

effects of CPA emerged slowly (three weeks after application), so any judgment of the degree of thinning was made after the time when normal hand thinning should have been completed for the fruit to gain maximum size at maturity. In early varieties such as Beauty and Burmosa the thinning effect did not show until long after normal hand thinning time. At 300 ppm 3-CPA applied at 8 to 10 mm ovule length killed many shoot tips on Laroda and Queen Ann. El Dorado and Nubiana reacted with heavy leaf roll and shot holing, but the reaction of other varieties appeared to be negligible.

At 50 ppm 3-CP was ineffective when applied two to three weeks post bloom at 6 to 10 mm ovule length on the varieties tested. It was an effective thinner, however, when applied at 100 and 150 ppm when ovules were 6 to 7 mm long. Slight to moderate leaf shot holing was evident at both rates. El Dorado and Nubiana were the most sensitive varieties.

#### Plum summary

NPA looks promising as a chemical thinner for a number of plum varieties. Its potential is greatest in early maturing varieties and in those varieties (both early and late) that set heavily every year. Since NPA must be applied immediately post bloom to be effective, the potential crop is not yet known at application time. There is a hazard of overthinning trees that set lightly.

Although effective, 3-CPA activity is too late for use on early varieties such as Beauty and Burmosa. In general, it looks good as a chemical thinner for later maturing varieties. Where the time of hand thinning is not critical, 3-CPA has much potential since it can be applied after crop set is known. At 50 ppm 3-CP was not an effective thinner, at 100 to 150 ppm it appears to have more potential but leaf phytotoxic effects may be a disadvantage.

Additional tests are being made to establish satisfactory rates, timing of sprays, varietal behavior, climatic effects, year to year performance, and phytotoxicity. Results of these tests are limited in scope and are reported to show potential, but none of these materials are presently recommended for use on plums.

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*J. Beutel is Extension Pomologist, University of California, Davis. M. Gerdts, J. LaRue, and C. Carlson are farm advisors, Agricultural Extension Service, in Fresno, Tulare, and Merced counties respectively.*

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The method proposed here for soil moisture and salt control in irrigation utilizes solar energy and clear plastic to recycle water from irrigated furrows to adjacent seed or plant beds. The use of clear plastic canopies over the irrigated furrows prevents evaporation and maintains a moist seedbed for long periods of time. Harmful concentrations of soluble salts can also be redistributed within the bed by recycling water from the wetted furrow. Installation of the hydrologic mini-cycle system can be beneficial in seed germination and establishment of many of our high value crops. It can also be useful in areas of insufficient rainfall and high temperatures, especially where water is costly or of poor quality. Adaptation to nursery and greenhouse culture could greatly reduce the labor required by the frequent watering of plants. Warmer soil temperatures found in the plant beds beneath the edge of plastic canopies could facilitate early spring seed germination when solar energy is available but outside air temperatures are still too low for a normal seeding date.

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## HYDROLOGIC MINI *for soil moisture and*

**T**HE PROBLEM of obtaining sufficient water for irrigated agriculture grows more and more acute as the world's population continues to increase at an alarming rate. It has been estimated that in only 30 years the world will double its present population. The impact of the estimated population increase becomes even more critical since it will occur during a period of an expected decrease in fresh water supply. Another consideration is the fact that land suitable for crop food production, although presently adequate in some areas, will someday become limiting. The demand for more food to feed the millions of new people every year confronts agriculture experts the world over. However, while great pressure for more food will be exerted on agriculture, increased demands for water for industrial and domestic use will literally put the squeeze on irrigated agriculture. Roughly 50 per cent of the water used in the United States today is used by agriculture for irrigation. The present distribution ratio of water among agricultural, industrial, and domestic users can be expected to undergo considerable change in the future. It is apparent that if agriculture is to compete effectively for future water needs, the most efficient water management practices must be used.

