EVALUATION AND DEVELOPMENT OF WALNUT SEEDLINGS, SELECTIONS, CULTIVARS, INTRODUCTIONS AND ROOTSTOCK

G. McGranahan, R. Snyder, D. Ramos, and H. Forde

ABSTRACT

The genetic improvement program for walnuts has been expanded in 1988. Evaluation of seedlings derived from controlled crosses by Forde was completed with seedlings either retained as selections (n = 10), or unusual genotypes (n = 3), or discarded. Emphasis continues on identification and development of pollenizers for 'Chandler', 'Howard' and 'Hartley'. 'Cisco' (UC 66-178) was released and recommended as a pollenizer for 'Chandler' in high density plantings. Twelve field trials of 'Cisco' are underway in 9 counties. Five previously discarded seedlings have been identified as potential 'Chandler' pollenizers and are undergoing evaluation. Seedings from controlled pollinations (1986 & 1987) by McGranahan/Snyder for protogyny and late leafing are under preliminary evaluation for leafing dates. The "Introductions" collection has been expanded to 76 clones or seed sources including material from China, France, Poland, India, Korea, Spain, and U.S.A. Our walnut collections have been reorganized and repurposed to assure efficient progression of items through the program. In addition, we have compiled and presented in this report information on cultivar, selection, and rootstock evaluation trials statewide to allow us to develop comparative information.

OBJECTIVES

The general objective of this project is to release new cultivars and rootstocks which will serve the needs of the walnut industry. The specific objectives are: a) to continue evaluations of seedlings, introductions, selections, and cultivars in our collections; b) to develop pollenizers for 'Chandler', 'Howard', and 'Hartley' by evaluating existing collections and new seedlings resulting from controlled crosses designed to produce protogynous pollenizers; c) to introduce germplasm which will broaden the genetic base available for breeding; d) to identify rootstocks tolerant of adverse conditions and diseases such as blackline and crown and root rots. (The high density planting and management system report is submitted separately.)

PROCEDURES

Data was collected on the following traits for seedlings, introductions, selections, and cultivars: dates of leafing, first and last anther dehiscence, first, peak and last pistillate bloom, and harvest; catkin density; percent lateral fruitfulness; blight incidence; tree vigor; estimated yield; shell shape, texture, strength and seal; nut and kernel weight and resulting percent kernel; kernel color and frequency of kernel shrivel or blanks. Diamond Walnut Growers kindly provided us with a commercial crack out evaluation of selected cultivars and selections. A panel reviewed the data, observed the kernels and recommended action (save for further evaluation, select, or discard) on those with at least 5 years evaluation. Specific attention was focused on selections and seedlings that shed pollen from peak to last pistillate flower receptivity of 'Chandler'.
Seedlings from controlled crosses in 1986 were evaluated for leafing date and precocity.

Plot designs and locations of cultivar, selection, and rootstock field trials developed by UC Farm Advisors were solicited to assist us in developing comparative descriptions of items growing under different environmental conditions.

RESULTS AND CONCLUSION

Cultivars: Cultivar performance at UC Davis (Tables 1, 2, & 3) was relatively poor this year. The decline was expressed in reduced shoot growth, estimated yield, kernel color and percent kernel. Potential causes include adverse conditions during bloom and development, for example, high winds (especially for 'Chico'), excessively high temperatures, and water stress due to drought.

Cultivars from the old "Variety and Selection Blocks" have been repropagated into a cultivar collection at Wolfskill Experimental Orchards for permanent holding.

'Cisco' (UC 66-178) was released as a pollenizer for 'Chandler' in high density plantings. A complete description is available in the release notice.

Selections: Brief descriptions of the current selections are provided (Table 4). Ten selections are under evaluation for release; another three are being maintained for specific or unusual traits in the cultivar collection at Wolfskill. Other older selections that we do not expect to release but that are popular with growers in specific areas, are also being maintained at Wolfskill but are no longer evaluated.

UC 67-13 is closest to release and should be multiplied so sufficient material will be available to growers. Because UC 67-13 is an offspring of 'Serr' the decision on release will be postponed until the frequency of pistillate flower abscission is established.

