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# DRIP IRRIGATION IN CALIFORNIA[1/]

by

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# DRIP IRRIGATION IN CALIFORNIA

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## SUMMARY

Drip irrigation has expanded fairly rapidly in California on orchards, vineyards, strawberries, and vegetables where water and growing costs are high. Savings in water, application labor, cultural operations and fertilization may offset the initial cost of equipment and installation. Many different drip systems are being used on the different crops, and the orchard, vineyard, and certain flower crops are generally using the more sophisticated and permanent emitters (Fig. 7-8-9). One or more types of filters are usually essential for most drip systems. Six staked tomato and two cucumber drip irrigated field trials, where properly grown, resulted in slightly higher yields and appreciable water savings, compared to furrow application.

## INTRODUCTION

The commercial use of drip irrigation started in 1961 by three individuals from three countries: R. D. Chapin, New York, USA; Vollmer Hansen, Denmark; and S. Blass, Israel. These systems were perforated pipes and spaghetti drip irrigation. Both field and greenhouse production of crops were tested with the drip system to evaluate plant growth and yields. After limited field trials, several benefits were fairly obvious. Less water per crop was applied and some saline water could be used with more frequent applications. Savings in water application were obtained with drip irrigation. If adequate rains are not typical of the growing area, another irrigation system may be needed to leach the salts out of the root zone.

Drip irrigation in California began its commercial application in greenhouses and with the potted plant industry with especially spaghetti and other special systems in 1965. Orchard and row crops have had a limited start in 1968, yet the larger and continued expansion occurred in the early seventies. Over 40,000 acres of crop land were irrigated with drip irrigation in California in 1973. The technology of drip irrigation is developing rapidly and this has encouraged the rapid and expanding use of this type of water application. Where most of the emitter systems cost $175 to $300 an acre or more for row crops, the advantages in water and labor savings, and the crop improvement have to be closely considered on crops other than potentially high income ones.

## METHODS, MATERIALS AND RESULTS

Eight drip trials versus eight furrow irrigation trials were conducted from 1970 to 1973 on tomatoes and cucumbers, and these are reported, which include six staked tomato tests. Two spring crops of cucumbers were started under plastic row covers. Four replicates of each treatment were compared in each field trial. Full row replicates with adequate guard rows were used in each commercial field test. Three different emitters were evaluated in one or more of the trials.

Two fall staked tomato trials were conducted in the fall of 1970 on the Cozza and Jaekel - Rogers ranches. An observation field trial was made on a spring staked

tomato trial in 1970. The favorable plant and crop response on this test encouraged the two fall tests where full crop production records were taken in comparing furrow with the twin-wall hose (8-mil, black polyethylene film) with .025 orifices, spaced 18 inches apart (Fig. 1). With the 1½ to 2 PSI pressure on the line, each orifice delivered approximately one quart of water per hour.

First Tomato Trial - Cozza Ranch - The Cozza Ranch trials were direct seeded on June 2, 1970, and all plots were germinated with furrow water. Irrigation by the twin hose drip method was started on July 16. The furrow irrigation water was applied at intervals of 7 to 10 days, depending on the plant size and the weather. Two furrows were located between the tomato rows and filled with water for two to four hours. The soil was cultivated and refurrowed between irrigations through October to assist in water penetration. The drip irrigation frequency was weekly for the first month and increased to twice weekly after mid-August. Length of drip application varied from 4 to 8 hours, depending on the tensiometer readings and plant size. Liquid fertilizers were injected into the line totaling 107 pounds of nitrogen and 227 pounds of phosphorus and potash per acre. A total of 407 pounds of nitrogen and 207 pounds of phosphorus and potash per acre were supplied in the furrow as well as the drip trials. Soil samples were taken at the start of the drip application July 16, November 11, and December 18. The latter date was at the end of harvest. Two inches of rain fell from November 27 through December 6, 1970. Soil samples were taken in the plant row and between rows on the last two samplings. Soil salinity was determined by measuring the EC of the saturation extract, and the data are given in Chart 2.

Results - First Tomato Trial, Cozza Ranch - The results of this trial showed a significant difference in yield, fruit size and amount of culls in favor of the drip irrigation given in Chart 1. The drip trials consistently outyielded the furrow irrigation plots. The water applications for each method for the entire crop were as follows: Drip - 2.6 acre feet; furrow - 3.9 acre feet. Not only did the drip irrigation plots use less water per acre, but the time to apply the drip water required only a fraction of the time compared to the furrow method. Fewer weeds developed in the drip irrigated planting compared to the furrow.

Second Tomato Trial - Jaekel-Rogers Ranch - The twin-walled hose drip system was compared with furrows. Each replicate consisted of two drip or two furrow rows, and in each row, three tomato varieties were replicated three to six times. The three varieties tested were: Royal Ace, #428, and #662, and 12 plants comprised each replicate. The plants were transplanted on July 22, 1970, and furrow and drip irrigation were applied on similar days. The drip hose was placed two to three inches away from the plant, and the furrow water was applied adjacent to the plant row. This trial was conducted on heavy clay adobe diablo soil. Only light water applications were made to prevent overwatering in the root zone as this could cause stunting or death to sensitive tomato plants. Soil samples were taken before and at the end of harvest to determine soil salinity. Row lengths were 222 feet long and 5 feet wide. Weekly harvests started on October 14, and continued through December 11, 1970. The evaluation was made of fruit number and weight of marketable and culls.

