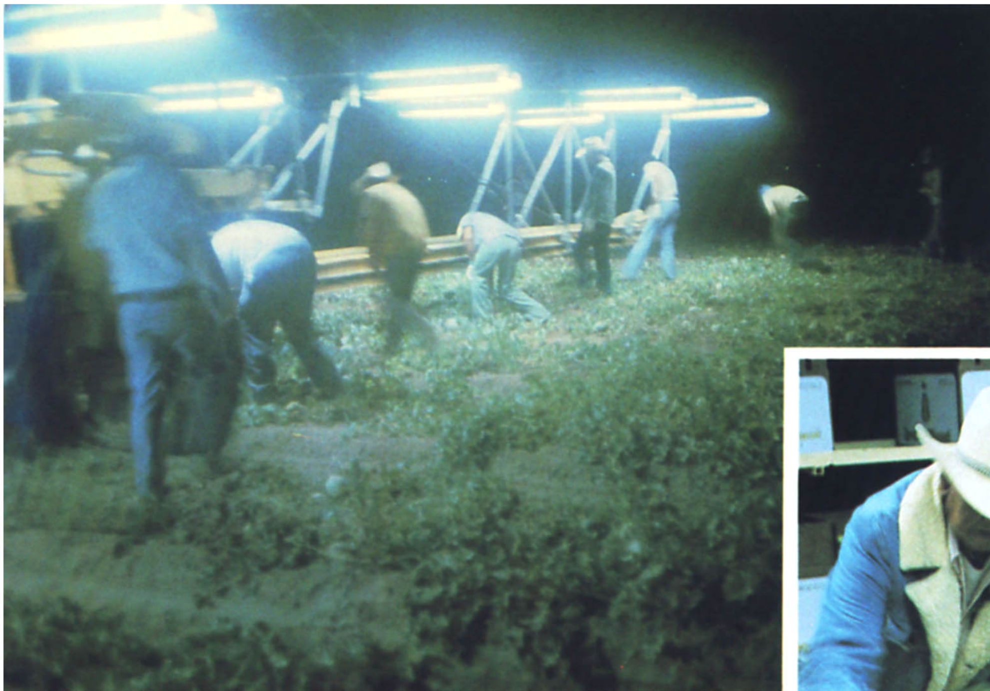

Max Clover

Fluorescent lamps mounted on harvesters provide the uniformity, brightness, color balance, and overall visibility to harvest melons (left), broccoli (below), and other crops during the cool nighttime hours.

Night picking

William C. Fairbank □ Leslie L. Ede □ Hunter Johnson, Jr.
Donald A. Luvisi □ Rudy A. Neja

Permits major savings in cooling costs

The concept of picking perishable crops at night isn't new. In the 1950s, U.S. Department of Agriculture and University of California research demonstrated reduced bruising and longer shelf life of fruits picked before the sun warmed their pulp.

Despite proved and potential advantages, the idea never advanced to field reality, because the illumination systems tried were ineffective. More recently, the high cost of electricity to operate precoolers has caused growers to reexamine night picking as a way to reduce the refrigeration heat load and extend the shelf life of perishable crops.

Design

A team of UC Cooperative Extension researchers, fresh-market grower-shippers, and Southern California Edison Company lighting specialists began to study the feasibility of night picking in May 1980. The group investigated industrial lighting technology to find a way to illuminate picking tasks in a situation with no ceiling or wall reflectance.

June-harvested cantaloupe in southern California's hot Palo Verde Valley was the first crop investigated. Melons are harvested by teams of 16 workers behind 16-bed self-propelled belt loaders, which deliver the fruit onto highway transport trucks. We determined that light fixtures and a 120-volt motor-generator could be carried on this mobile harvest aid (fig. 1). During the hot, clear summer, the nighttime low temperatures are typically 30°F below the daytime highs, suggesting that cooling time could be shortened and substantial energy savings realized simply by capturing and retaining nighttime coolness.

