WALNUT ORCHARD MANAGEMENT: FIELD TESTING, ADAPTIVE RESEARCH AND PROBLEM SOLVING BY COOPERATIVE EXTENSION ADVISORS AND SPECIALISTS


ABSTRACT

Walnut cultivars and promising selections are being field evaluated at 24 sites in 13 counties by U.C. Cooperative Extension Farm Advisors. In addition, walnut rootstocks (Juglans species and English walnut seed sources and clones) are being tested in 7 field trials. A new cultivar, 'Tulare', was released on the basis of performance data collected from some of these trials. Mechanical topping treatments were established in the Chico walnut hedgerow trial (22' x 11') which was planted near Vina in 1974, trained into fruiting walls and mechanically pruned since 1978. The treatments designed to evaluate ways in which to lower and control tree height include (a) annual hedging one side - no topping, (b) annual hedging or topping one side, (c) hedging and topping one side, (d) hedging and dormant topping followed by summer topping one side, and (e) standard density - hand pruned control. Walnut cultivars and advanced selections are being evaluated for their performance under high density hedgerow management in trials in Tulare, Yolo, and Stanislaus Counties. 'Tulare' continues to show considerable promise for hedgerow planting with yields comparable to 'Chico'. The cultivars 'Vina' and 'Chandler' also have high relatively yields and appear suitable for hedgerow planting. In contrast 'Howard' being a tree with smaller stature needs to be planted more closely to fully utilize available space and maximize per acre yield. It also appears that 'Howard' does not perform well in sites that limit tree vigor/size. Tree density and row orientation affect yield and must be considered along with the increased costs of planting and tree development associated with greater tree numbers. Cultivars with a spreading type of growth habit (e.g. Vina) may be particularly sensitive to problems associated with increased tree crowding and shading. A trial was initiated in a young 'Chandler' orchard in a standard planting (26' x 26') comparing three mechanical hedging and two hand pruning techniques. Evaluations are being made on economics, yield and fruit quality to assess the adaptability of mechanical hedging as a substitute for hand pruning in conventional walnut orchards.

OBJECTIVE

The general objective of this project is to support applied and site-specific adaptive research conducted by C.E. Farm Advisors and Specialists, field testing of rootstocks and cultivars, and AES mission-oriented research efforts. All of this activity is reported through normal workgroup and industry liaison channels, however, specific information (e.g. objectives, results, and conclusions) on some of the projects will be found in other research reports. A listing of Farm Advisors' relevant research activities supported by this project in the past season is provided under procedure (see below).
Following is a listing of Farm Advisor or other research projects undertaken/supported in FY 1992-93 as part of this overall project:

<table>
<thead>
<tr>
<th>Farm Advisor/Researcher</th>
<th>County/Campus</th>
<th>Project Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buchner, Rick</td>
<td>Tehama</td>
<td>Long-term walnut hedgerow study; Walnut rootstock evaluation: <em>J. regia</em> seed sources and own rooted trees, and clonal paradox</td>
</tr>
<tr>
<td>Coates, Bill</td>
<td>San Benito</td>
<td>Walnut cultivar/selection performance in a standard planting (2 trials)</td>
</tr>
<tr>
<td>Edstrom, John &amp; Krueger, Bill</td>
<td>Colusa</td>
<td>Effects of walnut hedgerow planting, soil modification, rootstock selection and drip irrigation under adverse soil conditions</td>
</tr>
<tr>
<td>Grant, Joe</td>
<td>San Joaquin</td>
<td>English rootstock evaluation: <em>J. regia</em> seed sources (2 trials)</td>
</tr>
<tr>
<td>Hasey, Janine</td>
<td>Sutter/Yuba</td>
<td>Walnut species (5) and Paradox (seedling and clonal) rootstock evaluation</td>
</tr>
<tr>
<td>Hendricks, Lonnie</td>
<td>Merced</td>
<td>Walnut cultivar/selection performance in a standard planting (3 trials); English rootstock evaluation: <em>J. regia</em> seed sources</td>
</tr>
<tr>
<td>Kelley, Kathy</td>
<td>Stanislaus</td>
<td>Comparison of 1 vs 2-year-old Paradox rootstocks; Evaluation of various pruning treatments at time of planting of June budded walnuts; Walnut cultivar/selection performance in hedgerow configuration (2 trials); English rootstock evaluation: <em>J. regia</em> seed sources</td>
</tr>
<tr>
<td>Olson, Bill</td>
<td>Butte</td>
<td>Evaluation of mechanical hedging vs. hand pruning systems in a standard, high-density Chandler orchard; Effect of pruning to reduce catkin-load on PFA of Serr walnut</td>
</tr>
<tr>
<td>Farm Advisor/Researcher</td>
<td>County/Campus</td>
<td>Project Description</td>
</tr>
<tr>
<td>------------------------</td>
<td>---------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>Reil, Wilbur</td>
<td>Yolo/Solano</td>
<td>Walnut hedgerow spacing and row orientation (2 trials); Walnut cultivar/selection performance in hedgerow configuration (2 trials); Walnut species rootstock evaluation for resistance to <em>A. mellea</em>.</td>
</tr>
<tr>
<td>Sibbett, Steve</td>
<td>Tulare</td>
<td>Walnut cultivar/selection performance in hedgerow configuration</td>
</tr>
<tr>
<td>Mircetich, John</td>
<td>UCD</td>
<td>Strategies for control of walnut blackline: effect of systemically infected and non-infected English and other rootstock species on yield and quality of Chico and Hartley walnuts.</td>
</tr>
<tr>
<td>Polito, Vito</td>
<td>UCD</td>
<td>Pollination and pistillate flower abscission: effect of catkin/tree removal of Tehama pollenizers on Serr PFA and yield</td>
</tr>
<tr>
<td>Schroth, Milt</td>
<td>UCB</td>
<td>New approaches to controlling walnut blight: yield measurements associated with field experiments</td>
</tr>
</tbody>
</table>

