Report to the Almond Board – June 2006

Project Title: **Nickels Soil Lab Projects 05-JE-01**
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1. Pruning Trials for High Density Orchards

John Edstrom and Bill Krueger

Trial Background

The **objective** of this trial is to evaluate tree training/pruning methods for maximum early production while maintaining long-term yields in tightly spaced almonds.
In 1997 almonds on Lovell peach rootstock were planted at a 16' X 22' spacing, north and south. The soil was slipped plowed prior to planting and the trees are irrigated 2X per week with microsprinklers to meet Etc. The soil series is Arbuckle, a sandy loam with a clay layer at 25 to 60 inches. Ample amounts of nitrogen, potassium and zinc are applied monthly to maintain high leaf mineral levels. The orchard design is 1:1 with Nonpareil rows alternating with pollinator rows of Monterey, Carmel and Aldrich. Four different training systems as described below began in the first dormant season. There are four replicates of Nonpareil, three of Monterey, two of Aldrich, and two of Carmel. Beginning in the fourth leaf, yield data has been collected,

Treatments

1) **Standard** - Three primary limbs selected at 1st dormant, tipped but long pruned, secondaries selected 2nd dormant, centers kept open, limb tying/staking as necessary. Yearly traditional, light pruning continued.

2) **Unpruned** - Three primary limbs selected, tipped and left long at the 1st dormant pruning then no additional pruning unless needed to facilitate orchard operations or to remove broken limbs. Minimal staking as necessary.

3) **Mechanically Topped** - Same as unpruned, but with machine flat-topping to remove half of prior season's top shoot growth during the 2nd dormant season and again in spring of the 4th leaf. No additional pruning.

4) **Temporary Scaffolds** - Train limbs at 1st dormant to favor 3 permanent upright primary scaffolds, temporarily retain lower less dominant branches, removing only ones competing strongly with permanent scaffolds. Retain as much wood as possible. Temporary limbs scheduled for gradual removal during years 5-8 after producing some crop or sooner if they threaten primaries.

2005 Results

Nonpareil and Aldrich nut set was too low this season to add any new information on the effects of the different pruning styles. The Carmel variety appears to be the only variety tested that declines in production without pruning. Carmel 2005 and accumulated yield is also considerably below the other varieties in the non-pruned trees. By contrast, the yield of Monterey is considerably higher in the non-pruned trees than any other treatment or variety. It appears that Carmels should not be left unpruned after about the 6th leaf while Nonpareil, Aldrich and Monterey produces well without pruning at least until the 10th leaf.
'Temporary' method tree structure has improved over time and appears quite similar to the standard pruning. Only a few tree trunks show pruning wounds that may be vulnerable to shaker damage. The "Mechanically topped" trees exhibit poor secondary/tertiary limb development with much shading in the mid canopy but still have not lost productivity.

Table 1.

	Aldrich		Carmel		Monterey		Nonpareil	
	Accum	2005	Accum	2005	Accum	2005	Accum	2005
Standard	11,627	**1,504**	11,128	**2,143**	11,520	**2,273**	10,411	**1,603**
Temporary Scaffold			11,664	**1,926**	11,836	**2,381**	10,804	**1,602**
Mech Hedged	11,483	**1,927**	12,168	**2,263**	11,431	**2,390**	10,734	**1,625**
Unpruned	11,535	**1,421**	9,723	**1,657**	14,100	**2,757**	11,310	**1,639**
Accum. 4-9th leaf.								

Visual observations of the various pruning methods resulted in a general rating of six traits as listed in the following chart; early yield, accumulated yield, vigor, shading of fruitwood, tree height, and structure.

General Traits of Pruning Systems

PRUNING TYPE	Early YIELD	Accum YIELD	VIGOR	SHADE	HEIGHT	STRUCTURE
STANDARD	Moderate	High	High	Low	Tall	Very Good
TEMPORARY	High	High	High	Low	Medium	Good
UNPRUNED	High	High	Fair	High	Medium	Fair
MECH TOPPED	Moderate	High	Low	High	Low	Poor

Results to Date

Overall tree vigor has been very good in this planting but not at the highest levels seen in other areas of the state. Our class II soil conditions provide a realistic evaluation of the unpruned method under local conditions where shoot vigor produces 24 inch shoots while supporting 2000 pound crops. Tree canopies have closed in now during the 9th year, forming a dense orchard canopy, so we could expect maximum cropping in the next few years.