The first attempt by a grower to pick at night relied on incandescent lamps hung in a row immediately behind the loader belt, above the workers. This attempt failed because of bright spots, deep shadows, nonuniformity, and an insufficient overall intensity of the lighting on the bed. Another grower tried high-wattage, high-intensity-discharge (mercury or sodium vapor) parking-lot fixtures mounted about 15 feet high above the field. The "envelope" of light surrounding the worker was larger, but the point-source illumination still resulted in bright spots and nonuniformity. Neither system could provide harvest efficiency approaching normal daytime performance.

Industrial lighting standards prescribe no less than 20 foot-candles (215 lx) of uniform illumination to find cantaloupes among vines and leaves that are almost the same color, and to judge the subtle difference in appearance between ripe and immature melons. Light contrast on the work surface should not exceed 3:1, a value that could not be obtained from point-source lights that create strong shadows.

Southern California Edison lighting engineers designed an illumination system, first characterizing the melon bed and the picking task, then subjecting the specifications to computer analysis. Standard F-40 fluorescent lamps were selected for uniformity and color balance with the least wattage. The lighting specialists and UC agricultural engineers designed the installation within the limits set by the load-carrying ability of a belt loader, the 45-day picking operation for amortization, and the volatility of melon profits.

The resulting design was a fluorescent lamp system giving previously unattained uniformity, brightness, color quality, and overall visibility. A lamp fixture support structure of thin-wall steel tubing proved adequate in all respects and kept the cost well below the usual outdoor lighting systems designed for permanence.

Melon harvest tests

We then sorted immature, "eastern (shipping) ripe," and mature cantaloupe under these pure light sources in standardized lamp test booths in the Westing-

UC agricultural engineers worked with industrial lighting specialists to develop a fluorescent lighting system that could be installed on harvesters and make possible nighttime picking of perishable crops in hot southern California desert valleys.

house Industrial Lighting Laboratory, El Monte, California (table 1). In the field, the lighted belt loader was judged acceptable, based on casual observation, lightmeter measurement, and picker reaction. Later, in field tests, we found no significant difference in picking rate or in yield and cullout of melons picked under fluorescent illumination as compared with daylight norms. During the following season, at least seven melon belt loaders lighted with this sytem were used in the 4,000 acres of spring cantaloupe in the Palo Verde Valley.

Packing and precooling operations usually start four hours after picking begins, allowing for loading and transport of the first truck loads and a continuing supply until the day's harvest ends. Night picking normally starts at midnight, and the packing operation runs from about 4:00 a.m. until midday.

Temperature profiles of the air and of melon pulp over 24-hour periods established the potential benefit of refrigeration conservation (fig. 2). We first performed tests to correlate pulp temperature and average melon temperature to solar and night-sky exposure, degree of leaf shading, and air temperature. Because of the temperature variation from the hot upper portion exposed to the sun to the cool underside on the bed, we found center temperature in the seed cavity to be the most practical and reliable way to specify average melon temperature. After equalization, pulp temperature varies from center temperature only if the outside of the melon is exposed to a new thermal influence.

Shading by leaves significantly reduced direct solar radiation and nighttime radiant cooling of melons (fig. 3). Shading kept average fruit temperature close to air temperature, but with a time lag of up to 1.5 hours.

Cantaloupes that have remained in a truck trailer from field to packing plant are usually close to air temperature when they enter the packing line (fig. 4). Monitoring and analysis of day and night air temperature, melon pulp temperature extremes and averages, and heat exchange mechanisms in the field and through the transportation and packing operations indicated that fruit could enter the precooler with about a 5°F temperature gain from the nighttime low.

