WALNUT ORCHARD MANAGEMENT: PILOT PROJECTS, FIELD TESTING, ADAPTIVE RESEARCH AND PROBLEM SOLVING BY C.E. FARM ADVISORS AND SPECIALISTS


ABSTRACT

Walnut cultivars and promising selections are being field evaluated at 27 sites in 14 counties, in cooperation with 11 farm advisors. In addition, walnut rootstocks (Juglans species and English walnut seed sources and clones) are being tested in eight cooperative field trials. Tulare was the highest yielding cultivar in a large trial in Yolo County comparing 13 cultivars in a hedgerow configuration. Statistically the yield was comparable to Chico and Vina. The 1993 yield of Tulare represented a substantial increase over 1992 which was the only year in the past four in which did not have the highest production. Thus, Tulare continues to appear to be highly suitable for hedgerow planting, with a performance record in Yolo County that parallels the results previously obtained from a similar trial in Tulare County. Chandler was significantly lower yielding in 1993 than Chico and Tulare in contrast to 1992 and 1991 where the yields were similar. Howard was lower in yield than Chandler but the difference was not statistically significant. The yield would be expected to be higher if the trees were planted more closely in conformity with the smaller tree stature of Howard. Increased tree density (9' x 18') increased yield as compared with the more conventional 11' x 22' spacing, but the economics are questionable when the increased costs of planting and tree development associated with greater tree numbers are considered. Row orientation also was a factor with more crop produced on the south side of an east-west oriented hedgerow as compared to the north side. However, total yield was high and it appears to be consistent with what would be expected from a north-south oriented hedgerow. The second year of yield data from a young Chandler orchard in a standard planting comparing mechanical hedging with hand pruning showed no significant difference. Accumulative yields after two years of treatments show no clear trend at this time, and several more seasons of evaluation will be required to fully assess the adaptability of mechanical pruning to conventional walnut orchards.

OBJECTIVE

The general objective of this project is to conduct applied and site-specific adaptive research in cooperation with C.E. Farm Advisors, including field testing of rootstocks and cultivars, and to support AES mission-oriented research efforts. Much of this research activity, by its very nature, is long term. As such, this overall report is largely a compilation of progress/status reports of many field trials located throughout the walnut growing areas of the state. Where sufficient data is available, information is provided on specific procedures and results for the past year. However, in most cases this report simply provides a brief description, location and an indication of the current status of the project. A listing of farm advisors' relevant research activities supported by the project in the past year is shown under PROCEDURE (see below).
PROCEDURE

The following is a listing of specific research activities supported in 1993 as part of this overall project:

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<th>Researcher/Farm Advisor</th>
<th>Location</th>
<th>Project Description</th>
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| Buchner, Rick           | Tehama        | 1) Long-term walnut hedgerow study near Vina: Mechanical topping/tree height control  
2) Walnut rootstock evaluation: *J. regia* seed sources and own rooted trees, and clonal paradox |
| Coates, Bill            | San Benito    | Walnut cultivar/selection performance in a standard planting (2 trials)                                                                               |
| Edstrom, John & Krueger, Bill | Colusa       | Walnut hedgerow planting, soil modification and rootstock performance under drip irrigation in marginal soil                                        |
| Grant, Joe              | San Joaquin   | English rootstock evaluation: *J. regia* seed sources (3 trials)                                                                                     |
| Hasey, Janine           | Sutter/Yuba   | Walnut species (5) and paradox (seedling and clonal) rootstock evaluation                                                                         |
| Hendricks, Lonnie       | Merced        | 1) Walnut cultivar/selection performance in a standard planting (2 trials)  
2) English rootstock evaluation: *J. regia* seed sources |
| Kelley, Kathy           | Stanislaus    | 1) Comparison of one vs. two year old paradox rootstocks  
2) Evaluation of various pruning treatments at time of planting of June budded walnuts.  
3) Walnut cultivar/selection performance in hedgerow configuration (2 trials)  
4) English rootstock evaluation: *J. regia* seed sources |
| Olson, Bill             | Butte         | 1) Evaluation of mechanical hedging vs. hand pruning systems in a standard high density Chandler orchard.  
2) Evaluation of erratic cropping behavior of Chandler walnut. |
| Reil, Wilbur            | Yolo/Solano   | 1) Walnut hedgerow spacing and row orientation (2 trials)  
2) Walnut cultivar/selection performance in hedgerow configuration (2 trials)  
3) Walnut species rootstock evaluation for resistance to *A. mellea* |
| Sibbett, Steve          | Tulare        | Walnut cultivar/selection performance in hedgerow configuration (2 trials)                                                                         |
| Micetich, John          | UCD           | 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. |
RESULTS AND CONCLUSIONS

Cultivar/Selection and Rootstock Field Studies

Field evaluations of walnut cultivars and promising selections are being conducted at 27 sites in 14 counties with 11 cooperating Farm Advisors (Table 1). In addition, we are testing walnut rootstocks (Juglans species and English walnut seed sources and clones) in eight cooperative field trials (Table 2). Some trials are small, designed to evaluate a few specific clones or seed sources, and others involve large collections of species or selections/cultivars grown under different training systems. Data collected from these trials have been used to describe new cultivars for release (e.g. Tulare) and to provide useful information for statewide walnut educational programs and for individual growers to make better informed decisions in replanting or establishing new walnut orchards.

