

THE ALMOND INDUSTRY OF MEXICO

by

SUSAN EDWARDS

A RESEARCH PAPER

submitted to

THE DEPARTMENT OF GEOGRAPHY

OREGON STATE UNIVERSITY

in partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE

June 1975

ABSTRACT. Almond growth has recently been initiated in Mexico in the effort to realize commercial production. This research paper is an evaluation of the physical environment conditions which favor almond production and an attempt to apply them to Mexico. It is shown that areas in the Northwest and Central Plateau are suitable for Almond growing. Inasmuch as Mexico currently is importing \$850,000 worth of almonds the paper suggests that domestic production would be desirable.

TABLE OF CONTENTS

I.	INTRODUCTION	1
II.	PHYSICAL FACTORS WHICH AFFECT THE LOCATION OF ALMOND PRODUCTION	3
	A. Climate	3
	B. Soils	7
	C. Terrain	9
	D. Drainage	10
	E. Diseases and Pests	11
III.	PRESENT ALMOND GROWTH IN MEXICO	13
IV.	ALMOND PRODUCTION POTENTIAL IN MEXICO	18
	A. Topography	19
	B. Soils	19
	C. Climate	20
	D. Economic Considerations	25
V.	IMPLICATIONS OF COMMERCIAL PRODUCTION	29
VI.	CONCLUSION	32
	BIBLIOGRAPHY	39

INTRODUCTION

The almond (*Prunus amygdalus*, Batsch.) is unique among nut crops in that it belongs to the botanical family Rosaceae and is closely related to the peach, plum and other stone fruits. The Spaniards introduced the almond into Mexico in the 1500's together with the peach, apricot and fig. The latter three trees adapted to the Mexican environs, and today are known as "creoyos." The almond completely disappeared. Speculation as to why the almond did not or could not adapt has yielded no satisfactory explanation.

Recently the almond has been re-introduced into Mexico in the effort to realize commercial production. The National Fruit Commission, a developmental agency of the Mexican government, began establishing orchards some six years ago, and continues to have great interest in the future of almond production in Mexico. The National Agricultural College at Chapingo maintains test plantings of almond trees, in order to determine the suitability of different varieties in Mexico. In addition, the Fruit Commission together with the Agricultural College work in cooperation with the private farmer.

The recent interest in almond production in Mexico is apparent; its success or failure is yet to be seen. This paper is an attempt to evaluate the potential of Mexico for almond production by analyzing the physical

requirements of the almond tree and the degree to which certain areas of Mexico meet these requirements, and to assess the economic implications of a productive almond industry in Mexico.

PHYSICAL FACTORS WHICH AFFECT THE LOCATION
OF ALMOND PRODUCTION

Climate is the single most important factor in limiting commercial almond production. The tree itself is relatively cold-hardy and can be grown as far north as southern Canada; however, little or no nut crop can be realized in such locations. For commercial production the growing requirements of the almond are quite exacting, and have for the most part limited production to the Mediterranean climatic regions of the world. Major almond producing nations, in order of importance, are the United States (with 99 percent of production from California), Spain, Italy, Iran, Portugal and Morocco. The mild winters followed by early spring conditions, and long, hot and dry growing season characteristic of these regions are highly favorable to the development of a good nut crop.

The number of chilling hours¹ required by the almond is less than the number required by most other commercially grown deciduous fruit and nut species. Blooming can be spurred quite early (from the second week of February to

¹ A chilling hour is generally defined as one hour during which the tree or buds are exposed to temperatures below 45°F. The almond requires between 200 and 500 chilling hours, with the earlier-blooming varieties having the shorter requirements. (From: R. H. Aron, "Climatic Chilling and Future Almond Growing in Southern California", p. 1.)

the first week of March, depending on the variety) after relatively short periods of warm temperatures in late winter or early spring.

Unlike the tree itself, the almond bloom and young nut are very frost-sensitive.² Any frost which occurs after rest is completed or after the nuts are set can greatly reduce yield.³ Consequently, commercial almond production is precluded from northern areas because of this sensitivity to frost. In his attempt to grow almonds in the state of New Mexico, A. B. Fite states that the trees thrived under the local climatic conditions until the bloom, at which time the temperature dropped sufficiently to kill most of the nuts in six out of seven years.⁴ Winter temperatures must be sufficiently low to provide the almond with enough chilling hours to come out of dormancy, thus ensuring normal spring growth and flowering, while at the same time followed by early spring conditions which minimize

² As the almond flower opens it becomes more and more tender. It may stand 20-25°F. at the pink bud stage (depending on variety), 28-30°F. at full bloom, with 31°F. being capable of killing small nuts. (From Meith, C. and A.D. Rizzi. Almond Production - Part II, Calif. Agr. Ext. Ser. Pub., AXT-83:1-24, 1966.)

³ "There is a great range in degree of the frosts which will cause injury, depending largely on the conditions of the tree during the time that the fruit buds are forming and developing, as well as the duration and severity of the frost." (R.H. Taylor, The Almond in California, Calif. Exp. Sta. Bulletin 297 (California: University of California Press, 1918), p. 8.)

⁴ A.B. Fite, Almonds, Agr. Exp. Sta. Bulletin 171, (New Mexico College of Agriculture and Mechanic Arts, 1929), p. 11.

the hazard of frost damage to the relatively early-blooming almond, thereby allowing for a good fruit set.

Flowers of commercial almond varieties are self-sterile, making cross-pollination necessary, the primary agents of which are domestic honeybees. During cool weather, bee activity is considerably reduced. Bees generally will not leave the hive until temperatures reach at least 60°F., with the greatest activity occurring within a temperature range of 60° to 80°F. Thus, the length of time temperatures exceed 60°F. during the bloom is, as one would suspect, positively coorelated with the size of the almond crop in a given year.⁵

Conditions for almond growth become increasingly favorable as rainfall decreases, assuming that sufficient water can be supplied for both tree growth and nut production.⁶ A long, hot and dry growing season is necessary to mature the crop. Higher yields and fewer problems are realized (assuming other factors equal) in areas under irrigation, than in those relying solely on rainfall, which may not be optimum in timing or amount. Rain or high humidity during blooming, ripening or harvesting of the almond have a number of adverse effects. Rain during

⁵ Clem Mieth and A.D. Rizzi, Almond Production - Part II, (Calif. Agr. Ext. Ser. Pub., AXT-83:1-24, 1966), p. 23.

⁶ Tree survival requires a minimum of 16 inches of water per year. Continued nut production requires 32-34 inches of available water annually.

the bloom may impede bee activity thus reducing cross-pollination and therefore the amount of buds which are set. Flower blossoms may be knocked off by rains, decreasing the likelihood of pollinization since a bloom without petals is less attractive to bees.

As the hull beings to crack open, periods of rain or high humidity are conducive to hull rot (Rhizopus), shot hold fungus, and other diseases of the leaf or tree. Soggy ground together with warm temperatures provide conditions in which the almond is very susceptible to crown rot. Extended periods of rainfall during the harvest (which ranges from mid-August to early November, depending on variety and weather conditions) can lead to nut loss caused by mildew, rot and other diseases.

Local climatic variations also affect almond production, as illustrated by the following quotation from M. Donald Rough, Farm Advisor in San Joaquin County, California:

In spring on the east side, morning fog, overcast, heavy dews and moisture are a problem and the bees fly later. On the west side, fog, overcast and heavy dews are less of a factor. However, winds shorten bee flight. When the winds come up, the bees quit . . . As far as frost is concerned, I know of no orchard in the west side and particularly in the Tracy-Banta-Vernalis area where frost protection has paid for the equipment. On the east side this is not ⁷ the case.

⁷ R. H. Aron, The Changing Location of the California Almond Industry, p. 15.

