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How Commodity Marketing Orders Help Solv

Agricultural research is the backbone of California's $14 billion yearly farm income produced by more than 200 plant and animal crops. As public budgets tighten, producers and handlers are providing an increasing proportion of the support needed by scientists to develop new cultivars and better pest and disease controls and to help growers increase crop yields in the face of constantly rising costs. Through state and federal marketing orders, farmers, handlers, ranchers, and processors are assessing themselves so much per ton, box, bale, etc., of crops produced to pay for work desired.

Marketing orders can be established for research; for advertising, promotion, and market development; and for supply control and other needs. Benefits accrue to both sides in this "university-industry connection" (5), but consumers are the real beneficiaries, enjoying the fruits of this farmland diversity through stable, competitive prices.

Funds for agricultural research also come from commodity groups, generally for specific and short-term projects, and from the state commission form of self-help program. Commissions have basically the same provisions as marketing orders but function differently. Commissions are established by the legislature specifically for individual commodities and are approved by the vote of the industry. They handle their own funds and authorize their own programs with the concurrence of the director of the Department of Food and Agriculture. A major difference between a commission and a marketing order is that, to date, a commission has not been authorized to conduct quality or quantity control programs. Commodities using commission programs in California include avocados, pistachios, and kiwifruit. The lettuce industry uses the commission program for promotion and the marketing order program for production research.

This article deals with the marketing order system's research aspects for production, protection, and quality improvement in a few of California's many plant crops.

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The Scope

In California, 37 state marketing orders contribute more than $3 million in research funds and federal marketing orders covering 19 crops (Fig. 1) contribute another $0.5 million. Portions of all these monies go to the USDA-ARS and to California state universities, but most goes toward University of California work on basic and applied aspects of food production and processing. Marketing order support to the three departments of plant pathology of the University of California during 1980–1981 was: funds from 15 boards used by 9 faculty at Berkeley, funds from 14 boards used by 11 faculty at Davis, and funds from 6 boards used by 9 faculty at Riverside. Researchers quickly approach new or current industry problems for immediate solutions as well as carry on long-term investigations.

Table 1 is a partial list of funds provided to the University of California during 1981–1982 and shows the range of plant-based commodity groups involved. The $3,394,276 was distributed as follows: $1,785,077 to the Davis campus, $1,083,194 to the Riverside campus, $387,471 to the Berkeley campus, and $138,534 to statewide cooperative extension (7). These dollars not only contribute greatly to research continuity but also help build a resource of trained agriculturists, since many who work on the projects as graduate students, postdoctoral candidates, and technical assistants eventually go into commercial agriculture.

Probably some of the greatest direct benefits of marketing order activities derive from the personal contacts and better understanding evolving between scientists and farmers. The close working relationships start with liaison committees for each commodity under a marketing order. Each year, groups within the university and within the crop organizations decide research areas individually, then set priorities together. Final decisions are subject to approval by the state or federal regulatory agency involved. Throughout the year, meetings on campuses, in the field, and between liaison personnel ensure exchange of knowledge on progress, new problems, and individual concerns. In addition, most boards require formal annual reports covering each of their projects. Thus, all growers or handlers contributing to an order can find out on what and how their dollars were spent and what was achieved (9).

Provisions vary slightly between federal (10) and state (4) marketing orders. Most federal orders involve commodities produced in more than one state, and California orders generally cover more commodities and are more adaptable to problems of specialty crops. State orders cover a broad range of regulations or activities (Table 2). For example, the Fresh Market Tomato Advisory Board's budget for 1 April 1982 to 31 March 1983 (3) designated over $250,000 for: 1) variety development, 2) flavor improvement, 3) preharvest and postharvest diseases, 4) postharvest physiology, 5) insect pest management, 6) development and testing of experimental harvesting systems, 7) biochemical resistance to insects, 8) epidemiology and control of frost injury incited by leaf surface ice nucleation, 9) cause and control of corky root, 10) mechanisms to facilitate production of hybrid seed, 11) control of alfalfa mosiac virus disease, 12) implementation of integrated pest management programs, 13) biology and control of late blight, 14) epidemiology and control of powdery mildew, 15) epidemiology of bacterial canker, and 16) etiology of pith necrosis.