Discussion

Temporary limb concept

This particular multiple scaffold method is probably not worth the extra effort. The only yield advantage came during the 4th leaf. During the 5th & 6th harvests, production was equal to the standard pruned trees. Seventh leaf production (after the remaining temporary scaffolds were cutoff) was below the standard and unpruned trees. However, yields have recovered to equal the other treatments, possibly indicating that permanent limbs have now replaced fruiting wood lost during temp limb removal. We will now watch to see if these trees will outproduce the unpruned trees given the more sunlit open center canopy.

The pruning effort required to establish temporary limbs, that don't overly stunt permanent ones, is quite difficult. Aldrich growth habit was incompatible with this method and was discontinued in the 3rd winter. An alternative method of starting with 5-6 scaffolds and maintaining them until they crowd may be preferable to our temp method. However, we chose to avoid over crowded crotches (and the breakage) by positioning limbs low on the trunk for early removal. Our overall minimum pruning strategy was to develop strong crotches and rely on unthinned secondaries to produce extra fruitwood instead of maintaining extra primaries.

Some "temporary" limbs will be maintained "permanently" on Monterey, as all scaffolds developed uniform on some trees despite our extra training efforts. We will then be able to track the sustainability of 5-6 scaffolds on Monterey trees. Multiple scaffold trees planted here on a 16' x 22' spacing maybe less prone to breakage compared to the larger trees that develope on wider spacings.

Unpruned

This method continues to demonstrate commercial potential. Nearly all unpruned trees look acceptable or very good. 'Nonpareil' and 'Aldrich' did appear too dense in the upper canopy with more shading below, but the crops produced since 2002 opened the centers naturally. In 2 of six years Carmels produced less crop when left un-pruned. This tendency needs confirmation however. Given the low vigor of Carmel, pruning maybe more critical with this variety to expand/maintain fruitwood. Of some concern is the loss of lower/interior fruitwood on unpruned 'Aldrich'. Some 'Monterey' trees are misshapen and have "mushroomed" open, but the Nonpareils and Carmels look good. Monterey continues to produce the highest yields as unpruned trees, which is surprising given its more willowy growth habit. Some thinning cuts could be made to open the trees and reduce shading. However, any cuts will likely cause sucker growth and set up the demand for more pruning. Most unpruned trees grow more evenly without overly vigorous limbs and appear to allow enough light penetration to promote cropping. These trees are also somewhat shorter which helps promote light penetration and facilitates most orchard operations There has been no problem with crop removal at harvest despite the dense fruitwood, as the trees grow this may become a problem. Decreased light penetration over time and its impact on production is our main concern.

Mechanically Topped

All varieties in this treatment are shorter in height than in the other methods and appear thicker and more crowded in the middle and upper canopy. Aldrich benefited some from topping with better branching forming a wider canopy, but appears too dense in the center with a noticeable loss of interior fruitwood. In general, excessive shoot growth resulted from the dormant topping in 1998. Too much was removed during that operation resulting in very vigorous growth the following spring. This dense upright growth of 3 to 8 feet was cut in half during the May 2000 topping. This resulted in cutting into some prior year's wood, de-invigorating the trees and reducing tree height. As expected, re-growth of top shoots after spring topping was only moderate. Since the forth season this treatment has received no pruning. Monterey and Nonpareil tree structure appears most negatively affected by topping. Apparently, heavy topping should be avoided or done very carefully during canopy development.

Standard

These trees are the tallest of all treatments and also exhibit a standard, "open vase" canopy. However, pruning in this treatment in the past would best be described as "minimum", as not enough wood was removed in the early years to qualify as standard pruning. This may have inflated accumulative yield figures. During the past two dormant seasons, trees in this treatment were pruned more heavily, removing more crowded and crossing limbs. This heavier pruning was reflected in reduced production compared to the unpruned and mechanically topped treatments last year. This season production is equal to the other treatments. Primary and secondary scaffold development is good, producing well balanced trees. Greater tree height resulting from standard pruning may become troublesome over time.

Summary

The "no pruning" treatment continues to look promising, except possibly for Carmels. After selecting three primary scaffolds, trees receiving no pruning for 8 years are as productive, or more, than pruned trees. To date, accumulated yields for this treatment are the highest. The trees appear well balanced with acceptable tree architecture, which should be capable of long-term high production. The impact of shading over time remains a question as well as maintaining vigor in later years. The accumulated reduction in pruning costs ($700/acre) represents a significant savings to the grower. Trees settle down more naturally, so far, without shading lower fruitwood (except Aldrich). Consistent cropping has also moderated growth. Now, after 9 seasons, many Nonpareil trees look dense, but very good and most are acceptable. Varieties like, Monterey, Carmel and Aldrich may require different methods. But this "unpruned" method continues to perform remarkably well, both in terms of production and tree framework.

