FULL REPORT

Pistachio Canopy Management by Moderate Mechanical Hedging and Topping: Fifth Year Progress Report

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SUMMARY

Increasing labor costs, limited numbers of skilled pruners, large acreage and aging pistachio canopies requiring heavy pruning to provide light, reduce foliar diseases and restrict tree size for harvest are all reasons why California pistachio growers are considering mechanical pruning as an economical method for long term canopy management.

The first research on mechanically pruning pistachios was primarily focused on mitigation of alternate bearing. Ferguson conducted a trial from 1985-91 with Paramount Farming in western Kern County to compare severe hedging and topping before the off-year to hand pruned trees (2). Severe topping (removal of four to five year-old growth) reduced in-shell split yield much more than severe side hedging during the season in which each practice was performed. Topping also significantly reduced but did not eliminate alternate bearing compared to hand pruning. Yield differences between topped and hand pruned trees persisted longer than between hedged and hand pruned. Therefore, mechanical topping of pistachios has been approached cautiously by the industry.

From 1988-91, Ferguson et. al. incorporated observations from the first trial into a second mechanical pruning experiment to study the effects of moderate single and double sided hedging on production (3). Using two locations, replicated experiments conducted prior to on and off-bearing years showed no significant yield reductions between hedged and hand pruned trees. Beede later reported pistachios compensate for substantial fruit bud removal by increasing the number of nuts per cluster and to some degree, fruit size (1).

These trials are the present basis for implementing mechanical pruning in California pistachios. Growers have also contributed significantly by sharing personal experiences with long term side hedging. Most agree side hedging reduces pruning costs without sacrificing yield. However, opinions widely differ on how long one can side hedge before dealing with the multiple branching produced from the heading cuts by selective hand pruning. In addition, growers and researchers are uncertain about how to employ topping without suffering the large yield depression reported. Consequently, this pruning study was initiated in 1997 to study the long-term response to hedging and topping individually and in combination so that improved guidelines could be offered to the industry. This report summarizes the results from the fifth of at least a six-year study.

PROCEDURES

A dense, uniform 17 year-old Kerman pistachio orchard spaced 17 ft. x 17 ft. and grown on *P. integerrima* (Pioneer Gold I) rootstock was selected for the study near the southwestern border of Kings County and Interstate 5. Owner Kewel Munger has provided an ideal 30 acre test area because it is one of the oldest and most dense orchards on *P. integerrima* stock. Drip irrigation, uniform tree size, row orientation (north-south), short row lengths (59 trees), absence of any previous mechanical

pruning, heavy production history and lack of foliar or nut diseases to interfere with yield make this an excellent site to study the response from mechanical pruning.

Prior to the 1997 season, the following pruning treatments were randomly assigned to entire rows as a split-plot experimental design:

1. Hand pruned
2. Hedge one side
3. Hedge one side + top one year-old wood 50%
4. Hedge one side + top one year-old wood 100%
5. Hedge two sides
6. Hedge two sides + top 50%
7. Hedge two sides + top 100%
8. Top one year-old wood 50%
9. Top one year-old wood 100%

The 30 acre site was divided into four blocks (replications), each consisting of 18 rows. Each block was then equally divided into a north and south half to which the on and off-year pruning factor was randomly assigned. Treatment rows are bordered by non-data rows which were pruned in the same manner as its neighboring treatment. Side hedging was performed approximately six feet from the tree trunk with the saw boom slanted seven degrees into the canopy. This resulted in cutting the uppermost portion of the canopy one foot deeper than the canopy skirt. Topping height was adjusted to cut the one year-old wood either approximately in half or close to 100%. The 100% topping level was gauged by the number of cuts made into two year-old wood. Normal hand pruning was then performed on the control trees and those portions of the hedged and topped trees not done mechanically.

