the main vegetables that are packed and sold in these plastic containers. Oranges, grapefruit, and apples are the 3 main fruits that are packed in perforated plastic containers. The use of these clear plastic bags necessitates uniformity, good quality produce that is visible and acceptable to the purchasing consumer. Besides polyethylene, other films such as polystyrene and polypropylene are being used in increasing quantities.

In the large markets and chain stores, a good portion of the meats are wrapped with a polyvinylchloride film (PVC) that has the desired "cling to" quality which is especially true for the tight meat packs. Where the meats are cut or prepared in various desirable sizes for the family need, the PVC film of 1/2 to 3/4-mil thickness is ideal cling-to covering. This film, like polyethylene, polypropylene, and polystyrene also "breathes," which is essential in much of the packaging today. Another material developed from wood fiber is cellophane. It basically does not allow gaseous exchanges and is very effective in packing hard candies and other materials that do not deteriorate. This cellophane film also excludes moisture exchanges.

The annual use of packaging films comprises the largest use of agricultural plastics and is estimated at 180 million lb. annually.

Other uses
The plastic uses that have been discussed are the main ones used in California. There are many other uses that comprise smaller but appreciable tonnage of plastics. A fairly common but unpredictable quantity is used in rain protection of grains and hay that is stacked in fields. Wide sheets of 2 - 4 mil sheets are pulled over the field stacks and are secured by placing soil on the ends at the ground level.

Another rather unique use of the plastics is the encapsulation of vegetable seeds in a water-soluble polyethylene oxide tape. The seed is precision spaced on the tape for the desired crop, and the tape is drilled into the ground. When water wets the tape the plastic dissolves, allowing the seed to germinate.

The inexpensive plastics and the new types and formulations of the plastics will see expanded uses in agriculture. Biodegradable films will be required, however, because of increasing disposal problems.

Literature Cited

Plastics in California Strawberries
Victor Voth
University of California, Davis

California's $60,000,000.00 annual strawberry business accounts for more than 58% of the nation's strawberry production, although it has only 16% of the United States strawberry acreage.

In 1970, California produced 300 million lb. of strawberries on 8,400 acres with an average yield of 17.3 tons per acre. In 1957, 224 million lb. were produced on 20,700 acres with an average yield of 5.4 tons per acre. This increase in production per acre and total yield has been brought about by the introduction of winter and summer planting, new improved cultivars, annual planting, polyethylene mulch, and soil fumigation. These innovations have also increased fruit size, quality, shelf-life and total solids in the fruit.

Successful strawberry growing in California is built around the interrelationship of photoperiod, growing temperatures, and chilling under planting systems designed to condition a maximized fruiting response. California strawberry culture is one of the few examples of commercial exploitation of the effects of unsatisfied plant rest due to lack of chilling commonly referred to as delayed foliation in deciduous fruit trees. The plants receive enough chilling to give sufficient vegetative growth to support high total production and large, high quality fruit but not enough to drive them to runner production.

Plastic mulch
Winter planting. Clear polyethylene mulch is used on all winter plantings (Oct. - Dec.) of University cultivars, about 1/3 of the south coastal acreage. It is applied as soon after planting as possible (within a few weeks), and yields are increased 70% or more (2). This is primarily a temperature effect. During the critical short day period when flower bud induction takes place, soil temperatures are raised as much as 10°F on polyethylene mulched beds as
compared with unmulched controls. Since the success of winter plantings depends upon how much they grow in the winter, the mulch must be used (3). The timing of application is critical as shown in Table 1. When applied too late, the clear mulch actually reduced yield by stimulating early runner production.

Experiments with polyethylene mulch plus polyethylene row covers increased early production only slightly under California conditions and reduced fruit quality (5).

Summer planting. Summer planting (July – Sept.) is the dominant system in California because of the high yield and high fruit quality. Since fruit quality on 2nd year plantings is relatively poor, approximately 7,000 of the 8,400 state’s acreage is now replanted each year, and over 90% of this 7,000 acres is mulched (Fig. 1). Polyethylene is also very helpful to summer plantings. All growers have realized the advantage of reduction in picking cost associated with plastic mulch and the pickers are reluctant to work in fields that are not mulched, especially when paid on an incentive basis.

