the farmers harvested from 5.0 to 6.1 tons of sorghum per hectare; SARH's expected yields were 5.0 tons per hectare. The majority of farmers (64%), however, produced less than the target, as Table 7 shows. In contrast, SARH's expected wheat yield was 4.2 tons per hectare and 63% of the farmers reached or exceeded that target (Table 7). Thus, nearly twice as many farmers met or exceeded SARH's standards for wheat than for sorghum production.

Profits from wheat are much greater than those from any other crop in Paloma Blanca. In 1983, the average income of the farmers who sowed wheat/soybeans was $4,224 compared to $1,104 for those who sowed beans/sorghum. The average income from wheat alone was $3,581, compared to $940 from sorghum, although the average number of hectares sown in each crop was the same. Farmers earned $337 per hectare with wheat, 3.8 times as much as with sorghum at $88 per hectare. High wheat profits compensate for the losses with soybeans, the complementary crop in that rotation, but low sorghum profits do not compensate for losses with the complementary bean crop. Since credit is available for both sorghum and wheat, the rational farmer chooses the latter crop combination for its ease of production and higher profits. The constraints on sorghum production associated with this shift to wheat will be discussed later.

Ejido San Marcos

The Arroyo Ocoroni River runs through the farmland of San Marcos, dividing the ejido into two communities. Two-thirds of the 4,000 ejidatarios live on the north side of the river (arroyo) in La Trinidad, a rural center

and headquarters for SARH in Section Two of Irrigation District 063 (Map 2). La Trinidad has a population of 12,000 and many urban services: a post office, telephones, police persons, two schools, a church and a medical clinic. Because the road is paved to and from Guasave, bus travel is frequent (every hour) through the town, even in bad weather. There are also numerous grocery stores, several cafes and a CONASUPO.

One-third of the ejidatarios live on the south side of the arroyo, in San Marcos proper. Although their houses are only three miles from La Trinidad they form a separate community with few amenities. There is no bus service into town, no grocery stores and no piped water. In the rainy season the arroyo becomes impassable, isolating these households from La Trinidad. But the ejidatarios like the space and quiet of their small community; they have room to keep livestock and have easy access to their fields.

As in Paloma Blanca, ejidatarios in San Marcos report that their parcels of land provide an adequate livelihood and off-farm employment is not necessary. In fact, most of them have not worked off the farm since they began farming their parcels. But in comparison to Paloma Blanca, San Marcos is just beginning to resemble a prosperous rural community. After a profitable wheat harvest in 1983, there was a flurry of construction and refurnishing in the ejido. Brick walls replaced the wood in old houses and new refrigerators sat on the dirt floors until cement ones were poured. Although bedrooms often doubled as living rooms, all of the houses had electricity, gas, and indoor kitchens. Gas stoves, refrigerators, electric fans and kitchen cabinets are common household items, as are less essential goods like televisions, sewing machines and stereos.

The ejidatarios' diet as well as their material goods reflects their economic well-being. Dietary data show that the average household consumes meat two or three times each week and exceeds its caloric needs by 10%. Although San Marcos is beginning to become organized for commercial production, its agriculture already provides adequate support for the ejidatarios.

Agricultural Resources. San Marcos' current agricultural status and its effort to organize production are typical of the average ejido in Guasave. In 1976, the ejido's 1,843 hectares were leased to a private farmer who cleared the land. This process took several years and, as a result, the ejidatarios did not have access to their parcels until 1980 or 1981. Until this time they sharecropped with the private farmers or worked as wage laborers, locally or in Sonora. Full scale irrigation became available, necessitating a new system of farming, when the ejido was established. Prior to 1982 irrigation was limited because of the use of wells.

Originally, there were 99 ejidatarios in San Marcos with parcels of 19 hectares each. Since ejidal parcels averaged 9 hectares in the district, the ejidatarios split their land into 9 or 10 hectare parcels in 1978, deeding one parcel to another family member rather than risking loss to outsiders through Agrarian Reform. These family members were most often children below the age of sixteen, the legal age for landholding, so the original ejidatarios actually retained control of their entire parcels. While most households (67%) have between 13 and 19 hectares of land, one household has 29 hectares. Only 30% of the households have 9 or 10 hectare parcels. Thirty-five percent of the farmers combined their parcels into one plot; those with two plots

(44%) were older and had been cultivating small plots of alluvial land (no more than 4 hectares) along the arroyos since the 1940s.

A current problem is that a locally prominent private farmer cultivates export crops on rented ejidal land next to San Marcos and possesses privileged access to the water supply. The extension agents' first priority is to ensure water to the export crop. Despite the ejidatarios' formal complaints their crops are not irrigated on time. The ejidatarios report that a particular farmer pays sizeable bribes to obtain irrigation water; they plan to take the matter to the central SARH office in Guasave.

Bank credit has funded San Marcos' agricultural production since 1980, but the ejido is still being organized Because membership in the work sectors is unstable, some people work part of their land independently. The lack of organization in the work sectors as well as lack of coordination between the sectors and the extension agents who help arrange credit, caused delays in sowing during the first two years. By mid-1983 both groups were better organized and not only did the bank credit arrive on time but the farmers were able to plant on schedule.

Technical assistance from SARH has been available in San Marcos since 1980. The field headquarters of the extension agents for Section Two is located only a ten-minute walk from the center of the ejido, which is easily accessible to the farmers.