Following is a brief description of specific procedures employed with research reported directly through this project:

The mechanical hedging treatments (one-side alternate vs. two-sides hedged) in the Chico hedgerow trial (22' x 11') established in 1974 near Vina were terminated as of the 1991 season. Commencing in 1992, the entire trial was hedged on one side only and a set of topping treatments imposed to evaluate ways in which to lower and control tree height. The mechanical topping treatments are (a) annual hedging one side - no topping, (b) annual hedging or topping one side, (c) hedging and topping one side, (d) hedging and dormant topping followed by summer topping one side, and (e) standard density-hand pruned control. Dormant topping was performed on March 27, 1992. Overall tree height before topping was estimated to be about 28'-30'. The topping was performed at a slight angle to facilitate use of the equipment and brush removal. The upper most cuts in the center of the tree row were made at around 21' and the cutting bar angled downward to about 17' on the outside of the row canopy. Summer topping (treatment d) was performed on July 7, 1992 at approximately the same position and angle as the dormant topping except that it was attempted to remove only new growth. The length of shoot growth removed in the summer topping ranged from 2'-6' in length. The trial will be continued for at least 3 years to determine the effectiveness of these treatments in maintaining tree height. The experimental design consists of 5 replications of each treatment with 3 rows of 10 trees in
each plot and data collected from the center row. The first harvest was in 1992 with data collected on yield and nut quality.

Performance of walnut cultivars under a high-density hedgerow management system are being evaluated in Tulare, Yolo and Stanislaus Counties in cooperation with Farm Advisors Sibbett, Reil and Kelley, respectively. The Visalia trial (20' x 10') was planted in 1982 and grafted in 1983 to 15 cultivars in three replications of 9 trees per plot with the rows oriented east-west. The Winters trial (24' x 12') consists of 520 Black walnut trees planted in 1984 and grafted in 1985 to 13 cultivars in 4 replications of 10 trees per plot with the rows oriented north-south. The Hickman trial in eastern Stanislaus county (22' x 11') was planted in 1987 and grafted in 1988 to 15 cultivars and advanced selections in single north-south rows of 13-17 trees each. Additional trials have been planted or are planned for establishment in the coming year in all three locations to compare the most promising standard cultivars with more recent advance selections coming out of the breeding program.

Five cultivars (Chico, Vina, Chandler, Howard, and Amigo) are being evaluated at 2 different spacings (22' x 11' and 18' x 9') with east-west oriented rows in a trial in Solano County. The 350 trees in this trial were planted as Black walnut seedlings in 1983 and 1984 and allowed to grow one year before grafting in 1984 and 1985.

A trial was begun in a 7 year old (planted 1985) Chandler walnut orchard (26' x 26') comparing 3 hedging and 2 hand pruning techniques in a standard planting. Evaluations are being made on economics, yield and fruit quality. The treatments are (1) annually hedged alternate centers, (2) annually hedged alternate row sides, (3) annually hedged one tree quadrant, (4) alternate year hand pruning, (5) annual hand pruning. There are 4 replicates per treatment with each plot consisting of 26 trees. The experiment is laid out in a randomized block design.

RESULTS AND CONCLUSIONS

Cultivar, selection and rootstock field studies. Trials have been established by UC Cooperative Extension Farm Advisors in 14 counties (Table 1 and 2). Some trials are small, designed to evaluate a few specific clones or seed sources, and others involve extensive collections of species or selections/cultivars grown under different training systems. Data collected from these trials were used to describe a new cultivar for release (i.e. Tulare) and in statewide walnut educational programs.