Only 58 pounds of actual nitrogen, phosphorus and potash were applied as a dry powder in the furrow or at each dripper. There was a strong carry-over of these elements from a celery crop grown for the February, 1970 harvest. The tomato plants developed into good sizes.

Results - Second Tomato Trial, Jaekel-Rogers Ranch - On the second heavy soil trials at Jaekel-Rogers Ranch, with the light water application, drip outyielded the furrow. Each of the three varieties produced higher yields with less culls in the drip system, compared to the furrow application. Marketable yields, culls and fruit weight for the two irrigation methods are given in Chart 3. In both the furrow and drip application, the soil wetted was less than half of the area between rows. This was planned to reduce the overwatering on this heavy soil with moisture sensitive tomato plants. Where the drip was compared to the furrow treatment, and combining the varieties, the drip irrigation also consistently outyielded the furrow system. Slightly larger plants also developed from the drip system.

Third Tomato Trial - Vener Ranch - Spaghetti and twin-walled hose drip systems and furrow irrigation were compared with four replicates of each irrigation method. Grand Pak plants were started under plastic row covers on February 1, 1971. One furrow was located adjacent to each row and was used throughout the growing season to apply the furrow water. The two different drip lines were installed adjacent to the plant rows. The water application intervals varied from one to five days, depending on the weather, plant size, and tensiometer readings. The plants were spaced 20 inches apart on five foot centers. Root development was mainly in the top 10 to 12 inches of soil throughout the growing period. Soil moisture was maintained in the root zone during the growing and harvest season on two treatments. During the last three weeks of harvest the twin-wall treatments were a little short of moisture due to the heavy water usage of this heavy crop. Soil samples taken at the end of harvest revealed this problem. Liquid fertilizer was injected into the drip lines and dry fertilizer was used in the furrows. All of the plots had two tons of composted chicken fertilizer applied as a preplant application. Also, a complete fertilizer, 4-10-10, was placed in the furrows at the rate of 700 pounds per acre. The entire field had 25 yards of dairy manure applied September 19, 1970, prior to the plastic tarped fumigation with methylbromide and chloropicrin. The fumigation was used for control of disease, weeds, and pests. The soil type was Aliso fine sandy loam. Applications of dry fertilizer were applied to the furrow treatment during the growing season. Liquid fertilizers were injected into the lines on the two drip systems. The following quantity of fertilizer was used for the crop in pounds per acre:

| | Furrow | Twin Wall | Spaghetti |
|---|---|---|---|
| Nitrogen | 371 | 352 | 352 |
| Phosphoric acid | 405 | 475 | 475 |
| Potash | 445 | 455 | 455 |

The entire field was cluster-treated with 4-CPA (Parachlorophenoxyacetic acid) for fruit set from late March through mid-May. Six applications were made at 10- to 14-day intervals. Harvest of colored fruit started on May 20, and continued through August 5, 1971. A box of fruit for each replicate of each treatment was graded for size, weight, and culls. Harvests were made on a three- to four day schedule.

Results - Third Tomato Trial, Vener Ranch - The three irrigation systems: furrow, spaghetti, and twin-wall hose resulted in similar total yields, average fruit size, and percent culls, as is given in Chart 4. This Aliso sandy loam soil absorbed the water from the twin-wall hose as it was delivered. The water ran off slightly from the spaghetti trials. This would indicate that a quart per hour per orifice on 18-inch spacings may be a more desirable water infiltration rate for this soil. The furrow wet an area 6 to 8 inches beyond the edge of each side of the furrow, or a total

width of 20 to 24 inches.

Fourth Tomato Trial - Takahashi Ranch (Hillside) - Two drip systems, twin-wall hose and bi-wall hose, were compared with furrow irrigation on a 10% hillside slope planting. In both drip systems the orifices were spaced 18 inches apart and the water discharge was similar from each hole. The bi-wall tube orifices were .0025 of an inch and the pressures were maintained at 4 to 5 pounds on the 12-mil black plastic line. The individual tomato rows had a one to two percent downward grade from the drip line attachment to the end of the rows.

The Ace tomato variety was transplanted 20 inches apart on 5-foot rows on July 8, 1972. The new transplants were set in the furrow water and the two drip systems were started the first week of August. Applications of complete (NPK) fertilizers were placed in the bottom of the furrows at planting. Five hundred pounds per acre of actual nitrogen as a slow-release fertilizer (isobutylidene diurea "IBDU") were applied in the bottom of the furrows of the two drip treatments. Three to four inches of soil covered this fertilizer and the drip hoses were placed above this fertilizer band. In the furrow treatment, the slow-release fertilizer was cultivated into the soil and then refurrowed. This comprised the total fertilizer application for the tomato crop. The water in the drip systems was applied twice weekly and the length of time ranged from three to nine hours at each application. The furrow water was applied on a 7- to 12-day interval.