The farmers are organized into 16 work sectors. Each sector averages nine nonfamily members who farm and purchase machinery together. Work sectors comprise 72% of the ejidatarios in 1983. The remaining farmers were still in the process of selecting a sector or were farming independently. Because parcels are large, many farmers sow 15 hectares within the sector using bank credit and sow the rest of their hectarage independently (i.e., raise crops for household consumption or the market). However, increasing costs of production are motivating the independent producers to join the work sectors to take advantage of bank credit.

Most of the farmers in San Marcos (65%) own vehicles or tractors. Seventeen people (50%) own pickups, the preferred vehicle, and eleven farmers (32%) have their own small tractors (60-80 h.p.), which were purchased second-hand. In addition, 12 work sectors own eight tractors, seven of which are International Harvesters, 1486. Because these tractors are large and expensive they are shared by two or three work sectors and 15 to 24 farmers own each tractor. Farmers purchased new International Harvesters through SARH's mechanization program, but virtually all of the tractors have needed repairs. The ejidatarios have paid for these expenses, which have added to their debts and ultimately delayed the production process. Five sectors do not have any tractors and depend on rented machinery for all of their work. Thus, the 540 hectares are farmed by 14 small and 7 large tractors. In 1984 there were no combines in San Marcos but a neighboring ejido had three which were available for rental. As in Paloma Blanca, the shortage of machinery is a chronic problem for the farmers.

Livestock are not an important resource in San Marcos. Of the six farmers (18%) who own cattle, only two have sizeable herds (17 and 21 cattle), which are kept outside the irrigation district. Forage sorghum is not grown in the ejido and there are only 1.5 hectares of alfalfa. The cattle graze on

field sorghum stubble as well as on vegetation along the roads and canals; irrigated land is primarily used for crops. Chickens and pigs, however, are common household animals.

Use of Agricultural Resources. Agricultural production in 1980 consisted of drought tolerant crops and food staples: safflower, sorghum, corn and beans. As in Paloma Blanca, small areas of other crops were grown; pasture grass, cucumbers, cotton and peanuts (Table 8). Large amounts of land also were left fallow due to lack of water. In the summer of 1982, 31% of the farmers left their entire parcels fallow rather than struggle with the wells and risking increased indebtedness. Beans and sorghum were the predominant crops through the fall of 1982; only small areas of wheat and soybeans were sown. Beans and sorghum were originally logical choices because beans were a staple food and sorghum was suited to dryland conditions. But with the arrival of irrigation water in 1983, the farmers' first crop choices became wheat and soybeans.

In 1982, only 14 farmers (41%) in the sample grew spring crops due to the water shortage. Nine of these (64%) sowed sorghum as their major crop (half the parcel or more) and fifteen (63%) sowed beans that fall, continuing the rotation (Table 9). Only five farmers sowed soybeans in the spring of 1982, and nine followed that rotation in the fall by sowing wheat. But in 1983, when irrigation water was available and 94% of all the farmers sowed spring crops, 62% sowed soybeans, increasing the area of that crop by 261%, while the sorghum area increased by only 17%. That fall a small area of beans was planted for household consumption only, a total of 29 hectares among 12 households, and all of the farmers sowed wheat as their major fall crop (Table 9). Because soybeans follow wheat, sorghum was eliminated as a summer crop in San Marcos in 1984. The farmers had replaced the bean/sorghum rotation with wheat/soybeans.

The low sorghum yields in San Marcos partly account for farmers' decision to plant wheat. In 1983, SARH provided credit for sorghum production based on a yield of 5.0 tons per hectare, but only two farmers (15%) harvested 5-7 tons per hectare (Table 10). Thirty-two percent of the farmers produced less than 3.0 tons of sorghum per hectare. Beans, the crop following sorghum, were a productive crop in San Marcos in 1982 (the last year they were sown as a major crop), and 65% of the farmers met SARH's expected yield of 1.2 tons per hectare. (But, the good bean yields do not compensate for the low sorghum yields, and farmers have abandoned the bean/sorghum rotation.)

As in Paloma Blanca, the main incentives to grow wheat are the ease of production and the potential for high yields and profit. In 1983, 36% of the farmers met SARH's expected yield of 4.2 tons per hectare, and 39% harvested more than 5 tons per hectare (Table 10). The disadvantage of growing wheat is that the crop to follow in rotation is soybeans which has small profits. Due to the lack of combines in Guasave, the 1983 wheat harvest was delayed, and the majority of the farmers sowed their soybeans late. When early summer rains flooded the ejido the farmers lost their soybeans; 39% of the soybean producers had no harvest at all. However, the farmers intended to continue sowing wheat/soybeans and said that production would improve with better organization.

Table 8. Crop history, San Marcos, 1982-1984

	Summer 1982			Fall 1982-1983			Summer 1983			Fall 1983-1984		
	Farmers		Area	Farmers		Area	Farmers		Area	Farmers		Area
	N*	%	ha's	N	%	ha's	N	%	ha's	N	%	ha's
Sorghum	11	38	118	0	0	0	14	41	136	0	0	0
Soybeans	8	28	82	0	0	0	24	71	272	0	0	0
Wheat	0	0	0	9	28	121	0	0	0	33	97	463
Beans	0	0	0	18	56	232	0	0	0	12	35	29
Corn	5	17	44	4	13	30	9	26	19	1	3	.5
Safflower	1	3	19	7	22	42	2	6	13	1	3	7.5
Pasture Grass	0	0	0	0	0	0	0	0	0	1	3	1
Cucumber	0	0	0	0	0	0	0	0	0	1	3	6
Cotton	0	0	0	0	0	0	0	0	0	1	3	2.5
Peanut	0	0	0	0	0	0	1	3	2	0	0	0
Fallow	9	31	120	1	3	17	1	3	17	0	0	0

* = Number of farmers growing a particular crop.

