# Crop Time Line for
# Cantaloupes, Honeydews, and Watermelons
# in California

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**October 11, 2002**

**Prepared for the U.S. Environmental Protection Agency**
**Office of Pesticide Programs**
**Washington, D.C.**

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## Introduction

This time line has been written to provide specific information on crop production of cantaloupes, honeydews, and watermelons grown in California. This report will provide a general review of key pests and also worker activities normally expected in crop production. This time line has also been prepared to provide information to help assess worker risk and to hopefully identify benefits of pesticide applications where concerns may have arisen.

Differences in crop production of melons are identified with their associated cultural activities and pesticide applications. Methods of application of pesticides are being provided to allow insight into common practices that may vary somewhat by the different production regions, identified in Figure 1, which have varying geographical influences and weather patterns. Table 1 illustrates average price per unit by region.
Tables 2-4 identify the different pesticide classes with the most common materials used in melon production in California. Tables 5-6 identify the use of Diazinon. Table 7 identifies the time line of various crop events and worker activities for the main melon production regions that occur in the Sacramento (Area I) and San Joaquin Valleys (Area II) compared to the Coachella, Palo Verde, and Imperial Valleys (Area III). Key pests and typical pesticide applications are shown in a time line for all melons in the state.

Several key developments have occurred in the melon industry in recent years which have impacted on decision-making by growers, packers, and shippers. Some of these changes have resulted in adjustments to pesticide use while others influenced innovation and modifications in cultural practices and worker activities. The most significant of these developments include:
1) Presence of a new species of whitefly in the desert growing regions,
2) General acceptance of field packing versus shed packing for some melon types,
3) Development and acceptance of sulfur resistant melon varieties,
3) Development and acceptance of hybrid melon seed,
4) Development and utilization of precision planters,
5) Decimation of feral bees by varroa mites and also tracheal mites,
6) Presence of Africanized honey bees in the state, and
7) Adoption of drip irrigation by some melon growers.
These developments will be discussed in more detail in various sections of this report.

It should be noted that there are many variations to the harvesting of different types of melons utilized by packers and shippers. Therefore, there is no industry-wide acceptance of any one method of picking, packing, transporting, and shipping of the melon types covered in this report. Variations are employed by an individual company involved in the harvest stage as adjustments are made to try and lower labor costs or other production related costs or just to increase market share. Harvesting and packing methods have been employed by a shipper for a specific produce buyer for warehouse type outlets while they use another method for the balance of their harvest (12). These variations can be looked upon as attempts to gain a competitive advantage by packers and shippers in the melon industry due to the highly perishable commodities and also due to a consolidation of produce buyers and retail outlets.

## Crop Production Facts

Melons belong to the cucurbit family of plants, known as Cucurbitaceae, which includes cucumbers, gourds, squash, and pumpkins. There are several different genus names used in the family. Cantaloupes (*Cucumis melo* L. var. *cantalupensis*) (4) and honeydews (*Cucumis melo* L. var. *inodorus*) (14) are classified in a different genus than watermelons (*Citrullus lanatus*) (25). Melons are warm-season annuals that are very sensitive to frost.

### Cantaloupes

- California ranks first in the nation in production of cantaloupes. Acreage plantings for the year 2000 from the USDA National Agricultural Statistics Summary show California ranked number one with 58,500 acres of the total 102,430 planted acres in the United States. This puts the state's production at approximately 57% of all cantaloupes grown in the US (23). Harvested acreage was 57,500 acres.
- Total production of cantaloupes grown in the US in 2000 was 20,292,000 hundred weight (cwt) with an average US yield per acre of 207 cwt. This would equate to 517.5 cartons per acre using a 40 pound box. The average yield of cantaloupes in California was 220 cwt which would equate to an average yield of 550 cartons per acre. Cantaloupe growers in California would identify an excellent yield as 800 cartons per acre (12).
- In 2000, cantaloupes ranked 35th in gross value among all California agricultural commodities with a total of $156,590,000 (19). Based on data from the offices of the County Agricultural Commissioners in California, the average value per harvested acre was $2,694.
- Cantaloupes grown in California are shipped throughout the US market as shipments to Canada have declined in recent years due to the large difference in exchange rates for the dollar. The need for refrigeration (38 degrees F) after harvest has prevented growers from shipping cantaloupes overseas.

### Honeydews

- California also ranks first in the nation in production of honeydew melons. The same 2000 summary shows California ranked number one in planted honeydew acreage at 22,000 acres of the total 28,600 planted acres in the US. This puts the state's production at approximately 77% of all honeydews grown in the US (23). Harvested acreage was also 22,000 acres.
- Total production of honeydews grown in the US in 2000 was 5,572,000 hundred weight (cwt) with an average US yield per acre of 196 cwt. This would equate to 653 cartons per acre using a 30 pound box. The average yield of honeydews in California was 190 cwt which would equate to an average yield of 633 cartons per acre. Honeydew growers in California

would identify an excellent yield as 1,000 cartons per acre though I have seen a field yield 1,250 c/a (12).

- In 2000, honeydew melons ranked 59th in gross value with a total of $45,172,000. Based on data from the offices of the County Agricultural Commissioners in California, the average value per harvested acre was $2,709 (19).
- Honeydews of top quality are exported to Pacific Rim countries such as Japan. The amount of honeydews shipped overseas via boat usually fluctuates during every year based on the money conversion from dollars to yen as the exchange rate and current economic conditions in Japan can have a great impact on sales. Another favorite market is in Hong Kong. When the money exchange rate is an issue, honeydews would be targeted at US markets.

**Watermelons**

- California ranks fourth in the nation in production of watermelons. Acreage plantings for the year 2000 from the USDA National Agricultural Statistics Summary show California ranked behind Texas, Florida, and Georgia (23). There were 12,300 acres of watermelons planted and harvested in California. This puts the state's production at approximately 6.5 % of the total 189,360 planted acres in the US.
- Total production of watermelons grown in the US in 2000 was 37,152,000 hundred weight (cwt) with an average US yield per acre of 226 cwt (23). This would equate to 11.3 tons per acre as most watermelons are not packed in individual boxes. In terms of total US production, watermelons were the third highest crop behind head lettuce and onions. Even though California growers were ranked fourth in total acreage planted with watermelons, they were ranked number one in yield per acre. The average yield of watermelons in California was 500 cwt which would equate to an average yield of 25 tons per acre. Watermelon growers in California would identify an excellent yield as 50 tons per acre (12,17).
- Watermelons ranked 58th in gross value in the state with a total of $48,059,000 in 2000. Based on data from the offices of the County Agricultural Commissioners in California, the average value per harvested acre was $4,122 (19).
- Most watermelons grown in California would be shipped into the western US as marketing conditions would not favor the extra cost for transport to compete with watermelons grow in the southeastern US.
- Seedless watermelons are produced by crossing a diploid male plant with a normal number of chromosomes with a tetraploid female plant which is considered a mutant because it has double the number of chromosomes (13). The result is a triploid hybrid, which can be grown in the same regions of California where other melon types are grown. Triploid melons generally produce small, white seed that is not viable, hence the naming of "seedless". Seedless watermelons can and will occasionally produce a few seeds in each melon, all of which will not reproduce as a triploid.

**Production Regions**

The main melon growing areas in California are shown in Figure 1 on page seven. Area I located in the northern San Joaquin Valley and lower Sacramento Valley grows approximately 6% of the state's <u>cantaloupes</u> with production focused in Stanislaus County. Area I produces 56% of the <u>honeydews</u> with production in Sutter, Yolo, and Stanislaus Counties. Counties are being listed in order of highest planted acreage (6). Area I also produces 24% of the watermelons in San Joaquin, Stanislaus, and Sutter Counties. Planting of melons is from April to early July with harvest from mid-July to mid-October. Rainfall varies from about 26 inches per year in the Sacramento Valley to about 16 inches per year in Modesto in the northern San Joaquin Valley (3). Area I uses flood irrigation to pre-irrigate melon fields then utilizes dryland farming techniques to force the melon plants to send their root systems downward to a low water table. This allows melon growers to avoid subsequent irrigations via furrows.

Area II, the southern San Joaquin Valley, produces about 66% of the cantaloupes grown in the state. Production of cantaloupes occurs in Fresno, Merced, Kern, and Kings Counties (6). Area II produces 24% of the honeydews with production centered in Fresno County. Area II also produces 45% of the watermelons in Kern, Fresno, and Merced Counties. Melons are planted from mid-March to mid-July with a harvest period from late-June into mid-to-late October depending on weather. Fresno receives about 10 inches of rainfall per year while Kern County receives about three inches per year (3). Furrow irrigation is very common in Area II, though there are some growers using subsurface drip irrigation in all three melon types. The growing region in Area II is commonly referred to as the westside district for melons as production occurs along the western part of the valley. The majority of the trucking of melons into markets occurs on Interstate 5 which is the main corridor between Los Angeles and San Francisco.

Area III, the desert growing region, covers Coachella, Imperial, and Palo Verde Valleys. Area III has both a spring and a fall crop of cantaloupes and honeydews (23) but only a spring crop of watermelons (25). Planted acreage of cantaloupes and honeydews in Area III is split with about 76% of the acreage in a spring planting and the balance of 24% in a fall crop (23) . This region grows about 28% of the state's cantaloupes with production across Imperial and Riverside Counties (6). Area III also produces 20% of the honeydews in the same counties. Area III produces 31% of the watermelons with most of the production in Riverside and Imperial Counties and minor acreage in San Bernardino County. Spring planting starts in mid-December and goes through March with harvests from mid-May into mid-July. Fall melon planting occurs in July and August with a fall harvest period from October into late December (14). This area produces melons with less than four inches of rainfall per year (3). Furrow irrigation is commonly used though there may occasionally be drip.

The average value of the melon types produced in the state can vary by production region as melons enter into different markets with competition from other states. The range in prices is illustrated in Table 1 with each region compared to the state average. The figures were calculated from county specific data on total value divided by the total production units to come up with a weighted average for each area in the state (6).