Seedlings: The Serr/Forde seedlings have been discarded or advanced to selection status with the exception of five that are being reevaluated as potential pollenizers. Seedlings from controlled crosses 1986 and 1987 designed to provide late leafing, protogynous cultivars that could serve as pollenizers are being selected in the second growing season for leafing date. This early selection will reduce the amount of land required for long term evaluation.

Introductions: Seventy-six introductions from China, France, India, Korea, Poland and USA regions are being evaluated as potential selections, rootstock or germplasm resources. Seven of the fifteen French J. regia clones were immediately designated as advanced selections due to the extensive evaluations conducted by E. Germain in France. Evaluations at U.C. Davis show these French individuals to be mid to late leafing with two demonstrating pistillate precocity and one showing staminate precocity in the second year after grafting. The Chinese J. regia clones leaf out before or with Payne and two showed extreme precocity with pistillate and staminate bloom produced by the graft wood buds. These two also expressed extreme lateral fruitfulness (rated for three years at 100%) and vigor (first year shoots grew 10 to 15 feet). Additionally, the second year yields rated high, but shell strength and kernel color were poor with very large kernels (ranging from 8.4 to 10.7 gms) and percent kernel ranging from 60
to 74. The Polish clones are early leafing and also demonstrate pistillate and staminate precocity. The rootstock introductions are either being maintained as germplasm or have been developed for field rootstock trials.

**Field Trial Summaries:** Rootstock, cultivar and selection trials have been established by Farm Advisors in 9 counties (Tables 5 & 6). Some trials are small, designed to evaluate a few specific clones or seed sources; others involve extensive collections of species or selections and cultivars grown under different training systems and/or environments. By compiling the information from these trials we hope to provide a statewide evaluation of specific items in the future. Please help us by providing any missing information.

In this report we have attempted to provide detailed information in tables that can be used by Farm Advisors and growers. We would appreciate suggestions on how to improve the tables for future reports.
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<th>5 yr</th>
<th>Pollen Shedding 1st</th>
<th>Last</th>
<th>Density&lt;sup&gt;b&lt;/sup&gt;</th>
<th>Pistillate Bloom 1st</th>
<th>Peak</th>
<th>Last</th>
<th>Fruitful Lateral</th>
<th>% Yield&lt;sup&gt;c&lt;/sup&gt;</th>
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<sup>a</sup>"DAP" denotes "days after Payne".

<sup>b</sup>Catkin density: 0 = no catkins, 5 = very dense catkin production.

<sup>c</sup>Yield estimate: 0 = no walnuts, 5 = very high yield.

<sup>d</sup>Blight score: 0 = no sign of infection, 5 = severe infection.
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a"DAF" denotes "days after Payne".
bShell Seal Grading: 1 = very well, 5 = very poor.
cShell Strength: 1 = strong, 4 = very weak.
dShell Thickness: 1 = very thin, 5 = very thick.
eKernel Fill: 1 = very well, 5 = very poor.
### TABLE 3. 1988 U.C.D. CULTIVAR EVALUATIONS BY SUN DIAMOND

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<th>Cultivar</th>
<th>Total Weight of Nuts in Sample (gm)</th>
<th>% Large Size</th>
<th>RLI&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Total Kernel Yield (percent in-shell wt.)</th>
<th>Internal Damage (Number)</th>
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</table>

<sup>a</sup> Relative light intensity

<sup>b</sup> Other damage = mold, insects, black
TABLE 4. DESCRIPTION OF SELECTIONS