Prior to the 1998 season, the same treatments were established on the other half of the row which received hand pruning in 1997. Trees hedged on only one side in 1997 were hedged on the other side in 1998. Topping was also repeated; however, based upon on-site advice provided by members of the pistachio research committee, treatments requiring 100% topping were not re-topped at the same level. The committee felt removing all the one-year-old fruit wood again would further depress yield based on the first year results. Hence, to simulate what growers would most likely do commercially, trees receiving 100% topping in 1996 were re-topped at only 50%. In 2001, the trees in the first treatment set received their fifth cycle of pruning. The other half of the trial was mechanically pruned for the fourth time.

The 2000 season was the first time the severely topped treatments were re-topped during the summer (August 1). This was done to discover a practical method for controlling the vigorous re-growth associated with dormant topping. Without this, managing tree height in mature orchards will be difficult because they will rapidly regain their original size. Due to the lack of re-growth, these trees were not topped prior to the 2001 season.

Except for 2001, 30 clusters were sampled prior to harvest from each treatment to determine any treatment effects on nuts per cluster. This data was discontinued this season since no differences had been recorded since 1997.

Commercial harvest was performed September 26 and 27. Fruit from each treatment was brought from the field in marked bins to a staging area for weighing prior to dumping. A 30 pound sample randomly collected from each plot was submitted immediately to the processor for third party evaluation. The results were then used to produce a growers receipt statement from which the total dry yield, edible split nuts, edible closed shell, shelling stock and blank nuts were determined on a per acre basis.

RESULTS

This is now the fifth year of data collection for the pruning treatments initiated in 1997. Comparing their average edible split nut yield for all nine treatments with the average from the block initiated in 1998 shows an alternating trend in production between the two plots that is well correlated with pruning severity. Average overall yield is consistently lower in the block that is double-side hedged prior to the bearing year.

Tables 1 and 2 show the 2001 yield summaries for the 1997 and 1998 pruning treatments. This was the second off-year experienced during the project. The hand pruned trees averaged 1,482 pounds of edible split nuts compared to 1,418 pounds for trees hedged on one side and 1,395 for trees hedged on both sides. Therefore, no significant differences in edible split nut production were observed among the side hedging treatments. Also, for the second consecutive year, trees hedged on both sides prior to the current season were not significantly less in edible split nut yield compared to trees hedged on only one side. In 2000, trees hedged on two sides yielded 4,216 pounds of edible split nuts compared to 4,208 for the single-side hedging treatment. In 2001, the edible split nut production was 1,267 and 1,494 pounds, respectively. Although not statistically significant, double-sided hedging prior to an off-year reduced edible split nut production by 15% compared to the single-side treatment. Review of previous years data indicates that the degree to which two-sided hedging depresses yield is inversely related to potential crop load (the greater the expected crop, the less depression in yield).

Tables 1 and 2 show some significant differences in edible closed and blank nut production were observed in the side hedging treatments during the 2001 off-year. However, plotting the data suggests it is much more correlated to the amount of total dry nut production than to side hedging.

The five-year cumulative yield data for the 1997 treatments is summarized in table 3. Hand pruned trees have produced 13,103 edible split pounds compared to 12,825 for trees hedged one side annually and 12,114 for trees hedged on both sides biennially. Although these values do not differ statistically, annual hedging on one side has yielded most similar to hand pruned trees. The cumulative edible split nut yield of trees hedged on both sides is 989 pounds (7.5%) less than the hand pruned treatment. Table 4 shows the results from four years cumulative yield data for the treatments initiated in 1998. They are very similar to the treatments initiated in 1997.

Review of data collected in 1999, 2000 and 2001 suggests that the impact topping has on loss of edible split nut production is most strongly correlated to the potential crop level. During these three years, almost identical flower bud numbers were removed from the 50% topping treatments initiated in 1997. The resulting reduction in yield compared to hand pruned trees was similar. However, in 1999 and 2001, both off-years, the loss represented 21.5% and 28.6% of the hand pruned trees. In contrast, a similar loss in yield in 2000, a heavy on-year, represented only 6.6%. Thus, the reduction from topping becomes significant when excessive bud numbers are removed relative to the trees cropping potential.

