ANNUAL REPORT TO THE ALMOND BOARD DECEMBER 31, 1989

Project No. 89-S1 - Improving Almond Pruning Decisions

Project Leader: Mr. Joseph Connell
Butte County Farm Advisor
2279 Del Oro Ave., Suite B
Oroville, CA 95965
(916)538-7201

Cooperating Personnel: J. Edstrom, M. Freeman, (L. Hendricks, R. Beede)
B. Krueger, W. Reil, M. Viveros, W. Micke.

Objectives: The objective of this project is to develop information to answer pruning questions with factual information. Six trials seek to provide answers to the following questions: (1) What is the best method for training temporary trees in double-planted orchards and how are those trees best removed when they crowd? (Connell) (2) What is the best method for training and pruning a high density hedgerow orchard? (Edstrom) (3) What is the best way to prune, to invigorate low vigor varieties? (Freeman, Hendricks, Beede) (4) What is the impact of alternate year pruning versus annual pruning? (Krueger) (5) What effect does time of pruning have on yield? (Reil) (6) Is mechanical hedging and/or topping a viable alternative? (Viveros).

Interpretive Summary: Trials designed to answer the preceeding six questions are outlined in order in the following summary. Some observations are preliminary, others report progress following a decade of work.

1) Almond Temporary Tree Training Trial

J.H. Connell, W. Micke, J. Yeager, J. Hasey, B. Krueger, C. Weakley

In recent years, growers have experienced increasing costs for orchard establishment and lower net returns from producing orchards. This creates a situation where greater production in the early years of an orchard's life is essential for survival of the operation. One solution has been to double plant the orchard by placing an extra tree in the row between two trees planted at traditional tree spacings. In this scheme tree populations per acre is twice the normal population and early yields are greater. The goal of this project was to develop temporary trees at the least cost while providing the greatest early production. Health and longevity of permanent trees in a double planting is also an important goal. Six pruning treatments designed to achieve these goals were evaluated.

Methods

The trial was established with the first dormant pruning in December 1982. Trees were planted in a 2:1 arrangement with the varieties 'Mission' and 'Butte'. There are 141 trees per acre with 24 feet between rows and trees 13 feet apart in the row. When temporary trees are removed the permanent trees will be offset with 26' between trees in the row and 28' between trees in different rows.

Three pruning treatments were established on permanent trees and three treatments were established on the temporary trees as follows:

Permanent Trees
1) Selected 3 scaffold branches, left them long.
2) Selected 3 scaffold branches, headed them at 36".
3) Selected 2 scaffold branches, headed them at 36".

Temporary Trees
1) No pruning (except to remove low sprouts on the trunk).
2) Selected 3 scaffold branches, left them long, no further pruning.
3) Selected 6 scaffold branches, left them long, no further pruning.

Treatments were established on 5 tree plots using a randomized complete block design. Each treatment was replicated four times on the 'Butte' and 'Mission' varieties.

Once pruning treatments were established at the first dormant pruning subsequent pruning on the temporary trees was confined to removing low sprouts on the trunk that would interfere with shaking.

Subsequent pruning on the permanent trees maintained the treatments in a more conventional manner. Low sprouts were removed from the trunks, branches were thinned out to ensure that each tree had the correct number of primary scaffolds, and secondary scaffolds were thinned to eliminate crowding and crossing limbs.

The orchard is located eight miles north west of Chico on Farwell clay loam, a soil that has 2 to 3 feet of clay loam overlaying a loam soil.