During the day, melons often require cooling from their arrival temperature near 95° to their holding temperature of 40°F, a drop of 55°F. Night harvest could theoretically reduce the incoming temperature to 70°, for a cooldown of 30°, or a theoretical cooling load reduction of 45 percent. Taking into account that there might be a 5° temperature rise of night-picked melons between field and packing line, the load reduction might actually be closer to 36 percent. Subsequent observation of a typical precooling and shipping operation has indicated that a refrigeration reduction benefit of this magnitude is possible by the indirect method of reducing cooling time.

We compared picking efficiency of nighttime and daytime harvesting by selecting uniform areas of a typical ripe field on each of two days and marking 100-foot lengths of bed with similar appearance and fruit count. Eight beds were picked one hour before dawn, and eight were picked by the same crew and belt loader an hour after sunrise. After the harvested fruit was counted, each bed was repicked by daylight to count the number of ripe fruit missed (table 2).

There was great variation between replicates, but the growers had the impression that night picking presented no problem with fruit maturity determination or with worker efficiency.

Other crops

After succesful night picking of cantaloupes, other warm-season crops that require heavy refrigeration loads for precooling were considered. The first such crop was table grapes. Preliminary field tests in the Coachella and San Joaquin valleys confimed that it is physically possible to direct fluorescent light of adequate brightness into the fruit zone under the leaf canopy and that the common fruit defect waterberry (soft, immature, sour fruit) is more easily recognized under directed artificial light than under shaded daylight. A minimum of 30 foot-candles in the fruiting zone and 100 foot-candles at the trimming table are desired for visibility at least as good as daytime norms.

Table grapes require a very accurate determination of bunch ripeness and the instant recognition of defective berries. Light-booth tests conducted at the Southern California Edison light laboratory compared the use of preselected fluorescent lamps and sunlight for discrimination of quality and recognition of defects. Field-box-size fresh samples of four common varieties were judged for quality by farm advisors specializing in grapes.

The four varieties were judged successively and repeatedly under sunlight and the five selected fluorescent lamps. The most common quality determinants of overall appearance, color, bloom, waterberry, mold, raisining, and bird pecks were compared for each variety. A quality factor or defect that was easy to recognize was assigned a value of +1; a factor that seemed neutral was 0; a factor or defect that was difficult to recognize in the variety under that light source was −1. Each quality factor or defect carried the same relative importance.

N-84 and N-85 color-enhancement lamps were better than sunlight and all other lamps tested for recognizing the defects present (table 3). They were essentially equal to sunlight for recognizing bloom on the bunches.

Early-season strawberries were considered for night picking, because harvest during cooler hours as summer progresses could extend fresh market utilization. Lighting trials were performed with fluorescent 2F40 fixtures suspended 80 inches above the beds. Ultralume 4100 K (N-84) and 5000 K (N-85) lamps were tested. They produced 31 and 45 foot-candles of brightness, respectively. The farm picking foreman reported that color separation and visibility were satisfactory with either lamp at a brightness of 35 foot-candles on the bed. The specific fluorescent color spectrum for different lamps did not appear to be critical for strawberries, because the color change from immature to market ripe is distinct.