The "temporary" system looks questionable. Yields don't appear to justify the extra pruning efforts. Long-term yields could reveal mature tree yield gains to this idea when compared to the possible declining yields of the "unpruned" mature trees.

2. Comparison of Microirrigation Systems for Almonds

John Edstrom, Dr. Larry Schwankl, and Stan Cutter

A 22-acre field demonstration began in 1990 to evaluate the three major types of microirrigation: Drip, Subsurface Drip (SDI) and Microsprinklers. This trial uses 36 one-half acre plots to simulate commercial conditions on four almond varieties, 'Nonpareil', 'Butte', 'Carmel' and 'Monterey'. The systems under study are:

1. Surface Drip - single hose	4 - 1 gph Netafim PC emitters/tree
2. Surface Drip - double hose	8 - 0.5 gph Bowsmith emitters/tree 4 ft. from rows
3. Microsprinkler	1 - 10 gph Bowsmith Fanjet between trees
4. Microsprinkler double	2 - 5 gph Bowsmith Fanjets around trees
5. Microsprinkler double1.2 ET	2 - 7.5 gph Bowsmith Fanjets around trees
6. Subsurface Drip - double hose	8 - 0.5 gph Geoflow emitters/tree, 4 ft. from rows
7. Surface Drip double hose150% Et	8 - 1 gph Netafim PC emitters at 4 ft.
8. Subsurface Drip double New	8 - 0.5 gph PC Geoflow emitters at 4 ft

Subsurface drip treatments were established the first year with surface hoses and early in the 2nd year converted to SDI with the tubing installed at a depth of 15 inches. Previously, Netafim Ram tubing was evaluated as SDI but became extensively plugged by almond root intrusion. All of these lines were replaced in the spring of 2000 with pressure compensating Geoflow trifluralin impregnated SDI placed at a depth of 8-10 inches directly above the abandoned Netafim hoses. This treatment is # 8 - New Geoflow double. During the peak irrigation season all drip systems irrigate 5-6 times per week while micros are run 2-3 times per week.

2005 Results

New for this year was the discovery of root intrusion into the Rootguard® (trifluralin impregnated) emitters. Less than 1 % of these emitters have been found to be clogged by almond root growth into the emitter. The vast majority of the emitters are still operating normally after 15 years in the field.

Yield data continues to support our previous results that showed equal production between irrigation systems when equal water is applied. SDI yields continue to equal those from standard drip. The irrigation schedule this season applied 30-34 inches of water to the1.0 Et treatments (1-4, 6& 8) , approximately 39 inches to the 1.2 Et treatment (#5) and about 48 inches to the 1.5 Et treatment (# 7).

One small section of this trial has received 240% of Etc via microjets since the day of planting. These 'Monterey' trees out-yielded every other plot in the trial significantly until the last 4 years when phytophthora root rot infections began. Today, 13% of these trees have died while 45 % are heavily infected and should perish shortly. The implication of this experience maybe that heavy irrigation, well above Etc amounts, can sometimes result in higher production, but, puts trees at great risk for disease and early removal.

Results

All irrigation systems produced nearly equal yields this year except for the Double Microjet 1.2 and Drip Double which both applied extra water above Etc rates. Applying 120-150% of Etc over a wider soil area improved yields again this year over all other treatments for 'Butte'. However, this has not been a consistent result over the years, nor has it been consistent with all varieties. High irrigation rates can saturate root zones in areas of shallow soil and in the swales. When these site conditions of a restricting clay layer at 24-60 inches are combined with the limited wetted area of single hose drip, roots can't access the additional water. Roots have better access to this moisture if applied over the larger surface area wetted by microjets which also reduces soil saturation. But, when equal amounts of irrigation water (1.0 Etc) are applied using drip, SDI or micros, no consistent yield differences have been found in the 15 years of this test. Further, no yield advantage has been found for double micros (1.0 Etc) verses single micros. Previously, soil moisture uptake measurements indicated that an advantage might be obtained from surrounding the tree canopy with wetted soil (Micro Double) verses a circular wetted area midway between trees (Micros). However, improved frost protection may be obtained by applying water directly beneath canopies verses between trees.