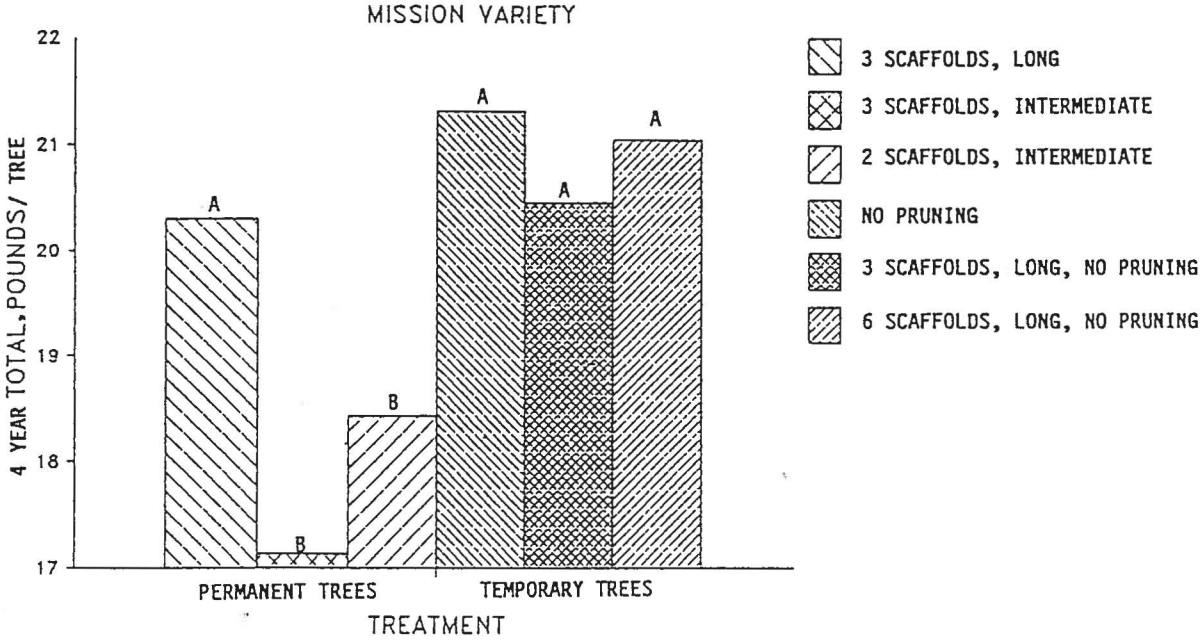
Data collected includes trunk circumference measurements, individual treatment yields, and observations on tree growth. The trial is harvested by commercial harvesting equipment. Gross field weight is taken by plot and then net yields are calculated by processing a four pound subsample.

Results and Discussion

On both the 'Butte' and 'Mission' varieties the temporary trees had the greatest yields. Cumulative per tree yields for the 1984 through 1987 seasons are shown in the figures. Trees that had no pruning had the highest per tree yields followed by trees pruned to 6 scaffolds and then those pruned to 3 scaffolds. Although these differences were not different statistically, the same trend held for both 'Butte' and 'Mission'.