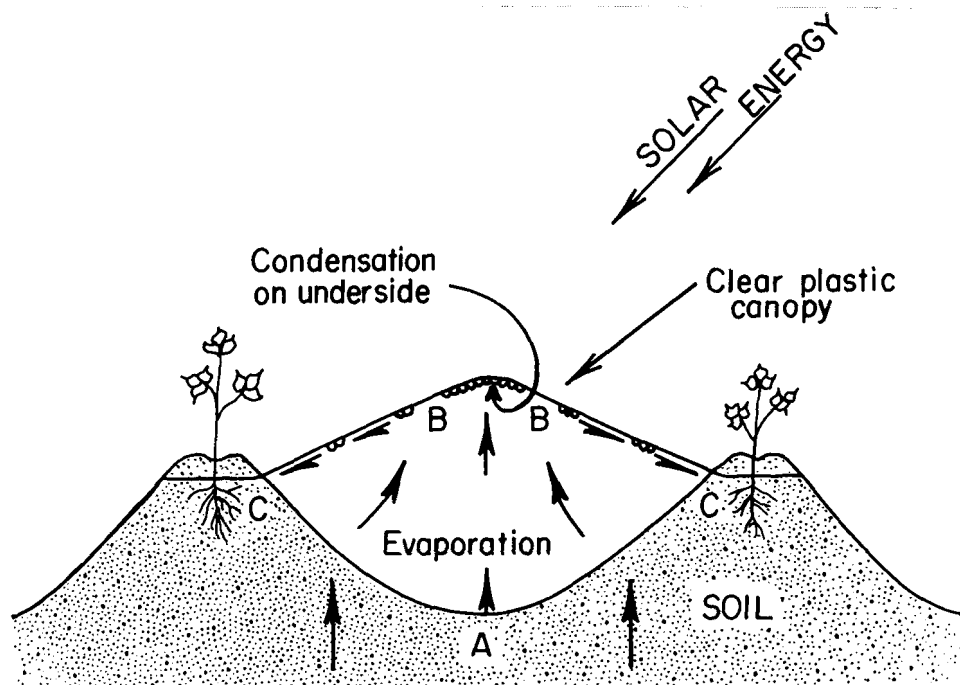
In arid and semi-arid regions of the world, where small amounts of rainfall

are generally insufficient to grow food crops, supplemental irrigation water must be obtained from some external source by costly systems of aqueducts, canals, or by wells. Since these sources of water are not only expensive but are limited in terms of an input for food crop production, continuous efforts must be made by agriculture to devise the most efficient means of water use. The maintenance of salt balance in the soil is also essential to the existence of irrigated agriculture. A buildup of excess soluble salts in soil under irrigation has caused total crop failures and disastrous social consequences within ancient civilizations—and is still a major barrier to maintaining high production on irrigated lands.

Transpiration by plants and evaporation from the soil surface (evapotranspiration) account for the greatest water losses during crop production. Even though transpiration serves as a cooling mechanism for plants, and is often referred to as a "necessary evil," efforts have been made to decrease water loss by retarding transpiration. Studies have involved use of metabolic inhibitors as well as physical transpiration barriers applied to leaf surfaces. Both methods show promise for future use, providing the metabolism of the plants does not change to cause an inferior or unacceptable plant product.

In an effort to reduce evaporation from

ROBERT J. MILLER



Sketch showing cross-section of two planted beds and furrow covered by plastic canopy illustrates principle of the hydrologic mini-cycle in recycling soil moisture. Cotton seed was planted through the edges of the plastic, as shown, in an experiment at the West Side Field Station in 1968 to test the feasibility of the method for crop production.

## CYCLE

### *salt control in irrigated agriculture*

the soil surface plastic was used over bare soil to minimize evaporation between plant rows. In one test there was a 56 per cent reduction in total water losses by evapotranspiration. In agricultural areas where insufficient water is available for optimum irrigation needs, prevention of evaporation losses would be comparable to an apparent increase in water supply. However, this increase may be less than expected, since it was found that when most of the evaporation between planted rows was prevented, more water was used in transpiration and resulted in an increase in crop yield. It is apparently easier to vary the relative proportion of evaporation to transpiration than it is to decrease total evapotranspiration. A reduction in water losses by soil-surface evaporation that did not seriously affect the metabolic functions of plants could result in a more efficient use of water.