Some Accomplishments

Fruit crops. In the marketing of fresh fruits (stone fruits, 55,000 ha, FOB value $360 million; citrus, 100,000 ha, FOB value $700 million), crop losses up to 50% were common during long-term storage, distribution, and retail sales—until effective control measures were developed with marketing order support. Among the gains were findings that the primary organisms in postharvest decay of sweet

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cherries, apricots, nectarines, peaches, and plums are *Monilinia fructicola* and *Rhizopus stolonifer*. Less common but equally important at times are *Botrytis cinerea, Alternaria alternata, Gilbertella persicaria, Mucor piriformis,* and other *Rhizopus* species (11).

Basic knowledge gained on the epidemiology of these pathogens led to today's preharvest and postharvest control measures. For example, reductions achieved in blossom blight and preharvest fruit rots plus introduction of the postharvest DCNA-benomyl-wax treatment prevented new infections of *M. fructicola* and suppressed established ones throughout the fruit ripening period. The wax treatment also controlled *R. stolonifer* but not other *Rhizopus* species (*R. arrhizus, R. circinans, R. oryzae*) and not *Gilbertella, Mucor,* or *Alternaria*.

Another important finding was that the addition of chlorine (50 ppm) to hydrocooling water used at around 0 C immediately after harvest reduced fungal spore contamination on the fruit and in the water. This is especially beneficial in fighting fungi such as *M. piriformis* that are not controllable with currently available chemicals or through cold storage.

Recently, monitoring programs in the orchard detected benomyl-resistant *Monilinia* isolates and even *M. fructicola* that was not being effectively controlled by 1 μg/ml of benomyl. Excessive fruit losses were avoided by quickly devising an alternative treatment with triforine (Funginex 50WP), a fungicide with a different mode of action than benomyl.

For citrus, control of green and blue mold decay caused by *Penicillium digitatum* and *P. italicum*, respectively, is most critical during storage and marketing of oranges, lemons, tangerines, and grapefruits. The long-term, repeated use of sodium orthophenylphenate (SOPP) and biphenyl (related compounds with known cross resistance) in packing box treatments resulted in *Penicillium* resistance to both. Then, with the introduction of the benzimidazole fungicides thiabendazole and benomyl, selection of resistant *Penicillium* occurred faster than alternative chemicals could be registered.

The answer to decay control problems was to improve packinghouse sanitation and to alternate fungicides with different modes of action, using monitoring to determine the sensitivity levels of the specific resistant populations. The fungicide 2-aminobutane (Tutane), developed by the University of California (2), was incorporated into the program,