CUMULATIVE YIELDS, LEWIS PRUNING TRIAL

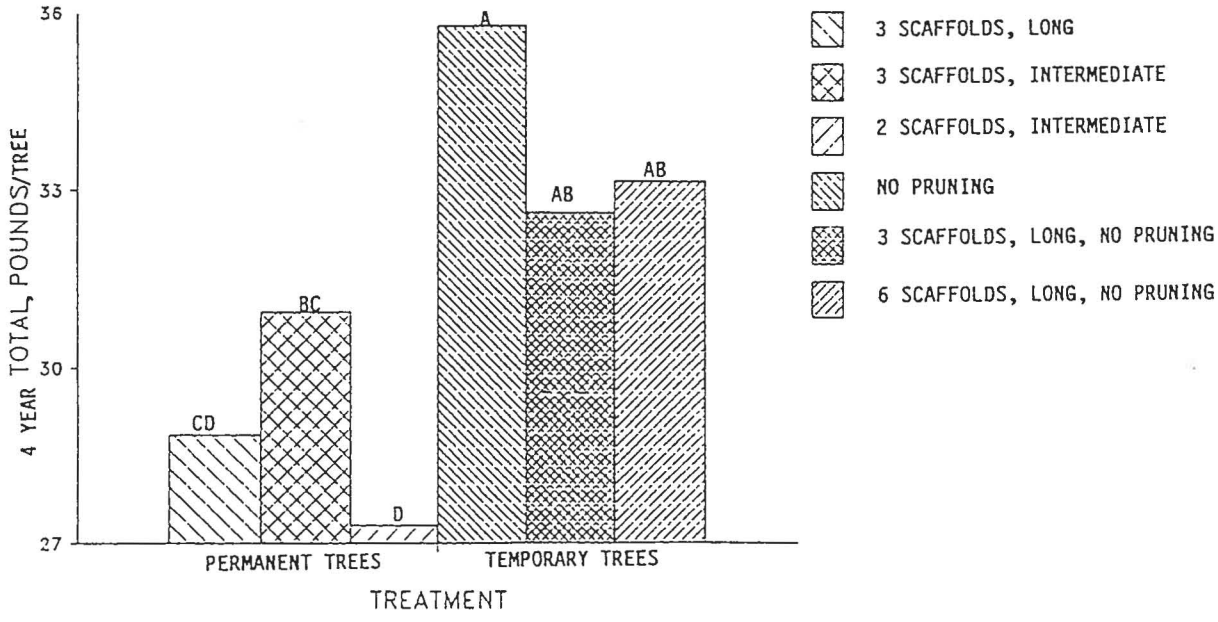
MISSION VARIETY



MEAN SEPARATION BY DUNCANS MULTIPLE RANGE TEST, P = 0.05.

CUMULATIVE YIELDS, LEWIS PRUNING TRIAL

BUTTE VARIETY



MEAN SEPARATION BY DUNCANS MULTIPLE RANGE TEST, P = 0.05.

Permanent trees generally had lower yields than the temporary trees because more pruning was done in the second, third, and fourth dormant seasons to maintain a sound branch framework for long term development. Yield variations between 'Butte' and 'Mission' relative to treatment are a result of different varietal growth habits.

When permanent 'Mission' trees were long pruned, there was little unwanted growth. With little need for subsequent pruning, yields were similar to those of unpruned temporary trees. Permanent 'Mission' trees pruned to two and three scaffolds and headed, generated more secondary branching which had to be pruned in the second and third years hence bearing was delayed.

'Butte' is a variety that is naturally more vigorous and more freely branching than 'Mission'. Permanent 'Butte' trees that were pruned to three scaffolds and left long and those pruned to two scaffolds required heavier pruning to maintain the desired framework. As a result, cumulative yields on those two treatments were lower, again due to a delay in bearing. The yields of the permanent three scaffold 'Buttes' that were headed were nearly as good as those of temporary trees where scaffold selection had taken place. On a freely branching variety such as 'Butte', some secondary scaffold selection due to first dormant season heading seems to have been beneficial in reducing the amount of subsequent pruning needed thereby hastening heavier early production.

Each method of tree training had an effect on tree development and on the type of pruning that would have to be done later if the tree was to be kept for the long term. Several observations were noteworthy regarding both the permanent and temporary trees.

All three treatments applied to permanent trees resulted in tree structure that would provide good tree longevity. Generally, only slight thinning of tertiary branches will be needed on these treatments as the trees reach full production. On the three scaffold long pruned trees secondary branches generally start at about six to seven feet. Tree structure is good for the long term and limb shaking will be possible when needed as trees increase in size. Three scaffold trees that had primary limbs headed at 36" generally had secondary scaffolds starting at about four to five feet. These trees display good growth and structure and good low fruitwood development. Occasionally, secondary branching may be too low on the primaries for limb shaking and some retraining may be necessary later. Two scaffold trees with primary limbs headed at 36" generally had secondary limbs starting at about five to six feet. These will make good long term trees but the training required in the early years is excessive. Under the good conditions in this orchard, vigorous watersprouts that continued to arise in the third and fourth years had to be pruned out to prevent development of a third or fourth primary scaffold limb.

All three treatments given to temporary trees worked well for the purposes of this trial. Trees receiving no pruning and those trained to six scaffolds have many primary limbs that could be easily removed when it's time to whisk back the temporary trees. Trees trained initially to three scaffolds were less crowded but had sufficient secondary branching that cutting them back before removal was still reasonable.