Table 9. Major crops by agricultural cycle, San Marcos, 1982-1983

	1982			1983			
	Farmers		Area	Farmers		Area	% Change
	N	%	ha's	N	%	ha's	in ha's
Spring Crops							
Sorghum	9	64	109	11	34	128	+17
Soybeans	5	36	72	21	66	260	+261
Fall Crops							
Beans	15	63	214.5	0	0	0	-100
Wheat	9	37	121	33	100	463	+283

Table 10. Sorghum and wheat yields, San Marcos, 1983-1984

	Sorghum, tons/ha*				
	1.3-2.9	3.0-4.0	4.1-4.9	5.0-6.0	7
Number of farmers	4	4	3	1	1
Percent	31	30	23	8	8

*SARH's expected yield: 5.0 tons/ha

	Wheat, tons/ha*			
	2.3-3.0	3.1-4.1	4.2-4.9	5.0-6.8
Number of farmers	2	6	12	13
Percent	6	18	36	39

*SARH's expected yield: 4.2 tons/ha

Wheat is presently the economic mainstay in San Marcos. In 1983, the average income was $6,246, 95% of which was from wheat profits. Sorghum profits were $61 per hectare while those of wheat were $417 per hectare. With a stable supply of water and bank credit, wheat is certainly the rational crop of choice.

Incentives and Constraints on Irrigated Sorghum Production

Farmers in the Paloma Blanca and San Marcos ejidos consider a number of factors in deciding what crop rotations to grow. In each rotation there is a problem crop, either beans or soybeans. The main disadvantage in growing either beans or soybeans is low yields due to pest or disease problems. In 1983, only one-fourth of the farmers in Paloma Blanca met SARH's expected average bean yield and only one out of twenty-two met the expected yield for soybeans. Not one farmer made a profit from the bean crop and 64% of the soybean producers did not make a profit either. Farmers reported that heavy fall rains and a soil fungus ruined the bean crop that year. Some said that there was no treatment for the fungus while others reported that a chemical was available but was prohibitively expensive and difficult to find. In any case, nobody treated the bean crop; the only beans harvested were those used for household consumption. Soybean yields are decreased by both weed and insect problems, especially if seeds are planted late in the summer cycle when these pests proliferate. Weed control in soybeans is particularly difficult during the rainy season when herbicides cannot be used. Because ejidos lack machinery, soybeans are generally sown in the late spring and consequently sustain damage.

The two profitable crops, sorghum and wheat, cannot be grown in rotation in the same agricultural year. A wheat/rice rotation, an alternative that the farmers reportedly want to try, is not yet possible because of the district's limited water supply. The rotation choice, then, is clearly between sorghum, which is sown in the spring, and wheat, in the fall.

There were three initial incentives to grow sorghum: (1) sorghum is drought tolerant, (2) sorghum is moderately tolerant of saline soil, and (3) sorghum stubble could be used for livestock grazing. By 1983, a number of factors constrained sorghum production: insects, lack of machinery, weeds, stubble removal, and the weather.

The extensive fields of sorghum sown in both ejidos and the adjoining farmland support large inset populations. The farmers report and INIA's local field station acknowledge (CIAPAN, 1983) that the midge, Contarinia sorghicola, is the crop's major pest, especially when the crop is sown late. The fall army worm (Spodoptera frugiperda) and panicle smut (Sphaceloteca sorghi) are minor problems. Control of the midge is difficult for two reasons. First, by the time the extension agents certify the need for fumigation and a plane is located--resource in the summer--the crop often does not warrant the monetary investment. Second, since not every parcel of sorghum (781 hectares in Paloma Blanca in 1983) is fumigated, fumigation is less effective.

Because sorghum is often sown late in the growing cycle (mid-February rather than early January) the pest problem is exacerbated and other problems result. Low sowing mainly is due to the farmers' lack of machinery. Farmers who own tractors sow on schedule while those who rent them generally sow late. Sorghum sown late is exposed to the summer rain, winds and pests at a more vulnerable stage in its development. Although the farmers report that Johnson grass is not present in their farmland, late sorghum has to compete with the other weeds that proliferate during the rainy season. Sorghum sown late is

harvested late, causing further losses in the field and preventing the farmer from sowing his next crop on schedule. This begins a cycle of tardiness from which the farmer cannot escape.

Removing sorghum residue from the fields is also cited by farmers as a constraint to production. Locating tractors and cultivating the sorghum stubble is an undesirable investment of time, labor and money for the farmers. Sorghum stubble must be cultivated three to four times at approximately two week intervals to prevent "volunteers" from springing up in the next crop. The farmers who do not own tractors cultivate only twice because of the difficulty in renting tractors. As a result of inadequate cultivation, volunteer sorghum appears, presenting additional bird and pest problems for the following crop.

Weather conditions during the years 1980 to 1983 affected the farmers' crop choices. The heavy summer rains were not favorable for sorghum production; abundant weed and insect populations made harvesting difficult. When the sorghum crop was too wet, CONASUPO rejected it. When it was too dry, some grain shattered in the fields before harvest. As a result, farmers' profits decreased and the problem of volunteer sorghum increased. In the fall of 1983 an unseasonably late and heavy rain killed the bean crop and the farmers replanted with wheat, abandoning the sorghum rotation. Although the summer weather conditions have been poor for growing sorghum, the winter conditions have been favorable for growing wheat.