In summer planting the increase in production, due to plastic mulch is never as great as in winter plantings, but it does modify the production pattern favorably, increases fruit size and yield, and enhances earliness and fruit quality. The mulch is usually applied in Jan. or Feb., depending upon area, plant size, planting date, and cold requirement of a given cultivar. If plants are under-developed or planted later than the recommended date (4), clear polyethylene mulch should be applied earlier, possibly even in Nov., as soon as runnering has ceased (Table 2). However, it should never be applied early on properly timed plantings since yield and fruit size will be affected unfavorably.

Plastic and soil fumigation

In California 12 to 15 thousand acres are fumigated annually with mixtures of methyl bromide-chloropicrin tarped with 1 mil natural polyethylene (Fig. 2). The strawberry industry (fruit and plant production) accounts for over 8,000 acres of it or about 60%. Some strawberry growers in fruit growing areas have fumigated the same soil annually since 1957.

Experiments (7) on soil cropped 6 consecutive years with strawberries and fumigated 5 times with the conventional 2:1 mixture of methyl bromide-chloropicrin at a rate of 250-300 lb./acre increased yield by 25 to 50%, depending upon the cultivar. On the average, this increase represents about 8 tons per acre in California.

The weed control that results from this type of fumigation is necessary when clear polyethylene mulch is used in California. Unfumigated soils are so weedy that the clear mulch is difficult to hold in place.

At the present time, research is continuing on rates of materials and use of a more impervious tarp (cover) after injection of the fumigant. This experimental work includes study of weeds which have some resistance to control with methyl bromide and also takes into consideration need for better weed control in general.

Plastic and plant storage

At the present time in California, between 200 - 250 million strawberry plants are stored annually. Of these 50 - 75 million are grown at high elevation nurseries for winter planting. These plants are dug during Oct. and stored at 34°F for 10-15 days, depending upon digging dates and recommended planting dates for the cultivar and upon the weather. Few problems are encountered in the short term storage involved in these plantings. The polyethylene liner prevents desiccation (Fig. 3).

The remaining 150 - 200 million plants are grown at the low elevation nurseries and harvested from late Dec. through Jan. and stored at 28°F for summer planting. Plant storage tests (1)

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**Table 1.** Comparing early and late mulching on high elevation winter planting.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Time of mulch application</th>
<th>Yield/acre (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tioga</td>
<td>Early (Nov. 15)</td>
<td>17*</td>
</tr>
<tr>
<td></td>
<td>Late (Feb. 1)</td>
<td>12*</td>
</tr>
<tr>
<td>Fresno</td>
<td>Early (Nov. 15)</td>
<td>17.5*</td>
</tr>
<tr>
<td></td>
<td>Late (Feb. 1)</td>
<td>13.5*</td>
</tr>
</tbody>
</table>

*Difference significant at 5% level.

**Table 2.** Comparing early and late mulching on summer planting.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Time of mulch application</th>
<th>Yield (tons/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tioga</td>
<td>Early (Oct. 1)</td>
<td>27.5</td>
</tr>
<tr>
<td></td>
<td>Late (Feb. 1)</td>
<td>31.3</td>
</tr>
<tr>
<td>Fresno</td>
<td>Early (Oct. 1)</td>
<td>23.0</td>
</tr>
<tr>
<td></td>
<td>Late (Feb. 1)</td>
<td>24.0</td>
</tr>
</tbody>
</table>

---

**Fig. 1.** Polyethylene mulch (natural) on summer planted strawberries.

**Fig. 2.** (Top) Soil fumigation with 2:1 mix of methyl bromide chloropicrin, injection and tarp laying. (Bottom) Polyethylene tarp removal - after 48 - 72 hr.
have been conducted comparing the effect of 1 mil, 2 mil, 4 mil and 6 mil thick polyethylene liners on long term storage (6 to 9 months). The results showed that 2 mil or less gave the best results. Some damage to tomatoes was found on some cultivars when 4 mil was used and with 6 mil almost all plants were killed after 6 months. The liners used and recommended at the present time are 1 mil or less since it serves as an adequate moisture barrier and permits adequate gas exchange in cold storage.