If goals changed and a decision was made to keep the temporary trees, retraining them for the long term would be difficult. Temporary trees receiving no pruning and those trained to six scaffolds had secondary branching starting high in the tree at about seven to nine feet. If primary branches were to be thinned out the choice of what to leave would often be poor. Since there were not many good choices to cut to, it would be difficult to correct the framework of these trees if they became permanent and limb shaking was necessary. Another observation of interest is that there was generally poor development of lateral fruitwood low in the tree on both of these treatments. This was especially true of the 'Mission' variety. Temporary trees trained to three scaffolds are a little better. Growth is more rangy with secondary scaffolds starting at three to five feet. If these trees were to be retrained, significant thinning of secondary and tertiary scaffolds would be needed but it could be done successfully with a decent tree resulting.

Overall, cumulative yields were greater with less pruning. Cumulative 'Butte' yields for the third through sixth years on permanent three scaffold trees left long (standard pruning) amounted to 2,020 pounds of meats per acre. Temporary 'Buttes' receiving no pruning accumulated 2,503 pounds of meats per acre in these first four harvests. At $1.20 per meat pound this translates to nearly a $580 per acre benefit if our best temporary tree treatment (no pruning) is compared to standard pruned trees. The 2,500 extra meat pounds per acre for the first four years translates to a gross benefit of approximately $3,000.00 per acre when a double planting with temporary trees is compared to a standard planted orchard. In spite of the increase that can be achieved through minimal pruning, training permanent trees for good structural strength should not be abandoned in pursuit of short term gains.

I wish to acknowledge the assistance and advice of Sam Lewis, Jr. in whose orchard this trial was conducted. Without the support and excellent cooperation provided by Sam and his crews this work would not have been possible.

2)

TRAINING AND PRUNING HEDGEROW ALMONDS

J. Edstrom, W. Krueger, J. Connell, W. Micke,
J. Osgood, W. Reil, J. Yeager

Our purpose was to develop methods to train Nonpareils for a hedgerow configuration and develop pruning systems capable of sustained high yields.

Interpretive Summary

Production Economics have pressed growers to increase the bearing in newly developed orchards. High density plantings can proportionately increase early yields given the increased trees planted per acre. Hedgerow systems where tree spacing is less within the row than between rows has allowed heavy early production with the use of existing equipment.

Concern over the viability of almond hedgerow systems arises as the trees crowd. Limited sunlight entry into the canopy can affect fruit bud formation and may confine production to the top of the canopy. Yields may then begin to decline resulting in a hedgerow orchard with less productive capacity or one with higher cultural costs than that of a standard planting.

Hedgerow research in other tree crops has shown the value of various tree training and pruning practices on maximizing early production without sacrificing mature yields.

In 1979 a Nonpareil - Price 1:1 block, was planted 7' x 22' (270 trees/acre) at the Nickels Soil Laboratory. The following four pruning treatments were begun at the end of the first growing season.

1) **Interplanted:** Trees were trained to 3 scaffolds then standard pruned 2nd - 6th years. Alternate trees were marked for removal and whisked back during 7th and 8th years to allow room for permanent trees to spread. Whisked trees removed after 9th year leaving a 14' x 22' spacing.

2) **Permanent Hedge:** Trees trained to 3 scaffolds and standard pruned throughout, maintaining 7' x 22' hedge.

3) **Two Scaffold Hedge:** Heavy 2nd and 3rd year training required to form 2 main scaffolds growing into the row middles. Standard pruning used 4th year on with hedge maintained.

4) **Unpruned Hedge:** Trees trained to 3 scaffolds then no further pruning.

Alternate trees whisked back two years before removal and then again one year prior to removal had 15% reduced yield each year following whisking. Removing 50% of the trees at the 9th year then reduced yields by 30%. Now, three years after removal, yield still lags by 18%. (See Figure 1).

When adding together 6 years of yield data no differences were found between the three tight hedgerow systems. However, the 4th treatment where alternate trees were removed yielded 2000 lbs. less over the 6 year period. (See Table 1).