Performance of walnut cultivars in hedgerow configuration. The trees in the Visalia walnut cultivar trial have completed their 10th year of growth following field grafting. They were mechanically hedged at 4 feet from the trunk on the south side while the north side remained unpruned to maximize crop. The trees were not topped. Tulare continues to be the highest yielding, being equal to Chico in 1992 (Figure 1) and the leader in cumulative (1986-1992) yield (Figure 2). Among other suitable cultivars for hedgerow planting, Vina and Chandler yielded well in 1992. Howard was substantially lower yielding in this trial in 1992, but it must be noted that the trees are smaller, not fully utilizing the available space and generally have not performed well at this site. Under more
suitable growing conditions and perhaps on Paradox rootstock, Howard would be expected to perform better in a hedgerow configuration.

Harvest data from the eighth leaf walnut cultivar trial in Yolo County show that Chandler ranked among the leaders and exceeded Chico in 1992 yields (Table 3). In cumulative yield (1988-1992), Tulare, Payne and Vina continue to perform well (Figure 3). Again it should be noted that the yield of Howard should be expected to be higher if the trees were planted more closely in conformity with their smaller tree stature.

Performance of hedgerow walnuts at two spacings in east-west oriented rows. The yield data from the ninth leaf walnut hedgerow trial in Solano County shows a greater comparative yield advantage of the closer tree spacing in 1992 than in previous years (Table 4). All four cultivars had greater yields with the higher tree population associated with the 9' x 18' planting as compared to 11' x 22'. The average yield differential was 26% which is substantially more than occurred in previous years. As expected, there is a substantial increase in gross dollar value with the higher tree density, however, one must also take into consideration the increased costs of planting and tree development with the greater number of trees. Vina, which had significantly less crop in 1992, may be less suited to the increased tree crowding associated with the closer spacing because of its spreading type of growth habit.

The yield differential related to light exposure between the north and south sides of the tree wall in this east-west oriented planting continues to show the greater cropping potential on the south side of the tree (Table 5). There was slightly more crop on the south side of the tree wall in 1992 on trees having the south side pruned and the north side left unpruned. The yield differential was accentuated, as would be expected, on those trees where the hedging was performed on the north side and the south side left unpruned in 1992. The results are consistent with those obtained in prior years. These data are still considered preliminary and several more years will be required to fully assess the influence of row orientation/spacing on tree productivity.

Mechanical hedging versus hand pruning in a standard Chandler planting. There was no significant difference in the first year’s yields following the hedging or pruning treatments (Table 6). This trial will need to be continued for at least 3 to 4 more seasons to begin to adequately evaluate the influence of the treatments on productivity and assess the feasibility of mechanical hedging in mature, standard orchards. It took 3 hours to hedge the 6 acres of the trial or a rate of 2 acres/hour. Under normal grower conditions hedging can be done twice as fast as in this experiment. The cost of hedging was $170/hour or $42.50/acre. Hand pruning took 8 to 10 hours per acre at an estimated labor cost of $48 to $60/hour. Alternate year pruning would be 1/2 this cost.
TABLE 1. WALNUT CULTIVAR AND SELECTION FIELD STUDIES

1. Cultivar and Selection Performance in High Density Configuration
Principal Investigator: G. Steven Sibbett  Cooperator: L. Bennett
Location: Visalia, California  Established: 1983
Design: 15 cultivars or selections (Ashley, Amigo, Chandler, Chico, Hartley, Howard, Payne, Pedro, Serr, Sunland, Tehama, Vina, UC 76-11, UC 67-13, and UC 68-104) were planted in 9 tree plots (20' x 10' spacing, 3 trees per row by 3 rows wide, oriented east/west) replicated 3 times.
Evaluation: Bloom characteristics, yield, nut quality and vegetative growth characteristics.

2. Cultivar Performance in High Density Configuration
Principal Investigator: G. Steven Sibbett  Cooperator: L. Bennett
Location: Visalia, California  Established: 1987
Design: Cultivar Cisco (UC 66-178) was established on 2 trees as a pollenizer in a 20' x 10' hedgerow planting.
Evaluation: Leafing date, pistillate and catkin bloom periods, yield estimate, and relative tree vigor.

3. Cultivar Performance in High Density Configuration
Principal Investigator: Wilbur O. Reil  Cooperator: C. McNamara
Location: Winters, California  Established: 1984 and 1985
Design: 5 cultivars (Chico, Vina, Chandler, Howard, and Amigo) were planted at two spacings (18' x 9'; and 22' x 11'). Rows oriented east-west, a total of 350 trees in trial.
Evaluation: Yield, nut quality, and vegetative growth characteristics.