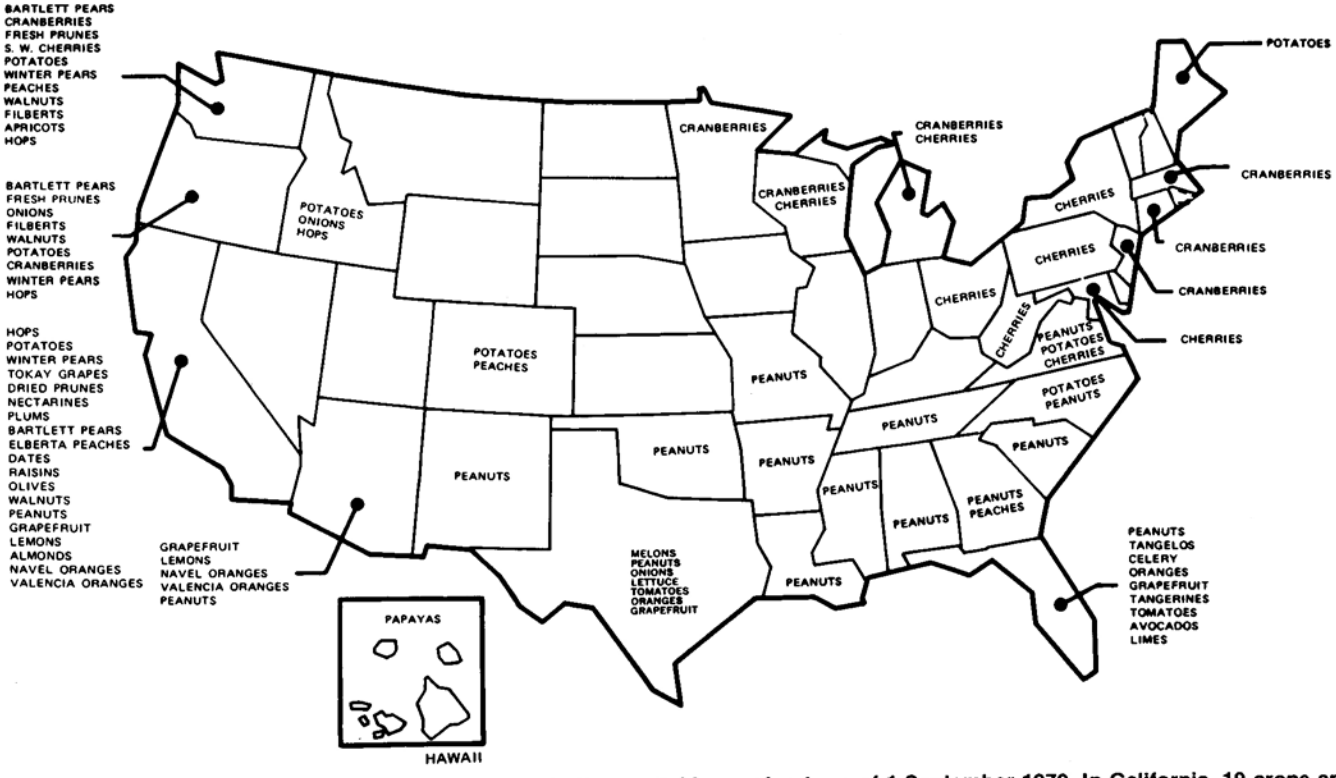

Fig. 1. Federal marketing agreements and orders for fruits, vegetables, and nuts as of 1 September 1979. In California, 19 crops are covered.

and today imazalil is used under an emergency permit and CGA-64251 is being tested as a future alternative. The benefits of the program were achieved not only through close cooperative research with the citrus industry but also through the invaluable help of private commercial groups, such as the Decco-Tiltbelt Division of Pennwalt Corporation, FMC Corporation, and the Brogdex Company.

Other marketing order studies on citrus are: 1) testing for biological control of *P. digitatum* with nonpathogenic *Penicillium* spp., 2) developing selective media for *P. digitatum* to improve monitoring, and 3) studying the fitness of the fungicide-resistant isolates to ensure effective treatment for *Penicillium* spp. as well as *Geotrichum candidum*.

Table 1. Partial list of expenditures for research on plant crops provided to the University of California by marketing orders during 1981–1982

Commodity	Total
Alfalfa	$ 90,323
Almond	181,897
Apple	9,322
Avocado	275,534
Brussels sprout	481
Bushberry	2,295
Celery	44,224
Citrus	539,837
Dry bean	121,262
Dry fruit	90,469
Grape	165,110
Kiwifruit	15,978
Lettuce	197,827
Melon	82,391
Peach	77,924
Pear	33,701
Potato	90,463
Raisin	163,566
Rice	373,309
Strawberry	333,731
Tomato	327,527
Wine	177,105
Total	$3,394,276

Avocados. The California avocado industry, through marketing order funds currently administered by the California Avocado Commission, has provided substantial support for research on Phytophthora root rot of avocado, caused by *Phytophthora cinnamomi*, the most serious problem facing the avocado industry in California and in most other production areas (12). The California avocado crop in recent years has had a market value in excess of $100 million. Losses from Phytophthora root rot are estimated at 20–25% of the 20,000–24,000 bearing hectares.

Progress in control has been significant under marketing orders, with development of resistant rootstocks and use of soil fungicides. These gains have been supported by new information on the life cycle of the pathogen and on the effects of environmental factors, such as soil moisture and temperature, on fungus and disease development.