Yields obtained for two scaffold trees were equal to yields from three scaffolds in close spacings. This trial will be maintained to evaluate the long term effect on yields of the 4 training systems.

FIGURE 1

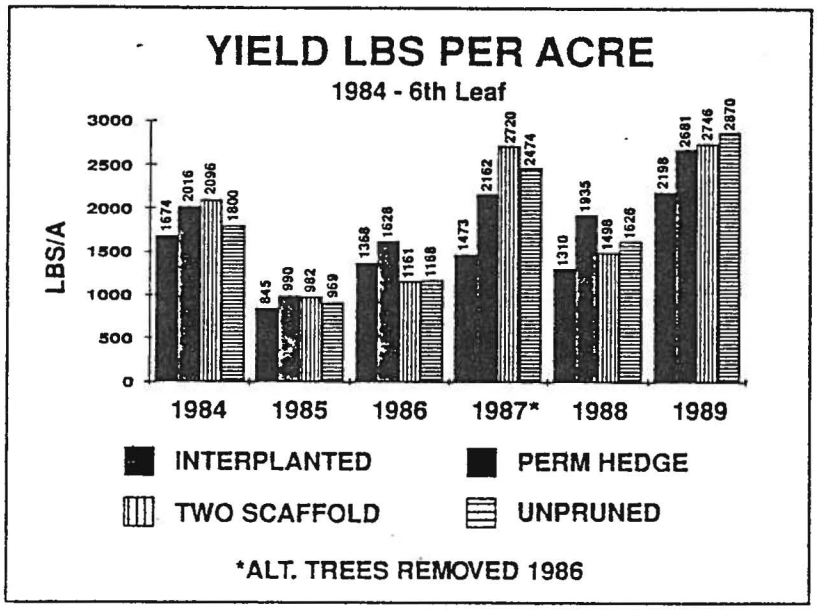


TABLE 1.

HEDGEROW ALMONDS

NonPareil - Price 1:1

Treatment	Accum. Yld Lbs/A
Interplanted	8,868
Perm Hedge	11,412
Two Scaffold Hedge	11,203
Unpruned Hedge	10,907

1984-89

3. What is the best way to prune to invigorate low vigor trees? (Warren Micke, Mark Freeman, Lonnie Hendricks, Robert Beede and James Yeager)

Some of the newer precocious varieties (such as Merced, Carmel and Harvey) produce little new vegetative growth by the time they reach full maturity around 10 to 12 years old. When using the conventional pruning technique of thinning out several 1 to 3 inch diameter limbs each year these varieties are not usually invigorated. In addition it is often hard to find limbs to thin out when pruning such trees. At the conclusion of a long term rootstock trial at the Westside Field Station we had Harvey almond trees in such a condition on almond, Lovell and Nemaguard rootstocks.