Performance of Walnut Cultivars in Hedgerow Configuration

Project Leaders: Wilbur Reil, Kathy Kelley, Steve Sibbett

Evaluation of walnut cultivars under a high-density hedgerow management system is continuing in Tulare, Yolo and Stanislaus Counties in cooperation with farm advisors Sibbett, Reil and Kelley, respectively. The oldest of these trials in Visalia, planted in 1982 (20' x 10') in an east/west orientation and grafted in 1983 to fifteen cultivars (three replications with nine trees per plot), was terminated in 1992. The trees had completed their tenth year of growth following field grafting and 1992 was the seventh year of yield data collection which began in the fourth leaf. These data which were reported in last year's report showed Tulare to be the highest yielding, slightly ahead of Chico in 1992, and the leader in cumulative (1986-1992) yield. Chandler was significantly lower yielding than Tulare and Chico in 1992, although it exceeded two tons per acre. But more importantly, the cumulative yield over the seven years from Chandler was only about three quarters of that obtained from Tulare. These results from the Visalia trial caused some concern as to the suitability of Chandler for hedgerow planting.

The Yolo County trial, being two years younger than the one in Visalia, was continued in 1993. It consists of 520 black walnut trees planted in 1984 (24' x 12') and grafted in 1985 to 13 cultivars in four replications of ten trees per plot with the rows oriented north-south. The 1993 yield data representing the ninth leaf in this trial showed Tulare to be the highest yielding and statistically on a par with Chico and Vina (Table 3). This was a substantial increase in yield over 1992, which was the only year of the past four in which Tulare did not have the highest production. Tulare continues to appear to be highly suitable for hedgerow planting, a conclusion which can be more clearly seen by looking at the six-year (1988-1993) cumulative yields from this trial (Fig. 1). The yield of Vina also has been consistently high, and it ranks up with the leaders, both in 1993 and in cumulative yield. Chandler was significantly lower yielding in 1993 than Chico and Tulare. It is interesting to note, however, that this was not the case in 1992 nor in 1991 where the yield of Chandler was among the highest. This suggests that there may be other factors (e.g. pollen availability/fruit set) which may be limiting Chandler yields in some seasons and not in others. There remains the question, though, as to the suitability of Chandler for hedgerow planting that needs further investigation. Howard continues to yield about as well as Chandler and would probably be higher if the trees were planted more closely in conformity with their smaller tree stature. It is interesting to note the extremely low yield of 67-13 which undoubtedly is due to its extreme sensitivity to pistillate flower abscission.

The Hickman hedgerow trial in eastern Stanislaus County (22' x 11') was originally planted in 1987 and grafted in 1988 to 15 cultivars and potential selections in single north-south rows of 13 trees to
17 trees each. These were reduced to nine items in 1993 and only 76-80 and 77-12 of the original numbered selections remain in the test. A new replicated trial was established in eastern Stanislaus County in cooperation with Kathy Kelly in 1992 with seedling black walnut rootstock. The trees were grafted in 1993 with Chandler, UC 76-80, and 3 French selections from Germain’s breeding program in Bordeaux, France. There are 3 replications with 8 trees per plot in a randomized complete block design.

Four cultivars (Chico, Vina, Chandler, and Howard) are being evaluated at two different spacings (22’ x 11’ and 18’ x 9’) with east-west oriented rows in a trial in Solano County in cooperation with Wilbur Reil. 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. The 1993 yield data representing the 10th leaf shows the production of Chandler, in particular, to be outstanding with about four tons per acre (Table 4). The improvement in Chandler yields with tree age in this trial suggests that it might be slower in coming into early production perhaps because of delayed tree, spur and canopy development, but that it has the capacity to bear substantial crop at maturity. The data continues to support the conclusion that the comparative yield advantage of the closer tree spacing does not appear to justify the increased cost of planting and tree development with the greater number of trees. In addition, it is becoming increasingly more difficult to maintain the 9’ x 18’ planting and there appears to be more deadwood accumulating in the interior lower portion of the canopy.

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 substantially more crop on the south side of the tree wall on trees having the north side pruned and the south side left unpruned. This yield differential was not as great, as would be expected, on those trees where the hedging was performed on the south side and the north side left unpruned in 1993. These results are consistent with those obtained in prior years. Even though the difference in productivity between the north and south sides of this east-west oriented hedgerow is clear, it would be difficult to conclude that there was any overall suppression of yield as compared with a north-south row orientation. The yield of the trees hedged on the south side in 1993 approached 3 tons per acre and exceeded 3-1/2 tons per acre where the trees were hedged on the north side. In either case, these are outstanding yields and they would appear to compare very favorably with north-south oriented hedgerows. Furthermore, any mechanical pruning regime most likely would have half the orchard hedged on the south side while the other side was hedged on the north side of the row in any given year which would tend to minimize year-to-year variation in production.

