WALNUT IMPROVEMENT PROGRAM 2014

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ABSTRACT

The Walnut Improvement Program works to develop improved scion cultivars for the California walnut industry and new rootstocks with pathogen and abiotic stress resistance while simultaneously increasing knowledge about the genetics of the crop and maintaining breeding resources. The primary objective of scion breeding is generation of new cultivars with early harvest dates, yield, and good kernel color. This year we continued to assist nurseries in obtaining wood for increase and production of the recently released 'Solano', an early to mid-season harvesting variety with excellent kernel color and timing similar to Vina but with better color and tree structure. Several additional advanced selections with Payne-time to mid-season harvest dates and excellent color continue to show promise and are under serious consideration for release. Wood of these was distributed to interested nurseries and growers for increase and further evaluation. This year we also continued evaluation and propagation of 81 scion selections on campus and in state-wide grower trials and completed early evaluations on over 3700 seedling trees. We continue to evaluate 109 backcross seedlings, of 4^{th} and 5^{th} generation crosses tested as virus resistant by DNA marker analysis, for their yield, bearing habit, and nut traits. The most promising of these were grafted into a patch testing block for confirmation of virus resistance and several were used as parents for next generation crossing. We collected DNA samples from all breeding program seedlings and DNA markers, and we collected leaf samples from all breeding program seedlings prior to planting for DNA analysis and determination of marker applicability to lateral bearing determination. Current field trials of transgenic crown gall resistant rootstock selections continue to be observed and used for graft union studies and pathogen resistance testing in the field,. We continued to improve the tissue culture propagation, tissue culture media for clonal plantlet elongation, improved the gene modification process, developed air layering and softwood cutting methods for genotypes that are difficult to work with in tissue culture, and explored ways to more rapidly and efficiently germinate black walnut seed, particularly for Juglans microcarpa accessions of interest for rootstock work. Field and tissue culture germplasm collections continue to be maintained as a breeding resource, for supplying material to commercial labs and nurseries, and for use by other research projects.

OBJECTIVES

The objectives of the Walnut Improvement Program are:

- To provide the California walnut industry with improved walnut cultivars and rootstocks
- To develop knowledge that will increase the efficiency of walnut breeding
- To develop and maintain an array of traits available for breeding in the future
- To develop and apply new molecular methods to walnut genetic improvement

The program consists of several projects with specific objectives:

- The classical cultivar breeding project uses traditional methods to develop and release new cultivars that combine precocity (high early yield) and early harvest date with kernel quality, in-shell traits, and disease resistance.
- The backcross breeding project for blackline is designed to move the resistance to cherry leafroll virus found in black walnut and Paradox into commercial quality English walnut varieties.
- The rootstock improvement program seeks genetic solutions to rootstock related problems including *Phytophthora*, nematodes, crown gall and *Armillaria* and works to improve rooting and clonal propagation methods. Both rootstock breeding and gene insertion methods are used to develop new genotypes which are multiplied and grown for pathogen resistance testing.
- New technologies that increase the efficiency of breeding and the range of genetic material available for walnut improvement continue to be evaluated, developed, and adapted to walnut breeding as opportunities arise including gene modification and genomics information.
- Germplasm collections are maintained, and augmented when possible, for future breeding use, as a source of foundation material for commercial labs and nurseries and for other researchers.

SIGNIFICANT FINDINGS

- Growth of breeding program seedlings in pots for the first year followed by direct planting of containerized seedlings in the orchard in early September resulted in excellent establishment.
- Promising selections including 93-028-20, 03-001-1372, 03-001-1457, 03-001-1938, and 03-001-2357 were moved to additional trials and are candidates for release.
- DNA markers identified for lateral bearing in the Chandler x Idaho poulation did not work well enough in a breeding cross test population in an initial trial this year to allow use with confidence for selection purposes.
- A single crown gall resistant transgenic line was selected for the deregulation application process.
- An improved scorable marker for laboratory selection of transgenic plants was developed. We expect this to provide improved efficiency for future gene modifications.
- A combination of shell cracking and Promalin application improved *J. microcarpa* germination.
- Methods were successfully developed for propagation of walnut and wingnut genotypes by air layering and semi-hardwood cuttings. This is useful for propagating clonal copies of genotypes that are difficult to introduce or multiply by tissue culture.