Shoot growth data collected over the above three years indicates greater vigor during the off-year. Following the 1999 season, shoot length from the 50% topping treatments averaged 18 inches. After the 2000 on-year, the average shoot length was only five inches. The amount of growth was proportional to topping severity prior to the off-year.

Results from topping in season in an effort to mitigate the vigorous re-growth caused by severe topping in winter appear promising. Trees topped in early August of 2000 just above the fruiting zone produced minimal new growth. Data reported last year also indicated no adverse effects on closed or blank nut production. Due to the lack of re-growth, no winter topping was performed on these treatments. This resulted in an average increase in split nut production of 243 pounds compared to the hand pruned trees. However, the increased yield was not nearly sufficient to compensate for the 1,351 pounds of edible split nuts lost from severe topping in 2000. Trees receiving moderate topping prior to the 2001 off-year averaged 492 pounds less edible split nuts (tables 1 and 2).

After five years, the cumulative yield loss from moderate mechanical topping alone is 892 pounds of split nuts compared to the hand pruned trees (table 3). When combined with single or two-sided hedging, the average loss is 1,379 pounds. Table 4 shows the same trend is present in the four-year cumulative data from plots initiated in 1998.

Table 3 also shows the five-year cumulative yield loss from severe mechanical topping. The loss from severe topping alone is 1,989 pounds. This reduction would actually be greater if severe topping had been performed annually. However, in 1998 these treatments were re-topped at only 50% to allow observations on yield recovery. They were also not topped prior to the 2001 season since in-season topping prevented sufficient re-growth. When severe topping is combined with single or two-sided hedging, the average loss in edible split nuts relative to hand pruned trees is 1,562 pounds.

Tables 5 and 6 show that nut size continues to be slightly larger in the mechanically pruned trees. Less difference was observed in 2001 than 2000, suggesting that nut size is more sensitive in heavy crop years. Differences in nut size were not observed until 2000. The in-season topping performed in 2000 did not appear to have any negative effect on nut development in 2001.

CONCLUSIONS AND PRACTICAL APPLICATION

This trial and others preceding it strongly suggest pistachios can be mechanically hedged without suffering economic yield loss. Although data collected only during the first year supports it, previous detailed pruning experiments show pistachio compensates for lost fruit buds by increasing the number of nuts set per remaining cluster. Results from this trial indicate there is less yield fluctuation by hedging one side every year compared to hedging both sides every other year. Cumulative yield data also suggests that the fluctuation may lessen with repeated side hedging. This may be associated with the amount of growth removed when hedging is first initiated. Due to the density of the test orchard at the time hedging began, the large amount of growth removed may have been more than the tree could compensate for.

The yield differences between single and double-side hedging in any given year is also affected by the potential crop. Based on results from this experiment, two-sided hedging should not be preformed prior to a low production year. Evidence for this recommendation is found in the last three seasons. In

1999, edible split nut production was only 1,900 pounds per acre in the hand pruned trees. Double-sided hedging significantly reduced edible split nut yield by 316 pounds (19%) per acre compared to single-side hedging. In 2000, edible split nut production was in excess of 4,000 pounds and no significant yield difference was recorded between single and double-side hedging. Trees hedged on both sides the previous year produced significantly more edible split nuts (363 pounds) in 2000 than trees hedged on one side annually. This increase was very close to the yield reduction recorded in 1999 from hedging. In 2001, another off-year, two-sided hedging reduced edible split nut yield by 227 pounds relative to single-side hedging

It is still unclear whether pistachio canopy height can be managed by mechanical topping without suffering significant yield loss. Thus far, topping at levels designed to replace manual tipping has not significantly reduced yield. This appears to be an acceptable, cost saving substitute that has already been implemented by growers. However, repeated mechanical topping of one-year-old growth by 50% will continue to allow additional gains in tree height and eventual shading in the lower canopy. Correction will most likely require a remedial topping to remove up to five feet of growth. Data collected during the past three seasons suggests that the yield loss from topping is more correlated to the potential crop than physiological conditions associated with on and off-year bearing cycles. This conclusion is based on the absolute versus percent yield loss recorded from trees with almost identical numbers of flower buds removed by topping. In this case, a similar loss in edible split nuts was observed but the percentage relative to hand pruned trees was much greater in low production years. These results suggest that topping for tree size control prior to an off-year will most likely aggravate low yield in the current season and accentuate alternate bearing.