Methods using solar energy and clear plastic (a distillation process) to obtain drinking water from brackish water have also been used in agriculture for a number of years. Solar energy and clear plastic have also been used recently to obtain fresh water from cut cactus plants in desert survival tests.

The use of plastic and solar energy is essential to the method to minimize evaporation described here. However, this proposed method differs from earlier

methods in that it minimizes evaporation loss by intercepting the evaporated water, and then distributes it to a position more convenient to the plant roots. The method might aptly be called a "hydrologic mini-cycle" since it is similar to the hydrologic (water) cycle existing in nature, but on a much smaller scale.

The hydrologic mini-cycle shows promise for increasing the efficiency of water use and salt control in irrigated agriculture and related industries, especially in areas where high value plants are produced. The method uses available solar energy which penetrates a clear plastic canopy supported by wires over wetted soil. The sketch shows a simple installation between two planted beds. After an irrigation in furrow (A) the ends of the plastic canopy are placed onto the soil surface and covered lightly with soil. The canopy, for all practical purposes, is completely enclosed. Since inside temperature increases and conditions are such that rapid evaporation takes place under the enclosing plastic canopy, the moisture reaches the dew point on the underside of the plastic and condenses as small beads of water (B). As evaporation and condensation continue, the small beads of moisture become larger, until gravitational force overcomes the surface tension at the water-plastic interface. The droplets of water then migrate downward

along the underside of the plastic canopy. The configuration of the canopy is such that droplets of distilled water are deposited on the soil surface at the point of contact with the plastic (C) near the top of the planted bed. This recycling of water from a wetted soil area to a plant bed causes a localized soil area to remain moist for a longer-than-normal period of time. Another—and perhaps the prime—benefit of the recycling of water is that soluble salt concentrations are reduced locally in the planted bed, thus preventing intolerable salt accumulations. These two desirable benefits—the persevering moisture, and reduced salt—could be extremely important in assuring germination of salt sensitive seeds under the highly evaporative conditions in arid regions. The proposed method is amazingly simple and requires little maintenance after installation.

The plastic canopies can be supported by wires positioned at intervals and shaped to give desired slope to the canopy. Angles of slope greater than 22 degrees were satisfactory because they promote better migration of water droplets along the underside of the plastic canopy and to the point of contact with the soil.

On August 7, 1967, beds and furrows were formed on a Panoche clay loam soil located at the University of California

West Side Field Station in the San Joaquin Valley. One-half of the furrows were then covered with 4 mil clear plastic in a way similar to the method shown in the sketch, except that the plastic canopy was terminated at the point of contact with the bed. The other half of the furrows were left uncovered, as under normal irrigation practices. Radish seed was then planted about 2 to 2.54 cm deep and 5 cm from the outside of the edge of the plastic, in the center of the bed. On the following day, all furrows were irrigated with 11.7 cm (4.6 inches) of water classified as permissible for irrigation, and the extended ends of the plastic canopies were folded over and sealed with soil.

Soil samples from the 0 to 15.24-cm depth were taken at planting time and at four different dates during the following 43 days. The soil samples were taken directly beneath the point where the plastic canopies met the beds and at the comparable position (shoulder) on the open beds. Soil moisture and soluble salt content of the saturation extract were determined for all samples.

The changes in moisture content of the soil at the 0 to 15.24-cm depth for the two treatments (plastic canopy and open bed) for 43 days after an application of 4.6 acre-inches of water on August 8, 1967 are shown in graph 1. The initial moisture content of the soil at the start of the experiment was 13.8 per cent by weight and was a little above the permanent wilting point (P.W.P.) for this soil—corresponding to 15.0 atm. of negative pressure as determined by laboratory analysis. Although the soil moisture content after irrigation was a conservative estimate, all subsequent moisture contents

were determined by the laboratory methods. In addition to the P.W.P., the soil moisture content at estimated field capacity (F.C.) corresponding to 0.33 atm. of negative pressure was determined to be 27.6 per cent by weight. Soil moisture available for plant growth lies between P.W.P. and near saturation and includes F.C., as shown in the graph.