Results - Fourth Tomato Trial, Takahashi Ranch (Hillside) - Harvest was taken from October 2, 1972 through January 2, 1973. The same random fruit sampling per pick per treatment was evaluated for quality. The two drip systems resulted in slightly higher yields compared to furrow of marketable fruit as is shown in Table 5.

TABLE 5. FALL HILLSIDE STAKED TOMATO DRIP VS. FURROW IRRIGATION YIELD SUMMARY
HOWARD TAKAHASHI SPRING VALLEY FARM

| | Accumulated Marketable Yields In Tons/A Through | | | *Water Applied Per | Average Fruit Wt. |
|---|---|---|---|---|---|
| | Oct. | Nov. | Dec. | Acre Inches | In Pounds |
| Twin-Wall Hose Drip | 10.1 | 19.2 | 23.2 | 14.2 | .403 |
| Bi-Wall Hose Drip | 9.5 | 17.8 | 22.3 | 13.6 | .331 |
| Furrow | 8.9 | 14.7 | 19.4 | 20.0 | .421 |

*Between 3 and 4 inches of rainfall during the latter part of this crop harvest.

Fifth Tomato Trial - Johnson-Redon Ranch - Eight different treatments--six with twin-wall hose drip irrigation, and two with furrow applications were compared. In this test another evaluation of slow-nitrogen release (IBDU) fertilizer was compared with liquid nitrogen injected into the drip line (Fig. 3). One treatment in the furrow also had the slow-release placed at the bottom of the furrow before planting, and the other furrow treatment was the growers' standard treatment of applying the fertilizer periodically in the furrow. The eight following treatments were made on the spring staked tomato crop, started under plastic row covers.

| | Irrigation Method | Irrigation Frequency | Fertilizer Used |
|---|---|---|---|
| 1. | Drip twin-wall | 2x weekly | IBDU fine |
| 2. | " " | " " | IBDU coarse |
| 3. | " " | daily | IBDU fine |
| 4. | " " | " | IBDU coarse |
| 5. | " " | " | N in water |
| 6. | " " | 2X weekly | " " " |
| 7. | Furrow | " " | IBDU coarse |
| 8. | " | " " | dry in furrow |

The #6718 hybrid variety was planted in this field on January 16, 1973 on 18-inch spacings on 5-foot rows. Drip irrigation was used for the entire crop and the plants were set into the moist soil from the drip application. The longevity of the drip application ranged from three to eight hours on the twice-weekly application--and comparable time per week on the daily treatments. The fruit set, 4-CPA hormone, used as a cluster-treatment was applied at 10 to 12 days interval. Harvest started on May 2, and continued through August 6. Fruit was graded into marketable and culls, and sized on twice weekly harvest.

Results- Fifth Tomato Trial, Johnson-Redon Ranch - On this fairly heavy soil, all of the eight treatments yielded very well. The two furrow treatments had a tendency to be slightly earlier, yet the furrow with the slow-release fertilizer gave the highest yield in the late harvest (Chart 7). The six drip systems resulted in similar early as well as total yields. Twice weekly drip irrigation had similar yields compared to the daily application (Chart 6). Also, the slow-release drip trials had similar total yields, yet the trials with the fine, slow-release IBDU fertilizer appeared to be slightly later maturing. The liquid nitrogen in the water either daily or twice weekly was equal in early and total yields. Even though the furrow and drip treatments resulted in similar high yields, this tomato variety, #6718 hybrid, responded to frequent irrigation, and the daily application in the drip treatment was equally as good. Fruit size was similar with slight variations in the different harvest periods. The furrow irrigation, with the frequent dry fertilizer application, had more cull fruit in the early picks than the other treatments. By the end of harvest the amount of culls was similar for all treatments.

Sixth Tomato Trial - Tony Cacho Ranch (Hillside) - Where considerable acreage of tomatoes as well as other vegetables are planted on hillsides, another test was established on a 22 percent hillside slope for fall tomatoes. The Ace variety was planted on June 25, 1973, on 20-inch plant spacing, and rows were 5 feet apart. The row lengths varied from approximately 100 to slightly over 200 feet on this hillside planting. The twin-wall hose (8 mil thickness) was used as the drip irrigation system and one furrow was used on the upper side of the tomato plants. In the drip irrigation rows, 350 pounds of nitrogen (IBDU) slow-release fertilizer was placed in the bottom of the furrow and covered with two to three inches of soil. The drip lines were placed over this band of fertilizer. In the furrow for both the drip and furrow trials, 1000 pounds of 16-16-16 were placed in the bottom of the furrow before the drip lines were installed. During the growing period, 20 gallons of 12.5-5-5 liquid NPK were applied per acre in the water at each irrigation on both the furrow and the drip lines. The soil was a sandy loam type in which these trials were conducted.

In one treatment of twin-wall hose, an 18" wide, 1½ mil clear perforated plastic film was placed over the drip lines to keep the orifices damp between irrigations and to conserve water under the mulch (Fig. 3).

Results - Sixth Tomato Trial, Tony Cacho Ranch (Hillside) - Hillside tomato plantings with fairly steep slopes are very practical with drip irrigation and the yield results from the two drip and one furrow treatments resulted in similar yields(Chart 8). The fruit size and the amount of culls were also the same. The savings in water was about equal to the cost of the drip system and the labor of application was a financial gain. A one percent drop in rows is satisfactory for the individual drip irrigation rows.