Experimentation with in-season re-topping to control vigorous growth appears promising. Trees re-topped in early August of 2000 grew very little and nut quality was not adversely affected that year. However, the severe topping reduced split nut yield by 1,351 pounds compared to hand pruned trees. Leaving these trees un-topped in the winter resulted in 243 pounds more split nuts than the hand pruned trees, making the net loss over two years 1,108 pounds.

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LITERATURE CITED

1. Beede, R., L. Ferguson, D. Rose and J. Padilla. Effect of pruning on the yield components of pistachio. California Pistachio Commission Ann. Rept. 1990-91. pp. 90-92.
2. Ferguson, L., J. Maranto and R.Beede. Mechanical topping mitigates alternate bearing on 'Kerman' pistachios. Hort. Science. vol. 30(7):1369-1372.
3. Ferguson, L., J. Maranto and R. Beede. Effect of mechanical hedging on yield of pistachios: final report. California Pistachio Commission Ann. Rept. 1991-92. pp. 105-7.

Table 1. Mature pistachio tree 2001 yield and nut quality for hand pruned versus various hedging and topping treatments initiated prior to the 1997 on-year. Treatment values with different letters differ significantly. ($P \leq 0.05$).

	Pounds/acre @ 5% Moisture			
Treatment	Total Dry Yield	Splits-Clean +Light Stain	Edible Closed Shell	Blanks
1. Hand Pruned	3085 c	1249 b	1105 bcd	136 bc
2. Hedge 1 side	3532 bc	1494 ab	1223 bc	210 abc
3. Hedge 1 side + mod. top	2308 d	888 c	859 de	164 bc
4. Hedge 1 side + severe top	3741 bc	1546 ab	1333 b	260 ab
5. Hedge 2 side	3084 c	1267 b	971 cde	178 bc
6. Hedge 2 side + mod. top	1935 d	695 c	749 e	119 c
7. Hedge 2 side + severe top	3581 bc	1516 ab	1235 bc	216 abc
8. Top one-year-old mod.	2202 d	892 c	750 e	179 bc
9. Top One-year old severe	4418 a	1684 a	1712 a	293 a
LSD (P=0.05)	557	339	302	86

	Contrasts			
	Total Dry Yield	Splits-Clean +Light Stain	Edible Closed Shell	Blanks
1. Hand Pruned vs. 1 or 2 side hedging	N.S.	N.S.	N.S.	N.S.
2. Hedge 1 side vs. hedge 2 sides	3194 * 2867	N.S.	N.S.	N.S.
3. Hand pruned vs. mechanical	N.S.	N.S.	N.S.	N.S.
4. Topped 50% vs. topped 100%	2148 * 3913	822 * 1582	786 * 1427	164 * 256

N.S. = Not Significant at P= 0.05
* = Significant at P=0.05

Table 2. Mature pistachio tree 2001 yield and nut quality for hand pruned versus various mechanical hedging and topping treatments initiated prior to the 1998 off-year. Treatment values with different letters differ significantly ($P \leq 0.05$).