Methods and Materials

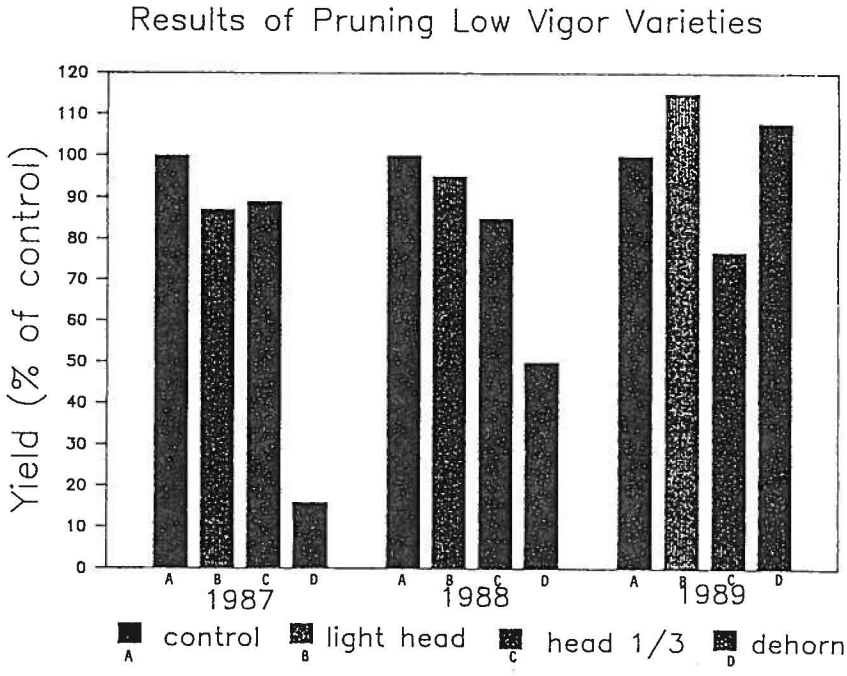
A test plot was established during the winter of 1986-87 using 11-year-old Harvey trees on almond, Lovell and Nemaguard rootstock which were making little or no new growth. The 4 pruning treatments used were (1) normal thinning out (control), (2) approximately 20 small heading cuts - 1/2 to 1 inch in diameter - made per tree (heading), (3) moderately head back all the terminal branches on 1 scaffold, generally one-third of the tree, each year for a 3 year cycle (heading-1/3), and (4) cutting back the entire tree to 6 to 8 feet (dehorning).

For the 1987-88 and 1988-89 winters, the controls have continued to be thinned out; the heading treatment have continued with a moderate amount of heading; the heading-1/3 trees have continued to have one-third of the tree headed each year; and the dehorned trees had excess shoot growth thinned out.

In 1987 the yield on each tree was estimated independently by 4 of the project leaders and the data compiled giving a good estimation of the production for that season. In 1988 and 89 actual yields were taken similar to methods used in the Regional Variety Trials.

Results and Discussion

In 1987, dehorning drastically reduced production while the two heading treatments reduced yield moderately as compared to the control (see the following figure).



However, tree vigor was improved by both heading treatments (heading-1/3 mainly increased vigor on the headed scaffold) and, as expected, dehorned trees responded with very vigorous growth. In 1988, the control still had the highest yield. As compared to the control, yield was reduced on the heading treatment by about 5%, the heading-1/3 treatment by approximately 15% and the dehorning treatment by nearly 50%. By 1989 the heading and dehorning treatments outyielded the control by 15% and 8%, respectively, though these differences were not statistically significant. However, the control significantly outproduced the heading-1/3 treatment by 23%. This may be a result of heading of one-third of the tree just the previous winter while the other heading treatments had the most severe pruning done 2 years earlier. Plans are to continue collecting production data from this plot in 1990.

4. Alternate Year Pruning of Almonds

William Krueger, Warren Micke, James Yeager and Joseph Connell

Objectives

Annual pruning is a recommended procedure for mature almonds. Growers who prune every other year or even once every three years have been observed with no apparent deleterious effects to tree vigor or production. Alternate year pruning has been shown to be an acceptable practice with lateral bearing walnuts. This study was undertaken to compare the impact of alternate year pruning to that of annual pruning on mature almond production and kernel quality.

Procedure

A mature uniform 20 acre block of almonds planted in 1978 located in Hamilton City was selected for the trial. The planting is a 1:1 planting with 50% NonPareil, 25% Price and 25% Peerless and 70 trees per acre. Only NonPareil was used for the pruning treatments. The 10 acres of NonPareil were divided into a randomized complete block with four treatments and five replications. Yield data was collected one year prior to assigning the treatments to make sure that there were no significant differences due to block location. The treatments were initiated during the winter of 87-88 and included; 1.) annual pruning, 2.) pruning in even numbered years, 3.) pruning in odd numbered years, and 4.) unpruned (starting in 1987). Pruning has been the same for all the pruned treatments and consisted of four, approximately 1.5 inch or larger cuts per tree or the equivalent. Average pruning weights have been collected following each pruning.