The climatic factors of major importance which affect the location of almond production are sufficient chilling during dormancy; freedom from severe spring frosts; sufficiently high temperatures during the bloom for bee activity and during the growing season for the nut to mature, yet not excessive so as to increase the likelihood of Bud Failure, together with a lack of rainfall or high humidity during the critical growth periods.

Soils

Assuming climatic suitability, soils are the next most important factor affecting the success of almonds for commercial production. The almond will grow on a wide variety of soils, ranging from the finer valley loams to the coarse, rocky types found on foothills, however, well-drained loams provide the most favorable soil base for optimum growth and production. Dr. Kester has stated:

Because the almond tree can withstand neglect, it has often been grown in poor soil with a minimum of care. Nevertheless the almond responds so well to proper management that commercial production is considered profitable only under good soil and climatic conditions and with fertilization, irrigation⁸ and other aspects of intensive management.

Problems of disease and/or lower yields are more frequent when almonds are grown on poorly-suited soils.

⁸ Dale E. Kester, "Almonds," Handbook of North American Nut Trees. Knoxville, Tennessee: Northern Nut Growers Association, 1969, p. 304.

Heavy soils which exhibit poor drainage are not conducive to good almond production and encourage tree disease. The growth of a fungus in the soil following long periods of wetness, coupled with warm temperatures, causes a disease of the tree called Crown Rot.

The almond requires a minimum of nutrients (leaf levels, dry weight, from July 1 to July 31) in the following amounts: Nitrogen, 2-2.5%; Calcium, 2%; Potassium, 1.4%; Magnesium, 0.25%; Phosphorus, 0.1%; Boron, 30-65 ppm.; and copper, 4 ppm. Elements of Boron, Chloride and Sodium are in excess if over 85, 0.3 and 0.25 ppm. respectively.⁹ If leaf analysis shows these nutrient requirement levels to be met, this generally indicates adequate soil nutrients present. If analysis shows something less than the required nutrient weight present, the indication is generally that the soil is deficient in this nutrient.

A lack of any one or more of these nutrients in the soil is not generally a limiting factor in the selection of a site for almond growth, however, since nutrients can be added in the form of chemical or plant fertilizers. Nitrogen is the element more frequently lacking since it does not accumulate in the soil. Yearly applications of 1½ to 2 pounds of actual nitrogen per tree are recommended for the almond. Potassium is the other major element most

⁹ Clem Meith and A.D. Rizzi, Almond Production - Part II, p. 9.

often required. When a deficiency is found by leaf analysis or leaf symptoms, 25 pounds of potassium sulfate per mature tree (applied in a ring around the tree) is recommended for orchards on deep soil. No follow-up is necessary until the trees show a deficiency again, which may be as long as 10 years later. Soil deficiencies of micronutrients, such as zinc and boron, also affect production and should be supplied when needed.

The presence of certain elements in excessive amounts can be detrimental to almond growth. Excess boron is occasionally found in almond-growing areas, and can have an adverse affect on growth. Leaching has been used as a means of decreasing boron content in the soil, and is generally considered economically feasible, since almonds yield a high return per unit of water. One problem with leaching, however, is that as the tree grows its roots will extend below the level of leaching, and the tree may again be troubled by boron excesses.

Terrain

Terrain as a limiting factor in the commercial production of almonds depends largely upon which technological and cultural practices are to be employed. Gravity irrigation requires graded or flat terrain (water is allowed to flow through ditches, or the entire orchard is flooded). Rolling and hilly areas are suitable, however, if sprinkler irrigation

is used. If mechanical harvesting is practiced, less relief is desirable, whereas hand labor is adaptable to hilly areas. Valley bottoms are seldom suitable because in addition to the deterrents of heavy soils and high water tables, they generally lack air drainage, and so are conducive to frost damage.

Drainage

Both water and air drainage limit the locations of successful almond production. Almonds do not do well in a poorly drained soil, such as heavy clay. Prolonged wetness of the tree roots and crown can damage or kill the tree by the promotion of crown rot. A loam to sandy-loam soil type will, because of its coarser texture, better facilitate drainage.

The role of air drainage (the gravitational flow of an air mass down-slope) cannot be underestimated in the determination of a suitable location for almond production. Owing to air drainage, valley bottoms are often much colder than adjacent slopes, and thus trees planted in such locations are much more subject to frost damage. A slope or high ground location may be free from frost, while frost prevails in valleys and closed troughs, due to gravity-induced displacement of air.

Diseases and Pests

Diseases and pests are, for the most part, a control problem and generally do not restrict areas from production. Locations conducive to disease and pests, such as those with adverse climatic or soil conditions, may, however, greatly increase production costs. For example, cool, damp climates generally decrease the tree's resistance to attacks of disease or pests.¹⁰

Two almond "diseases" that do affect location are Noninfectious bud-failure and Verticillium fungus. Noninfectious bud-failure (BF) is not a disease, but is a serious disorder affecting almond plantings which is thought to be related to a genetic abnormality and seems to be brought out by excessively high daytime temperatures. Dale E. Kester, in an article entitled, "Noninfectious Bud-Failure in California Almond Varieties," states:

¹⁰ A major disease in cooler areas of almond production is Limb Cankers (Ceratocystis canker). For detailed coverage of diseases and pests affecting the almond tree, the reader is referred to the following: (1) M.M. Barnes, et. al., Pests and Disease Control for Almonds, Sacramento: California Agricultural Experiment Station Extension Service, 1969; (2) Dale E. Kester, "Almonds," Handbook of North American Nut Trees, Knoxville, Tennessee: Northern Nut Growers Association, 1969, pp. 302-314; and (3) Frances M. Summers, Insects and Mite Pests of Almonds, California Agricultural Experiment Station Circular 513, California: University of California Press, 1962.

It is a serious economic problem in that many thousands of trees had to be replaced, and at least one variety, the 'Jordonolo,' is being eliminated because of its susceptibility to BF.

A tree affected by BF is sparse in foliage with many twigs lacking leaves and others producing leaves at only a few nodes. Trees affected for several years will, in that time, produce an unusually large number of branches, some of which are clustered together at the base or top of the supporting branch. Not infrequently, the branches will have changed their direction of growth several times, some bending back upon themselves, resulting in a 11 crooked, tangled appearance.

The problem of Bud Failure can be lessened or avoided by choosing almond varieties which do not have a history of the disorder, and/or by a careful selection of the nursery with whom the grower deals.

11 Dale E. Kester, et. al., "Noninfectious Bud-Failure in California Almond Varieties," (unpublished work available at the University of California at Davis, Pomology Library, 1969), p. 1.

PRESENT ALMOND GROWTH IN MEXICO

At present almonds are being grown in four states in Mexico: (1) Guanajuato (near San Miguel de Allende); (2) Aguascalientes (near Aguascalientes); (3) Zacatecas (near Fresnillo); and (4) Sonora (near Caborca and Hermosillo). Some are also grown near Ensenada in the Territory of Baja California. Historically, Mexico has had no commercial almond production; the appearance of the limited number of orchards now in existence has been very recent. These orchards are still young, and as yet very little commercial production has been realized. Most orchards were planted on a limited, experimental basis, with the idea of expansion should production prove successful.

Case Study Farms

The present almond growing areas in Mexico fall into either the Central Plateau Region or the arid North. One farm was selected for study from each region in order to compare and contrast physical and economic conditions between the regions under which almonds are being grown. The farms selected are not typical of other farms in their surrounding areas. They are, however, typical of those electing to grow almonds.

Case Study One

First considered is a privately-owned family farm of 335 hectares near San Miguel de Allende, Guanajuato, in the Central Plateau.¹² Peaches are the primary fruit crop with 150 hectares in production. Other fruit crops include apricots, grapes, pears and apples, the latter three of which are being grown experimentally. Also grown are alfalfa (30 hectares); corn (15 Ha.); barley (15 Ha.); and vegetables (1 Ha.). The remaining hectares are in non-farm land and domestic constructions.