Yield Comparison Following Various Hedging and Hand Pruning Techniques

Project Leader: Bill Olson

A trial was begun in 1992 in a seven year old (planted 1985) Chandler walnut orchard (26’ x 26’) comparing three hedging and two 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/year
4. Alternate year hand pruning
5. Annual hand pruning
There are four replicates per treatment, each replicate consisting of 26 trees. The experiment is laid out in a randomized block design.

It took three hours to hedge the 6 acres of the trial or 2 acres/hr. Under normal grower conditions hedging can be done twice as fast (4 acres/hr.) as in our experiment. The contract cost of hedging was $170/hr. or $42.50/acre. Hand pruning took 6 hours/acre at a labor cost of $36/acre plus pruning tower cost of $150/acre equalling $186/acre to hand prune. Alternate year pruning would be one half this cost or $93/acre.

As was the case in the first year, there was no significant difference in second year (1993) yields following the hedging or pruning treatments (Table 6). Quality data for 1992 indicated a significant reduction in percent large size nuts where hedging was used or where hand pruning was skipped in 1992 (Table 7). Quality data for 1993 is not available at this time.

In this north-south planting where hedging took place the non-hedged side had significantly more yield in 1992 and 1993 (Table 8). It is clear that hedging reduces crop load on the side that is hedged and no additional data on this question will be gathered. In non-hedged treatments the west sides of tree rows out yielded the east side slightly.

Accumulative yields after two years of treatments shows no clear trend at this time with all treatments producing between 5.5-6.0 tons/acre total (Fig. 2). This trial needs to be continued for at least two more seasons to further evaluate the influence of these treatments on productivity.
### 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  
**Status:** Completed 1992  
**Design:** 15 cultivars or selections (Ashley, Amigo, Chandler, Chico, Bartley, 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  
**Status:** Continuing  
**Design:** Cisco cv. (UC 66-178) was established on 2 trees as a pollinator in a 20' x 10' Chandler cv. hedgerow planting.  
**Evaluation:** Leafing date, bloom characteristics, 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  
**Status:** Continuing  
**Design:** 5 cultivars (Chico, Vina, Chandler, Howard, and Amigo) on J. hindssii rootstock were established at two spacings (18' x 9', and 22' x 11') for a total of 350 trees. Row orientation is east/west.  
**Evaluation:** Yield, nut quality, and vegetative growth characteristics.  
**Publications:** WALNUT RESEARCH REPORTS (1986-1992); "Fruit and Nut Notes" (U.C.C.E. Yolo Co. Newsletter).

#### 4. Cultivar and Selection Performance in High Density Configuration
**Principal Investigator:** Wilbur O. Reil  **Cooperator:** J. Fukumoto and J. Martinez  
**Location:** Winters, California  
**Established:** 1984 (J. hindssii rootstock was planted) and 1985 (J. regia scions were grafted)  
**Status:** Completed in 1993  
**Design:** 14 cultivars (Amigo, Ashley, Chandler, Chico, Howard, Payne, Pedro, Sunland, Tehama, Tulare (UC 67-11), Vina, UC 67-13, UC 68-104, and Cisco [(UC 66-178) established in 1987]) were planted at 24' x 12' spacings. Ten tree plots (with north/south orientation) were 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:** D. Scheuring  
**Location:** Guinda, California  
**Established:** 1989  
**Status:** Continuing  
**Design:** 11 cultivars or selections (Chandler, Cisco, Tulare [UC 67-11], UC 67-13, UC 72-13, UC 72-36 [established in 1990], UC 76-80, UC 77-10, UC 77-12, UC 78-10, and UC 78-189) were planted in a 22' x 11' hedgerow configuration. Four tree plots are replicated three times on two rootstocks (J. hindssii and Paradox). Demonstration plantings of four other cultivar/selections (UC 76-98, Lara, Ronde Montaigne, and Meylanaisse) are also present. Eight acres of UC 67-13 are planted adjacent to the trial.  
**Evaluation:** Bloom characteristics, yield, nut quality, and vegetative growth characteristics.  
**Publications:** WALNUT RESEARCH REPORTS (1990-1992); and, "Fruit and Nut Notes" (U.C.C.E. Yolo Co. Newsletter).

#### 6. Cultivar and Selection Performance in High Density Configuration
**Principal Investigator:** Kathleen M. Kelley  **Cooperator:** W. Deardorff  
**Location:** Hickman, California  
**Established:** 1988  
**Status:** Continuing
Design: 15 cultivars and selections, reduced to 9 items in 1993 (Amigo, Chandler, Cisco, Howard, Marchetti, Pedro, Tulare, UC 67-13 [deleted], UC 68-104 [deleted], UC 76-80, UC 76-98 [deleted], UC 76-112 [deleted], UC 77-12, UC 78-10 [deleted], and UC 78-189 [deleted]) were established as a demonstration plot in single rows oriented north/south with 13-17 trees each.