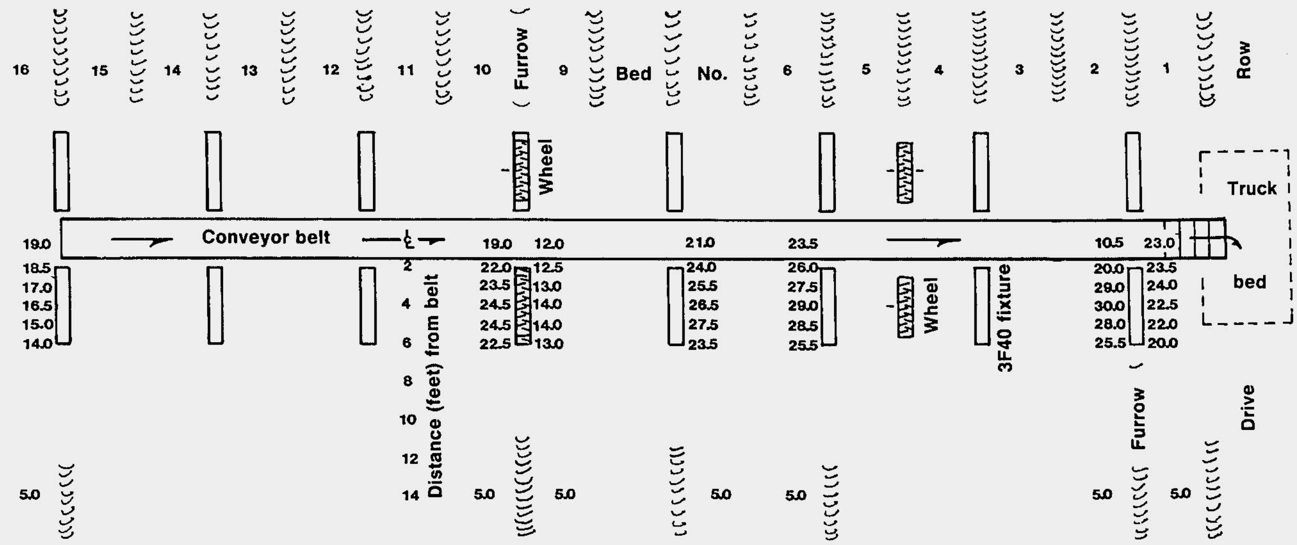

Fig. 1. Diagram of belt loader used to harvest cantaloupe, showing foot-candles of illumination on the bed with all lights operating. The 100-foot-long conveyor belt, carried on a four-wheel self-propelled vehicle, extends across 16 rows.

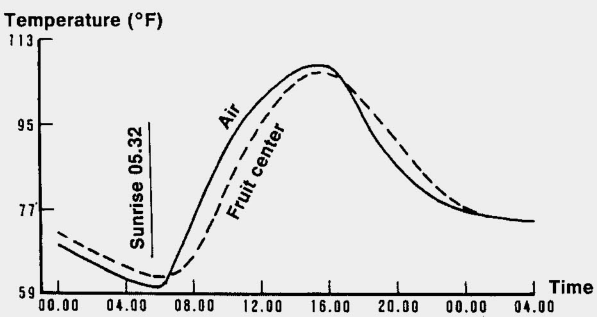

Fig. 2. Typical temperature profile in a desert valley and within melon suggests potential cooling benefit of night picking.

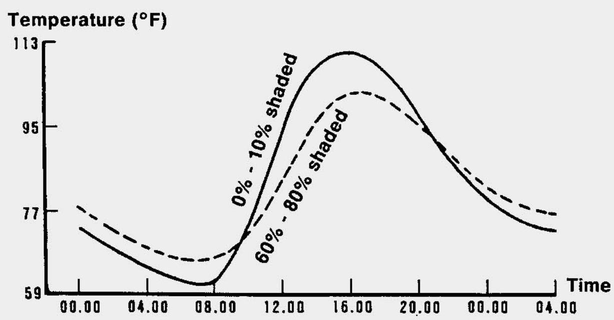

Fig. 3. Leaf shading moderated the effects of daytime solar heating and nighttime radiant cooling on cantaloupe.

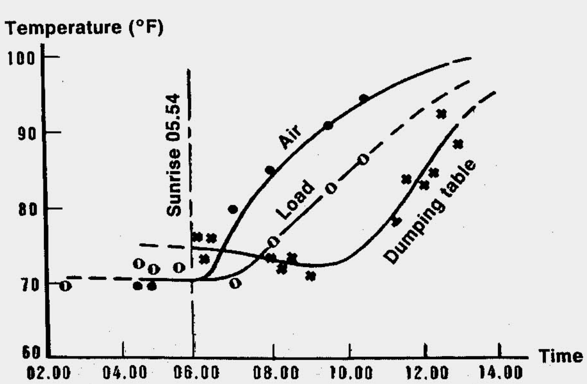

Fig. 4. Temperatures of air and of melons in the truck, and averages of three fruit (per data point) selected at random on the dumping table.