First Cucumber Trial - Jaekel-Rogers Ranch - Two trials were conducted on early spring plastic row cover plantings where the drip method was compared with the furrow application. In both trials the usual two 36-inch natural clear plastic sheets were used to form the row covers. The sheets were also perforated with 1/4-inch holes on 3-inch spacings. The Triumph hybrid variety was used in both trials. The first trial was conducted on the Jaekel-Rogers Ranch by Bob Conforth in Chula Vista. The spaghetti drip or slow water application was compared with furrow. A 1/2-inch polyethylene pipe was placed outside of the cucumber row covers, and spaghetti tubes were attached to the pipe. One tube was used per cucumber plant and the plants were spaced 24 inches apart. The furrow near the center on the inside of the row cover was used to soak up the soil and germinate the seed. Three furrow applications of water were made prior to using the spaghetti drip. The spaghetti tubes were placed inside the tunnel and on the opposite side of the plant. As water was applied by the spaghetti tubes a light to medium leaf burning took place as the salts that were deposited on the opposite side of the plant were redissolved and forced back under the plants. As soon as this was observed, extra quantities of water were applied, forcing the salt back into the furrow area and out from underneath the plant. Some plant stunting took place, but within three to four weeks the plants appeared to have largely recovered. The drip irrigation was applied on generally a one- to three-day interval and the water in the furrow was run weekly. Liquid fertilizer was injected into the drip lines and both liquid and dry fertilizer were used in the furrow treatment.

Results - First Cucumber Trial, Jaekel-Rogers Ranch - Harvest started on April 6, and continued through June 5, 1972, where two picks were made weekly. Out of each replicate in each treatment a box was graded for quality, fruit size and culls. The summary of the yields is given in Table 9. The furrow treatment resulted in higher yields due to the salt injury occurring when the drip lines reversed the salt movement under the plants.

TABLE 9. 1972 YIELD SUMMARY OF CUCUMBER DRIP VS. FURROW TRIALS
JAEKEL-ROGERS CHULA VISTA RANCH

| | Yield #1 Fruit | | Total | % #1 | Average | Amount Water |
|---|---|---|---|---|---|---|
| | April | Through May 15, '72 | Tons/A | Fruit | Fruit Weight | Used/A. Inch |
| Spaghetti Drip | 8.7 | 19.4 | 28.2 | 83.99 | .75 | 24.4 |
| Furrow | 9.8 | 22.3 | 31.9 | 82.50 | .72 | 39.2 |

Second Cucumber Trial - Tony Cacho Ranch - These trials were established to eliminate the early plant growth salinity problem that was encountered in the 1972 drip trials. The test was conducted by Tony Cacho of San Ysidro on a light but fairly tight soil. The twin-wall hose was used where one series of hoses was covered with an 18-inch clear, perforated, 1½-mil plastic mulch, and the other treatment was the uncovered

drip hose (Fig. 4). The twin-wall hose was placed in a narrow 1½ to 2-inch depressed furrow which placed the tube just below the soil level. The furrow was used to germinate the seeds that were planted on January 12. The furrow irrigation was used to start the plants. In all treatments the fertilizer was placed at the bottom of the furrow. Two applications of complete mix (NPK) were applied in the planting furrow for both types of irrigation. Three hundred and fifty pounds of nitrogen per acre (slow release IBDU = 31-0-0) was placed at the bottom of the furrow for the drip irrigation, and the fertilizer was covered with three to four inches of soil. The twin-wall drip tubes were placed above the fertilizer band, two to three inches away from the plant in the small depressed furrows. Water was applied mainly on a weekly basis on both the furrow and the drip application. The furrow irrigation was allowed to run approximately four hours for each application, and the drip was used eight to 10 hours per application. The furrow had liquid fertilizer applied to the water in most of the applications, while clear water was used in the drip system. The furrow irrigation was changed from inside the row cover to the outside next to the row cover in early April. This change was made due to the cucumber vines clogging the furrows as is illustrated in Figure 5. A good portion of the plastic adjacent to the furrow was lifted up to allow more even wetting of the soil near the plants.

Results - Second Cucumber Trial, Tony Cacho Ranch - Harvest started on April 9, and continued through June 27 on the 1973 Cacho trials. Two picks were made weekly, and one box was graded from each plot of each treatment per pick. The fruit was graded into four grades, although the main grade is the number one. The yields of these three treatments for three harvest periods are given in Table 10. Another problem with excess water in the row covers has been pink rot. Evaluation of the infected fruit was recorded along with the amount of water used per acre for the drip and furrow treatments. From these results the yields were similar yet the two drip systems had a slightly higher yield. No difference in yield or pink rot incidence occurred in these trials.

