# The Economic Value of Drip Irrigation in California

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# Drip Irrigation

- California has long been threatened by chronic water shortages
- 1965-1975: Early Development and Adoption: UCCE San Diego
  - Don Gustafson — Avocados
  - Bernarr Hall – Strawberries & Vegetables
- 1975-87: Technical Problems and Reputation Effects
- 1976-77: Drought, Drip acreage more than doubles
- 1980: CSU Fresno Center for Irritation Technology
- 1982: California Irrigation Management Irrigation System - CIMIS

# Drip Irrigation

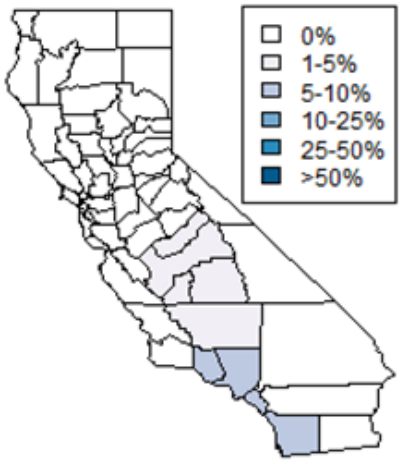
- 1985: Drip as partial solution to drainage problems
- 1987-91: Drought, Drip acreage doubles, more low value crops
- 2003: Drip Irrigation Salinity Management for Row Crops
- 2004+: Spreading fast in developing countries

# Drip Irrigation

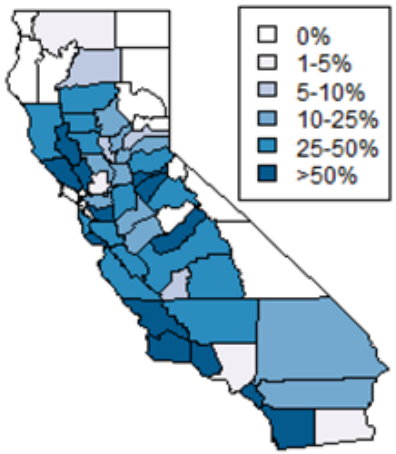
- Drip as a land quality augmenting technology
  - Drip increasing water use efficiency *(Caswell & Zilberman 1985, 1986).*
- Drip improves timing of application of water
  - Increase yields, reduce drainage, may save water at field level *(Shani et al 2009; Kan et al 2002; Caswell et al 1990).*
  - Adopted on lower quality land first, such as steep hills and sandy soil *(*Schoengold & Zilberman 2007).
  - Distinguish between extensive and intensive margin effect (*Shah et al. 1995).*
- Profitability was a key factor explaining diffusion of drip in Israel
  - Weather was a source of heterogeneity affecting timing of diffusion *(Fishelson and Rymon 1989).*
  - *Dinar and Yaron (1992)* identify sequences of transition from less advanced to more advanced technologies—influenced by yield effects, water-savings and subsidies.
- In Spain, adoption of drip started in perennial crops and moved to annuals
  - Adoption probability increased with water scarcity, credit availability, education, and access to information *(Alcon et al. 2011)*.
- Adoption of drip in Crete and Greece
  - Profitability, production risk, and water shortage contribute to adoption in Crete *(Koundouri et al. 2006).*
  - Better access to information from informal and formal sources enhances likelihood of adoption. Formal and informal information sources are complementary *(Genius et al. 2014).*

# Drip Irrigation

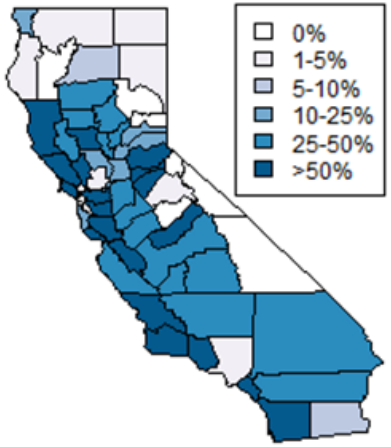
(a) 1975 Drip Irrigation (% of Irrigated Acres)