Almond trees were planted relatively recently on approximately three hectares of land on a semi-experimental basis. The high market value of the nuts in Mexico indicated that commercial production, if possible, would prove profitable.¹³ If production is successful, plantings will be increased by 5 to 10 hectares, with possible further expansion at a later date through the purchase of new lands.

Most of the trees are still too young to produce; of 1025 almond trees planted, only 25 trees had any nut crop

¹² San Miguel de Allende, Guanajuato: Coordinates, 20°57' lat., 100°45' long.; elevation, 6102.3 feet (1852 m.); mean annual temperature, 64.2°F.(17.9°C.); warmest month average (May), 70.2°F.(21.2°C.); coldest month average (Jan.), 57.4°F.(14.1°C.); annual precipitation, 19.9 inches (505.2 mm.); soils, Volcanic, Chestnut and Alluvial.

¹³ Market value of almonds in Mexico is approximately \$1.80 (U.S.) per pound, (1973).

at all. The yield of these 25 trees was too light for commercial value, so the nuts were consumed by the family.

The almond trees are irrigated with row, or ditch irrigation, with a well as the source of water. The harvesting is by hand labor. The wage is paid on an hourly basis rather than by the quantity of nuts picked to discourage the picking of unripe nuts.¹⁴

The major problems in this area are temperature related. First, it has been difficult to find sites which consistently provide the tree with enough chilling hours so that it will come out of dormancy into normal spring growth and flowering. Second, the problem of late spring frosts has been critical in this area. Any frost after mid-February when the almonds start blooming can damage the buds, flowers or young nuts.

Temperatures as low as minus 5 C. in late February, March and April have necessitated the use of orchard heating. Straw bales have been burned in the past, using oil and diesel, and producing more smoke than heat. This method has been somewhat effective, however. Bales were burned on ten occasions in 1972, while neighboring farms used nothing; this farm was the only one in the area to harvest fruit--500 tons. The owners, nevertheless, plan to purchase smudge pots to increase heating efficiency.

¹⁴ A picker earns 18.70 pesos (\$1.50 U.S.), the minimum salary in this part of the state, for eight hours of labor, (1973).

Case Study Two

The second farm is located in the state of Sonora near Caborca.¹⁵ Like the farm in Guanajuato, it also is privately owned and approximately 300 hectares in size. Crops grown include oranges, peaches, apricots, nectarines, pears, plums, quince, figs, pomegranates, grapes, walnuts, and almonds.

Ten hectares are planted in almonds. The trees are young, three and five years of age, and are of the varieties Nonpareil, Ne Plus Ultra, Peerless and Nemagard. The almond trees at present number 1,800; however, 900 of these will have to be removed because of Bud Failure.¹⁶

Irrigation is necessary with a well as the water source. Ditch irrigation has been used but there is much interest in the relatively new "drip" irrigation as a way of maximizing water efficiency.¹⁷ In the winter the soil is "washed" by applying gypsum to eliminate salt accumulation. Fertilization is necessary with nitrogen, potassium and phosphorus.

¹⁵ Hermosillo, Sonora: Coordinates, 29°5' lat., 110°57' long.; elevation, 780.9 feet (237 m.); mean annual temperature, 77.4°F. (25.2°C.); warmest month average (July), 90.7°F. (32.6°C.); coldest month average (Jan.), 63.0°F. (17.2°C.); annual precipitation, 9.6 inches (244 mm.); soils, Brown semi-desertic, Alluvial, Chestnut.

¹⁶ Removal will be of three-year-old trees of the varieties Nonpareil and Ne Plus Ultra.

¹⁷ Drip irrigation was commercially introduced in 1971. A regulated amount of water is taken into the soil by capillary action, and thus water waste is greatly reduced.

In 1972, 150 bee hives were provided for the purpose of pollination; the trees were in bloom 18 days, with 3 or 4 percent of the blooms becoming fruit. At present, trees are planted with two rows of Nonpareil to one row of Peerless. It has been suggested, however, that a one to one relationship of the two varieties would ensure more effective pollinization.

The area has approximately 600 hours of chilling and thus should not have a problem with prolonged bud break in most years. The problem of late spring frosts occurs here, as in the Central Plateau, and necessitates the use of some method of orchard heating. Harvesting is by hand labor.¹⁸

Summary

The conditions of growth in the San Miguel de Allende region are fairly representative of other growing areas in the Central Plateau, while those of Caborca fairly well typify other almond-growing areas in the more arid North. The success or failure of commercial almond production on the two farms discussed could very well indicate the possibility of regional success or failure. As previously discussed, climate is the major factor in determining probable success of almond growth. The following chapter discusses this and other factors of locational importance, in an attempt to determine which areas in Mexico are suitable for almond growth.

¹⁸ Payroll of 40 pesos (\$3.20 U.S.) per day to each of eight pickers, (1973).

ALMOND PRODUCTION POTENTIAL IN MEXICO

In attempting to determine those areas suitable for the commercial production of almonds the initial step was to eliminate areas clearly unsuitable for their production. Topographically unsuitable areas due to excess slope included the Sierra Madres Occidental, Oriental and del Sur, and the Neo-Volcanic zone. Secondly, areas unsuitable climatically because of excessive humidity were eliminated. The third elimination was on the basis of soils and were those deemed generally unsuitable (clays, laterites, etc.) according to the World Soil Classification System of the FAO.

It is important to note that these eliminations are on a macro scale, and it is recognized that there will be local exceptions, especially with respect to soils. For example, a region dominated by a particular soil type not conducive to good almond growth may possess local areas quite favorable, and vice versa. (See map on page 37).

Within the areas remaining, the determination of specific sites conducive to favorable almond growth must be based primarily on field observation and experimentation. The three criteria used for large-scale elimination of unsuitable areas (topography, soils and climate) will now be considered with focus on local conditions.

Topography

Discounting areas of excessive slope, topography as an isolated factor plays a relatively minor role as a limiting factor in selecting a suitable site for the almond orchard. Of more importance is the manner in which topography affects the micro climate and the soil.

A slope location is highly desirable in nearly all almond growing areas in Mexico as a protection against frost damage. In the central area, frosts can occur at the relatively low latitude due to an elevation of 4-6,000 feet. In the Northwest, frosts occur at a much lower elevation because of the higher latitude. In both areas, the grower is at an advantage if he can plant in a slope location; however, flat topography may be suitable where some means of orchard heating is provided.

Soils

Almonds in central Mexico are grown primarily on Volcanic and Chestnut soils. In the North, growth is predominantly on Brown semi-desertic soils. Deep, well-drained soils provide most favorable growing conditions. Fertilization is usually necessary; for example, in Caborca, a grower finds it necessary to augment his soil with potassium, phosphorus and nitrogen. Local areas in the Northwest exhibit high salt and boron content; the high ph problem is met with the application of gypsum.

A disease known as "Texas Root Rot" which attacks almond trees planted in a soil with a particular fungus has been a rather serious problem in central Mexico. This fungus is associated with soils in which cotton has been grown; the soil remains contaminated after a change from cotton to other crops. Almond trees that are affected will grow for about four or five years and then begin to die. Texas Root Rot has been a serious production problem and one of which more research is needed. Experiment with a fungicide developed at the University of Mexico proved unsuccessful, but the possibility of selecting rootstocks which are more resistant to this fungus appears promising.

Climate

Climatic conditions characteristic of the typical Mediterranean climate which favors almond growth cannot be found in Mexico. A major difference is with regard to the distribution of precipitation. The Mediterranean climate features a dry summer, while Mexico's wet season generally falls at that time (from March to September) except in a small area of northern Baja Peninsula. Although the rainfall in much of Mexico is not excessive, its untimely occurrence when the nuts are ripening presents potential problems of rot, disease, decreased pollination, and low production. The steppe climate (BS), as found in northwestern Mexico, however, could be considered comparable to a

Mediterranean climate with the correct application of water in both amount and timing (irrigation).