PROCEDURES

Scion cultivar breeding

Seedlings for evaluation are generated through controlled crosses. This involves bagging female flowers prior to anthesis to exclude unwanted pollen, collection and storage of pollen from chosen parents for up to a year, and careful timing in application of the appropriate pollen to receptive flowers. The crossing designs used during the 2007-2014 seasons place priority on crossing the best kernel quality, nut trait and yield selections with the earliest harvesting selections as shown in the Tables 1-10.

Seed from these crosses is collected in the fall before nut drop, air dried before storing and chilled until the end of harvest season. To ensure the highest possible germination, nuts are chipped open at the blossom end using a "Texas Nut Cracker" which opens a hole in the shell without damaging the embryo. Nuts are then immersed in cold, slowly running, water for 2 days before planting in the greenhouse. The resulting seedlings are chilled for 2 months in a cold room, unheated greenhouse, or outdoors to give them their first year of dormancy. In the spring the dormant seedlings are planted in a nursery for a year prior to replanting in seedling blocks at UC Davis. For many years Burchell Nursery has generously donated this service.
Seedlings to be evaluated are planted on relatively close spacing (6') and any that appear to be terminal bearing or have other early defects (dwarfs, extra-lates etc.) are culled at age 3 to 4. By age 5, trees with apparent low yield or other problems are also cut down. Full evaluations are undertaken only on precocious and laterally fruitful individuals. Surviving seedlings are evaluated for phenology (leafing, flowering and harvest dates), precocity, lateral fruitfulness, estimated yield, blight incidence, and crack-out characteristics (shell shape, texture, thickness and strength, kernel weight, percent kernel, kernel color, fill, plumpness and ease of removal in halves). Samples of the most interesting selections are also sent to Diamond Foods for independent evaluation using their grading system.

Data is then presented at an annual crackout evaluation meeting that includes growers, processors, nurserymen, and farm advisors. Participants inspect kernel boxes and data sheets to identify possible selections. Data available includes current year field and crack-out data, performance data from past years, Diamond evaluations and computer-assisted selection. Team evaluations are followed by a general group discussion of each team's recommendations.

Promising individuals are repropagated into selection blocks and grower trials where evaluations continue. Grower field trials are an essential component of releasing a new cultivar. We continue to evaluate current trials, seek opportunities to expand at current locations, and attempt to identify growers interested in participating at additional locations.

In addition to evaluating seedlings of crosses designed to produce new varieties for growers, we continue to maintain for further evaluation a large set of over 400 trees from a Chandler x Idaho cross designed to give significant segregation for traits of interest in evaluating varieties. The purpose of this material is to be able to correlate the accumulated phenology, yield, bearing habit, nut, and kernel trait data with unique DNA coding regions for development of breeding markers. Once developed, these could speed selection by identifying young seedlings most likely to express desirable mature-tree traits. Additional genomics and marker development work using the current and past breeding populations is proceeding in the Neale lab and we provide support in the form of plant material and data.

Backcross breeding for scion varieties resistant to cherry leafroll virus.

The backcross breeding project is designed to introduce genetic resistance to blackline disease from northern California black walnut into commercially acceptable English walnut cultivars. Crosses are conducted using the same methods as in conventional cultivar breeding but the selection process includes an additional component of screening for virus resistance. Seedlings are first screened for potential resistance to the cherry leafroll virus using a DNA marker as reported in Walnut Research Reports (1998) and modified more recently (see WRR 2003). Retained seedlings are then culled based on the same shell, kernel, yield, and horticultural traits used for conventional scion breeding.

The fidelity of the marker currently used for selection has a 10% chance of error, so as potential parents and selections advance in the program it is necessary to confirm resistance directly. For this process, described in previous reports, a selection is grafted onto both black and English rootstock (two each). After the grafts are established, bark from a CLRV tree is patched into the English rootstock and into the selection scions grafted onto black rootstock. If a selection is resistant to the virus it will survive on the black rootstock because the inoculum patch was rejected, and die (exhibiting a black line) on the inoculated English rootstock. Confirmed resistant, thin-shelled individuals with the best commercial traits are then used as parents for the next generation of backcrosses to an English walnut parent with nut and kernel quality.