(b) 2001 Drip Irrigation (% of Irrigated Acres

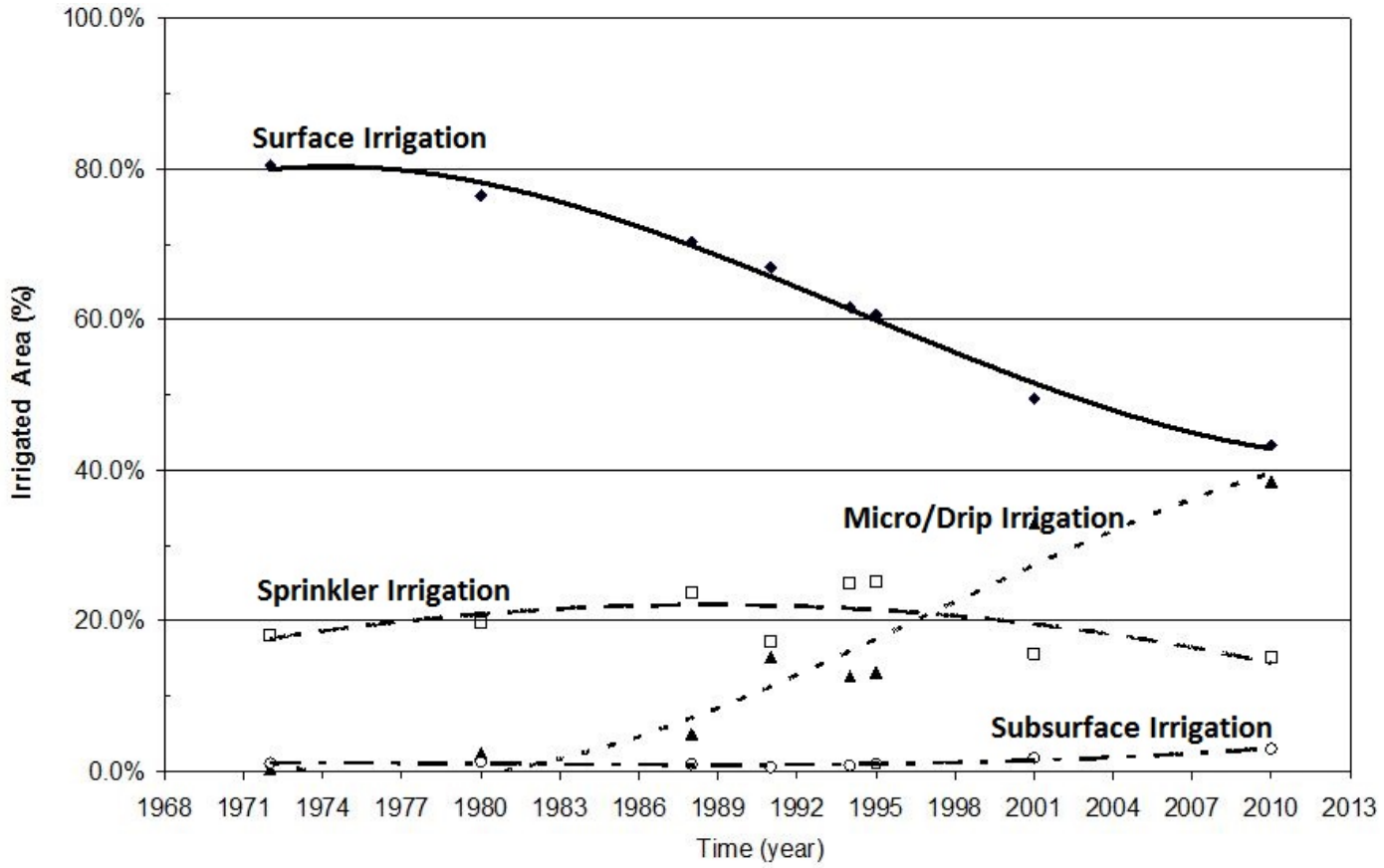



(c) 2010 Drip Irrigation (% of Irrigated Acres)




Source: Highstreet et al. (1980); CDWR Irrigation Survey, 2001 & 2010.