4. Cultivar and Selection Performance in High Density Configuration
Principal Investigator: Wilbur O. Reil  Cooperator: J. Fukumoto
Location: Winters, California  Established: 1985
Design: 14 cultivars (Amigo, Ashley, Chandler, Chico, Howard, Payne, Pedro, Sunland, Tehama, Vina, UC 67-11, UC 67-13, UC 68-104, and Cisco [UC 178, established 1987]) were planted at 24' x 12' spacing. Ten tree plots (north-south orientation) are replicated 4 times.
Evaluation: Bloom characteristics, yield, nut quality, and vegetative growth characteristics.

5. Cultivar and Selection Performance in High Density Configuration
Principal Investigator: Wilbur O. Reil  Cooperator: David Scheuring
Location: Guinda, Yolo County, California  Established: 1989
Design: 10 cultivars (Chandler, Cisco, UC 67-11, UC 67-13, UC 72-13, UC 76-80, UC 77-10, UC 77-12, UC 78-10, and UC 78-189) were planted 11' x 22'. Four tree plots are replicated three times on two different rootstocks (Northern California Black Walnut and Paradox). Observation plantings of four other varieties (UC 76-98, Lara, Ronde Montignac, and Meylannaise) are also present. Eight acres of UC 67-13 are planted by trial. UC 72-36 added in
Evaluation: Bloom characteristics, yield, nut quality, and vegetative growth characteristics.

6. Cultivar and Selection Performance in High Density Configuration
Principal Investigator: Kathleen M. Kelley  Cooperator: W. Deardorff
Location: Hickman, California  Established: 1988
Design: 15 cultivars and selections (Amigo, Chandler, Howard, Marchetti, Pedro, Cisco [UC 66-178], UC 67-11, UC 67-13, UC 68-104, UC 76-80, UC 76-98, UC 76-112, UC 77-12, UC 78-10, and UC 78-189) were established in single north-south rows of 13-17 trees each.
Evaluation: Leafing date, bloom characteristics, yield, nut quality, and vegetative growth characteristics.

7. Cultivar and Selection Performance
Principal Investigator: Lonnie Hendricks  Cooperator: B. Crane
Location: Merced, California  Established: 1978
Design: 10 cultivars (Chandler, Chico, Howard, Serr, Sunland, Tehama, UC 59-124, UC 60-119, UC 63-396, and UC 64-57) were planted at 28' x 28' spacing.
Evaluation: Bloom characteristics, yield, and nut quality.

8. Cultivar and Selection Performance
Principal Investigator: Lonnie Hendricks  Cooperator: B. Crane
Location: Merced, California  Established: 1987
Design: 10 cultivars and selections (Chandler, Cisco [UC 66-178], UC 67-11, UC 67-13, UC 68-104, UC 76-39, UC 76-80, UC 76-112, UC 77-12, UC 78-57) were at standard spacing. 1990 UC 72-36 and 77-10 added.
Evaluation: Leafing date, bloom characteristics, yield and nut quality.

9. Selection Performance
Principal Investigator: Lonnie C. Hendricks  Cooperator: G. Schmidt
Location: Merced, California  Established: 1985
Evaluation: Yield, nut quality, and vegetative growth characteristics.

10. Cultivar and Selection Performance in Coastal Valley Region
Principal Investigator: William H. Coates  Cooperator: A. Bonturi
Location: Hollister, California  Established:
Design: 7 cultivars and selections (Payne, Serr, Howard, Chandler, Pedro, Hartley, and UC 64-57) established in standard plantings.
Evaluation: Leafing date, bloom characteristics, blight susceptibility, yield, and nut quality.

11. Cultivar and Selection Performance in Coastal Valley Region
Principal Investigator: William H. Coates  Cooperator: N. Zanella
Location: Hollister, California  Established: 1990
Design: 1 cultivar and 6 selections (Cisco [UC 67-178], UC 67-11, UC 67-13, UC 76-80, UV 77-12, UC 78-10, and UC 78-189) were established in a standard planting.
Evaluation: Leafing date, bloom characteristics, yield, nut quality, and vegetative growth characteristics.
12. Cultivar and Selection Performance

Principal Investigator: William H. Olson  Cooperator: William Stuke
Location: Gridley, California Established: 1987
Design: 4 cultivars and selections (Cisco [UC 66-178], UC 67-11, UC 67-13, UC 68-104) were established in limited numbers in a standard planting.
Evaluation: Leafing date, pistillate and catkin bloom periods, yield estimate, and relative tree vigor.

13. Cultivar Performance

Principal Investigator: William H. Olson  Cooperator: C.S.U. Chico
Location: Chico, California Established: 1987
Design: Cultivar Cisco (UC 66-178) was established as a pollenizer in a standard planting.
Evaluation: Leafing date, pistillate and catkin bloom periods, yield estimate, and relative tree vigor.