New technologies for genetic improvement of walnut

In addition to conventional field breeding, the Walnut Improvement Program utilizes tissue culture and gene modification techniques to enhance or develop traits of commercial interest, continues to establish and evaluate field trials of transgenic plants, and is working to help facilitate development of new genomics information and transfer into practical markers for more efficient selection of key traits in the breeding process. Current laboratory work includes improvements in micropropagation methods, enhancement of procedures for introducing material into culture, better ways to control and eliminate contamination, methods for bench-budding small containerized plants, and generally increasing the efficiency of clonal plant production for commercial use.

Germplasm resources

Germplasm collections are maintained and augmented when possible for future breeding use and are available for other researchers. Current field collections at Wolfskill and Davis include a diversity of California cultivars, leading cultivars and selections from around the world, material with unusual traits, and germplasm of interest for rootstock development. Our collection differs in emphasis, content, distribution policy, and cultural practices from that of the USDA Germplasm Repository.

The in vitro germplasm collection is maintained in the laboratory. It includes diverse scion and rootstock genotypes which are maintained for experimental use and to supply material to both research and commercial labs on request.

RESULTS AND DISCUSSION

Cultivar breeding

The conventional scion breeding portion of the improvement program currently includes over 3700 seedlings under evaluation in our orchard and 81 selections under evaluation at Davis and in state-wide selection blocks and grower trials (Table 1). Crosses and numbers of seed and seedlings produced for each objective are shown in Tables 2-10. This year we continued to make crosses for blight resistance using the best current information available to select parents and we initiated a set of crosses specifically for short season as a possible approach to water use reduction. We planted 1308 new seedlings and generated 2128 seed from these conventional crosses. Phenology, yield, and nut trait data for the advanced selections under evaluation are provided in Tables 11-13 and a description of the most promising selections can be found in Appendix 1.

Burchell Nursery again grew and all the seedlings generated from the 2012 crosses and returned them in the spring of 2014 for planting in an evaluation block. Seedlings from the 2013 crosses were germinated as usual in the greenhouse at Davis but after chilling, the seedlings were bare-rooted and then re-potted by Sierra Gold Nursery staff into larger containers and grown at their facility through August. Seedlings were then returned to Davis and planted in early September in a new seedling evaluation block. As a result, we planted two seedling blocks this year, one for the 2012 and one for the 2013 breeding crosses. The first was planted in the spring as bare-root one-year-old trees, the second in the fall as current-year potted seedlings. As a further variation in procedure, the spring planting was established using drip irrigation. Initially, at planting time, double-line buried drip was installed but we felt we were not getting sufficient subbing from the side to properly irrigate the newly planted trees so a single additional surface drip-line was installed adjacent to the trees and the irrigation was moved to this line rather than the buried lines, for the remained of the first year. We likely will either switch to the buried double lines in the coming year or install micro-sprinklers. One incentive to use buried drip was to avoid tree squirrels chewing on the lines but the drip lines serve as gopher highways and are more difficult to monitor.

Prior to dormancy of the 2012 seedlings in the nursery and before inducing dormancy of the 2013 potted seedlings, each plant was tagged with an individual number, a leaf sample was collected in a coin envelope, the samples were dried for DNA extraction, and piece of each dried sample was weighed and prepared for DNA extraction and bioinformatic analysis in David Neale's lab by Pedro Martinez-Garcia. Samples were scored for the presence or absence of DNA markers previously identified in the Chandler x Idaho population as associated with the lateral bearing trait.

'Solano' an early-to mid-season variety with leafing, bloom, and harvest dates very similar to 'Vina', but with better color and a more upright branch structure, was released in 2013 and we continue to provide information to interested growers through publications and grower meetings and to assist nurseries with wood requests. 'Solano' produces uniform nuts with good appearance and solid shells. Both the yield and kernel quality were excellent in trial samples again this year but color was generally not as light as Ivanhoe and in several cases growers reported darkening in cases where nuts were not harvested promptly and this should be watched. Due to its later

leafing and male-first bloom habit, this variety is anticipated to be more suitable for planting in the Sacramento Valley than Ivanhoe and the nuts are larger with a stronger shell. Suggested pollenizers include 'Tulare', 'Chandler' and 'Howard'. Further data can be found in Appendix 1 and Tables 11-14.