Results and Discussion

After two years there have been no significant differences in yield or kernel size. However, in 1988 the unpruned trees had the highest yield, followed in order by those pruned in 1987-88 (but not in 1988-89), by those pruned in 1988-89 (but not in 1987-88), and finally by annually pruned trees. Unpruned trees will undoubtedly decline in production in the future as bearing wood becomes old and is not renewed. The full effect of alternate year versus annual pruning will not be known for at least two more years, and possibly longer, and plans are to continue this study for at least two more years.

5) COMPARISON OF PRUNING NONPAREIL ALMOND TREES BEFORE LEAF DROP IN THE FALL VS. DORMANT PRUNING

Wilbur Reil, Warren Micke, Jim Yeager, and Charles Langston

A pruning trial was initiated in Yolo County on Nonpareil almonds in 1985 to evaluate early vs. complete dormant pruning. Labor for pruning during the winter is becoming increasing scarce. If some pruning could be done after harvest more labor would be available and weather conditions are generally more condusive to field work. This experiment was designed to evaluate if there might be any adverse effects to early pruning.

The grower orchard was on deep Yolo loam soil with a solid set sprinkler irrigation system. Trees were uniform, eight years old and had a good production history. The 48 trees were randomized in a complete block using single trees for each treatment. The three treatments were pruning each year approximately October 15, November 15, and December 15. The same workers pruned the trial throughout the four years of the trial and tried to remove comparable quanities of wood and develop the same type canopy each year.

Pruning consisted of making approximately 3 to 6 cuts of 2 to 4 inch diameter with the least cuts from trees having the larger limbs removed. Limbs were pruned from any area that might interfer with cultural practices from cross limbs, dense crowded areas and from the center of the canopy. Trees had been pruned every year before the trial so had strong, healthy growth at the beginning of the trial and this youthful condition was maintained. One year old water sprouts were also removed except when needed for a replacement limb. Approximately 10% of the fruiting wood was removed each year.

Leaf analysis for several elements was conducted each summer to compare treatments. During the four years no statistically significant differences in levels of nitrogen, potassium, calcium, magnesium, zinc, manganese or copper occurred.

Trees were individually harvested and the gross weight per tree taken. A sample of the gross was used to compute the percent kernal weight which was then multiplied to convert gross weight to net weight. Trunk circumferences were measured and converted to cross sectional area. Statistically there were no differences between treatments in yield each year, average yield, trunk cross sectional area, increase in trunk cross sectional area, yield / cross sectional area or yield / increase in trunk cross sectional area. The actual yield was slightly higher in the October pruned trees and slightly lower in the November pruned trees. The November pruned trees actually had two trees that showed more weakness than any of the other trees in the trial causing the decrease in yield and growth each year of the trial.

TABLE 1 DIFFERENCES BETWEEN THE THREE TIME OF PRUNING TREATMENTS

TIME OF PRUNING	OCT.	NOV.	DEC.
AVERAGE YIELD (LBS./AC)	2035	1838	1961
INCREASE IN TRUNK CROSS SECTIONAL AREA (SQ. IN.)	360	353	366
YIELD / CROSS SECTIONAL AREA	2.19	1.98	2.05

Observations on disease incidence showed no adverse effects from any of the pruning timings. Based on these trials it appears that almond orchards can be pruned after harvest without a deliterious effect on the next years crop or the nutritional status of the tree.

6) MECHANICAL PRUNING OF ALMONDS

PROJECT LEADERS:

Mario Viveros
Farm Advisor
1031 S. Mt. Vernon Ave.
Bakersfield, CA 93307
(805) 837-1338

Paramjit Dosanjh
Manager of Technical Services
500 Laval Road
Arvin, CA 93203
(805) 858-2291

COOPERATING PERSONNEL:

Lynette Beurmann and John Vernon

OBJECTIVES:

To evaluate mechanical hedging on mature almond trees for fruiting wood renewal, light penetration, mummy removal and yield performance.

METHOD:

A mature almond orchard (14 years-old) was selected for this plot. The orchard is a 2 and 1 variety combination - two Nonpareil, one Mission and one Merced row. The planting distance was 24' X 24'.