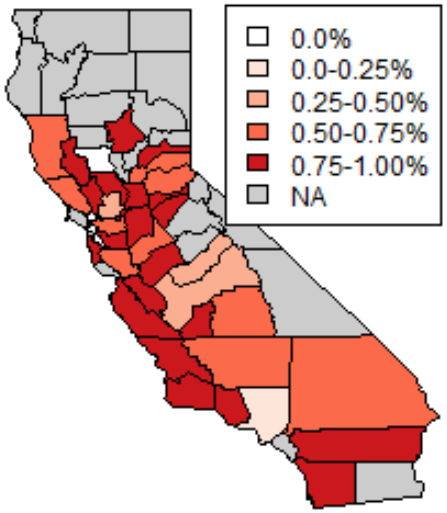
# Drip Irrigation



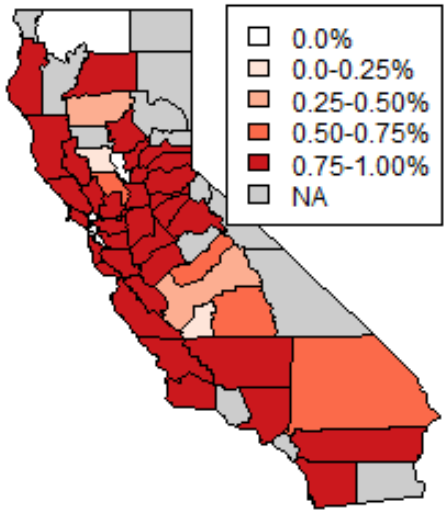

Tindula et al. (2013). Survey of Irrigation methods in California in 2010

# Drip Irrigation

**2001 Vines in Drip (% of Irrigated Acres)**



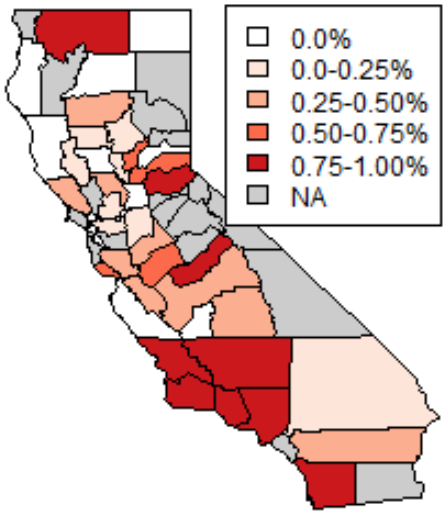

**2010 Vines in Drip (% of Irrigated Acres)**




Source: CDWR Irrigation Survey, 2001 & 2010.