Almonds being grown in the central area near San Miguel de Allende are under a summer rainfall regime with an average annual mean of 19.9 inches. Rainfall in this area, however, characteristically comes heavily once per day, which is less hazardous than if it were of a more continuous nature. Nevertheless, summer precipitation increases the probability of having to contend with the problems of rot, disease, decreased pollination, and low production in this area.

As one progresses northward (on the Central Plateau and on both coastal plains) although rainfall occurs during the summer months, it decreases in amount and in its effectiveness. Hermosillo, Sonora, for example, receives about ten inches of rainfall annually, much of it when the nuts are ripening. Due to the extremely high daytime temperatures, however, the nuts remain dry and rot is not a problem.

With respect to temperature, a major problem has been to find sites with adequate winter chilling, which at the same time provide frost free spring conditions. If an area is selected where late spring frosts are not a problem, generally the number of chilling hours available is inadequate. Conversely, if the area is selected to provide an adequate number of chilling hours, it is probable that the grower will have to contend with the problem of frost. The early-blooming almond is extremely sensitive to frost, and frost

damage to orchards has been a major problem in virtually every area of present growth.

In central Mexico, the relatively low number of available winter chilling hours necessitates the use of almond varieties (such as Ne Plus Ultra and Peerless) that require less hours of chilling. The bloom, then, can start as early as the second week of February. Varieties selected should require as many chilling hours as are available at the site, or slightly more. If the almond has a slight deficiency in the number of hours of chilling, the result will be delayed foliation which would be beneficial in protection from frost.

With the frequent late frosts in this area (often until April) risk of crop damage is great unless some means of orchard heating is available. Orchard heating is not always feasible, however, because frequent use of orchard heaters significantly increases the cost of production. A grower in the Trinidad Valley of Baja California (3000 feet in elevation) had to use orchard heaters 18 times in one year, amounting to a cost in excess of the financial returns of the almonds.

In the more northern areas, chilling hours are generally sufficient to allow the use of the later blooming varieties, which helps to lessen the frost hazard.

Tabuenca has suggested that perhaps those varieties could be selected which have a high heat requirement. Varieties with a large heat requirement, after the chilling

requirement is satisfied, would not blossom as early and would be less susceptible to frost damage. These varieties could be considered, and limited test plantings established, in areas where serious frost damage has been a problem.¹⁹

Temperature requirements of the almond are fairly exacting if yield is to be high enough for commercial production. The large contrasts in temperature in Mexico due to elevation and latitude make local observation and experimentation necessary to determine specific sites conducive to favorable almond growth. Nevertheless, in order to provide a rough yardstick as to that elevation (at a particular site in Mexico) which will provide the closest approximation in temperature to the most favored sites for almond production in California, maximum and minimum temperature data from selected stations in California and Mexico were evaluated.²⁰

Fifteen stations were selected in three valleys in California which are known for outstanding almond production-- six from the San Joaquin Valley, six from the Sacramento Valley, and three from Antelope Valley.²¹ Mean monthly maximum and minimum temperatures, for the period of 1951

¹⁹ See Tabuenca, p. 388.

²⁰ The fact that 99 percent of almonds produced in the United States are grown in California can attest to its climatic suitability.

²¹ San Joaquin Valley - Bakersfield, Merced, Oakdale, Porterville, Stockton, and Visalia; Sacramento Valley - Centerville, Chico, Orland, Oroville, Willows, and Winters; Antelope Valley - Fairmont, Lancaster, and Palmdale.

to 1960, were plotted for all stations in each valley. The resultant curves were overlaid on comparable curves for available stations in Mexico, most of which reveal temperature conditions too warm for almond culture.²² In order to locate areas that would provide adequate chilling, a technique of simulating higher elevation temperatures was employed. Allowing $3\frac{1}{2}$ degrees Fahrenheit temperature change for every 1000 feet of increased elevation, the elevation which would provide an approximate optimum temperature curve was determined. For example, location at an elevation of 428 feet higher than Santa Ana, Sonora, would provide temperature conditions approximately comparable to those in California's almond-growing San Joaquin Valley. (See table on page 39.)

The elevations necessary to bring each temperature curve into California's range are intended to be only one informational input in determining potential success of almond production in a particular area, and do not indicate definite success at a predicted elevation or failure at an elevation other than that predicted. A large difference, however, between actual and predicted elevation may indicate marginal change for successful almond production.

²² Altar, Sonora; Hermosillo, Son.; Santa Ana, Son.; Delicias, Chihuahua; Aguascalientes, Aguascalientes; Calvillo, Ags.; Dolores Hidalgo, Guanajuato; Fresnillo, Zacatecas; San Luiz de la Paz, Gto.; San Miguel de Allende, Gto.

Economic Considerations

A second set of considerations in determining the possibility of almond production are economic. To establish an almond orchard to the fourth year, a capital outlay of approximately \$3000 per hectare is required. Maintenance of an orchard (fertilization, irrigation, pruning, harvesting) requires about \$400 per hectare per year.²³ The fact that the orchard does not begin to yield monetary returns for four to seven years, depending on the variety, is another economic consideration which should be taken into account.

It can be seen that the option to grow almonds, or any other tree fruit for that matter, is limited to the more affluent farmer. The ejidatario, a subsistence farmer with a government-endowed use-right to a small parcel of land (generally 10 hectares) probably could not consider commercial almond production. He does not own his land so has limited capacity to borrow capital for the initial investment, but more important, his very life depends on a yearly crop harvest.

The land tenure system in Mexico also allows for private land ownership with a maximum limit of 100 hectares of irrigable land. When land is planted in tree crops, the allowable maximum is 300 hectares. The farms growing almonds at present are integrated, however, so fall under the 100 hectare limit. Many farmers, however, manage holdings of

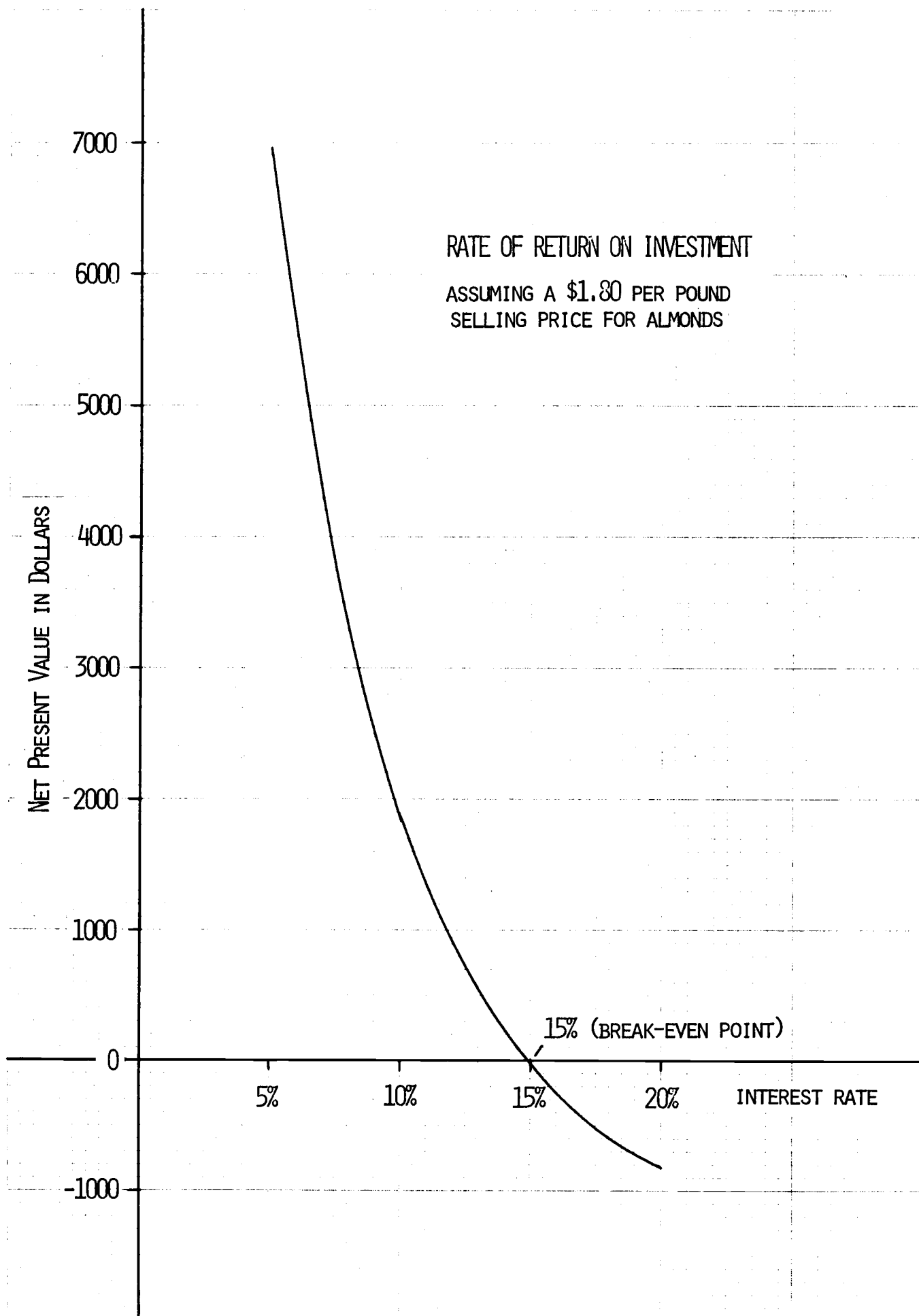
²³ Heriberto Marquez G., almond grower, Caborca, Sonora. Taped Interview, 1973.