The data shown below in Table 1 illustrates that Area III in the desert consistently brings in a higher value crop compared to the state average as the region competes with markets from Arizona and Mexico and to a lesser degree the state of Texas. Another observation to highlight is that Area II contains the self proclaimed Cantaloupe Capital of the World, the city of Mendota. Yet the region with the highest percentage of cantaloupe production brings in the lowest average dollar value per carton.
Table 1. Average Price per Unit

| | Area I | Area II | Area III | State Average |
|---|---|---|---|---|
| Cantaloupes | $5.62 / carton | $4.24 / carton | $6.03 / carton | $4.70 / carton |
| Honeydews | $3.47 / carton | $4.65 / carton | $4.32 / carton | $4.08 / carton |
| Watermelons | $110 / ton | $161 / ton | $152 / ton | $147 / ton |

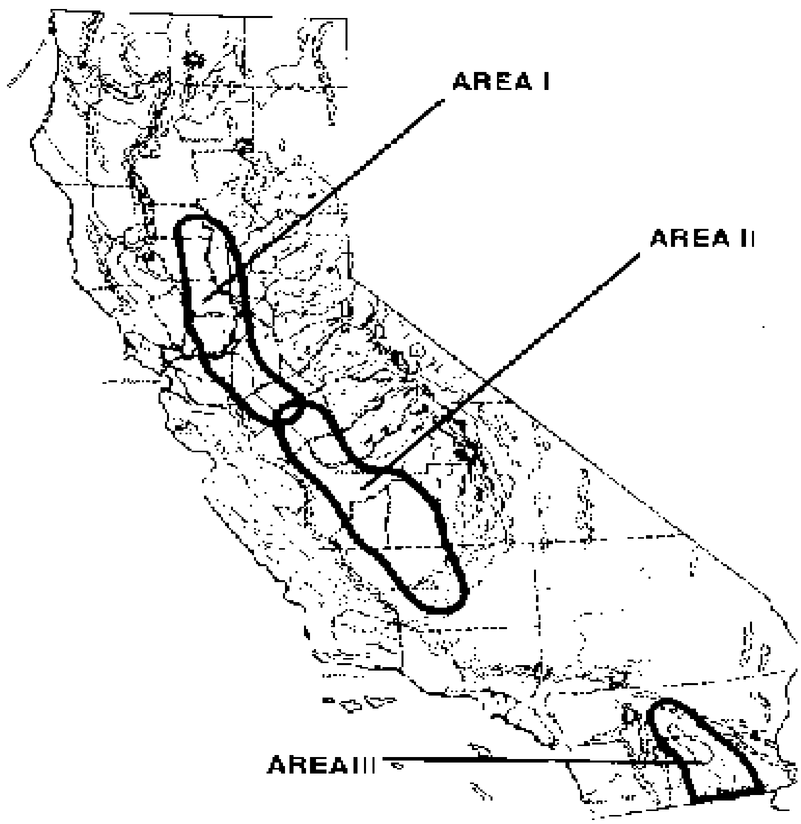


**Figure 1.** Major Melon Producing Areas in California (5).

## Worker Activities

**Land/Bed Preparation** is the first step before planting melons. Almost all melons are planted on raised beds in California. This facilitates cultivation and irrigation of the melon crop, as well as improving drainage, which minimizes root diseases. Land preparation consists of several discing operations, chiseling to break up hardpan layers at the bottom of the disc zone, and sub-soiling with heavy machinery such as caterpillars to break up deep compacted layers. The number of discing and chiseling passes needed to prepare a field for melons usually depends on the preceding crop. Triplane leveling, sometimes in two passes across the field, would be used for proper grading for furrow irrigation. Listing of beds, cultivating, and bed shaping for final bed preparation usually is done by November of the year that precedes planting (15). All bed preparation operations involve machinery with drivers that usually cover an average of 80 acres a day in a ten hour shift (12). Melon beds are most often 80 inches wide (4).

Growers in Area II would make sure that the furrows were deep enough for irrigation while growers in Area I would make very shallow rows as they don't need deep irrigations due to the low water table. Growers in Area III utilize a modified bed called a Yuma bed to capture more solar radiation in south-sloped beds in early spring in the desert region. This type of bed allows for more heat penetration and absorption of energy (25). After seedling emergence, Yuma beds would then be reshaped to a more traditional flat bed. Yuma beds are not used for the fall plantings in Area III.

Land preparation for watermelon growers may differ in that black plastic mulch may be used for temperature control with mid-January to February transplants in Area III and early spring plantings in Area II. After installation of sub-surface drip irrigation tape six inches deep down the center of the bed, black plastic mulch would be laid over the top of the bed and down the side of the bed. Dirt is then pulled up onto the sides of the bed by a tractor to hold the plastic in place. A hand crew would then follow to make sure that all of the plastic was secured in place to prevent the wind from damaging the plastic and lessening the retention of solar radiation. A tractor pulling a single row propane burner would be used after the laying of plastic but just prior to transplanting to burn a small hole in the plastic for the placement of the melon plug. A tractor pulling a three-row marker would be used prior to the propane burner to punch holes in the plastic every 30 inches. This operation allows the next driver to follow a straight line down the row so that the transplants are centered on the bed. Some growers use plastic on all of their watermelon acreage to keep weeds from interfering with the crop and to conserve on water use. When drip irrigation is installed, a grower may plant melons for several seasons before moving into a new crop for rotation.

After drip systems are in place, methyl bromide and plastic mulch can be used prior to transplanting. Methyl bromide was used on 645 acres of cantaloupes and 1,774 acres of watermelons in California in 2000 (18). The database didn’t show any use of methyl bromide on honeydews or other mixed melons. Another fumigant that may be used after bed preparation but prior to planting would be methylcarbamodithioic acid (metam-sodium) which would be applied to the seed line under a cap of soil.

Fallow bed herbicide treatments of oxyfluorfen (Goal) by ground rig or aerial applicators are sometimes used after bed preparation in Areas I and II to prevent winter weed growth of annuals such as shepherdspurse and London rocket. This also allows early spring melon planting without the need of cultivation (11).

**Planting Method** for the different melon types doesn’t involve a lot of variation as the land is usually picked out with minimal slope of the terrain in Areas I and II. Almost all cantaloupes and honeydews are direct seeded. A few growers have used greenhouse transplants to try and enter a market niche in early spring before the seeded fields but the scale has been very limited as frost potential limits the use of transplants. The cost of the transplants along with the higher labor costs makes the venture extremely risky when weather is variable. A grower would plant seeds if an entire field of seeded watermelons was desired. Many growers use the exact same type of planter for the planting of cantaloupes, honeydews, and seeded watermelons as the drill plate can be fairly easily changed to match the size of the opening with the seed size. Most planters would cover three rows of 80-inch beds in a single pass. A single tractor driver is involved in the planting of melon seeds with an average of 80-100 acres a day being planted (12). The older style planters could use dusts such as Lindane (Isotox Seed Treater F) insecticide inside the planter boxes, mixed with the seed, for protection from soilborne insects. The planters could also be fitted with nozzles to drop fungicides into the drill row during the planting phase as tanks were strapped to the planter bar. The tractor driver would also be the mixer/loader in these cases. These older planters were used with open-pollinated melon varieties with an average of three pounds of seed used per acre.

As plant breeders keyed in on the development of hybrid seed for stronger plant vigor, a gradual change was made by growers in the late 1990's. Once the new varieties were identified for a specific planting slot, hybrid melon seeds came into greater use even though the cost was significantly higher. The makers of seed planters then came out with new precision planters that could fairly accurately plant seeds in the row at almost any given spacing. These precision planters were air-based to pick up and hold an individual hybrid seed on the drill plate. But the holes were so small that the use of insecticide dust could plug the holes and cause skips during planting. Most growers therefore dropped the use of any dust not recommended by the planter manufacturer. This brought the focus onto the control of soil pests as dusts and liquids could not be applied through the plastic tubing associated with the air planters. Growers tried larger tanks attached to the bar to keep planters in action so as not to reduce the number of acres a day that could be planted. As tanks needed to be filled and pesticide combinations mixed, support personnel were now needed for the planter. This meant that the tractor driver was expected to be a driver and the support personnel became the mixers/loaders of fungicides and insecticides (12).

Most growers now use hybrid seed varieties for cantaloupes. About half of the honeydews produced in the state are with hybrid seed as open-pollinated dews still are used for export as they can handle the several weeks in ship transport better than some of the hybrid varieties which tend to go soft from higher sugar levels. Cantaloupes, honeydews, and seeded watermelons are usually direct seeded in one row per bed due to the spreading manner of growth of the runners that develop from the main stem.

Many growers plant melons in fields based on a quarter section of land - 160 total acres but usually only 150 planted acres. The average field size for <u>cantaloupes</u> would range from 100-150 acres with growers frequently planting an entire quarter section. The average field size for <u>honeydews</u> would be about 75 acres so that growers could get two plantings into a quarter section. The average field size for <u>watermelons</u> would be about 50 acres so that growers could get three plantings into a quarter section. Growers stagger their plantings across many weeks so as to avoid too much produce ripening at any one time. This also gives them access to a longer period in the marketplace where prices can fluctuate with supply and demand.

**Cultivation** of seeded melon beds is usually performed two to three times per crop by tractor pulled implements. The first pass may be made as soon as the seeds have emerged and the tractor driver can see a line of plants across the field so as not to damage any of the emerging seedlings. Cultivation is performed up until layby stage, which is the last pass across the field prior to the canopy covering the top of the bed. Cultivators can cover about 90-100 acres a day in a 10 hour shift (12).

**Thinning/Weeding** would start several weeks after melon seed emergence with a hand labor crew sent in to thin the stand around the two true leaf stage (5). Growers change the plant spacing in between plants in the row across the growing season to control melon size. Larger spacing between plants is used in early season plantings to get adequate melon size whereas smaller spacing is used in later plantings to keep the melon size from growing too large. This spacing impacts on the amount of acres a day that a crew can cover. An average work crew of 20 people would be able to thin a 150 acre field in 2-3 days with 10 hour shifts. This is usually followed by hand weeding crews one to two times per season on immature plants prior to full canopy. Weed crews made up of anywhere from 10-30 people would work on approximately 75 acres per day. Single row crops are easier to cultivate, thin, and weed compared to double row crops (such as processing tomatoes) and usually require fewer passes across a field.

**Transplants** have been used by seedless watermelon growers due to poor seed germination rates and lower plant vigor. Seed germination levels may vary by seed company for different varieties as the average germ level would be around 70 to 75% (13). Germination levels are not based on genetic make-up but rather appear to be related to quality control practices. The high cost of transplants has forced growers to plant to a stand with a average spacing of 30 inches between transplants in the row. The spacing may vary from 2-3 feet depending upon variety (25). The use of transplants and plastic mulch have eliminated thinning and cultivating of plants. Tractors pull the transplanting rigs with workers handling and placing the plants into precut openings when plastic mulch is used. Generally, there are six people on a machine covering three rows. The workers alternate in placing the individual plants into the field (two people per row) with 20-25 acres planted in a day. Growers order color coded trays of both seeded pollinator and seedless transplants from commercial greenhouses. One row of seeded pollinators is needed for every 2-3 rows of seedless.