'Ivanhoe', a very early harvesting variety with excellent kernel color, was released to nurseries and growers four years ago and continues to exhibit very early harvest timing and excellent production of extra light kernels. The early leafing and flowering dates suggest planting this variety in the southern part of the Central Valley. The female flowers of 'Ivanhoe' open before the catkins. 'Serr' and 'Payne' are suitable pollenizers. Although in most cases many female flowers of 'Ivanhoe' open before any other cultivars have begun to shed obvious pollen, 'Ivanhoe', in practice, produces an abundant crop, frequently setting nuts in threes and fours. We do not suspect virgin birth. Instead, it is likely a few early catkins are sufficient to set crop or the female flowers remain receptive until pollen sources are shedding more fully. Ivanhoe trees are not large in stature so this variety should be grown on Paradox rootstock to ensure vigor and should be planted on closer spacing than 'Chandler'. See additional information in Appendix 1 and Tables 11-14.

We also continue to collect data and observations on performance of previously released varieties and industry standards. Updated information is included in the Appendix 1 and the data tables.

Several additional advanced selections with early to mid-season harvest dates and consistently light to extra-light kernel color are under active and serious consideration for release. Those with the most extensive evaluation data and most promising features are indicated with an asterisk next to the descriptions in Appendix 1. These are currently included in grower trials and wood distribution to interested nurseries is in progress. An updated comprehensive list of grower trials and nursery blocks that include new scion selections and recent releases, their locations by county, the year each was established, and the growers involved is included in Appendix 2.

Suggested pollenizers for recently released varieties

Cultivar	**Pollenizers**
Tulare	Chandler, Howard
Sexton	Sexton, Howard, Tulare
Gillet	Payne, Serr, Vina
Forde	Ivanhoe, Howard, Tulare
Ivanhoe	Serr, Payne
Solano	Chandler, Tulare, Howard

Backcross breeding for resistance to cherry leafroll virus.

We are continuing backcross breeding to develop English walnut cultivars with resistance to the cherry leafroll virus. Backcross seedlings are evaluated for nut quality, harvest date, and yield

traits, as with standard cultivars, but in addition they are tested for virus resistance. We currently retain 109 individuals under active evaluation from an original population of over 800 4th generation crosses determined as likely resistant to CLRV using a DNA marker. Several of the most promising individuals were used as parents again this year to produce a fourth year of BC5 seed and seedlings. This year we used Solano as a pollen parent for several backcrosses and recovered 76 seed from crosses on 06-032-20 and 07-063-20. Seedlings from last year's crosses were planted for evaluation and patch testing (Table 6). We continue to develop a bark patch testing block containing the most horticulturally promising of the DNA tested BC4 trees to confirm the marker results before moving these to new grower trials and continuing their use as parents for the next generation. In cooperation with Sudhi Mysore we are also attempting to develop more rapid screening procedures that will allow a direct reading of virus resistance and speed up the testing and breeding process.

In addition to the patch testing on campus, graftwood of the more promising BC4 and BC5 seedlings continues to be sent to grower trials. Field trials of virus resistant scion selections established in San Benito County by Bill Coates, Contra Costa County by Janet Caprile, and San Joaquin County by Joe Grant continue to be evaluated (see Appendix 2 and separate reports). Field observation this summer from a trial in San Benito County suggests 94-022-24 can be highly productive under CLRV pressure and we are pursuing further evaluations of this and other of the more promising selections.

We also began working on alternate strategy to prevent blackline disease. This is a gene silencing approach, somewhat similar to the method we have already used to develop crown gall resistant rootstock, but in this case we are attempting to develop and test a virus-inhibiting inter-stock (see 2013 proposal by Sudhi Mysore). Use of a male-sterile genotype for this work in order to avoid any pollen shedding issues should greatly improve regulatory acceptance and the work requires somatic embryo cultures of a genotype that also exhibits a tolerant (English type) response to cherry leaf roll virus. Tolerant backcross selections, those that will not go forward in the resistant scion development program, meet both these requirements. For this work we are using a previously developed and maintained somatic embryo line 48-12 which originates from an immature nut of tolerant backcross selection 93-048-6. One suitable construct and vector was already available in the Dandekar lab and was used for this initial exploratory work. Development of others is anticipated in conjunction with the Dandekar and Mysore labs. This year, in conjunction with the Dandekar lab, we developed transformed somatic embryos and generated several shoot line that are now in the process of confirming transformation and expression.