In comparison to sorghum, wheat is a relatively trouble-free and profitable crop. Wheat does not appear to have many insect problems and weeds are easily controlled by one or two tractor applications of herbicides. Farmers report that wheat is easy to produce because most of the labor inputs occur at the beginning of the cycle; irrigation, harvest, and stubble burning require subsequent labor inputs. Timeliness of cropping operations is not as critical for wheat as for sorghum. However, the strongest incentive to growing wheat is its high yield and profitability compared to sorghum. More farmers have exceeded SARH's expected yield with wheat than with sorghum, and wheat is approximately four times more profitable per hectare than sorghum.

The farmers' crop choices in San Marcos and Paloma Blanca are corroborated by SARH's data on crop profits. Of the farmers' four major crops (wheat, sorghum, beans, and soybeans) wheat has been the most profitable since 1980 (Table 11). Wheat profits increased 381% from 1980 to 1983 while sorghum profits increased only 20%. During these same years soybean profits decreased 12% and beans, 19%. The trends in Table 11 are based on SARH's expected crop yields, which generally are higher than the farmers' yields, particularly with respect to sorghum, beans, and soybeans. Therefore, ejidal profits on these three crops are probably lower than SARH's estimations. After 1983, wheat and soybeans became the most profitable crop rotation; farmers had chose wisely in adopting this rotation.

Since the bank only provides credit for basic grains, the ejidatarios' crop choices are limited. Since many factors (weather patterns, pests and the feasibility of their control, the availability of machinery and market prices) are independent of the farmers' control, crop choices may be viewed as short-term adaptations to national-level planning (e.g., bank credit availability for specific crops) and local conditions. When asked about their future

Table 11. Estimated profit per hectare of major crops in Guasave, 1980 to 1983

Crop	1980-1981 (peso)	1981-1982 (peso)	1982-1983 (peso)	$U.S. 1982-1983*	% Change 1980-1983
Sorghum	8,521	12,645	10,200	75	+20
Beans	15,000	13,500	12,124	89	-19
Wheat	7,350	11,940	35,353	260	+381
Safflower	4,064	6,046	13,113	96	+223
Soybeans	7,480	15,800	6,614	49	-12
Corn	4,600	16,700	8,124	60	+77

*U.S. 1 = 136 pesos
Source: SARH, Guasave, 1983

decisions, farmers said that they would sow wheat until profitability dropped and then return to the sorghum rotation, unless rice or another alternative became available.

Outside the Irrigation District: Rainfed Sorghum Production

Dryland agriculture and sorghum production prevail outside Guasave's irrigated valley. Grain sorghum, a major dryland crop, occupied one-third of the rainfed farmland in northern Sinaloa in 1983 (Secretaria de Agricultura by Recursos Hidraulicos, 1983). Dryland agriculture, however, is not productive, the farmers are poor, and by the summer of 1984 corn was replacing sorghum in northern Sinaloa.

Outside the irrigation district, against the foothills of the Sierra Madre, farming is the traditional mode of making a living. Here the farmland's summer green turns into yellow emptiness during the dry season. Like the land, the dryland villages and farmers exist on the outskirts of modernity. These villages do not have electricity or piped water, and transportation on the dusty roads is as often by foot or horseback as by bus. The ejidatarios' houses are either of adobe construction with thatched roofs or are shacks of wood, tarpaper and aluminum siding. Women still grind their corn by hand on stone metates and cook the tortillas outdoors on wood-burning adobe stoves, sharing the backyard with goats and chickens. Most of the dryland farmers are Mayo Indians who still speak the Mayo language and celebrate the holy days with their traditional masks and dances.

The dryland farming area east of Guasave is separated from the irrigation district only by a dirt road. Approximately 63,000 hectares of rainfed agricultural land, divided into two districts, adjoins Irrigation District 63. SARH headquarters for these dryland districts is in San Blas, a two hour drive away. The fieldwork was conducted in El Limon, a dryland district of 33,000 hectares (Map 2). Because 97% of El Limon is ejidal land, ejidatarios were interviewed regarding the dryland farming system.

Methodology. The work in the two dryland ejidos was limited to one month due to time constraints and the difficulty of reaching El Limon in the rainy

season. Political problems in both ejidos made collecting quantitative data almost impossible, statistics on dryland sorghum production are therefore limited. Farmers were unable to provide their expenditures, sorghum yields or profits because the ejidal leaders who manage their affairs withhold this information. According to the leaders there have been no harvest profits in the past three years, although this seems improbable. The study uses qualitative data about dryland farming and sorghum production obtained through interviews with the ejidal leaders and other farmers who worked independently and were able to give information on their production costs and yields. In addition, a few informal interviews focused on sorghum production in a third dryland ejido. These data indicate the serious production constraints faced by dryland farmers and point to reasons for their shift from sorghum to corn in 1984. The data from both ejidos are combined and presented as that from El Limon.

Agricultural Resouces in El Limon. Apart from their land, the farmers in El Limon have few agricultural resources. The 2,258 hectares of ejidal land were cleared in 1978 and the ejidatarios began receiving bank credit in 1979. Each ejidatario has 20 hectares of farmland plus three hectares of scrubby pasture. Although the land is divided into parcels, the Agrarian Reform office has not yet assigned each ejidatario a particular parcel, so the ejido works most of its land collectively. In 1983 the government constructed a well but did not provide a pump, thus, the only source of water was the river that ran through the ejido. There are a few private wells in the ejido but the expense of maintaining even small pumps and fueling them limits their use. Machinery is scarce in El Limon: at most, six people have tractors. The two farmers with tractors rent them within the ejido; the rest of the machinery is rented from outsiders in the irrigation district. Scarcity of machinery is a serious problem for the farmers.