Evaluations: Leafing date, bloom characteristics, yield estimate, nut quality, and vegetative growth characteristics.


7. Cultivar and Selection Performance

Principal Investigator: Lonnie C. Hendricks, Cooperator: B. Crane
Location: Merced, California Established: 1978 Status: Completed in 1990
Design: 10 cultivars or selections (Chandler, Chico, Howard, Serr, Sunland, Tehama, UC 59-124, UC 60-119, UC 63-396, and UC 64-57) were planted at a 28' x 28' spacing.

Evaluations: Bloom characteristics, yield, and nut quality.


8. Cultivar and Selection Performance

Principal Investigator: Lonnie C. Hendricks, Cooperator: B. Crane
Location: Merced, California Established: 1987 Status: Continuing
Design: 12 cultivars or selections, reduced to 9 for 1994, (Chandler, Cisco, Tulare, UC 67-13 [deleted], UC 68-104 [deleted], UC 76-39 [deleted], UC 76-80, UC 76-112 [deleted], UC 77-10 [deleted], UC 77-12, 72-36 [deleted] and UC 78-57 [deleted].


9. Selection Performance

Principal Investigator: Lonnie C. Hendricks, Cooperator: C. Schmidt
Location: Merced, California Established: 1985 Status: Terminated 1988
Design: 1 cultivar and 5 selections (Tulare, UC 67-13, UC 68-104, UC 59-165, UC 63-378, and UC 75-74) were established in a standard planting.

Evaluation: Leafing date, bloom characteristics, nut quality, and vegetative growth characteristics.


10. Cultivar and Selection Performance in a Coastal Valley Region

Principal Investigator: William W. Coates, Cooperator: A. Bonturi
Location: Hollister, California Established: 1983 Status: Continuing
Design: 16 cultivars and selections (Ashley, Chandler, Chico, Cisco, Hartley, Howard, Nuggett, Payne, Pedro, "Red leaf" Serr, Serr, Scharch Schrannette, Sunland, Tehama, Vina, and UC 64-57) were established in a standard planting.

Evaluations: Leafing date, bloom characteristics, blight susceptibility, yield, and nut quality.


11. Cultivar and Selection Performance in a Coastal Valley Region

Principal Investigator: William W. Coates, Cooperator: K. Sanella
Location: Hollister, California Established: 1990 Status: Continuing
Design: 2 cultivars and 5 selections (Cisco, Tulare, UC 67-13, UC 76-80, UC 77-12, UC 78-10, and UC 78-189) were established on Paradox rootstock in a standard planting.

Evaluations: Leafing date, bloom characteristics, yield, nut quality, and vegetative growth characteristics.


12. Cultivar and Selection Performance in a Coastal Region

Principal Investigator: William W. Coates, Cooperator: K. Sanella
Location: Hollister, California Established: 1981-82 Status: Continuing
Design: 5 cultivars and 1 selection (Chandler, Hartley, Howard, Payne, Serr, and UC 64-57) were established in
12. Cultivar and Selection Performance
Principal Investigator: William H. Olson  Cooperator: W. Stuke
Location: Gridley, California  Established: 1996  Status: Terminated
Design: 2 cultivars and 2 selections (Cisco, Tulear, UC 67-13, and UC 68-104) were established in a standard planting.
Evaluations: Leafing date, bloom characteristics, yield estimate, and relative tree vigor.

14. Cultivar Performance
Principal Investigator: William H. Olson  Cooperator: C.S.U. Chico
Location: Chico, California  Established: 1987  Status: Terminated
Design: Cisco was established in limited numbers as a pollinator in a standard planting.
Evaluations: Leafing date, bloom characteristics, yield estimate, and relative tree vigor.

15. Cultivar Performance
Principal Investigator: Delbert S. Farnam  Cooperator: C. Dunlap
Location: West Point, California  Established: 1985  Status: Terminated
Design: Cisco was established in limited numbers as a pollinator in a standard planting.
Evaluations: Leafing date, bloom characteristics, yield estimate, and relative tree vigor.

16. Cultivar and Selection Performance
Principal Investigator: Rachel Elkins  Cooperator: A. Suchan
Location: Upper Lake, California  Established: 1990  Status: Continuing
Design: 1 cultivar and 3 selections (Howard, UC 76-80, UC 77-12 and UC 78-10) were replicated five times in a standard planting of Howards and Hartleys.
Evaluations: Leafing date, bloom characteristics, yield estimate, and relative tree vigor.

17. Cultivar Performance
Principal Investigator: Joseph A. Grant  Cooperator: J. Cotelli
Location: Stockton, California  Established: 1987  Status: Continuing
Design: Cisco was established on 10 trees as a pollinator in a standard planting.
Evaluations: Leafing date, bloom characteristics, yield estimate, and relative tree vigor.

18. Cultivar Performance
Principal Investigator: Joseph A. Grant  Cooperator: B. Vink
Location: Tracy, California  Established: 1990  Status: Continuing
Design: Tulear was established in limited numbers for field evaluation.
Evaluations: Leafing date, bloom characteristics, yield estimate, and relative tree vigor.