TABLE 1. Fluorescent lamps tested for night picking of melons

Lamp designation	Comments	Judgment*	Price†
Color-Match	Insufficient brightness, color distortion	NA	—
Daylight	Low output, poor color	NA	—
Warm White	Med. brightness, poor color separation	+1	1
Cool White	Superior brightness, fair recognition	+3	1
Ultralume 3000 (N-83)	Superior color separation	+4	4x
Ultralume 4100 (N-84)	Good color separation, good brightness	+4	4x

* Judgment ratings: 1 = poor acceptance; 4 = best performance (price not considered).
† 1 is the base price of the least expensive standard fluorescent F40 lamp.

TABLE 2. Efficiency of night versus day picking of melons

Harvest	Avg. no. fruit/ 100 ft	Avg. minutes to pick 100 ft	Fruit/ minute	Ripe fruit missed	Percent missed
Night picked	431	2.7	172	23	5.4
Day picked	241	1.9	119	20	11.6

TABLE 3. Summary of cumulative lamp scores in table grape quality determinations

Variety	Sunlight	Fluorescent lamp type: White	Cool White	N-84	N-85	C-75
Recognition of defects:						
Ribier	0	+1	+1	+6	+3	+1
Exotic	+3	−2	−1	+7	+7	−1
Flame Seedless	+3	−2	−6	+5	+4	−3
Avg., colored varieties	+2	−1	−2	+6	+5	−1
Thompson Seedless	+2	−1	−2	+3	+6	+1
TOTAL SCORE	+8	−4	−8	+21	+20	−2
Judging bloom appearance:						
Ribier	+1	0	0	+1	0	−1
Exotic	+1	+1	+1	+1	0	0
Flame Seedless	+1	0	−1	+1	+1	−1
Thompson Seedless	−1	−1	0	−1	0	−1
TOTAL SCORE	+2	0	0	+2	+1	−3

NOTE: See text for explanation of scores.

White wine quality is sensitive to the temperature of the juice at the time of crushing (in general, cooler grapes make better wine). Refrigeration immediately after crushing is now standard. Observation in vineyards indicated that berry temperature follows air temperature very closely with no more than a 20-minute lag. The midday high to predawn low temperature variation is commonly 30°F. No temperature change from time of picking until late morning was measured in gondola loads of night-picked grapes if they were held in the shade.

The several vintners who tested night picking reported a reduction in the refrigeration load. Heat extraction from the juice by mechanical refrigeration and shell-and-tube heat exchangers is calculated to use about 6 cents worth of electricity per degree Fahrenheit per ton of crush. This would be a direct energy cost saving of $1 per ton for a 16° temperature benefit.

Conclusions

Fluorescent illumination can provide the intensity, uniformity, and color balance needed for night picking at daytime levels of performance. Cool-White fluorescent lamps gave the greatest overall brightness on all crops evaluated, but color enhancement lamps (N-74 or N-75) gave superior color separation to detect ripeness and defects on cantaloupe and table grapes.

Up to 36 percent refrigeration energy conservation was estimated as a result of a lower temperature drop through the precooler. Also, since more of the cooling would take place before noon under night picking, it might be possible to reduce compressor operation during peak energy-use hours (noon to 8:00 p.m.). Off-peak energy (10:00 p.m. to 8:00 a.m.) costs are now one-third to one-half as high as peak energy costs and are expected to go still lower.

The electricity consumed by lamps for night picking is in the range of 100 to 300 Watts fluorescent per picker. This gives a calculated energy effectiveness ratio (refrigeration energy saved divided by light wattage used) of more than 10.