TABLE 10. 1973 CUCUMBER DRIP VS. FURROW IRRIGATION YIELD SUMMARY
TONY CACHO, SAN YSIDRO GROWER

| Accumulated Marketable Yields of #1 Fruit in Tons/A Through | | | | Ave. Frt. Weight | % Frt. W/Pink Rot | *Water Used Per/Acre Inches |
|---|---|---|---|---|---|---|
| | April | May | Total | | | |
| 8-Mil Twin-wall Hose and Clear Mulch | 3.2 | 21.1 | 28.8 | 0.719 | 0.42 | 18.1 |
| 8-Mil Twin-wall Hose | 4.4 | 18.8 | 27.7 | 0.686 | 0.38 | 18.1 |
| Furrow | 5.3 | 16.9 | 26.3 | 0.648 | 0.65 | 33.2 |

*Over 6 inches of rainfall from January 1 through early April.

CONCLUSION

Drip irrigation supplies water more uniformly and this results in more even plant growth.

Cultural operations can be carried out in the drip water crops at any time, while

close coordination of these operations is essential when using furrow or sprinkler irrigations.

Drip irrigation requires certain essential investments to be effective. They include adequate filtration through screen filters and a sand filter to remove especially coarse materials (Fig. 6). Plants that need frequent soil feeding will require a fertilizer injector installed in the system.

If water supply is limited, more acreages can be grown with the reduced needs applied as a drip method.

Hillside farming with drip irrigation works very well if properly engineered. Slow-release fertilizers were more satisfactory for short term crops. Frequency of water application determines the rate of slow-release fertilizer solubility and availability.

Waters with higher salinity can be used on drip irrigation compared to furrow or sprinkler application. In areas of low rainfall and where the waters contain limited salts, leaching of the accumulated salts may be necessary with furrow, or preferably a sprinkler system.

Plastic mulch placed over drip lines assists in keeping the small orifices moist and reduces plugging.

Growers wishing to test drip irrigation for the first time are advised to install a small economic unit where the necessary filter, fertilizer injector, plastic pipes, pressure gauges and tensiometers are used. After growing and experiencing the main problem of test drip irrigation, larger acreage can be explored with greater success.

Slow-release fertilizers may assist in short time crop needs, depending on rapidity of release and crop needs.

Where world food shortages continue to be a critical factor, the most judicious use of available water can increase acreage in water-limited areas and allow greater food production.

Row crops with higher income potential will see continued expansion in drip irrigation. Present equipment and installation costs run from $200 to $300 per acre. Savings in water and its application in many areas can be amortized in the first year. If yields and quality of the crop are improved this could return additional income per acre.

Water savings are usually greater with a drip system on sandy soils compared to heavy soils. The major savings on annual crops are made in the smaller plant growth. Where water is applied in drip equipment the amount of water applied per application and the frequency for the individual growing area needs to be developed. Another problem that needs research evaluation is the application on sandy soil versus heavy soils.

## APPRECIATION

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Chart 1

1970 FALL STAKED TOMATO DRIP VS. FURROW IRRIGATION
GROWER: TORZA RANCH, JOSH NAKEGAWA, MANAGER, SAN YSIDRO

| Accumulated Yields Thru | Yield Item | Irrigation Method: Twin-Wall Hose Drip | Furrow |
|---|---|---|---|
| 10/15/70 | Marketed in Tons/Acre | 14.0 | 12.0 |
| | % Culls | 5.01 | 5.96 |
| | Ave. Fruit Wt. | .48 | .44 |
| 11/12/70 | Mkt. Fruit in Tons/Acre | 28.1 | 22.8 |
| | % Culls by Wt. | 5.51 | 7.23 |
| | Ave. Individ. Fruit Wt. | .42 | .38 |
| 12/16/70 | Mkt. Fruit in Tons/Acre | 33.1* | 26.5 |
| | % Culls | 7.99 | 10.76 |
| | Ave. Individ. Fruit Wt. | 0.33 | 0.34 |
| | # Feet of Water Used Per Acre | 2.6 | 3.9 |

*Highly significant

Chart 2 1970 FALL STAKED TOMATO SOIL SALINITY IN ELECTRICAL CONDUCTIVITY

GROWER: COZZA RANCH, TOSH HASEGAWA, MANAGER

| Soil Depth Drip | Sampling Dates At Plants Start 7-20 | Mid 11-11 | End 12-8-71 | Sampling Dates Between Rows Mid 11-11 | End 12-8 |
|---|---|---|---|---|---|
| 0-6" | 2.70 | 6.57 | 4.95 | 10.5 | 7.87 |
| 7-12" | 1.62 | 2.83 | 2.37 | 3.85 | 7.85 |
| 13-18" | 1.78 | 2.15 | 1.99 | 2.23 | 7.40 |
| Furrow | | | | | |
| 0-6" | 2.70 | 9.03 | 6.47 | 6.75 | 5.70 |
| 7-12" | 1.62 | 6.12 | 5.50 | 3.62 | 2.83 |
| 13-18" | 1.78 | 3.40 | 4.25 | 2.62 | 2.25 |

Chart 3

STAKED TOMATO YIELD SUMMARY FOR DRIP VS. FURROW IRRIGATION

GROWER: MAEKEL & ROGERS RANCH, CHULA VISTA

| Irrigation Method | Varieties | Market Yields In Tons/Acre Thru Oct. | Nov. | Dec.11 | % Culls | Ave. Frt. Weight | Acre Feet Water Used |
|---|---|---|---|---|---|---|---|
| Furrow | Combination of Three | 4.5 | 7.4 | 8.2* | 31.76 | 0.26 | 0.969 |
| Drip | Combination of Three | 5.3 | 10.1 | 11.9 | 25.76 | 0.31 | 0.603 |