<table>
<thead>
<tr>
<th>Selection</th>
<th>Leaves out</th>
<th>Laterally fruitful (%)</th>
<th>Pollenizer</th>
<th>Yields</th>
<th>Kernel rating</th>
<th>Harvests after or with</th>
<th>Counties</th>
</tr>
</thead>
<tbody>
<tr>
<td>66-178 (Cisco)</td>
<td>3 to 7 days before Hartley</td>
<td>90%</td>
<td>Chandler</td>
<td>Poor to very good with kernels of variable quality. Harvests with Franquette.</td>
<td>Poor to very good</td>
<td>2 weeks after Payne</td>
<td>Butte, Colusa, Merced, San Benito, San Joaquin, Stanislaus, Tehama and Tulare Counties.</td>
</tr>
<tr>
<td>67-11</td>
<td>3 to 7 days before Hartley</td>
<td>75%</td>
<td>Laterally fruitful (75%). Yields are very good with recent poor ratings. Harvests 2 weeks after Payne. Potential pollenizer for Vina. Released under test agreement for field evaluations (standard and hedgerow plantings) in Butte, Merced, Stanislaus, Sutter, Tehama, Tulare and Yolo Counties.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>67-13</td>
<td>2 to 7 days after Payne</td>
<td>90%</td>
<td>Laterally fruitful (90%). Yields are very good to excellent. Near homogamous flowering. Produces large numbers of catkins. Kernel quality has varied from poor to very good with consistently high &quot;percent kernel&quot; ratings. Harvests with Payne. Initial good performance in hedgerow plantings and as a pollenizer for Chico. Questioned in regard to pistillate flower abscission frequency. Released under test agreement in Butte, Kern, Merced, San Benito, Stanislaus, Tulare and Yolo Counties.</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>68-104</td>
<td>2 to 9 days before Hartley</td>
<td>85%</td>
<td>Laterally fruitful (85%). Yields are average to excellent. Nut size is small, yet &quot;percent kernel&quot; is high. Kernel quality is variable. Harvests one week after Payne. Appears to yield in shaded areas of tree. Released under test agreement (standard and hedgerow plantings) in Butte, Merced, Stanislaus, Tulare and Yolo Counties.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>76-21</td>
<td>1 day before to 7 days after Scharsch Franquette</td>
<td>Laterally fruitful. Yields are poor with small to average sized nuts and poor to average &quot;percent kernel&quot;. Will be maintained in germplasm collection due to leafling and extreme dichogamous traits.</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>76-80</td>
<td>6 days before to 1 day after Hartley</td>
<td>70%</td>
<td>Preco-cious catkin and pistillate flower production. Laterally fruitful. Yields are average to very good. Very good kernel quality with average &quot;percent kernel&quot; ratings. Shell seal in question. Released under test agreement in Merced and Stanislaus Counties.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(cont'd)
76-98

Leafs out from 7 days before to 6 days after Scharsch Franquette. Laterally fruitful (90%). Very dichogamous. Yield varies from average to very good. Kernel quality is generally excellent with one year of poor quality. Percent kernel rating is average. Retained in germplasm collection for leafing and dichogamous traits. Released under test agreement in Stanislaus County.

76-112

Leafs out from 2 to 8 days before Scharsch Franquette. Laterally fruitful (60%). Exhibits excessive dichogamy. Yield is average. Kernel quality is very good to excellent with above average "percent kernel" ratings. Retained in germplasm collection for leafing and dichogamous traits. Released under test agreement in Merced and Stanislaus Counties.

77-12

Leafs out from 2 to 6 days after Hartley. Laterally fruitful (65%). Protogynous. Short season for nut development. Yield varies from average to very good. Kernel quality varies from average to excellent with average "percent kernel" ratings. Kernels may have unusual oil composition exhibiting high percent of unsaturated fatty acids. Advanced to selection status in 1988. Released under test agreement in Merced and Stanislaus Counties.

78-7

Leafs out from 37 to 55 days after Scharsch Franquette. Produces large numbers of catkins for late pollination. Laterally fruitful (50%). Average to poor kernel quality. Retained in germplasm collection as late pollen source.

78-10

Leafs out 3 days before to 5 days after Scharsch Franquette. Potential pollenizer for Chandler, Howard and Hartley. Laterally fruitful (95%). Yield varies from average to good. Kernel quality is excellent with average "percent kernel" ratings. Advanced to selection status in 1988. Released under test agreement in Stanislaus County.