Livestock are a major resource in El Limon. Approximately 30% of the farmers own cattle, as well as goats, horses and mules. These households own as many as 25 cattle, 24 goats, 5 horses, 2 mules, and 6 burros. The livestock graze on the scrub at the edges of the ejido and on the stubble after the crops are harvested. Forage sorghum is not sown for the cattle, but the farmers without livestock sell their sorghum and corn stubble for $5 per hectare. To augment their incomes, some farmers raise calves belonging to other people in the irrigation district and retain one-third of the sale price as payment. Cattle owners also make money selling milk, cheese and animals for slaughter. Every household raises chickens and pigs for home consumption.

In 1979, bank credit became available in El Limon for the ejidatios' commercial crops: sorghum, corn and safflower. In 1983, ANAGSA's cost of production for one hectare of dryland sorghum was about $70.00 (Table 12). Banrural's estimated production cost, according to the farmers, was $90 per hectare. The major problem with credit is that it is insufficient and arrives late. Limited credit means that farmers often do not plant their entire 20 hectares and often cannot afford to use inputs such as fertilizer or insecticide; many have not used fertilizer since they began farming in 1979. Limited credit also means that some farmers cannot afford to fumigate their crops, because the amount of credit allotted for that operation is either insufficient or nonexistent.

Table 12. Dryland sorghum: Estimated production cost per hectare, 1983

Operation	Cost in U.S. Dollars
First deep plowing	9.94
Second plowing	12.65
Seeding	5.87
Sowing	3.92
Fertilizer	5.72
Fertilizer application	2.71
Insecticide	2.41
Insecticide application	2.71
Harvest	18.68
Bank interest	5.64
Total Cost	$70.25

$1 U.S. = 166 pesos
Source: ANAGSA, Guasave, Sinaloa (National Agricultural and Livestock Insurance)

Farmers emphasize that late credit was their most serious problem. Credit for the summer cycle arrives in June after the optimum sowing date for sorghum and corn, and after the rainy season has started. By then the rain and mud often prevent the tractors from reaching the fields or from preparing them properly. This delays sowing even longer and ultimately exposes the immature crops to heavy, late summer rains, insects and thriving weeds. Then, late harvests delay sowing the following crop on time, locking the farmers into a late cycle that they cannot change. When the combination of rain and the lack of machinery delays sowing much beyond SARH's scheduled dates, the farmers lose the crop cycle entirely. Some people consequently work part of their land with their own resources, mainly to sow corn and beans for household consumption, or to seek private credit in hopes of avoiding these problems.

Private credit may be obtained outside the ejido, sometimes as personal loans from the extension agents who work with the farmers. The investor sets the crop's price and the amount to be purchased at harvest. This is called a "dead-price agreement" because the crop's price is fixed when the money is loaned, even if the market price rises. Since the government's guaranteed prices always rise several times after the harvest, this arrangement is more profitable for the investor than for the farmer. Farmers use this credit either for cash crops, such as sesame or peanuts, or for subsistence crops of corn and beans. Few outsiders risk large investments in dryland production. Profits are so small that farmers must obtain credit from Banrural, whose credit includes crop insurance to cover their losses.

Like the rest of their agricultural resources, technical assistance for El Limon is limited. The field office for the SARH personnel is only twenty minutes from the ejido but the extension agents do very little work there. Leadership, insufficient credit, and lack of machinery are obstacles to dryland production that extension agents cannot address. It seems that extension agents consider the problems faced by the dryland farmers insurmountable, beginning with the dirt roads that lead to El Limon. This general belief is shared by the ANAGSA and Banrural officials, resulting in little professional assistance for the ejidatarios. If the extension agents inspect the crops for insects, other officials may not authorize treatment or even come to inspect losses. Lack of assistance is a serious handicap for the farmers, who need professional help to improve their production.