The soil is a very deep sandy loam from the Hisperia soil series. The orchard has had a good yield record. It's yield of 2,000 meat pounds has been very consistent.

The orchard has been hand prune every other year. The pruning consisted of opening the tree center, cutting off crossing over limbs and removing old-fruiting wood. The other cultural practices such as irrigation and fertilization have been standard practices.

The test plot consisted of two replications. There were two Nonpareil, one Merced and one Mission row in each replication. There were 55 trees in each row. The data came from the two Nonpareil rows.

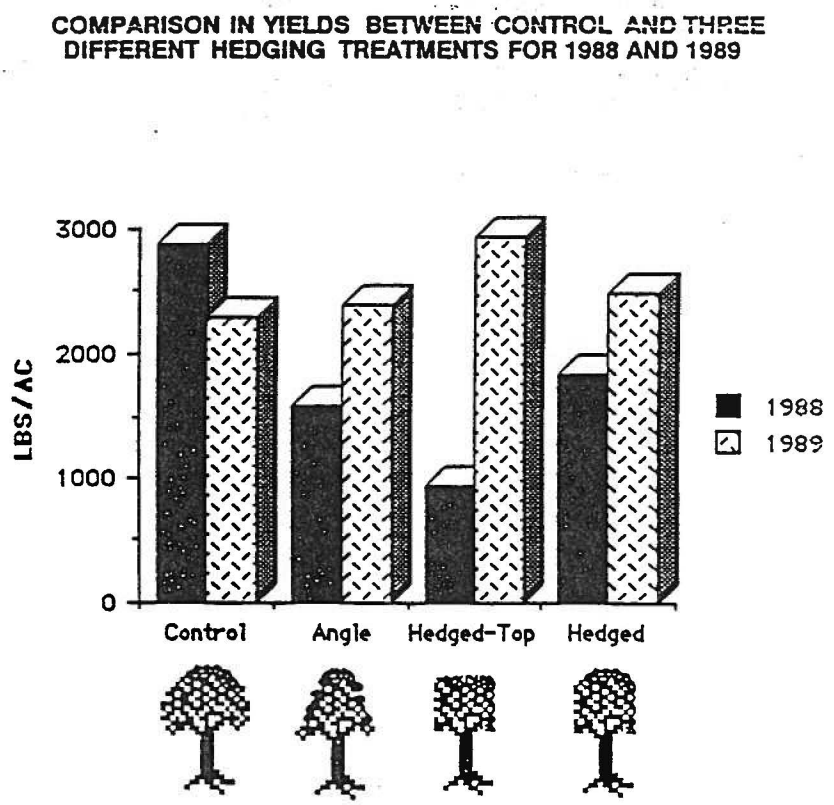
The treatments were established during the 1987 dormant season and they were: Hedging, Angle hedging, Hedged-topped and Control. The hedging was done perpendicular to the ground, eight feet from the trunk and down the tree row. This treatment left a distance of eight feet between rows. The angle hedging treatment was done by tilting the hedging arms of the hedging machine 30 degrees from the vertical position. The hedged-topped treatment was done by hedging perpendicular to the row, eight feet from the trunk and down the tree row. Then, the trees were topped at 30 feet. The control treatment was not pruned but it was pruned in the 1986 dormant season. The test plot was harvested by commercial harvesting equipment. Gross weights were taken and then net yields per acre were calculated by standard procedures.

RESULTS AND DISCUSSION:

The test plot was harvested in 1988 and 1989. The results can be seen in the following table.

TREATMENT	*YIELD 1988*	*MEAT POUNDS/ACRES 1989*
Control	2875	2300
Hedging	1840	2482
Angle Hedging	1590	2386
Hedged-Topped	945	2948

The yield in 1988 decreased proportionally to the severity of hedging. The more fruiting wood was removed, the greater the yield losses. In 1989, both hedging and angle hedging increased in yield. However, the increase wasn't much different from the control. The dramatic increase was on the hedged-topped treatment. The yield increased 648 meat pounds over the control. This increase however doesn't come close to the 1930 meat pounds lost in 1988.



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