### Soil moisture

After the irrigation, the soil moisture content at the 0 to 15.24-cm depth of the open bed decreased to near P.W.P. in eight days and below this point two days later. The moisture content of this soil continued to decrease until about September 1 (14 days later) and then apparently leveled off to remain at about 6 per cent by weight. During the same period, the soil moisture content at the same depth but under the edge of the plastic canopy (C in sketch) decreased to about 19 per cent by weight eight days after the irrigation. Subsequent soil samplings indicated that the soil moisture remained above 16 per cent by weight and above P.W.P. during the next 35 days. At no time during the course of the experiment did the soil moisture content under the edge of the plastic canopy drop below the lower limit estimated as being unavailable for plant growth or P.W.P.

The maximum daytime temperatures experienced during this 43-day investigation ranged from 75° to 106°F with 20 days of 100°F or above. The temperature inside the plastic canopies ranged from 14° to 30°F higher than the outside temperatures. The differential generally increased with higher outside temperatures and with time, as the amount of moisture

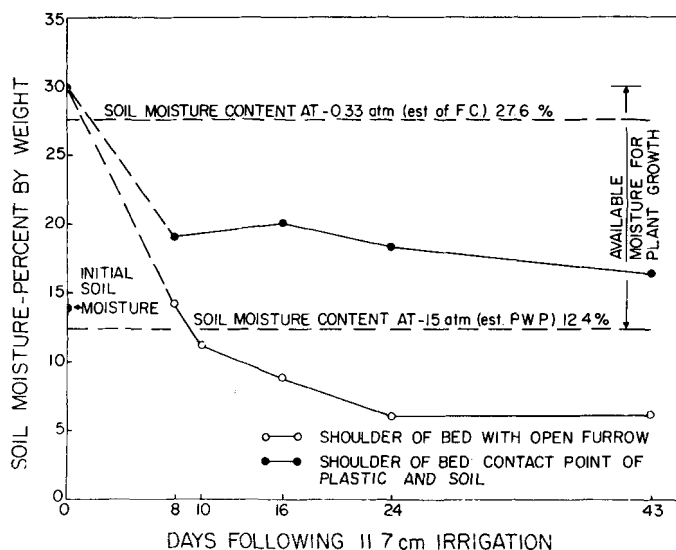
available for recycling decreased. There was no rainfall during this period.

An estimate of the amount of distilled water recycled during the experiment was accomplished by recording the rate of drops per minute as the water flowed along the underside of the plastic canopy toward the soil at the shoulder of the bed. The drop rate for 10-minute periods at mid-day along a 1 meter length of plastic canopy ranged from a low of 0 to a high of 118, averaging 32 drops per 10-minute period from August 10 to September 11. The volume of the drops of water recycled ranged between 0.03 and 0.08 cc, and averaged about 0.06 cc (a rate equivalent to about 0.03 inch of water per day).

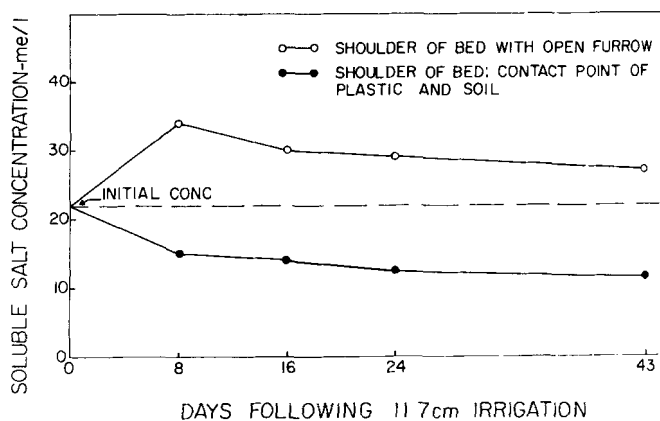
When there was sufficient moisture available for recycling, along with high outside temperatures and a variable breeze, the drop rate was considerably higher than on cooler days with no apparent wind. However, the drop rate was found to decrease with time as the supply of moisture under the plastic canopy decreased—regardless of temperature differential between inside and outside of the plastic and the existing wind velocity.