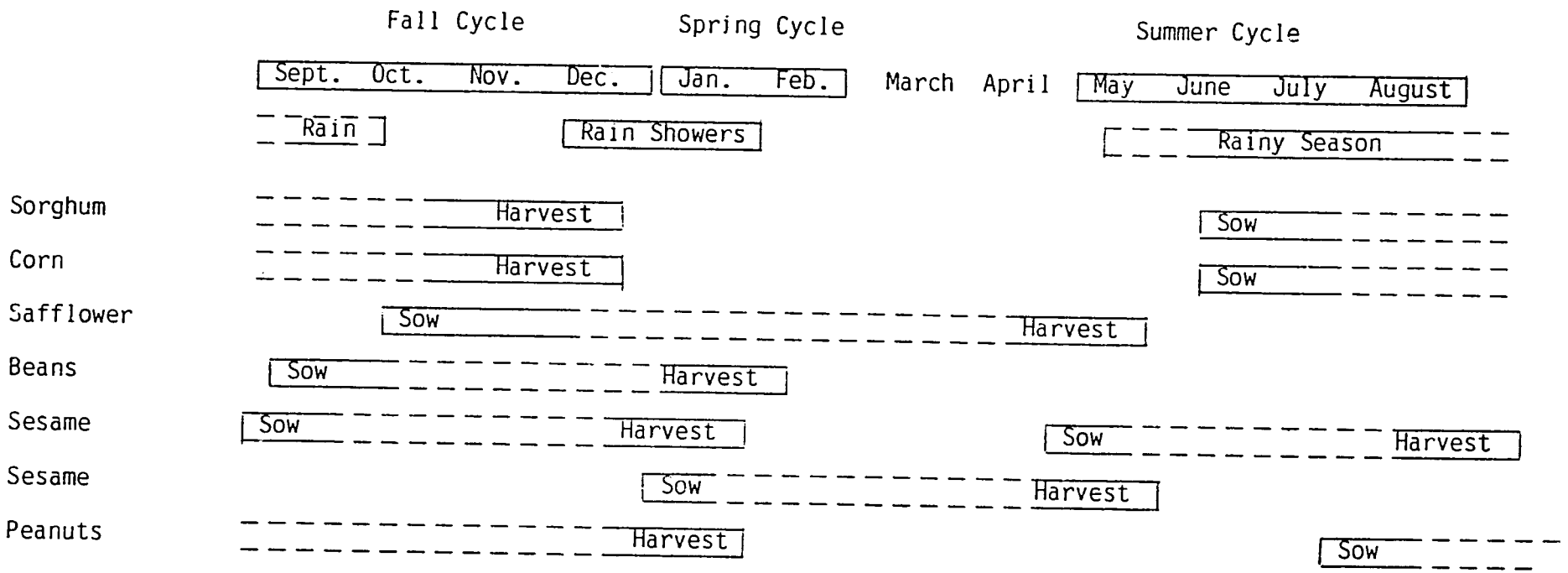
Because dryland farmers' agricultural cash incomes are low, several additional economic strategies are used to subsist. Corn and beans are grown for household consumption and sorghum, safflower, peanuts and sesame for market. Wage labor is a necessity for dryland farmers. Some cut wood in the foothills, pick cotton, and harvest vegetables in the irrigated valley. Others leave the ejido in the fall to work in the local towns and return in the summer to plant crops. One farmer pointed out that the cattle-owners have benefited most from the recently cleared and cultivated ejidal land. Lacking the resources necessary for successful agricultural production, the ejido has a surplus of pasture. Selling their stubble to the cattle-owners provides a small recompense to cultivators.

Dryland farmers' distance, both geographical and social, from the irrigation district headquarters, banks and agricultural supply stores, are constraints to agricultural production. Very few farmers own vehicles to transport their agricultural supplies to the ejido or to attend meetings in Guasave with the officials who administer their agriculture. Machine operators harvest the dryland fields last, after the more convenient and lucrative irrigation market is finished, and often charge more for the work because of the inconvenience of transporting machinery so far. Because dryland farmers are poor and of Mayo descent, they are treated as social inferiors by the technical personnel. SARH's field office for El Limon is disorganized, and the extension agents lack interest in their clients. The extension agents, as well as the Banrural officials and administrators of the dryland system, state that rainfed agriculture is hard work and no profit. Their apparent unwillingness to help dryland farmers makes this belief a self-fulfilling prophecy.

Use of Agricultural Resources: Incentives and Constraints to Sorghum Production. Sorghum, corn and safflower are the major crops in the dryland farming system. As Diagram 4 shows, sorghum and corn are sown in the summer cycle, followed by safflower in the fall. In 1983, sorghum and corn occupied 72% of the dryland fields around Guasave (Secretaria de Agricultura y Recursos Hidraulicos, 1983). That fall safflower occupied 85% of the area. These three crops are produced for the commercial market although some of the sorghum is retained for animal feed and some of the corn is kept for consumption.

Beans (Phaseola vulgaris), sown mainly for household consumption, accounted for only 15% of the cropland in 1983 (Secretaria de Agricultura y Recursos Hidraulicos, 1983). Sesame and peanuts are cash crops; sesame is very profitable because of its high price. In 1982-83 peanuts occupied 7% of

Diagram 4. Dryland cropping cycles, Guasave



the dryland area and sesame, 16-25% (Secretaria de Agricultura y Recursos Hidraulicos, 1983). Sorghum, corn and safflower crops in El Limon are funded by the bank and production is mechanized. Other crops are funded by private creditors and usually are sown with mules and harvested by hand.

CIAPAN recommends the same sorghum varieties for the dryland area that are used in the irrigation district. In 1984, SARH's dryland headquarters reported the use of Master Gold, 911, Northrup King 180 and 233, TY 101, Oromex 70, Asgrow Dorado E and white Hegari (for forage) in the dryland districts. SARH also was field testing DeKalb D-55, D-50, D-50a, 38 and SX-7 (a sudan grass cross) for dryland fields that year. Farmers in El Limon have been sowing Northrup King 233, Northrup King 180 and TY 101 (in 1983 only) and report that Northrup King 180 is a good producer. The white Hegari, a tall sorghum, was sown in 1981 and is reportedly very productive, however, the seed is no longer available. SARH determines which variety for each crop is appropriate for the district, although, some years, more than one variety is available.

Sorghum and corn are sown around the end of June and harvested in November or December (Diagram 4). Production is completely mechanized, except in the case of a poor yield when the farmers salvage what they can by hand. Farmers do not fertilize or fumigate these crops because credit does not cover the input costs, although they are listed in ANAGSA's production costs (Table 12).

Dryland crop yields are low, even in years with good weather. The average yield for dryland sorghum is 1-1.2 tons per hectare. Farmers reported that one year, when weather was good, 2 tons per hectare were harvested. However, in 1983, yields were only 300-500 kilograms per hectare. ANAGSA bases its production and insurance costs on a yield of 1.8 tons per hectare, which is considerably more than the farmers produce. The situation is similar for corn. In 1983 corn production averaged 0.4 tons per hectare; only one farmer harvested one ton per hectare. From 1981 to 1983, the corn yield was so low that renting combines to harvest it was not feasible.

