MICROIRRIGATION OF ALMONDS

John P. Edstrom and Larry J. Schwankl
University of California Cooperative Extension
Davis, Ca 95616
USA

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Abstract

A large scale field trial was conducted at the Nickels Soils Laboratory in the Sacramento Valley of California to evaluate three microirrigation systems; Surface Drip, Subsurface Drip (SDI) and Micro-jet on four cultivars of almonds, 'Nonpareil', 'Butte', 'Carmel' and 'Monterey' (*Prunus dulcis* [Mill.] D.A.Webb.).

Ten years of evaluation has shown that high commercial yields (2500 kg/ha) of high quality almonds can be produced using all three types of microirrigation. Micro-jet irrigated trees tended to outyield drip irrigated trees by about 10% in some years for some cultivars. No consistent yield differences were found. Tree growth under SDI, as measured by trunk size, was comparable to surface drip irrigation but slightly smaller than micro-jet irrigated trees when equal amounts of irrigation water were applied. Root development was more extensive under micro-jet irrigated trees compared to both single hose drip systems. No significant root intrusion was found in trifluralin impregnated SDI emitters but standard SDI emitters were plugged by almond root growth after five years of field operation. Minor root pinching was evident on the buried flexible supply hoses in both SDI and surface drip systems. Micro-jet irrigation increased system maintenance and resulted in higher herbicide use to control vegetation on the orchard floor.

1. Introduction

Drip irrigation has been successfully used in California almond production for over 30 years to improve water use efficiency, to increase yield and to expand production onto marginal soils. Tree productivity has been good, however, wider adoption of drip has been limited by possible yield limitations from restricting lateral root growth, from the interference problems caused by drip hoses placed on the soil surface and the lack of frost protection. Microsprinkler irrigation can distribute applied water over a larger surface area encouraging wider root development which may effect yield or quality. Subsurface placement of supply hoses can avoid most surface hose problems but SDI has not been adequately tested for almond production nor for potential problems to hoses when placed in the rhizosphere. Comparative studies of the effects of microirrigation types on almond kernel quality and productivity and on almond cultural practices have not been conducted.

2. Materials ands methods

An 8 hectare (20 acre) test orchard was established in 1990 at the Nickels Soils Laboratory in Arbuckle, California to evaluate the performance of the three primary types of microirrigation: Drip, Subsurface Drip (SDI) and Micro-jets. The site was designed for replicated evaluation of the systems while also of sufficient size to evaluate the farming aspects of each system.

Four almond cultivars, 'Nonpareil', 'Butte', 'Carmel' and 'Monterey', planted on 'Lovell' peach rootstock are under evaluation using six replicates of 44 trees at a spacing of 4.9 m x 6.7 m (308 trees/ha.) using each of the following irrigation system configurations:

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1. Surface Drip - single hose — 4 –4 lph Netafim PC emitters/tree
2. Surface Drip - double hose — 8 -2 lph Netafim PC emitters/tree 1.2 m from tree row
3. Microsprinkler — 1 – 40 lph Bowsmith Fanjet per tree
4. Microsprinkler double — 2 – 20 lph Bowsmith Fanjets per tree
5. Microsprinkler double1.5 ET — 2 – 30 lph Bowsmith Fanjets per tree
6. SDI single hose — 4– 4 lph Ram emitters/tree 0.6 m from tree
7. SDI double hose — 8 – 2 lph Ram emitters/tree 1.2 m from tree
8. SDI double hose — 8 – 2 lph Geoflow emitters/tree 1.2 m from tree

Subsurface drip treatments were established the first year with single hose surface drip and early in the 2nd year converted to subsurface drip installed at a depth of 0.38 m (15 inches). Single hose SDI were placed 0.6 m from the tree rows while double hoses were placed at 1.2m on each side of the trees. Equal amounts of water were applied to all systems on a weekly and seasonal basis except for treatment number 5 which received 1.5 ETc weekly. Evapotranspiration was determined by a nearby weather station operated by the California Irrigation Management Information System (CIMIS). Separate irrigation submains allowed for independent watering schedules for drip and micro systems. All drip systems were operated 4-6 times per week during peak water demand while micros were run two times per week. Amounts of applied water were monitored using inline flow meters and application durations were adjusted for each system to meet evaporative demand and maintain equal application rates between systems. Leaf stem water potential was monitored to assess plant water status and to guide irrigations. Total seasonal water applied ranged from a low of 610 mm in 1998 to a high of 1016 mm in 1997. The fertility program consisted of monthly injections (April-August) of urea ammonium nitrate at 250 kg/ha/yr and October soil applications of potassium sulfate at 500 kg/ha/yr and foliar applications of boron and zinc.