Two of the newest clonal-resistant rootstocks, Duke 7 and G6, are being produced in large numbers by nurseries; several hundred thousand trees on these rootstocks were sold in 1982. The soil fungicide ethazol (Terrazole) is now registered for avocado trees in California, and two other materials, metalaxyl (Ridomil) and fosetyl aluminum phosphite (Aliette), that have controlled root rot when applied in irrigation water or in granular form are early candidates for registration. Metalaxyl has recently been registered for use on nonbearing avocado trees in California.

Sugar beets. In the early 1970s, a major new disease hit sugar beets in California. Yield dropped noticeably because of a rot that destroyed the beet center, leaving many low-quality, rotted roots and only hollowed shells to harvest (8). In some fields, 30–40% of the beets were severely rotted.

With industry backing, a UC-USDA research and extension team was organized to determine the cause and incidence and to find a solution. Very quickly, a bacterium was isolated, and inoculation trials in the greenhouse and the field established it as the cause of root rot in commercial fields. The bacterium was similar to the common soft rot bacterium, *Erwinia carotovora*, but a taxonomic study of California strains showed it did not fit any known group. On the basis of pathogenic and physiological differences, the bacterium was named *E. carotovora* subsp. *betavasculorum*. The rot occurs in most California beet-growing areas, and annual losses are estimated at 5–10%.

Many factors contribute to disease severity. Plants are susceptible to infection at all stages of growth, but early infection is what leads to severe losses. The disease is favored by high temperatures and plant injury. Growth cracks related to nitrogen nutrition levels and plant spacing are also factors. The number of diseased roots and the amount of rot per root are higher with increased nitrogen, and the percentage of diseased roots increases steadily with plants spaced farther apart than 8–10 in.

A cooperative program with the USDA at Salinas, Woodland, and Dos Palos proved that the newly released yellows-resistant hybrids US H9 and US H10 are more susceptible to the bacterial pathogen than are the older beet

Table 2. Some active California marketing orders and programs

Title	Regulations or activities authorized	Effective and termination dates
Alfalfa Seed Production Research Program	Research relating to production of alfalfa seed	Effective 9 July 1973; referendum every 5 years
California Brandy Marketing Order	Advertising and sales promotion; production, processing, and marketing research and survey studies	Effective 1 April 1977; referendum every 3 years
California Citrus Improvement Program	Research relating to agricultural chemical residues; variety improvement, including registration and certification program for nursery stock; other production and marketing problems	Effective 24 October 1968; referendum every 5 years
Marketing Order for California Raisins, as amended	Advertising and sales promotion; production, processing, and marketing research	Effective 28 June 1949; referendum every 5 years
Growers Marketing Order for Processing Cling Peaches, as amended 1981–1984	Producers only: quality determination, advertising and sales promotion, research and acreage surveys	Effective 12 July 1962; termination 30 June 1984
Processors Marketing Order for Clingstone Peaches, as amended	Processors only: quality determination, regulations, mandatory inspection, quality research	Effective 22 May 1964; indefinite term
California Potato Research Program	Research and survey program relating to variety development, production, harvesting, processing, and distribution; studies relating to health, food, nutritional, therapeutic, dietetic, and similar qualities	Effective 23 September 1974; referendum every 5 years
California Fresh Market Tomato Research Program	Research, development, and survey programs relating to variety development, production, harvesting, handling, transporting from field to processing points and from processing points to market, and processing or preparing for market, except cherry tomatoes	Effective 12 June 1972; referendum every 5 years

cultivars. This susceptibility had been inadvertently incorporated into the pollen parent during selections for yellows resistance. Through an intensive selection program at Salinas, a clean pollinator was found and an *Erwinia*-resistant line was soon developed. Thus, within a relatively short time after a potentially serious problem was discovered, an intensive cooperative research program determined the cause, spelled out factors contributing to severity, and produced an improved sugar beet cultivar to control it.

Rhizobacteria. The recognition that beneficial bacteria (rhizobacteria) can aggressively colonize roots and displace pathogenic microorganisms is leading to a relatively new approach to biological pest control (1). Well over 60 replicated field plots, each testing different strains of root-colonizing bacteria, have been run by the university since 1975. In all cases, rhizobacteria were found that statistically and significantly increased growth and yields of potatoes, radishes, sugar beets, melons, lettuce, and beans; the highest increase was 144% in radishes.