Although some workers find it difficult to adjust to a nighttime schedule, an unpublished survey by UC Cooperative Extension indicates that many workers prefer predawn field work to daytime harvesting in the hot summer. Night picking also offers growers the flexibility of adding picking and packing shifts when time is critical in harvesting a crop.

William C. Fairbank is Agricultural Engineer and Hunter Johnson, Jr. is Vegetable Specialist, Cooperative Extension, University of California, Riverside; Leslie L. Ede and Rudy A. Neja are Farm Advisors, Riverside County; and Donald A. Luvisi is Farm Advisor, Kern County.

Characteristics of women in farming

Orville E. Thompson □ Douglas Gwynn □ Charlotte Sharp

Although the substantial contributions of women in agriculture are recognized (see "Women on Commercial Farms." *California Agriculture*, May-June 1985), no definitive studies have been reported on the division of labor between spouses on California family farms. Nor is much known about the external conditions and internal perceptions that influence women's involvement in farming. A telephone survey of 228 married farm women in Yolo County revealed that economic and structural changes have created a greater demand for women to work on the farm.

The survey population was drawn from lists obtained from the Yolo County Assessor's Office, the Agricultural Stabilization Board, and the Davis Farmers' Market. A total of 363 farms were found to be owned and operated, at least in part, by the individual farm family, which was a requirement for inclusion in this study. The 228 farms from which completed interviews were obtained closely paralleled the Agricultural Census data on family farmers in Yolo County and were not significantly different from the farms not in the sample. The study was designed to find out how the involvement of these women is influenced by farm type and size, by their education and age, where they lived, the use of hired labor, and the presence of extended family in the area.

We selected Yolo County for the study because of the importance and diversity of farming in the area. Agriculture is the county's largest industry: more than 85 percent of the land area is in farms. Major crops include tomatoes, wheat, rice, corn, sugarbeets, almonds, alfalfa, walnuts, barley, and melons.

Who does what

To learn how tasks were allocated and decisions made on the family farm, we asked 19 questions about decision-making and division of labor. We grouped these in the four general areas of production decision-making, production tasks, management support services, and homemaking (table 1).

In 50.2 percent of these cases, husbands made all the decisions regarding which crops to plant, while in 18.7 percent of the cases, these decisions were shared by the spouses. Males also played the dominant role in hiring and supervising labor. When decisions on size of farm, purchasing equipment, borrowing money, or determining scale of animal production were made, there was a strong tendency toward sharing the tasks.

Men dominated in all tasks related to production, such as cultivating, irrigating, harvesting, and hand work. On the farms in this study, few women performed production tasks either alone or with their spouses.

In those tasks related to management, males continued to dominate in all areas except in bookkeeping, where twice as many wives (44 percent) as husbands had exclusive responsibility. This task was shared less than 9 percent of the time. In running errands and reading publications, the wife's involvement was moderate and quite often shared with her spouse.

Finally, as anticipated, wives took primary responsibility for homemaking. In only one case did we find the husband taking exclusive responsibility for meal preparation or child care. In about a fourth of the cases, yard and child care were shared. Women had virtually exclusive responsibility for meal preparation and child care. Planning social events and recreation were shared by most, with more wives taking exclusive responsibility than husbands.

There appeared to be two general types of farm women. Our data showed that one type, while active in homemaking, participated very little in production decision-making, production tasks, or management support services for the family farm. In contrast, the other type was involved directly in one or more of these farm operation activities in addition to carrying on homemaking. Furthermore, the farm wife who was directly involved in an activity such as production decision-making was also relatively more likely to be actively involved in production tasks and/or management support services and vica versa.

Differences in involvement

We tested statistically the involvement of farm women in the farming operation against variables that, based on previous studies, may affect this involvement. This allows us to better understand why some farm women are highly involved in the farming operation, while others are not.

The variables that best predicted this (by regression analysis) were, in order of importance: residence on the farm, presence of extended family involvement in