19. Cultivar Performance
Principal Investigator: Janine K. Balsey  Cooperator: J. Conant
Location: East Nicolaus, California  Established: 1984  Status: Terminated
Design: Tulear was established on 50 trees in a standard planting.
Evaluations: Leafing date, bloom characteristics, yield estimate, and relative tree vigor.
20. **Selection Performance**
Principal Investigator: G. Steven Sibbett  Cooperator: R. Waite
Location: Bakersfield, California  Established: 1988  Status: Terminated
Design: Selection UC 67-13 was established on approximately 200 trees in a standard planting.
Evaluation: Leafing date, bloom characteristics, yield estimate, and relative tree vigor.

21. **Cultivar Performance**
Principal Investigator: Richard P. Buchner  Cooperator: J. Repanich
Location: Corning, California  Established: 1984  Status: Terminated
Design: Tulare was established on a limited number of trees in a standard planting.
Evaluation: Leafing date, bloom characteristics, yield estimate, and relative tree vigor.

22. **Cultivar Performance**
Principal Investigator: Richard P. Buchner  Cooperator: W. Sartori
Location: Cottonwood, California  Established: 1984  Status: Terminated
Design: Cisco was established as a pollenizer in a standard planting.
Evaluation: Leafing date, bloom characteristics, yield estimate, and relative tree vigor.

23. **Cultivar Performance**
Principal Investigator: Richard P. Buchner  Cooperator: R. Darrow
Location: Vina, California  Established: 1988  Status: Terminated
Design: Cisco was established as a pollenizer in a standard planting.
Evaluation: Leafing date, bloom characteristics, yield estimate, and relative tree vigor.

24. **Cultivar and Selection Performance**
Principal Investigator: Kathleen M. Kelley  Cooperator: R. Driver
Location: Modesto, California  Established: 1984  Status: Terminated
Design: 1 cultivar and 5 selections (Tulare, UC 59-165, UC 63-378, UC 67-13, UC 68-104, and UC 75-74) were established in limited numbers in a standard planting.
Evaluation: Leafing date, bloom characteristics, yield estimates, and relative tree vigor.

25. **Cultivar and Selection Performance**
Principal Investigator: Kathleen M. Kelley  Cooperator: Burchell Nursery
Location: Stanislaus County, California  Established: 1988  Status: Terminated
Design: Cisco and selection UC 67-13 were established in limited numbers in a standard planting.
Evaluation: Leafing date, bloom characteristics, yield estimates, and relative tree vigor.

26. **Chandler Performance Under Various Mechanical Hedging and Hand Pruning Techniques**
Principal Investigator: William H. Olson  Cooperator: W. Cilker
Location: Gridley, California  Established: 1991  Status: Continuing
Design: Chandler trees (6 years old) were comparatively treated with 3 mechanical and 2 hand pruning techniques as follows: 1.) annually hedged alternate centers; 2.) annually hedged alternate row sides; 3.) annually hedged one tree quadrant per year; 4.) alternate year hand pruning; and, 5.) annual hand pruning. There are four replicates per treatment (each replicate consisting of 26 trees). The experiment is laid out in a randomized complete block design.
Evaluations: Yield, nut quality, and comparative economics of the treatments.
27. Cultivar, Selection, and Introduction Performance in Hedgerow Configuration

Principal Investigator: Kathleen M. Kelley  Cooperator: L. Grunder
Location: Jamestown, California  Established: 1992  Status: Continuing
Design: 1 cultivar, 1 selection, and 3 French introductions (Chandler, UC 76-80, H91-10 (Fr.), H94-11 (Fr.), and H94-12 (Fr.) were replicated 3 times (8 trees per plot) on J. hindsii rootstock in a hedgerow configuration.
The experiment is laid out in a randomized complete block design.
Evaluation: Yield and nut quality.
Publication: To be determined.
TABLE 2. ROOTSTOCK FIELD STUDIES

1. Walnut High Density, Soil Modification and Rootstock Performance
Principal Investigators: John P. Edstrom, William H. Krueger, and Wilbur O. Reil Cooperator: Nickel's Estate Soils Laboratory
Location: Colusa, California
Established: 1986
Status: Continuing
Design: 2 rootstocks (J. hindsii Rawlins and Rawlins Paradox) grafted with either Chandler or Howard were planted in 5 tree plots replicated 6 times in a completely randomized design. Additionally, the ground for one half of the plots was "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: C. McNamara
Location: Winters, California
Established: 1986
Status: Continuing
Evaluation: Survival (tolerance to A. mellea) and relative tree vigor.

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

4. Walnut Species Rootstock Performance
Principal Investigator: Lonnie C. Hendricks Cooperator: W. Linville
Location: Gustine, California
Established: 1986
Status: Terminated
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 grafting done onto failures in 1988.
Evaluation: Survival, initial rootstock vigor, comparative vigor of Vina, yield, nut quality, nematode tolerance, and salinity tolerance.

