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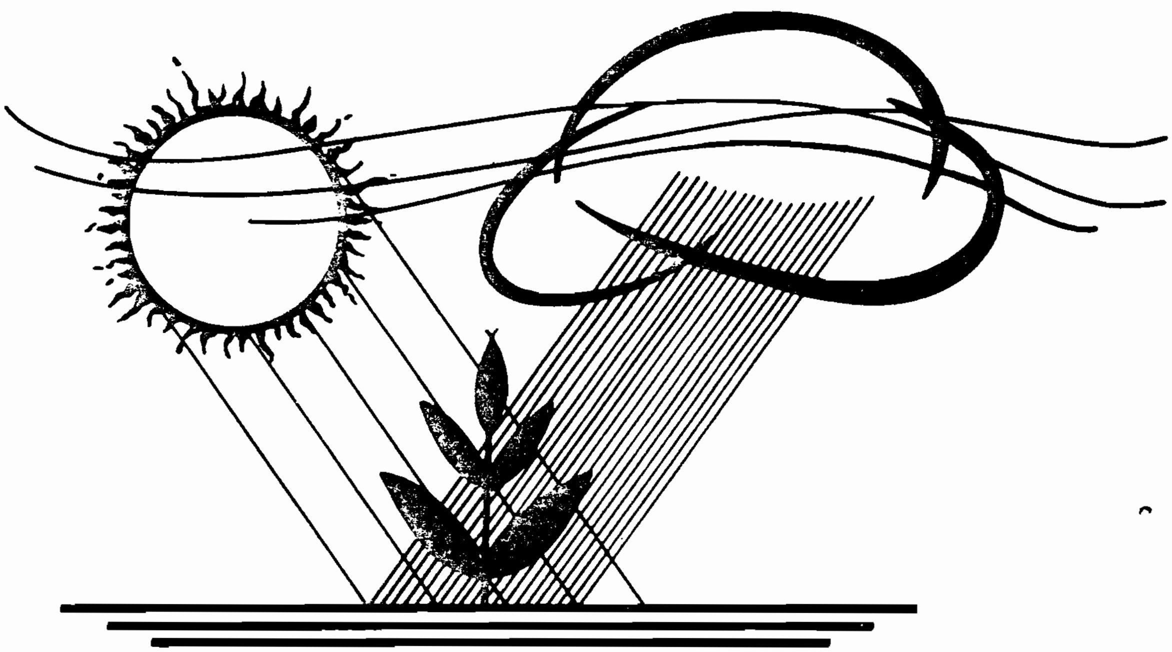
Keeping Agriculture Prosperous



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OUTLOOK FOR CALIFORNIA'S EXPORT CROPS

Exporting Tree Nuts -
Walter Payne, Vice-President-Sales & Marketing, California Almond Growers Exchange, Sacramento

Exporting Raisins -
Clyde E. Nef, Manager, California Raisin Advisory Board, Fresno

Outlook for California Export Crops - Exporting Cotton -
Bruce K. Groefsema, Calcot Ltd., Bakersfield

CUTTING POSTHARVEST ENERGY COSTS

Overview of Energy Inputs in the Postharvest Handling Systems for Horticultural Crops -
Adel A. Kader, Dept. of Pomology, U.C. Davis

Comparative Energy Costs of Cooling Methods -
Robert F. Kasmire, Extension Vegetable Marketing Specialist, U.C. Davis

Energy Costs in Cold Storage -
F. Gordon Mitchell, Extension Pomologist, U.C. Davis

Reducing Energy Use During Transportation -
Michael S. Reid, Extension Postharvest Specialist, U.C. Davis

Energy Conservation in Processing of Agricultural Crops -
M. O'Brien and R.P. Singh, Agricultural Engineering Department, U.C. Davis

Energy Costs of Rice Drying -
George F. Miller, Extension Agricultural Engineer, U.C. Davis

KEEPING AGRICULTURE PROSPEROUS

The Role of Financial Institutions -
C. Gallagher, Vice President, Agri-Business Finance, Bank of America, San Joaquin Valley

The Role of the Farmer -
Donald A. Rosendahl, President, Fresno County Farm Bureau

MAXIMUM CROP YIELDS AND PROFITS: PLANT BREEDING

A Public Plant Breeder/Administrator's Perspective -
Calvin O. Qualset, College of Agricultural and Environmental Sciences, U.C. Davis

Breeding Rice for Maximum Yields and Profit -
H.L. Carnahan, California Co-operative Rice Research Foundation, Inc., Rice Experiment Station, Biggs

Breeding Cotton for Maximum Yield and Profit -
M. Van Elswyk, Jr., Assistant Dean and Professor of Agronomy, School of Agriculture and Home Economics, California State University, Fresno

Breeding Vegetables and Flowers for Maximum Yields and Profits -
David J. Thompson, Research Division, Ferry-Morse Seed Company, San Juan Bautista

Breeding Crop Plants for Maximum Yields and Profits: A Private Plant Breeder's Perspective -
Donald L. Smith, Cal/West Seeds, Woodland

IMPROVING WATER PENETRATION IN NON-ALKALI SOILS

Introduction to Water Penetration Problems -
William E. Wildman, Extension Soils Specialist, U.C. Davis

Effect of Xanthate, Phosphogypsum and Straw on Infiltration and Runoff of a Sprinkler Irrigated Soil -
J.D. Oster, W.E. Wildman, J.D. Wood, and R. Fuller (University of California, C.E., USDA-ARS and Tierra Rejada)

Soil Conditions and Their Effect on Soil Water Penetration (Water Drainage in Surface Disturbed Soil) -
B.J. Hoyle, Vegetable Crop Specialist, U.C. Davis

An Overview of Problems With Soil Water Penetration -
Les Stromberg, Fresno County Farm Advisor (Retired)

"KEEPING AGRICULTURE PROSPEROUS"

"OUTLOOK FOR CALIFORNIA'S EXPORT CROPS"

"EXPORTING TREE NUTS"

by Walter Payne - 1/27/82
Vice-President - Sales & Marketing
California Almond Growers
Exchange, Sacramento

My comments today will address the three major California Export Tree Nuts, Almonds, Walnuts and Pistachios. I will devote special emphasis to Almonds, since they are California's #1 food export and because I'm more familiar with them.

Almonds

The growth of the California almond industry is well established. As recently as 1968, California almond production was 81,000,000 lbs. By 1973 production had virtually doubled to 155,000,000 lbs. Sales remained good. Prices increased. Plantings flourished and by 1977 production had again doubled to 313,000,000 lbs. By 1979 the harvest was 376,000,000 lbs. and for 1981 the forecast was for 450,000,000 lbs., more than 5-1/2 times the 1968 figure. These production figures refer to kernel weight of almonds. During this same period of time (1968-1980), prices escalated by 275%. Plantings doubled from less than 185,000 acres to 375,000 acres by year end 1980.

The single most important factor contributing to this phenomenal growth was the development of an export market that was virtually nonexistent before the 60's. Exports during the first half of the decade of the 60's averaged 13,000,000 lbs. and accounted for 20% of California's total sales. By 1979 exports had reached 225,000,000 lbs. and accounted for 72% of California's almond sales. Export value to 88 foreign countries approached $500,000,000 and accounted for 1% of the U.S.'s total farm exports.

They say that necessity is the father of invention. Nowhere could this be truer than in the almond industry of the 60's and 70's. Heavy plantings forced the development of new markets, which let to greater sales and higher prices which in turn led to more plantings.

The industry worked hard to accomplish its enviable record. It's remarkable no matter how you slice it. However, we did have a few things going for us. First, there was a vast wealth of untapped markets waiting for the right sales pitch. (We know that now, but we didn't then!) Secondly, we had an excellent product. Thirdly, world political and economic conditions, again in retrospect, were fairly stabile. Finally, we had a U.S. dollar that was slowly eroding in value, masking the effects of progressively higher prices and making sales slightly easier.

This weakening trend of the dollar briefly reversed itself in the Spring of 1980 as U.S. interest rates shot up, attracting foreign investment in U.S. money markets and restricting the supply of dollars. Since most of the crop had been sold on a firm basis prior to this occurrence, and the duration of high interest rates was short, it amounted to nothing more than a sneak preview of what might come. By Autumn interest rates were down and the dollar was its old weak self. The 1980 crop was sold, with more difficulty than in 1979, but nonetheless sold.

In November 1980 a new President was elected which seemed to be very well received by our foreign allies. This general "feeling" that things might be on the "right track" in America came at a time when tight money and high interest rates returned in earnest. The dollar turned into a "tiger" and by August of 1981 was 40% stronger versus most major European importing currencies. This coupled with a record crop in California (20% more than the previous record), and a record crop in Spain (25% more than the previous record), led to a very rapid decline in prices from $1.85 for the 1980 crop to $1.09 or less for the 1981 crop.

Although interest rates have since abated somewhat, and the dollar is now only 25% stronger than it was in August 1980, it appears that we have entered into a new era. Government competition for savings is here to stay even if we do balance the budget. Interest rates are likely to stay higher than we've known them for the past 10 years. A new dollar/European currency relationship is likely to be realized with the dollar at a higher level. Our ability to get back on our steeply escalating export curve and good prices will take a few years to work out. We already have the potential in California to produce 500,000,000 lbs. from existing plantings. Spain has, in the ground, the potential to produce 225,000,000 lbs., or 36% more than this year's record. Moreover, they could gain entry into the common market as early as 1983 or 1984. This could result in limiting California's access to markets that now consume 60% of our exports. With the escalating cost of land and high cost of money, it would seem that this would be a time to proceed with new almond plantings, very cautiously. Only well financed, well managed, high yield new plantings should be contemplated for at least the next 3 years.

Walnuts

California accounts for roughly 70 to 80% of the free world's supply of walnuts. If you add the walnuts grown in the people's Republic of China, this percentage drops to about 50%. As you can imagine, it's pretty difficult to estimate the tonnage grown in China.

Other significant walnut producing countries include France with about a 20,000 to 25,000 metric ton crop; Italy with about 15,000 metric tons, and India at about 15,000 metric tons.

In the past 10 years the California walnut industry has made great strides in walnut production with an average crop now roughly 200,000 tons. In the late 60's, the average California crop was about 100,000 tons. It is interesting to note that in this same period of time, total walnut acreage has increased by less than 10%. So the volume gains are coming primarily from improved yield per acre. These walnut production figures are on an inshell basis.

Over the same period the foreign production of walnuts has remained relatively flat. At this time we are not aware of any substantial increase in walnut acreage or tonnage that is planned in any foreign country.

During the past 10 years, California exports of walnuts have increased dramatically. Today the industry ships about 45 to 50,000 tons of walnuts in the shell to foreign markets compared to 14,000 tons in 1970, a threefold increased. California also ships about 7 million pounds of shelled walnuts now versus 2 million pounds in 1970.

In spite of this growth in export, however, export today accounts for only about 25% of the total California walnut crop. As a result the walnut industry is not as heavily dependent on the export markets as the almond industry is.

As noted earlier, the industry's export business is primarily inshell or about 85% of the total export business.

The California walnut industry has not established itself in the minds of international consumers as a baking and cooking ingredient nut as we have in the U.S. This remains a prime opportunity area for us in the future.

In the U. S. Market over 80% of industry tonnage is sold as shelled walnuts. In addition to consumer sales, the industry has achieved a substantial business via industrial sales to major packaged goods companies such as Sara Lee, Pillsbury, General Mills and Proctor and Gamble.

For 1981 the walnut industry has a record drop of about 222,000 tons. This is up 13% versus last year and up 7% versus the previous record of 207,000 tons in 1979. The crop was average in most respects as to size and quality.

Reflecting strong sales activity, and in spite of a 13 percent increase in walnut production, reported field prices in early November were better than those for the prior year.

Pistachios

Continuing essentially in its original role, the pistachio still retains much of its market today as a snack nut, with but limited demand from industrial users for reasons we will examine later. One of the unique features of the pistachio is its ability to serve as a quick, convenient snack even though it is the only tree nut offered in the Inshell form for this purpose in competition with other nuts which are almost always shelled and ready to eat.

The familiar dehiscent characteristic of the pistachio shell which, as it ripens, splits about half way down one side from its apex, exposes the kernel for easy access. enabling the processor to roast and salt the kernel itself without removing the shell, and the consumer to extract the kernel by pulling the shell halves apart.

The pistachio, whose ripened nuts appear on the trees in grape-like clusters, is indigenous to Southwest Asia, the principal producing countries in that area being Iran and Turkey. Other countries in that general region are also pistachio producers including Afghanistan, Syria, Iraq, Italy, Greece and the Island of Crete.

Though introduced into this country a hundred years ago, little demand was created for the pistachio here until about 50 years later when consumption began to climb until imports had reached 9 million pounds by 1952. United States imports of pistachio nuts averaged annually in the ten year period 1969-78, 22 million pounds inshell, 17 million pounds coming in from Iran, and nearly 5 million pounds from Turkey. Other countries accounted for less than one percent of our inshell pistachio imports. In the same ten year period, U.S. imports of shelled pistachios averaged only 435,000 pounds annually. Turkey supplied about half our shelled imports, Iran about one-fifth, and the rest came mostly from Afghanistan, Italy and Greece.

Prior to the hostage crisis, the United States was Iran's most important customer for pistachio nuts inshell, taking in an average year nearly 60 percent of Iran's total exports of this nut. With the rapid deterioration of the political situation bringing about at least a temporary loss of this source of supply, California pistachio producers, evidently blessed with a sense of good timing, moved into the void left by Iran with a 1979 record yield of 17.2 million pounds, said to be 8 times the yield of California's 1978 pistachio crop.

The future for California's pistachio industry is described by some in rather glowing terms. One report tells us that, compared to the 4,300 full-bearing acres which produced the 17.2 million pound crop in California in 1979, the prospect is for 24,500 bearing acres by 1981. This same report projects a crop of 46 million pounds by 1985 and says the total harvest potential from all presently existing trees at full-bearing capability is estimated at 93 million to 124 million pounds per year in California alone.

With U.S. pistachio consumption presently averaging about 22 million pounds annually (one tenth of a pound per capita inshell basis), the layman has to wonder where the California Industry intends to put the 4 to 5 times our present consumption supply when the large crops predicted finally arrive. It will be a phenomenon well worth the watching, one that may prove to be unparalleled in the annals of tree nut production, and one that may become the greatest marketing challenge yet to confront any tree nut industry. Not even the tremendous growth in production registered by California almonds and Turkish hazelnuts in recent years seems to approach the magnitude of the oncoming California Pistachio problem from the standpoint of finding buyers to take all of the crop.

Pistachio trees usually begin to produce nuts in the 4th or 5th year after planting, and good production takes 8 to 10 years, with full-bearing maturity occurring after 15 to 20 years.

The kernel of this dioecious nut tree is as different in size and flavor from the almond, hazelnut, walnut, pecan and cashew in the one extreme as the Brazil nut kernel is in the other extreme. We said earlier that relatively small quantities of pistachio kernels are produced commercially for the market. The nuts that are shelled by the processors are usually those that fail to split open naturally when ripe. These are separated either by hand or mechanically from the nuts that are partially split, and shelled, usually by machines, though shelling may be done manually, especially in some of the foreign producing countries.

The principal use for pistachio kernels in this country is in ice cream. Fancy cakes may sometimes have a few decorating the icing. Luxury-line candy makers use a few (one kernel on top of a bon bon usually makes a good impression). In Germany they are used in sausage and in Italy they are occasionally used in Torrone (Nougat).

When the California Pistachio production gets much larger than it is at present, it appears certain that new uses for substantial quantities of the kernels will have to be found.

No doubt the California Pistachio producers have given much thought to questions concerning profitable disposition of future crops. Some years ago they had the foresight to form the California Pistachio Association which has been looking into ways to increase consumption of their product. There may be good opportunities for export but that can be a long and sometimes rough road, usually strewn with the barriers of well-established foreign competition. For many years the United States has been the principal pistachio-consuming market anyway, so new sales opportunities do not look all that abundant, though obviously much remains to be done for the California Pistachio in the domestic market while attempting to find a way in export.

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Clyde E. Nef, Manager
California Raisin Advisory Board
Fresno

EXPORTING RAISINS

Raisins are produced in commercial quantities in only eight countries of the world. All the raisins produced in the United States are produced in the Central Valley of California in an area with a radius of roughly 100 miles from the city of Fresno. Raisin production in California represents approximately 30% of the world's raisin production. Although, essentially, all of the raisins begin with the same type of grape; because of the cultural and drying practices, most of the world's raisin supply differs from the Natural Thompson Seedless raisin produced in California. Only part of the production in South Africa and part of the production in Afghanistan resembles the California Natural Thompson Seedless raisin.

Normally, from California, we export 55 - 70,000 tons of raisins annually, which represents something in the neighborhood of 20 - 25% of our total annual raisin shipments. With the exception of Australia, which exports roughly two-thirds of their production and South Africa which exports approximately half its production and the United States, essentially all of the raisin production in other countries is exported.

The United Kingdom is the single largest importer of dried vine fruits followed, probably by Germany and the USSR. The largest single importing country for California raisins is Japan, which accounts for approximately one-third of all of our annual exports. California has a significant part of the consumer package business in Scandinavia and enjoys a very limited percentage of the UK and German markets and essentially none of the market in the USSR.

Historically, we have been able to maintain a market of between 20 and 22,000 tons annually into the countries which presently make up the European Economic Community. This tonnage has been maintained in spite of the fact that in the majority of the years the price of California raisins into the European Economic Community has been between $200 and $400 per ton higher than those of our competitors in the Mediterranean area. We have been able to continue to maintain this position due to the cleanliness of our raisins, consistency of quality and reliable service. In most cases the raisins from the Mediterranean countries require rewashing and cleaning by the importing country prior to their being utilized.

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Unfortunately, during the decade of the 1970's, California experienced three of the greatest disaster years in raisin production that have been experienced since 1915, two years of below average production and three years of normal production and two years of near record production. Because of the violent fluctuations in production, we observed our competitor's attempts to encroach on some of our markets, particularly in the Pacific, which we had come to feel were essentially ours. Fortunately, the experience by these importing countries and the quality, consistency and delivery service of our competitors were such that we were able to gain back the majority of our normal business in these markets as soon as sufficient supplies were again available. However, we're certain that raisin importers and users in those countries are still very concerned about our ability to supply their market needs in the long term.

The export of 60 to 65,000 tons annually at today's prices represents a contribution to the American Balance of Trade of between $120 and $130,000,000. The California Raisin Industry has been of the opinion that if we could assure a stable supply situation that we could build our exports of raisins significantly. To that end the Industry has utilized the provisions of a Federal Marketing Order to store excess supplies in long years to be used to supplement the supply in short production years. These activities involve a considerable financial contribution on the part of raisin producers. However, producers have felt that such activity is to their advantage and thus have been willing to accept the financial burden of building storage containers and of carrying the financing and storage costs of such raisins until the market demand dictated their need.

In addition to this activity, the Industry through the authority of a State Marketing Order, has assessed raisin producers and handlers to obtain funds for promoting California raisins in foreign markets. Our annual budget, for foreign market promotion during the current crop year, is approximately $1.2 million dollars.

The Industry currently is experiencing great difficulty in maintaining its exports to the European Economic Community. On January 1, 1981, Greece became the first dried vine fruit producing country to become a member of the European Economic Community. For a number of years, Greece has guaranteed minimum prices to their raisin producers. We have been of the opinion that much of the American aid for military installation dollars were used by the Greek Government to subsidize raisin production. As part of the negotiations for Greece's entrance into the European Economic Community, the level of subsidies to be assumed by the Community has been a major point of difference. The activity by the Greek Government the last two or three years prior to their entrance into the Community and thus far during their first year after entrance into the Community, has resulted in a current difference in our market prices in Europe of between $800 and $1,000 per ton as compared with the traditional difference of $200 to $400.

The Pacific area continues to appear to be the greatest potential for increasing exports. For a number of years, the Industry has been working very closely with our Government International Negotiators to remove trade barriers, reduce tariffs and other conditions which discourage the export of California raisins to those markets. A bright spot in the year 1981 was the removal of import licensing for raisins entering Korea and simultaneously, a reduction in the import duty from 80% to 60%. During the first four months of the current marketing year, we have noted an increase in the exports of California raisins to Korea, which in four months are four times greater than what we used to export in a year. With the expressed philosophy of the current political administration in Washington to free trade, we are continuing to exert all the influence we can on our political negotiators to continue their activities to reduce trade barriers.

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OUTLOOK FOR CALIFORNIA EXPORT CROPS

- EXPORTING COTTON -

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Cotton is perhaps unique as an agricultural commodity as it is more an industrial raw material than are most other agricultural products. Being such a material it is for the most part a vital commodity to both developed and developing countries who rely on their textile industry as either an integral part of their respective economies or as a strategic industry necessary for the assurance of adequate necessitites in times of potential strife. As such the world cotton trade is relatively free of trade restrictions such as quotas and tariffs. Resultingly, the trading of cotton worldwide (or at least of the available free market supplies) is a most competitive business with the key focus on price. On the supply side, no one focuses more on this competitive world cotton market trade than the U.S. farmer.

While facing a relatively stable domestic demand for his cotton (6.0-6.5 million bales per year) the annual variation in the production of cotton by the U.S. farmer has been directed towards the increased demand of our export markets. World cotton consumption has been increasing at about an average of one million bales per year for the past decade. Few cotton-producing countries other than the United States have been able to increase their production to keep pace with growing demand. The result has been that the U.S. farmer is looked towards to produce the needed additional volumes of cotton by the world and in recent years accounts for over 30 percent of the world cotton trade. Of course, in times of strong world demand for cotton fiber, the U.S. farmer (or merchandiser) may reap large profits; however, in situations such as today's when the world economy is weak and demand poor, the farmer can suffer greatly.

In view of the relatively constant growth rate of world cotton consumption and the key role U.S. producers have in satisfying such growth, the future outlook for exportation of U.S. cotton is excellent. No other country appears to have the ability of the U.S. to readily adjust their production to world needs. In most cases cotton-producing countries already face the dilemma of deciding to allocate their land resource to cotton for export (to earn foreign exchange), or to grains to try to achieve self-sufficiency (i.e., Soviet Union, China, and Mexico). Thus it is expected that the U.S. producer will have to continue to satisfy a significant part of the expected increase in world demand.

For several reasons no producer in the U.S. is better suited to meet this task than those in the Far Western United States. Firstly, the qualities grown in the Far West are recognized as some of the finest in the world, especially the San Joaquin Valley Acala varieties. Secondly, as the major markets are in the Far East, the Far Western producer has a significant logistical advantage to other U.S. producers that gives him a competitive edge. Thirdly, the level of production efficiency in the West relative to not only other cotton-producing countries but to the rest of the U.S. cotton belt (which is a key factor in the westward shift of cotton production in the U.S. the past decade), provides the Western farmer with additional competition advantages. And, finally, the reliability of both quality and quantity is becoming increasingly important to textile mills worldwide.

Currently the key export markets for U.S. cotton are: PRC (People's Republic of China), Japan, South Korea, Taiwan, and Western Europe. While U.S. exports have ranged from 3.3 million to 9.2 million for the past 10 years, the Far Eastern (Asia) market continually accounts for about 80 percent of the total U.S. exports with the balance heading to Europe. The 80 percent to Asia accounts for about half of Asia's total imports of cotton.

While Asia is expected to continue being the key market for cotton exports, we do see some shifts in types of textile products produced in our traditional markets such as Japan and Korea from labor-intensive standardized products to more specialized, higher-value products requiring higher levels of technology. The end result is a much more capital-intensive industry as the traditional textile-producing countries find themselves unable to compete any longer in the labor-intensive product range as newly-developing areas (such as the ASEAN countries) begin to capitalize on their comparative cheap-labor advantage.

This trend is expected to continue as the textile industry in each country evolves to take advantage of any relative advantages they may have over others. Of course existing trade restrictions (and the possibility of additional ones) can distort the economic realities and serve to subsidize and protect from competition textile industries of individual countries. The key to continued successful marketing efforts for U.S. cotton farmers is to follow closely such changes and evolution of the industry so that our exports can grow with the development of new textile industries.

Other important factors that must be closely watched that will seriously influence the exportability of U.S. cotton are: (1) the foreign growth production situation, as we must compete regularly in cotton-importing countries with such growths, (2) the fluctuation of monetary exchange rates worldwide, most specifically the dollar against the currencies of cotton-importing countries, and (3) the man-made fiber situation, as cotton must continue to fight for market share of total fiber consumption.

OVERVIEW OF ENERGY INPUTS IN THE POSTHARVEST HANDLING SYSTEMS FOR HORTICULTURAL CROPS

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The postharvest handling systems for horticultural crops begin with harvesting and involve preparation for fresh market, cooling, processing, transportation, storage, and/or marketing. In all steps, proper procedures are essential for quality maintenance and minimizing postharvest losses between production and consumption points. Energy requirements for the various steps in the handling system vary by commodity, its prepared form for marketing (fresh, semi-processed, processed), and distance between production and consumption sites. The limited available data on energy use indicate that it takes 3 times more energy to process, package, refrigerate, and transport food from the farm gate to the home than it does to produce it (Hirst, 1974; Barton, 1981). The total energy used in food distribution is estimated to be 9% of the total U.S. energy consumption, and thus cutting postharvest energy costs can be significant in the overall effort of energy conservation.