*Highly Significant

Chart 4

## 1971 SPRING STAKED TOMATO DRIP VS. FURROW IRRIGATION TRIALS
## GROWER: SAM VENER RANCH, CHULA VISTA

| Yields Through | Yield Item | Irrigation Method | | |
|---|---|---|---|---|
| | | Furrow | Twin Wall Hose | Spaghetti |
| June 14 | Mkt. Yd. Tons/A | 4.8 | 5.8 | 5.2 |
| | % Culls | 15.60 | 8.81 | 9.85 |
| | Ave. Frt. Weight | .41 | .44 | .43 |
| June 28 | Mkt. Yd. Tons/A | 12.2 | 14.7 | 12.6 |
| | % Culls | 15.00 | 10.60 | 10.95 |
| | Ave. Frt. Weight | .36 | .37 | .38 |
| Total Thru 8-2-71 | Mkt. Yd.. Tons/A | 38.8 | 39.0 | 42.8 |
| | % Culls | 14.49 | 11.39 | 11.93 |
| | Ave. Frt. Weight | .33 | .32 | .34 |

Chart 6

1973 SPRING STAKED TOMATO YIELD SUMMARY - TRICKLE VS FURROW IRRIGATION
SLOW-RELEASE FERTILIZER VS LIQUID NITROGEN VS DRY FERTILIZER
GROWER: JOHNSON & REDON, CHULA VISTA

| Accumul. Yields Thru | Yield Item | Twin Wall Drip 2X Weekly Fine IBDU | Twin Wall Drip 2X Weekly Coarse IBDU | Twin Wall Drip Daily | Twin Wall Drip Daily |
|---|---|---|---|---|---|
| May | Tons/Acre | 14.0 | 15.7 | 14.3 | 13.9 |
| | % Culls | 13.12 | 12.44 | 13.31 | 13.33 |
| | Ave.Frt.Wt. | .39 | .41 | .40 | .39 |
| June | Tons/Acre | 30.7 | 32.2 | 29.2 | 29.8 |
| | % Culls | 13.85 | 12.36 | 13.41 | 13.16 |
| | Ave.Frt.Wt. | .37 | .37 | .37 | .39 |
| Total Aug 8 | Tons/Acre | 47.3 | 47.9 | 47.0 | 46.8 |
| | % Culls | 13.41 | 12.50 | 13.51 | 13.68 |
| | Ave.Frt.Wt. | .37 | .37 | .36 | .36 |
| | Water Used | 17.0 | 17.0 | 17.0 | 17.0 |

Chart 7

1973 SPRING STAKED TOMATO YIELD SUMMARY - TRICKLE VS FURROW IRRIGATION
SLOW-RELEASE FERTILIZER VS LIQUID NITROGEN VS DRY FERTILIZER
GROWER: JOHNSON & REDON, CHULA VISTA

| Accumul. Yields Thru | Yield Item | Twin Wall Drip Daily N in Water | Twin Wall Drip 2X Weekly N in Water | Furrow 2X Weekly Coarse IBDU | Furrow 2X Weekly Dry Fertilizer |
|---|---|---|---|---|---|
| May | Tons/Acre | 14.5 | 15.8 | 16.6 | 18.1 |
| | % Culls | 15.75 | 14.74 | 14.68 | 17.87 |
| | Ave.Frt.Wt. | .42 | .44 | .40 | .41 |
| June | Tons/Acre | 32.3 | 30.8 | 32.8 | 34.5 |
| | % Culls | 14.32 | 14.41 | 14.54 | 16.70 |
| | Ave.Frt.Wt. | .39 | .39 | .38 | .40 |
| Total Aug 8 | Tons/Acre | 47.9 | 47.7 | 51.1 | 47.9 |
| | % Culls | 14.12 | 13.77 | 14.20 | 15.69 |
| | Ave.Frt.Wt. | .37 | .37 | .36 | .37 |
| | Water Used | 17.0 | 17.0 | 35.0 | 35.0 |

Chart 8

## 1973 FALL STAKED TOMATO YIELD SUMMARY - TRICKLE VS FURROW IRRIGATION
## GROWER: TONY CACHO, BONITA

| Accumul. Yields Thru | Yield Item | Furrow | Twin Wall Drip | Twin Wall Drip + Plastic Mulch |
|---|---|---|---|---|
| Oct.15 | Tons/Acre | 5.5 | 5.7 | 5.0 |
| | % Culls | 13.25 | 14.85 | 16.25 |
| | Ave.Frt.Wt. | .44 | .43 | .43 |
| Oct. 29 | Tons/Acre | 12.6 | 14.6 | 15.0 |
| | % Culls | 13.19 | 14.30 | 14.26 |
| | Ave.Frt.Wt. | .46 | .45 | .44 |
| Dec. 13 | Tons/Acre | 27.2 | 28.4 | 28.3 |
| | % Culls | 10.10 | 10.69 | 10.03 |
| | Ave.Frt.Wt. | .43 | .42 | .42 |
| | Water Used | 48 In | 19 in. | 19 In. |

Fig. 1. Twin-wall drip line used on early spring staked tomato planting. Line placed on furrow bank close to plants. Plants and orifices 18 inches apart.