5. J. regia Walnut Rootstock Performance
Principal Investigator: Richard P. Buchner Cooperator: Father Joseph (Trappist Monastery)
Location: Vina, California
Established: 1986
Status: Continuing
Design: 4 rootstocks (J. regia Eureka, J. regia Manregian, clonal paradox, and clonal [own rooted] Chandler) were established in a hedgerow configuration. The rootstock was grafted (excepting clonal Chandler) with Chandler or Howard scions.
Evaluation: Survival, relative rootstock vigor, yield, and nut quality.
6. *J. regia* Walnut Rootstock Performance
Principal Investigator: Joseph A. Grant  Cooperator: J. Ferrari
Location: Linden, California  Established: 1989  Status: Continuing
Design: 5 rootstocks (*J. regia* Manregian seedlings, *J. regia* Eureka seedlings, *J. regia* Spain seedlings, *J. regia* Ronde de Montignac seedlings, and *J. regia* Corne seedlings) grafted with Chandler scions were planted in 5 tree plots replicated 3 times. The experiment was organized in a randomized complete block design. The trees were established in a hedgerow configuration.
Evaluation: Relative tree vigor, yield, and nut quality.

7. Walnut Species Rootstock Performance
Principal Investigator: Kathleen M. Kelley  Cooperator: J. DeMartini
Location: Modesto, California  Established: 1989  Status: Continuing
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 "100+" Paradox seedlings) were grafted with Chandler scions and planted in 5 tree plots replicated 3 times. The experiment was established in a randomized complete block design.
Evaluation: Relative tree vigor, yield, and nut quality.

8. Walnut Species Rootstock Performance
Principal Investigator: Joseph A. Grant  Cooperators: 2 (To be determined)
Locations: 2 (To be determined)  Established: In 1994  Status: Rootstock has been propagated in the nursery
Design: 7 rootstocks (*J. regia* Carpathian [Lawyer 64-5961], *J. regia* Russian seedlings [Schildgans], *J. regia* Eureka seedlings [Stuke], *J. regia* Waterloo seedlings [Driver], *J. regia* Sunland seedlings [Driver], *J. regia* Chandler seedlings [Driver], and paradox seedlings [Driver]) were grafted with Chandler and will be established in plantings to be determined.
Evaluation: Survival, relative tree vigor, yield, and nut quality.
Publication: To be determined.
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<td>19,431</td>
</tr>
<tr>
<td>Tulare</td>
<td>4377 A</td>
<td>2446 BCD</td>
<td>4056 A</td>
<td>4170 A</td>
<td>2480 CD</td>
<td>971 CD</td>
<td>18,500</td>
</tr>
<tr>
<td>Vina</td>
<td>3914 ABC</td>
<td>2834 ABC</td>
<td>3823 AB</td>
<td>3623 ABC</td>
<td>2338 CDE</td>
<td>1103 CD</td>
<td>17,644</td>
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<tr>
<td>Payne</td>
<td>2210 FG</td>
<td>3492 A</td>
<td>3034 BC</td>
<td>3397 ABC</td>
<td>3405 A</td>
<td>1823 AB</td>
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<tr>
<td>Pedro</td>
<td>3593 ABCD</td>
<td>3178 AB</td>
<td>3864 AB</td>
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<td>1842 DEF</td>
<td>887 DE</td>
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<td>68-104</td>
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<td>2260 CD</td>
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<td>3472 ABC</td>
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<tr>
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<td>987 D</td>
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<td>67-13</td>
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<td>1213 E</td>
<td>3828 AB</td>
<td>3079 BC</td>
<td>3024 AB</td>
<td>2033 A</td>
<td>14,964</td>
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<tr>
<td>Sunland</td>
<td>2004 GH</td>
<td>1816 DE</td>
<td>3294 ABC</td>
<td>2921 C</td>
<td>3558 A</td>
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<td>Chandler</td>
<td>3142 CDE</td>
<td>3357A</td>
<td>3358 AB</td>
<td>2920 C</td>
<td>970 G</td>
<td>704 DE</td>
<td>14,651</td>
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<tr>
<td>Howard</td>
<td>2559 EFG</td>
<td>2589 ABCD</td>
<td>3243 ABC</td>
<td>3231 BC</td>
<td>1969 DEF</td>
<td>894 DR</td>
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<td>Tehama</td>
<td>2830 DEF</td>
<td>2798 ABC</td>
<td>3426 ABC</td>
<td>2851 C</td>
<td>1608 FG</td>
<td>424 E</td>
<td>13,937</td>
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<tr>
<td>Amigo</td>
<td>1183 H</td>
<td>1240 E</td>
<td>1394 D</td>
<td>1860 D</td>
<td>1710 EF</td>
<td>867 DE</td>
<td>8,884</td>
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<tr>
<td>Cisco*</td>
<td>1292</td>
<td>1641</td>
<td>1900</td>
<td>561</td>
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*Top worked - 7th leaf graft
Table 4. 1993 Solano County 10th leaf walnut hedgerow trial east-west oriented rows. Yield in lbs/acre.