Reduction of postharvest losses in quality and quantity of horticultural crops means saving of energy. This requires use of proper temperature management which is the most important tool available for extending postharvest-life of fresh horticultural commodities. Many technological procedures are used commercially as supplements to temperature and relative humidity management including the following:

A. Treatments applied to the commodity: curing of certain root crops, cleaning, sorting by maturity and quality, sizing, waxing, heat treatments, treatment with fungicides, use of sprout inhibitors, special chemical treatments (scald inhibitors, calcium dips, etc.), fumigation for insect control, and ethylene treatments for degreening and ripening of fruits.

B. Manipulation of the Environment: packaging, air movement and circulation, air exchange or ventilation, exclusion and/or removal of ethylene, modified or controlled atmospheres, and sanitation procedures.

All these postharvest treatments require direct and/or indirect inputs of energy but there are no data available on energy requirements for each of these procedures in the postharvest handling system. It is likely, however, that energy used for cooling and refrigeration is the largest single component of the total energy inputs in the system.

Preparation for Market:

In the past, strong incentives for mechanization and expanded energy use resulted from the relative cost relationships between energy and labor. Energy inputs for preparing a commodity for market include energy used for operating equipment and for manufacturing of waxes, fungicides, shipping containers and other packaging materials, etc. There are very few studies that deal with energy use estimates and identification of areas where savings can be affected. Naughton et al. (1979) estimated energy use in four citrus packinghouses and concluded that the four energy intensive operations were degreening/precooling, washing/waxing/drying, holding, and storage. Because of the large differences in handling procedures among commodities and even for the same commodity among various packing operations, an accounting for energy inputs and possible savings will have to be done for each operation.

Some of the recent trends and developments which may have an impact on energy inputs in preparation for market include:

1. Increased mechanization in harvesting, bulk handling from field to packinghouse or processing plant, and during transport to destination markets.
2. Changing from a packinghouse operation to a field packing operation for some commodities (lettuce, celery, cauliflower, etc.).
3. Increased interest in direct marketing (roadside stands; "pick-your-own", farmer's markets, etc.) of fresh produce.
4. Increased marketing of partially prepared fresh vegetables (cut lettuce, cabbage, carrots, etc.) for both institutional and consumer use.
5. Expansion of use of modified atmospheres in consumer packages, pallet shrouds, transit vehicles, and cold storage rooms for a wide range of commodities.
6. Reduction in the number of shipping containers types used to a few modular sizes each of which would accommodate a large number of commodities.
7. Increased use of palletization and slip sheets as a substitute for wooden pallets.

8. Increased use of returnable plastic containers for distribution of produce within a given organization or within certain geographic areas.
9. Use of new surface coatings such as "Prolong" on bananas and possibly other commodities and individual film wrapping ("Unipack") of citrus and other fruits may make it possible to ship such commodities under ambient conditions.
10. Use of ambient air and/or heat from the refrigeration system's condensor for surface moisture removal in citrus packinghouses.
11. Increased pressure for proper waste disposal and protection of the workers and environment.
12. Development of new methods for utilization of cull produce including production of methanol as an energy source.

Cooling and Storage:

Many postharvest handling procedures can be used to reduce energy consumption in cooling and storage. These include: harvesting during early morning, protection of the commodity from the sun during harvesting operations and transport, and removal of cull produce before cooling. Alternate cooling methods such as evaporative cooling, use of deep well water, use of high altitude cold air, use of ice formed in shallow ponds during the winter in some areas, and use of night air ventilation have been suggested for possible utilization for some commodities under certain conditions (Thompson, 1981).

Correct use of refrigeration in preserving perishables depends upon the efficiency with which cold is produced on the effectiveness of cold utilization (IIR, 1978 and 1980; Opila, 1980). Wasted energy, i.e., the total refrigeration effect produced by the compressors minus the cooling load of the product, can be minimized by: (a) adequate insulation, (b) use of better temperature monitoring and control equipment, (c) minimizing warm air infiltration and water vapor inflow, (d) proper maintenance of all equipment for operation at maximum efficiency, (e) use of lighting only when needed, (f) control of electrical demand to achieve the least expensive rates, (g) utilization of heat from the refrigeration system's condensor to heat water used for cleaning purposes or for heating adjacent areas, and (h) use of microcomputers for control of equipment operation, scheduling of stocking and removal of commodities, etc., to maximize energy efficiency. More information about cutting energy costs in cooling and storage will be presented by Bob Kasmire and Gordon Mitchell in two separate sections to follow.

Transportation:

Energy inputs in transportation includes fuel needed for transportation vehicles between field and shipping point and from there to wholesale or distribution centers (domestic or export). Additional energy is needed for operation of the refrigeration unit to maintain the cold chain during transit. Most fresh horticultural commodities (92%) were shipped by truck in 1979. The potential for energy savings in transportation will be discussed by Mike Reid in a separate presentation.

Drying:

Significant cuts in energy used for drying of horticultural crops can be achieved by modifications in currently used procedures or by using alternative drying methods. Following are some examples:

1. Improving efficiency of heated-air dehydration facilities.
2. Use of heated-air at 200° instead of 160°F for pistachio nuts speeds up drying and reduces energy consumption per unit weight.
3. Sizing prunes before drying improves dehydrator capacity since small fruits dry faster than large fruits.
4. Use of fuel from agricultural wastes to operate dehydrators.
5. Ambient-air drying of pistachios and walnuts.
6. Use of heated-air for partial drying, then ambient-air to complete drying.
7. Solar drying of various fruits and tree nuts.

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COMPARATIVE ENERGY COSTS OF COOLING METHODS

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The percentage of the total energy input (TEI) needed to produce, harvest, package, and cool fresh fruits and vegetables that is needed for precooling is small. Only 4.5% of the TEI was needed to cool summer cantaloupes an average of 30°F, according to Johnson and Chancellor (1978). Hydrocooling Florida sweet corn required only 0.8% of the TEI from production through cooling, according to Gaffney (1980). Even within these limited energy use estimates, there are opportunities for reducing energy use in cooling operations. However, the economics of any potential reductions need to be evaluated. Energy and economic considerations must be included in planning, design, operation, and maintenance of coolers to improve cooling efficiency (i.e., the amount of cooling obtained per energy input).

Planning: The product mix and types of products to be cooled, size and density of products, final product temperatures desired for each product, and the quantity of product to be cooled per unit of time must all be considered. The effects of packaging materials, their design and use, will affect cooling efficiency. Cooling method (CM) to be used will depend upon (1) the compatibility of the products to be cooled with CM's considered, (2) familiarity of management and operations personnel with CM's possible, (3) length of cooling season, (4) product storage before or after cooling, and (5) cooler locations.

Design: Factors affecting cooler efficiency include (1) type of refrigeration system available and/or used, (2) product exposure to cooling medium, (3) circulation rate of cooling medium, (4) exposure of cooling medium to refrigeration source, (5) length of cooling cycle needed, (6) product temperature measurement, (7) average maximum product heat load, (8) operations heat load, (9) labor requirements, (10) maintenance requirements, (11) operations costs, (12) size of cold room needed with cooler, and (13) initial capital investment needed.

Cooler Operation: This can be the key to the efficiency in limiting cooler costs and energy inputs. Knowledgeable, skilled operators are essential. Factors involved include (1) product temperature measurement before and after cooling, (2) use of cooling schedules, (3) labor and power costs, (4) product handling methods and costs, and (5) cooler operator's knowledge of the CM used, the specific facility used, and use of an operations manual.

Maintenance: This could be included under operations but it is identified separately to properly emphasize its importance. Maintenance factors affecting cooler efficiency include (1) operations checks before, during, and after cooling, (2) cooler cleaning, (3) safety, (4) periodic and annual maintenance, and (5) use of maintenance manuals. All of the physical features of a cooler must be properly maintained for efficient operation. These include refrigeration system components, cooling medium circulation components, conveyors, lubrication points, electrical system, doors and door seals, and flap doors. Unfortunately, some of these features are considered of minor importance and are inadequately maintained, resulting in market cooler inefficiency. Comparing the energy costs of various cooling methods would be futile without first knowing the energy efficiency of the individual facilities being compared, including effects of their design, operation, and maintenance.

Energy Costs in Cold Storage[1/]

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Energy costs in cold storage are largely a result of satisfying heat removal requirements. Sources of heat in the system are thus the first area of concern. Table 1 shows the primary heat source in a strawberry cooling facility.

Table 1. Heat input into a strawberry cooling facility.

Heat Source	% of Heat Input
Fruit	40
Propane Forklift	33
Walls & Ceiling	10
Fans & Motors	10
Lights	4
Air Leakage	3
	100%

Where cooling and storage occur in the same facility these relationships would hold true. In a cold storage operation without cooling, the percentages would change considerably from these values. The product heat input would be essentially that produced by respiratory activity (vital heat) -- just a small percentage of that involved in cooling. The forklift heat input would be greatly reduced because of the lesser frequency of product movement. Under these conditions then heat input through walls and ceilings, from equipment operation, and from leakage into the facility would become of primary concern.

[1/] The author is grateful to James F. Thompson, Extension Engineer, U.C. Davis, for considerable input into the background for this paper, and for providing Table 1.

Conventional Refrigerated Storage

In a conventional storage facility the heat input is accommodated by mechanical refrigeration that is available on demand. In such a system any reduction in that demand will proportionately reduce energy costs. If a significant permanent demand reduction can be made, then refrigeration equipment requirements can be reduced and energy demand charges reduced. Some important operational or equipment changes may be made in existing facilities that will affect energy usage. Some changes, however, may be possible only when constructing or drastically remodeling a storage facility.

Product Heat Load

If cooling and storage are combined, then the incoming product temperature will directly affect energy requirements. Because of the heat load of the product and of the loading operation, this will create a peak demand situation for the plant. Any reduction in incoming product temperature will reduce this heat load. If, for example, 30°F product cooling is needed, the product heat load could be reduced 10% by only a 3°F decrease in average incoming product temperature. This might well be achieved by better timing of harvest to cooler periods of the day, and by prompt movement from the field to the cold room to minimize opportunity for product warming after harvest.

Forklifts

The importance of forklift operation on heat load will depend on the duration of storage. In the strawberry example cited above, with only one or two days' holding, the forklift heat load can be almost as great as the product heat load. In long term storage, such as controlled atmosphere apple storage, however, the forklift heat load will be insignificant. Heat production by a propane forklift is high, typically about 75,000 BTU/hr, requiring 6.3 tons of refrigeration to remove. An electric forklift to do the same work would produce only about 15% as much heat (11,200 BTU/hr), requiring 0.9 tons of refrigeration. Use of the electric forklift in the strawberry operation would result in a net saving of electric energy plus a 100% saving in propane energy.

Walls and Ceiling

Under any fixed conditions, the heat load will be proportional to the amount of insulation, doubling the R value of the insulation will halve the heat load through walls and ceiling. In sun-exposed conditions, the color of the exterior walls and roof will also affect heat load. Light colors will greatly reduce surface temperatures. Dark, flat roofs create the most severe conditions, which can be improved simply by use of aluminum paints. On sun-exposed walls the estra heat load can be avoided by use of foliage for shade. These heat load problems will vary due to season and climate.

Fans and Motors

Air circulation is vital to temperature management of horticultural products. Normally fans, motors, ducts, etc. have been engineered for efficient operation. Many storage plants, however, especially those that cool and store in the same area, are designed with more air flow capability than is needed for storage. Storage air movement needs to be sufficient to remove heat leakage into the system and heat produced by equipment and by the product. It must be sufficiently uniformly distributed to prevent development of "hot spots" in the system. The ability to adjust fan operation during storage can result in net energy savings provided it is accompanied by good temperature monitoring.

Lights

The least efficient light source is from incandescent lights. The same light capacity can be achieved with mercury vapor lights with about one-half the energy. Even greater savings can be achieved with metal halide or high pressure sodium lights.

Compressor Efficiency

Compressors are designed to operate at 100% horsepower at about

95°F condensor temperature. This can be reduced if even lower condensor temperatures are achieved. In the Central Valley of California in the summer, however, much higher condensor temperatures may result. Water cooled condensors will greatly reduce the temperature, but water use is high and water costs may become excessive. Evaporative cooled condensors, however, are very practical and can greatly improve efficiency at minimum added cost. Despite maintenance problems associated with them, evaporative coolers should be considered under such conditions.

Reducing Peak Power Demands

More and more commercial users find themselves on "prime time" power rates that will multiply the base electric power rate as much as five-fold during afternoon hours. Thus anything that will avoid power needs during this period can greatly reduce energy costs. In a cooling operation product cooling can be timed to minimize power needs during this peak period. During storage, however, the power needs continue throughout the day. Certainly avoiding loading or unloading activity during peak hours will affect energy costs somewhat.

Some are considering the use of ice making equipment to accommodate a refrigeration reserve to carry through this critical time period. To my knowledge none are now in use. To accommodate this peak rate period of about six hours, energy demand during the balance of the day would be increased about one-third. This could, however, achieve a suitable net reduction in energy cost.

Alternate Systems

With continually increasing energy costs (especially those anticipated for electric power) the search for alternatives will intensify, and the economic use of certain alternatives may become more feasible. For certain commodities, locations, and handling situations, the potential of some alternatives already exists.

Evaporative Cooling

This method of air cooling can be useful for storage as well as for cooling if the dewpoint temperature is sufficiently low to allow temperature maintenance at a safe level. No matter how elaborate the evaporative system, the lowest achievable temperature is the air dewpoint temperature, usually between 50 and 75°F in California production areas through much of the harvest season. Thus only certain commodities could be safely handled with such a system.

Common Storage

This is an old system which utilizes cool outside air to maintain moderate storage temperatures. Buildings are well insulated (often built into the ground and ventilated to allow outside air movement through the facility). Coldest nighttime air is moved through the facility and vents are closed during the warm daytime hours to exclude heat. Storage conditions thus depend upon environmental conditions.

Underground Storage

At about six feet below the surface, soil temperatures are equal to the average annual air temperature for the area. Underground storage facilities can utilize this moderate temperature for storage (not cooling), but product respiration (vital heat) and equipment operation can cause some warming. Refrigeration may be needed to compensate for this introduced heat load.

Harvest and Storage of Ice in Mountain Areas

This was once widely practiced in California; however, transportation costs have increased faster than energy costs. This system remains uneconomical.

Storage at High Elevations

Air temperature drops about 5°F for each 1,000 foot rise in elevation. Thus at 5,000 foot elevation, day and night temperatures would be about 25°F lower than in the California Central Valley. Because much of the California production is transhipped over the Sierra Nevada mountains to eastern markets there might be a potential to incorporate such mountain storage into the handling system. Because the dewpoint temperature is also lower, use of a rammed-air evaporative cooler on the transport vans could allow extensive cooling enroute. Night temperatures might allow common storage, or at least minimal refrigeration to be used.

Future Needs

In considering alternatives, one must keep in mind the expected trends in energy costs. Electric rates have been increasing rapidly and are expected to continue a sharp rise. Peak-hour premium rates are expected to be a continuing reality. Oil prices, which have risen sharply in past years, are expected to remain relatively stable for the next several years, barring further severe political or military upheavals in the Middle East. These trends suggest the need for a serious review of all aspects of the storage operation to achieve best energy efficiency and lowest energy cost.

REDUCING ENERGY USE DURING TRANSPORTATION

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For Californian perishable products the energy required for transportation is a major fraction of the postharvest energy cost, accounting for from 0.3 to 0.6 of the total energy used in the production, handling, and distribution systems. Reducing the amount of energy used in transportation has been the subject of a good deal of study, and this presentation will draw on research and practical experience of university and industry personnel throughout the U.S. A number of approaches to decreasing the energy cost of transportation will be addressed.

1. Modal changes

The energy cost of different transportation modes differs widely, air freight, for example, being 100 times as costly in BTU/ton mile as transportation by water. The most common mode of transportation, motor truck, uses more than three times as much energy as transportation by rail. The "piggyback" combination of the low cost of rail transport and the flexibility of road transport is already becoming an inportant mode in the transportation of some perishables. Novel transportation methods, such as pipelines and dirigible airships are the subject of much interest because of their potential low energy use.

2. Improving energy efficiency of present transportation modes

Approximately 7% of all the petrochemicals consumed in the U.S. is used for intercity commodity transport. 69% of this is used in truck and rail commodity transportation. Accordingly, any reduction in energy costs of transportation by truck can have substantial effects on the postharvest energy cost, and on the nation's fuel supply. Recent reports have suggested that s?vings of up to 25% of the energy cost of long distance freight can be achieved by adopting the following modifications.

a. Reduction in aerodynamic drag At highway speeds, aerodynamic drag accounts for approximately half the fuel consumed by the vehicle. A typical rig travelling at 55 mph requires 130 horsepower to overcome aerodynamic drag alone! Air deflectors fitted to the front of the vehicle can reduce the drag sufficiently to cause a 4 - 8% savings in fuel consumption.

b. Reduction in rolling resistance As with domestic motor vehicles, the fuel economy of freight trucks can be improved by substituting radial ply tires for the traditional bias ply tires. This is due to the decreased energy lost in sidewall and tread flex, and in resistance to the road surface. Fuel utilization can be improved by up to 6% (some users report 12%) by changing to radial tires. Although the tires are more expensive, they have fewer punctures and can be re-capped more often.

c. Power train modification Substantial reduction in horsepower requirements must be translated into modification of the power train so that the engine continues to operate in the most efficient range. Modifications to the power train include the use of fan clutches, reduced horsepower, high torque rise engines and reduced rear axle ratios.

d. Regular maintenance and driver education Maintenance on a routine basis is essential to keep equipment operating efficiently. Driver education and incentives can improve gas mileage by as much as 1 to 3 mpg (a 20 - 40% saving!). Tachographs can monitor driving habits, and automatic devices can switch off idling engines.

e. Route planning, multiple trailers and palletization Careful planning of routes and construction of loads can result in considerable energy savings. A 10 - 15% reduction in transportation cost can result from carrying commodities in double or triple semi-trailers. Computer techniques can assist in the routing of trucks to minimize road miles. Palletization of loads can reduce idling time at drop-off points.

Overall, a considerable saving in energy cost is possible using these various approaches. At the present price of fuel (say $1.00 per gallon), a typical semi-trailer operated over 100,000 miles per year would use fuel costing $20,000. A 1% fuel saving for such a vehicle would therefore save the operator $200 per year. The 25% which can readily be saved using some of the techniques mentioned above would represent a saving of $5,000 per vehicle!

3. Reduction in losses of transported commodities

Perhaps the easiest savings in energy use during transportation could be achieved by minimizing losses of product during the transportation period. For perishable products this means proper precooling, pre-tripping the trailer to ensure efficient operation of the refrigeration system, careful handling to reduce physical loss, and proper stacking and dunnaging to ensure adequate air circulation through the load. Bottom air delivery, which has long been used for transportation of perishables by sea, is now becoming available for road transportation. In one system it is combined with an atmosphere control system which may substantially improve the quality of some transported commodities.

4. Reduction in transportation distance

It may be that the cost of long-distance transportation (for example from California) may become so high for some commodities that their production will shift nearer the centers of consumption. A good example of this is the nursery industry, whose product is not only voluminous but also heavy. Already, wholesale nursery production is increasing in States on the Eastern seaboard, supplanting materials previously produced in California and shipped to the East by truck. This trend will only be reversed if Californian agriculturists take every opportunity to reduce transportation costs using the techniques outlined above and others still in the research and development stage.

ENERGY CONSERVATION IN PROCESSING OF AGRICULTURAL CROPS

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Within California the food preservation industry ranks second (after sugar beet processing) in energy consumption among the various food and kindred products industries. A comprehensive research program was initiated at University of California, Davis in 1978 to identify the major energy intensive operations in the food canning industry. In addition, attempts were made to develop energy conservation procedures that can be readily adapted by the industry. This paper provides a summary of the results obtained to date. A more detailed description of the project and results is provided by Singh *et al*. (1981).

RESULTS AND DISCUSSION

Spinach Canning

Energy consumption data for canning spinach was obtained for several shifts. The results indicated that three operations namely, blanching, exhausting and retorting consume 98% of the total energy consumed in processing spinach in the cannery. Thus for energy conservation, evaluation of these three operations is necessary. Any major modifications of other operations such as receiving, dry-reel cleaning, washing, sorting, filling, seaming and palletizing will have negligible impact on energy conservation.

Peach Canning

Studies on energy consumption of canning clingstone peaches showed that lye-peeling and retorting are the major energy consumers in processing of peaches (Carroad *et al*., 1980). Thermal energy accounted for 98% of total energy consumed during an 8-hour shift for the various unit operations. Electrical energy use for handling waste water or boiler operation was not included in the above analysis.

Tomato Canning

Similar to peach canning, 99% of total energy consumption was by two unit operations, namely lye-bath peeling and retorting. Analysis of data obtained for manufacturing of tomato juice identified hot-break heaters and retorts as most energy consumptive, accounting for 98% of total energy consumption (Singh *et al*., 1980). For production of tomato paste, Singh *et al*. (1980) identified hot-break heating and evaporators as leading energy consumers.

The results from above studies identified five unit operations that are leading energy consumers in canning of fruits and vegetables. These five operations namely, blanching, heating (for hot-break of tomatoes), peeling (in lye-baths), concentrating (in evaporators) and sterilizing (in retorts) must be carefully evaluated to develop modifications for energy conservation.

Additional studies were conducted to develop energy conservation modifications of atmospheric retorts. First, an energy accounting study was conducted to determine the thermal energy efficiency of a conventional atmospheric retort. Next, a hardware modification was developed and additional data were collected to study its influence on energy reductions.

Atmospheric Retort

A continuous atmospheric retort with a rated capacity of 126 cans/min for processing whole peaches was monitored for steam consumption and mass flow. The results presented in Table 1 indicate that only 20 to 32% of heat supplied by

TABLE 1. Energy Use in a Continuous Atmospheric Retort Under Conventional Operating Conditions

Test #	Can flow Rate can/min	% max loading rate	Steam flow kg/hr	% heat into can
1	58	46	1216	20
2	77	61	1302	26
3	83	66	1476	24
4	100	79	1490	29
5	103	82	1407	32
6	104	82	1466	31
7	109	87	1565	31

steam actually transferred into the cans. The remaining energy is lost through several paths. At 80% loading rate the energy balance indicated that whereas 30.5% of energy emobdied in steam is transferred to cans, 5.1% leaves with condensate, 6.7% is lost from surface due to surface radiation and convection and 57.7% is lost due to incomplete steam condensation in water inside the retort (Chhinnan _et_ _al_., 1980). The incomplete steam condensation is due to small residence time and small temperature differential between steam and water. The uncondensed steam escapes through the can inlet and exit portholes. The loss of excessive amount of uncondensed steam indicates that modifications to improve steam to water heat transfer should be emphasized compared to other energy conservation modifications such as use of insulation to reduce surface heat losses which are relatively small.

Atmospheric Retort with Water-Recycle

As discussed earlier in this paper energy-use efficiency of atmospheric retort is low. The major cause of this low efficiency is incomplete steam condensation. The steam spargers used in these retorts result in poor energy transfer from steam to water. Chhinnan et al. (1978) have presented a water recycle system that allows for a more efficient energy transfer. The system involves use of a shell and tube heat exchanger located outside a retort. In the retort Energy-use data for the water-recycle retort is presented in Table 2. These data show dramatic improvements in energy-use efficiencies. The water-recycle system has resulted in substantial savings in energy costs to canneries that have converted atmospheric retorts to this system. In addition to elimination of "incomplete steam condensation," the water-recycle system has a more uniform steam requirement compared to the wide fluctuations in instantaneous steam demand of a conventional atmospheric retort. As a result the total load on the boilers is low for water-recycle system since peak demands are low. Problems associated with boiler carry-overs that cause can spotting are also eliminated in the water-recycle system.

TABLE 2. Energy Use in a Water-Recycle Continuous Atmospheric Retort (Chhinnan et al., 1978)

Test #	Can flow Rate can/min	% max loading rate	Steam flow kg/hr	% heat into can
1	42	33	683	26
2	43	34	681	27
3	61	48	672	37
4	70	56	812	38
5	74	59	832	37
6	96	76	962	45
7	108	86	999	48

CONCLUSIONS

1) Energy accounting of canning of spinach, peaches, tomatoes have identified blanchers, hot-break heaters, lye-bath peelers, retorts and evaporators as the leading energy consuming equipment.

2) Atmospheric retorts modified with a water-recycle system show dramatic reductions in energy-use.