# Drip Irrigation

**2001 Trees (other) in Drip (% of Irrigated Acres)**

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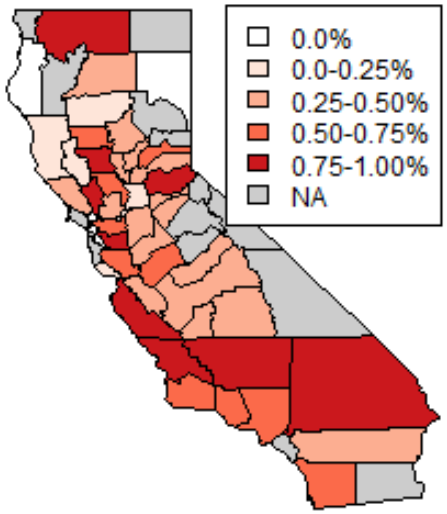
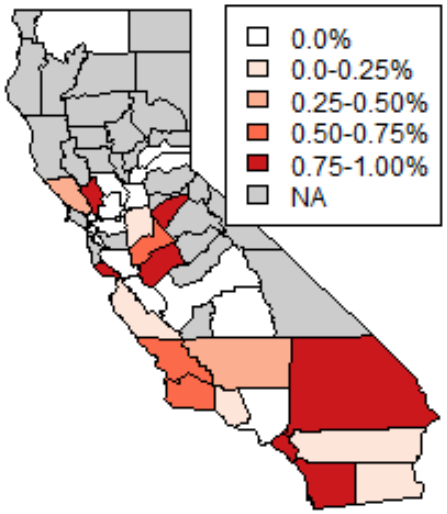



Source: CDWR Irrigation Survey, 2001 & 2010.

# Drip Irrigation

**2001 Truck Crops (other) in Drip (% of Irrigated Acres)**

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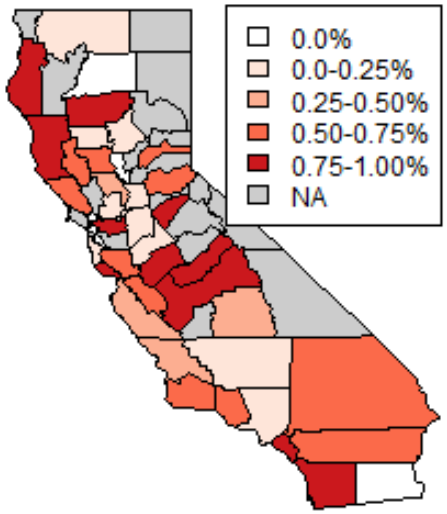
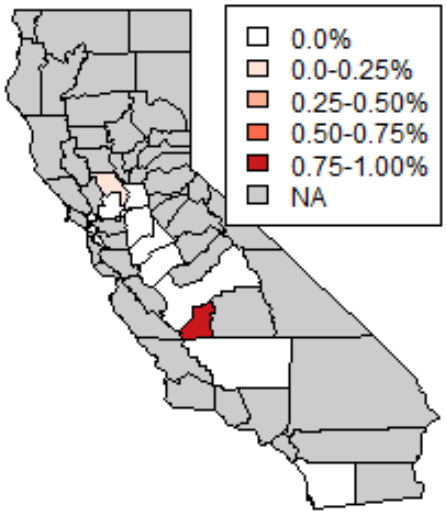



Source: CDWR Irrigation Survey, 2001 & 2010.

# Drip Irrigation

**2001 Process Tomato in Drip (% of Irrigated Acres)**

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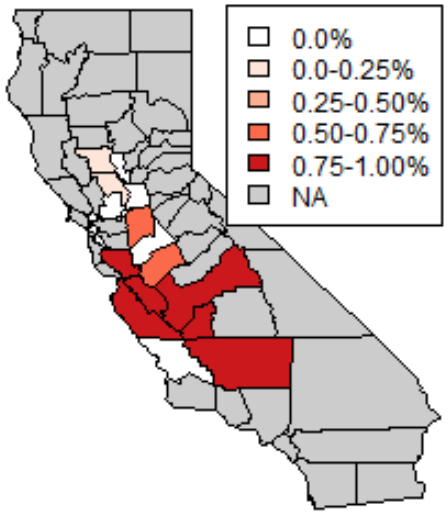