Evaluation of sub surface drip systems (SDI) suggests that the original deep placement of hoses at 15 inches maybe inferior to SDI installed at 8 inches (Shallow verses Deep Geoflow). This might be explained by the shallow soil at this site (24"-48"). However, the new SDI emitters are pressure compensating, the old ones are not, so a fair comparison isn't possible. Root intrusion was found in the standard SDI emitters (Netafim) after 6 years of operation and were abandoned.

In contrast, Rootguard® SDI emitters continue to perform well after 15 years in the field, with yields and performance similar to standard drip.

2005 YIELDS -- Lbs/Acre

System	Variety: Nonpareil	Butte	Carmel	Monterey	Average
Drip	1,489	2,159	2,056	2,176	1,970
Drip Double	1,515	2,107	2,060	1,803	1,871
Micros	1,663	2,199	2,042	2,133	2,009
Micros Double	1,589	2,280	2,174	2,095	2,035
Micros Double 1.2 ET	1,791	2,493	2,349	2,169	2,201
Drip Double 200% ET	1,505	2,473	2,019	1,957	1,989
SDI Double:					
Shallow New Geoflow	1,337	2,019	1,695	1,952	1,751
Deep Original Geoflow	1,613	2,156	1,832	1,832	1,858

3. Deep Tillage Slip Plow Effects on Almonds

John Edstrom & Stan Cutter

This field trial is evaluating the effects of slip plow soil modification on three varieties of almonds, 'Nonpareil', 'Carmel' and 'Aldrich' planted in 1997 on 'Lovell' peach or Brights peach/almond hybrid rootstock. Prior to planting, replicated areas of this 20 ac block received a commercial slip plow operation on a 10 foot grid to a depth of 6 feet in a north/ south direction and a diagonal pass (SE-NW), the locally recommended practice. Soil conditions at this site consist of a Class II (Arbuckle series) a sandy loam topsoil to a depth of 30-60 inches which is underlain by a dense clay layer. Soil beneath this layer is similar to the topsoil, a gravelly/sandy loam . These three layers were mixed in channels by the slip plow operation.

The planting receives biweekly irrigations via dual microsprinklers, applying 36-40 inches per season. Fertilizer materials for nitrogen and potassium are injected monthly to maintain high leaf mineral levels. Foliar sprays of zinc and boron are also applied annually.

Tree size in slip-plowed and unplowed areas was determined by measuring trunk diameters 12-16 inches above ground level in addition to gathering yield and kernel size data.

2005 Results

Nonpareil bloom conditions were quite limiting this spring so crop production stresses were minimized. As peak yield is reached in the next few years, differences may emerge. Yield data for 2005 continue to show no yield advantage to slip plow soil modification. Nonpareil yields were actually numerically higher in non-plowed soil than where soil was slip plowed. (1,393 lbs/ac for slip verses 1,657 lbs/ac non-slip. Kernel sizes were nearly equivalent and large at 1.4 gms/kernel or 20 kernels/oz. The applicability of these finding to other soil types is unknown. We would expect that the clay layered characteristic of the class II Arbuckle soil would be amenable to mixing by slip plow and lead to higher production. This has not been the case. Even in years of good production, 2002 & 2003 kernel yields were equal between treatments. One must question the net present value of spending $400/acre on slip plowing and then waiting four years onward for a return on investment. Depending on soil and drainage limitations we must carefully consider such high cost upfront verses the benefits of slip plow soil modification in micro-irrigated orchards.

Slip Plow Nonpareil Yields – 2005

Lbs/Acre

	Rep 1	Rep 2	Rep 3	Rep 4	Rep 5	Rep 6	Mean
Slip Plow	1,509	1,697	1,608	1,664	1,509	1,304	**1,548**
Non Slip Plow	1,835	1,880	1,828	1,944	1,886	1,676	**1,841**

Slip Plow Almond Yields

	lbs/acre						
	4th	5th	6th	7th	8th	9th	
	2000	2001	2002	2003	2004	2005	Accumulative
Slip Plowed	**894**	**1070**	**2725**	**2165**	**1869**	**1548**	**10,271**
Non Slip Plowed	**830**	**1243**	**2761**	**2323**	**1865**	**1841**	**10,863**

Past Results

Tree size measurements have shown no differences between slip and no slip trees for 9 consecutive years. Root excavation work done earlier via back hoe pits revealed deeper root systems on trees in slip plowed areas compared to roots in non-slip areas. The proportion of roots in deeper soil was minimal, however. The deeper rooting may become significant over time, but so far, no benefit has been measured.