	Pounds/acre @ 5% Moisture			
Treatment	Total Dry Yield	Splits-Clean +Light Stain	Edible Closed Shell	Blanks
1. Hand Pruned	3744 cd	1714 abc	1096 bc	228 bcd
2. Hedge 1 side	3904 cd	1682 abc	1324 b	230 bcd
3. Hedge 1 side + mod. top	3159 d	1253 cd	1209 bc	191 d
4. Hedge 1 side + severe top	4150 bc	1650 abc	1516 ab	295 abc
5. Hedge 2 side	3904 cd	1519 bc	1514 ab	206 cd
6. Hedge 2 side + mod. top	3388 cd	1283 cd	1330 b	232 bcd
7. Hedge 2 side + severe top	4941 a	2091 a	1796 a	305 ab
8. Top one-year-old moderate	2375 e	935 d	909 c	149 d
9. Top One-year old severe	4667 ab	1853 ab	1757 a	327 a
LSD (P=0.05)	725	453	381	83

	Contrasts			
	Total Dry Yield	Splits-clean +Light Stain	Edible Closed Shell	Blanks
1. Hand Pruned vs. 1 or 2 side hedging	N.S.	N.S.	1096 * 1419	N.S.
2. Hedge 1 side vs. hedge 2 sides	N.S.	N.S.	N.S.	N.S.
3. Hand pruned vs. mechanical	N.S.	N.S.	1096 * 1419	N.S.
4. Topped 50% vs. topped 100%	2974 * 4586	1157 * 1865	1149 * 1690	191 * 309

N.S. = Not Significant at P= 0.05
* = Significant at P=0.05

Table 3. 1997 -2001 cumulative yield of mature pistachios following various mechanical hedging and topping treatments initiated prior to the 1997 on-year. Treatment values with different letters differ significantly. ($P \leq 0.05$)

	Pounds/acre @ 5% Moisture			
Treatment	Total Dry Yield	Splits-Clean +Light Stain	Edible Closed Shell	Blanks
1. Hand Pruned	22032 a	13103 a	5366 a	1294 a
2. Hedge 1 side	22263 a	12825 ab	5804 a	1334 a
3. Hedge 1 side + mod. top	20941 a	12084 abc	5630 a	1289 a
4. Hedge 1 side + severe top	20718 a	11366 c	5848 a	1397 a
5. Hedge 2 side	21265 a	12114 abc	5694 a	1290 a
6. Hedge 2 side + mod. top	20537 a	11364 c	5769 a	1355 a
7. Hedge 2 side + severe top	21412 a	11717 bc	6173 a	1345 a
8. Top one-year-old moderate	20834 a	12211 abc	5247 a	1347 a
9. Top One-year old severe	20737 a	11114 c	6035 a	1413 a
LSD (P=0.05)	1669	1206	745	227

	Contrasts			
	Total Dry Yield	Splits-clean +Light Stain	Edible Closed Shell	Blanks
1. Hand Pruned vs. 1 or 2 side hedging	N.S.	N.S.	N.S.	N.S.
2. Hedge 1 side vs. hedge 2 sides	N.S.	N.S.	N.S.	N.S.
3. Hand pruned vs. mechanical	N.S.	13103 * 11849	N.S.	N.S.
4. Topped 50% vs. topped 100%	N.S.	N.S.	5549 * 6019	N.S.

N.S. = Not Significant at P= 0.05
* = Significant at P=0.05
** =Highly Sigbificant at P=0.01

Table 4. 1998 -2001 cumulative yield of mature pistachios following various mechanical hedging and topping treatments initiated prior to the 1998 off-year. Treatment values with different letters differ significantly. ($P \leq 0.05$)

	Pounds/acre @ 5% Moisture			
Treatment	Total Dry Yield	Splits-Clean +Light Stain	Edible Closed Shell	Blanks
1. Hand Pruned	18216 a	14082 a	4091 a	1011 a
2. Hedge 1 side	17724 ab	13184 ab	4229 a	1084 a
3. Hedge 1 side + mod. top	16652 bcde	12884 b	4193 a	1022 a
4. Hedge 1 side + severe top	15443 e	11011 d	4308 a	1031 a
5. Hedge 2 side	17321 abc	12666 b	4290 a	1046 a
6. Hedge 2 side + mod. top	16683 bcd	12495 bc	4276 a	989 a
7. Hedge 2 side + severe top	16501 bcde	11460 cd	4438 a	1099 a
8. Top one-year-old moderate	15854 de	12340 bc	3958 a	962 a
9. Top One-year old severe	16295 cde	11413 cd	4666 a	1120 a
LSD (P=0.05)	1163	1079	529	135