3. Results

The test orchard has produced good commercial yields for the 'Butte', 'Monterey' and 'Nonpareil' cultivars while 'Carmel' tree development and production has been below standard. On average over the years of this test the micro-jet irrigated trees have yielded about 10% more than trees on either type of drip system. (Table 1) This increase has been variable over the years and between the varieties. (Table 2) 'Nonpareil' and 'Butte' yields increased in some years with micros while 'Carmel' have never shown a response. 'Monterey' production has also been inconsistent between the three irrigation systems but with a slight advantage given to the micros. SDI yields have also been variable between the different configurations of SDI and between seasons and varieties. Generally, yields have tended to be a little lower with SDI compared to drip and micro. Removing from analysis the SDI treatments that developed root intrusion, then SDI yields equaled surface drip production. Double hose SDI plots yielded more than single and yields with double surface drip have been less than single drip. (data not shown) This is probably due not to the dual hoses but rather the lower 0.5 gph output of these emitters and the resulting shallower water penetration. No differences in weight per kernel has ever been found between any irrigation system. All yield differences can then be attributed to more kernels per tree and not larger individual kernels. Tree measurements show that trunk cross sectional area of micro-jet trees are slightly larger than drip and SDI trees which are equal. (Table 3)

4. Discussion

Each of the three systems can produce high yielding almond orchards. No system shows a clear superiority over the others under the shallow soil (0.7 – 1.0 m) conditions of this test. Each has advantages and disadvantages. Yields often tend to be greater for micros but increased weed control and irrigation costs must be considered. SDI requires more intensive management and exposes the system to greater risk. Double hose SDI appears to have practical advantages but with high investment costs. Single surface drip performs well under closely spaced orchards and is the most economical. Site conditions should be evaluated closely to determine the most appropriate type of system for the specific orchard.

Of major concern has been the problem of root intrusion into the buried SDI hoses. Almond tree roots have grown in through the emitters, plugging buried hoses and reducing flow of water. To date, only the non-herbicide impregnated SDI emitters have shown this problem. High concentrations of chlorine @ 240 ppm injected into the SDI hoses failed to resolve the plugging.

Geoflow SDI with trifluralin impregnated emitters continue to perform normally and trees in these plots yielded the same as surface drip and show no signs of root intrusion after 10 years in the field. Early in the test several flexible hose risers were pinched closed (strangulation) by tree roots in the SDI plots. This is probably due mainly to the placement (within 0.5 m) of the risers to the tree trunks. Subsurface drip irrigation continues to excel in relation to orchard floor management and harvest efficiency. However, concerns regarding tree roots pinching buried hoses, the siphoning of silt into emitters upon system shutdown and damage by gophers remain concerns in long-term SDI operation.

Micro-jets have also exhibited problems, mainly due to insects plugging the jet orifices. Micro-jet irrigated plots also require 2-3 extra foliar herbicide applications per season and still weeds interfere with harvest. Weeds in the SDI plots are considerably reduced and the absence of surface hoses increases harvest efficiency greatly by eliminating hand raking and allowing harvest irrigations to proceed without wetting the crop. Surface drip systems allow harvest irrigations to some extent also, but micro-jet irrigations rewet the drying almond hulls and delay processing or cause kernel deterioration.

Detailed soil moisture measurements were taken in 1998 (data not shown) for trees irrigated with single drip hoses. Soil moisture levels declined predictably in the densely rooted soil beneath emitters. Soil moisture some 2.7 m out from the drip hose (beneath row middles) also declined from March to July. The pattern of decline indicates that tree roots extracted water far beyond the confined root zone irrigated in summer. Drip root systems apparently access winter stored moisture beyond the limited summer wetted areas.

Mineral nutrient analysis of midsummer leaf samples found no difference in leaf nitrogen (%) between drip and micro-jet irrigated 'Nonpareil'.

References

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Table 1. Average yearly and historical mean yields (kg/ha) of four almond cultivars for three microirrigation types.

System	1994	1995	1996	1997	1998	1999	2000	Total	Mean
Drip	1176	1039	2396	2354	2579	2768	2197	14509	2073 ns
Micros	1721	1052	2692	2473	2766	2587	2517	15808	2258
SDI	1382	968	2268	2190	2427	2564	2201	14000	2000

Table 2. Yearly almond yields (kg/ha) by cultivar for three microirrigation types.

Year	Irrigation treatment	Cultivar			
		Carmel	Butte	Nonpareil	Monterey
1994	Surface drip		1173 b	1179 c	
	Microsprinklers		1728 a	1716 a	
	Subsurface drip		1383 b	1382 b	
1995	Surface drip	842 a	834 a	1030 a	1448 a
	Microsprinklers	801 a	813 a	1101 a	1492 a
	Subsurface drip	978 a	785 a	716 b	1390 a
1996	Surface drip	1990 a	2155 a	2645 a	2791 ab
	Microsprinklers	1958 a	2549 b	3033 a	3230 a
	Subsurface drip	1874 a	2066 a	2632 a	2499 ab
1997	Surface drip	2242 a	2764 a	2230 a	2182 ab
	Microsprinklers	2115 a	2815 a	2440 a	2522 a
	Subsurface drip	2048 a	2713 a	2068 a	1920 b
1998	Surface drip	1933 a	3161 a	2709 ab	2513 a
	Microsprinklers	2118 a	3342 a	3064 b	2542 a
	Subsurface drip	1793 a	3100 a	2620 a	2193 a
1999	Surface drip	2295 a	2974 a	3012 a	2598 a
	Microsprinklers	2396 a	2702 a	2961 a	2573 a
	Subsurface drip	2297 a	2526 a	2509 b	2383 a
2000	Surface drip	2188 a	2171 a	2068 a	2538 a
	Microsprinklers	2327 a	2594 b	2428 b	2707 a
	Subsurface drip	2261 a	2158 a	2043 a	2349 a

P=0.05 Fishers protected LSD

Table 3. Mean trunk cross sectional area in cm^2 (1998).

Irrigation treatment	Carmel	Butte	Nonpareil	Monterey
Surface drip	255.4 a	363.8 a	339.3 a	302.5 a
Microsprinklers	291.5 b	419.3 b	356.0 a	390.2 b
Subsurface drip	257.4 a	359.9 a	318.6 a	296.7 a