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Chico</td>
<td>6538</td>
<td>7077</td>
<td>3890</td>
<td>5452</td>
<td>5065</td>
<td>3870</td>
<td>2282</td>
<td>34,174</td>
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<tr>
<td>Vina</td>
<td>4942</td>
<td>1555</td>
<td>4149</td>
<td>2980</td>
<td>3857</td>
<td>2651</td>
<td>1537</td>
<td>21,671</td>
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<td>Chandler</td>
<td>8466</td>
<td>4235</td>
<td>4084</td>
<td>4237</td>
<td>2203</td>
<td>2725</td>
<td>1732</td>
<td>27,682</td>
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<tr>
<td>Howard</td>
<td>5344</td>
<td>4912</td>
<td>4707</td>
<td>4416</td>
<td>3155</td>
<td>2648</td>
<td>1583</td>
<td>26,765</td>
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<td>Amigo</td>
<td>4244</td>
<td>1221</td>
<td>2072</td>
<td>670</td>
<td>3928</td>
<td>1665</td>
<td>629</td>
<td>14,429</td>
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<tbody>
<tr>
<td>Chico</td>
<td>7590</td>
<td>8835</td>
<td>4963</td>
<td>6060</td>
<td>4445</td>
<td>4573</td>
<td>2759</td>
<td>39,224</td>
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<tr>
<td>Vina</td>
<td>5874</td>
<td>1928</td>
<td>4615</td>
<td>2865</td>
<td>3487</td>
<td>2398</td>
<td>1079</td>
<td>22,246</td>
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<tr>
<td>Chandler</td>
<td>7722</td>
<td>6046</td>
<td>4734</td>
<td>4257</td>
<td>2149</td>
<td>3447</td>
<td>1855</td>
<td>30,310</td>
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<tr>
<td>Howard</td>
<td>5734</td>
<td>5622</td>
<td>5326</td>
<td>5272</td>
<td>3443</td>
<td>3301</td>
<td>1803</td>
<td>30,501</td>
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</table>

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

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<th></th>
<th></th>
<th></th>
<th></th>
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<tbody>
<tr>
<td>11 x 22</td>
<td>6323</td>
<td>4445</td>
<td>4208</td>
<td>4271</td>
<td>3570</td>
<td>2974</td>
<td>1764</td>
<td>27,575</td>
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<tr>
<td>9 x 18</td>
<td>6730</td>
<td>5608</td>
<td>4910</td>
<td>4616</td>
<td>3381</td>
<td>3427</td>
<td>1874</td>
<td>30,546</td>
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</table>

<table>
<thead>
<tr>
<th></th>
<th>11 x 22/11 x 22</th>
<th>9 x 18/11 x 22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chandler</td>
<td>$22,146</td>
<td>$24,168</td>
</tr>
<tr>
<td>Chico</td>
<td>19,821</td>
<td>22,750</td>
</tr>
<tr>
<td>Howard</td>
<td>15,523</td>
<td>17,691</td>
</tr>
<tr>
<td>Vina</td>
<td>12,786</td>
<td>13,125</td>
</tr>
<tr>
<td>Amigo</td>
<td>8,657</td>
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</table>

Gross $ Value 1987 to 1993 Using 1991 Price Per Pound:
Table 5. 1993 Solano County 10th 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>1993 % on</th>
<th>1992 % on</th>
<th>1991 % on</th>
<th>1990 % on</th>
<th>1989 % on</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S. Side</td>
<td>S. Side</td>
<td>S. Side</td>
<td>S. Side</td>
<td>S. Side</td>
</tr>
<tr>
<td>1993 Hedged North Side Only</td>
<td>2307&lt;sup&gt;P&lt;/sup&gt;</td>
<td>2891&lt;sup&gt;P&lt;/sup&gt;</td>
<td>1796&lt;sup&gt;P&lt;/sup&gt;</td>
<td>2590&lt;sup&gt;P&lt;/sup&gt;</td>
<td>2000&lt;sup&gt;P&lt;/sup&gt;</td>
</tr>
<tr>
<td>1992 Hedged South Side Only</td>
<td>4812</td>
<td>3309&lt;sup&gt;P&lt;/sup&gt;</td>
<td>2701</td>
<td>2471&lt;sup&gt;P&lt;/sup&gt;</td>
<td>4145</td>
</tr>
<tr>
<td>1991 Hedged North Side Only</td>
<td>7119</td>
<td>6200</td>
<td>53&lt;sup&gt;%&lt;/sup&gt;</td>
<td>4497</td>
<td>49&lt;sup&gt;%&lt;/sup&gt;</td>
</tr>
<tr>
<td>1990 Hedged South Side Only</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>
</tr>
<tr>
<td>North</td>
<td>2569&lt;sup&gt;P&lt;/sup&gt;</td>
<td>2021&lt;sup&gt;P&lt;/sup&gt;</td>
<td>1765</td>
<td>1748&lt;sup&gt;P&lt;/sup&gt;</td>
<td>2885&lt;sup&gt;P&lt;/sup&gt;</td>
</tr>
<tr>
<td>South</td>
<td>3100&lt;sup&gt;P&lt;/sup&gt;</td>
<td>3158</td>
<td>1709</td>
<td>3133</td>
<td>2405&lt;sup&gt;P&lt;/sup&gt;</td>
</tr>
<tr>
<td>Total</td>
<td>5879</td>
<td>5179</td>
<td>61&lt;sup&gt;%&lt;/sup&gt;</td>
<td>3474</td>
<td>49&lt;sup&gt;%&lt;/sup&gt;</td>
</tr>
<tr>
<td>1991 Hedged Both Sides</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>1990 Hedged Both Sides</td>
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<tr>
<td>1989 Hedged Both Sides</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>North</td>
<td>2058&lt;sup&gt;P&lt;/sup&gt;</td>
<td>2551&lt;sup&gt;P&lt;/sup&gt;</td>
<td>2005&lt;sup&gt;P&lt;/sup&gt;</td>
<td></td>
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<tr>
<td>South</td>
<td>1833&lt;sup&gt;P&lt;/sup&gt;</td>
<td>2901&lt;sup&gt;P&lt;/sup&gt;</td>
<td>2405&lt;sup&gt;P&lt;/sup&gt;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3891</td>
<td>5452</td>
<td>53&lt;sup&gt;%&lt;/sup&gt;</td>
<td>5065</td>
<td>60&lt;sup&gt;%&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>P</sup> - Indicates the side that was pruned the previous winter.