14. Cultivar Performance

Principal Investigator: Delbert S. Farnam  Cooperator: C. Dunlap
Location: West Point, California Established: 1985
Design: Cultivar Cisco (UC 66-178) was established in limited numbers as a pollenizer in a standard planting.
Evaluation: Leafing date, pistillate and catkin bloom periods, yield estimate, and relative tree vigor.

15. Cultivar Performance

Principal Investigator: Rachel Elkins  Cooperator: Alex Suchan
Location: Upper Lake, California Established: 1990
Design: 3 selections (U.C. 76-80, 77-12, and 78-10) were established in limited numbers in a standard alternate planting of Howard and Hartley.
Evaluation: Leafing date, pistillate and catkin bloom periods, yield estimate, and relative tree vigor.

16. Cultivar Performance

Principal Investigator: Joseph A. Grant  Cooperator: J. Gotelli
Location: Stockton, California Established: 1987
Design: Cultivar Cisco (UC 67-178) was established on 10 tress as a pollenizer in a standard planting.
Evaluation: Leafing date, pistillate and catkin bloom periods, yield estimate, and relative tree vigor.

17. Selection Performance

Principal Investigator: Joseph A. Grant  Cooperator: B. Vink
Location: Tracy, California Established: 1990
Design: UC 67-11 established in limited numbers for field evaluation.
Evaluation: Leafing date, pistillate and catkin bloom periods, yield estimate, and relative tree vigor.

18. Selection Performance

Principal Investigator: Janine K. Hasey  Cooperator: J. Conant
Location: East Nicolaus, California Established: 1984
Design: Selection UC 67-11 was established on 50 trees in a standard planting.
Evaluation: Leafing date, pistillate and catkin bloom periods, yield estimate,
and relative tree vigor.


19. Selection Performance
Principal Investigator: G. Steven Sibbett Cooperator: R. Waite
Location: Bakersfield, California Established: 1988
Design: Selection UC 67-13 was established on approximately 200 trees in a standard planting.
Evaluation: Leafing date, pistillate and catkin bloom periods, yield estimate, and relative tree vigor.

20. Selection Performance
Principal Investigator: Richard P. Buchner Cooperator: J. Repanich
Location: Corning, California Established: 1984
Design: Selection UC 67-11 was established on a limited number of trees in a standard planting.
Evaluation: Leafing date, pistillate and catkin bloom periods, yield estimate, and relative tree vigor.

21. Cultivar Performance
Principal Investigator: Richard P. Buchner Cooperator: W. Sartori
Location: Cottonwood, California Established: 1984
Design: Cultivar Cisco (UC 66-178) was grafted as a pollenizer in a standard planting.
Evaluation: Leafing date, pistillate and catkin bloom periods, yield estimate, and relative tree vigor.

22. Cultivar Performance
Principal Investigator: Richard P. Buchner Cooperator: R. Darrow
Location: Vina, California Established: 1988
Design: Cultivar Cisco (UC 660178) was established on a limited number of trees as a pollenizer in a standard planting.
Evaluation: Leafing date, pistillate and catkin bloom periods, yield estimates, and relative tree vigor.

23. Selection Performance
Principal Investigator: Kathleen M. Kelley Cooperator: R. Driver
Location: Modesto, California Established: 1984
Design: 6 selections (UC 59-165, UC 63-278, UC 67-11, UC 67-13, UC 68-104, and UC 75-74) were established in limited numbers in a standard planting.
Evaluation: Leafing date, pistillate and catkin bloom periods, yield estimate, and relative tree vigor.

24. Cultivar and Selection Performance
Principal Investigator: Kathleen M. Kelley Cooperator: Burchell Nursery
Location: Stanislaus County, California Established: 1988
Design: Cultivar Cisco (UC 67-178) and selection UC 67-13 were established in limited numbers in a standard planting.
Evaluation: Leafing date, pistillate and catkin bloom periods, yield estimate, and relative tree vigor.
### TABLE 2. ROOTSTOCK FIELD STUDIES

1. **Walnut High Density, Soil Modification and Rootstock Performance**
   - **Principal Investigators:** William H. Krueger and John P. Edstrom
   - **Cooperator:** Nickel's Estate Soils Laboratory
   - **Location:** Colusa County, California  
     - **Established:** 1986
   - **Design:** 2 rootstocks (*J. hindsii* Rawlins and Rawlins Paradox) grafted to either Chandler or Howard were planted in 5 tree plots replicated 6 times in a completely randomized design. Additionally, one half of the plots were "slip plowed."
   - **Evaluation:** Relative tree vigor, yield, and nut quality.