larger size by having land registered in the names of other family members. With land holdings of this size, the farmer can diversify enough to easily survive the "waiting period" for the almond tree to come into production.

The acquisition of capital still remains a problem, however. Certain lines of credit have been traditional-- short-term loans for cotton, beans, wheat, and more recently sorghum, safflower, alfalfa, soy beans and sesame seeds. The newer lines of credit (long-term), for apricot, peach, olive, almond and walnut trees, are not as readily given. In addition, once credit is given, in order for it to be maintained, the young tree is often expected to be in full production sooner than is physically possible.

In addition to the availability of capital, of critical importance is the interest rate at which the capital is borrowed. Using the estimated cost of establishing one hectare of almonds to the fourth year as \$3,000 and the selling price of almonds at \$1.80 (U.S.), (1973), interest rates of 5, 10, 15, and 20 percent were discounted to present. The resultant figures show the "break even" point in interest rate to be at approximately fifteen percent. That is, should the interest rate be higher than fifteen percent, the grower will suffer a loss; should it be lower, he will make a profit. (See graph, p. 27)

Should either the cost of establishing the orchard, or the market price of the almonds alter, the "break even" interest rate will move higher or lower accordingly. (See table, p. 28)



PRESENT VALUE ESTIMATES
FOR ONE HECTARE OF ALMOND ORCHARD

YEAR	DISCOUNT FACTOR				INITIAL INVESTMENT (\$)	ANNUAL COST (\$)	ANNUAL RETURNS (\$)	DISCOUNTED ANNUAL RETURNS (\$)			
	5%	10%	15%	20%				5%	10%	15%	20%
0	1	1	1	1	1400	400	0	0	0	0	0
1	.95	.91	.87	.83			0	0	0	0	0
2	.91	.83	.76	.69			0	0	0	0	0
3	.86	.75	.66	.58			0	0	0	0	0
4	.82	.68	.57	.48			311	255	211	177	149
5	.78	.62	.50	.40			711	555	441	356	284
6-50	13.93	6.12	3.31	2.01			1067	14863	6530	3532	2145
NET PRESENT VALUE (\$)								6953	1822	-15	-822

IMPLICATIONS OF COMMERCIAL PRODUCTION

The question might be asked, "Why grow almonds at all in Mexico?" The answer is economic. Mexico presently imports some 450 short tons of almonds from the United States, amounting to a cash value of \$875,000 (10,937,500 pesos).²⁴ Increased production of domestic almonds could result in the reduction or elimination of almond imports and perhaps lead to their export in the future, thereby helping toward a more favorable balance of payments. In order to eliminate this import by becoming self-sufficient in almond production, a total of 3,750 acres of orchards at full production (yielding 240 lbs./acre) are necessary. A monetary investment of \$4,554,655 is required to establish these orchards, assuming the cost to establish one hectare of almonds to the fourth year to be \$3,000.²⁵

It has been speculated by one farmer in the Northwest that he can make more money per hectare growing almonds than any other crop. The almond competes very favorably with other crops because of its high yield per hectare; it is intensive and profitable on land where water availability is limited and costly. The domestic market for almonds is

²⁴ Tree Nuts, World Production and Trade Statistics, USDA, August, 1973.

²⁵ Estimate of Heriberto Marquez G., almond grower, Caborca, Sonora, 1973.

very good; the almond sells for approximately \$1.80 (22.50 pesos) per pound (1973). Under favorable conditions a mature orchard can yield 1 to 1½ tons of almonds (in shell weight) per acre, and with proper handling the trees can continue to produce well for 50 years or more.²⁶

Almond production in Mexico is highly labor intensive and can employ many times more men than needed in, say, wheat production. This socio-economic aspect of providing jobs is highly important in a country such as Mexico which has a large agricultural labor surplus. Moreover, marginal lands, those too dry or stony for other crops, could perhaps be utilized to grow almond trees with production for domestic consumption.

Almonds have a very good keeping quality relative to other fruit crops. Harvesting is not necessary at a critical time as with peaches; they can be harvested ten days late with no adverse affects. Once harvested, hulled and dried, they can be stored several months, under the proper conditions, without spoilage, enabling the farmer to more effectively negotiate prices.

The nutritional value of almonds is relatively high. One pound contains 84 percent of the minimum daily caloric requirement, and more protein, calcium and iron than

²⁶ Dale E. Kester, Almonds, p. 302.

recommended by the USDA as the minimum daily requirement for men 25 years of age.²⁷

Every ton of almonds produced yields 1,500 pounds of by-product material.²⁸ The major by-product is the hull of the almond which can be used as livestock feed. Morrison's Feeds and Feeding breaks the hull down into 66.2 percent total digestible nutrients (TDN), 9.7 percent crude fiber, 5.9 percent ash and 3.6 percent fat.²⁹ According to extension dairy nutritionist D.L. Bath, University of California (Davis), this break-down shows almond hulls to be worth approximately 84 percent of barley as an energy source.³⁰

A second by-product material of the almond is the shell. Approximately 800 pounds of shell are yielded by one ton of inshell almonds.³⁰ The shell is sold to manufacturing companies which grind the shell for use in various products, including charcoal briquettes.

²⁷ Almond Growers Exchange, "Almonds From California," n. d., p. 1.

²⁸ Almond Facts, Vol. 38, No. 4, July/August, 1973, p. 5.

²⁹ Ibid., p. 6.

³⁰ Almond Facts, Vol. 38, No. 4, July/August, 1973, p. 7

CONCLUSION

The economic implications should Mexico become self-sufficient in almond production are apparent. In addition to local economic and social benefits, the annual saving of \$800,000 on almond imports and the possibility of an export market are highly desirable. Mexico has averaged an annual import of some 415 short tons of almonds over the past decade;³¹ the domestic demand for almonds is well established. Were commercial production developed, the expanded acreage in almonds to supply domestic needs would decrease the flow of capital out of the country and improve the balance of payments. Also, if high quality almonds of varieties not found in the U.S. can be grown, Mexico might capture a specialty export market. From the local standpoint the almond competes very favorably with other crops. Few other crops in Mexico yield the monetary returns per hectare of the almond, assuming full production.