78-21

Leafs out 18 to 44 days after Scharsch Franquette. Laterally fruitful (100%). Exhibits extreme dichogamy. Retained in germplasm collection for leafing and dichogamous traits.

78-189

Leafs out from 1 day before to 7 days after Hartley. Protogynous, nearly homogamous. Potential pollenizer for Chandler, Howard and Hartley. Laterally fruitful (75%). Yield is average. Nut size is small. Kernel quality is excellent with average "percent kernel" ratings. Advanced to selection status in 1988. Released under test agreement in Stanislaus County.
TABLE 5. CULTIVAR AND SELECTION FIELD STUDIES

Walnut 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 67-11, 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) replicated 3 times.
Evaluations: Bloom characteristics, yield, nut quality and vegetative growth characteristics.
Publications: Walnut Research Reports

Walnut 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.
Evaluations: Yield, nut quality and vegetative growth characteristics.
Publications: Walnut Research Reports

Walnut 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 22' x 11' spacing. Ten tree plots are replicated 4 times.
Evaluations: Bloom characteristics, yield, nut quality and vegetative growth characteristics.
Publications: Walnut Research Reports

Walnut Cultivar and Selection Performance
Principal Investigator: Lonnie C. 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.
Evaluations: Bloom characteristics, yield and nut quality.
Publications: Walnut Research Reports

(cont'd)
Walnut Cultivar and Selection Performance
Principal Investigator: Lonnie C. Hendricks
Cooperator: B. Crane
Location: Merced, California
Established: 1987
Design: 13 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 76-121, UC 77-12, UC 78-1, UC 78-57 and UC 78-82) were planted at standard spacing.
Evaluations: Leafing date, bloom characteristics, yield and nut quality
Publications: Walnut Research Reports

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

Cultivar and Selection Performance in Coastal Valley Region
Principal Investigator: William H. Coates
Cooperator: Multiple
Location: Multiple
Established:
Design: 7 cultivars and selections (Payne, Serr, Howard, Chandler, Pedro, Hartley and UC 64-57)
Evaluations: Leafing date, bloom characteristics, blight susceptibility, yield and nut quality
Publications:

Walnut Cultivar and Selection Performance
Principal Investigator: Kathleen M. Kelley
Cooperator: W. Deardorff
Location: Hickman, California
Established: 1984
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 a standard planting.
Evaluations: Leafing date, bloom characteristics, yield, nut quality and vegetative growth characteristics
Publications:

(cont'd)
Cultivar Performance
Principal Investigator: William H. Olson
Cooperator: E. Skinner
Location: Durham, California
Established: 1980 and 1981
Design: 4 cultivars (Chandler, Howard, Cisco [UC 66-178], and Scharsch Franquette) were established in a standard planting. Chandler and Howard trees alternate in the two rows evaluated. Cisco (UC 66-178) and Scharsch Franquette are located in close proximity.
Evaluations: Catkin and pistillate bloom dates, yield and nut quality
Publications: Walnut Research Reports

Cultivar and Selection Performance
Principal Investigator: William H. Olson
Cooperator: William Stuke
Location: Gridley, California
Established:
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.
Evaluations: Leafing date, pistillate and catkin bloom period, yield estimate and relative tree vigor
Publications:

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

Cultivar Performance
Principal Investigator: Daniel M. Irving
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.
Evaluations: Leafing date, pistillate and catkin bloom periods, yield estimate and relative tree vigor
Publications:

(cont'd)
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 trees as a pollinator in a standard planting.
Evaluations: Leafing date, pistillate and catkin bloom periods, yield estimate and relative tree vigor
Publications:

Selection Evaluation
Principal Investigator: Kathleen M. Kelley
Cooperator: R. Driver
Location: Modesto, California
Established: 1984
Design: 6 selections (UC 59-165, UC 63-378, UC 67-11, UC 67-13, UC 68-104 and UC 75-74) were established in limited numbers in a standard planting.
Evaluations: Leafing date, pistillate and catkin bloom periods, yield estimate and relative tree vigor
Publications:

Cultivar and Selection Performance
Principal Investigator: Kathleen M. Kelley
Cooperator: Burchell Nursery
Location: Stanislaus County, California
Established: 1988
Design: Cultivar Cisco (UC 66-178) and selection UC 67-13 were established in limited numbers in a standard planting.
Evaluations: Leafing date, pistillate and catkin bloom periods, yield estimate and relative tree vigor
Publications:

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.
Evaluations: Leafing date, pistillate and catkin bloom period, yield estimate and relative tree vigor
Publications:

(cont'd)
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.
Evaluations: Leafing date, pistillate and catkin bloom periods, yield estimate and relative tree vigor.
Publications:

Cultivar Performance
Principal Investigator: Joseph W. Osgood
Cooperator: R. Darrow
Location: Vina, California
Established: 1988
Design: Cultivar Cisco (UC 66-178) was established on a limited number of trees as a pollenizer in a standard planting.
Evaluations: Leafing date, pistillate and catkin bloom periods, yield estimate and relative tree vigor.
Publications:

Selection Performance
Principal Investigator: Joseph W. Osgood
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.
Evaluations: Leafing date, pistillate and catkin bloom periods, yield estimate and relative tree vigor
Publications:

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

(cont'd)
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.
Evaluations: Leafing date, pistillate and catkin bloom periods, yield estimates and relative tree vigor.
Publications:
TABLE 6. ROOTSTOCK FIELD STUDIES

Walnut Rootstock Performance
Principal Investigator: Lonnie C. Hendricks
Cooperator: W. Linville
Location: Gustine, CA
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.
Evaluations: Survival, initial rootstock vigor, comparative vigor of Vina, yield, nut quality, nematode tolerance and salinity tolerance

Walnut Species Rootstock Performance
Principal Investigator: Janine K. Hasey
Cooperator: J. Conant
Location: Rio Oso, CA
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.
Evaluations: Survival, relative tree vigor, yield and nut quality

Walnut Rootstock Performance under "Dry Land" Management
Principal Investigator: John H. Foott
Cooperators: M. Whitner and D. Van Steenwyk
Location: Paso Robles, CA
Established: Rootstock - 1986 (Hartley to be grafted - 1989)
Design: 5 rootstocks (J. regia Manregian seedlings, J. regia Amigo seedlings, J. regia India seedlings, J. hindsii Rawlins and Rawlins [Calvert] Paradox) were planted in a completely randomized design with 5 tree plots replicated 5 times.
Evaluations: Survival, initial rootstock vigor, vigor of Hartley grafted trees, yield and nut quality

Walnut Rootstock Performance/Tolerance to Armillaria mellea
Principal Investigator: Kathleen M. Kelley
Cooperator: M. Crow
Location: Crows Landing, CA
Established: 1986 (grafted to Payne - 1988)
Design: 4 rootstocks (J. regia Manregian seedlings, J. hindsii Rawlins, Rawlins Paradox and Pterocarya stenoptera [wingnut] seedlings) were planted in 4 tree plots replicated 5 times. Payne was grafted to survivors in 1988.
Evaluation: Survival (tolerance to A. mellea) initial rootstock vigor, vigor of Payne grafted trees, yield and nut quality
Walnut Species Rootstock Performance/Tolerance to A. mellea
Principal Investigator: Wilbur O. Reil
Cooperator: C. McNamara
Established: 1986
Design: 11 rootstocks (Rawlins [Calvert] paradox, 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. ailantifolia [Japanese Black], and J. major [Arizona
   Black] were planted in 4 tree plots replicated 4 times.
Evaluations: Survival (tolerance to A. mellea), relative tree vigor

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
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".
Evaluations: Relative tree vigor, yield and nut quality

Walnut Rootstock Performance
Principal Investigators: Joseph W. Osgood and Father Joseph
Cooperator: Trappist Monastery
Location: Vina, CA
Established: 1986
Design: 4 rootstocks (J. regia Eureka, J. regia Manregian, clonal paradox and
   rooted Chandler) were established.
Evaluations: Survival, relative rootstock vigor, yield and nut quality