TRANSPORTATION

Energy forms are essential production and processing inputs for fruit and vegetable foods. Diesel, gasoline, LP gas, natural gas and electricity used for all agricultural production, transportation and processing represents 5.1% of California's total annual energy use for recent years. Also, 20.5% of this agricultural use is required for the production of fruits and vegetables. A significant factor in influencing production and processing of fruits and vege-
Eliminating most of the cull and off grade fruits and vegetables in the field instead of hauling them to processing plants and then hauling them for disposal

would signficantly reduce diesel fuel for hauling California's 10,371,000 tons of vegetables and 6,379,000 tons of fruits.

In a study with peaches and pears it was determined that close supervision and procedures for hand pickers and for sorters on harvesters would result in 40% reduction in culls. This reduction of peach culls would amount to 23,000 tons or 918 double trailer truck loads each weighing 25 tons each traveling an average of 290 miles per round-trip. Leaving these culls in the field would reduce truck hauling 266,220 miles and would save 54,330 gallons of diesel fuel annually. Similar data for pears show a 40% reduction, and hauling culls would amount to 257 double trailer truck loads traveling an average of 300 miles per round-trip. Leaving the pear culls in the field would reduce truck hauling 77,100 miles and would save 15,734 gallons of diesel fuel annually.

There are approximately 6,000,000 tons of tomatoes processed each year in California. There is approximately 14.4% loss between the field and the processing line. Calculations show that reducing this loss to 9.4% by not hauling it from the field would result in 30,000 tons or 12,000 truckloads traveling 140 miles round-trip representing 1,680,000 miles and 342,860 gallons of diesel fuel that could be saved annually.

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ENERGY COSTS OF RICE DRYING

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The methods of rice drying have passed through several stages. In the early years, 1913-1929, of rice production in California, rice was tied in bundles and the bundles were stacked so as to protect the grain from sun, rain, and dew while it was drying in the field, utilizing the energy from the sun. The grain was threshed in stationary threshers and sacked when it reached a moisture content safe for storage. It was stored in sacks and if the moisture content was too high, the sacks were stacked in storage so as to continue drying or they were stacked on a "pot hole" dryer to complete the drying process down to 14% moisture. The sacks were then put into dry storage until needed for further processing.

In the late 1920's and early 1930's, a method called swathing was popular for a few years when combine harvesters entered the picture. The rice was allowed to dry in the windrow down to safe storage moisture (14% moisture w.b.) and harvested with a pickup header on the combine. Thus, rice in the early years was dried by the sun and air movement in the field and the only energy inputs were those management costs associated with handling the rice prior to threshing.

In the early 1930's, the first column rice drier was introduced from Italy and with it came the opportunity to harvest mature rice at higher moisture content which helped in the search for higher quality rice. Much was learned about how to use the rice drier. It was determined that highest quality could be maintained through multipass drying with higher temperature air and short exposure times. Rice could be harvested at 22-25% moisture and head rice (lbs. of whole kernels per 100 lbs. of paddy rice) would be higher than if allowed to dry in the field. It was a faster harvest and required much less manpower. Energy costs were very low and various types of fuel were plentiful. This method was generally in use in the late 1930's and early 1940's. The rice was still being handled largely in sacks from the combine to the dryer. Bulk handling was being used in the warehouses and mills, but it wasn't until the middle to late 1940's when bulk handling from the field to dryers became popular. All through the early years of commercial drying, the costs for drying were 20-25¢ per 100 lbs. This price moved upward as fuel prices, construction costs, and labor costs began climbing during World War II. By 1960, drying charges reached 35¢ to 40¢ per 100 lbs. Much of this cost was for amortization and labor costs with fuel costs in the neighborhood of 35¢ per 100 lbs.

One practice, which seems unfair today, was to charge a flat rate per 100 lbs. of paddy rice regardless of the moisture content. Thus, a 100 lbs. of paddy at 25% moisture would cost the same as 100 lbs. of paddy at 15% moisture. This meant that the higher moisture rice only cost 10% more than the 15% paddy rice, but 10 times as much water had to be removed. This practice has been in effect, for the most part, until 1981, when some dryers began adjusting charges for different moisture content. This has been brought about by all types of increasing costs, including energy, labor, and new construction. The largest increase, of course, is in energy costs.

With the rising costs of energy experienced over the past few years, and the need to handle ever increasing production of rice, it has been necessary to build new facilities at ever increasing costs. Most drying facilities only partially dry the rice in column driers from 20 to 26% rice down to 17-18% moisture content. Then transferring to deep bed drying in bins or rectangular flat storage where natural unheated air is circulated through the rice when the relative humidity is less than 82%. This reduces the overall requirement for energy by using electric motor driven fans.

Some growers have dried all of their rice on the farm in bin driers at substantial savings in energy and dollars expended. A few growers seeking alternatives are going back to swath or windrow harvesting to reduce their energy costs for fuel and electricity. A reference to an inverted windrow produced by one early pioneer in the early 1930's or late 1920's gave us an incentive to test the advantages of this technique by hand windrowing rice in two ways. One was windrowed so that the grain heads were all exposed to sun and dew, and the other was inverted so that the stem end of the plant was exposed with the grain heads all covered and not exposed to the direct sunlight and dew. The results were remarkable. Exposed heads deteriorated in head rice rapidly (within a few days) where covered heads maintained or increased in head rice during a two week period. There seemed to be a great deal of tolerance to varied weather conditions, however, heavy rains can produce an unsatisfactory condition if grain must remain in the swath for very long.

Early season harvest (before October 10) appears to be the best time for using this technique and we still must develop a swather not available at this time that can produce an inverted windrow. If we can do it by hand, we ought to be able to do it mechanically. One grower swathed a large acreage in 1980 and a larger acreage in 1981, but only waited 48 hours to get the moisture from 29% down to 21%, but a single pass through the column drier was needed and the rice then went into deep bed finish drying with a large saving in energy costs. We have some work ahead of us, but it looks like partial if not total rice drying can be done in the field on early harvested rice. The result - large savings in energy useage in rice drying.

KEEPING AGRICULTURE PROSPEROUS
JANUARY 28, 1981

"The Role of Financial Institutions"

by

C. Gallagher, Vice President
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The primary role of a Financial Institution is to hang in there - during the good times and the bad. Farmers and ranchers have been faced with the proverbial cost price squeeze since 1950. Increasing land values have, primarily, provided the additional equity and support for the increase in agricultural debt. Historically, we have turned to agricultural land equities during periods of high cost and low returns. Long term loans were generally available at low fixed interest rates in the past. Now that long term rates have reached historically high levels, agriculture will face new challenges. Long term loan rates will float with the lender's cost of funds. A positive note is that lenders committed to agriculture will continue to have adequate funds available for agricultural lending.

Volatile commodity prices and increasing production costs are still with us. Today volatile interest rates have added yet another burden to challenge the producer's management skills. Growers and bankers alike must now fine tune their risk management approach.

Interest rates and commodity prices are the most discussed items in loan negotiations today. Projecting even short range interest rates and commodity prices is extremely difficult. Therefore, it is important that the grower and banker communicate their plans for 1982.

Faced with the continued inflation of production costs plus volatile commodity prices, it will be difficult to balance the 1982 projected crop budget. All should remember that budgets are only a projection. Who knows, interest rates could be down and commodity prices could be higher by the end of the 1982 season. To help balance the 1982 budget, farmers should consider the following items:

- Continued close control of crop production expenses. This has been the major cause of the cost price squeeze. But don't cut productive investments that give above average yields. It takes these above average yields to simply pay back the higher production costs that are projected in 1982.
- Review projected purchases of land, equipment and other fixed assets. The source of funds for these long term investments generally involves long term debt. Lenders usually charge higher interest rates for term borrowing. Term credits with fixed interest rates are a thing of the past. Today most lenders use variable floating rates. On the positive side of the coin, the new tax laws may provide benefits that offset higher interest rates. All investments should be penciled out and reviewed with your accountant and/or tax advisor.
- Drawing loan funds as they are needed will help reduce interest expense. Most suppliers now charge carrying charges. Delay in payment to suppliers may be costly and add to total expense.
- The timing of income from a sale of crops can help curtail interest expense. Each producer's tax position must be taken into consideration. Delay in sale or income from crops adds to interest expense or reduces possible investment returns.

Interest rates charged to farmers have been reasonably stable among agricultural lenders. The agricultural lending rate of many lenders has been below commercial prime rates most of the time for a number of years. However, historically, agricultural rates have been higher than commercial prime. As prime rates decline, producers must be prepared for a shift in their rates, relative to prime. If prime continues to fall, floating agricultural rates will once again be above prime. The borrower who changes lenders to obtain a temporarily lower yet more volatile prime based rate may later find they have made a long run management error. Farmers cannot expect the best of both worlds. Stable agricultural interest rates require a long term commitment on the part of the farmer and banker alike.

The grower and banker must maintain clear communications to assure proper loan structures and utilization. Both should keep in close touch with any sources that communicate interest rate movements for both short and long range loans. Competition and volatile interest rates has placed new challenges on ag bankers. Besides staying atuned to the money markets, the banker has found it necessary to find new methods of filling agriculture credit needs. This requires both imagination and creativeness.

Next to interest rates, commodity price volatility is one of the hottest issues in the farm community. While some talk of gloom, others turn to positive action. Understanding the commodity markets is one of the major elements of success in agricultural risk management.

Possible steps to consider to minimize risk during periods of volatile commodity prices are as follows:

- Study the markets on a local, regional, national and worldwide basis.
- Consider hedging or forward contracting as possible vehicles for locking in commodity prices. Know the difference between hedging and speculating.

- Understand that it is nearly impossible to hit the topside of the market every time. If you don't hit the top, remember that your goal was to lock in a reasonable profit. Many times it's best not to look back.
- Rotation and diversification have always been sound risk management tools. Future crop plans should not be based totally on today's prices.

Agricultural finance requires teamwork. Two opinions are usually better than one and farmers should consider their banker as an important team member in the production of food and fiber.

As farmers look to 1982, they should communicate with their banker. More time must be spent in a mutual search for ways to plan for the risks they both face. A recent article in the Journal of Commercial Bank Lending added four new "C's" to the requirement for a good financial services officer. They are: Commitment-Creativity-Consistency-Contact. All of the C's of credit come together with true communication.

Keeping Agriculture Prosperous

"The Role of the Farmer"

Donald A. Rosendahl, President
Fresno County Farm Bureau

Good morning, I am a Farmer.....I guess the end-product of what this gathering is all about, I've spent my lifetime in farming here in Fresno County and I've seen a lot of change and innovation in the past 30-years. Most of it good....some of it not so good. And, that's what I'm here to talk about, being on the firing line....as the person who has to deal with local, state and federal regulations gets tougher every year. Perhaps, this frustration is summed up best in a little saying known as the Farmer's Creed. "WE THE WILLING, LEAD BY THE UNKNOWING IN WASHINGTON (AND SOMETIMES SACRAMENTO) ARE DOING THE IMPOSSIBLE, FOR THE UNGRATEFUL. WE HAVE DONE SO MUCH, WITH SO LITTLE, FOR SO LONG, THAT WE ARE NOW QUALIFIED TO DO ANYTHING....WITH NOTHING!"

Someone asked me the other day how many different agencies I have to deal with in my day to day farming operations....it took me a minute....in fact several, but I finally settled on approximately 10-separate agencies I'm required to deal with regularly on the local and state level. Of course that doesn't even begin to take into consideration the federal alphabet soup of agencies I also must deal with, although a lot of our state agencies are patterned along the same lines, so there's some repetition and we don't have to deal directly with a great many at the federal level...we just have to know what most of the rules are.

I was also asked what was the biggest pain and burden among these agencies, and I think without much question, because I AM a diversified grower, it's the permit process at the county level for restricted materials, at least on a daily basis.

Anytime you have to use a permit you're in for many problems. I recently completed a dehydrator through which I process prunes and raisins, and thinking back on that project the air pollution people gave me the hardest time in getting a permit to S02 gas in the operation of the dehydrator.

It ends up taking over five months and many thousands of dollars, cost of hiring environmental, highly environmental assessment companies to model, to prove that I was in violation of the clean air act, and that would emit too many grams of S02 per hour. And then the cost of the money going up the difference between what it was when we started the project and when we finished the project as far as the loan process goes was tremendous. The increase in cost of the building materials in that five month span were tremendous, I figure the interest in the building cost alone we have spent an extra $250,000 to complete the project of the dehydrator project of 16 tunnels and 18 sulfur houses, because of the environmental regulations for air quality. A quarter million dollars in extra costs, because of the delays, approval, permits, testing, and all the rest.

How can I, as a grower, justify all that and how am I going to recover it?

Well, you certainly can't recover through the product, all you can hope is that is can take another few years of good management of your dehydrator to make the thing pay, there's no other way of recovering, it's impossible. It's just not built in, you can't ask more from your product, because you're just not going to get it.

On the other side of the coin, it makes you have to be a better farmer?

No question of that, it's getting to the point now where you've really got to be on top of everything you do, it's so easy for it to get away because of the cost. In the years past of being a farmer, some of these things we didn't really watch that closely, but now all of a sudden the costs are so great that you know with just a little bit of mis-management that whole crop for the year could be a lost situation, so you really have to be on top of these things with your labor, everything that you do, to make sure that it's handled properly.

Well, there's a lot of men who would not be able to afford these delays and costs because it takes a terrific amount of financing to do these things. A lot of them would probably not have the guts to go out and do it. You almost have to be stupid sometimes to attempt these things because of the chance of failure, the chances are so great that you're really sticking your neck out on the chopping block when you do. Anytime that you know that we have these situations I think it hinders all of agriculture, it's going to affect the economy of agriculture all the way down the line. Why did it take five months to get the process approved for one structure, one operation?

Well, probably because nobody knows what they're doing. I'll kind of give you a review of what happened. I applied for the permit through the company that was going to build the dehydrator. I think we spent $100.00 for the permit, or the application of the permit. These guys sat on it for 30 days, I guess it was, thinking about it. And then at that time they called and said hey, there's a problem, we're not going to be able to go with this thing. We think there's too many other dehydrators in the area, there's too much SO_2 being put into the atmosphere and we're going to have to go through a whole modeling and a whole hearing process on it. So, we went in and talked to them and hopefully we convinced them that we should and could make the project work. They posted the notice in the whole area, on power poles, in the paper, and everything. We had 30 days waiting period for that if there were any complaints. We had no complaints at all, until the last day of the 30 day process. And that complaint was issued by the State of California. Up to that time the county had already done its modeling and submitted the information to the state and the modeling showed that it would be OK, that we would meet the requirements. The state certainly could have done this the first few days of the hearing, but they waited till the very end of it. Said no we don't believe you in Fresno County, we don't believe the modeling is correct. We want it done over, or we're going to do it ourselves, because we don't think that you are right. Well, I don't know what in the world the local air pollution board is for then, I think that it's a waste of taxpayers' money, just a process of slow-down, and it costs everybody a bundle because of it, but the state air quality told the County that they didn't believe it. So, I went back in and talked to the county and I was pretty upset over it at that time, went back in and talked to all the people involved, asked them what in the hell their job was. How they could even justify their existence if the state wouldn't even believe them. They got pretty upset when I made that statement that's when they closed the doors, so nobody else could hear. And then we went on arguing and talking about it and finally one of the head men, the head sanitary engineer, said I want you to come up to my office and we're going to talk. We won't talk anymore here. So I went to his office and he told me, now if you want this, if I were you, if you want this project to go, I would contact a private company that makes environmental assessments for air quality and they would do their own modeling on it.

Now you have three entities, you have county, the state that filed an objection, and now they are telling me to go and find a private company. Hire this company to do some modeling for me and hopefully this would prove the results, we could prove to the state that the project was OK. So I went to this private company, they gave me the names of three of four companies in Houston, Texas and all around the country. And I picked one in LaJolla, California. And I was told these costs would probably be around a $1,000 to me, to do this type of work. So, I contacted the company, the people came up, they went to the Air Pollution Control Board, they got all the information they needed from them, they got the information they needed from me to make the modeling and when they finished, they showed that we were in violation of the clean air standards. In the meantime, the cost had gone from $1,000 to well over $4,000 just to get this modeling done. So, then we presented this to the county and the county at that time said no, we don't think we can issue the permit because it really looks bad. Well, then as time went on, they found some discrepancies in the information they'd given, discrepancies in the information that was put into the modeling. I also made some changes in the amount of SO2 gas that was required per ton and after another month or so of fighting we finally had a letter sent by these people recommending to the State of California that the project go ahead with all the results from the private modeling. And finally the permit was issued after five months of work. One of the big disappointments of the whole thing was meeting with the head sanitation engineer in his office, which was a lttle pigeon hole at the top of the building. A man came in with a suit on, took his shoes off, sat there, very cold type of person and if you wanted to talk to you you'd have to sit and crack walnuts with him out of a bowl of walnuts and almonds, and he had two hammers and the first thing when you'd talk he'd say, "Well, lets pop a nut together." So, you'd have to sit there and crack walnuts or almonds when either one of you talked to him. It was one of the most horrible experiences I've had with any agency as far as a permit process goes, it was a very emotional experience and I hope I never have to go through it again.

In all, it took five months for the permit while I had anticipated probably 30 to 60 days MAXIMUM!

During this five months' time, I couldn't build anything? Couldn't pour cement, put in electric, plumbing, anything?

We just sat!

And, lost at <u>least</u> three months, if not more.

We were on a line in time, but what really happened there, the real hurt came, that's when the money crunch hit and the interest rates went sky high. And if we had been able to do our financing at the beginning of our process, we would have saved quite a few points in interest. We did it through the Federal Land Bank, and of course they couldn't start any financing until we knew the project had permit to go. So the thing just hung there and it wasn't their fault it was just the money crunch that hit and we got caught in the middle of it, and that's where the biggest part of the increases in the cost of the dehydrator came from was because of the increased interest rates, and also there were some pretty substantial increases in concrete and other things at that time too because of the money crunch, so I figure the whole project cost at least a quarter of a million dollars more than it should have cost, if we had been able to do it on time. They now every year come out and inspect, ask questions, they walk around, looking and sniffing and we have to submit the amount of green tons that go through it, we have to tell exactly how many pounds of SO_2 gas we put into the tunnels or into the sulfur houses. One beautiful example of these people not knowing what they're doing is a few years previous to my application or probably a year previous to it any new dehydrator that was built that had sulfur houses to make golden bleached raisins the owners were required to put a scrubber in to scrub the air from these sulfur houses. So there was nothing released into the atmosphere. This was a cost of $25,000 for each dehydrator to put this scrubber in. Then all of a sudden, when we got ready to build ours, they decided the scrubber was no longer needed, that the problem really wasn't in the sulfur houses, the problem was the sulfur leaving the dehydrator as the raisins were dehydrating. So, that's the new angle that they came up with. I'm glad that I didn't have to spend the $25,000, but this is showing the inconsistencies and how screwed up they are that they demanded this and then all of a sudden they abandoned this, saying no this is not right, we were wrong, that really has come from over here and all these guys that have spent these thousands and thousands of dollars doing what they were required to do to get a permit and then all of a sudden saying we were wrong you really didn't need it after all, this is the problem we can't put a scrubber over here so now we don't know what we're going to do, we're not going to give you any more permits, is really what it amounted to. After going through the whole process, I really believe that some of the things that I was told were not true, I really believe that their job, or what they set out to do was try to discourage me from going through with it, I'm convinced of that, I don't think the state had a big a part in it as what they are trying to make me believe. Another thing that really burnt me up was that the head engineer told me that if I had been in Madera County and I had requested the permit in Madera County, I would have had it within 60 days. But being that it was Fresno County it took longer. And to me that's just something that we cannot tolerate that kind of stuff. You can do it up there, and you can do it in Tulare and Madera, but you can't do it in Fresno? So it boils down to the fact that the head sanitation engineer, I think, was the person who put the cabbash on the whole thing. He is the one man who had more to say than any of the head people here in the air pollution control board office. None of them had near as much to say as this head sanitation engineer, he's the man that stopped the whole project, he is completely responsible for everything that happened, I'm convinced. The one I call the nutcracker.

In my total operation, permits for restricted materials are the biggest day to day problem. Of course, I have a little bit of everything, grapes, treefruit, prunes, cotton, strawberries and boysenberries that just seems like a terribly frustrating process to go through this. These regulations change so rapidly that they're hard to keep up with.

It's hard to put a dollars and cents figure on these type of things. I know that my secretary puts a lot of time into this, my foreman spends a lot of time now, more than before, in the office. In fact, he spends several hours a week in the office now trying to keep up with this stuff and to do it right. What's required of us. We had an experience last spring when we planted our cotton. We were planting cotton in between our young prune trees,which are not in production. We used a material planted with the seed, it's a systemic, I can't remember the name now. Anyway, we applied for a permit to apply this with our planting seed.

So we put our intent in on Friday afternoon for planting Monday morning. They are supposed to go out and check the fields before and if there is any problem with it they are supposed to contact you, that's what the 24 hour period is for. Well, I guess being that it was a Saturday or a weekend coming up, nobody did anything so Monday morning we're planting cotton and we're putting this insecticide in. And my wife gets a telephone call from the inspector that's supposed to be looking at this ranch, he wants to know where it's at, he can't find it, well we had the location down exactly, but he says there's nothing there but trees. My wife says that's right, we're planting cotton between the trees. And he went into orbit, "You have violated all kinds of laws, you can't do this, it's going to, systemic is going to go into the fruit." We said there is no production, they are young trees, there's no fruit on them, there's not going to be any fruit on them this year, and there probably won't be hardly anything on them next year. "Oh, it's wrong, you can't do it, you're violating the law" and he went on and on and finally he backed off of it and let us continue to do it, but it's just another example of how screwed up they are and I guess they probably don't have enough help to do what they really need to do, but it's just another frustration that we have to go through. Very costly and aggravating.

Other regulations that I have to deal with are the wage and hour regulations as a grower and again because of diversity and the kinds of operations I'm doing from pruning and tying vines and trees to bushberries to strawberry beds to dehydrator work, harvest crews and people at the dehydrator, I've got a library full of rules and regulations when it comes to wages and working conditions, things of this nature.

It's a problem in our operation, not only mine, but in anyone's operation.

I employ somewhere in the neighborhood of 400 different people every year, mostly harvest part-time. In the grape harvest we employ a little over 100 to 125, the other harvest we hire a certain amount and then the boysenberry harvest we hire several hundred more, but they are all pretty short periods of time. But we have so many rules and regulations as far as the wage orders go, for instance, the dehydrator if I was to do any commercial work in there for another person, then we fall under wage order 13, which has a lot of other rules and regulations that you have to follow as far as hours go, it's difficult to keep track of it right, it's impossible to tell your employees why you're doing it because you're working under a different order just because you're doing some work for somebody else and not your own.

It's impossible to explain to your employees why they can only work so many hours and rather than wage order 14 where they can work different hours. 14 you can work 10 hours, 13, 8 hours. And you cannot explain to these people, they become very upset with you, they think you are trying to pull something on them, they just cannot accept the excuse that well I'm doing this and getting paid for it, so now you have to do this, and you're not getting paid for it anymore, so now you have to do this. It's very difficult for them to understand and it's very difficult to keep our books correct. And to make our proper pay schedules, having to put up with these two wage orders. Also, in the problem under wage order 14, of the harvest crews, when you're harvesting grapes you don't take off on weekends because it's their day off or overtime for it. You have to continue to harvest, you can't stop with the dehydrator, you have to run it 24 hours a day and you have to harvest 7 days a week. So you have your harvest crews and they are all working piece work and by law they all have to have, you can't work them over 10 hours of that overtime, you can't work them seven days without time and a half. And it's so difficult to keep track of your crews, who's had a day off, because during the week you're continually a day off and you're having to replace somebody else on the picking crew to make up for them and it's an almost impossible task to try to keep your records straight so that the IWC ever came down on you that they could understand it and you could prove that you were not in violation. I think that it is almost impossible to do it legally, I think that you would almost have to falsify your records to make it right, so you could prove that you were correct. I don't think that there is any other way of doing it, it's that big and cumbersome burden of keeping track of it.

I feel a double frustration about this because I served on the Industrial Welfare Commission when these wage orders were made and settled.

I keep thinking about all these things, all the rules that we supposedly made and recommended, but they're not made that way because agriculture wanted them that way, they were made that way because we had no say. All we can hope to do out there on the ranch is do the best we can and keep our fingers crossed that somebody doesn't come down on us or some employee doesn't complain and create some problems that are going to end up costing the grower thousands and thousands of dollars in fines and back pays and things like this, because you cannot prove exactly what went on. And, unless you can prove and prove without any doubt that you followed those regulations right down to the crosses on the t's, & if you can't prove them then you are going to be fined and you're going to have a big, big problem.

If you are going to make sure that you have those records accurate enough to where there is no question, you need a bookkeeper in the field. You certainly would, if it creates so many problems as far as the harvest crew is concerned, because there are so many guys that want to take off half days, etc. Then the first thing you know, they have worked their seventh day and they get hung up to dry on it, so it's really a very big problem and you probably have to keep half a crew of people around just to take up for the slack if you were to keep your records that accurate.