The major economic obstacle appears to be credit-related. There is need for more long-term, agricultural loans in the newer lines of credit. Bank advisors specialized in agriculture are highly desirable in order to better work with, and understand the problems of, the farmer. In

³¹ World Agricultural Production and Trade, Statistical Report, U.S.D.A., Foreign Agricultural Service, March, 1973.

addition, special interest rates for agricultural loans are necessary if almond production is to be profitable at the present cost of initial investment.

Many of the physical problems discussed (insufficient winter chilling, spring frosts, Bud Failure, disease, and soil problems) can be lessened or alleviated by the selection of almond varieties appropriate for local conditions, and by proper orchard management (proper use of fertilizers, pesticides, irrigation, pruning, breeding, etc.).

The problem of Bud Failure, which is possibly related to high daytime temperatures, can be reduced by the careful selection of varieties which do not have a history of susceptibility to the disorder, in addition to careful choice of the nursery with whom the grower deals.

A major problem at present is an inability to predict the number of chilling hours available in an area. Research done on this problem appears most promising. An equation to predict chilling hours in California almond-growing areas has been developed, and it is hoped that this can be modified to fit agricultural areas in Mexico.³² Almond varieties should then be selected which are appropriate for the number of chilling hours at a particular location.

³² See Robert H. Aron, Chilling as a Factor in Crop Location with Particular Reference to Deciduous Orchards in California, Ph.D. Thesis, Oregon State University, Corvallis, Oregon, June, 1975; and Robert H. Aron, "Climatic Chilling and Future Almond Growing in Southern California," The Professional Geographer, Vol. XXIII, No. 4, October, 1971, pp. 341-343.

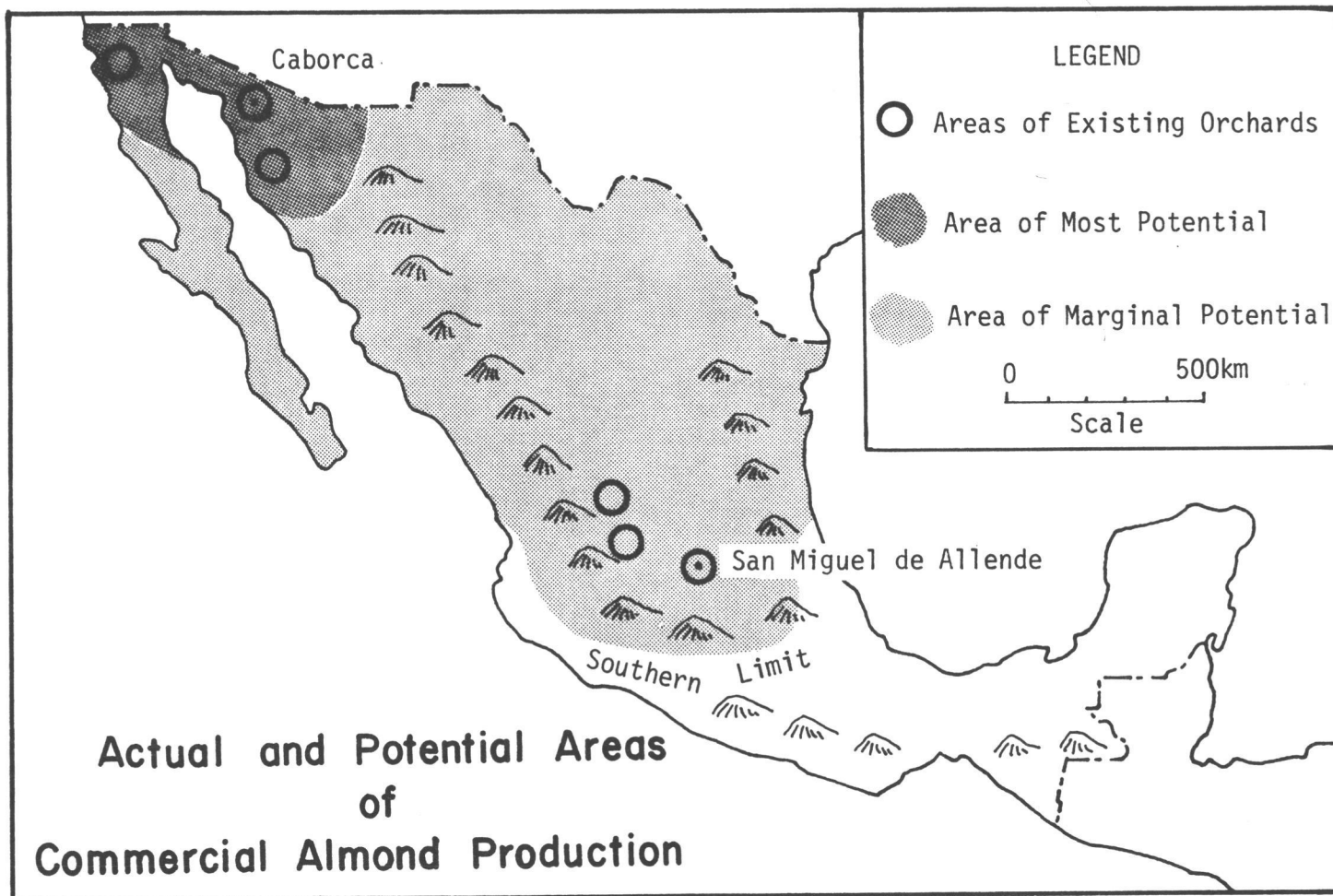
The greatest potential with respect to climate appears to be in the Northwest. Much of the climate here is comparable to that of the almond-producing southern San Joaquin Valley in California. No problem of insufficient winter chilling is evident as in the Central Plateau. Later-blooming varieties can be selected to decrease the hazard of frost damage. In contrast to the wet summers of the Central Plateau, conducive to disease and rot in the almond, the long, hot and dry growing season in the Northwest is highly favorable for almond growth.