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

| Yield per side of tree when pruned | 1974 lbs. | 2641 lbs. | 33.8% |
| Yield per side of tree when not pruned | 2540 lbs. | 3590 lbs. | 41.3% |
| Increase the year not pruned | 28.7% | 35.9% |
Table 6.

HEDGING VS. HAND PRUNING
2nd YEAR YIELDS PER TREATMENT

<table>
<thead>
<tr>
<th>TREATMENT</th>
<th>YIELD/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEDG. ALT. CENTERS</td>
<td>2.88 a</td>
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<tr>
<td>HEDG. 1 SIDE/ROW</td>
<td>2.94 a</td>
</tr>
<tr>
<td>HEDG. 1 QUAD/ROW</td>
<td>3.11 a</td>
</tr>
<tr>
<td>ALT YR HAND PRUNE-PRUNED</td>
<td>3.09 a</td>
</tr>
<tr>
<td>ALT YR HAND PRUNE-SKIPPED</td>
<td>3.30 a</td>
</tr>
<tr>
<td>ANNUAL HAND PRUNED</td>
<td>3.05 a</td>
</tr>
</tbody>
</table>

Means not followed by comm letter are sig. diff. 5%,LSD.

Table 7.

HEDGING VS. HAND PRUNING
1st YEAR NUT QUALITY COMPARISONS

<table>
<thead>
<tr>
<th>TREATMENT</th>
<th>% LARGE NUTS</th>
<th>% EDIBLE KERNELS</th>
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</thead>
<tbody>
<tr>
<td>HEDG. ALT. CENTERS</td>
<td>90.8 cd</td>
<td>50.0 a</td>
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<tr>
<td>HEDG. 1 SIDE/ROW</td>
<td>88.9 d</td>
<td>51.4 a</td>
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<tr>
<td>HEDG. 1 QUAD/ROW</td>
<td>90.0 d</td>
<td>50.8 a</td>
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<tr>
<td>ALT YR HAND PRUNE-PRUNED</td>
<td>92.8 ab</td>
<td>50.0 a</td>
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<tr>
<td>ALT YR HAND PRUNE-SKIPPED</td>
<td>91.0 bc</td>
<td>50.5 a</td>
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<tr>
<td>ANNUAL HAND PRUNED</td>
<td>94.2 a</td>
<td>50.4 a</td>
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</table>

Means not followed by comm letter are sig. diff. 5%,LSD.

Table 8.

HEDGING VS. HAND PRUNING
YIELD (POUNDS) INFLUENCES FROM HEDGING

<table>
<thead>
<tr>
<th>TREE SIDE</th>
<th>HEDG YR 1</th>
<th>HEDG YR 2</th>
<th>PRUNED YR 1</th>
<th>PRUNED YR 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>HEDGED</td>
<td>1013 a</td>
<td>1012 a</td>
<td></td>
<td></td>
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<tr>
<td>NOT HEDGED</td>
<td>1180 b</td>
<td>1368 b</td>
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</tr>
</tbody>
</table>

WEST

|            | 795 NS   | 922 NS   |

EAST

|            | 732 NS   | 823 NS   |

Means not followed by comm letter are sig. diff. t test 5%

93
Fig. 1. Yolo County Walnut Hedgerow 6 Year Cumulative Yield (152 Trees/Acre)
Fig. 2.

HEDGING VS. HAND PRUNING
ACCUMULATIVE YIELD OVER TIME

TONS/acre


HEDG. ALT. CNTRS. HEDG. 1 SIDE/ROW HEDG 1 QUAD/ROW
ALT YR HND PRUNE ANN HAND PRUNE