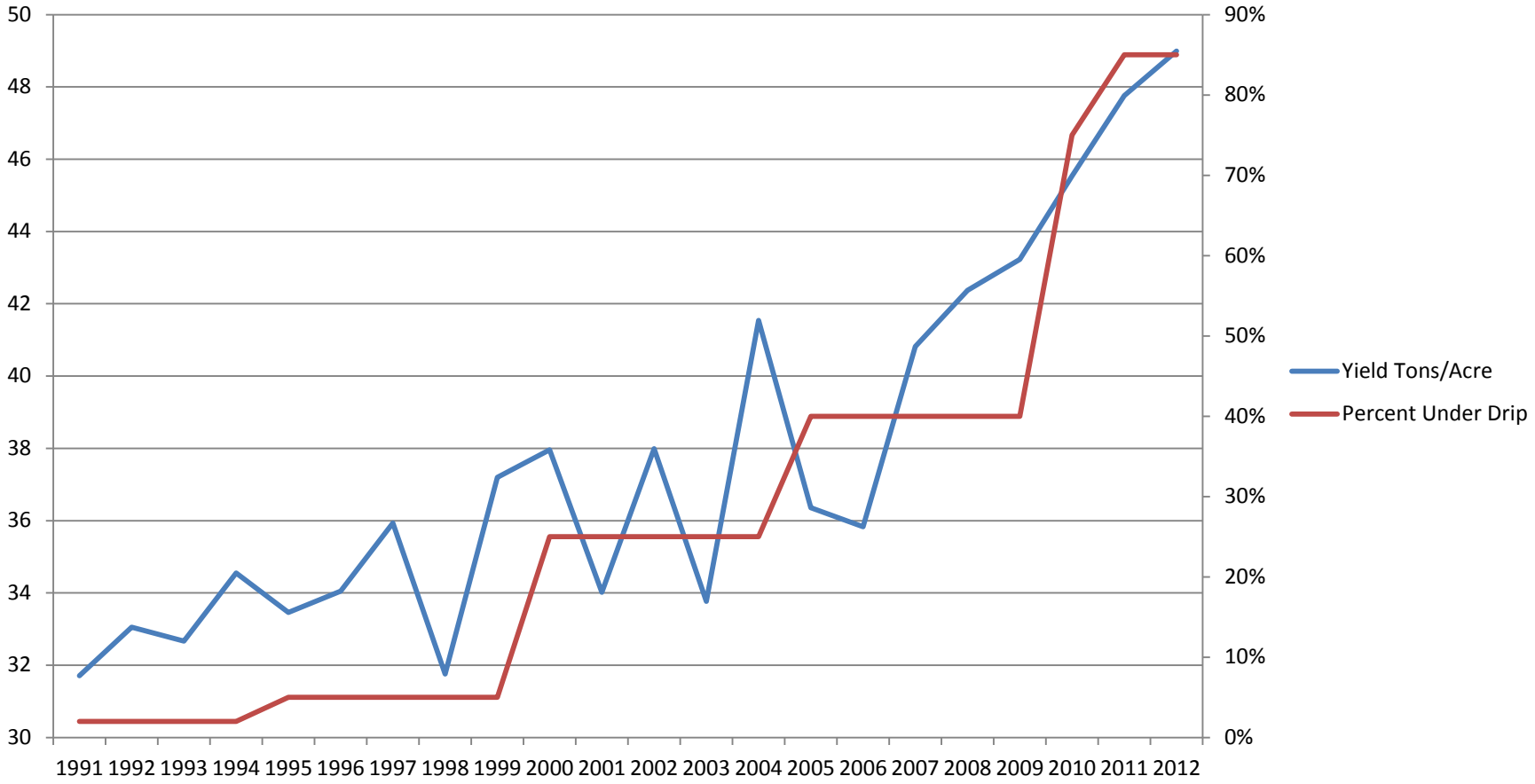

Source: CDWR Irrigation Survey, 2001 & 2010.