Suppose somebody said, can't you solve this problem by just hiring just a work crew to work, say, one crew to work four days a week and the other crew to work three days a week?

You could do this if there were enough people, but this past season in our harvest, I'm sure everybody knows that we were very, very short, very, very close, there were a lot of areas that had some very serious problems as far as not enough help to harvest and there is no way that these people will stay with you if you were to restrict their hours like that, they wouldn't work, they are going to go someplace where they can get the job and they can work everyday. Everyday that they want to work. They are not going to sit around and have you tell them that they can work today, but you can't work tomorrow. It just doesn't work that way.

A situation that I'm leading to didn't result because of too many rules and regulations, it resulted because there wasn't enough help, there was a situation I had in your boysenberry crop that was mostly because of the Border Patrol activities. This year in the boysenberries we had a very, very warm season that was early and extremely warm. It was out of the ordinary. So the berries ripened much faster than what we/ve ever seen them ripen before. We had many way over 100 degree days, so because of this we could not get enough labor to harvest the berries, so we lost over 50% of our berry production. And the reason that we could not get enough help is most of our berries are located on a main highway and every day at 9 or 10 o'clock the Border Patrol would come by. And at that time, when they were seen they never did actually stop and raid our field they would slow down and look and everybody would run and that would disrupt the whole thing for the day. You wouldn't get anymore harvesting done and a lot of the illegal aliens would not show up to work because they weren't going to take the chance of getting caught. They knew the immigration was coming by, they knew it was just a matter of time when they would stop and they would have nothing to do with the field. They stayed away from us like we had the plague and they told us so, and we just couldn't get anybody to harvest, so the crop was lost, because of those problems, shortage of help and the immigration.

As a result, we pulled out every other row and a whole field, which amounts to about 25 acres of vines, we are planting prunes in most of it, and in about two more years we will pull out the balance of the berries or just leave every other row, while the trees are small and we can harvest for two more years. And I think the sad part of it is that this is not only happening in my operation, I've seen this happening in a lot of other people's operations that because of our labor supply shortage and the instability of the labor supply that people are not going to take a chance any more in spending this tremendous amount of money to grow these specialty crops, like boysenberries, it costs an awful lot of money to grow them. It is very, very expensive. It is very expensive to harvest them and people are turning away from these specialty crops. They are going to plant crops that are mechanized and prunes certainly are a mechanized crop because it only takes a few people to do the harvesting and it is done mechanically so what we're seeing is the specialty crops here in California going - leaving California or going out of existence and this, I think, is going to be extremely bad because people are planting crops that are mechanized. These crops that are mechanized are already in over production at this time and all we're going to do by planting more is create more of an over production problem in these mechanized crops. The economy of California is going to be hurt from these specialty crops leaving us, the state of going out of existence. Not only will the economy be hurt, but the people in the United States are going to be the loser because they are not going to have this specialty crop in their diet any longer. Maybe they don't need it, but it's still something that they are used to having, they enjoy and they are not going to have some of these things in the future. Sure there are still plenty of these crops available yet, but I think what's happening, the trend is all these hand harvested crops, specialty type crops are going to leave because we can't mechanize them, there's not enough acreage enough of any one of these to warrant mechanization, justify building a mechanical harvester, or else they are so delicate in their nature that they would never lend themselves to mechanical harvesting. It just couldn't be done so I think we're seeing a big switch here and I think it's going to definitely hurt the whole economy of this state and deprive the consumers of something that they have known and enjoyed all these years.

A good case in point of the frustration of farming with outside interference... was this past summer's Medfly mess...brought on entirely by the inaction of our ineffective Governor, before the summer was over, we had fruit backed up in cold storage...packing houses scrambling to build fumigation chambers, a big fight over allowable traces of fumigants between Cal-Osha and the Federal Government...and quarantines by other states and countries coming out our ears. I was fortunate to be a part of a Medfly Task Force that flew to 6-states, from Florida to Texas, to tell them what we were doing to combat the threat of the most destructive Medfly. Some of the officials in those states were sympathetic and understanding, most were glad we had taken the time to come, and all of them thought we had the worst governor and most screwed up agricultural system in the country. And, while I haven't heard a recent figure, with all of the expenses I mentioned above and many more, the Medfly mess was so badly mishandled by the Governor and others in Sacramento, it cost Fresno County alone...OVER 20-MILLION DOLLARS in lost revenues...and, WE DIDN'T EVEN HAVE THE MEDFLY HERE! Believe me... THAT'S A FRUSTRATION to me as a grower!

Can you draw a parallel from that? To regulations per se. Why stay in farming? You're regulated to death, every time you turn around, every step of the way, every cultural practice, from January 1 to December 31st you're in trouble, you're challenged with it. Is the trend discouraging people from agriculture, is it discouraging you, or is there a place down the road where we start reversing the trend of over regulation.

Well, I hope we can get some of these regulations off our backs. President Reagan said that he was going to work hard towards it and I think that he has. I think that he is already getting OSHA off our back and hoepfully that some of these other regulations that we are faced with that are so severe at this time, will ease off. But, I think what I see happening is - it is not going to discourage people, or agriculture. Agriculture is always going to be here, production is always going to be here. But, what it is going to do is encourage larger operations because the smaller grower is going to be forced out because he doesn't have the help or cannot keep up with all these regulations that we have. It's going to be forced onto the larger grower because they will have to hire a person just to cope with all these rules and regulations and forms that have to be filled out. Where the little grower cannot. So they continue to talk about big is bad and the big farmer continually gets kicked and knocked and sworn at and called all sorts of names, but the government regulations are forcing agriculture into or farmers into a bigger operation because they cannot justify hiring these people that can deal with these regulations on a small basis, they have to have more acreage and then they hire a person to take care of that all by itself. So I see that we're forcing our regulations and out of state and federal regulations are forcing larger agricultural operations, which not necessarily is good, but it's not necessarily bad either. Because the larger operation in a way is more efficient, and there are other ways that it is much less efficient also, but it does create more jobs.

POTENTIAL OF RAPESEED AND MUSTARD SPECIES IN CALIFORNIA

P. F. Knowles, D. B. Cohen (Dept. of Agronomy and Range Science, UC Davis) and T. E. Kearney (Cooperative Extension, Yolo County)

We have been evaluating rapeseed and mustard species for four years at Davis and at locations in Yolo County. Some of the reasons for our interest in such species are the following:

1. Collectively rapeseed and mustard species rank as the world's fifth most important source of vegetable oil.

2. Some species are well established crops in areas with a winter climate like that of California.

3. Other countries with a Mediterranean crop are introducing rapeseed and mustard species into commercial production and are developing research programs.

4. As a result of several years of research, rapeseed species rank as the second most important field crop in Canada where they are grown as summer crops. They are increasing in importance in Europe.

5. In Canada and Europe, rapeseed varieties with high quality oil and meal have been developed.

6. At one time mustard species were grown as dryland crops in the Lompoc area of Santa Barbara County. The seed served as a source of mustard condiments.

7. Weedy mustard species do very well in California.

8. There is a need, at least in northern California, for a winter oilseed crop that will mature in the spring, well before safflower and sunflower.

9. Looking into the future, there may be a need for a source of low cost vegetable oil that will substitute for diesel fuel.

Species of major interest to us belong to the genus _Brassica_. They are interrelated and can be readily crossed, which magnifies the opportunities for developing types adapted to almost any agricultural situation.

A large range of germplasm was grown at Davis, the better introductions being evaluated in yield tests. Strip tests were grown in Yolo County.

Summaries of the data for 1980-81 from five tests (1 for each of 3 species, and 2 for B. napus) are given in Tables 1 and 2. The ratios of harvested to planted entries were as follows: B. juncea, 35/41; B. carinata 10/10; B. napus (spring types), 11/22; B. napus (winter types), 9/12; and B. campestris, 7/17. The main reason for not harvesting some entries was severe lodging, and in addition aphid damage in winter types of B. napus. False chinch bugs were abundant at the end of the growing season, but did no damage to yield tests.

B. juncea (brown or Indian mustard) continues to be the most promising species. Its superiority rests upon the following: earliness of many entries; general resistance to lodging; resistance to shattering; yielding ability; wide range in seed size; and fairly high oil contents and yield of oil per acre. In 1979-80, B. juncea performed better than other species under reduced levels of soil nitrogen. Its shortcomings are: general susceptibility to white rust caused by Albugo candida and downy mildew caused by Peronospora parasitica. All entries have higher than acceptable levels of erucic acid in the oil and glucosinolates in the meal. An Australian, Dr. John Kirk, has announced the discovery of two lines of B. juncea that are free of erucic acid.

B. carinata (Ethiopian mustard) is also a promising species and, on average, gave a higher yield than B. juncea. However, on average it flowers and matures later than other species, and this may lead to adverse effects in years when spring rains are scarce and high temperatures prevail. On average it has a lower oil content than other species. Like B. juncea, all entries have high levels of erucic acid and glucosinolates.

Spring types of B. napus (common rapeseed) yield reasonably well, have high oil contents, and in most cases have very low levels of erucic acid and glucosinolates. Unfortunately, all entries were moderately to severely lodged and all were susceptible to shattering. Except for one entry, Dong Hae 24, all were somewhat late.

Winter types of B. napus were severely attacked by aphids and were adversely affected by high temperatures, so that yields of harvested entries were very low. Such types are not adapted to the environment of Davis.

As in the past, B. campestris (turnip rapeseed) was inferior to other species, mostly because of a general susceptibility to lodging and low yields. Like B. napus, however, many entries have low levels of erucic acid and glucosinolates.

PECAN - A NEW CROP FOR CALIFORNIA

G. S. Sibbett, Tulare County Farm Advisor

Introduction

The pecan *Carya illinoenisis* Koch, is the most important horticulturally grown tree crop native to the United States. The principal native range includes Texas, Oklahoma, Louisiana, Arkansas, and Mississippi. Smaller areas of native trees occur in states bordering the principal range.

Cultivation of pecan began slowly in the mid-1800's. In early to mid-1900, substantial acreages of pecans were planted as new cultivars were selected. Now the cultivated range includes and overlaps the native range in the southern states from the East to West Coast. Cultivated pecans account for about 55 percent of the total acreage and a substantially greater proportion of the production. Now, pecan acreage exceeds that of any other nut crop. It ranks third, however, in production behind its principal competitors, almond and walnut which are grown almost exclusively in California.

The pecan crop is almost entirely marketed domestically, only a minimal export market currently exists. About 10 percent of the crop is sold inshell, the remainder being sold as kernels to the primary consumers of pecans, bakers, and confectioners. The pecan crop varies considerably from year to year due to the alternate bearing habit of the tree. This has a disruptive effect on marketing and allows walnuts and almonds to compete favorably.

The Pecan Tree

The pecan is a member of the *Juglandaceae* family which includes walnuts and hickories. Thus, it is closely related to the walnut and has many similarities in growth habit.

Like the walnut, pecan is monoecious; it has separate staminate (catkins) and pistillate flowers on the same tree. The catkins arise from buds on the previous season's growth while the pistillate flowers (borne in clusters of 4-10) arise from the tips of current season's shoot growth. As with many cultivars of walnut, pecan cultivars exhibit varying degrees of dichogamy; pistillate flowers are receptive to the wind disseminated pollen either before or after the catkins reach peak pollen shed. Commercial pecan varieties are either protandrous (type I) - pollen shed precedes pistil receptivity; or protygnous (type II) - pistils are receptive prior to pollen shed (see Table 1, Fig. 1). For this reason, commercial pecan plantings include at least two cultivars (one of each type), the pollinator comprising about 10 percent of the planting. Some growers use two pollinators in case one fails.

Pecans require good soil. Recommended sites for planting are those with deep, well drained and alkali free soil. Tree size and production can be expected to be reduced on more marginal soil.

The pecan is a vigorous, large growing tree - for this reason, the concept of ultra high density planting is not recommended for the cultivars being planted. The closest spacing currently recommended is 30' x 30' or 48 trees per acre. Even this spacing may require eventual tree removal to maintain optimal production.

A number of cultivars of pecan have been recently released by the USDA. These are termed "improved" cultivars as they are superior in yield & kernel quality to native trees and older cultivars. Of the "improved" cultivars, the following have performed well in the arid west (West Texas, New Mexico & Arizona): Wichita, Cheyenne, Mohawk, Choctaw, Kiowa, Shoshoni, Tejas and Apache. Western Schley, an old proven cultivar, has been planted for many years and continues to be the base for Western pecan plantings. Several patented cultivars have been recently released by private breeders and look promising for Western orchards.

In the West and Southwest, the most widely planted are Wichita, Western Schely and Cheyenne. Characteristics of these "improved" cultivars are found in Table 1.

The pecan is propagated much like walnut. Seed of Riverside, Apache, or in some cases Mahan, are used for rootstock as they make uniform sized, vigorous seedlings. The seedlings are grown from one to two years then grafted to the desired scion cultivar which is allowed to grow one year prior to sale. No rootstocks have been developed that are resistant to specific diseases or insects.

Like walnut, pecan value is judged on kernel color - nuts with the lightest kernels are most valuable. Kernel color deteriorates with delays in harvest. In the West and Southwest, the earliest maturing pecans grown in the earliest districts can normally be harvested in late October. Equipment utilized by walnuts can be used in pecan harvest. The late maturity of pecan may preclude its being grown in areas of heavy soils prone to early rains in winter.

A number of pests and diseases affect pecan. In the West, however, the primary pests are aphids. The blackmargined aphid, *Monellia caryella* (Fitch), is most common and has been found infesting all pecan orchards. Less common aphid pests include another yellow species, *Monelliopsis nigropunctata* (Granovsky) and Black pecan aphid, *Tioncallis caryaefoliae* (Davis). Each of these aphid pests are easily controlled with either foliar applied on certain registered, systemic insecticides.

Other minor pests of pecan are fall webworm *Hyphantria conea* (Drury) and red humped caterpillar, *Shizura concinna*. These rarely require control measures.

Gophers readily girdle trees and must be watched carefully.

Diseases common to pecans grown in humid climates (pecan scab, etc.) have not been problematic in arid growing areas; low humidity appears to preclude these diseases. The trees grown in the West suffer from saturated soils and other diseases, such as crown gall, that infect most trees.

Pecan trees require annual applications of nitrogen. In addition, zinc must be supplied on a regular basis, as pecan is a poor extractor of zinc from soils. Thus, the trees must be frequently supplied with zinc by foliar application when grown on alkaline soils. When grown in acid soil conditions, soil applied zinc sulfate is effective. Other nutrients may be required in specific circumstances.

Pecan Culture in California

The pecan has been grown in California for many years. In addition to many old large specimens in dooryards, small orchards, 1-5 acres, were planted for trial purposes or, to satisfy a local roadside trade. These crops were not sold in the regular commercial trade.

Pecans were not considered a commercial crop in comparison with walnut and almond. Observation of the small, special use plantings, showed that currently available cultivars would not produce until 6-7 years. They were highly alternate bearing and in the "on" or heavy crop year would not fill out the nuts. These cultivars also required in excess of 220 frost-free days to mature the crop, precluding production in all but the hottest growing regions. Cultural practices, such as zinc deficiency correction were also not well known, thus other crops proved more feasible.

New developments in pecan culture have stimulated renewed interest and planting of pecan as a commercial crop in California.

New Cultivars: The most important stimulus was provided by USDA plant breeders who, within the last 15 years, released cultivars well suited to arid growing conditions of the West (see table 1). These "new improved" cultivars are precocious (economic bearing occurring in the 4th year), are high yielding with less tendency to alternate bear, have a somewhat compact growth habit more suited to high density plantings, and mature within a 180 to 200 day growing season.

Local testing of these cultivars began in 1970 in Tulare County. The testing substantiated these attributes as well as demonstrating California grown pecans were early maturing and kernels were of very high quality. From cultivar test work, the cultivars - Wichita, Cheyenne, and Western Schley emerged as best suited for new orchards. Other promising varieties include: Tejas, Kiowa, Mohawk, Choctaw, and Chickasaw and are being tried to a limited extent. Testing of recently developed cultivars is continuing.

Economics: Yield of the "improved" cultivars is projected to be one ton of inshell nuts per acre based on commercial yields from full bearing trees in Arizona. Nuts from the "improved" cultivars sell for $.90 - $1.25 per inshell pound, twice what nuts from native cultivars bring. This is due to the higher quality and greater percentage of kernels. Thus, economic feasibility of pecan, as compared with walnut or almond at similar production costs, has improved substantially and competes favorably with these latter nut crops.

A pecan operation also fits well with an existing walnut or almond operation. Pecans are harvested in late October and early November following the harvest of the latest maturing walnut cultivars. The harvesting and drying machinery is similar which extends use of such equipment.

Marketing: Due to high quality and earliness, Western grown pecans are now being sought after by shellers. In addition, Diamond Walnut Growers, a walnut cooperative, and independent walnut buyers who market pecans with their walnut products, make them likely local buyers when sufficient tonnage develops.

Current Situation in California

According to the 1980 California Crop & Livestock Reporting Service, there are currently 1,650 acres of pecans in California of which approximately 1/3 are nonbearing. This represents a 15 percent increase in acreage since 1977.

The major portion of the pecans are currently being grown in the southern San Joaquin Valley counties of Tulare, Fresno and Kings. Smaller acreages exist in other parts of the Central Valley. Continued planting is occurring with nursery trees (grown locally) being available on an annual basis. Due to late harvesting, pecan plantings in northern California will be limited as rainfall in many years will interfere with harvest.

TABLE 1. Characteristics of pecan varieties recommended for the western U.S.

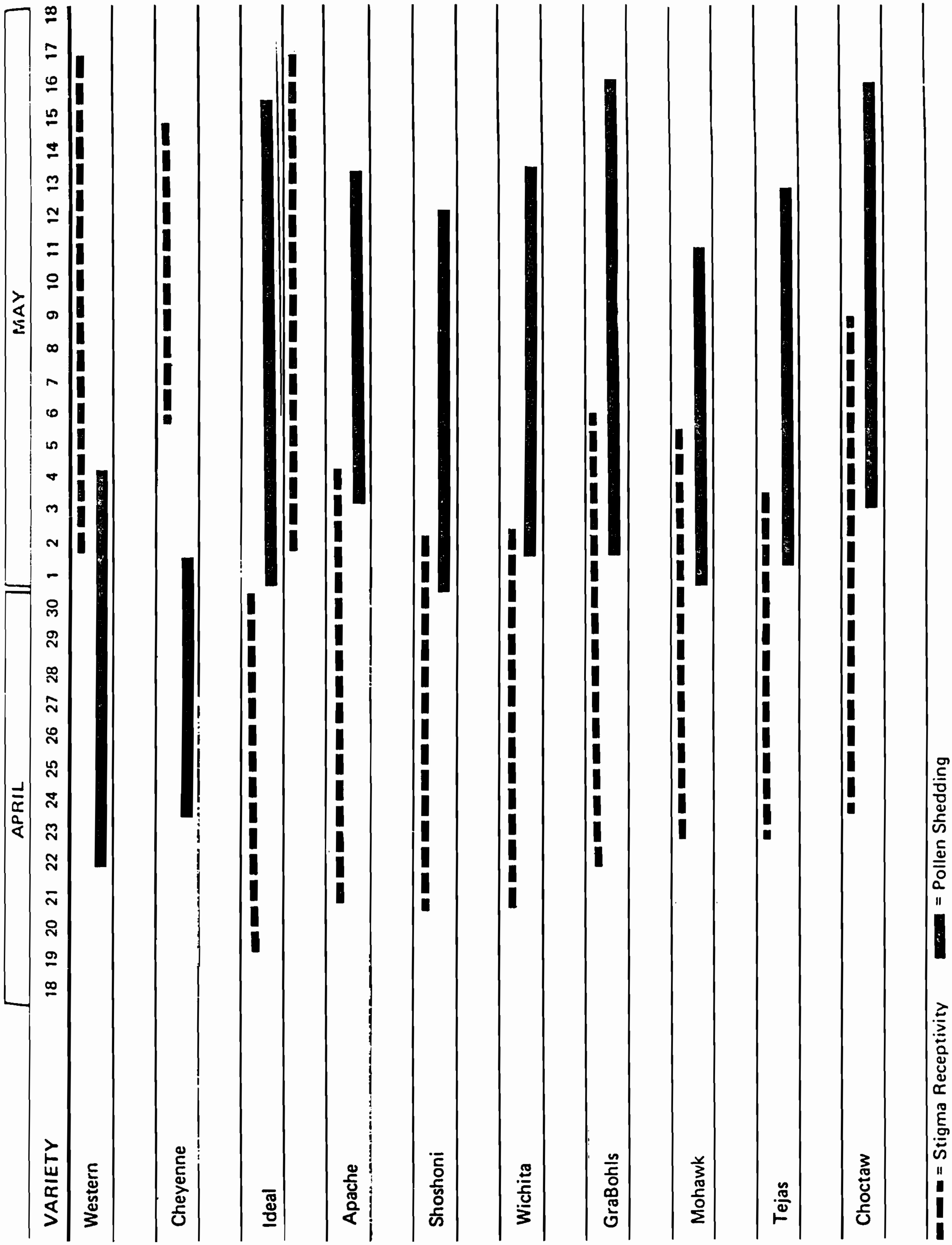
Varieties	Date[1/] 30% Bud Break	50% Shuck Split	Length of Season (days)	Flowering[2/] (Type)	Suitability High Density	Number Nut/lb.	% Kernel
Western Schley	3/31	10/15	198	I	Yes	50-60	56-59
Wichita	4/1	10/8	190	II	Yes	45-65	60
Cheyenne	3/31	10/8	191	I	Yes	55-70	57-61
Mohawk	4/1	10/1	183	II	No	35-50	55-60
Choctaw	4/5	10/17	195	II	No	40-50	60
Kiowa	-	-	-	II	Yes ?	40-50	55-60
Shoshoni	4/1	9/27	179	II	Yes	40-60	50-58
Tejas	4/8	10/17	192	II	No	50-75	50-56
Apache	3/30	-	-	II	No	45-55	60
Ideal	4/1	-	-	II	No	75-85	60-63
GraBohls®	4/4	10/11	190	II	Yes	44-54	59-63

1/ Dates at Brownwood, Texas

2/ I = pollen shed early, or precedes stigma receptivity.

II = late pollen shedding or stigma receptivity precedes pollen shedding.

Figure 1 Stigma Receptivity and Pollen Shedding of Pecan Varieties at Brownwood, Texas. 1974



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KIWIFRUIT

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Kiwifruit are produced by a large, deciduous vine botanically known as *Actinidia chinensis*. Individual plants bear either male or female flowers, so both types of plants are planted in a vineyard, at a ratio of 8 females to 1 male, to insure cross pollination and fruit set. Bees are necessary for pollination; wind pollination is totally unsatisfactory.

The first commercial kiwifruit vineyards were planted in New Zealand about 1950 in the Bay of Plenty district near the city of Tauranga. Fruit was exported to the United States as early as 1958 and was featured first as Chinese gooseberries and later as kiwifruit. In 1968, New Zealand export of kiwifruit to world markets amounted to 500,000 7 pound flats. In 1981, New Zealand exported 6 million flats harvested from several thousand acres.

The kiwifruit is a relatively new crop in California. The first plantings were made in 1967 and 68 and by 1971 a total of 100 acres had been planted in California, most of it being in Butte and Kern Counties. Experimental vines were grown at the USDA Plant Introduction Station at Chico as early as 1934. The mother and father vines of most of California kiwifruit are still growing and producing at this original location. The first commercial crop of 300,000 7 pound flats of kiwifruit were packed in 1977. In 1981, 1.6 million flats were packed in California. Most of the California fruit is exported to Japan and Western Europe. Acreage in California in 1981 is estimated at about 4,000 acres and half of this acreage is non-bearing.

Due to the rapid increases in plantings and production, California has doubled its production every 2 years. New Zealand has doubled its production every 3 years for the last decade. As long as prices for fruit remain good production will continue to increase.

Kiwifruit, if properly handled, can be stored for 3 to 6 months. New Zealand picks fruit in May and sells stored fruit worldwide through November, sometimes December. California and France sell kiwifruit December through March. Thus, in major markets of the world, kiwifruit are available year-round. More consumer education and kiwifruit promotion are needed in the United States and these will be provided by the California Kiwifruit

Commission established in 1981. The market for fresh kiwifruit should expand as the avocado market has over the last 20 years. Processing markets for kiwifruit are presently quite small but could be enlarged to use kiwifruit that will not make the fresh market grade.

The fruit is about the size of a hen's egg and has fuzzy brown skin which covers attractive, emerald green flesh filled with small, black, edible seeds. It is eaten fresh, can be canned or frozen, and is used for juice, jam, and wine. For best flavor, fresh kiwifruit should be allowed to soften like an avocado. Hard kiwifruit are very acid in taste. The fruit is high in vitamin C (100 mg per large fruit) and contains 50-65 calories.