Ecological and physiological studies have shown that some rhizobacteria produce an iron-chelating antibiotic called a siderophore. The iron is thus unavailable to many other microorganisms, which are displaced by the rhizobacteria. The studies also showed that rhizobacteria can colonize roots throughout the season under suitable conditions and that some strains are very inhibitory to various soil microflora.

A primary reason for increased plant growth is that rhizobacteria protect roots against deleterious infectious fungi and also against some injurious bacteria. So far, rhizobacteria have been much more effective against quasi pathogens than against primary pathogens, such as *Rhizoctonia* and *Verticillium*. Some strains, however, have recently reduced colonization and infestation of potato roots and tubers by *Erwinia* spp.

For years, this research on rhizobacteria was supported solely by the state and state marketing orders.

Fire blight. Marketing order funds played a significant role in the work on fire blight control (6). Along with state and Hatch funds, they supported studies that produced a medium to examine the ecology of fire blight bacteria. This led to the discovery of streptomycin-resistant strains and to the establishment of a monitoring program to determine when to apply bactericides. Studies on the ecology and pathogenicity of streptomycin-resistant strains revealed their long-term stability in the field, an important discovery concerning the significance and ramifications of drug resistance by many bacterial pathogens in agriculture.

The fire blight monitoring program led to today's forecasting method, based on daily temperatures, that tells growers when fire blight bacteria are most likely to colonize pear flowers. The number of applications of bactericides has been reduced from as many as 15 to several or even none, depending on the weather. Furthermore, postponement of early copper spray applications reduced the incidence of fruit russeting.

Establishing and Operating Marketing Order Programs

Marketing order programs in California are authorized by the California Marketing Act of 1937 and the federal Agricultural Marketing Agreement Act of 1937. To ensure that all segments of the industry are protected as well as benefited by a proposed program, development of a marketing order is a lengthy process (4).

Representatives of the industry to be served determine with the California Department of Food and Agriculture that their proposal is within the authority of the law and in the public interest. Industry funds are required to meet the state's expenses during this stage. An industry formulation committee, representing all types and sizes of producers or handlers affected by the proposed program, is then organized. This committee, working with a representative of the Department of Food and Agriculture, analyzes its particular marketing problems and drafts provisions; these usually specify the size of the advisory or operating board and how its members will be drawn from different segments of the industry. Terms of offices, maximum assessment rates, methods of application, and the term of the marketing order are decided.

When the committee feels its proposed program has significant industry support, the director of the Department of Food and Agriculture conducts a public hearing on the program. If, on the basis of testimony at the hearing, the director feels the program is justified, the Department of Food and Agriculture conducts an election among all affected persons in the particular industry.

The California Marketing Act provides that an order regulating *producers* goes into effect if: 1) at least 40% of the producers participate in a referendum and the order is approved by 51% of the producers marketing 65% of the volume or by 65% of the producers marketing 51% of the volume or 2) not less than 65% of the producers producing 51% of the commodity or 51% of the producers producing not less than 65% of the volume assent in writing. Marketing orders regulating *handlers* require approval of 65% of the handlers by number or volume. The exceptions are orders for canning fresh fruits or

vegetables and for packaging dried fruits; the requirements for these are 65% by number and 65% by volume.

The requirements under the federal Agricultural Marketing Agreement Act are similar but easier to fulfill. In essence, if two-thirds of the producers—either by number or by volume of product—approve the program and if handlers of a majority of the crop volume sign the marketing agreement, the secretary of agriculture establishes it for the entire industry (10).

California orders are administered through boards appointed by and advisory to the director of the Department of Food and Agriculture. Members are selected from nominees elected by industry from its ranks. In addition, each board or committee includes one person appointed as a public member. Most boards employ managers and staff to administer programs. Federal orders have administrative committees consisting of growers and/or handlers who are nominated by the industry and appointed by the secretary of agriculture. Managers, appointed by the administrative committee, handle daily activities and work closely with appropriate USDA marketing field offices.