Fig. 2. Drip irrigation twice weekly versus daily water application in 1973 spring staked tomatoes. Left row twice weekly, center daily, and both with slow-release fertilizer. Tomato row on right is twin-wall drip applied daily with liquid nitrogen injected into lines.

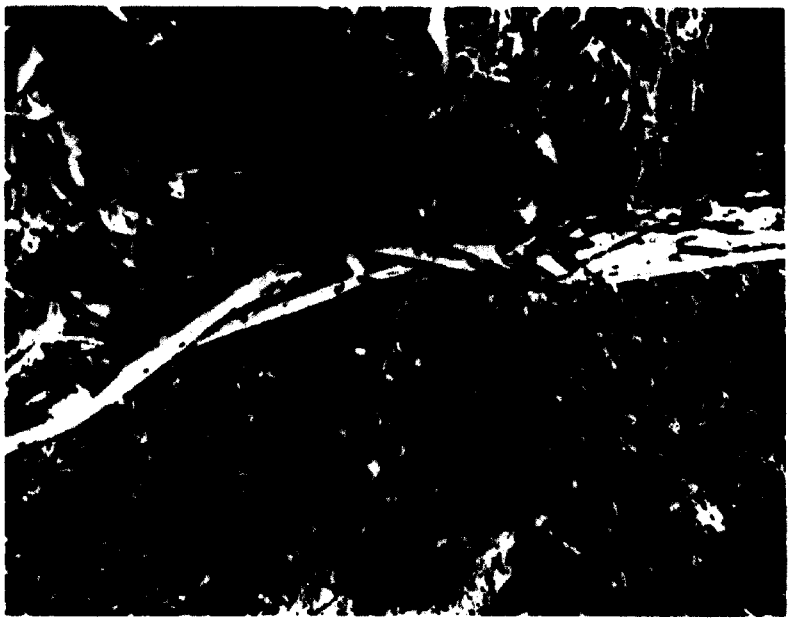


Fig. 3. Perforated clear plastic mulch placed over drip line to keep orifices moist and reduce plugging in fall hillside staked tomato planting. Shows plastic folded over to show drip line.

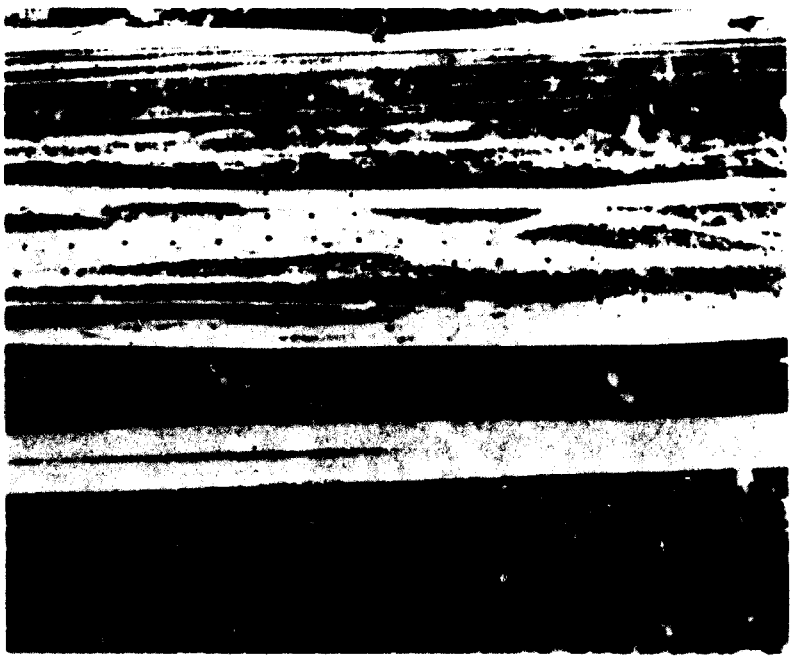


Fig. 4. Clear perforated polyethylene mulch placed over twin-wall drip lines in early spring cucumber row cover plantings. Shows newly germinated cucumbers growing close to the mulch.

Fig. 5. Early spring cucumbers grown in row covers with drip irrigation on left and furrow application on extreme right. Similar plant sizes developed from two types of water application.