Economics

Production of kiwifruit is expensive since a high capital investment for vines and supporting trellises is required and since it generally takes 3 to 4 years after planting to produce a commercial crop. Vines are commonly planted 20 feet apart in rows 15 feet apart, resulting in 145 plants per acre. The current price for grafted plants is $8.00 to $9.50 each. For support, vines must be trained on a sturdy trellis system consisting of 4 to 5 inch diameter poles 8 to 9 feet long with 2" x 6" x 6' cross arms. This T-shaped trellis with wires, end posts, and anchors costs about $1,600 per acre installed. Normally a solid set, overhead sprinkler system is installed to provide irrigation and frost protection. This costs $1,200 to $1,500 per acre to install, plus the price of drilling and casing the well (water from irrigation ditches is not available all year for frost protection). Costs to train and give cultural care to a new kiwifruit vineyard for 3 years are $2,400 to $3,000 per acre. Weed control, training and pruning, irrigation, and windbreak planting make up the major costs. Costs for good orchard land that can be used for kiwifruit range from $5,000 to $10,000 per acre. If the soil is fumigated for nematodes, this adds $500 to $700 per acre. Briefly summarized, the costs per acre of establishing a kiwifruit vineyard (over a 3 year period) are:

Plants and planting	$ 1,500
Plant stakes	150
Trellis materials	1,200
Installation of trellis and stakes	400
Sprinkler system installed	1,400
Care and training vines 3 years	2,700
	$ 7,350
3 years of 15% interest	3,308
	$10,658
Equipment	2,000
Land and well per acre	8,500
Per acre total investment	$21,158

Subsequent annual cultural costs (labor and materials) from pruning through harvest range from $1,000 to $2,000 per acre. Interest on the investment may be $3,000 per acre per year or more. One must also consider plant and crop losses from frost or wind, packing house and storage problems which would reduce sales of packed fruit, and other unexpected costs or losses. Despite these problems, it still appears that kiwifruit in good production areas should be profitable providing the investor has adequate capital and can obtain good management.

Production and income will vary with choice of vineyard site, future prices for fruit, management ability, and success of venture. Some approximate yields are listed below that may be expected with reasonable management and an average growing site. Higher and lower yields by individual growers can easily be found.

	Approx. Yield/Acre*
4th year	2 to 3 tons
5th year	4 to 6 tons
6th year	6 to 9 tons
7th year	8 to 9 tons
8th year and later**	9 or more tons

*Estimate 75% will be #1 grade.

**Vines are expected to be productive for 20 years.

The value of packed fruit will vary; fruit prices possible 5 years from now are impossible to predict. In 1979 and 1980, growers received $.80 to $1.00 per pound for the fruit packed and sold. If good export markets can be maintained, U.S. consumption increases, and inflation continues, one might expect similar prices in 1981 and 1982. Should production increase faster than consumption or should export problems occur, then grower prices could drop by 50% during the 1980's.

Production Areas in California

In California, the main production areas with a future are the Marysville-Gridley-Chico area, Fresno and Tulare counties, the San Luis Obispo area, and many orchard areas in the San Joaquin Valley. Hayward kiwifruit (the only acceptable female variety) need winter cold, as peaches do, to break dormancy. Without 700 hours under 45°F (7°C), plants flower late and poorly. It is too warm in the winter in Southern California for normal dormancy to develop in vines, so flowering is greatly reduced most years. In foothill and North Coast areas, frost limits kiwifruit culture.

Kiwifruit vines grow best on class I soils, especially deep, alluvial soils. Good and sometimes excellent production is obtained on class 2 soils if properly managed.

Kiwifruit vines require low-salt water as other fruit crops do. Chloride, bicarbonate, boron, and sodium are the most damaging soils. Critical levels for these salts vary depending on irrigation method and soil.

Primary Cultural Factors

Getting good bareroot or container plants is essential for a good start, and the ordering should be done a year ahead of planting. The bigger sized plants are preferred. More plants are lost in the first year when smaller plants are used and smaller plants take longer after planting before they produce. The only acceptable female variety is Hayward; any good male pollinator will work. Plant an outside row of all female (Hayward) plants. Follow that with a row consisting of one male plant between every two female plants, 2 rows of all female plants, another row with one male between every two females, 2 more rows of all females, etc. This means that every third plant in every third row should be a male.

Irrigation is extremely important for optimum plant growth and good production. Irrigation three times per week or more in the summer is usually advisable for the first three years after planting, and twice per week for bearing plants. Excessive irrigation or poor drainage can cause crown rot, yellow vines, and plant death. Under-irrigation will reduce growth and plants may be seriously set back.

Solid set, overhead irrigation is standard for irrigation and frost protection in most kiwifruit vineyards. Drip irrigation aids in establishing new plants and can save water. Furrow, flood, or sprinkler irrigation supplement drip irrigation on most bearing kiwifruit vineyards.

Select areas with minimum wind for kiwifruit because wind easily breaks canes, damages fruit, and reduces plant growth. Use of windbreaks will provide some to good protection depending on the type of tree used and the severity of the winds. Poplars are generally considered the fastest growing windbreaks, although some growers find certain kinds of pine and eucalyptus acceptable.

Frost damage to young vines in the fall and spring can result in plant death or killing of the budded portion of the vine. Temperatures below 29°F will damage leaves, fruit, and tender shoots. In November, temperatures below 27°F may cause trunk damage to young vines. In mid-winter, vines will tolerate temperatures below 20°F if they have been exposed to 27-30°F temperatures for several nights preceding. Cold sites are not satisfactory for kiwifruit vines, although some growers are able to grow vines but often take severe losses due to the cold. Sprinklers can help, but protection is limited to 6-8°F of frost (about 24°F minimum).

Pests and diseases so far are not serious, but it is obvious spraying will be necessary in older vineyards and established districts. Looper worms, especially O.L.R., and small white scale (Greedy and oleander scales) are increasing problems to California growers and are perennial problems for New Zealand growers. Soil diseases like armillaria (oak root fungus) and crown rot are fatal to kiwifruit vines. Rootknot and lesion nematodes are also damaging to kiwifruit roots if numbers are large. Fruit in storage may show Botrytis mold. Absence of registered chemicals for pest, disease, and weed control is a major problem of the kiwifruit industry.

Fertilization is important and consists mostly of nitrogen fertilizer applied 2 to 3 times per year. Avoid using too much, too close to plants. For full-bearing vines, use 150 pounds nitrogen per acre.

Harvest and Storage

Fruit is hand-picked when about 7% sugar and at a hard stage in October or early November. It should be cooled to 32-40°F within 8-24 hours after picking. Kiwifruit should not be stored with other fruit, especially those that produce ethylene since this will cause fruit softening and drastically limit storage time and sale of fruit. Fruit should be packed within 1 to 6 weeks after harvest. It is placed in plastic trays, then wrapped in plastic, and put in one-layer flats. Commercial packing is available in most areas. Only battery operated forklifts should be used in storage rooms to avoid generating ethylene which would quickly cause softening of kiwifruit.

The Pistachio in California

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The commercial pistachio tree, Pistacia vera, probably originated in Central Asia in areas known today as Iran, Turkestan, and Afghanistan. Plants were introduced into Mediterranean Europe about 2000 years ago, and to California early in the 20th century.

Iran, Turkey, Syria, Italy and Greece supply most of the world's pistachios. The U.S. product is highly competitive with imported nuts because it has a clean, white shell that adds esthetic qualities lacking in nuts from other sources. The red or white paint on imported pistachios is applied to cover stains caused by improper postharvest handling.

California produces at least 98% of the nation's pistachio crop, which constitutes 50-75% of the domestic market demand. There are 33,000 acres planted, 26,600 bearing and 6,300 nonbearing. Kern and Kings Counties claim 15,000 acres, Madera County 11,000 and almost all the remainder are planted in other parts of the Central Valley. Production is expected to double in the coming five years. About 15% of the U.S. population annually consumes 25,000,000 lbs. of pistachios. Planted acreage should produce 75-100,000,000 pounds when it reaches full potential.

The pistachio requires about 1000 hours of winter temperature below 7^{o} C (45^{o} F) for buds to open and grow normally and long, hot dry summers are necessary to properly mature the nuts. The southern San Joaquin Valley, parts of the Sacramento Valley, and areas around Barstow are well suited to pistachio culture, whereas coastal and southern California climates often do not meet these environmental demands.

Two cultivars of _P. vera_, 'Kerman' and 'Peters' are widely planted in California. Each is derived from a seedling selected in this state. Pistachio is dioecious, meaning pistillate (female) and staminate (male) inflorescences are borne on separate trees. 'Kerman', the pistillate, nut-bearing tree, can be traced to seed imported from Iran, and the staminate pollinator 'Peters', from trees of uncertain origin grown in the Fresno area. Two other pollinator cultivars, designated 02-16 and 02-18 are planted in some orchards to supplement 'Peters'. More cultivars, pistillate and staminate, are being tested and 'Joley', a new pistillate selection, may be competitive with 'Kerman'. Three species of _Pistacia_ are employed as root-stocks: _P. atlantica_, _P. terebinthus_, and more recently _P. integerrima_. The latter appears to have some tolerance to Verticillium wilt disease.

Propagation is accomplished by T-bud grafting of rootstock trees in the field. Cuttings do not produce roots thus rootstock plants are grown from seed in containers then planted directly in the orchard in June. Seed-lings do not tolerate transplanting in bare root condition. Grafting may be done in the same fall or following spring.

Orchard spacing varies from 11 to 15 feet per row and 22 to 30 feet between rows amounting to 97-180 trees/acre. Most common spacings are 11 x 22 or 12 x 24 (about 150 trees/acre) with removal of trees at a later date when crowding occurs. Mature trees in deep, rich soil should require 24 x 24 spacing. Usually one male tree is planted in the center of 8 female trees. There is some question about the optimum ratio of male to female for good pollination.

Young trees are trained to three main scaffolds, then secondary scaffolds headed back to 30 inches. After several years of this, the basic framework of the tree is formed, then new growth is cut back to 30 inches each year, and further pruning is light.

Pruning techniques for mature trees vary from those of other deciduous tree crops. Pistachio produces flowers laterally on shoots but forms very few lateral vegetative buds. Thus new length growth is terminal and is needed each season for best nut production, resulting in a continual spreading of the tree and peripheral bearing. Heavy pruning or heading-back of older pistachio does not trigger luxurious lateral shoot growth, due to few vegetative buds, as is common in other plants. Pruning practices for older trees is still under study.

Pistachio flowers have no petals and are wind pollinated. Following pollination and fertilization in early April, the pericarp grows rapidly but kernel growth does not begin until the first of July, and nuts usually are ripe by the first week of September. Trees begin to bear at about the 5th year, reach full production at 15 years, and may live as long as 400 years. Yields range from 10-40 lbs/tree during early producing years and should reach 60 lbs/tree by 15 years of age or when full capacity is attained. As trees approach full production, the characteristic of alternate bearing becomes increasingly pronounced. Countries with older, established plantings have production figures showing wide biennial fluctuations in yield. Planttings in California also alternate bear and may express this phenomenon more vividly as they age.

Trees are harvested with equipment used for prunes: a shaker and catching frame. Nuts do not fall naturally thus all fruit can be gathered in one operation. Hulls are removed, using modified walnut hullers, within 24 hours of picking to prevent shell staining. Nuts are dried, blanks and fruits with unsplit shells sorted out, then stored until further processing.

A wide range of soil types are tolerated by pistachio but growth is best in deep, well drained sandy loams. For maximal production and tree health, summer irrigations are necessary, the frequency depending upon climate and soil moisture status.

Precise nutritional requirements have not been established but nitrogen fertilization is necessary, and what appear to be zinc and boron deficiency symptoms have been described.

Several physiological disorders, diseases, and insect pests affect pistachio. "Blanking" or seedless fruit, the result of seed abortion or vegetative parthenocarpy, can be extreme, up to 25% in some cases. The extent of blanking appears to be affected by the rootstock and varies from year to year. Epicarp lesion, thought to be a genetic disorder carried by the 'Kerman' stock, is a discoloration of the hull that often causes nut drop or shell staining and is responsible for severe losses in some years.

Verticillium wilt (Verticillium dahliae) is the only serious disease of pistachio in California. Pistachio is very susceptible to wilt and infected trees usually die. An assay technique is available to determine inoculum levels in soils as an aid in planting decisions. Techniques are being tested for reducing fungus populations in established orchards by covering soil with polyethylene sheets for several weeks in summer. P. integerrima has some tolerance to Verticillium wilt and is used in many orchards. Pistachio also is susceptible to Armillaria mellea (oak root fungus) and Phytophthora root and crown rot.

Several insect species are known to inhabit pistachio in California. Only navel orangeworm (Amyelois transitella) is economically important and thus is regularly controlled by growers. Citrus flat mite (Brevipalpus lewisi) feeds on nuts and may become a serious pest. Black scale (Saissetia oleae) infestations have been reported as have several leaf feeding species.

Weeds are cultivated and managed with pre and postemergent herbicides.

Nematodes have not been reported as pests of pistachio.

The entire crop is sold domestically, 70% or more as salted in-shell snack foods, the remainder as a shelled product for use in other food preparation. The tree itself likely is not suitable for timber, however P. integerrima produces the much prized zebra wood of India.

The California Pistachio Commission became a legally constituted body in 1981. The Commission provides for all producers to take part in industry-wide marketing and research programs, and supplies all growers information on inventories, sales, exports and imports, receipts from producers and all other reports originating in the Commission. Members are assessed 1.5% of net returns from processor to support the Commission and its activities.

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Guayule - *Parthenium argentatum*

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Guayule is a rubber-producing shrub native to the TransPecos region of Texas and Chiuahuan desert of Mexico. It is a member of the Compositae family, producing an abundance of flowers throughout the warm season. Its root system can reach a depth of over 6 meters in good soil. Mature plants will reach a height of one meter with a nearly comparable spread. The latex is contained in individual cells in the stems and roots and not in ducts as in *Hevea*. Rubber content may be as high as 25% in some old plants in natural stands but is generally much less in field grown plants.

Guayule cannot be called a truly new crop since it was grown for rubber prior to and during World War II. At one time in the early part of the century, guayule provided over 50% of the rubber consumed in this country. Production was discontinued after World War II because guayule could not compete economically with the new synthetics and the renewed supplies of *Hevea* natural rubber from southeast Asia.

Interest in guayule as a rubber crop revived during the late 1980's and small research projects were initiated in several states, primarily Texas, New Mexico, Arizona and California. Research projects are presently underway in California at UCD, UCR, UCI, Shafter, the U.S. Salinity Lab, and The Los Angeles State and County Arboretum in Arcadia. The California Dept. of Food and Agriculture has been conducting a fairly large demonstration and applied research project with plantings in a number of places in California.

In 1978 Congress passed the Native Latex Commercialization and Economic Development act to promote guayule development. The act authorized $30 million for research but only a small amount of this has been appropriated to date. Present research is directed toward basic botany, physiology, biochemistry, breeding and genetics and agronomics. The ultimate goal of all research is to improve guayule especially its rubber yield and to develop efficient cultural methods so that it will be able to compete with other crops for land and water and compete with *Hevea* and synthetic rubbers in the market place.

At the national level research results to date include selection of the best six varieties from those developed during the post Emergency Rubber Project years and held at the National Seed Storage Laboratory, Ft. Collins, during the intervening years. With financial support from the U.S.D.A., seed increase plantings of these better strains have been made in several southwestern states. Some new strains have been selected by plant breeders and will be given wider testing soon. Hybrids between guayule and large non-rubber-producing related species have been made at several locations. These hybrids must be backcrossed to guayule to increase rubber content. Weed control studies have established that several preemergence herbicides may be safe for use on guayule. Early results indicate that fluid drilling may be an effective way of direct seeding of guayule. Tissue culturing of guayule has been accomplished.

Other studies underway from which results may be expected in the future include salinity tolerance, cold tolerance, disease control, irrigation and water requirements, and fertilization practices.

The future economic picture for guayule in general looks good. Indications are that rubber production costs can be brought down to a level close to that of *Hevea* rubber, all of which must be imported.

However, this picture is clouded somewhat by the uncertainties of future demand for natural rubber and future production of *Hevea* rubber. Successful commercialization of guayule will require continued support from both government and industry. Initially, government subsidy or price supports may be needed to get production underway. Since guayule rubber is almost identical to *Hevea* rubber, public acceptance should be no problem. Natural rubber from either *Hevea* or guayule must be used in blends with synthetics for many purposes such as radial and airplane tires because of its superior qualities.

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Management of High Density Walnut Plantings

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There are presently about 200,000 acres of walnuts grown in California. The acreage has tripled from 67,000 acres in 1957 and practically all of this increase has been in high density plantings involving Hartley and recently developed highly fruitful Payne-type varieties such as Ashley, Vina and Chico.

The early plantings were spaced about 50-60 feet apart on the square. The older varieties such as Franquette characteristically are slow in coming into bearing, develop into large trees and are relatively low yielding at maturity. A good Franquette orchard will average around 1 to 1-1/2 tons per acre.

In contrast, most of the more recent plantings, particularly of the lateral bearing Payne-type varieties, are spaced about 30 feet on the square. They are very precocious and the trees are much smaller in stature. Some of these plantings have yielded a ton to the acre by the 7th leaf, 2 tons per acre by the 9th year, and averaged around 3 tons per acre after 12 years of age under good soil and management conditions. This yield can be sustained provided that the spacing and pruning practices provide good light penetration into the lower part of the tree canopies which is essential for flower formation and nut production.

More typically, growers neglect pruning once trees reach full size and the lower portion of the tree canopy becomes unfruitful due to severe shade imposed by the crowded condition. It is common, therefore, to see orchards attain high early production as a result of the relatively large number of trees per acre but for yields at maturity to decline as lower fruit wood becomes shaded and nuts are borne only in the top of trees.

I will present some results from four long term pruning experiments designed to explore ways to sustain yields in high density walnut plantings. The first two involve selective hand pruning of mature Hartleys and Ashleys in an attempt to promote better light penetration and to re-establish lower fruitwood in crowded orchards. The third trial is an attempt to substitute mechanized tree hedging as an alternative to hand pruning and the fourth is a relatively new concept with walnuts, the use of hedgerow planting.

The first trial was in a block of mature Hartley walnuts planted in 1960 at 30 feet on the square. The orchard had not been pruned for several years prior to our differential treatment beginning in 1975. The trees were grown together with nut production restricted to the upper half of the canopy and yields stabilized at around 2 tons per acre. Limbs in the upper productive portion of each tree were thinned out in the dormant season for five years. The objective was to rejuvenate lower limbs by better light exposure, thereby increasing the yield of the orchard. Pruning consisted of 10 to 20 selective thinning cuts (1 to 2-1/2 inch) per year. Yield data collected over this five-year period showed that there was a significant reduction in crop on the pruned trees, but nut size was improved. In two of the five years, the yield of pruned trees was significantly reduced and in the other three years it was no better than non-pruned trees.

Photosynthetically active radiation measured early in the season three feet above the orchard floor under pruned trees was 50% greater than under non-pruned ones, yet this still only represented less than 3% of full sunlight. Yields from pruned trees were consistently lower than from unpruned ones, mainly because fruiting spurs were removed in the upper part of the trees while not promoting fruitfulness of the lower limbs. Thus, the results indicate that normal pruning procedures in a crowded, mature Hartley orchard cannot be expected to re-establish the level of production attained prior to the loss of fruitfulness in the lower part of the trees. In this situation, tree thinning where alternate diagonal rows are removed would appear to be the best solution to the problem.

The second trial, involving selective annual pruning in a crowded orchard, was with Ashleys (16 years old, 30' x 30') in a cooperative study with Butte County Farm Advisor Bill Olson. An average of 30 to 40 thinning cuts, mostly 1-1/2 inch or less in diameter were annually pruned out of each tree starting in 1978. In the first year of the test, the yield of the pruned trees was reduced by 320 pounds per acre from the non-pruned which yielded 2.1 tons per acre. In 1979, the yield was the same (1.3 tons per acre), but improved nut size and quality resulted in a higher dollar return per acre from the pruned trees. In 1980, the pruned trees surpassed the yield of the non-pruned (2.7 as compared to 2.6 tons per acre) but the difference was not statistically significant. When quality factors were considered, the value per acre was $85 greater in pruned plots as compared to non-pruned. In 1981, the differential became greater with the pruned trees yielding 2.3 tons per acre as compared to 2.0 for the non-pruned. The nut quality value although not presently available, should make this difference even greater.

Light measurements taken under the tree canopies showed that pruned trees had significantly more light penetrating through the canopy than non-pruned, particularly on the periphery of the tree. This was reflected in greater fruitfulness of spurs in the interior portion of pruned trees. Spurs in the interior two-thirds of the canopy of pruned trees were 48% fruitful as compared to only 25% in non-pruned. On the outer third of the tree canopy, the difference was significant but smaller with pruned trees averaging 55% fruitful spurs while non-pruned were 46%. These measurements revealed that pruned trees had nuts dispersed throughout the tree canopy while the crop on non-pruned trees was largely concentrated in the outer one-third. The results from this test with Ashley, a relatively small size tree, show that the benefits of pruning are not immediate but over time can result in sustaining higher yield with increased nut quality.

The question has arisen as to the feasibility of substituting mechanized tree hedging as an alternative to hand pruning to maintain high production of close planted orchards. To answer this question, an experiment was conducted in Tulare County in cooperation with Farm Advisor Steve Sibbett, comparing the effects of hedging heavily canopied walnut trees with detailed hand pruning and no pruning on nut production and quality. Mature Payne walnuts 13 years old planted 35 x 35 foot offset (25 feet between trees) which had been heavily canopied for several years were selected for the test. Extensive shading and crowding had resulted in extensive loss of lower fruitwood and production that had stabilized at an undesirable level. The hedger which performed in one direction, was a dual 22 foot vertical boom machine adjusted to cut a 7 foot width at the top of the boom and 4 foot at the bottom. Hedging was first done during the 1971-72 dormant season and repeated in the two subsequent years. Two hedging treatments were tried 1) hedging both sides of tree row each year, and 2) hedging alternate sides of tree row each year. These treatments were compared with hand pruning consisting of 20 to 25 moderate (1 to 2 inch) cuts per tree and no pruning.

In the first year of the test, hedged treatments produced significantly less crop. This result was to be expected because of the large amount of wood initially removed by the hedger. In the subsequent two years, no significant difference in production was obtained between any of the treatments. Nut quality was not affected by any treatment in any year of the experiment. The conclusion was that hedging did not alleviate shading. After cutting back old fruiting wood and opening up a channel of light between tree rows, substantial vigorous new growth developed and the orchard was again completely canopied by mid summer. Neither hedging treatment nor the moderate hand pruning performed in this test where the trees were severely crowded appreciably improved light conditions in the lower portion of the trees.

In an attempt to develop a new high density management system for walnuts, trees were planted in 1974 in a hedgerow (11 x 22 feet) and trained into a fruiting wall. The variety selected for the test was Chico, a small highly precocious Payne-type selection. For comparison, plots were also established with trees at 22 x 22 feet and trained in a conventional manner. Since 1978, the hedgerowed trees have been mechanically pruned with a vertical boom hedging machine. It was positioned to cut 4 feet from the trunks and the tree height is being maintained at about 25 feet by mechanical topping. Two hedging treatments are being compared: (1) hedging on both sides each year and (2) hedging on 1 side (alternate year hedging).

The yield of the hedging treatments from 1977 through 1980 has doubled that of the standard spaced and pruned trees. This is to be expected since the hedgerows constitute twice as many trees per acre and in the early years of the orchard, yield is a function of tree numbers. The 1980 yields were 5,378 pounds for 22 x 11 feet spaced trees hedged on both sides, 5,394 pounds for 22 x 11 foot spaced trees hedged on one side and 3,058 pounds for the 22 x 22 foot conventional trees. In 1981, the yields were 4,756, 5,492, and 4,309 pounds, respectively for the three treatments. This indicates that the advantage of tree numbers is diminishing as the conventional trees enlarge, as would be expected, and that the alternate side hedging treatment is beginning to show a yield advantage over the trees hedged on both sides each year. The difference in yield between the two hedging treatments is probably taking advantage of the lateral bearing potential of this variety. Since Chico is nearly 100% fruitful on lateral buds, there should be an advantage to allowing long shoots to remain unheaded for one year, thereby maximizing their potential to bear crop.

PRUNING--THE LONG AND THE SHORT OF IT

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There are two schools of thought on how to train an almond tree during its first dormant pruning. They are often referred to as 'long pruning' and 'short pruning.' They are essentially two training styles. Both consist of selecting three or four limbs evenly distributed around the trunk and well spaced up and down the trunk. The main difference between them is the amount of shoot growth left or cut off from the tree. The 'long pruning' style leaves all the lateral shoot growth along the selected scaffold branches (limbs) for leaf surface and early fruiting. No major heading back cuts are made in this pruning style.