Soluble salt concentration of the saturation soil extract was determined prior to irrigation, and at four different times during the following 43 days. Salt concentration in milliequivalents per liter (me/l) from the 0 to 15.24-cm soil depth are shown in graph 2. The salt content of the saturation soil extract of the initial soil sample was 22.0 me/l. The soluble salt in the shoulder of the open beds rapidly increased to 33.0 me/l eight days after an irrigation. The later samplings indicated a lowering of the salt content to 27.0 me/l at the last sampling 43 days

GRAPH 1. MOISTURE CONTENT BY WEIGHT AT 0 TO 15.24-CM SOIL DEPTH FROM COMPARABLE POSITIONS IN TWO TREATED BEDS.



GRAPH 2. SALT CONCENTRATION IN MILLIEQUIVALENTS PER LITER IN SATURATION SOIL EXTRACT AT THE 0 TO 15.24-CM SOIL DEPTH FROM COMPARABLE POSITIONS IN TWO TREATED BEDS.



after irrigation—an increase over the initial sampling of 5.0 me/l in salt concentration in the shoulder of the open bed. In contrast, the salt concentration in the soil beneath the edge of the plastic canopy steadily decreased. There was a sharp decrease in salt concentration between the initial and second soil sampling eight days after the irrigation, followed by a slight but steady decrease in soluble salt concentration from 22.0 to 11.5 me/l—a decrease of 10.5 me/l below that found in the initial soil sample. As indicated in this experiment (and also reported previously), salts can be redistributed readily in soil under unsaturated conditions.

Some troublesome elements (sodium, chloride, and boron) associated with irrigation water, and the soil in this area, were also investigated. In the shoulder of

the open beds the sodium content increased from 16.2 to 20.7 me/l, chloride increased from 3.0 to 4.2 me/l, and boron showed an apparent decrease from 3.3 to 2.3 ppm. Under the edge of the plastic canopy the sodium content decreased from 16.2 to 9.2 me/l, chloride decreased from 3.0 me/l to a trace, while the boron content decreased from 3.3 to 1.8 ppm. Decreases in these troublesome elements in the soil through use of plastic canopies could be beneficial in seed germination and early plant growth in some areas.

The plant population on the open beds was considerably greater than found 5 cm outside the plastic canopies. This reduction in plant population alongside the plastic canopies, unlike that shown in the sketch (in which the seed was planted through the soil covered plastic), was

attributed to the effect of the recycling water leaching the soluble salts outside, and the evaporative action concentrating the salts in the center of the beds where the radishes were planted. The differences in plant population also may have accounted for some of the increases in water losses from the open beds (through greater transpiration). However, previous work indicated that the increasing of plant populations causes only a small increase in total water use, but will result in a marked reduction of the amount of water used per plant. Chemical treatment of the soil for weed control was necessary prior to installation of the plastic.

*Robert J. Miller is Assistant Water Scientist, Department of Water Science and Engineering, University of California, West Side Field Station, Five Points.*



## CROSSBRED BEEF CATTLE

*are more profitable*

S. W. THURBER • REUBEN ALBAUGH

Crossbred Angus-by-Hereford calves (seen in photo above, and cover, at the Albaugh Ranch, Shasta County) yielded a significantly higher return per head at weaning and at yearling age than straight Hereford calves out of Hereford dams of the same age, under the same environmental conditions. At weaning age, crossbred calves weighed 62 lbs more than the straightbred, and (at \$27 per 100 lbs) were worth \$16.74 more than the straightbreds. Yearling crossbred steers brought an income of \$28 more than straight Hereford steers, and crossbred heifers brought \$16 more than Hereford heifers.

**C**CROSSBREEDING of beef animals has been practiced in many parts of the world over a long period of time. The hybrid vigor resulting from the crossing of two breeds of beef cattle is well known. The profitability of crossbreeding has varied with price levels and with degree of benefit derived. In most instances the highest level of advantage from cross-

breeding has resulted from the use of crossbred dams. In the past, little information has been available from tests involving straightbred dams, all of the same age.

In a trial conducted at Albaugh ranch in McArthur, Shasta County in 1966, 52 2-year-old Hereford heifers were selected at random. One-half of them were bred to