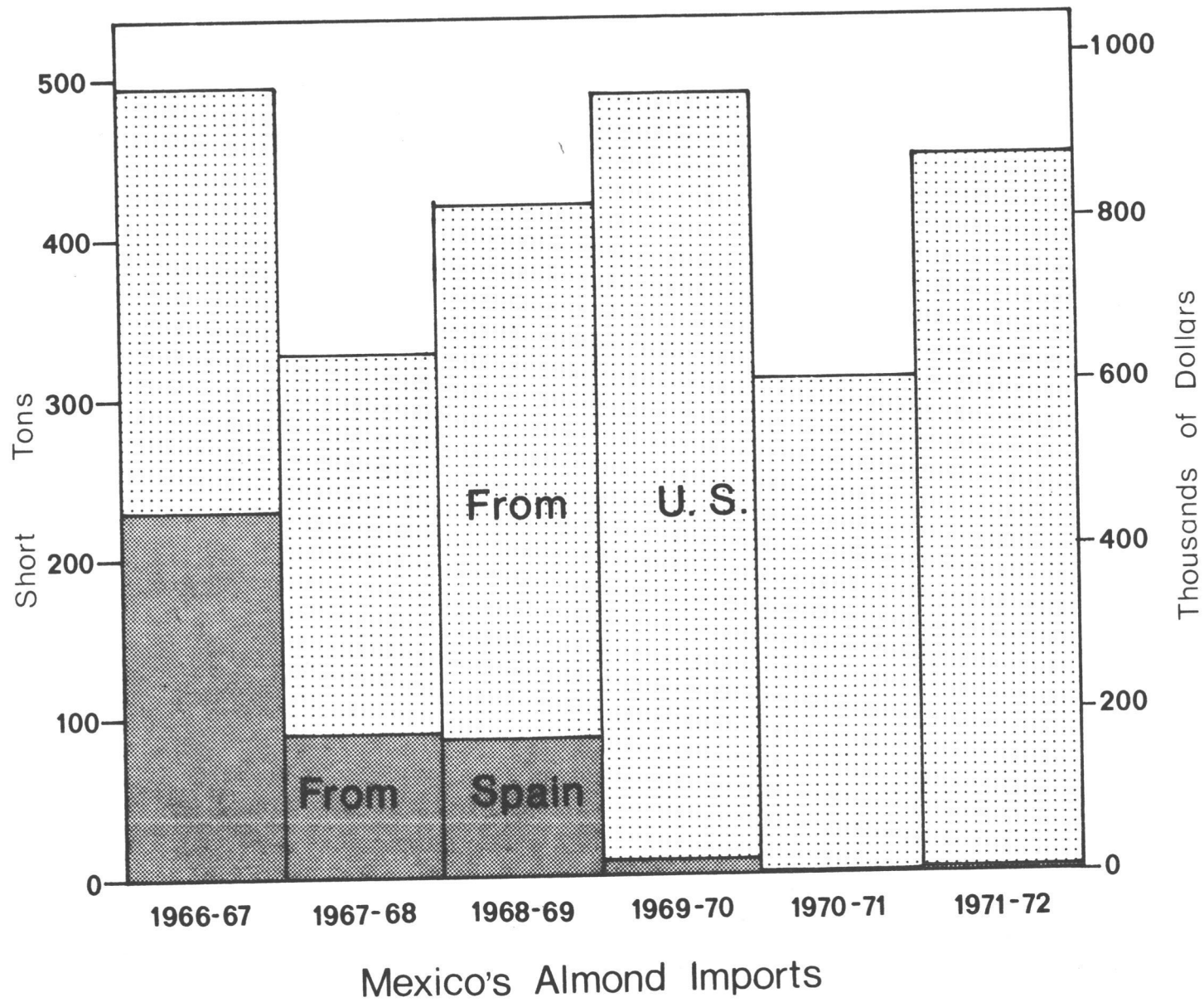
The prospect of growing almonds for commercial production in the Central region is sufficient to warrant experimentation. Small-scale plantings designed to determine growth differences between various combinations of variety, root-stock, and site should precede expansion of almond acreage. Almonds grown in this area should be planted in the higher valleys if possible, at an elevation which provides adequate winter chilling hours, and on slopes to take advantage of air drainage.

The conditions that favor almond production discussed in this paper are intended to aid in evaluating the feasibility of almond growth in Mexico. Specific site evaluation such as soil analysis and determination of available chilling hours, however, is necessary, before planting. Careful weighing of informational inputs, such as suitable elevation, soil, appropriate almond variety, production cost, interest

rate, and monetary yield will enable prospective growers to better evaluate local almond growth potential.

At present no commercial harvests have been accomplished, but several orchards have been planted on a commercial scale. There is reason to believe that they will be successful and that almond growing will expand in Mexico.





MEXICO STATION	LATITUDE/LONGITUDE	ELEVATION	MEAN ANNUAL MAXIMUM	MEAN ANNUAL MINIMUM	PRECIPITATION	ELEVATION NECESSARY TO APPROXIMATE CALIFORNIA'S TEMPERATURE
NORTHWEST						
Altar, Sonora	30°43'; 111°51'	1308' (397 m.)	89.1°F. (31.7°C.)	54.4°F. (12.4°C.)	10.2" (259.8 mm.)	2200' (600 m.)
Hermosillo, Son.	29° 5'; 110°57'	780' (237 m.)	88.7°F. (31.7°C.)	59.9°F. (15.7°C.)	9.6" (244.9 mm.)	3500' (1000 m.)
Santa Ana, Son.	30°33'; 111°7'	2254' (684 m.)	86.0°F. (30.0°C.)	51.8°F. (10.8°C.)	12.5" (317.2 mm.)	2600' (800 m.)
NORTH CENTRAL						
Delicias, Chih.	28°11'; 105°29'	3858' (1171 m.)	81.5°F. (27.4°C.)	50.9°F. (10.6°C.)	10.8" (275.2 mm.)	3800' (1100 m.)
CENTRAL						
Aguascalientes, Ags.	21°53'; 102°8'	6521' (1979 m.)	79.7°F. (26.4°C.)	50.0°F. (10.2°C.)	21.1" (535.0 mm.)	7600' (2300 m.)
Calvillo, Ags.	21°51'; 102°43'	5608' (1702 m.)	84.2°F. (29.2°C.)	51.8°F. (11.1°C.)	23.3" (591.3 mm.)	7200' (2200 m.)
Dolores Hidalgo, Gto.	21° 9'; 100°56'	6244' (1895 m.)	81.1°F. (27.5°C.)	49.1°F. (9.5°C.)	22.7" (577.7 mm.)	7400' (2200 m.)
Fresnillo, Zac.	23°11'; 102°53'	7374' (2238 m.)	76.7°F. (25.0°C.)	47.9°F. (9.0°C.)	16.0" (406.5 mm.)	7800' (2300 m.)
San Luiz de la Paz, Gto.	21°18'; 100°31'	6369' (1933 m.)	55.4°F. (13.0°C.)	39.4°F. (4.0°C.)	16.5" (418.6 mm.)	7200' (2100 m.)
San Miguel de Allende, Gto.	20°57'; 100°45'	6102' (1852 m.)	83.3°F. (28.3°C.)	55.4°F. (12.8°C.)	19.9" (505.2 mm.)	9000' (2700 m.)

Data from: Isotermas Extremas e Indice de Aridez en la Republica Mexicana. Instituto de Geografia. Consuelo Soto Mora y Ernesto Jauregui O. Universidad Nacional Autonoma de Mexico. Mexico, 1965.

BIBLIOGRAPHY

Aron, Robert Henry. An Analysis of the Changing Location of Almond Production. Unpublished M.S. Thesis, California State College at Long Beach, June, 1970.

_____. Chilling as a Factor in Crop Location with Particular Reference to Deciduous Orchards in California. Ph.D. Thesis, Oregon State University, Corvallis, Oregon, June, 1975. 196 pp.

_____. "Climatic Chilling and Future Almond Growing in Southern California," The Professional Geographer, Vol. XXIII, No. 4, October, 1971, pp. 341-343.

Azevedo, Eldon F. Almond Hulls as Livestock Feed. Oroville, California: Butte County Agriculture Extension Service, n. d.

Banco Nacional de Comercio Exterior, S. A. Mexico 1970. Mexico, D. F., 1970. 256 pp.

Bowen, Hollis H. "Breeding Peaches for Warm Climates." Breeding Fruit Crops for Adaptation to Warm Climates, HortScience, Vol. 6, No. 2, February, 1971, pp. 11-15.

Browne, T. "Raised Borders," Almond Facts, 33(1):22-23, January/February, 1968.

Bush, Carroll D. Nut Growers Handbook. New York: Orange Judd Publishing Company, Inc., 1953.

Butterfield, Harry M. A History of Subtropical Fruits and Nuts in California. University of California, Division of Agricultural Sciences, Agricultural Extension Service, Agricultural Experiment Station, September, 1963. 57 pp.

California Almond Growers Exchange. Almond Facts, Vol. 38, No. 4, July/August, Sacramento, California: Almond Growers Exchange, 1973.

_____. Annual Report. San Francisco, California: Almond Growers Exchange, n. d.

_____. From the Valley of California. San Francisco, California: Almond Growers Exchange, 1959.

California Department of Agriculture. Bureau of Marketing. Almonds: A Review of the Past and Present and Some Alternatives for the Future, by J. D. Rowell and Les Portello. Sacramento: California Department of Agriculture, 1965.