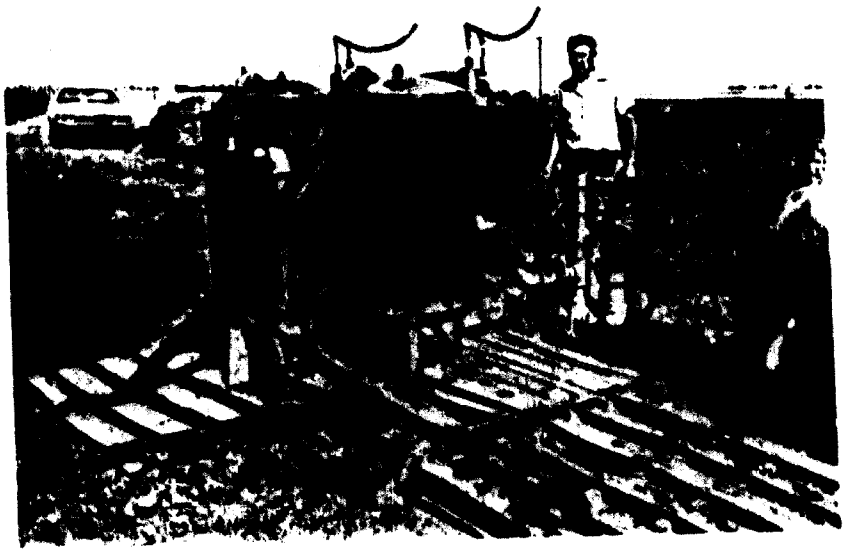
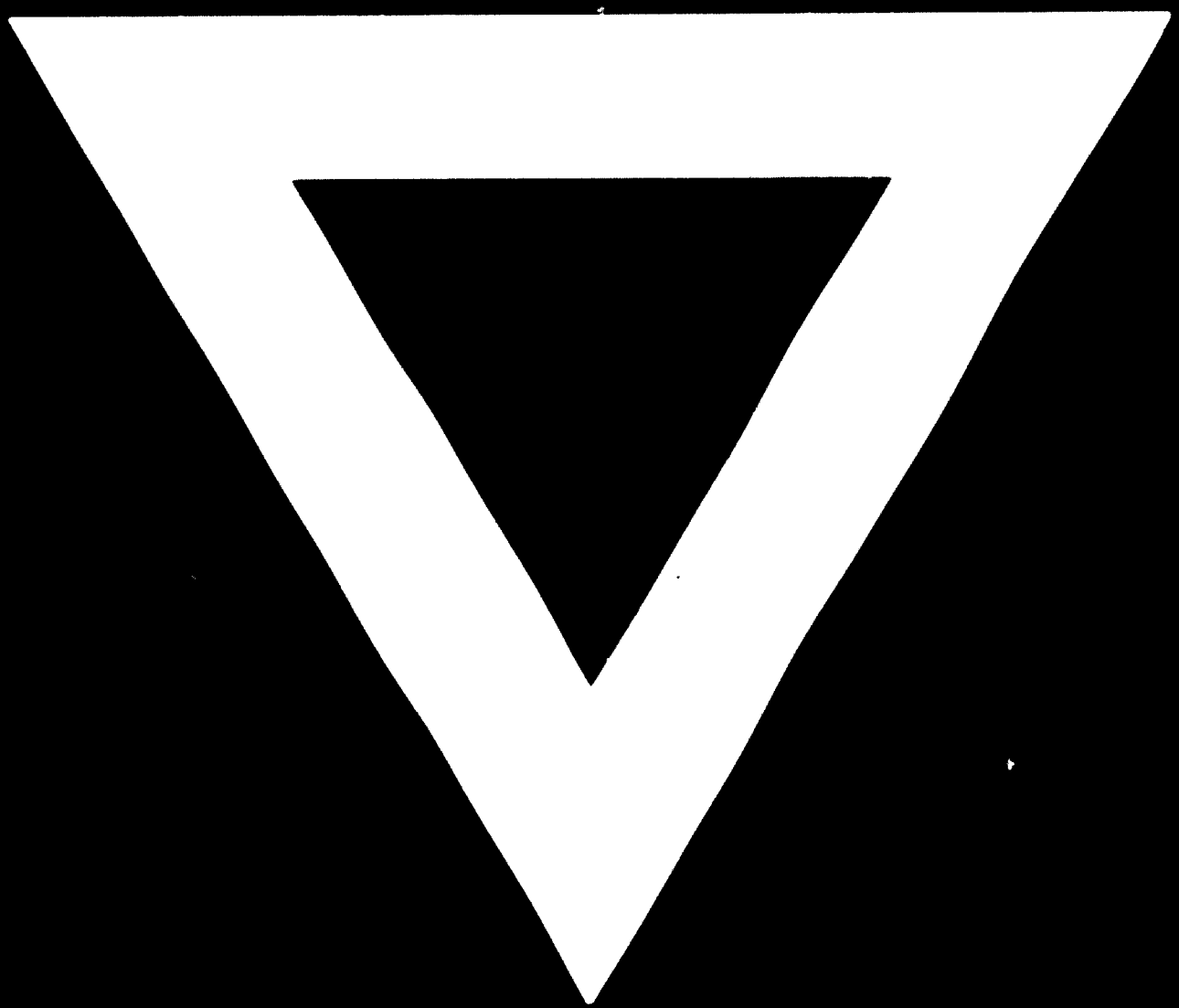


Fig. 6. Two types of filters used to clean water for drip orifices. Tall narrow screen filter on left and two large sand filters on right. Grower holding garden hose attached to main water line used to clean screen filters.

Fig. 7. Young grapefruit tree watered with spot spitter emitter. Shows soil wetting pattern. On the paper shows size of two emitters and spaghetti line used to plug in main line.

Fig. 8. Conflow drip system watering flowers. Shows spaghetti lines leading from central Conflow head.

Fig.9-Drip-Eze inline emitter showing wetted pattern on avocado orchard.



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