Boards and committees also are charged with initial investigation and reporting of complaints or violations. Marketing order enforcement under civil and criminal codes is primarily the responsibility of the state or federal government.

When 51% of the growers who also produce more than half the crop ask the director of the Department of Food and Agriculture or the secretary of agriculture to terminate an order, that must be done at the end of the marketing period. An order that does not carry out its declared policies also may be terminated.

A marketing order is as successful as its participants want it to be. Advisory board and administrative committee members are responsible for carrying out their industry's stated objectives. The university plays an important role by helping define research beneficial to industry, the public, and the general prosperity of the state. The interests of consumers as well as of producers are key elements in this process. To this end, the "university-industry connection" (5) has proved its viability and should be fostered and encouraged to meet future challenges in California and throughout the nation.

Acknowledgments

For helping compile the information in this article we thank W. B. Blackburn, USDA, Agricultural Marketing Service, Fruit and Vegetable Division, Sacramento, California; D. K. Ikari, Bureau of Marketing, Department of Food and Agriculture, Sacramento; and Melvin N. Gagnon, Agricultural Information, University of California Cooperative Extension, Davis.

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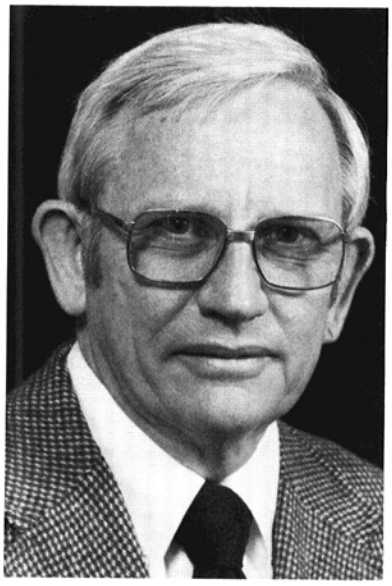

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Literature Cited

1. Burr, T. J., Schroth, M. N., and Suslow, T. V. 1978. Increased potato yields by treatment of seedpieces with specific strains of *Pseudomonas fluorescens* and *P. putida*. Phytopathology 68:1377-1383.
2. Eckert, J. W., and Kolbezen, M. J. 1964. 2-Aminobutane salts for control of postharvest decay of citrus, apple, pear, peach, and banana fruits. Phytopathology 54:978-986.
3. Fresh Market Tomato Advisory Board. 1982. California fresh market tomato research and education programs. 1981–82 Annual report. 194 pp.
4. Garoyan, L., and Youde, J. G. 1965. Marketing orders in California: A description. Division of Agricultural Sciences, University of California, Berkeley. Leaflet 2719. 20 pp.
5. Kendrick, J. B., Jr. 1980. The university-industry connection. Calif. Agric. 34(5):2.
6. Moller, W. J., Schroth, M. N., and Thomson, S. V. 1981. The scenario of fire blight and streptomycin resistance. Plant Dis. 65:563-568.
7. Schoonover, W. E. 1983. Donations for agricultural research, July 1, 1979–June 30, 1980. Calif. Agric. 37(1,2):27-29.
8. Schroth, M. N., Whitney, E. D., Thomson, S. V., Lewellen, R. T., and Hills, F. J. 1979. Bacterial rot of sugarbeet: problem and solution. Calif. Agric. 33(7,8):9.
9. State of California, Department of Food and Agriculture. 1975. Purpose and nature of marketing order programs. California Bureau of Marketing. 20 pp.
10. USDA Agricultural Marketing Service. 1979. Marketing agreements and orders for fruits and vegetables. Program Aid 1095.
11. Wilson, E. E., and Ogawa, J. M. 1979. Fungal, Bacterial and Certain Nonparasitic Diseases of Fruit and Nut Crops in California. Division of Agricultural Sciences, University of California, Berkeley. 190 pp.
12. Zentmyer, G. A., and Ohr, H. D. 1978. Avocado root rot. Division of Agricultural Sciences, University of California, Berkeley. Leaflet 2440. 14 pp.