	Contrasts			
	Total Dry Yield	Splits-clean +Light Stain	Edible Closed Shell	Blanks
1. Hand Pruned vs. 1 or 2 side hedging	N.S.	14082 * 12925	N.S.	N.S.
2. Hedge 1 side vs. hedge 2 sides	N.S.	N.S.	N.S.	N.S.
3. Hand pruned vs. mechanical	18216 * 16559	14082 * 12393	N.S.	N.S.
4. Topped 50% vs. topped 100%	N.S.	12573 * 11295	4142 * 4471	684 * 1050

N.S. = Not Significant at P= 0.05
* = Significant at P=0.05
** =Highly Sigbificant at P=0.01

Table 5. Effect of hand versus mechanical side hedging and topping initiated in 1997 on nut size in 2001.

Treatment	Nut Size:	Percent 18/20	21/25	26/30
1. Hand Pruned		60.7 c	39.3 a	0.0 a
2. Hedge 1 side		67.9 bc	32.1 ab	0.0 a
3. Hedge 1 side + mod. top		66.8 bc	33.2 ab	0.0 a
4. Hedge 1 side + severe top		71.0 ab	28.2 bc	0.0 a
5. Hedge 2 side		67.5 bc	32.5 ab	0.0 a
6. Hedge 2 side + mod. top		72.9 ab	27.1 bc	0.0 a
7. Hedge 2 side + severe top		67.8 bc	32.2 ab	0.0 a
8. Top one-year-old moderate		78.9 ab	31.1 c	0.0 a
9. Top One-year old severe		70.8 abc	29.2 bc	0.0 a
LSD (P=0.05)		9.6	9.6	0.0

	Contrasts 18/20	21/25	26/30
1. Hand Pruned vs. 1 or 2 side hedging	N.S.	N.S.	N.S.
2. Hedge 1 side vs. hedge 2 sides	N.S.	N.S.	N.S.
3. Hand pruned vs. mechanical	60.7 * 70.4	39.3 * 30.7	N.S.
4. Topped 50% vs. topped 100%	N.S.	N.S.	N.S.

N.S. = Not Significant at P= 0.05
* = Significant at P=0.05

Table 6. Effect of hand pruned versus mechanical side hedging and topping initiates in 1998 on the nut size in 2001.

Treatment	Nut Size:	Percent 18/20	21/25	26/30
1. Hand Pruned		62.3 a	37.7 a	0.0 a
2. Hedge 1 side		71.4 a	28.6 a	0.0 a
3. Hedge 1 side + mod. top		63.1 a	36.9 a	0.0 a
4. Hedge 1 side + severe top		70.2 a	29.8 a	0.0 a
5. Hedge 2 side		70.2 a	30.3 a	0.0 a
6. Hedge 2 side + mod. top		70.7 a	29.3 a	0.0 a
7. Hedge 2 side + severe top		62.2 a	37.8 a	0.0 a
8. Top one-year-old moderate		77.0 a	23.0 a	0.0 a
9. Top One-year old severe		71.0 a	29.0 a	0.0 a
LSD (P=0.05)		10.5	10.5	0.0

	Contrasts 18/20	21/25	26/30
1. Hand Pruned vs. 1 or 2 side hedging	N.S.	N.S.	N.S.
2. Hedge 1 side vs. hedge 2 sides	N.S.	N.S.	N.S.
3. Hand pruned vs. mechanical	N.S.	N.S.	N.S.
4. Topped 50% vs. topped 100%	N.S.	N.S.	N.S.

N.S. = Not Significant at P= 0.05
* = Significant at P=0.05