**Pruning/Tying/Staking** is not performed with melons.

**Fertilization** can vary between melon types. Many growers would apply preplant fertilizers to the seed zone during the bed listing phase. Most melons grown on furrow irrigated fields would then be side-dressed by tractors with shanks into the sides of the beds with nitrogen fertilizers prior to the first application of water. This field operation would typically follow a cultivation for weed control and a thinning crew if direct seeded so this activity is performed several weeks before full canopy. Fertilizer rigs usually work on about 75-80 acres a day. Growers using drip irrigation systems would apply fertilizers through the drip lines with an average of about 10 pounds of nitrogen per week. Some growers apply fertilizers through furrow irrigation by dripping materials out of nurse tanks into the side canals that feed the rows. This is a common way of applying acid-based fertilizers instead of using stainless steel tanks on tractors. The calibration of fertilizer nurse tanks is done by personnel working for the chemical supplier so the grower's work crews would just open or close tanks as needed.

**Irrigation** is used for all California melons. <u>Furrow</u> irrigation is commonly used in California melons. Proper grading is critical for good drainage and for reducing disease levels. Furrows must be maintained throughout the season to avoid flooding the tops of beds due to an increase in weed emergence and the risk of fruit diseases. Furrow irrigation is commonly performed every seven to 14 days depending upon weather conditions as deep and infrequent irrigations are preferred for the relatively deep root system. Workers can use siphon tubes or plastic liners to move water from ditches along the perimeter of the field into each row. This method would take several days to irrigate all rows in a field with the worker staying along the outsides of the field.

Sprinkler irrigation with movable lines can be used to germinate a direct seeded crop. Sprinklers are typically not used after bloom as the use of sprinklers during the day has a tendency to soak pollen in flowers and dilute nectar which then inhibits bee visitation. This is important because a melon flower is only open for one day (10).

Drip irrigation is being used on seedless watermelons, honeydews, and also on some cantaloupes. Drip irrigation provides for good water management and allows hand harvesting at regular intervals. Subsurface drip irrigation is preferred to surface laid drip tape for use with melons but this method should not be used when salty soils are encountered as salt has a tendency to rise upward. By maintaining a dry bed surface during the summer growing season, weed emergence and water use is reduced. Workers may check on drip irrigation systems throughout the growing cycle and many ride on all terrain vehicles to cover fields quickly. They are not in contact with foliage as they ride up and down rows and the only direct contact would be if a repair was needed. Systemic insecticides may be used with drip irrigation systems but their use would be supervised by a Pest Control Operator (PCO). The hard rind of watermelons and honeydews may play a part in the use of drip irrigation as over-irrigation of cantaloupes has been reported by some users. There is a definite learning curve in bringing drip irrigation into cantaloupe production.

An estimate of the percentage of growers using drip irrigation would be no more than 30% of all melon growers. It should be noted that growers may utilize drip on a portion of their acreage with watermelons being the melon type that most growers try first. Drip irrigation would only be encountered in Areas II and III as dryland farming is used in Area I to force plants to send their taproots down to a low water table. Although no more than 30% of melon growers are using drip irrigation, no more than 20% of the melon acreage would currently be using this system.

**Scouting** of all melon types occurs across the entire season with all stages of plant growth checked for pests twice a week due to the high value of the commodity. Scouts would be expected to cover 150 acres per hour (15). Pest Control Advisers (PCAs) are either independent and self employed, work for a chemical supplier or a private pest control business, or work in-house for a grower/packer/shipper with the industry split into an approximate equal number in each category. Independent PCAs tend to specialize in several crops and frequently would contract for services with several different melon growers. Independent PCAs may have seasonal workers, many of them college students majoring in agriculture, to help them in scouting of fields. Individual growers and also chemical suppliers do not hire nearly as many seasonal scouts as independent PCAs (12).

**Harvest** of melons has as many variations as growers can think of with modifications to both field packing and shed packing operations. In the early 1990s about half of all melons were shed packed after a crew had picked the melons and loaded them into trucks by walking up ramps with a bag of melons. Nowadays, most cantaloupes are harvested by hand crews who pick fruit at full-slip as they follow behind a tractor pulled packing machine. Canteloupes detach from the main stem of the plant when they reach full maturity. When fruit maturity approaches, the stem slowly starts to separate from the cantaloupe fruit. When a melon picker picks up a cantaloupe, the melon should easily detach from the stem if it is ripe. When this happens, the stem end of the cantaloupe will have a completely round area that shows that the plant released the melon and thus it had a full-slip. If the melon is not mature, and the picker picks the melon anyways, a portion of the stem would remain in the stem end. This is evidence that the fruit was ripped off the vine before the melon was fully mature. Depending on how much stem tissue is still attached at the stem end, the melon would then be considered to be at half-slip or quarter-slip stage. This is a good indicator for consumers to know if the cantaloupe melon was harvested at full maturity. Honeydews and watermelons do not slip off the vine, they are cut with knives. Ripe melons at full-slip would easily separate from the vine without any use of cutting knives. The pickers would then place the melon onto a wing or belt assembly supported by the main unit as the melons would roll down towards the packer. Most cantaloupe fields are picked once a day with a harvest period commonly across 10-14 days. Each melon picker would cover a single bed as the crew walked across the field. A typical field pack crew would have 20 people that covered 11 rows at a time. During peak harvest, a field of 150 acres of cantaloupes may need five crews. Each crew would be made up of a foreman, 11 pickers, 5 packers, 2 box makers, and the tractor driver. With field pack operations, only two people actually touch the melon - the one who picks it and the person who packs it into a box. Most packers place the boxes onto pallets carried on trailers behind the packing machine or slide them down chutes where a loader would pick up the carton and place it onto flat bed trucks that follow the crew. That way, once the melons reach the cooling facility, they can be easily unloaded by forklifts and taken into the refrigeration areas. There are many variations to this though as some cantaloupe packers utilize crews that may be up to 36 pickers feeding melons into a conveyor belt that carries melons into gondola trucks for transport into packing sheds for the actual size sorting and packing. At the packing shed, fruit is sometimes rinsed if it is a hydro-cooling operation, sorted for sizes and quality for packing into 40 pound cartons. The number of shed packing operations in California for cantaloupes has dropped in number to single digits.

Harvest of honeydews in two picks is by hand crews who pick up fruit cut with small knives by another crew walking several hundred feet in front of the packing machine. The cutters then place the dews onto the side of a melon bed as they walk down the row. For field packing operations, the crews are made up with fewer pickers as only nine rows are harvested in a pass due to the heavier weight of the honeydew compared to a cantaloupe. About 40% of the honeydews that are cut and picked in the field by crews are field packed. The other 60% are picked and loaded into trucks or gondolas pulled by tractors for transport to the shed where they are sorted for culls.

Harvest of watermelons in multiple picks is split into field and shed pack operations. Most watermelons would be cut by a crew, picked up and then tossed by hand from person to person in a human chain into trucks for transport to a shed. Watermelons do not need refrigeration and some sheds may place the watermelons in bins in the shade while others are being packed into cardboard boxes. Crews harvest seeded pollinators in a separate operation to keep seeded melons out of the seedless packout (12,17).

**Post-harvest** activities involve washing of shed packed honeydew fruit in wash or dump tanks where chlorine is added to water which is slightly warmer in temperature than the product in order to prevent water uptake and also entry of decay-causing organisms. Washing is performed prior to sorting and packing operations. Food grade wax may be applied to export honeydews to replace naturally occurring waxes removed in the washing and cleaning operations. This also improves appearance and reduces water loss. There is no washing of produce in water baths in any melon type that is field packed. Some growers have previously tried to use hand-held water nozzles to wash leafhopper excrement and dirt off of honeydews to clean up fruit for export but this process was extremely labor intensive and slowed the harvest crews down considerably (12). These attempts were only tried with smooth skinned honeydews and not with netted cantaloupes. Forced air cooling is used on almost all cantaloupes. The older packing sheds used to utilize hydro-cooling with cantaloupes dumped into water baths to remove heat from the melons. All of the newer facilities being built for vegetable storage are designed around air cooling with automated computer controls. The air temperature is usually no lower than 38 degrees Fahrenheit (3.3 degrees C) as cantaloupes are typically held for four hours in a cooler. Once the cartons reach the desired temperature, a forklift operator would move the pallets out of the cooler directly into refrigerated trucks ready for transit.

**Pesticides** that were the most commonly used materials in California melons in 2000 are listed below in Tables 2-4. Not all materials would necessarily be used on a single crop. Pesticides are ranked based on total acreage treated with the highest one first.

**Table 2. Most Common Pesticides Used in Cantaloupes, 2000.**

| Insecticides | Fungicides | Herbicides |
|---|---|---|
| Imidacloprid | Sulfur | Trifluralin |
| Methomyl | Mefenoxam | Bensulide |
| *Bt (Bacillus thuringiensis)* | Trifloxystrobin | Glyphosate |
| Avermectin | Benomyl | Oxyfluorfen |
| Endosulfan | Thiophanate-methyl | Sethoxydim |
| Diazinon | | |
| Carbaryl | Seed treatment-Thiram | |

**Source**: California Department of Pesticide Regulation, 2000 Annual Pesticide Use Report Data Indexed by Commodity.

**Table 3. Most Common Pesticides Used in Honeydews, 2000.**

| Insecticides | Fungicides | Herbicides |
|---|---|---|
| Bifenthrin | Sulfur | Trifluralin |
| Methomyl | Trifloxystrobin | Glyphosate |
| Carbaryl | Mefenoxam | Oxyfluorfen |
| Diazinon | Thiophanate-methyl | Bensulide |
| Esfenvalerate | Benomyl | Ethalfluralin |
| Imidacloprid | Azoxystrobin | |
| *Bt (Bacillus thuringiensis)* | Seed treatment-Thiram | |

**Source**: California Department of Pesticide Regulation, 2000 Annual Pesticide Use Report Data Indexed by Commodity.

**Table 4. Most Common Pesticides Used in Watermelons, 2000.**

| Insecticides | Fungicides | Herbicides |
|---|---|---|
| *Bt (Bacillus thuringiensis)*<br>Avermectin<br>Methomyl<br>Imidacloprid<br>Bifenthrin<br>Cryolite<br>Diazinon | Sulfur<br>Trifloxystrobin<br>Benomyl<br>Thiophanate-methyl<br>Mefenoxam<br><br>Seed treatment-Thiram | Sethoxydim<br>Ethalfluralin<br>Trifluralin |

**Source**: California Department of Pesticide Regulation, 2000 Annual Pesticide Use Report Data Indexed by Commodity.

**Insecticides** are used on 76% of all cantaloupes grown in California compared to 74% of the total US melon crop (1). Insecticides are used on 78% of all honeydews grown in California compared to 80% of the total US honeydews crop (1). Insecticides are used on 67% of all watermelons grown in California compared to 47% of the total US watermelon crop (1). Most treatments are applied to the melon foliage after crop emergence with sprays made to protect the crop after fruit has set. The primary pests to all melon types targeted by these foliar treatments include aphids, whiteflies, cabbage loopers, and leafminers (15). The primary soilborne pests targeted by insecticide treatments prior to, and at planting, include wireworms, seedcorn maggots, darkling ground beetles, cutworms, and flea beetles.