There are three major incentives to grow sorghum in El Limon. First, the crop is drought tolerant and potentially productive, given the 17-inch-average rainfall that comes during the summer months. Some farmers also report that sorghum produces better than corn does under local conditions when the midge does not cause significant crop losses. Secondly, because sorghum is a basic grain designated for ejidal production, bank credit is available, including crop insurance to cover harvest losses. Third, there is a local market: CONASUPO has local offices to buy and store the grain. These incentives, especially the availability of bank credit, have motivated farmers to sow sorghum from 1979 to 1984, but this trend is changing.

The constraints that decreased sorghum production are partly due to the infrastructure of dryland agriculture and partly due to the characteristics of the crop itself. Bad weather and late bank credit are the roots of the problem of dryland sorghum production. Farmers report that it is most efficient to prepare the land in May and sow the sorghum in early June, before the rainy season begins. At that time of the year the soil is dry and easy to cultivate, the weeds are small, and tractors are available for rental before the busy summer season. But the credit needed to rent machinery--there are

only 4 tractors available within the ejido's 2,258 hectares--doesn't arrive until late June. By that time the machinery is scarce, the soil is wet and requires more time to cultivate, and the weeds are established.

Late sowing also causes problems later in the crop cycle. Summer rains encourage the proliferation of weeds and prevent tractors from cultivating effectively. Johnson grass, although not a problem in the irrigated district, is clearly a problem in the dryland areas. Some farmers report that it is worse than any of the insect pests. Panicle smut (Sphaceloteca sorghi) is a disease but only causes minimal crop losses in El Limon. Insects that thrive in the heat and humidity of midsummer attack the sorghum.

Although several insects attack sorghum, farmers emphasized that the midge (Contarinia sorghicola) causes the most damage. Other insect pests are the fall army worm (Spodoptera frugiperda), the hairy worm (Estigmene acrea) and a variety of large locust. Because chemical pesticides are not available to dryland farmers, crop losses are extensive. One year, when the estigmene acrea infestation was heavy, some farmers reported that they used a solution of powdered laundry soap and water to somewhat reduce the insect population.

Birds and weather also pose problems in the fall. Migratory doves arrive in October and November and eat some of the crop. According to the farmers, birds do less damage to a mature crop with hard grains than to an immature crop. Unseasonable winds and hurricanes in 1981-1983 also contributed to complete the destruction of the crops. The only cash return farmers received during these years was from selling sorghum to the cattle-owners as forage.

In addition to these problems, farmers cite a characteristic of sorghum as a crop that constrains production. Without adequate machinery, it is impossible to eliminate sorghum "volunteers". The bank provides credit for only two plowings to uproot the sorghum after the harvest, yet farmers report that four are necessary. Surviving sorghum volunteers attract birds and other pests to fall crops.

Due to problems with sorghum, farmers began switching back to corn in 1984. In 1982 and 1983, 1,800 hectares of sorghum and 250 hectares of corn were sown in El Limon, but in 1984 the farmers planned to sow only 1,000 hectares of each crop.

There are three significant incentives to sow corn instead of sorghum. Like sorghum, corn is a mechanized, bank-funded crop with a guaranteed price and a local market. In 1984, bank credit for corn included the cost of fertilizer for the first time, and the farmers said that fertilized corn was a potentially better crop than unfertilized sorghum. Second, although both crops have summer pests, corn has sustained less insect damage than sorghum during the past few years. Without the option of aerial spraying for either crop, farmers report that there is less risk of insect damage for corn. Most importantly, sowing corn guarantees farmers some grain for household consumption. If the corn yield is low and is not worth harvesting by machine for the market, as was the case in 1983, it can be harvested by hand for household and domestic animal purposes. Like sorghum, corn is usable as forage. Unlike sorghum, corn provides food for people as well as for animals. As Table 13 shows, El Limon's switch to corn conforms to the trend in the rest of the dryland districts in 1984. Early in the summer season, 56% of the

Table 13. Cropland planted in corn and sorghum, 1978-1984

Year	Hectares	Percent of Total	Percent of Ejidal Production	Yield, kg's/ha
		SORGHUM		
1978	18,627	43	78	1.80
1979	16,980	23	N.D.	0.55
1980	25,574	45	92	1.23
1981	34 631	58	98	0.61
1982	17,563	51	97	1.04
1983	10,037	32	N.D.	0.72
1984	3,832	20		
		CORN		
1978	6,503	15	73	1.15
1979	12,771	18	N.D.	0.36
1980	10,828	19	85	1.41
1981	12,181	21	99	0.71
1982	9,193	27	97	0.41
1983	12,456	40	N.D.	0.52
1984[a]	10,523	56		

[a] Preliminary data
N.D. = No data.
Source: SARH, San Blas, Sinaloa, includes one dryland district north of Guasave.

dryland district was sown in corn and only 20% in sorghum, a complete reversal of the two crops' relative areas in 1981 and 1982. Given the conditions faced by the farmers in El Limon, especially the fact that corn is a food staple, their shift to corn production is rational.