# Processing Tomatoes

## Processing Tomatoes 1990 - Present

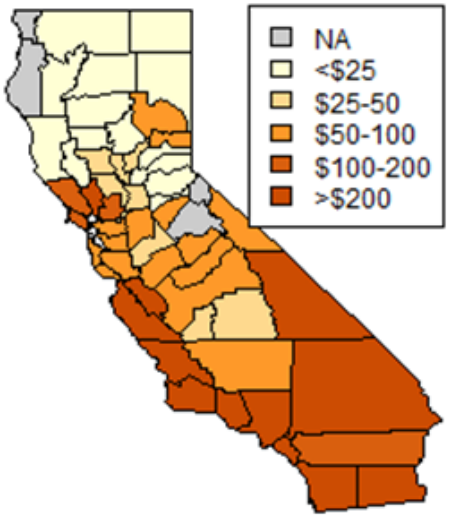
- Decreased Water Use
- Reduced Acreage
- Increased Yield and Quality
- Increased Production


# Processing Tomatoes

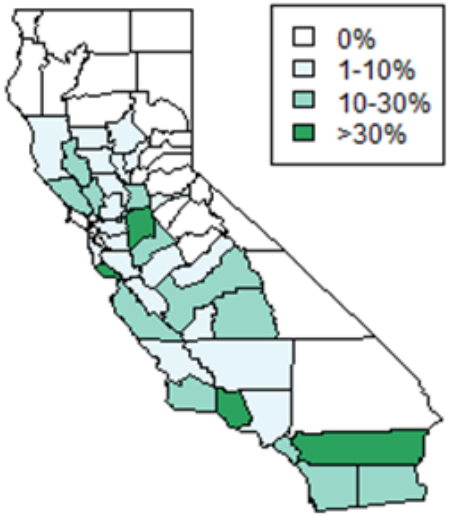


# Drip Irrigation

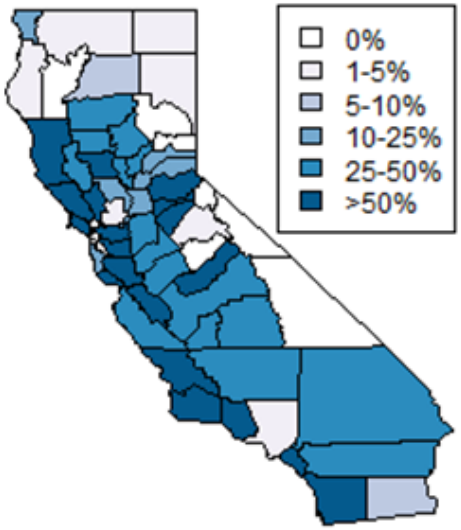
(e) Water Cost by Acre ($/acre-foot), 2001




(d) % Crop Acreage that is High Value, 2001




Drip Irrigation (% of Irrigated Acres)




Source: Highstreet et al. (1980); CDWR Irrigation Survey, 2001 & 2010.
Source: CDWR Bulletin 132; CDWR Irrigation Survey, 2001 & 2010.

# Drip Irrigation

- Agronomists found that the introduction of drip failed in many countries, despite its successes in Israel and US.
- They attributed the successes to the:
  - Co-evolution of the drip technology and other agronomical practices.
  - Introduction of a network to support the technology and its adoption.

# Drip Irrigation

- Netafim analyze 112 studies of drip irrigation versus flood irrigation.
  - Find yield effects range from 18-50% *(Durand and Birrell, 2010)*.
- We compare 31 published studies across 15 crops:
  - Half of the studies report no statistically significant difference in yields.
  - Half of studies report significant and positive yield effects, ranging from 12-66%.
  - **Average yield effect across all studies is 16%.**
- 11 out of 31 studies also report positive water-savings effects
  - **35% on average for the 11 studies**