The importance of Diazinon for pest control in melons and the diversification of methods of application can be shown by its use for both soilborne and foliage pests. A special search of the 2000 database for Diazinon applications to cantaloupes and honeydews provided detailed information on: 1) acres treated by county, 2) pounds and total number of uses by county, 3) acres treated by product formulation, 4) pounds and total number of uses by product formulation, 5) acres, pounds, and total uses identified by month of use, and 6) acres, pounds, and total uses by type of application (20). The Diazinon database highlights are presented in Tables 5 and 6. Table 5 shows total diazinon use in the state broken down by production area.

**Table 5. Diazinon Applications to Cantaloupes and Honeydews by Region**

| **Cantaloupes** | Area I | Area II | Area III |
|---|---|---|---|
| Acres treated | 3% | 66% | 31% |
| Number of uses | 3% | 57% | 40% |
| Pounds | 2% | 35% | 63% |
| **Honeydews** | | | |
| Acres treated | 62% | 28% | 10% |
| Number of uses | 48% | 32% | 20% |
| Pounds | 55% | 36% | 9% |

Some significant differences can be seen in the data for the melon production regions:
1) The majority of the total pounds of Diazinon used in cantaloupes occurred in Area III where soilborne pests are a problem during planting and stand establishment, especially during the fall planting in the desert. The method of application varied from sprinkler injection to protect emerging seedlings to the use of granular Diazinon applied at planting.
2) The important use of Diazinon for leafhopper control in honeydews can be seen in the significant increase of total number of uses and in pounds for Area I. This area is primarily a honeydew producing region with limited production of cantaloupes.

The significant difference in the use of granular Diazinon between cantaloupes and honeydews is seen in the data below.

**Table 6. Use Pattern of Diazinon and Types of Application**

| | **Cantaloupe** | **Honeydew** |
|---|---|---|
| Granular form - % of total pounds of Diazinon | 57% | 21% |
| % of all Diazinon applied by ground rigs | 51% | 63% |
| % of all Diazinon applied by aerial applicators | 45% | 34% |
| Month of year with highest use of Diazinon | August - 27% | July - 45% |

These data show that ground rigs made most of the Diazinon applications in the state of California for honeydews (20). This is due to the fact that honeydews are dryland farmed in Area I without the use of furrow irrigation so tractors can enter fields at any time. Area II depends upon furrow irrigation and ground rigs can not be used once water has been applied to the rows. Thus, aerial applications are crucial to the growers in Area II. These statistics may be indicative of other insecticide applications but it certainly can not be guaranteed for systemic materials that may be applied through drip irrigation systems. Contact materials usually require excellent coverage for effective control and ground rigs are preferred up until water runs in furrows as canal delivery systems prevent tractors from entering fields. The month of highest use is also noted as cantaloupes in Area II would be treated for aphids and leafhoppers during the time that growers in Area III would be using the granular formulation for soil pests. The high use of Diazinon in honeydews in July coincides with the peak production of dews in Areas I and II and the need to export top quality fruit that is free of leafhopper frass (excrement).

**Pesticide Applications** may be made by trained workers employed by a grower or by an outside company. Workers who handle category 1 materials with a danger/poison label are required to be under medical supervision and have their blood monitored for cholinesterase levels with monthly checks. Some growers would have their own workers make ground rig applications while most of the smaller operators would hire a company to treat their fields. Most aerial applications are made by fixed wing aircraft with closed cockpits as helicopters are used by fewer pilots and pest control operations in row crops. Typical tank mixes for aerial applications would use 5-10 gallons per acre while ground rigs would use about 25-40 gallons per acre for a full canopy application. Ground rigs with electrostatic sprayers are used in the desert region for whitefly control as coverage of the underside of leaves is crucial. Ground rigs would be expected to cover 90-100 acres a day (12). Most growers who employ trained applicators would have a support team at the field to help mix and load.

**Fungicides** were used on 52% of the cantaloupes grown in California in 2000 compared to 60% of the total US cantaloupe crop (1). Fungicides were used on 10% of the honeydews grown in California in 2000 compared to 26% of the total US honeydew crop (1). Fungicides are used on 78% of the watermelons grown in California in 2000 compared to 79% of the total US watermelon crop (1). Most fungicide applications are made by foliar treatments. The major disease organism targeted by these treatments is powdery mildew (4, 14).

**Herbicides** are used for weed control on 42% of the cantaloupes grown in California compared to 43% of the total US crop (1). Herbicides are used for weed control on just 3% of the honeydews grown in California compared to 12% of the total US crop (1). Herbicides are used for weed control on 6% of the watermelons grown in California compared to 52% of the total US crop (1). A postplant herbicide application of Trifluralin (Treflan) is made at layby by some growers across the 80 inch bed except the 10-inch band centered on the seed line (12). Layby is considered the last stage of melon growth when cultivation equipment can still be used as melons would be in bloom with runners advancing across the bed. This preemergent herbicide is applied to the area outside the seed line to control late emerging weeds. After layby, there would be no herbicide applications until after the crop was harvested.

**Plant Growth Regulators** are not typically used to hasten or accelerate fruit ripening or to increase early yields of melons.

## Insect Pests

Numerous insect pests attack melons in all of the growing regions of the state and can occur at damaging levels most seasons. The insect pests can be divided into: 1) seedling pests such as darkling ground beetles, flea beetles, wireworms, and seedcorn maggots, 2) foliage pests such as whiteflies, aphids, leafhoppers, cabbage loopers, leafminers, and armyworms, and 3) fruit pests such as crickets, beetles, and cutworms. These pests are being presented in this report in order of possible appearance during the crop stage. It should be noted that aphids remain the primary pest for growers in Areas I and II as they can vector numerous mosaic viruses that can cause substantial damage to melons whereas whiteflies continue to be the primary pest of concern to growers in Area III (5).

Pest pressure varies between hybrid plants and open pollinated seed lines. Hybrid plants are known to be stronger in overall plant vigor. This phenomenon is commonly referred to as hybrid vigor and technically it is referred to as heterosis. This means that progeny that results from genetically different parent seed lines has an increase in vigor compared to the average parent lines. Therefore, hybrid seed lines are able to tolerate more pest pressure than the open-pollinated seed lines. Some hybrid seeds can tolerate more plant disease pressure while other seed lines may tolerate more insect pressure. Plant breeders investigate the effects of hybrid vigor and try to develop a stronger plant for industry. When that happens, the high cost of development shows up in the much higher priced hybrid seed.

Darkling ground beetles (*Blapstinus* spp., *Caelus* spp. and others) can damage melons at planting time in all areas by chewing on emerging seedlings and cutting them off at the ground level. Beetles can reduce a stand if not controlled. This pest was considered a minor pest when open-pollinated seeds were used as three pounds of seed were commonly used at planting time. That would mean that anywhere from 50,000 to 60,000 seeds used to be planted for a desired stand of 7,841 plants per acre (12). So if a few plants were damaged by beetles, a good stand could still be achieved. But with the acceptance of hybrid seed by growers and the development and utilization of precision planters that are now dropping seed at five inch spacing, only 15,682 seeds would be used on a single acre of melons. A single seedling taken out by a pest would put the spacing at 10 inches at that site, which is the desired spacing for early season cantaloupes. With fewer seeds per acre being planted, darkling ground beetles and other soilborne insects have now become major pests of cantaloupes and honeydews while they also attack watermelon transplants. Ground beetles can also damage melon flowers by feeding on the blossoms during bloom, eating plant tissue on the undersides of leaves, and by feeding on fruit as melons begin to ripen (5). Diazinon and carbaryl insecticides would be the choices for control of soilborne pests. No biological or effective cultural controls are available.

Flea beetles (*Epitrix hirtipennis)* and a few other species in the Chrysomelid family can damage melon seedlings as they chew holes in the leaves and stems thereby reducing photosynthetic leaf surfaces (21). Stems damaged during pest feeding may lead to plants falling over and a reduction in the overall plant stand. Flea beetles can be a problem on both early spring and fall melon plantings (15). The pest has been known to overwinter on various weed species or in the previous crop residue. Carbaryl (Sevin Bait) is an excellent insecticide that controls flea beetles and numerous other insect species such as darkling ground beetles, cutworms, earwigs, and crickets. Bait can be placed out around the perimeter of a field, be applied by ground rigs or by aircraft. Research is underway looking for alternatives to Carbaryl with insecticide chemistries such as the neonicotinoid thiocloprid (Calypso) being evaluated (9). No biological or effective cultural controls are available.

Wireworms ( *Limonius* spp.) have also become a more serious pest in recent years due to the reduced number of seedlings used with hybrid seed in cold and wet soils in early spring weather. The pest can become a problem at any time of the year in just about any soil type (21). Wireworms are larvae of click beetles (5). Wireworms used to be controlled by lindane dust (Isotox Seed Treater F) but new air planters have almost totally stopped this practice because of clogging in the precision seed plates (12). Growers prefer to use granular formulations of Diazinon for control of this pest in Area III as problems have arisen with liquid pesticides in the clay soils at planting time (15). Liquid Diazinon could be used as an injection into sprinkler systems for pest control at seedling emergence but this would not protect seedlings being attacked under ground during the gemination stage. There are no biological controls for this pest. Suggested cultural controls of waiting several weeks after a plow down of a previous crop to allow time for residue decomposition (21) would force growers out of the planting window in double cropping systems when melons follow cole crops or small grains.

Seedcorn maggots (*Delia platura)* are pests that reduce melon stands in early spring in Areas I and II and in fall plantings in Area III. This insect is another example of a pest that used to be just an occasional problem when open-pollinated seed was planted. But with fewer hybrid seeds being planted per acre, this insect has became a much more important pest. Even watermelon plugs transplanted into black plastic mulch have been attacked by these maggots, as they are pupating larvae of a Dipteran fly (12). The adult is a small fly that likes to lay eggs in plant residue in the soil. Maggots may overwinter in the soil. Precision planters usually wouldn't use lindane dust in seed hoppers. Diazinon granular is the preferred formulation for use in the desert with fall plantings behind vegetable crops that haven't had a lot of time for decomposition of crop residues.