2. **Walnut Species Rootstock Performance/Tolerance to *A. mellea***
   - **Principal Investigator:** Wilbur O. Reil  
   - **Cooperator:** G. McNamara
   - **Location:** Winters  
     - **Established:** 1986
   - **Design:** 11 rootstocks (Rawlins [Calvert] Paradox, various sources), Royal, *J. hindsii* Rawlins, *J. regia* Manregian, *J. regia* Amigo, *J. californica* [So. Calif. Black], *J. microcarpa* [Texas Black], *J. nigra* [Eastern Black], *J. ailanthifolia* [Japanese Black], and *J. major* [Arizona Black] were planted in 4 tree plots replicated 4 times.
   - **Evaluation:** Survival (tolerance to *A. mellea*), relative tree vigor.

3. **Walnut Species Rootstock Performance**
   - **Principal Investigator:** Janine K. Hasey  
   - **Cooperator:** J. Conant
   - **Location:** Rio Oso, California  
     - **Established:** 1987
   - **Design:** 7 rootstocks (*J. californica* seedlings, *J. major* seedlings, *J. microcarpa* seedlings, *J. hindsii* seedlings, Paradox seedlings, clonal Paradox and *J. ailanthifolia* seedlings) grafted to Chandler were planted at a 25' x 25' spacing (except *J. ailanthifolia* established at a 12.5' x 25' spacing) in a randomized complete block design with 20 replicates.
   - **Evaluation:** Survival, relative tree vigor, yield, and nut quality.

4. **English Walnut Rootstock Performance**
   - **Principal Investigator:** Lonnie C. Hendricks  
   - **Cooperator:** W. Linville
   - **Location:** Gustine, California  
     - **Established:** 1986
   - **Design:** 5 rootstocks (*J. regia* Manregian seedlings, *J. regia* India seedlings, *J. regia* Amigo seedlings, *J. hindsii* Rawlins and Rawlins [Calvert] Paradox) were planted in 5 tree plots replicated 3 times. Vina was budded onto the rootstocks in 1987 with Vina scions applied to failures in 1988.
   - **Evaluation:** Survival, initial rootstock vigor, comparative vigor of Vina, yield, nut quality, nematode tolerance, and salinity tolerance.

5. **English Walnut Rootstock Performance**
   - **Principal Investigators:** Richard P. Buchner and Father Joseph
   - **Cooperator:** Trappist Monastery
   - **Location:** Vina, California  
     - **Established:** 1986
   - **Design:** 4 rootstocks (*J. regia* Eureka, *J. regia* Manregian, clonal Paradox, and rooted Chandler) were established.
   - **Evaluation:** Survival, relative rootstock vigor, yield, and nut quality.
6. English Walnut Rootstock Performance
Principal Investigator: Joseph A. Grant  Cooperator: James Ferrari
Location: Linden, California  Established: 1989
Design: 5 rootstocks (J. regia Manregian seedlings, J. regia Eureka seedlings, J. regia Spain seedlings, J. regia Ronde de Montignac seedlings, and J. regia Carne seedlings) grafted with Chandler were planted in 5 tree plots replicated 3 times.
Evaluation: Relative tree vigor, yield, and nut quality.