Genomics and marker assisted breeding

We continue to maintain a large block of Chandler x Idaho seedlings generated for genomics work aimed at marker development. The parents of this cross were chosen to develop a large seedling population segregating for as many important traits as possible (lateral bearing, harvest date, kernel color, leaf date, bloom phenology, insect resistance, blight response, shell appearance, etc.). More than 400 seedlings were established and data has been collected annually on each. Trees from this cross continue to be available for any further phenotyping in support of genomics projects.

DNA collected from all existing seedling trees in the breeding program was processed for use by the Walnut Genomics Project in developing markers for key horticultural and pest or pathogen resistance traits. Following DNA analysis and bioinformatics work in Dave Neale's lab, and using the previously evaluated 2008 crosses as a test population, we decided that, although the markers identified for lateral bearing had good predictive value in the Chandler x Idaho population, they were not sufficiently predictive in the wider breeding crosses that we were comfortable in discarding seedlings this year based on these markers alone. After discussion, we decided to plant all the 2013 and 2014 breeding cross seedlings. The DNA collection ID number was retained for each of these seedlings and seedlings were mapped with this information so as the trees mature and are evaluated we can match their phenotypes to the DNA marker information at a later data. This will allow confirmation of marker utility or development of better information and will allow use future use of existing DNA samples for work with other traits as they are scored.

Transgenics

Additional rooted plantlets of eight lines expressing the construct for crown gall silencing in two different background genotypes (J1 and RR4) and the appropriate control plants were produced this year, rooted, and grown in the greenhouse for further testing of efficacy. We have now identified J1 1A as the preferred clone for deregulation. We continue to maintain this wider array of genotypes for the present for further comparative testing.

We continue to manage and monitor a one-acre field trial of rootstock lines containing the RNAi construct for crown gall resistance and the appropriate controls. This block is maintained under APHIS field permit. The rootstock selections are grafted to Chandler or in a few cases kept as ungrafted trees for observation in an ungrafted state. These trees continue to be observed for both horticultural performance and any natural occurrence of crown gall. These trees have been used for DNA, RNA and protein analysis needed for deregulation and continue to be available for any necessary further work. We also managed and evaluated growth of a new field planting of these genotypes at the Armstrong Field Station where trees can be exposed to crown gall under field conditions.

Plants with altered expression of shikimate dehydrogenase (SDH), an enzyme that regulates gallic acid/tannin production, and plants with suppressed polyphenol oxidase (PPO) expression which is thought to play a role in disease resistance and kernel color traits, are now established in a field plot under APHIS permit. Nuts produced by these trees will be used to examine the role of tannins and polyphenol pathway products in nut quality and in insect, nematode and disease resistance. The first few nuts from these trees were harvested this fall. Chandler trees expressing the cry1A(c) BT gene, and which have shown good efficacy against codling moth in previous USDA tests are still maintained in pots for future use if desired.

This year, in conjunction with the Dandekar and Tricoli labs, we inserted a gene construct for a new scorable marker protein into walnut somatic embryos to determine if we could use this marker in the future to increase the efficiency of selecting material expressing genes of interest for walnut improvement. This work employed a construct containing a gene for the red fluorescent protein DsRed. Embryos expressing the gene were readily distinguishable and could be selected intact using red light emission fluorescence microscopy. This marker is more stable

in embryos with varying phenolic content than the previously tested green fluorescent protein and direct selection of intact embryos using this marker avoids time consuming histochemical staining of excised tissue samples. We expect to adopt use of this marker in future work.

Improving micropropagation methods

Efforts in the laboratory to improve multiplication, rooting, acclimatization, and gene insertion methods continue. Although most walnut genotypes elongate and multiply well on the standard DKW formulation, others, particularly many *J. cathayensis*, *J. cathayensis x J. regia*, and some *J. microcarpa* hybrid accessions, continue to do poorly. Improvements in elongation, multiplication, and rooting rates for standard rootstock varieties would also contribute to more efficient plant production and reduce cost to growers. In one student experiment, six potential rootstock genotypes of interest that have consistently elongated poorly on conventional DKW medium were grown on either DKW or DKW supplemented with increased IBA concentrations. Although this increased shoot height of one genotype by 8% the approach was judged generally not effective.