Silverleaf Whitefly (*Bemisia argentifolii*) and Sweetpotato whitefly (*Bemisia tabaci*) can attack melon crops, especially in Area III. Whitefly eggs and early instar nymphs are difficult to identify without the use of a hand lens. Whiteflies typically colonize the undersides of melon leaves where the eggs are laid. Whitefly nymphs feed on plant sap with sucking mouthparts. Whiteflies excrete copious amounts of a sticky substance called honeydew, which acts as a suitable substrate for the development of black, sooty mold. This leads to unmarketable melon fruit. Whitefly populations inflicted serious crop losses in 1991 as a new species moved into the southern desert growing region. This led to the Section 18 use of Imidacloprid (5). Imidacloprid is a systemic material that works very well as a preventive for low populations. It now has full registration for use on all melon types and its importance can be seen in Tables 2-4. Silverleaf whitefly now attacks numerous crops while the sweetpotato whitefly has been reduced in importance. The pest can move to melons in the spring but detrimental populations usually don't arise until later in the summer after the spring melon crop has been harvested. Several species of parasites and predators offer effective biological control of low populations of whiteflies. Several species of ladybird beetles, including *Delphastus pusillus*, prey upon whiteflies. *Encarsia* and *Eretmocerus* wasp species parasitize some species of whiteflies but cannot be expected to control silverleaf whitefly populations in most situations. Efforts are made to reduce pest resistance by including insecticides of a different chemistry in a combination spray. Oxamyl is a systemic carbamate used postplant and it can be injected into drip irrigation systems.

Melon aphid (*Aphis gosypii)*represents a species that is a major pest to both melons and cotton (21) as it has been showing up on a regular basis every year in Areas I and II. This aphid species is heat tolerant and effectively establishes itself on all melon types. Some cantaloupe varieties tolerate or suppress aphid populations (15). There are several native biological control organisms that occur in fields but they can not keep up with the asexual reproduction rate of the aphid. Thus, chemical controls are usually needed to keep this pest from flaring up. Another aphid species that is of minor concern to melon growers is the green peach aphid (*Myzus persicae)*which rarely requires chemical control. The major threat from both species is the viral disease complex that the aphids vector (5). Aphids have sucking mouthparts that pierce plant tissue during feeding. Systemic insecticides such as Imidacloprid have been effective in early season control. Ground application offers the best coverage needed for control of aphids but oftentimes is not available due to irrigation schedules in Area II.

Leafhoppers (*Empoasca* spp.) feed on melon leaves and reduce chlorophyll. The pest sucks on plant sap as they feed on the bottom sides of the leaves. Leafhoppers can also do considerable cosmetic damage to honeydews and other smooth skinned melons that lack netting. If not controlled, the pest can turn leaves yellow and move onto developing fruit where their excrement (frass) spots fruit. Systemic insecticides have been effective in early season pest control but late season sprays have been needed to protect fruit. Diazinon has been crucial in controlling leafhoppers in honeydews (see previous Tables 3, 5-6). Leafhoppers are a minor pest in the desert as there is a different species (21) that impacts the spring melon harvest in June. Leafhopper problems occur in Areas I and II from May through September (15).

Cabbage looper (*Trichoplusia* ni) has become an annual problem in most melon production areas, especially in the San Joaquin Valley. Absence of long killing frosts and broad overlap of melon planting dates and numerous other vegetable host crops may be helping a pest population buildup. Small instar larvae will chew on the bottom sides of melon leaves. Larger sized cabbage loopers are a threat as the worms chew on mature melon fruit. Very few PCAs reported the use of pheromone traps for the monitoring of the pest though there is an effective pheromone attractant available for use (5, 15). Some biological control of the cabbage looper takes place from several parasites (21). Attempts to augment the natural predator and parasite complex with releases of beneficial insects and parasites for lepidopterous larval control have been very limited in scope and success (5, 15). Chemical control may include a tank mix of Bt (such as Dipel) with a contact material such as methomyl (Lannate), if larger-sized larval instars are present, as the Bt material is most effective against small worms (5). As previously shown in Tables 2-4, Bt had widespread use in watermelons but very limited use in honeydews. The thick and hard rind of watermelons offers some plant defense to attacks from loopers whereas the need for export quality fruit with no rind blemishes on honeydews forces the use of Bifenthrin (Capture) and Methomyl (Lannate) as contact materials involve almost instant control instead of a slowing down of feeding by Bt. The high use of Bifenthrin can also be explained by its control of all looper life stages including eggs. Endosulfan is used for looper control in cantaloupes as it has activity against both the larval and adult stages. Endosulfan is seldom used in furrow irrigated fields late in the crop cycle since the 300 foot buffer restrictions are in place for applications with drainage into waterways. It also has restrictions regarding its use when irrigation water is running in the field. This restriction especially impacts Fresno, Merced, and Kings Counties in the San Joaquin Valley.

Leafminers *(Liriomyza trifolii, L. sativa, and L. huidobrensis)*are small dipteran flies which can cause considerable damage to melon leaves. Adult females lay their eggs in leaf tissue. Larvae emerge inside the leaves and mine their way in narrow tunnels between the lower and upper leaf surfaces. As the larvae grow, the width of the tunnels increases. Leaves may dry out and yields can be reduced in moderate infestations. Under heavy pest pressure, plants may die and entire fields can be lost if not correctly protected with insecticides (12). Growers are aware that it is important to try and preserve the beneficial predator and parasite complex present in a field. *Diglyphus*, a parasitic wasp, can be effective in biological control of leafminers if they are not removed from the fields by pesticide applications (21). Systemic insecticides such as oxamyl have effectively controlled some species of leafminers. Ground rig applications usually provide better coverage and are preferred to aerial applications. Successive treatments of the same class of insecticide are avoided as repeated applications of the same material can lead to pest resistance. Therefore, materials of different chemistries are utilized by growers if multiple applications are needed for adequate control. Abamectin controls spider mites and also leafminers. Cyromazine (Trigard) is an insect growth regulator that offers effective control of leafminers if applied at the proper time before pest populations get out of control.

Beet armyworm (*Spodoptera exigua*) and Western yellow striped armyworm (*Spodoptera praefica* and *S. ornithogalli*) are three species that attack melon fruit. Armyworms are an occasional pest problem. Pest monitoring becomes crucial as melon fruit size increases. Bts were generally not regarded as effective control chemicals by growers and PCAs involved in cantaloupe and honeydew fields as the timing of applications based on a larval instar stage is crucial in timing the pesticide to the stage of growth where the pest is most vulnerable. Armyworms are susceptible in the first three instars, making correct timing difficult and frequent applications costly (21). Organic melon growers report that Bts (Xentari) are very important in their production fields, as alternatives approved for organic production are limited (15). Some biological control of beet armyworm takes place in melon fields from several parasites and a viral disease called nuclear polyhedrosis (21). *Hyposoter exiguae* is a parasitoid on beet armyworms (5). This wasp can reduce armyworm populations if pesticide use is kept at a minimum, as the natural predator and parasitoid complex will be reduced by applications. *Trichogramma pretiosum*, a parasite on lepidopteran eggs, is available from commercial insectaries for augmentative and inundative releases of eggs (12).

Crickets (Field Cricket in the Gryllid Family & Mole Cricket in the Gryllotalpa Family) are occasional pests in late spring plantings in Area III and main season plantings from June through September in Areas I and II. Field crickets can damage melons by chewing deep holes into the fruit and by staining fruit with their excrement (5). Mole crickets can damage drip irrigation equipment by chewing on plastic drip lines. They can also damage young seedlings or transplants by feeding upon melon roots. Carbaryl bait remains the primary material that controls crickets when applications are made to control darkling ground beetles, flea beetles, and cucumber beetles.

Dried Fruit Beetles (*Carpophilus hemipterus)* are a minor pest that can occur in Areas I and II. The beetles belong to the Nitidulidae family and are sometimes referred to as sap beetles (5). Fruit beetles feed on soft plant tissue as they look for any entry into melon fruit from mechanical or insect injury. More importantly, when cantaloupes approach maturity and are at half slip stage, a small entry point develops as the stem end starts to separate from the melon, which is enough for the pest to get access to softer tissue. Thus, this type of entry does not occur with honeydews or watermelons which are cut with knives. With the acceptance of hybrid cantaloupe seed by growers, many packers had to learn when to harvest the new varieties as some didn't develop the normal, golden color that open-pollinated varieties did (12). The pest is usually controlled by other insecticide treatments applied to melons. Problems can arise if neighboring fields have decayed or culled fruit rotting nearby, especially figs, grapes, citrus, or stone fruit (21). Cultural control efforts would therefore need to be aimed at reducing the favorable conditions for the buildup of the pest during the summer months of June through September.

Cucumber Beetles (*Diabrotica* spp.) have been reported to be a problem in Areas I and II during the months of June through September as they chew up holes in the leaves (15). As fruit starts to develop, the insects can chew on fruit surfaces and cause scars (5). They may occasionally make a presence during the spring months of March to May in the San Joaquin Valley and it is this early flush of insect activity that has been of concern as the beetles can vector and spread Squash Mosaic Virus (21). The pest is usually controlled by sprays for other melon pests such as aphids and cabbage loopers or by baits applied for other beetles or soil pests.

Black cutworms *(Agrotis ipsilon)* and variegated cutworms (*Peridroma saucia)* can become problems during seed germination and emergence and can attack transplants. Black cutworms and variegated cutworms are larvae of the Noctuid family of moths. Large cutworm larvae can be found in debris in the top soil of fields. Cutworms cut off plants at the soil surface and can reduce stands. Management strategy is to avoid planting into fields with copious plant residues or fields coming out of pastures if adequate time has not been provided to allow for breakdown and decomposition of organic debris (21). Carbaryl controls cutworms, flea beetles and numerous other insect species such as darkling ground beetles, earwigs, and crickets. Bait can be placed out around the perimeter of a field, applied by ground rigs or by aircraft. When large numbers of cutworms are encountered in a melon field, Permethrin (Pounce 3.2 EC) can be applied by ground or aerial applicators.