7. English Walnut Rootstock Performance
Principal Investigator: Kathleen M. Kelley  Cooperators: James DeMartini (grower) and David Bonilla (nurseryman)
Location: Modesto, California  Established: 1989
Design: 7 rootstocks (J. regia Manregian seedlings, J. regia Eureka seedlings, J. regia Spain seedlings, J. regia Ronde de Montignac seedlings, J. regia Corne seedlings, J. regia Serr seedlings, and Paradox seedlings) grafted with Chandler were planted in 5 tree plots replicated 3 times.
Evaluation: Relative tree vigor, yield, and nut quality.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Chico</td>
<td>3183 AB</td>
<td>3895 AB</td>
<td>3852 AB</td>
<td>3238 AB</td>
<td>1034 CD</td>
<td>15,202</td>
</tr>
<tr>
<td>67-13</td>
<td>1213 E</td>
<td>3828 AB</td>
<td>3079 BC</td>
<td>3024 AB</td>
<td>2033 A</td>
<td>13,176</td>
</tr>
<tr>
<td>Tulare</td>
<td>2446 BCD</td>
<td>4056 A</td>
<td>4170 A</td>
<td>2480 CD</td>
<td>971 CD</td>
<td>14,123</td>
</tr>
<tr>
<td>Payne</td>
<td>3492 A</td>
<td>3034 BC</td>
<td>3397 ABC</td>
<td>3405 A</td>
<td>1823 AB</td>
<td>15,151</td>
</tr>
<tr>
<td>Sunland</td>
<td>1816 DE</td>
<td>3294 ABC</td>
<td>2921 C</td>
<td>3558 A</td>
<td>1179 CD</td>
<td>12,768</td>
</tr>
<tr>
<td>Vina</td>
<td>2834 ABC</td>
<td>3823 AB</td>
<td>3623 ABC</td>
<td>2338 CDE</td>
<td>1103 CD</td>
<td>13,730</td>
</tr>
<tr>
<td>68-104</td>
<td>2260 CD</td>
<td>2591 C</td>
<td>3472 ABC</td>
<td>2701 BC</td>
<td>1489 BC</td>
<td>12,513</td>
</tr>
<tr>
<td>Pedro</td>
<td>3178 AB</td>
<td>3864 AB</td>
<td>3155 BC</td>
<td>1842 DEF</td>
<td>887 DE</td>
<td>12,926</td>
</tr>
<tr>
<td>Ashley</td>
<td>3501 A</td>
<td>3090 BC</td>
<td>3112 BC</td>
<td>2497 CD</td>
<td>987 D</td>
<td>13,187</td>
</tr>
<tr>
<td>Howard</td>
<td>2589 ABCD</td>
<td>3243 ABC</td>
<td>3231 BC</td>
<td>1969 DEF</td>
<td>894 DE</td>
<td>11,926</td>
</tr>
<tr>
<td>Tehama</td>
<td>2798 ABC</td>
<td>3426 ABC</td>
<td>2851 C</td>
<td>1608 FG</td>
<td>424 E</td>
<td>11,107</td>
</tr>
<tr>
<td>Chandler</td>
<td>3357 A</td>
<td>3358 AB</td>
<td>2920 C</td>
<td>970 G</td>
<td>704 DE</td>
<td>11,509</td>
</tr>
<tr>
<td>Amigo</td>
<td>1240 E</td>
<td>1394 D</td>
<td>1860 D</td>
<td>1710 EF</td>
<td>867 DE</td>
<td>7,701</td>
</tr>
<tr>
<td>Cisco*</td>
<td>1641</td>
<td>1900</td>
<td>561</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Top worked - 6th leaf graft.
Table 4. 1992 Solano County 9th leaf walnut hedgerow trial east-west oriented rows. Yield in lbs/acre.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Chico</td>
<td>7077</td>
<td>3890</td>
<td>5452</td>
<td>5065</td>
<td>3870</td>
<td>2282</td>
<td>27,636</td>
</tr>
<tr>
<td>Vina</td>
<td>1555</td>
<td>4149</td>
<td>2980</td>
<td>3857</td>
<td>2651</td>
<td>1537</td>
<td>16,729</td>
</tr>
<tr>
<td>Chandler</td>
<td>4235</td>
<td>4084</td>
<td>4237</td>
<td>2203</td>
<td>2725</td>
<td>1732</td>
<td>19,216</td>
</tr>
<tr>
<td>Howard</td>
<td>4912</td>
<td>4707</td>
<td>4416</td>
<td>3155</td>
<td>2648</td>
<td>1583</td>
<td>21,421</td>
</tr>
<tr>
<td>Amigo</td>
<td>1221</td>
<td>2072</td>
<td>670</td>
<td>3928</td>
<td>1665</td>
<td>629</td>
<td>10,185</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Chico</td>
<td>8835</td>
<td>4963</td>
<td>6069</td>
<td>4445</td>
<td>4563</td>
<td>2759</td>
<td>31,634</td>
</tr>
<tr>
<td>Vina</td>
<td>1928</td>
<td>4615</td>
<td>2865</td>
<td>3487</td>
<td>2398</td>
<td>1079</td>
<td>16,372</td>
</tr>
<tr>
<td>Chandler</td>
<td>6046</td>
<td>4734</td>
<td>4257</td>
<td>2149</td>
<td>3447</td>
<td>1855</td>
<td>22,488</td>
</tr>
<tr>
<td>Howard</td>
<td>5622</td>
<td>5326</td>
<td>5272</td>
<td>3443</td>
<td>3301</td>
<td>1803</td>
<td>24,767</td>
</tr>
</tbody>
</table>