In contrast, in the 'short pruning' style, the selected limbs are headed back at 12-16 inches high and all lateral shoots are removed from the limbs.

Almond growers have asked, what training method is best? This is a difficult question to answer since we didn't have the information on how 'long pruning' will perform under our local conditions. Therefore, a test plot was established to compare short and long pruning in a Nonpareil-Carmel almond orchard. The evaluation of these two pruning styles was based on trunk diameter and limb caliper measurements, crop yield and general observations.

The major difference between the two styles occur during April to May. At this time the long pruned trees grew very rapidly and because of it wind becomes a problem. To prevent tree breakage roping became necessary on all long pruned trees. In contrast, the amount of shoot growth was very limited on short pruned trees and wind was not a problem. The wind problem was only temporary and the rope was not necessary after the first week of June.

Trunk diameter and limb caliper were taken during the following winter. The results are in the following table.

	Variety	Trunk Diameter	Limb Caliper
Long Pruning	Nonpareil	3.4 inches	2.0 inches
	Carmel	3.6 inches	2.0 inches
Short Pruning	Nonpareil	3.2 inches	2.0 inches
	Carmel	3.2 inches	2.2 inches

There are no major significant differences between pruning styles or varieties on trunk diameter or limb caliper. However, based on visual measurements, the 'long pruned' trees were taller than the 'short pruned' ones.

The second dormant pruning was done in January. In the 'short pruning' style, two secondary limbs were selected for each primary limb and headed back (topped) at 42 inches high. The 'long pruning' treatment consisted in removing only problem limbs from the tree and its natural growing habit was kept intact. After the trees were pruned, short and long, they were roped to prevent limb breakage.

The trees came into their third growing season. There were big differences in the amount of bloom and subsequent fruit set between the two pruning styles. The bloom and the fruit set was more abundant in the 'long pruned' trees than on the 'short pruned' ones.

We harvested in September. The yields are shown in the following table.

	Variety	Yield pounds/acre
Long Pruning	Nonpareil	192 pounds
	Carmel	422 pounds
Short Pruning	Nonpareil	28 pounds
	Carmel	45 pounds

There are significant yield differences between pruning styles and varieties. The yields are superior on 'long pruning' in both varieties; however, Carmel is more productive on the 'long pruning' style.

The higher yields on 'long pruning' is the result of two basic principles. The first is the faster the tree grows the quicker it comes into production. The second principle is that pruning is a dwarfing process. It reduces leaf surface and tree size; therefore, it delays production.

Now, based on the results just presented, can we say 'long pruning' is the best way? The answer lies within each individual grower. It really depends on him. We have learned that 'long pruning' requires more attention in the second and third leaf than 'short pruning.' The trees must be roped after each dormant pruning and the orchard patrolled in April-May to cut back the ends of the bending over limbs. These two operations cost money and effort. Over the orchard, however, the extra cost and effort pay in the form of larger trees and early production.

NON-TILL GRAIN SORGHUM

W.L. Kellogg
Kellogg Seed Service, Chico

Growers attempted to grow non-till grain sorghum several years ago in the Sacramento Valley using several row crop systems with limited success. Good crops following wheat could be grown with equipment specialized and custom built to the task. The equipment could only be used for corn and grain sorghum.

Now, through the use of the Multiseeder the practice of non-till grain sorghum production is expanding. The Multiseeder is versatile, and available by renting. In 1980 approximately 60 acres in the Chico area was planted to non-till grain sorghum. In 1981 in excess of 600 acres was planted from Woodland to Cottonwood in non-till grain sorghum. I'm sure 1982 will see even larger acreage planted.

Why this expansion? Cutting of costs without lowering yields. Equipment (Multiseeder) is easy to operate, having low horse power requirements. The equipment can be operated at relative high speeds (6-8 MPH) and be accurate.

What difficult problems are there? Weed control. Only two herbicides proven to work in this area on watergrass in grain sorghum. Both can fail. Concept coated seed may change this situation.

How is it done?

Either burn stubble or use straw spreader, plant with starter fertilizer dry, apply herbicide and irrigate up. Apply nitrogen and irrigate in or water run nitrogen in irrigation water. Spray for insect control as needed. Harvest when crop is ready. You can plant the same day you are harvesting.

Simple, inexpensive, quick, only the equipment purchase is high.

The Multiseeder will also plant conventionally worked seedbeds or non-till the following crops - sudangrass, alfalfa, irrigated pastures, wheat, barley, oats, rangeland, clovers, grasses, vetch, bell beans, rice, and so forth.

Non-till grain sorghum and the Multiseeder should only be the beginning as other equipment and crops are brought in to the picture.

NEW TECHNOLOGIES IN TRANSPLANTING

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The high value of vegetable crops in conjunction with the high costs associated with their production, and the high value of good vegetable land lead the vegetable industry to continually look for ways to obtain maximum crop yields and land utilization. For example, little land is wasted in headlands when cash rents range from $300-$1,000 per acre and the turnaround time from one crop to another is as little as 10 days in order to obtain maximum land utilization. There is renewed interest in transplanting by the California vegetable industry as a means of obtaining maximum yields and optimum land utilization.

The favorable climatic conditions in most California vegetable production areas coupled with the long growing season and in-state winter production areas have limited transplanting in the industry to a few crops such as celery and Brussels sprouts where particular circumstances have made the practice desirable. However, in other vegetable-producing areas such as the Northern United States, Canada, and Northern Europe, transplanting has been widely accepted as a means of extending growing seasons that are limited by climatic conditions. In some of these areas, local field production of vegetable crops would not be possible without transplanting. In the past few years, the California vegetable industry has shown increased interest in transplanting due in a large part to the development of transplant systems which utilize a rooted transplant as opposed to the traditional bare root transplant. Rooted transplants show minimal transplant shock if any and take off quickly and uniformly in comparison to bare root transplants. In some cases, increased uniformity over even direct-seeded fields has been reported. Other factors such as the increased use of expensive hybrid seed have resulted in renewed interest in transplanting. At the same time, continually increasing land costs are forcing growers to attempt to increase the number of crops per acre per year. The possibility of mechanizing the rooted transplant systems has considerable appeal to growers due to the reduced labor requirements of a mechanized system.

The rooted transplants utilize a container of some sort to hold the plant and growing media in or are grown in special trays or frames which hold the growing media in cells of varying types and configurations. The containerized systems use a biodegradable container made of paper, plastic, or other materials and the plant is placed in the field container and all. The container cost is critical in this approach to transplanting since the cost of the containers alone can make this system too expensive for widespread commercial use. However, the container may offer some potential advantage from the standpoint of mechanizing the field portion of the transplanting operation. Systems of this general type include the ITW One-Way System, the Paperpot System, and the system developed by the National Institute of Agricultural Engineering in England.

The special tray systems, of which the Speedling® System is typical and widely known, grow the plants in a special tray or frame. The plants are removed from the growing tray and the roots hold the growing mix together while the plant is being put into the field. The growing trays are reusable, thus, keeping container costs minimal. In this type of system, the roots of the mature seedling hold the growing mix together after the seedlings have been removed from the growing trays. In a variation of this system, resins are used to hold the growing media together making a very stable plug that can be handled mechanically. This type of system eliminates the cost of a consumable container, but those systems which use the plant roots to hold the growing media together may be less adaptable to mechanical transplanting in the field than containerized transplants. Systems of this type include the previously mentioned Speedling System and similar systems used by several plant growers in California including Golden Fields Nursery and Krikorians Nursery. A resin plug-type system is under development by Castle and Cook Agrisearch Inc.

The economics of transplanting versus direct-seeding of vegetable crops such as lettuce are not fully clear at this time. Certain costs such as thinning would be eliminated and there would be possible reductions in other costs such as irrigation and weeding. On the other hand, the cost of the plants themselves which is in the range of \$17-\$19 per thousand plus the cost of putting them into the field which is estimated at \$200 per acre or more will add to the total cost of the transplanted crop. In some cases, these higher costs may be offset by greater yields and/or better quality. At certain times of the year, primarily spring and fall, the uncertainty of obtaining a stand when direct-seeding could be, for all practical purposes, eliminated by transplanting. Transplanting during these periods would also insure that growers obtained good standards rather than the poor stands often obtained by direct-seeding during those portions of the year when field conditions are unfavorable.

There are several active projects going on in the development of mechanized transplant systems. In this approach to transplanting, entire systems from the plant growing to in-field planting equipment are being developed as a unit with considerable emphasis on providing a proper growing environment for the plants and on the development of mechanized handling and planting systems to reduce the handling and in-field planting costs. These systems can be adapted to a variety of crops other than vegetables. One of the new systems which appears to have considerable potential and includes an automated transplanting machine, has transplanted guayule in Arizona with a good degree of success.

In conclusion, the future of transplanting in the California vegetable industry will probably depend on the success or failure of the new systems that are being developed. Transplanting will most likely be more expensive than direct-seeding, but the potential of higher yields and greater uniformity could more than offset the higher initial cost when compared to direct-seeding. However, if these goals of more uniformity and higher yields are not reached, transplanting may remain an interesting but limited production technique in the California vegetable industry.

Vineyard trellis, row spacing, and rootstock investigations

Amand N. Kasimatis, Extension Viticulturist

In 1972 a vineyard trial with Cabernet Sauvignon was established at the experimental vineyard of the Dept. of Viticulture and Enology near Oakville (Napa County) to study trellis, row spacing, and rootstock interactions. Performance data have been collected since 1977. Project leaders are Lloyd Lider and Mark Kliewer, Dept. of Viticulture and Enology, and Amand N. Kasimatis, Cooperative Extension.

The site is non-irrigated; annual rainfall averages about 35 inches. The soil is fairly deep, well drained, and classified as a Bale clay loam; profile available waterholding capacity is estimated at 10 inches.

The experimental design is a split, split plot in 5 blocks; row spacings are the main plots, trellis and training as subplots, and rootstocks as sub-subplots. Main plots were between row-spacing; in-row spacing was maintained at 8 ft.

9 feet - results in a per acre vine population of 605, and 7.3 rows/acre.
12 feet - results in a per acre vine population of 454, and 5.5 rows/acre.

The trellis and training treatments (subplots) include the following:

- Wye - consists of 2 horizontal wires 4 ft. apart and 5 ft. high supporting fruiting canes originating from a divided (wye) vine.
- Tee - has a 3 ft. wide crossarm, 5 ft high, with 4 horizontal wires supporting fruiting canes from a head-trained vine.
- Vertical - the standard for comparison, consists of 3 wires at 3-1/2, 4, and 5 ft. high, with fruiting canes tied on the lower wires.

The rootstock treatments (sub-subplots) include:

- St. George - vigorous, produces large vines.
- 110R - low to moderate vigor, produces medium-size vines.
- AXR #1 - moderately vigorous, the standard for comparison.

Observations have been made for 5 years on the following: vine yields, cluster number, berry weight, fruit composition, and weight of one-year wood prunings.

The 1977-1981 data have not been combined for years and summarized because the 1981 pruning weight data have not been collected as yet. The record for the 1980 season is typical, however, and is presented in Table 1 to illustrate responses.

Significant responses were few in 1980; results have been consistent from year to year, however. There were no significant interactions.

Table 1. Summary of responses of Cabernet Sauvignon vines grown at Oakville to between-row spacing, trellis and training, and rootstock treatments. Harvested Sept. 30, 1980.

Treatment	Calculated per acre: Yield, ton	Calculated per acre: Prunings, ton	Calculated per acre: Cluster no. $X10^3$	Cluster wt., lb	Berry wt. g	°Brix
Row spacing (main plots)						
9 feet	7.3	1.75	70.6**	.21	.99	24.2**
12 feet (control)	6.9	1.52	62.2	.22	.99	23.6
LSD 0.05	ns		3.0	ns	ns	.4
0.01			5.0			.6
Trellis (sub plots)						
Vertical (control)	6.8	1.58	60.6	.22	.99	24.0
Tee	6.8	1.70	63.9	.21*	1.01	23.9
Wye (divided)	7.8	1.69	74.7**	.21*	.96**	23.8
LSD 0.05	ns		6.6	.01	.02	ns
0.01			9.0	-	.03	
Rootstock (sub, subplots)						
AXR #1 (control)	7.2	1.68	67.5	.21	1.00	23.8
St. George	6.9	1.81	61.2	.21	.98	23.9
110R	7.1	1.47	65.5	.21	.99	24.0
LSD 0.05	ns		ns	ns	ns	ns
0.01						

There were no significant interactions.

Grape Growth Increases on High Magnesium Soils Following Gypsum Applications

Roland D. Meyer, William E. Wildman, Amand N. Kasimatis and Keith W. Bowers

Serpentine deposits have an extensive distribution along the north coast of California. Soils having their origin from these high magnesium parent materials have resulted in reduced plant growth and these effects have been observed in a number of plant species and locations. The intensity for agricultural development within the state has and will continue to bring these and other soils into production of various crops. A situation was brought to our attention where grapes grown for wine production in the Pope Valley of Napa County were being planted on soils having high magnesium concentrations. The objectives for this study were as follows: to evaluate the effect of incorporation of a soluble source of calcium, gypsum on the growth and yield of grapes. A second objective is to evaluate those plant and/or soil analyses which could be used to identify those sites where the potential exists for improvement of grape growth and yield.

The results of preliminary soil samples taken on November 17, 1978 from a proposed site are given in Table 1. The pH is near neutral at the surface but increases to a pH of 8 at the 30-36" depth. Exchangeable calcium and magnesium determinations reveal a ratio of calcium to magnesium which varies from 1:3.9 up to a high of 1:6.3. Reduced plant growth has been observed in several crops when soil solution concentrations of magnesium are greater than 60 percent and calcium less than 40 percent. Thus the site would indicate a potential for increased plant growth following the addition of calcium to augment a change in the calcium to magnesium ratio. Since it was the growers intention to plant grapes the following spring, it was decided to initiate a trial wherein several rates of gypsum would be trenched into the rows over which the grapes would be planted. It was determined that a trench 2 feet wide and 3 feet deep would provide an adequately treated area of modified soil for root development of the

Table 1. Initial soil characteristics of high magnesium soil in Pope Valley, Napa County. (Samples taken Nov. 17, 1978)

	Analysis						
Soil Depth (inches)	pH	EC_e (mmhos /cm)	Ca+Mg (meq/l)	Na (meq/l)	Exch Ca (meq /100 g)	Exch Mg (meq /100 g)	Ca/Mg ratio
0-6	7.1	.39	4.8	< 0.1	10.0	42.0	1:4.2
6-12	7.3	.32	3.8	< 0.1	10.8	41.6	1:3.9
12-18	7.7	.25	2.9	< 0.1	9.6	41.6	1:4.3
18-24	7.8	.25	2.8	< 0.1	8.4	43.2	1:5.1
24-30	7.8	.30	3.2	< 0.1	7.6	44.8	1:5.9
30-36	8.0	.37	3.3	0.4	7.0	44.2	1:6.3

grapes. A calculated rate of approximately 115 tons of gypsum per acre would be required to alter the initial soil having a solution magnesium percentage of approximately 80 to a situation wherein calcium was approximately 3 times greater than the magnesium concentration. Since this would be an extremely high rate of application for practical purposes, a tenth of this quantity and also 1/100 of this rate would represent more economical levels to apply to the trenched area prior to the planting. The incorporation of these rates was carried out by spreading the gypsum over the proposed rows (approximately 2 feet wide) and the mixing accomplished by the trencher picking up the gypsum as well as trenching out the soil. The mixed material was then bulldozed back into the trenches. The gypsum treatments were applied on December 4, 1978. The remaining cultural practices and planting were completed in the spring of 1979.

The analysis of soil samples taken on October 16, 1979 are given in Table 2. These samples represent an average of 4 replications with individual plot samples being a composite of 16 cores. It can be observed that the only significant impact on soil characteristics which has occurred was at the 115 tons/A rate. The initial calcium to magnesium ratio of 1:3 or 1:5 was altered to a 1:0.5 by the highest gypsum treatment. Very little growth had occurred during the first year so no plant tissue samples were taken.

Table 2. Analyses of soil samples (0-6") taken on October 16, 1979 following the application of gypsum treatments on December 4, 1978.

Treatment:	pH	EC_e (mmhos/cm)	Exch Ca (meq/100 g)	Exch Mg (meq/100 g)	Exch Ca/Mg (ratio)
1. Control	7.2	1.58	11.4	35.2	1:3.1
2. 1.15 tons/A	7.5	0.75	7.8	38.0	1:4.9
3. 11.5 tons/A	7.5	0.71	11.4	35.6	1:3.1
4. 115 tons/A	7.4	3.60	57.2	26.8	1:0.5

Table 3 gives the analyses of soil samples taken a year later, September 19, 1980. These samples reveal, as did the earlier samples, that pH changed very little. The EC_e was increased by the 115 tons/A rate. Exchangeable calcium and magnesium as well as the calcium to magnesium ratio changed very little from the previous year, either in actual or relative value. The greater solubility of magnesium relative to calcium gives rise to the wider ratios contained in the saturated extract. The magnitude of the change in sodium concentration between treatments was large, but levels were in general relatively small as compared to calcium and magnesium.

Table 3. Analyses of soil samples (0-6") taken on September 19, 1980 following the application of gypsum treatments on December 4, 1978.

Treatment:	pH	EC_e (mmho /cm)	Exch Ca (meq/ 100 g)	Exch Mg (meq/ 100 g)	Exch Ca/Mg (ratio)	Sol Ca (meq/l)	Sol Mg (meq/l)	Sol Ca/Mg (ratio)	Sol Na (meq/l)
1. Control	7.4	.83	10.5	36.5	1:3.5	1.4	7.0	1:5	0.1
2. 1.15 tons/A	7.5	.59	10.4	36.3	1:3.5	0.9	4.9	1:6	0.2
3. 11.5 tons/A	7.5	.58	11.3	38.4	1:3.5	0.9	4.9	1:5	0.2
4. 115 tons/A	7.3	2.51	38.2	22.6	1:0.6	24.1	21.8	1:0.9	0.4

The results of petiole and leaf samples taken in 1980 are given in Table 4. Concentrations of calcium, magnesium and potassium and the calcium to magnesium ratio are somewhat similar for the first 3 treatments but quite different from treatment 4.

Table 4. Analyses of petiole and leaf samples taken on September 19, 1980 following the application of gypsum treatments on December 4, 1978.

	Concentration			
Treatment:	Ca (%)	Mg (%)	Ca/Mg (ratio)	K (%)
1. Control	0.64	1.28	1:2.0	0.69
2. 1.15 tons/A	0.42	1.28	1:3.1	0.69
3. 11.5 tons/A	0.68	1.14	1:1.7	0.71
4. 115 tons/A	1.18	0.66	1:0.6	0.86

The results of both the soil and plant tissue samples agree very closely in that the first 3 treatments are similar but quite different than treatment 4.

Observations of plant growth were, however, somewhat different than the soil and plant tissue analyses. Treatments 1 and 2 had similar but substantially less growth than treatments 3 and 4 which were quite similar to each other. Although measurements were not taken to quantify this growth difference, photographs indicate the very dramatic contrast. This points out a dilemma with the use of plant and soil analyses which do not correlate well with differences in plant growth. Observations recorded on October 12, 1981 indicate the control and lowest rate of gypsum had similar grape growth. The third treatment was intermediate in growth between the first two treatments and the highest rate of gypsum applied. Table 5 indicates that soil test results were similar to previous years. Treatments 1, 2 and 3 were very similar but quite different from treatment 4. This further illustrates the lack of correlation with plant growth. Plant tissue analyses have not been completed for samples collected October 12, 1981.

Table 5. Analyses of soil samples (0-6") taken on October 12, 1981 following the application of gypsum treatments on December 4, 1978.

Treatment	pH	EC_e (mmho /cm)	Exch Ca (meq/ 100 g)	Exch Mg (meq/ 100 g)	Exch Ca/Mg (ratio)	Sol Ca (meq/l)	Sol Mg (meq/l)	Sol Ca/Mg (ratio)	Sol Na (meq/l)
1. Control	7.7	.47	9.1	34.6	1:3.8	0.7	3.4	1:4.9	0.6
2. 1.15 tons/A	7.7	.39	8.9	36.3	1:4.1	0.6	3.0	1:5.2	0.3
3. 11.5 tons/A	7.7	.51	12.5	34.5	1:2.8	0.9	3.9	1:4.4	0.3
4. 115 tons/A	7.5	2.83	35.5	23.2	1:0.7	22.3	20.5	1:0.9	1.5

Plans for the future include the continuation of soil and plant tissue evaluation with some modification, and collecting yield data as growth and production would indicate.

Breeding Crop Plants for Maximum Yields and Profit - A Public Plant Breeder/Administrator's Perspective

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Crop plant breeding is a highly integrative activity, using information and techniques from throughout the agricultural sciences. The relative roles of public and private institutions in protecting and improving food production are rapidly changing. It is essential that open dialogue be continued to establish clearly the independent and joint strategies that the public and private sectors can use to the ultimate benefit of the public. This presentation will attempt to identify the major issues for this discussion, with emphasis on the review from the public side.

It is mandated in the Land Grant University system that research be undertaken for the betterment of agriculture and thus for the public in general. Crop variety development ("seed improvement") was one of the early and obvious activities undertaken in the State Agricultural Experiment Stations. This was originally done because there was no private sector activity for most crop plants. As plant breeding science advanced, it became possible for the private sector to adopt the technology and protect their own developments for economic gain in some commodities. Thus cultivar development of some crops, such as corn and alfalfa, is almost entirely done by private industry. Whatever the role private industry takes in producing and marketing cultivars, the training of professionals to staff these programs in agronomy, plant pathology, entomology, genetics, and plant breeding will be done by public institutions. It is generally agreed that on-going plant breeding programs in the universities are very important components in the training programs.

Two essential components for crop breeding include (1) a sound research base in biology and methodology and (2) an extensive germplasm base. The public sector has contributed strongly to these components and most analysts agree that this must continue to be a major role of public institutions. It must be remembered that the research base includes much more than development of information on the genetics of crop plants and the innovation of new breeding methods. Strong research programs are needed in crop physiology, pest management, crop management, marketing, and environmental quality. Germplasm research includes detailed study of the origin of domesticated crop plants, geographic distribution of their non-domesticated wild relatives, maintenance of broad-based collections, evaluation of collections for specific characteristics, and distribution of germplasm and information to all users. It is clear that private organizations individually cannot carry out all of these activities to the extent necessary and further it is not in their best interests economically to distribute information and germplasm freely to all users. It is essential that publicly supported programs continue aggressive programs on all important or potentially important plant species. This is an "insurance policy" owned by the public that is independent of the worth of any species (commodity) to the economy and independent of the sometimes transient interest in crop species by the private sector.

Public Breeding of Cultivars -- Which crops?

There is probably little controversy in the foregoing statements, but it was mentioned that cultivars of "some commodities" are developed by the private sector. The commodities chosen by the private sector are the ones which can be bred, protected, and marketed profitably. Interestingly, the dominating factor in the choice of these commodities by private industry was, until recently, the breeding system of crop plant rather than the economic worth of commodity. The enactment of the Plant Variety Protection Act has made it economically feasible for industry to include more commodities in their programs, especially the self-pollinating crops such as small-grained cereals and soybeans. Should public programs discontinue cultivar development programs when this role is assumed by private industry? In some cases yes, in others, no. I feel strongly that public programs must retain cultivar development programs until it has been demonstrated that private programs develop cultivars (1) for all major adaptation zones, (2) with attention given to all major yield-reducing factors, (3) with proper attention to crop quality, (4) reasonable assurance of ability to develop cultivars for a substantial period of time.

What about minor crops? It is clear that the private sector will have difficulty supporting cultivar development programs for crops that have inadequate sales to meet the development cost. If the private sector were to assume all cultivar development activities, then the crops giving high returns would have to subsidize the low-return crops. This is no doubt the case in some companies, especially where "full service" is a desirable goal, as for example in the vegetable industry. More recently, we have seen seed companies being purchased by larger companies, where it may be possible to absorb economic losses in one segment of the business if it complements other profitable segments. Public programs are also reluctant to direct resources to breeding minor crops because of the relatively small impact these crops have on the economy or because of a small clientele of users. Public plant breeding programs depend heavily upon funding beyond tax support, mainly from commodity groups of growers or processors. This support base is obviously not available for breeding and research on minor crops. It is often not in the best interests of the University in general to step aside from cultivar development programs after a long history of service to the public. Administrators usually point to successes in cultivar development, adoption of the cultivars in agriculture, and the ultimate "value" of the cultivars to the economy when justifying the worth of their research and development programs to federal and state funding agencies.

Breeding for Maximum Yields -- Of What?