Seed germination experiments with J. microcarpa

J. microcarpa is an important species for rootstock development on breeding work but has repeatedly proven to be difficult to germinate and, in the experience of past breeding program work and the current SCRI rootstock project, requires an abnormally long period of stratification. For this reason an experiment including many treatments of potential value in reducing the required duration of stratification was designed and carried out.

A preliminary experiment was conducted using seeds from mother tree DJUG 29.11 to determine the minimum stratification time required for seeds from that accession. This experiment showed that no seeds of this accession germinated when grown at 25 C following five months of stratification at 3° C, 30 % germinated after six months of stratification and 60 % germinated after seven months of cold.

Based on these results, an experiment was undertaken to find a method to reduce the duration of stratification required to only 5 months and to obtain the maximum germination possible with this shortened stratification. In addition to seed from mother tree DJUG 29.11, seed from DJUG 31.02 and DJUG 53.04 were also used. Several factors were tested for their influence on germination percentage after five months stratification including 24 hour soaks in still or running water , hull removed or intact, cracking after soaking, cracking after stratification, treatments with KOH to soften the suture, incubation at 25° C to soften the suture, and treatment with Promalin at three concentrations over a four- fold range. Germination results at 25° C (Table 15) show that poorest germination was with the hull intact, with or without still water soaking. With hulls removed, some germination occurred after five months stratification with a 24 hour soak in still or running water (10-20 %). Cracking of seeds without hulls, before or after stratification, improved the germination to 40-50 % for seed from two of three mother trees (29.11 and 53.04). However, the best germination rates occurred in uncracked seeds without hulls that had been soaked in Promalin for 24 hours. With this treatment, seeds from two of the mother trees (29.11 and 53.04) germinated at 70-90 %. The germination of Promalin-treated, uncracked seed from mother tree 31.02 was not better than the water soaked, stratified seeds but cracking the seeds from this mother tree did improve germination slightly. This suggests that suture strength may be

the limiting factor for germination of seeds from this mother tree. No germination occurred in Promalin-treated, un-stratified, un-cracked seeds. Promalin treatment of cracked seed was not included in the experiment.

These results indicate that hull removal, soaking in water, cracking and Promalin soaks in this order, show increasing efficacy for reducing the duration of stratification required for maximum germination of *J. microcarpa* seeds.

Improving greenhouse and field propagation methods for clonal rootstocks

Air layering as a method for clonal propagation of walnut rootstock species:

Air layering of walnuts was successfully accomplished on shoots of three types of plant material: 1) actively growing containerized seedlings, grafted clones and clones from cuttings growing in a greenhouse; 2) actively growing shoots on grafted trees growing in an orchard and; 3) basal sprouts on mother tree seed sources growing in an orchard. Species that were clonally propagated this year by air layering are: *Juglans microcarpa*, *J. nigra*, *J. major*, *J. regia* 'Chandler', *J. cathayensis* '#21', *J. olanchana*, *J. neotropica*, *J. australis* and *J. ailantifolia* (Tables 16 -19). The air layering process, for most plant material, involves making 3 four-centimeter longitudinal cuts through the bark near the base of the shoot, girdling the shoot below the wound site, wrapping the wound site with paper towel material wetted with 8000 mg/l K-IBA, covering the wound site with a water-soaked plasticized peat plug (5 cm long and 3 cm diameter), and finally, covering the peat plug with aluminum foil. The plasticized peat plug needs to be kept wet by alternate-day hand-watering or use of a drip irrigation system. In the case of the mother trees growing in an orchard, basal sprouts were induced to grow first by girdling half the circumference of the trunk six inches above ground level. Then the wet plasticized peat plugs were applied to the sprouts and covered with wet pine shavings (not aluminum foil) the pine shavings were watered weekly. Two *J. microcarpa* and two *J. ailantifolia* mother trees were clonally propagated successfully using this procedure. Air-layered shoots had roots protruding through the plasticized peat plug in three to eight weeks. Rooted shoots were severed below the rooted area, planted in one liter containers in the greenhouse, and hardened off under intermittent mist followed by growth under shade cloth on a greenhouse bench.