**Mite Pests**

Spider Mites have eight legs and therefore are not classified as insects which have six legs. Two-spotted spider mites (*Tetranychus urticae*), strawberry spider mites (*T. turkestani*), and desert spider mites (T. desertorum) are all considered minor pests of melons. Mites are very small and are difficult to see with the naked eye. Mites feed on the stems and leaves of melon plants. Leaves infested with mites develop a greasy appearance, curl upwards, dry out, and then become bronze in color. Mite damage is most severe in hot weather when environmental conditions favor the pest and quicken the pace of the life cycle. Spider mites can infect melon transplants in the greenhouse but most often the pest blows into a field from neighboring areas. Fields are monitored for bronzing on lower leaves and treatments are initiated when crop damage begins to spread. If the canopy has not fully developed across the bed, a ground rig could be used with dicofol (Kelthane) or abamectin (Agri-Mek). Organic melon growers have also noticed that the use of dusting sulfur had a suppressing effect upon mite colonies. There are several biological control organisms such as predacious mites, thrips, lady bird beetles, and lacewings that are effective predators of spider mites (21). Growers can also control spider mite populations by keeping roadways around fields watered down to limit dust movement onto the plant canopy.

**Diseases**

Melon production can be impacted by numerous biotic diseases caused by plant pathogens as well as abiotic diseases caused by stress from environmental factors or from toxic substance exposure (e.g., ozone injury). Biotic diseases represent the most serious threat to melons. Plant pathogens can be soilborne or airborne and consist of bacteria, fungi, and viruses. Irrigation management plays an important role in reducing the threat from some plant diseases. The method of irrigation can influence environmental conditions necessary for disease occurrence or enhance conditions needed for disease expression of foliage and fruit diseases.

Damping Off/Seed Rots (*Pythium* spp., *Phytophthora* spp., *Acremonium* spp., *Rhizoctonia* spp. and others) are a complex of fungal pathogens that attack seedlings during the germination and emergence stages in all melon production regions during the cooler months of the year. Growers in Area III have reported problems during both the spring and fall plantings (5, 15). Fungicides have been used at planting time as a soil drench or in-furrow treatments. The withdrawal of benomyl (benlate) has forced growers to look for alternatives and ask for an addition to the label for thiophanate-methyl which already has an aerial label for mildew control (15). Cultural controls include modifying the depth of seed placement during the planting season to encourage a faster germination period and quicker emergence of the seedling during the cooler weather compared to deeper placement during the hotter months. This suggested method of control has not been readily accepted by some growers who are afraid of not having adequate soil moisture to germinate seeds (12).

Viral Disease Complex consists of aphid vectored Cucumber Mosaic Virus (CMV), Watermelon Mosaic Virus (WMV), Zucchini Yellow Mosaic Virus (ZYMV), Papaya Ringspot Virus (PRSV), and Cucurbit Aphid-Borne Yellows Virus (CABYV) (5). The complex also includes Squash Mosaic Virus which is vectored by the spotted cucumber beetle (*Diabrotica* spp.). Squash Mosaic Virus is also seedborne so cultural control of this disease includes using virus-free seed for elimination of the primary inoculum (21). Insecticide use for control of insect vectors has not stopped the transmission of viruses into all melon types. When viruses impact on a melon field, symptoms can range from mild to severe depending on the stage of growth. Aphid infestations can vary from year to year and attempts to destroy alternate hosts such as weeds and crops finished with harvest can help in area-wide pest management. Cultural alternatives to the use of pesticides include the use of silver-colored reflective, plastic mulch. The high cost of plastic, installation, removal, and disposal of the plastic mulch has limited its use in large scale melon production fields.

Powdery Mildew (*Sphaerotheca fuliginea)*is a disease that is expressed when the crop is stressed by environmental factors such as high temperature combined with poor soils, salts, and irrigation problems. The disease can appear in all melon production regions of California (15) though watermelons are not as susceptible as other cucurbits (21). Disease development is favored by high relative humidity associated with mild air temperatures. High daytime air temperatures favor disease expression and damage. Best growing practices aimed at minimizing plant stress are suggested to reduce impact from the powdery mildew pathogen.

In the early 1990's, most melon varieties were not resistant to sulfur. Some growers didn't like having melon fields next to their beet and tomato fields. Problems used to arise from drift from sulfur applications to sugar beet and tomato fields as sulfur would burn the sensitive melon foliage. Sulfur dust or wettable powder formulations are commonly used for powdery mildew control and suppression of spider mites too. Plant breeders were asked to screen melon varieties for resistance to sulfur as part of their new variety development programs (12). By the mid-1990s, several new cantaloupe varieties were developed with sulfur resistance and growers readily accepted them into production. By the late 1990s, just about all melon varieties used by growers in the state were resistant to sulfur.  This not only eliminated problems with farming neighbors, it changed the management of powdery mildew in melons.  Prior to the development of sulfur resistant melons, triadimefon (Bayleton) fungicide was used by growers in attempts to control powdery mildew in melons in California.  But the triadimefon label stated that it did not control *Sphaerotheca fuliginea (7).*   Sulfur is now the most widely used fungicide in all melon types (see previous Tables 2-4) while triadimefon use has been greatly reduced (18).  Dusting sulfur is the cheapest agri-chemical available, is considered beneficial to the soil as an amendment to offset high alkalinity, and is acceptable in organic crop production.  Aerial operators make most applications at nighttime as sulfur has a fire hazard associated with air temperatures above 90 degrees Fahrenheit.

<u>Fusarium Wilt</u> (*Fusarium oxysporum f.* sp. *melonis)* Race 2 attacks *Cucumis melo* varieties such as cantaloupe and honeydew melons while <u>Fusarium Wilt</u> (*Fusarium oxysporum f.* sp. *niveum)* Race 1 attacks watermelons (21).  There is limited resistance to Race 2 of the disease in cantaloupe seed varieties but more resistance to Race 1 in watermelon varieties.  Growers and PCAs reported problems from Fusarium occurred in Areas I and II but not in Area III (15). Symptoms typically occur after fruit set with a collapse of entire plants possible (5).  Crop rotations usually do not help in disease management as the pest can survive in the soil for 20 years.  A major exception to this would be rice paddy production in Area I as the constant flooding can significantly lower the inoculum load of Fusarium.  There are no chemical controls for Fusarium wilt during the growing season.   Soil fumigation with methyl bromide or chloropicrin would control the plant disease but the cost is considered too high for melon growers.

<u>Verticillium Wilt</u> (*Verticillium dahliae)* is only a problem for melons grown in Areas I and II (15). The fungal pathogen can infect roots, plug up xylem water transport tissue, and progress through the entire plant.  The pathogen infects many species of plants and can infect all cucurbits. Therefore, growers should not plant melons into cotton fields in a crop rotation if cotton was attacked by Verticillium in the previous year (21). There are no chemical controls for Verticillium wilt during the growing season.   Soil fumigation with methyl bromide or chloropicrin would control the plant disease but the cost is considered too high for melon growers (5, 21). Verticillium wilt is usually a cooler season problem in May whereas Fusarium wilt usually occurs during the hotter summer months from June through September.  Resistant varieties can be used as a cultural control method but resistance varies between melon types.

<u>Vine Decline</u> (*Monosporascus cannonballus*) or root rot used to be a serious problem in the desert region with entire fields being infected so severely that the entire crop would be lost (5). The pathogen tolerates high soil temperatures and is capable of surviving on a variety of crops but only causes symptoms on melons (21).  There is concern that the pathogen has caused problems for growers in Area II in the hottest months of July and August (15).  Growers in Area III report root rot problems to both the spring and fall melon plantings.  Methyl bromide used to the best chemical control of vine decline.  Melon research, underway for several years, has been looking into alternative controls due to the expected phase out of methyl bromide.  Growers used to use herbicides like glyphosate to quickly kill a melon canopy after harvest had ended to try and stop the pathogen from reproducing during the period from harvest to discing up the field. Researchers with experimental work at UC Cooperative Extension field stations have now

suggested that the use of herbicides was detrimental in that the pathogen speeded up its life cycle. Recommended cultural practices now include an immediate discing of the field after harvest to expose the roots to the hot and dry weather (15).

**Weeds**

The most common weeds infesting California melons are black nightshade (*Solanum nigrum),* hairy nightshade (*S. sarrachoides*), field bindweed (*Convolvulus arvensis)* which is commonly referred to as perennial morningglory, yellow nutsedge (*Cyperus esculentus),* purple nutsedge (*C. rotundus),* pigweed (*Amaranthus* spp.), purslane (*Portulaca oleracea*), and dodder (*Cuscuta spp.)* as they are the most difficult to manage (11, 15). Most herbicides registered for use in melons for other target weeds such as annual grasses are ineffective and thus, hand labor is also needed to manage these weeds. Nightshades are in the same family as tomato and thus, most tomato herbicides are not effective against these weeds. This family represents the most troublesome weeds in fields in Area II with regular rotation of tomatoes to melons. Preplant applications of metam-sodium provide good nightshade control but are not practical for early season plantings due to the reentry period for planting that keeps crews out for 14 days (7). Field bindweed is a troublesome perennial weed with a vining growth habit. Field bindweed infestations can smother melon plants as they out-compete the intended crop. Nutsedges**,** both yellow and purple, are perennial weeds reproducing primarily from tubers (commonly referred to as nutlets). Nutsedge infestations are very competitive and can substantially reduce all melon crop yields. Cultivation and hand weeding fail to provide lasting control as the weed quickly grows back into the beds. Dodder is a parasitic weed that attacks many broadleaf crops and weeds. It germinates in the soil and attaches to the stem of a host. Once attachment occurs, the soil connection is eliminated. Control generally involves cultivation by tractors for removal of the host plant. Regional differences occur in weed distribution. Purple nutsedge is primarily limited to the areas south of Madera County in Area II. All areas of the state have tremendous weed pressure requiring numerous weed control operations each season.

Fallow bed treatments are often applied to fields in preparation for early season planting (early-to-late March). In these fields, winter rainfall may reduce the opportunity for cultural weed control and thus fallow bed treatments help to maintain prepared beds free of weeds and allow melon planting during brief winter dry periods. In later plantings (April to mid-July), non-selective herbicides (glyphosate or paraquat), cultivation, and preplant incorporated herbicides can all be used (11).