The theme of this symposium focuses on maximum yields and profits. From the public research point of view the question of what aspect of "yield" is to be maximized is a very serious consideration. Traditionally, maximum dry matter productivity per hectare of marketable product has been the major criterion or selection goal. With increased costs of energy, plant nutrients, pesticides, water and labor, it has become more important to consider net return to producer and processor as a selection criterion. This may result in lower per hectare yields but production at significantly lower cost. Thus, breeding of crop plants that conserve energy in production and marketing is becoming an important consideration. Certain crops may be bred for environments quite different from the ones currently used in production. With the use of crop plants directly for energy production (e.g., ethanol, methane), total biomass may become the maximized yield objective in breeding. In other crops there is the maximum yield of high quality product which will become more important than high dry matter yields.

In general, public and private plant breeding programs have similar goals for maximum yield. Public institutions should give major attention to definition of the various goals more precisely through basic research in pathology, genetics, physiology, and related fields. The results from this research can be translated to well-defined selection criteria for the plant breeder. This research is relatively slow, very expensive, and of high risk in terms of identifying useful selection criteria. However, the results of such research advance knowledge in scientific disciplines and provide an essential training vehicle for students. Most private organizations developing and marketing cultivars do not have the ability to provide their own basic research to back up the breeding programs.

Breeding for Maximum Profits -- To Whom?

The question of who profits from breeding crop cultivars has in recent months been raised. It has been implicitly believed that the user -- grower and processor -- of cultivars were the target population for "profitability." Ultimately the consumer benefits by having readily available high quality products at low cost and the U.S. economy is the benefactor. This is the bottom-line profit agenda for public and private plant breeding. Of more concern to those developing plant breeding policy, both public and private, are other concepts of profit that are fundamental to whether cultivar development programs are to be undertaken.

Good cultivars provide profit for public institutions through credits and recognition to their funding agencies and by direct financial return through the marketing of protected or patented cultivars. The plant breeder in public institutions can realize profit, and thereby incentive, through recognition by advancement in rank and salary for success in developing cultivars. In many institutions, this is judged as "development" rather than "research" and advancement hinges on new research discoveries rather than new cultivars. The public plant breeder can, at some institutions, gain "profit" to the research development program by return of funds generated by sales of cultivars. Less often the public breeder can gain personal profit through sharing of patent royalties by the institution with the breeder.

In the private sector, profit concepts are more clearly visible and defined through the ledger sheet. It is expected that cultivar sales will profit the company and their breeders, the seed or plant materials sales organization, the grower, the handler, the processor, and the ultimate retailer of the products. The policy and activities of public institutions can have a great bearing, positively and negatively, on the profit ability of private industry. On the negative side, direct competition from publicly developed cultivars can reduce profit. It is this area that open discussion is essential so that public resources are used efficiently and private enterprise can flourish. Such discussions are necessary for each commodity and production region. Generalizations of policy cannot be applied. On the positive side, public cultivars are marketed through private organizations, most of which do not have the resource base to develop their own cultivars. Public cultivars thus provide the opportunity for small businesses to exist. In some cases, privately developed cultivars are distinct but genetically closely related to cultivars originally developed and established in agriculture through public programs. The "coattail effect" is important in the initial establishment of private cultivars and becomes a much less important factor in profitability after the private breeding industry becomes well established (e.g., corn and alfalfa).

It is clear that profit concepts of public and private industry are not independent and close cooperation and mutual respect are essential.

Public/Private Plant Breeding -- A Changing Perspective

It is true for almost all commodities that private industry have some dependence upon public institutions in their cultivar development programs, especially for germplasm maintained in world collections and for new knowledge in breeding methodology or selection criteria. Likewise, public institutions are becoming increasingly dependent upon extramural funding for plant breeding research and cultivar development. In the past, these extramural funds have come from mainly growers and to a very limited extent from the private plant breeding companies. With the advent of the "new plant breeding" using molecular genetic techniques, there has been a vast influx of funding to the private sector for "genetic engineering in agriculture." Many new companies have emerged in the past two years, some with broad-based goals in cultivar development and marketing. The impact of these developments on public programs has been profound. (1) Scientists have been hired from public institutions; significantly these have been faculty members most able to train students in modern genetic and plant breeding techniques. (2) Faculty members have been recruited to serve as consultants or equity-holding members of companies while retaining faculty states. (3) Private companies have entered in contractual arrangements with universities for plant breeding research, with the first licensing rights to all patentable developments guaranteed to the company.

These developments cause great concern by public institutions, especially in the Land Grant University/State Agricultural Experiment Station system where service to the public is a major element of the research approach. If properly defined, these relationships can provide a new mode of funding for research basic to plant breeding and for cultivar development directly. The opportunity for public and private programs jointly training graduate students is an exciting possibility, and was pioneered and found effective in California by Iver Johnson, Paul Knowles, and David Ferguson some years ago. The definition of what represents proper arrangements requires extended discussion among public and private institutions. This should be actively pursued. Public institutions, in developing new policy for public-private interactions will need assurance that their role in servicing the public need is not compromised. We recognize both substantial positive and negative aspects of new opportunities for closer relationships in plant breeding with private industry and welcome the opportunity to contribute to developing productive relationships.

BREEDING RICE FOR MAXIMUM YIELDS AND PROFIT

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Rice (Oryza sativa L.) is a naturally self pollinating diploid having 12 pairs of chromosomes. Two sub-species --japonica or sinica and indica are recognized. Crosses between sub-species are achieved readily but degrees of F_1 sterility are prevalent. The japonicas typically are grown in temperate climates while indicas are adapted to tropical or sub-tropical climates.

The California Co-operative Rice Research Foundation, Inc. is a non-profit foundation supported entirely by California rice growers. Its 370-acre Rice Experiment Station is utilized primarily for rice breeding research and for the production of foundation seed of publicly developed rice varieties. An additional 18 acres at a cold location in the San Joaquin valley are leased and serve the purpose of screening for cold tolerance. One to two acres at the University of California at Davis has served a similar purpose. U. C. Extension personnel conduct on-farm state-wide tests of 72 advanced experimentals and check varieties each year. On-station trials have been at a high nitrogen fertility level while other state-wide trials were at grower fertility levels. Additionally a winter nursery of about 5500 lines is grown in Hawaii each year under contract with the University of Hawaii. This permits two generations per year and the opportunity for disruptive selection. The Foundation cooperates with the University of California and the United States Department of Agriculture in rice breeding and several other disciplines of rice research. It is governed by a Board of Directors elected by the rice industry.

Permanent personnel of the Station include the station director, a director of plant breeding and two other professional plant breeders, a professional plant pathologist, 7 technicians and a secretary. As many as 25 hourly workers are employed during the peak seasons of planting and harvesting. We have been successful in having a minimum turn-over of both permanent and seasonal employees.

The specific breeding objectives when the expanded and accelerated breeding program was initiated in 1969 were to develop short, medium and long grain varieties having:

increased yield, good seedling vigor, earlier maturity, a range of maturities, shorter stature with less straw to manage, more resistance to lodging, fertilizer responsiveness, resistance to cold-induced sterility (blanking), long grain variety adapted to California, disease (stem rot) and insect (water weevil) resistance, higher protein content, hybrid rice and grain qualities acceptable to consumers.

Our research and that of others soon convinced us to drop two objectives--namely developing hybrid rice and varieties with higher protein content.

Attacking the Objectives

Pedigree breeding has been the backbone of our procedures. Since 1969, 7604 crosses or backcrosses have been made--an average of 634 crosses per year. Generations beyond the F_2 are grown under conditions simulating that of rice growers. Early-generation segregates with outstanding individual characteristics have been used extensively as parents.

Ten to 25 acres of F_2 populations are grown annually. Between 200,000 and 300,000 panicle selections are made each year. These are reduced to 40,000 to 60,000 on the basis of seed appearance--shape, breakage during shelling and translucency. Progeny are water-sown in rows 4' long and 18" apart. Approximately 5,000 F_4 through F_8 rows are harvested annually. Four thousand 4' x 6' preliminary yield plots either in duplicate or single replicate with systematic checks are grown. Characteristics other than yield are used to discard about 50% prior to harvest.

Four hundred and fifty to 500 entries are tested at Biggs in preliminary combine-size 12' x 20' plots with 2 replicates at each of 2 seeding dates each year. Twenty-four entries including checks in each of three maturity groups are tested at our station and at 2 to 3 state-wide locations by U.C. Extension in 4-replicate combine-size plots. Additionally, most yield-trial entries are evaluated simultaneously at 2 cold locations and in a night-refrigerated greenhouse for tolerance to low temperature-induced sterility. Seeds of entries in combine-size plots are maintained in a dry-seeded water-flushed nursery. Many of these are discarded prior to harvest on the basis of prompt analysis of yield and other data. Further discarding on the basis of seed appearance is achieved before seed is cleaned.

Head-rowing of as many as 30 promising entries per year is done in order to accelerate varietal releases of the select few. Further 1/2 to 1 acre "breeder seed" increases are made of up to 10 entries per year. This serves for extensive quality evaluation and/or further seed increase. Foundation seed from 1 to 4 entries is produced on 4 to 60 acres each year for release or discard as the data may suggest.

The most popular current variety, M9, was derived by hybridizing the semi-dwarf introduced exotic indica variety, 'IR-8' with a California variety and backcrossing 3 times to California germplasm. Other breeding procedures have also been employed. A natural mutation, having intermediate maturity, 'M5', was selected from the then popular variety, CS-M3. Three CO_{60} induced mutations resulted in varietal releases. The semi-dwarf 'Calrose-76' was derived by Rutger and co-workers from the highly adapted tall 'Calrose' and was the first released semi-dwarf for California. This adapted semi -dwarf has been extremely valuable as a parent in the development of many additional varieties. We derived 'Calmochi-201' as a waxy or sweet rice mutant from the then popular short grain variety, 'S6'. Likewise, we obtained the mutant semi-dwarf variety, 'M-401', from the tall private premium quality 'Terso' variety.

Progress in Attaining the Objectives

The bottom line in evaluating the impact of a breeding program is to what extent have the new varieties replaced the old; and what impact have they had on yield, on handling the crop and on profits. We are fortunate to have progressive growers in the rice industry. Numbers attending our annual field day have increased to the most recent 750. Distribution of an annual research progress report to each grower and annual winter meetings conducted by U.C. Extension have kept the growers informed. In 1980, an estimated 95% of the acreage was seeded to the improved semi-dwarf varieties released during the last 5 years. The 3-year state-wide average yield for 1967-1969 (immediately preceeding the initiation of the accelerated and expanded breeding program) was 5250 lbs per acre. The 3-year state-wide average yield for 1979-1981 was 6690 lbs per acre. Assuming that a conservative 60% of this yield increase is directly attributed to varieties, an average value of $10 per cwt for paddy rice on 590,000 acres provides a conservatively estimated increase return of more than $ 50 million due to new varieties alone. Additional benefits of the new varieties can be cited. All varieties were pubescent before 1969. Now about 90% of the acreage is grown to glabrous varieties. These produce less dust and itch during harvesting and processing and require significantly less space during trucking and storage. The semi-dwarf varieties produce an estimated 10 to 15% less straw per acre than the old tall varieties and an even greater advantage when expressed on a "per pound of rice produced". This has a significant impact in reducing the smoke emitted from the necessary burning of the rice straw. One additional advantage in the new semi-dwarf varieties is in harvester efficiency. Growers have estimated a 25% increase in harvester efficiency through the harvesting of more standing rice, less down time, and the spreading of the harvest season through choice of varieties of several maturities.

In spite of the indicated progress with rice, we have lots of room and opportunity for further improvement in many areas. Among others--further improvement in quality and adaptation in long grains; improved straw strength; tolerance to stem rot; tolerance to the rice water weevil;

improved milling quality and further increased yields are needed. Performance of an experimental early maturity medium grain in the 1979-1981 state-wide testing attests to the potential for further progress. It has averaged 940 lbs per acre higher yield than M9, the most widely grown current variety, and averaged only 4% lodging vs 56% for M9. Foundation seed was produced in 1981.

In closing I should like to say that our procedures have been flexible and subject to considerable streamlining during the years to maximize efficiency. We have had solid financial support, excellent cooperation with both the University of California and the U.S.D.A., a minimum of distractions, encouragement from the growers, and continuity of a good team.

BREEDING COTTON FOR MAXIMUM YIELD AND PROFIT

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Yield improvements of many crops in the U.S. from the 1930's until now have had significant increases. Indeed, sorghum increased over fourfold from 0.73 T/ha in 1938-40 to 3.05 T/ha 1978/80. Corn, peanuts and potatoes each more than tripled in this period. Lint yields of cotton did not quite double (.27-.52 T/ha) in this period. While most crops made sizable increases in each decade, cotton has remained the same for the last 20 years (0.52 T/ha). If other crops can be an example, much work is yet to be done to improve yield of cotton.

The yield of cotton in California since 1938-40 has increased 54% to 1958-60,and has decreased in each decade since. Current yields are 33% greater than 1938-40 and 13% less than 1958-60. While yield in California is over twice the U.S. average (1.1 T/ha) there appears to be opportunities for improvement. Breeding is not expected to reverse all of this alone. Help from the environment and cultural practice will be needed. Many factors contribute to improving yields and profit. On the profit side, current prices may preclude much talk about profit this current year on whether or not we could improve efficiency of production Many factors influence price; current prices are not much different from six years ago. Robert T. Davis (1979) representing the textile industry (at a spinner/breeder seminar) recently said, "While you cotton breeders, growers and ginners have made progress, you certainly have not had the degree of flexibility enjoyed by man-made fiber producers." This was in reference to the changing characteristics of the spinning process. Many processes have increased the speed of handling fibers. Carding, for instance, is at a tenfold increase (from 8 to 90 pounds per hour), drawing frames increased from 100'/min. to 1500'/min. and spindle speeds from 9000 to 14,000 revolutions per minute. These and other changes have resulted in a need for improved quality. California has clearly led the industry in providing consistent quality as well as quality improvement over the years. But without an opportunity to turn quality into price advantage, profit is minimized.

The characteristics of cotton desired by the spinners are those California has been providing for some time. To quote Davis again, "Fibers at least 1 1/16" with few short fibers, uniform micronaire, high pressley, easy to clean, requires minimum blending for dye uniformity, and is reasonably priced in comparison with practically waste-free man-mades." All of these characteristics are in Acala cottons to one degree or another.

In dealing with specific needs, two or three characteristics seem to be most important. A narrow range of micronaire of 3.8-4.6 with an average of about 4.2 is desired. It is important to have uniformity of fibers. Uniformity within a bale is as important as among bales. Even then, open-end or rotor spun yarns would probably be better off with a mike of 3-3.4. Also strong fibers with a fine mike are necessary in order to produce a strong yarn.

Most of the quality factors are under genetic control and progress is being made. In fact, California has consistently maintained a lead in high quality. Yield, quality and input costs ,of course, all affect profit. Environmental factors consist of those we can control and many which are uncontrolled. Among the controllable factors are the choice of field, dates of culture, fertilization, irrigation, and pest control. Uncontrolled factors are mostly related to the annual vagaries of the weather.

Profit, of course, is made up of different salable portions of the cotton plant. We have traditionally obtained the highest income from the lint portion, and the seed portion has been valued for its linters, oil, protein and meal content. Recently, the dairy industry has been consuming more whole cotton seed. It has come to my attention recently, too, that while five to six pounds per day per cow has been the recommended feed level there may be some who are feeding as much as ten pounds per day per cow. A 1,000 cow dairy feeding six pounds per day would consume 1,095 tons of cotton seeds per year. In 1980 there were 875,000 dairy cows in California. This places cotton seed feeding in direct competition with cotton seed processing, but this is an alternative use where alternative values may be found. Perhaps it would be possible to breed cottons that are more suitable to alternative uses simply based on improved cotton seed quality. Aside from the value of the cotton seed to the grower, there are questions on the safe limits of feeding whole cotton seed to dairy cows. Some research is needed to ascertain the safe limits.

One of the constituents that is related directly to feed value is Gossypol. Therefore, if Gossypol free cotton becomes a reality perhaps it would disappear from concern. There are other implications of Gossypol free cotton such as insect susceptibility. But, if we look at the San Joaquin Valley, Acala Cotton Board cotton variety test and the regional cotton variety tests around the nation, we find that there are significant differences in free Gossypol percentages among current varieties as well as locations.

Breeding can contribute to the control available over pests, planting dates, bloom and fruit set cycles and maturity, fertilizer efficiency, water efficiency and, of course, quality characteristics.

As an attempt to gain some additional control, interest in narrow row-culture has been intensified recently. This is due to a potential for more compact fruit set, earlier maturity and higher yields. It also has been given some justification from studies reported (with mostly standard varieties) over the last decade.

El-Zik, Yamada and Walhood (1980) report differences between SJ-2 and SJ-5 for onset of bloom, rate of bloom, peak bloom and maturity. SJ-5 was from a week to 10 days earlier in most characteristics studied. Earliness is important in improving efficiency of productin and profits.

Yield of narrow-row culture of SJ-1 grown at several locations over three years (1971-73) indicates about a 10% advantage over conventional culture. The range of response was from 1% to 39% except for one location in 1973 showing a 16% decrease. With the variety Coker 310 in 1972 and 1973, the advantage of narrow-rows was 20%. New varieties may improve upon this performance.

Another factor now plaguing the mills is dust; this comes from raw cotton. In the competitive higher speed spinning of today it is a significant problem. If the U.S. mills are hampered by the presence of dust, then foreign competition (who do not have the same OSHA regulations) may have an advantage in marketing. Just what the dust situation will lead to if large narrow-row culture catches on we do not know.

It seems that the plant breeder has improved cotton for yield and profit. Yield is at a plateau with the need for a breakthrough of some kind. In some circles hybrid cotton varieties are thought to provide a breakthrough. Reports in the literature so far have been quite mixed. While heterosis of as much as 48% have been shown, and hybrids are used in India there are many problems to be overcome before they are important in California. Production of A-, B- and R-lines will require effort to identify proper combinations. The procedure for assured pollination using bees is not sufficiently established as yet. Insect control methods are needed that do not eliminate pollinator bees.

In summary, opportunities for breeding cotton for maximum yield and profit are concerned with plant efficiencies. Varieties with greater fertilizer and water efficiencies are needed. Varieties to provide alternative cultural methods could help. Prospects for improved cotton performance in California are good and with many people working on it there should be good news ahead.

BREEDING VEGETABLES AND FLOWERS FOR MAXIMUM YIELDS AND PROFITS

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Many authorities have warned us that the number of desperately hungry people in the world is increasing. They have also told us that American agriculture will be a crucial and determining factor in supplying the world's food needs. Opinion polls have shown that The American public consistently gives more support to "combating world hunger" than to most other U.S. foreign policy goals. Eberstadt has, however, recently noted,

> "The whole debate over world hunger - and how America can help to end it - is badly distorted by the lack of reliable statistics. In their zeal, many specialists on hunger have employed faulty data and shrill, headline-catching rhetoric. The problem is serious enough already; exaggeration serves only to make it seem less manageable and more hopeless than it is."

The role of the horticultural plant breeder in providing maximum yields and profits is obvious. Most of the significant plant breeding successes in the past have been in the area of accomplishing increased gross yields per acre. Breeding for gross yield will continue to be very important for as long as farmers are paid on basically those terms. Vegetables and flowers have, by and large, not received the breeding efforts accorded to most of the agronomic crops. It would seem, therefore, that large advances in yields and profits are still possible using classical plant breeding methods. The growing food requirements of the world, however, presents us with a clearly unacceptable time frame for the development of new crop varieties to meet those requirements.

The technology already exists which will enable us to reach breeding objectives in a timely and efficient fashion. Cell and organ culture techniques offer a particularly rapid method for the multiplication of a superior plant or plants. Parasexual reproduction offers us the possibility of obtaining new genetic combinations between plants which normally do not cross sexually. While I personally feel a great deal of sentimental attachment to the classic "good old way" of sexual reproduction, I feel this is an area where one has to separate one's business life from one's personal life. Single cell culture techniques afford us the potential for screening immense populations for specific attributes at the single cell level. The "gene splicing" or "recombinant DNA technology" can lead to unique and useful crop varieties. These new technologies will, in my opinion, supplement, rather than replace, conventional plant breeding methods.

The food production challenges presented by a growing world population can, and will, be dealt with effectively. The Malthusian possibility is still here, of course, and will be here so long as populations grow unchecked and natural resources are depleted. The solutions to the challenges involve inter-relationships between agriculture, energy usage, economic policies, and other factors.

BREEDING CROP PLANTS FOR MAXIMUM YIELDS AND PROFITS: A PRIVATE PLANT BREEDER'S PERSPECTIVE

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Maximum yields and the cultural systems for attaining superior performance may have quite different meanings and thus implications to the private plant breeder depending upon utilization of the product, for example; a producer of an alfalfa variety for seed as contrasted to the producer of alfalfa for forage. Maximum profits and means of attainment take on as many different meanings and strategies as there are private plant breeding organizations.

The consumers of the products of the breeding projects and their concepts of maximum yield must be clearly understood, defined and incorporated in program objectives. In the process of identifying the needs of the various consumers of the research products, the characteristics that constitute yield of the crop and their relative importance are identified.

The strategy of a plant breeder working for a private profit motive organization must, by necessity, usually include objectives and systems which will compliment the specific mission of the owners and management of the business. The expectations for regular profits is a real constraint on the utilization of certain breeding systems. The breeder may encounter the need for breeding strategy compromises that might not otherwise be the case if regular profits were not the norm. In addition, changing market conditions require a continued assessment of breeding priorities. An awareness of the strategies of breeding projects and product performance of competitors is essential.

Perceptions of consumers regarding maximum yield are quite distinct as are perceptions of profit by business owners and managers and thus the breeder's strategy needs to accommodate each of these various interests. The plant breeder bases the strategies of the breeding and testing systems on the information and technologies available. However, the manipulation of the technologies to meet both short and longer term goals, as well as the required economic payoff, is a responsibility of the plant breeder.

A knowledge of the production and marketing strategies is another important area that the plant breeder must consider in the design of breeding projects. The breeding program must be complimentary to and provide the technical base for market development. Business organization, marketing and management skills are all areas of concern that a private plant breeder must have a working knowledge about in order to implement a successful program.

All of these, coupled with the desirability for increased scientific capabilities and professional advancement, make breeding plants for maximum yield and profit in the private sector economy a most challenging encounter.

Introduction to Water Penetration Problems

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Definitions

Infiltration, sometimes called intake, means entry of water into a soil surface. Water enters through pores of varying size between soil particles. Further downward movement of water through largely gravitational influence is called percolation. Water penetration is a broad term that includes both infiltration and percolation to some assumed depth, usually the root zone of the crop. The term permeability refers to the ease or difficulty with which water enters and percolates through the soil. Both infiltration and permeability are often expressed as rates in inches or millimeters of water per hour. Permeability classes as defined by the USDA - Soil Conservation Service are as follows:

very rapid	> 20	inches/hour	
rapid	6 - 20	"	"
moderately rapid	2 - 6	"	"
moderate	0.6 - 2	"	"
moderately slow	0.2 - 0.6	"	"
slow	0.06 - 0.2	"	"
very slow	< 0.06	"	"

These classes presumably include infiltration as well as further downward percolation.

Drainage refers to the presence or absence of a water table at a depth shallow enough to affect root growth or soil properties. Drainage and permeability are not necessarily related. A well drained soil may have slow or very slow permeability. The term well drained indicates only that there is no present water table and no evidence - in the form of reduced colors or mottling - of a former one. The term internal drainage, however, is almost synonymous with permeability.

A Channel System Concept

Dixon (1, 2) has developed a model of soil porosity to try to explain the wide range of permeabilities that occur in soils. He defines six states as follows:

Pore State	Soil Surface	Pore Description	Field Equivalent
A	rough	macropores open	stubble mulch tillage
B	"	macropores constricted	moldboard plowing, listing
C	"	macropores closed	plowed or listed, sealed by heavy rain
D	smooth	macropores open	turfgrass or legume crops
E	"	macropores constricted	freshly prepared grass or legume seedbeds
F	"	macropores closed	denuded desert soils, water sealed seedbeds

Dixon's work shows that soils with pore state A have infiltration rates of several inches per hour. In these cases, the bulk of the water enters through macropores that constitute 1% or less of the total surface area. In pore states C and F, water enters by capillarity rather than as free water.

Macropores of 1 mm diameter have 100 times the cross sectional area of micropores 0.1 mm in diameter, but transmit 10,000 times as much water. It is little wonder, then, that there is up to 1000 fold difference between the very slow and very rapid permeability rates.

Infiltration and Permeability of California Soils

Except for sandy soils, permeability rates of California soils are generally moderately slow to very slow. Recently University of California farm advisors were asked what they considered to be an optimum average infiltration rate. Most agreed that 0.25 inches per hour was rapid enough to allow wetting the root zone in a reasonable time. Rates greater than 0.5 inches per hour were felt to be too rapid to permit efficient flood or furrow irrigation. These high rates, however, are acceptable under sprinkler irrigation. Infiltration rates of 0.1 inches per hour or less give increasing problems of inadequate depth of water penetration, poor aeration, and potential for root and crown diseases. These slow rates are rather common in California soils, particularly in orchards.