Chandler, William Henry. Deciduous Orchards, Philadelphia, Pa.: Lea & Febiger Company, Inc., 1957. 492 pp.

Comision Nacional de Fruticultura. "El Almendro," by Ing. Francisco Carvalho C., Folleto No. 10, Mexico, 1972.

Controlled Water Emission Systems, "Drip Irrigation News," Vol. 2, No. 1, 585 Vernon Way, El Cajon, Ca. 92020, 1974.

Farrell, Kenneth R. The California Almond Industry: Market Trends and Prospects. Berkeley: University of California, 1965.

Economic Trends in the California Almond Industry. Berkeley: University of California Agriculture Extension Service, 1960.

Fite, A. B. Almonds. Agriculture Experiment Station Bulletin 171. New Mexico College of Agriculture and Mechanic Arts, 1929.

Food and Agricultural Organization of the United Nations. Production Yearbook, New York, 1972, p. 165.

The Soil Resources of Latin America. World Soil Resources Reports #18, Soil Map of the World, FAO/ UNESCO Project, October, 1965. pp. 107-116.

Gutierrez Jarquin, Ing. Antonio, Comision Nacional de Fruticultura, Mexico, 5 D. F., Mexico. Taped Interview.

Holmberg, D. and Werenfels, L. "Water Use of Dry-Farmed Almonds Under Clean and Noncultivation Conditions." Calif. Agr. 21(9):6-7, September, 1967.

Howes, F. N. Nuts: Their Production and Everyday Uses. London: Faber and Faber, Ltd., n. d.

Isotermas Extremas e Indice de Aridez en la Republica Mexicana. Instituto de Geografia. Consuelo Soto Mora y Ernesto Jauregui O. Universidad Nacional Autonoma de Mexico. Mexico, 1965. 119 pp.

James, Preston E. Latin America. New York: The Odyssey Press, 1963. 590 pp.

Kester, Dale E., Professor, Department of Pomology, University of California, Davis, California. Taped Interview.

_____. "Almonds." Handbook of North American Nut Trees. Knoxville, Tennessee: Northern Nut Growers Association, 1969. pp. 302-314.

_____. California Almond Varieties. Davis, California: California Agricultural Experiment Station, Extension Service, 1962.

_____. Combination Plantings for Almond Orchards. Davis, California: California Agricultural Experiment Station, Extension Service, 1963.

_____. "Major Factor in the 1958 Crop Losses Was Rain During Blossoming Season," Almond Facts, XXIII, November/December, 1958, pp. 6-7.

_____. "Noninfectious Bud Failure of Almonds in California." (1) The Nature and Origin. Calif. Agr. 23(12):12-14, 1969.

_____. A Review of Almond Varieties. Davis, California: University of California Agricultural Extension Service, 1966.

Kester, Dale E., Asay, R. and Serr, E. F. The Kaparill Almond. California Agricultural Experiment Station Bulletin 798. Berkeley: University of California Press, 1963.

Kester, D.E., Rizzi, A.D., Williams, H.E. and Jones, R.W. "Noninfectious Bud Failure of Almonds in California." (2) Identification and Control of Bud Failure in Almond Varieties. Calif. Agr. 23(12):14-16, 1969.

King, A. D., Miller, M. J. and Eldridge, L. C. "Almond Harvesting, Processing, and Microbial Flora." App. Microbiol. 20(2):208-214, August, 1970.

Marquez G., Heriberto, Almond Grower, Caborca, Sonora, Mexico. Taped Interview.

Maycott, Fortunato, Jr., Almond Grower, San Miguel de Allende, Guanajuato, Mexico. Taped Interview.

Micke, W. C. et. al. "Early Harvesting of Almonds." Calif. Agr. 20(12):14-16, December, 1966.

Mieth, Clem and Rizzi, A. D. Almond Production. Davis, California: University of California Agricultural Extension Service, 1966.

Moss, D. E. Commercial Almond Growing. Southern Australia Department of Agriculture Extension Bulletin #16, 1970. 29 pp.

Moss, D. E. and Cowley, R. W. "Commercial Almond Growing." Fruit World Market Grower 71(9):42,44,46,48, September, 1970.

Nuevo Atlas Porrúa de la Republica Mexicana, Editorial Porrúa, S. A., Av. Republica Argentina 15, Mexico, 1 D.F., 1972.

Papadakis, J. Agricultural Potentialities of World Climates, Av. Cordoba 4564, Buenos Aires, Argentina, 1970. 70 pp.

Climates of the World and their Agricultural Potentialities, Av. Cordoba 4564, Buenos Aires, Argentina, 1966. 170 pp.

Reed, A. D. Machinery Costs and Performance. Davis, California: University of California Agricultural Extension Service, 1967.

Schacht, Henry. "California Almond World Market." San Francisco Chronicle, August 23, 1968.

Smith, J. Russell. Tree Crops, A Permanent Agriculture. New York: The Devin-Adair Co., 1950.

Tabuenca, M. C. "Necesidades de Frio Invernal en Almendro." Estacion Experimental de Aula Dei, Zaragoza. Centro de Investigacion y Desarrollo Agrario del Ebro., Zaragoza.

Tabuenca, M. C., M. Mut and J. Herrero. "Influencia de la Temperatura en la Epoca de Floracion de Variedades de Almendro." Estacion Experimental de Aula Dei, Zaragoza. Centro de Investigacion y Desarrollo Agrario del Ebro., Zaragoza.

Tapia Martens, Ing. Francisco, Association of Nut Growers of the Hermosillo Coast, Hermosillo, Sonora, Mexico. Interview.

Thompson, L. M. "Almonds Grown Above the Orchard Floor," Western Fruit Grower 19(7):13-14, 1965.

United States Department of Agriculture. Agricultural Statistics, by James Kendell, Chairman. Washington, D. C.: Government Printing Office, 1968.

United States Department of Agriculture. Almonds: Selected References on the Industry 1929-1940. Economic Library List No. 23. Washington, D.C.: Government Printing Office, 1941.

____ Economic Research Service. The Domestic Tree Nut Industry: An Economic Appraisal. Agricultural Economic Report No. 62. Washington, D.C.: Government Printing Office, 1964.

____ Economic Research Service. Fruit Situation. Washington, D.C.: Government Printing Office, 1969.

____ Economic Research Service. U.S. Foreign Agricultural Trade by Commodities, Calendar Year 1959-1969. Washington, D.C.: Government Printing Office, 1969.

____ Foreign Agricultural Service. The Almond Industries of Italy and Spain, by Theodore Horoschak. Washington, D.C.: Government Printing Office, May, 1971.

____ Foreign Agricultural Service. The Almond Industry of Italy, by H.C. Bryan. Washington, D.C.: Government Printing Office, July, 1965.

____ Foreign Agricultural Service. The Almond Industry of Spain, by H.C. Bryan. Washington, D.C.: Government Printing Office, July, 1965.

____ Foreign Agricultural Service. Tree Nuts: World Production and Trade Statistics. Fruit and Vegetable Division. Washington, D.C.: Government Printing Office, August, 1973.

____ Foreign Agricultural Service. World Agricultural Production and Trade, Statistical Report. Washington, D.C.: Government Printing Office, March, 1973.

Uriu, K., Martin, P.E. and Hagan, R.M. "Effects of Irrigation, Crop Density on Almond Trunk Growth," Calif. Agr. 23(3): 8-11, 1969.

Veihmeyer, P.J. and Hendrickson, A.H. Essentials of Irrigation and Cultivation of Orchards. California Agricultural Experiment Station Circular 486. Berkeley: University of California Press, 1960.

Viveros A., Mario, Programa Nacional Viticola, Misisipi 48 - 6^{to} Piso, Mexico, 5 D.F., Mexico. Taped Interview.

Woodroof, Jasper G. Tree Nuts: Production, Processing, Products. Westport, Connecticut: AVI Publishing Company, Inc., 1967.