Crop rotation is important in weed management (11). Crop rotation typically involves growing melons once every two to four years, with crops such as cotton or vegetable seed fields grown in the other years in Area I, cotton, tomatoes, or safflower in Area II, and cole crops or other vegetables in Area III. Late plantings of melons in Area II made in June to mid-July are frequently made behind small grain crops of wheat or barley for double cropping. Cultivation is used in all melons types grown in California with one to three cultivation operations per melon crop. Hand weeding crews are used by all melon growers in California to manage weeds that were not controlled by herbicides. The high value of the melon crop permits the expense of hand weeding, which would not be practical in lower value crops such as wheat or barley. Oxyfluorfen is used for preemergent and postemergent control of annual broadleaves. Fall bed applications after weeds emerge would utilize Glyphosate or Paraquat which is used for control of emerged annual weeds and suppressive knockdown of perennials as these materials are non-selective herbicides.

**Nematodes**

Root knot nematodes (*Meloidogyne incognita*) are microscopic, unsegmented roundworms that live in soil and inside plant roots. Root knot nematode is the major species of nematode of economic importance to melon production in California (5, 15). While there are other species of root knot nematodes present in California soils, *M. incognita* is among the most common. These parasites feed upon plant roots and produce swelling in the area of feeding. The formation of galls in roots disrupts the flow of water and nutrients in the plant. This leads to stress, which can become quite severe during hot weather, especially when fruit is developing. Plants infested with root knot nematodes are less vigorous and don't respond to fertilizer as well as healthy plants. Population increases are dependent upon several factors such as local climate, soil type, and the number of overwintering nematodes present in the spring. High numbers of nematodes may build up in sandy soils where significant crop loss can be expected in susceptible host plants. Nematodes can cause a plant to develop shallow root systems with numerous laterals that can not match evapotranspiration demands during hot temperatures. Knowledge of approximate population size and distribution across a field can help in choosing nematode control strategies. Soil samples can be collected in the field and transported to a nematode-testing laboratory for analysis of *Meloidogyne* spp. (21). Several control strategies can then be implemented. There are no resistant melon varieties available for nematode control (15). Methylcarbamodithioic acid (metam-sodium) is a biocide that is used as a preplant material (7).

Different species of root knot nematodes have been known to occur together in a field. Oxamyl is a systemic carbamate that can be shanked into the beds or applied through drip irrigation to control *M. incognita,* though it does not control *M. javanica* (7). No single chemical control tactic when used alone will totally eliminate nematode populations. Soil solarization is another cultural control practice that can be employed to reduce nematode populations, ideally during the hottest time of the year. Most production fields would not coincide with this timing, as a field would have to be fallow during the warm summer months. No relevant biological control programs have been identified for nematode control.

**Vertebrate Pests**

Horned Larks *(Eremophila alpestris*) are one of the most notorious bird species that are known to reduce plant stands when direct seeding is used (5, 12). The birds reduce the plant population by pulling up seedlings as they walk up the planted rows during feeding. The only effective control strategy to reduce horned lark damage to seedlings is to try and protect the crop by a constant patrol of the field with movement and noise acting as a deterrent to feeding during daytime hours. Once they have established a feeding pattern, horned larks will not be scared away with noisemakers such as propane cannons or even shooting. If they do fly off, it may be only for a short distance. The use of Mylar tape strips attached to solid set sprinkler pipes or risers in the field has had very limited success. Horned larks have become a bigger problem for growers since the introduction of hybrid seed with fewer seeds planted per acre. Growers who need to thin a melon field should delay thinning activities until plants achieve at least two true leaves. Larks are not a problem when transplants are used.

Crows (Corvus spp.) damage melons in the harvest ready stage as the birds peck into the fruit in attempts to get the seed. When a single puncture wound has been made into the flesh, the melon is unfit for harvest. Once they have established a feeding pattern, crows will not be scared away with noisemakers such as propane cannons or even shooting (5, 12, 15). If they do fly off, it may be only for a short distance.

Rabbits (*Sylvilagus spp*.) may feed on melon seedlings from early spring through mid-summer. Bait stations with diphacinone baits have been effective in controlling the pest along field borders (5). Damage may be high when fields are located next to almond orchards. They are considered a minor pest as they reduce plant populations along borders where protective cover occurs (15).

Ground squirrels (*Spermophilus beecheyi*) may damage melon seedlings in early spring planted fields that border almond orchards as they can chew on young plants. Ground squirrels usually do not make their burrows inside melon fields due to all the discing and cultivating activities. Bait stations with diphacinone baits have been effective in controlling the pest along field borders (5). Squirrels have also become a bigger problem in recent years for the same reason as other hybrid seed pests due to the lower plant populations of emerging seedlings (12).

Pocket Gopher (*Thomomys* spp.) activity should be monitored along field borders as this is where most gopher damage occurs in melon fields. Gophers can damage melon plants by their burrowing activity and by feeding on roots. They also can damage irrigation canals. Special tractor driven field implements can be used to create artificial gopher tunnels for use with strychnine or anti-coagulant baits prior to planting (5). Predation of gophers by owls can be encouraged by providing nesting sites along field borders but this method of control hasn't been extensively established (15).

Coyotes (*Canis latrans)* can damage drip irrigation equipment by chewing through lines in order to get to a water source (15). Damage from coyotes chewing on drip irrigation equipment adds to maintenance and repair costs. Coyotes also do minor damage to all melon types as they chew on fruit close to harvest times. No control options have been employed (5).

Voles (*Microtus spp*.) are sometimes referred to as meadow or field mice. They are considered a minor pest in fields in Area II but voles seldom become a problem due to the quick growth of melons with a typical period of 75 days from plant to pick for main season cantaloupes. Several bird species such as owls and hawks are predators on voles. Owls can be encouraged to stay in an area if adequate nesting sites are provided. Voles will not explore new areas unless adequate cover is present to protect them from bird predation.

**Pollination**

All melons require pollination by honey bees in order to produce fruit because the pollen grains are large, sticky, and not moved by the wind (10). In the past, some growers used to rely upon feral bees for pollination of melons. But the native bee population in the state has been decimated in recent years by varroa mites and tracheal mites. In addition to these mite pests, European honey bees have been competing with the Africanized honey bee in southern California since 1994 (2). Prior to the entry of the Africanized honey bee in the state, growers used to have their beekeepers place bee hives inside melon fields whenever possible to decrease the length of the flight path. With bee hives inside fields, many worker activities would occur in close proximity to hives. Irrigators and even tractor drivers carry bee nets to place over their faces when bee activity was high to prevent bee stings to the face and neck area (12).

The placement of hives inside fields used to also create problems for ground rig applicators and even aerial applicators as a 48-hour notice had to be given to a bee keeper prior to a pesticide application. Some beekeepers would then come out prior to a spray and cover the hives with plastic. But during extremely hot weather, many bees would cling to the outside of the hive where they are at a higher risk of being sprayed.
Once the Africanized bee became established in the lower desert region, growers and beekeepers changed the hive placement strategy to keep hives at a distance away from workers. Now, most bee hives are placed outside of the field along the perimeter or even along a nearby road. This lessened the threat to bees from spray drift while also keeping the majority of bees away from where workers are. Beekeepers have also taken an aggressive strategy to replace queen bees with a new European queen when a hive is suspected of being taken over by an Africanized bee swarm. Bee hives are usually held in cantaloupe fields for 30 days, in honeydew fields for 40 days, and in watermelon fields for 50 days for multiple picks.

**Post-Harvest Concerns**

There are no major post-harvest concerns that growers and shippers are worried about from the production side of the industry (15). There are no known fumigation requirements for export of melons nor are there any insect pests that are of concern for marketing of melons in the US. Once produce has left the shipping point, food safety concerns need to be addressed by the retail industry on the receiving side. There have been concerns over Salmonella outbreaks from melons grown in Mexico but there have never been any problems identified with melons grown in California (16, 22).

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**Acknowledgement**

AgriDataSensing, Inc., a small business located in the center of the San Joaquin Valley that specializes in agricultural research and consulting and in the analysis and interpretation of digital satellite imagery, was responsible for the research and collection of information on crop

production and actual practices of California melons. John LeBoeuf, a Certified Professional Agronomist and a licensed Pest Control Adviser, was involved in the preparation and writing of this document.