# Agronomic Studies of Drip

| Crop | Paper | Location | Yield Effect | Comparison |
|---|---|---|---|---|
| Alfalfa | Bui & Osgood, 1990 | Hawaii | - | sprinkler |
| Alfalfa | Hutmacher et al., 1992 | California | 19-35% | furrow |
| Cabbage | Bucks et al., 1974 | Arizona | - | furrow |
| Cabbage | Rubeiz et al., 1989 | Arizona | 29% | furrow |
| Cabbage | Tiwari et al., 2002 | India | 62% | furrow |
| Cantaloupe | Bucks et al., 1981 | Arizona | - | furrow |
| Carrot | Bucks et al., 1981 | Arizona | - | furrow |
| Cotton | Howell et al., 1987 | California | - | furrow |
| Cotton | Phene et al., 1992 | California | 13% | furrow |
| Cotton | DeTar et al., 1994 | California | - | furrow |
| Cotton | Henggeler, 1995 | Texas | 20% | furrow |
| Cotton | Muhammad et al., 2011 | India | 20% | furrow |
| Lettuce | Sammis, 1980 | New Mexico | - | furrow |
| Lettuce | Hanson et al., 1997 | California | - | furrow |
| Okra | Sivanappan et al., 1987 | India | 40% | furrow |
| Onion | Bucks et al., 1981 | Arizona | - | furrow |
| Onion | Halvorson et al., 2008 | Colorado | 15% | furrow |
| Peanut | Adamsen, 1989 | Virginia | 14% | sprinkler |
| Pepper | Xie et al., 1999 | New Mexico | 43-66% | furrow |
| Pepper | Paul et al., 2013 | India | 28% | flood |
| Pistacchio | Goldhamer et al., 2002 | California | 13% | flood |
| Potato | Sammis, 1980 | New Mexico | - | furrow |
| Potato | DeTar et al., 1996 | California | 27% | sprinkler |
| Potato | Erdem et al., 2006 | Turkey | - | furrow |
| Sweet corn | Phene & Beale, 1976 | South Carolina | 12-14% | furrow, sprinkler |
| Sweet corn | Wendt et al., 1977 | Texas | - | furrow |
| Sweet corn | Adamsen, 1992 | Virginia | - | sprinkler |
| Tomato | Schweers & Grimes, 1976 | California | 14% | furrow |
| Tomato | Rose et al., 1982 | California | 20% | furrow |
| Tomato | Pruitt et al., 1984 | California | 13-19% | furrow |
| Tomato | Bogle et al., 1989 | Texas | 22% | furrow |
| Tomato | Yohannes & Tadesse, 1998 | Ethiopia | 39-54% | furrow |
| Tomato | Hanson & May, 2003 | California | 15-35% | sprinkler |
| Tomato | Semiz & Yurtseven, 2010 | Turkey | 14-27% | furrow |
| Zucchini | Rubeiz et al., 1989 | Arizona | 13% | furrow |

# Drip Irrigation

| Value of Water Savings from Drip Irrigation (annually) | |
|---|---|
| Cost of Water ($/acre-foot) | Value of Annual Water Savings from Drip Irrigation (millions) |
| $80 | $128 |
| $150 | $240 |
| $220 | $352 |

**Assumptions:** Agricultural Water Use is 33.32 MAF/Year
Percentage of Irrigated Crops Adopting Drip is 40%
Percentage of Agricultural Water Saved from Adopting Drip is 12%

# Drip Irrigation

| Increase in Farm Income from Drip Irrigation (annually) | |
|---|---|
| Yield Effect of Drip Irrigation | Increase in Farm Income from the Yield Effect (millions of $) |
| 5% | $185 |
| 15% | $508 |
| 25% | $778 |

**Assumptions:** Net Farm Income in Crop Production is $7.2 billion
Percentage of Irrigated Crops Adopting Drip is 40%
Percentage of Agricultural Crop Value from High-Value Crops is 86%

# Drip Irrigation

Combined Value of Drip = $313 to $1,130 million per year

- Pesticides and fertilizer use reduction not measured
- Consumer surplus not measured
- Not included are extensive margin effects- land expansion because of drip
  - Grapes, avocado in foothills, almonds on slopes…

# Thank You