Chemical and Physical Factors in Slow Infiltration

Mineral particles that are coated with certain organic materials may repel water and thus retard infiltration. Some soils under coniferous forest or chaparral show this characteristic. Forest or brush fires increase the non-wettability of soil particles. Most agricultural soils are easily wetted and the reduction of infiltration due to non-wettability is insignificant.

The primary chemical limitation to infiltration is due to excessive exchangeable sodium in the soil or high sodium adsorption ratio of the irrigation water. Low salt content of the irrigation water can also slow down water infiltration. These effects are discussed elsewhere in this proceedings.

The physical-chemical complex known as soil structure or aggregation plays an important part in water infiltration. Granular aggregates at the surface and in the soil profile promote macropore space and hence rapid infiltration. Unfortunately, most California soils have only weak aggregation which often disintegrates when wetted. This is due in part to low organic matter content and in part to other factors such as particle size, clay mineralogy, and exchangeable cations. Intensive cultivation and use of heavy machinery reduce the aggregation and allow the rearrangement of soil particles into a dense matrix. The direct effects of soil compaction are to slow water movement, reduce aeration, and impede root growth. Indirect effects are to decrease plant uptake of nutrients and increase the potential for toxicity and root diseases. Structural breakdown often appears to be greatest at the soil surface, because of the slaking effects of water flowing over the surface, or of water droplets forcefully impacting the surface. Thus, in some soils the surface is the rate limiting layer. In other cases compaction to 12 inches or greater is as great a limiting factor as the surface.

Loosening Soils, Stabilizing Structure, Controlling Traffic

Some soils clearly need to be physically loosened. The arrangement of particles and pore spaces that results from loosening, however, is pretty much a matter of chance. We need better methods to prescribe soil treatments that will result in the desired structure and porosity. We need to be able to strengthen and stabilize soil structure without reducing the intensity of cropping. Controlled traffic systems will help, but are not the complete answer. An integrated management system combining soil loosening, structure stabilization, and controlled traffic is needed.

Literature Cited

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EFFECT OF XANTHATE, PHOSPHOGYPSUM AND STRAW ON INFILTRATION AND RUNOFF OF A SPRINKLER IRRIGATED SOIL

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A replicated field experiment was conducted over a period of three months, beginning May 1981 to determine which amendment resulted in the greatest improvement in infiltration. The seven year old vineyard is irrigated with a solid set sprinkler system at a rate of 3.3 mm/h. The surface soil is a sandy loam with an exchangeable sodium fraction, E_{Na}, of 0.13.

The treatments (Table 1) were applied to an area of 22 x 7 m in conjunction with tillage on May 13, 1981. Each treatment was replicated three times. Runoff from half the treated area, which was not retilled during the remainder of the experiment, was measured with Persian water splitters. Soil water contents were measured at two locations in each replicate with a neutron probe, (0.15-0.6 m) and at greater depths, with soil samples. Other measurements made included: grape and pruning yield, soil solution and exchangeable ion composition, water application rates on each replicate, the σ of the runoff and characterization of the clay mineralogy.

Runoff resulted from crust formation which limited infiltration. Forty-five percent of the applied water was collected as runoff for the untreated plots. The corresponding runoff for the X, G, and S treatments was 22, 14 and 12% respectively. Gypsum mixed into the soil was not beneficial: runoff for the GG and G treatments were the same. Mixing gypsum into the soil enhanced the effectiveness of xanthate: runoff from the XG treatment was 3 percent.

One irrigation was sufficient to create a crust. For the control, the percent runoff from the second and following irrigations was relatively constant (45%) and greater than from the first irrigation (28%). Runoff from the xanthate (X) treatments increased from 8-20% during the first three irrigations. Under humid, warm conditions in the laboratory, the stabilizing effects of xanthate decreased rapidly. In thirty days there was no measurable difference, in permeameter studies, between xanthate treated and untreated aggregates. Runoff from the gypsum treated soils (G, GG, and XG) was relatively constant until the last irrigation. The σ of the runoff from this irrigation was about the same as that of the applied water. Perhaps the added electrolyte concentration, resulting from gypsum dissolution, was effective in enhancing soil stability after the exchangeable sodium fractions were reduced. The exchangeable sodium fraction of the gypsum-treated, surface soil after the last irrigation was 0.06.

Poor infiltration has resulted in reduced vine growth and yield in portions of the Tierra Réjada vineyard. Within the field where the experiment was conducted, yields varied about six fold between areas where infiltration is not a problem--no runoff occurs--and where it is a problem. The experimental data show that chemical amendments can increase infiltration and assure a water filled profile in August. Irrigation is terminated in late July or early August to provide the proper conditions for maturing grapes. If the soil water content is the sole limiting factor in areas of poor infiltration, grape yield could be at least doubled per unit land area, and per unit of applied water, in the field where the experiment is located. In addition, tillage could be reduced. The common practice is to till after most of the irrigations. In this experiment, the land was tilled once, on May 13, 1981.

Surface application of gypsum during May, immediately after the soil is tilled, appears to be the most practical amendment. The rate of application should equal or exceed 3 Mg/ha. Straw or residue management would also be effective. Growth of a winter intercrop would provide a source of straw. However, frost protection is already needed during March and April and a green intercrop would increase the severity of this problem. Spreading straw, grown elsewhere, introduces weed and grain seeds with a consequent increase in weed management problems during the summer irrigation season.

Xanthate applied at a rate which corresponds to 0.05% of the mass of treated soil illustrates the effectiveness of an organic polyelectrolyte for stabilizing soil structure. It binds soil particles together in a manner which an inorganic ion cannot do. If this material were commercially available, it undoubtedly would find application in soils which benefit from inorganic amendments, as illustrated by the data obtained in this experiment, and in soils for which inorganic amendments are not effective.

TABLE 1

TREATMENTS USED AT PASO ROBLES DURING THE SUMMER OF 1981

Treatment		Application depth mm	Rate Mg/ha
C	control	-	
S	straw	0	11
G	gypsum	0	3
X	xanthate	0-10	0.06
GG	gypsum	0	3
	gypsum	0-100	3
XG	xanthate	0-10	0.06
	gypsum	0-100	3

Soil Conditions and Their Effect on Soil Water Penetration
(Water Drainage in Surface Disturbed Soil)

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Water drainage through soil is only dependent upon the size and tortuosity of the pore spaces, that they remain open and unplugged, that there is lack of restricting cohesion between aggregates, and swelling is not a factor. Pore space is proportional to bulk density. Plugging of pore spaces occurs with an increase in density as well as by fine, dispersed particles. Dispersion is a function of wetting by water as well as chemicals present, especially Na as in the ESP of the water. Mechanical forces of tillage and falling water are important causes of dispersion. Cohesion is a function of soil mineralogy, cementing agents, and other chemicals. Individual aggregate sizes and their proportions in soil mixes are probably the most important factor in drainage.

Optimum drainage in a soil is found at its initial state after tillage. Drainage is slowed down as water crosses the interface between the tilled layer and into the non disturbed zone below. With the initial watering, the greatest physical and chemical changes which always decrease drainage potential occurs within the tilled zone. The most visible reaction in the soil caused by water are the changes at the surface where slacking and dispersion of exposed aggregates takes place. The fine particles which are formed block the pores and may cause crusting. Such complete dispersion and blockage when it occurs is limited to a few mm in depth with good aggregation persisting at the deeper depths even though the subsurface aggregates have been emersed in free water. Thus, by stabilizing a thin surface layer of aggregates, drainage can be greatly improved. Since water drainage for both tilled and non tilled soil is dependent upon open pores, once the pores are blocked they can not be opened except by mechanical means. This would indicate that the addition of chemicals to improve drainage must have some other action than creating open pore spaces -- such as reducing cohesion. The action of most chemicals is to preserve an existing state. It needs to be emphasized that the initial tillage practices, especially in dry soil, can produce very high amounts of particles small enough to plug soil spaces and create a poor initial drainage state.

There may be exception and variations to the above brief and simplified statement of the drainage problem and I hope there are. But at the present time the chance for improved drainage falls within understanding and working with these basic principles, mainly to first of all create a good system of open draining pores, and secondly to preserve these pores primarily by chemically or physically stabilizing these aggregates against both water and mechanical or physically stabilizing these aggregates against both water and mechanical dispersion. A number of experiments are discussed which show the relationships between drainage, pore size, and dispersion.

Aggregate Size and Dispersion Affecting Drainage

In Table 1 it is noted that drainage through aggregates of different size which do not disperse appears to have a threshold effect at about 0.5 mm, above which drainage is very rapid and more or less uniform and below which drainage is very slow. This threshold also is the dividing point between high and low density. The high density is created by gravity formed mixtures of small particles below 0.5 mm falling into pore spaces between larger aggregates and no compaction is required. Stabilized soil does not readily disperse but stable particles below 0.5 mm have high density as do normal soil mixtures approaching 2/3 by volume of large, and 1/3 by volume of particles below 0.5 mm. This table indicates that pore plugging occurs with aggregates below 0.5 mm. It also shows that water penetration is much faster in stabilized aggregates of 0.5 mm than in non stabilized aggregates of 0.5 mm, compare treatments 4 and 9.

Stability of Aggregates influence Water Penetration

In Table 2 we show that different solution strengths of a stabilizer, Nalco 2190, affects the stability of the aggregates. Other stabilizers have a similar effect. As stabilizing solutions increased in strength, the subsidence and shrinkage of the granules decreased. The amount of water held after drainage was found to increase slightly with the very weak solutions and then to decrease as solution strength increased. The most striking effect is that of water penetration. Small increments of stabilizer solution strength caused large differences in water penetration rates. At the value of 5 seconds for water penetration shown in Table 2, the water pours out the bottom of a tube nearly as fast as it is poured in the top. For practical purposes the time of 45 seconds and lower for this table is considered rapid and complete drainage. Anti cohesion and non crusting effects take place at as low a solution as 0.25%. At 1.0% to 2.0% solution strength, and higher, the existing granules are stabilized and ramain visually unchanged in appearance with repeated waterings. At weaker concentrations the granules disperse and in appearance resemble the water check. Impedance was measured as drying takes place and is correlated with water penetration rate. An impendance of 100 and lower on this scale is practically no resistance and the soil remains granular and pours easily from a pot after irrigation and use.

The effect of stabilizer strength on soil dispersion throughout the soil mass is shown in Table 3. Four solution strengths were used with the expected result of increased drainage with each increase in solution strength, and with results similar to Table 2. After drainage, the soil of Table 3 was dried and crushed gently and rescreened to determine any changes in aggregate sizes. The results show that as solution strength decreased there was a steady increase in the fraction smaller than 0.5 mm and a steady decrease in aggregates on top of the 1 mm screen which was the original size. This indicates that some second screening causes some dispersion, the actual values are high. The appearance of treatments 4 and 5 on the surface, and their mechanical analysis were about the same. Yet, treatment 4 had greatly improved water penetration, formed no crust, and poured from the tube while the check formed a crust and was largely solidified. The differences in cohesion between these two treatments indicate that dispersion by itself is not as bad as when there is dispersion and cohesion increase at the same time.

Dispersion caused by irrigation water in one soil screened to different aggregate sizes is shown in Table 4. For soil of one sized aggregates, the larger the aggregate size the greater the loss of this initial size due to water, but not necessarily with a large increase in the soil plugging fines. Generally, a vast majority of the initial size survives with out significant dispersion during a long period of time. In one experiment, aggregates of the sizes shown in Table 4 were used to fill large pots in which tomatoes were grown to maturity. Following this crop the soil was dried, the pots refilled and a second crop grown to maturity, using well over 100 inches of water for the two crops. At the conclusion of the second crop and after drying, each soil was predominently and easily identified as to its initial size. There was a slight reduction in the rate of water penetration during the period of growth but nothing striking. For the field run soils 6 and 7 of Table 4, the stabilized soil ended up essentially as they started relative to aggregate size with little dispersion into the less than 0.5 mm range. These soils when dried broke up easily into their original sizes. On the other hand, the non stabilized soils drained and dried slowly and were quite cloddy. The finer particles surrounded the larger ones and the various sizes were visable in the matrix but they were stuck together and did not break easily into the initial units. For this reason, the results for the final non stabilized soil are indicative but not very accurate. The results in Table 4 were obtained by stabilizing with an 8% Nalco solution which gives strong stability as noted in Table 3.

In other work, a soil composed entirely of aggregates below 0.5 mm was used and one treatment was mixing the soil vigorously with water until it began to aggregate. Different irrigation practices with and without a stabilizer were used. The granulation treatment noted above was the only one that improved drainage without stabilization.

Capillary rinse of water in the soil was improved slightly by stabilization as shown in Table 5. The large effect of reduced shrinkage by the stabilized soils is also shown. Of all the measurements made, mechanical resistance and lack of shrinkage with the first irrigation was most nearly correlated with drainage. In our work we used the draining rate as the best measure of stabilization, pore space and high quality seed beds.

The mechanism of drainage in soil is not easily understood from a few experiments or relationships, either chemical or physical. The series of experiments shown here show that good drainage in the surface disturbed soil is dependent upon creating and maintaining aggregates above 0.5 mm, or by reducing cohesion between the aggregates. Aggregates below 0.5 mm, as a class, are pore plugging and poor drainage increases as aggregate size decreases. Mixtures are worse than uniform sized aggregates, with the worst being about 2/3 between 2 and 5 mm and 1/3 below 0.5 mm. This mixture creates a large increase in density without compression and a big decrease in drainage potential. A system of stabilizing soil was described and it was shown that soil shrinkage caused by soil dispersion and settling was the chief cause of poor drainage. Tilling soil properly at the right moisture, a little on the damp side, has been shown to be the best method of forming desirable aggregates. Once aggregated, the soil must be stabilized in order to maintain drainage. Pore plugging dispersion is found chiefly at the surface-air interface to a depth of a few mm and is primarily caused by mechanical, rather than chemical forces. Cohesion caused by physical and chemical bonds occur in both the wet and dry state. Stabilizing with Nalco eliminates the chemical bonding and this is believed to be the main reason Nalco can improve drainage among aggregates below 0.5 mm. For larger aggregates it can eliminate dispersion.

Table 1. The effect of stabilized aggregate size on water penetration

Treatment	Aggregate Size	Soil Stabilized	Relative Water Penetration	Bulk Density
1	5 mm	yes	5 sec.	1.05
2	5	yes	5	1.00
3	1	yes	6	1.03
4	0.5	yes	38	1.07
5	> 0.5	yes	86	1.31
6	F-1	yes	145	1.41
7	F-2	yes	116	1.19
8	F-1	no	400+	-
9	> 0.5	no	400+	-

F-1 and F-2 are selections of two field run soil, F-1 of high and F-2 of low density due to different proportions of particles below 0.5 mm in diameter. This was on a clay loam.

Table 2. The degree of stability affects drainage and other things

Treatment	% Nalco Solution	% Water Gain	Relative Water Penetration	shrinkage mm	Impedance
2 mm soil	water ck	34.1	3500 sec	4	4000
	0.125	35.7	1500	4	1000
	0.25	38.2	420	3	100
	0.5	36.8	150	3	100
	1.0	33.3	45	3	100
	2.0	33.4	15	3	100
	4.0	30.9	15	2	100
	8.0	28.1	10	2	100
	16.0	27.0	5	2	100
	50.0	24.4	5	2	100
5 mm soil	water ck	30.1	-	17	3000
	0.5	36.6	5	7	100
	1.0	26.7	5	6	100
	2.0	23.9	5	4	100
	4.0	22.2	5	4	100
	8.0	20.0	5	4	100

After the stabilizer soak the soil was immersed in free water, then drained and dried before placing in tubes. Impedance was the highest value reached upon drying. Units are grams exerted against a 3/32 rod. On a clay loam soil.

Table 3. Reduced dispersion as affected by stabilizing solution strength
The initial soil was a graded 2 mm clay loam

Treatment	Nalco Solution Strength %	Relative Draining Time, sec.	Impedance	% Final Distribution top 1 mm	top 0.5 mm	thru 0.5 mm
1	4	5	100	67	24	9
2	2	20	100	60	25	15
3	1	60	100	29	29	42
4	0.5	360	100	6	14	80
5	water ck	3360	1500	5	12	83

Drainage time is for 8 cm of water to pass through 4 cm of soil in a 2" tube.

The final distribution of aggregates was determined after draining 50 cm of water through the soil.

Table 4. The effect of watering on dispersion of aggregates

	Soil	Per Cent Aggregate Size, mm, in Soil 5	2	1	0.5	> 0.5
1.	Initial soil mix stabilized	100	0	0	0	0
	final mix 1	84	9	2	2	3
	final mix 2	71	14	5	4	6
2.	Initial soil mix stabilized	0	100	0	0	0
	final mix 1	0	81	8	5	6
	final mix 2	0	89	5	2	4
3.	Initial soil mix stabilized	0	0	100	0	0
	final mix 1	0	0	94	4	2
	final mix 2	0	0	91	6	3
4.	Initial soil mix stabilized	0	0	0	100	0
	final mix 1	0	0	0	96	4
	final mix 2	0	0	0	97	3
5.	Initial soil mix stabilized	0	0	0	0	100
	final mix 1	0	0	0	0	100
	final mix 2	0	0	0	0	100
6.	Initial soil field run A, poor.	19.1	20.0	12.3	12.3	36.4
	final mix stabilized 1	16.7	19.1	12.2	12.9	39.1
	final mix stabilized 2	17.3	18.0	11.4	11.6	41.7
	final mix not stabilized 1	37.9	19.1	10.4	11.6	21.7
	final mix not stabilized 2	-	-	-	-	-
7.	Initial soil field run B, good	39.5	28.4	12.6	8.9	10.5
	final mix stabilized 1	36.4	28.4	13.9	9.3	12.0
	final mix stabilized 2	29.8	28.3	15.9	11.9	14.2
	final mix not stabilized 1	49.7	21.2	8.8	6.2	14.1
	final mix not stabilized 2	59.2	23.9	8.3	4.6	3.9

Mix 1 was a very wet irrigation treatment and mix 2 was minimal in water use.
The final mixes were after seedlings were grown and harvested.
Soil stabilization was done with an 8% Nalco 2190 solution which makes a very stable aggregate.

Table 5. Shrinkage, water movement and mechanical impedance compared between stabilized and non stabilized soil of different aggregate sizes and mixtures

		Sizes of aggregates in mm							
							Dense		
Measurment	Stabilized	5	2	1	0.5	0.5	Mix	Field ck	Mean
Final mechanical	yes	260	100	50	50	112	100	100	110.3
resistance	no	675	225	525	1250	3050	3475	2750	1707.1
Shrinkage in mm	yes	0	-1	-1	0	-1	+1	0	-0.3
	no	-8	-10	-8	-8	0	+1	0	4.7
Time for water to	yes	14	19	28	40	18	14	43	25.1
sub to surface. min.	no	55	42	48	23	42	120	90	60.0

Mechanical resistance units are in grams exerted on a 3/32 probe. A reading of 1000 is the point where no seedlings will emerge. Values up to about 250 are soil that remains very loose and will normally pour from the pot after drying.

AN OVERVIEW OF PROBLEMS WITH SOIL WATER PENETRATION

Les Stromberg*

Slow infiltration of irrigation waters is an exceedingly serious problem in the San Joaquin Valley and elsewhere in California. It is estimated that at least 1.25 million acres of otherwise good farmland in the San Joaquin Valley has an infiltration rate less than 0.15 inches (4 mm) per hour. A large portion of this has an infiltration rate of less than a third of this rate. These rates which have been measured have not been corrected for the evaporation from a free water surface which may be a significant amount when compared to these low figures.

The cost to the agricultural industry amounts to several millions of dollars per year. These losses are incurred by the need for frequent irrigations, loss of crop yield and loss of plants by protracted standing water during and following irrigations. In soft fruits there is a loss caused by the lack of tree growth, fruit sizing and turgidity brought about by moisture stress as well as premature death of trees.

There are no supportable data to quantify losses but estimates have been made that the production of almonds is reduced by one-third and the loss of trees over the life of an orchard may be as high as 20 percent. In some cases, the percent of under-sized peaches, nectarines, and plums have reduced the marketability of the fruit.

Many workers in the field have agreed that we can cope reasonably well with a minimum infiltration rate of 0.2 inches per hour. This really isn't a very high rate but may serve as a first goal for those doing research aimed at understanding and improving infiltration rates.

Several possible reasons for low infiltration rates have been proposed -- none of them explain all of my observations.

Fields with critically low infiltration rates are most commonly found where the soils do not crack substantially when dried. This means that most of the alluvial soils from the Sierra Nevada Ranges have infiltration problems. This includes all but the very sandy soils.

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The presence of even a relatively small amount of mica among the sand sized particles also seems to greatly reduce the infiltration rate. This may be due in part to the tendency of these flakes to be oriented at right angles to the flow of water. This clogs the macropores and increases the tortuosity of the water path.

Low infiltration rates are also exacerbated by irrigating with low salt waters below the flocculation threshold. Infiltration is further reduced if the water has a high sodium adsorption ratio (SAR) and made even more severe if the dominant anion in the water is bicarbonate. These types are again found on the east side of the valley in both ground water and water diverted from Sierra streams.

Infiltration problems on the west side of the valley of soils derived from alluvium of the Coast Ranges are not as widespread but they do exist. The clay in these soils is predominantly montmorillonite which swells and shrinks with alternate wetting and drying. Water from the California Aquaduct and the Delta-Mendota Canal are fairly low in total salt and can and do cause some dispersion.

Not all the infiltration problems can be so easily explained by attributing them to mica, to the properties of the clays, the low level of electrolytes, the SAR or the bicarbonates in the water. Traffic pans also may contribute to the breakdown of soil structure with the resulting reduction of infiltration. These are not the whole cause of the problem.

We have some anomalies which I cannot explain. How do we explain that for the first few irrigations in the spring following winter rains the infiltration is reasonably rapid but as the summer advances, the rates become exceedingly slow?

Possibly, during the interval between irrigations the surface soil consisting of dispersed fine particles, each well lubricated with water, are compacted by tension forces which build up as the soil drains and the surface soil moisture evaporates. Even this argument is faulty because progressively lower infiltration rates have been observed with drip irrigation where there is very little dehydration between water applications.

Could it be that some microorganism proliferates in the surface soil as the weather becomes warmer? If so, this could restrict the pore space. Perhaps something as simple as a few parts per million of copper ion may be worth a try.

What can be done in the hopes of improving infiltration? What is being done by growers?

If the quality of water is thought to be responsible for poor water penetration, then altering the quality would seem to be the obvious cure. We've had some experience doing this.

Some success has been had by adding soluble salts, usually calcium sulfate, to water with low electrical conductivity (less than 0.5 daS/m).

The SAR can be reduced by the addition of soluble calcium to the water. Adding soluble calcium to the water in amounts to materially affect the rate of infiltration is usually not practical because of cost and physical difficulty.

Mechanical gypsum applicators were commonly used years ago but are almost never used now which attests to their lack of success and value.

The adjusted sodium adsorption ratio (SARa) can be reduced by replacing the bicarbonate ions with sulfate by either adding sulfuric acid or sulfur dioxide to the water. This is sometimes done.

Removing the bicarbonate ion will reduce the SARa but will not reduce the SAR nor increase the infiltration rate of the first irrigation. However, it still may be worthwhile to remove the bicarbonate bacause as the soil dries, the bicarbonate in the soil solution is concentrated. This removes the calcium from the clay by precipitation and eventually creates a sodic soil.

In carefully controlled field trials, the removal of all of the bicarbonate from a high bicarbonate water showed no increase in the rate of infiltration in any one of eight irrigations.

Claims are made for several other materials added to water to improve water penetration. In another trial, there was no change in infiltration rate by adding calcium polysulfide or ammonium polysulfide during seven irrigations of sugar beets.

The only successes we have had on a field scale trial with chemical amendments has been with gypsum applied to the soil surface. Even this has resulted in only temporary improvement and then not of great magnitude.

The application of 3 tons of gypsum per treated acre showed some improvement for three irrigations with low salt waters -- usually those with an EC of 0.3 daS/m. With irrigation waters containing 3 or more milliequivalents of bicarbonate per liter, the improvements were measurable in only the first of seven irrigations of sugar beets.

Winter covercrops, even of grasses, offered no substantial improvement unless the practice was continued for several years. We have developed no practical method of materially increasing organic matter in soils with the inhospitable summers in the San Joaquin Valley.

Grass cultures during the summer months in vineyards and orchards offer some relief where it is compatible with the other cultural practices.

In summary, slow infiltration of irrigation water is a widespread and serious problem. There are many reasons for this, some of which we know and probably other reasons not yet described. We don't fully understand any of the known or suspected reasons for slow infiltration. The practices we know that can bring limited improvement are usually difficult or expensive and, therefore, not widely accepted.