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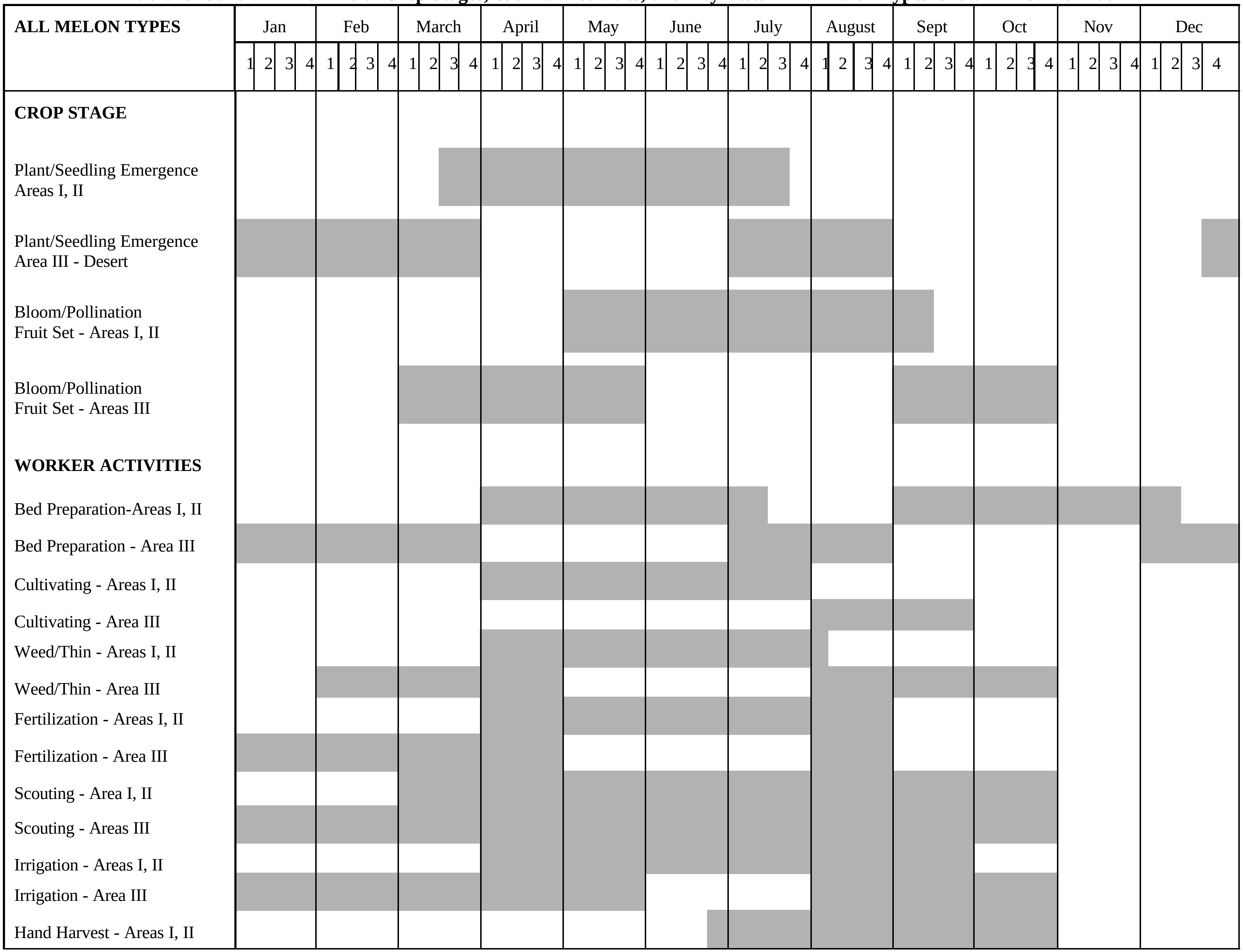
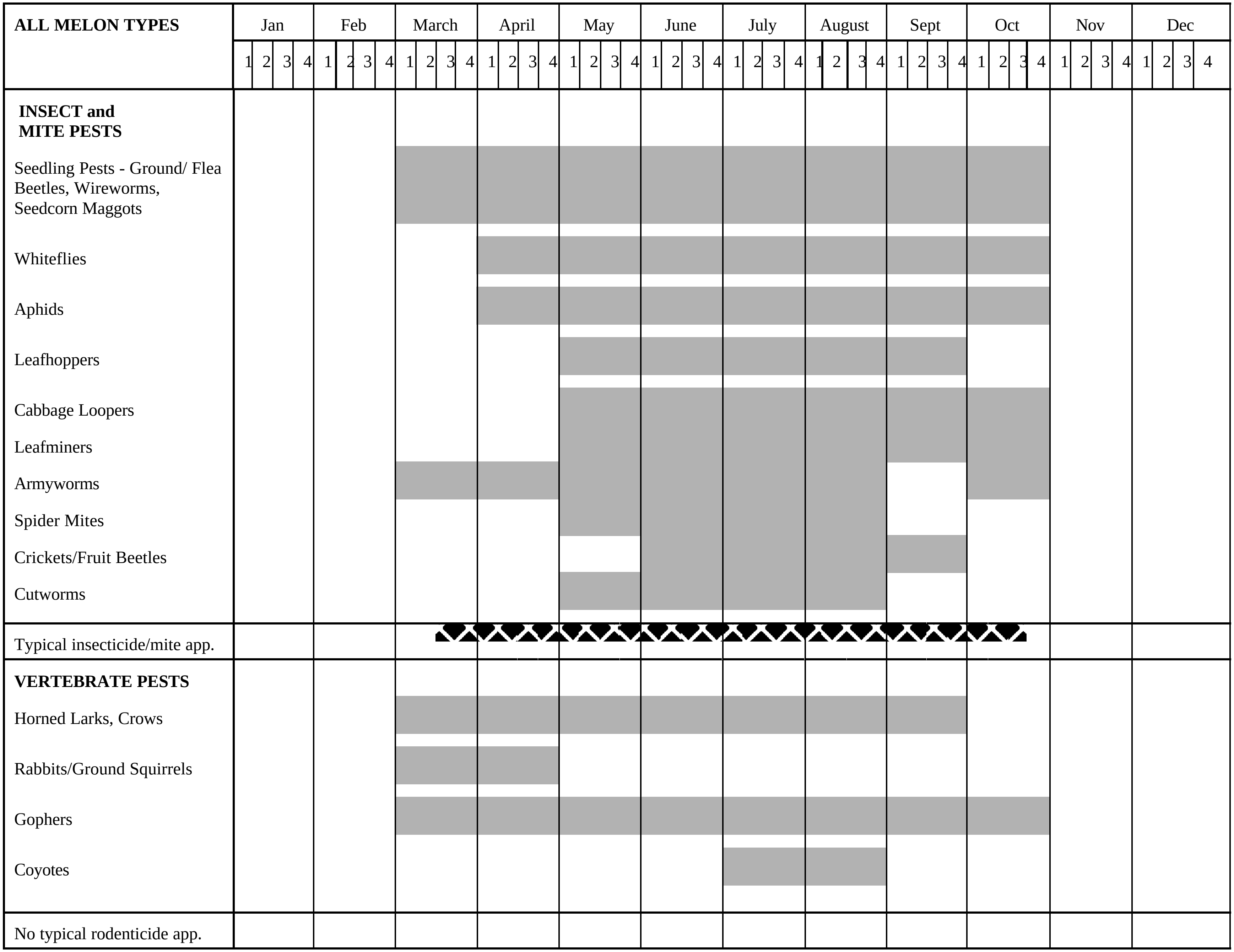
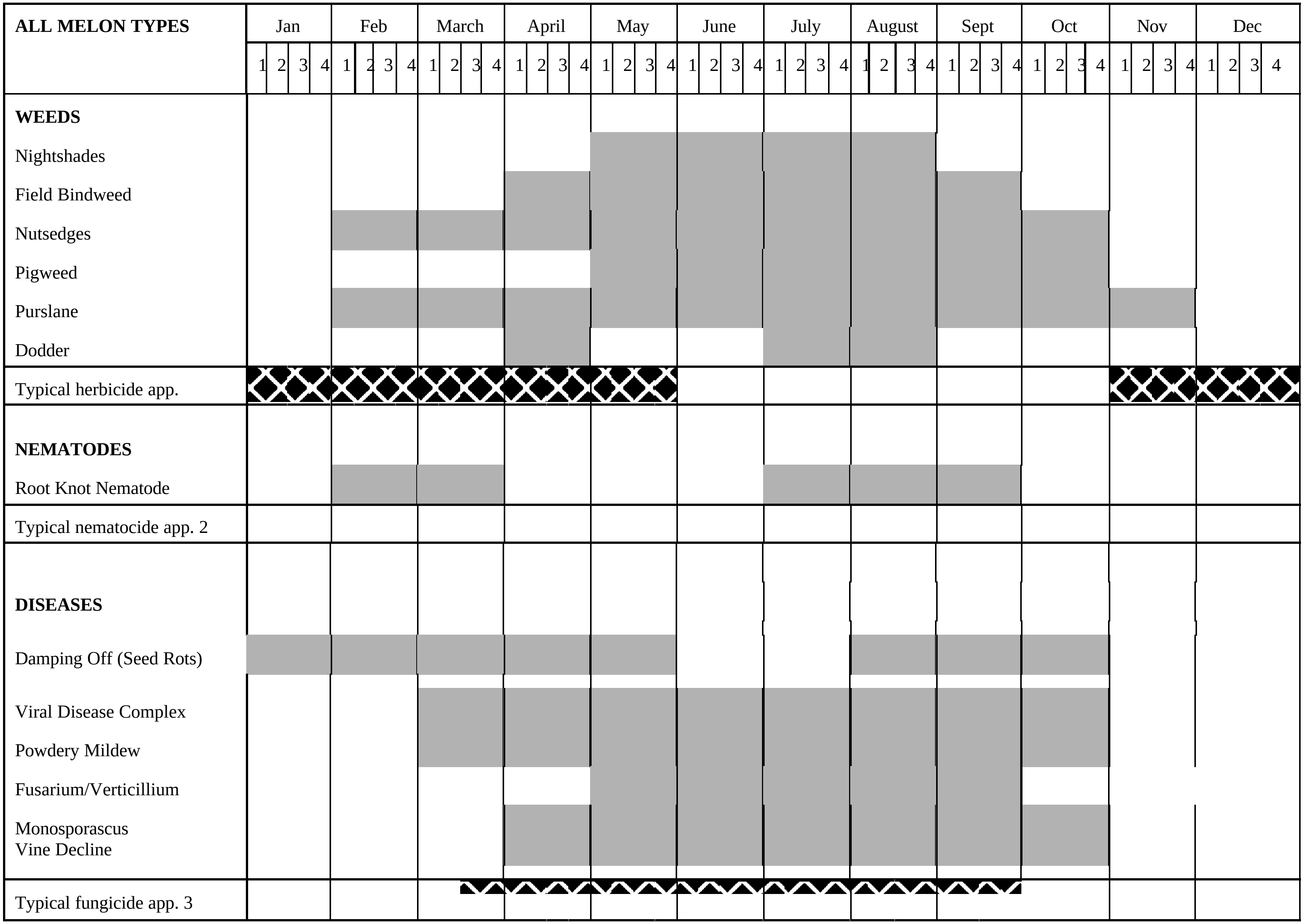
Numerous growers, shippers, farm managers, and PCAs, active in the melon industry in California, willingly provided information on current crop production practices and materials used in pest control. Researchers from the University of California Cooperative Extension along with board members of the California Melon Research Board (CMRB) who attended a Pest Management Strategic Plan meeting held on January 7-8, 2002 also provided valuable input on current production practices. The strategic plan meeting was sponsored jointly by the CMRB and the California Minor Crop Council with assistance from Dr. Lori Berger and facilitators Mr. Rick Melnicoe and Ms. Linda Herbst from the Western Region Pest Management Center located at U.C. Davis.

**Table 7. General Time Line of Crop Stages, Worker Activities, and Key Pests in All Melon Types Grown in California.[1]**



| **ALL MELON TYPES** | Jan | | | | Feb | | | | March | | | | April | | | | May | | | | June | | | | July | | | | August | | | | Sept | | | | Oct | | | | Nov | | | | Dec | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 2 | 3 | 4 |
| Hand Harvest - Area III | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |


ALL MELON TYPES
Jan
Feb
March
April
May
June
July
August
Sept
Oct
Nov
Dec
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4
INSECT and MITE PESTS
Seedling Pests - Ground/ Flea Beetles, Wireworms, Seedcorn Maggots
Whiteflies
Aphids
Leafhoppers
Cabbage Loopers
Leafminers
Armyworms
Spider Mites
Crickets/Fruit Beetles
Cutworms
Typical insecticide/mite app.
VERTEBRATE PESTS
Horned Larks, Crows
Rabbits/Ground Squirrels
Gophers
Coyotes
No typical rodenticide app.




1 The horizontal bars represent the usual range of time when the events occur for the entire crop. These times vary depending on production Areas I, II, or III.

2 No typical sprays as field specific decisions are made prior to, or during, the season.

3 Fungicide applications are applied as preventive for damping off and as preventive and curative for powdery mildew. No sprays for virus complex.