**Plastic and marketing strawberries**

The plastic 1-pint basket is the one most commonly used container in California at the present time, about 80% of the baskets used (Fig. 4). A small amount of paper pulp and wood baskets are also used but these baskets are not very popular. Even though baskets of wood or paper pulp are as good or possibly better than the plastic (because they injure the fruit less during handling), the more attractive plastic baskets predominate. The “deceptive pack” aspect of both paper and wood container is not a factor with plastic. One would expect that pre-cooling would be facilitated with plastic baskets but tests (unpublished data) have shown very little difference in time required to cool fruit in wood and paper baskets when compared with plastic baskets.

**Plastic and irrigation**

The use of plastic pipe or tubing for water placement is a new concept being explored for all crops (Fig. 5). The past 4 years, experiments have been conducted with different types of polyethylene pipe with orifices every 2 ft, perforated tubing and porous pipe.

The main drawback encountered on all systems is the clogging of the small orifices. The use of filters is mandatory and the smaller the orifice the more difficulties are encountered.

The results of the experiments (6) conducted at the USDA Horticultural Field Station during 1967-68, using irrigation water with 1,000-1,100 ppm total salts, indicate less water consumption, lower salt accumulation, higher yields and increased fruit size (Table 3).

Approximately 1/2 acre ft of water were used in land preparation and plant establishment prior to Dec. 1 when treatments started.

There are several obvious advantages to the “trickle” or “drip” system under the conditions of this experiment. First, less than 50% of the amount of water normally used sustained the plants adequately through the production cycle. Second, the amount of salt (as reflected by electrical conductivity) was actually reduced under the “trickle” system during the course of the experiment. Third, yield during the 2nd half of the production period was increased and fruit size was larger on the plants under the “trickle” system. The performance difference is probably due to the difference in the amount of water applied and the method of application.

Leaf burn was evident under the conventional furrow system by about May 1 on all selections and particularly severe on highly susceptible cultivars. There was little or no leaf burn on the same selections under the “trickle” system.

Experiments conducted during 1969-70 are showing that the number of plants per acre can be increased 50% with equal plant performance by changing bed shape, thus increasing yield by at least that amount using the “trickle” system of irrigation.

**Literature Cited**


### Table 3. Effect of irrigation systems on strawberry performance in La Jolla, California, 1967-1968.

<table>
<thead>
<tr>
<th>Irrigation system</th>
<th>Water used (acre ft.)</th>
<th>Soil conductivity Dec.</th>
<th>Yield (g/plot) Mar-April</th>
<th>Avg fruit size (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard furrow</td>
<td>2.20</td>
<td>4.63 5.64*</td>
<td>246</td>
<td>14.8*</td>
</tr>
<tr>
<td>Trickle*</td>
<td>0.95</td>
<td>4.22 1.86*</td>
<td>244</td>
<td>15.6*</td>
</tr>
</tbody>
</table>

*Bed Top "drip" system.

* Differences significant at 5% level.

### PLASTICS IN CALIFORNIA STRAWBERRY PRODUCTION

<table>
<thead>
<tr>
<th>Soil fumigation</th>
<th>Nurseries: 600 acres</th>
<th>Production: 7000 acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total: 7600 acres @ 250 lb./acre</td>
<td>= 1,900,000 lb.</td>
<td></td>
</tr>
<tr>
<td>200 million plant @ 25/g/1000 plants</td>
<td>= 11,000 lb.</td>
<td></td>
</tr>
<tr>
<td>7000 acres @ 230 lb./acre</td>
<td>= 1,610,000 lb.</td>
<td></td>
</tr>
<tr>
<td>12,600,000 trays @ 100 g</td>
<td>= 2,790,000 lb.</td>
<td></td>
</tr>
<tr>
<td>50 gal barrel liners = 16,000 lb.</td>
<td>Miscellaneous = 20,000 lb.</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>= 6,331,000 lb. or 3,165.5 tons</td>
<td></td>
</tr>
</tbody>
</table>
FLOWER COLOR CHANGES

Flower color can be changed chemically according to USDA scientists. A bronze-colored chrysanthemum flower contains lavender-colored anthocyanins in the vacuoles and yellow-colored carotenoids in the chloroplasts and the combination in the outer cells of the flower created the bronze color. Various chemicals that turn pigment synthesis off and on selectively cause changes to lavender, yellow, cream, or various combinations of these colors.