Comparison of the two spacing - average of the four common varieties lbs/ac.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>11 x 22</td>
<td>4445</td>
<td>4208</td>
<td>4271</td>
<td>3570</td>
<td>2974</td>
<td>1784</td>
<td>21,252</td>
</tr>
<tr>
<td>9 x 18</td>
<td>5608</td>
<td>4910</td>
<td>4616</td>
<td>3381</td>
<td>3427</td>
<td>1874</td>
<td>23,816</td>
</tr>
<tr>
<td>9 x 18/11 x 22</td>
<td>+26</td>
<td>+17</td>
<td>+8%</td>
<td>-5%</td>
<td>+15%</td>
<td>+5%</td>
<td></td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th></th>
<th>11 x 22</th>
<th>9 x 18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chico</td>
<td>$16,029</td>
<td>$18,348</td>
</tr>
<tr>
<td>Vina</td>
<td>9,870</td>
<td>9,659</td>
</tr>
<tr>
<td>Chandler</td>
<td>15,423</td>
<td>16,191</td>
</tr>
<tr>
<td>Howard</td>
<td>12,424</td>
<td>14,365</td>
</tr>
<tr>
<td>Amigo</td>
<td>6,111</td>
<td></td>
</tr>
</tbody>
</table>
Table 5. 1992 Solano County 9th leaf Chico walnut hedgerow trial, east-west oriented rows 11 x 22 spacing, alternate side hedging, both sides of all plots were hedged in 1988 and before. Yield in lbs. per acre per side of tree and total yield.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>1992</th>
<th>% on S. Side</th>
<th>1991</th>
<th>% on S. Side</th>
<th>1990</th>
<th>% on S. Side</th>
<th>1989</th>
<th>% on S. Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992 Hedged South Side Only</td>
<td>2891</td>
<td>53%</td>
<td>1796P</td>
<td>60%</td>
<td>2590</td>
<td>49%</td>
<td>2000P</td>
<td>67%</td>
</tr>
<tr>
<td>1991 Hedged North Side Only</td>
<td>3309P</td>
<td>4497</td>
<td>2701</td>
<td>5061</td>
<td>4145</td>
<td>6145</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990 Hedged South Side Only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1989 Hedged North Side Only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>6200</td>
<td>53%</td>
<td>4497</td>
<td>60%</td>
<td>5061</td>
<td>49%</td>
<td>6145</td>
<td>67%</td>
</tr>
<tr>
<td>1992 Hedged North Side Only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991 Hedged South Side Only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990 Hedged North Side Only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1989 Hedged South Side Only</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North</td>
<td>2021P</td>
<td>1765</td>
<td>1748P</td>
<td>1733</td>
<td>2885</td>
<td>2405P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>South</td>
<td>3158</td>
<td>3474</td>
<td>3133</td>
<td>4881</td>
<td>5290</td>
<td>45%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5179</td>
<td>61%</td>
<td>49%</td>
<td>64%</td>
<td>5290</td>
<td>45%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991 Hedged Both Sides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990 Hedged Both Sides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1989 Hedged Both sides</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North</td>
<td>2058P</td>
<td>2551P</td>
<td>2005P</td>
<td>2005P</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>South</td>
<td>1833P</td>
<td>2901P</td>
<td>2405P</td>
<td>2405P</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3891</td>
<td>5452</td>
<td>53%</td>
<td>60%</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

P - Indicates the side that was pruned the previous winter.

Summary comparing yield on side that is pruned compared to yield on side not pruned.

<table>
<thead>
<tr>
<th></th>
<th>North</th>
<th>South</th>
<th>% Increase on South Side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield per side of tree when pruned</td>
<td>1891 lbs.</td>
<td>2474 lbs.</td>
<td>39%</td>
</tr>
<tr>
<td>Yield per side of tree when not pruned</td>
<td>2533 lbs.</td>
<td>3284 lbs.</td>
<td>30%</td>
</tr>
<tr>
<td>Increase the year not pruned</td>
<td>34.0%</td>
<td>32.7%</td>
<td></td>
</tr>
<tr>
<td>Treatment</td>
<td>Yield/Acre</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------------</td>
<td>------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hedged Alternate Centers</td>
<td>2.71 a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hedged Alternate Row/Sides</td>
<td>2.81 a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hedged 1 Tree Quadrant</td>
<td>2.82 a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternate Year Hand Prune-Pruned</td>
<td>2.82 a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternate Year Hand Prune-Skipped</td>
<td>2.87 a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual Hand Pruned</td>
<td>2.83 a</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Means not followed by common letter are significant difference, 5% LSD.
FIG 1. PERFORMANCE OF WALNUT CULTIVARS IN HEDGEROW CONFIGURATION

Visalia, CA 1992

AVERAGE TONS/ACRE

2.78 2.74
2.12 1.97
2.25 2.08
2.42 2.40
2.37 2.27

10' x 20' = 218 trees/ac
FIG 2. PERFORMANCE OF WALNUT CULTIVARS IN HEDGE ROW CONFIGURATION
Visalia, CA

Total T/ae 1988 - 1992

10' x 20' = 218 trees/ae
Fig. 3

Yolo County Walnut Hedgerow

5 Year Cumulative Yield (152 Trees/Acre)

Tons/Acre

Variety

Year
- 1992
- 1991
- 1990
- 1989
- 1988