Chapter 4. Conclusions and Recommendations

The ejidatarios with irrigation hold the key to agricultural success in northern Sinaloa. Access to water guarantees government support for modernized commercial production which includes: bank credit, hybrid seed, technical assistance, and machinery. In addition to the infrastructural support of ejidal agriculture, local ecological conditions enable the farmers to produce two crops annually. This combination of government subsidies and a favorable climate gives farmers the flexibility to rotate crops easily at the end of a cropping cycle, or twice each year. This flexibility is a significant advantage for the ejidatarios who can choose among a number of crops, within the limits set by government credit.

Farmers in Guasave produce for the commercial market rather than for their own subsistence. Commercial farmers evaluate the relative profitability of the alternative crops that can be produced. Two factors primarily determine profitability. The first is the productivity of a specific crop under local conditions, including technical factors such as machinery and technical assistance, and ecological factors such as current trends in the weather and pest population. The second major consideration is the government's financial package of credit, crop insurance, and guaranteed market prices that are set at the beginning of each crop cycle.

Sorghum production is decreasing in the irrigated sector as a result of its relatively low productivity and low market price compared to wheat. Sorghum's low productivity mainly is due to delay's in providing credit and a shortage of tractors that prevents early sowing of sorghum. Late planting exposes the crop in a vulnerable stage of development, to the Contarinia sorghicola (midge), resulting in significant losses in the field. Another cause of low productivity is administrative inefficiency in pest control. Because these farmers are commercial producers who do not maintain livestock, they have no incentive to produce a feed grain that is less profitable than their alternative crops.

Wheat production is increasing in the irrigated ejidal sector because it is a productive and profitable crop under local conditions. A significant advantage in growing wheat in the undermechanized ejidal sector is that less machine-hours are needed to produce it. In 1983, there were no pests or diseases that caused wheat losses in the field or necessitated investing time in the local bureaucracy to arrange expensive treatments. These advantages minimize local constraints which result in costly delays. Ease of production, higher yields, and high prices make wheat the farmers' economic mainstay in Guasave. From 1983 to 1984, wheat profits constituted 95% of the farmers' agricultural income in the two ejidos studied. Based on the farmers' criteria of productivity and profitability, wheat is unquestionably preferable to sorghum as a major crop.

Because small farmers in Guasave generally have access to agricultural resources and the flexibility to choose among a number of crops, they are usually successful as commercial producers. The constraints to sorghum production in the irrigated sector have less to do with the characteristics of the crop itself than with the infrastructural constraints on ejidal production in general. The major technical constraints to sorghum production that can be addressed by INTSORMIL are pest depredations caused by the midge (Contarinia

sorghicola) and fall army worm (Spodoptera frugiperda). Insect-resistant varieties that are adapted to the hot, humid conditions of northern Sinaloa are needed to increase yields and therefore the profits for farmers. However, as this field research shows, infrastructural factors magnify pest problems.

The dryland agricultural system is significantly different from the adjoining irrigation district. Dryland farmers lack infrastructural support and organization to obtain essential resources. Lack of credit, technical assistance and machinery are major constraints to agricultural production in general and to sorghum production in particular. Although it is possible to produce two crops per year in the rainfed areas, these farmers have little flexibility in selecting crops. Their agricultural repertoire is limited by local ecological conditions and the availability of bank credit to three major crops. Another serious limitation on production is the apparent negative attitude of officials who administer the dryland agriculture and who report little success with both the farmers and the crops.

Farmers in Sinaloa's dryland areas produce for subsistence as well as the market. They depend on their land to produce corn and beans for household consumption. If the cash crop (such as sorghum) fails, farmers sell their labor to generate income. Given their limited agricultural resources, these farmers' crop choices are determined primarily by their household needs and by the availability of bank credit. Credit is available for sorghum since it is well adapted to the local conditions of rainfed agriculture. In addition, sorghum provides forage for the livestock that are an important economic resource in the dryland districts. These were the major incentives for the dryland farmers to produce sorghum until 1984.

Because sorghum is not a food crop it represents a significant constraint to dryland production. In Guasave, sorghum is a cash crop that also provides forage for livestock and grain for household animals. But corn has several advantages over sorghum for these farmers. It is not only a cash crop, with a higher market price than sorghum, but a forage crop as well as a staple food grain. In 1984, bank credit for corn included fertilizer for the first time, which the farmers perceived as a significant incentive to sow the crop. Another incentive is that corn is less vulnerable to insect damage which partially balances its greater vulnerability to drought. Most importantly, corn is the farmers' primary food staple whereas sorghum is a feed grain suitable only for animals. These factors, especially the latter, make corn preferable to sorghum among the dryland farmers.

The midge is the most important technical constraint to sorghum production in the dryland districts. Of course, higher yielding hybrids with resistance to the midge are desirable. However, dryland farmers most need infrastructural support. This includes bank credit that would enable them to sow on schedule and to rent planes for fumigation. The farmers also need technical assistance, as sorghum is not a traditional crop and commercial production began only seven years ago. Lack of technical assistance has hampered farmers' development as commercial producers. Because sorghum is adapted to local conditions, it is potentially the dryland farmer's most important commercial crop. Because farmers have continued trying to raise sorghum despite minimal support, it indicates their interest in the crop. With improved varieties, appropriate program support, and technical

assistance, these farmers could increase sorghum production and improve their economic status. A local market, storage facilities, and government supported prices already exist.

Farmers in both irrigated and dryland areas in northern Sinaloa have sown white-seeded sorghum (white Hegari, a forage sorghum) and report that it is a productive crop. Grain sorghum for human consumption is possible. However, these farmers are commercial producers, and their evaluation of sorghum is based on productivity and profits. To be accepted, a white-seeded sorghum and bean rotation would have to equal wheat and soybeans in profitability.

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