Research being conducted by Sam Asen, USDA - ARS, plant physiologist, may produce a blue rose, if he can find the proper anthocyanin. He has found that blue flowers, contrary to popular belief, develop in nature without the presence of aluminum taken up by the plant. According to Asen, an anthocyanin-flavonoid complex produces the blue color in flowers.

PYRUS COLLECTION

During the past 10 years M. N. Westwood, Oregon State University, Corvallis, has assembled one of the world's largest collections of Pyrus, including 187 cultivars of P. communis, 6 of P. pyrifolia, 17 of P. ussuriensis and about 20 hybrids of these species. This collection should prove increasingly valuable for studies in cold hardiness, cultivar improvement, and disease resistance of pear.

PRESERVING ENVIRONMENTAL QUALITY

Management of the earth's resources, including production, should be achieved through a careful monitoring of all eco-biological rates. These studies, which reveal the cleansing and regenerating capacity of land, water and air, force us to recognize that these resources are not unlimited and free to be squandered.

Crop scientists conducting field experiments to improve biological production must measure and understand the import and consequences of any management changes resulting from studies of our natural resources. No longer can we be satisfied to measure their effectiveness only in terms of yield.

D. R. Nielsen, Associate Dean, University of California, Davis

YOU MAY PAY FOR PHOTOCOPIES

Four years ago, the Williams & Wilkins Co., Baltimore publishers of more than 30 prominent scientific and medical journals, sued the National Institutes of Health and the National Library of Medicine (NLM), alleging that their photocopying activities constitute an infringement of copyright. In September 1970, the case came before the U. S. Court of Claims and now, after reviewing masses of data, James Davis, a commissioner of the court, has rendered a decision in favor of the publisher. Davis ruled that Williams & Wilkins clearly has grounds for complaint, that photocopying diminishes its potential market, and that the company is entitled to compensation.

INTEGRATED PEST MANAGEMENT

Chemical pesticides are a familiar example of a technological innovation which has provided important benefits to man but which has also produced unintended and unanticipated harm. New technologies of integrated pest management must be developed so that agricultural and forest productivity can be maintained together with, rather than at the expense of, environmental quality. Integrated pest management means judicious use of selective chemical pesticides in combination with nonchemical agents and methods. It seeks to maximize reliance on such natural pest population controls as predators, sterilization, and pest diseases. The following actions are being taken:

- I have directed the Department of Agriculture, the National Science Foundation, and the Environmental Protection Agency to launch a large-scale integrated pest management research and development program. This program will be conducted by a number of our leading universities.
- I have directed the Department of Agriculture to increase field testing of promising new methods of pest detection and control. Also, other existing Federal pesticide application programs will be examined for the purpose of incorporating new pest management techniques.
- I have directed the Department of Agriculture and of Health, Education, and Welfare to encourage the development of training and certification programs at appropriate academic institutions in order to provide the large number of crop protection specialists that will be needed as integrated pest management becomes more fully utilized.
- I have authorized the Department of Agriculture to expand its crop field scout demonstration program to cover nearly four million acres under agricultural production by the upcoming growing season.

Through this program many unnecessary pesticide applications can be eliminated, since the scouts will be used to determine when pesticide applications are actually needed.

In my message on the environment last February, I proposed a comprehensive revision of our pesticide control laws—a revision which still awaits final congressional action. Also essential to a sound national pesticide policy are measures to ensure that agricultural workers are protected from adverse exposures to these chemicals.

- I am directing the Departments of Labor and Health, Education, and Welfare to develop standards under the Occupational Safety and Health Act to protect such workers from pesticide poisoning.