Use of semi-hardwood leafy cuttings to clonally propagate *J. cathayensis* '#21'

J. cathayensis '#21' is one of only two clones for which Mike McKenry has identified resistance to lesion and root knot nematodes that is effective for up to five years. Unfortunately, it has not been possible to introduce clone #21 into tissue culture for propagation by microshoots. We have also tried dormant, hardwood cuttings with minimal success. However, an experiment this past summer with semi-hardwood, leafy cuttings under intermittent mist showed moderate success using cuttings from current season's growth on orchard trees. Cuttings taken in August from field-grown trees in the Walnut Improvement Orchards at Davis were rooted in HortiCubes with bottom heat at 26C. Tooted cuttings were planted in three inch peat pots and hardened off under intermittent mist followed by transfer to 1 L containers under shade cloth in a greenhouse. Results are shown in Table 20 and observations in the course of this work suggest that the quality of the cuttings can be improved and better rooting results can be obtained by hedging or pruning the stock plants to generate new in-season wood. We may be able propagate sufficient numbers of #21 for use in replicated field trials and perhaps for commercial propagation if

further trial continue to provide good results.

Clonal propagation of a wingnut seedling population segregating for crown gall resistance

A wingnut seedling population was grown previously from seed of *Pterocarya* accession DPTE 1.09 at the NCGR-Davis collection at Winters, CA and individuals were tested multiple times for crown gall susceptibility. This population clearly appears to segregate for crown gall resistance (see previous Clonal Propagation Reports in the Walnut Research Reports 2011, 2012). This year softwood and semi-hardwood leafy cuttings of each seedling were treated with 8000 mg/l K-IBA, stuck in HortiCubes, and rooted on a bottom heated (26 C) intermittent mist bench in a greenhouse. After roots developed in about four weeks, they were potted into three inch peat pots for hardening under shade cloth in a greenhouse for about two weeks and then repotted into one liter containers. As shown in Table 21, more than 600 plants of these two populations were produced for use by Dan Kluepfel's laboratory to study mechanisms of resistance. A portion of this material was also planted in the orchard on close spacing as a germplasm bank to preserve the segregating population and as source of additional propagating material if needed in the future.

Gibberellin and Promalin treatments for elongating young clonal plantlets

During the last two years we have established that applying a low rate (5.5ml/L) of the commercial product Promalin (a GA4/7 BAP mix) early in the greenhouse growing process and at frequent intervals (twice weekly) produces consistent and predictable shoot elongation of small clonal tissue culture produced plants. We have used this protocol routinely for the last two years with good success for producing liner plants of a larger size, to achieve plant uniformity, to sustain active shoot growth for a longer period of time for our SCRI work, and for generating sufficient in-season growth for plants to be pathology tested without a requirement for dormancy. Last year we tested the effects of GA treatment on root growth. Results showed that stimulation of shoot growth was more rapid than root response but after an initial lag period the plants treated with either Promalin or gibberellic acid alone produced larger root systems than controls and root mass corresponded to increased shoot growth. Several notes of caution: 1) the initially high shoot to root ratio resulting from GA application means care should be taken to prevent shoot desiccation if these plants are transplanted at an early stage; 2) our results indicate there may be genotype differences in response and all genotypes may not respond well to GA treatment, but current commercially available genotypes all appear to respond well; 3) at least one commercial greenhouse facility has experienced phytotoxicity issues in testing use of this protocol and to our knowledge the reason this occurred had not been resolved yet; 4) we use the low doses because we have experienced phytotoxicity in the past with higher concentrations, particularly at high greenhouse temperature; 5) we have not tested the effect of Promalin treatment on subsequent plant dormancy but have seen no obvious adverse effects.

Field practices and observations

This was a low chill year leading to staggered leafing and bloom but leafing dates were generally very similar to 2013. Harvest was early for most early varieties but harvest was more spread than last year and later varieties were ready to harvest approximately at the average time. The summer was quite hot during several extended periods and this may have contributed to poorer quality than normal in many of our samples and among growers statewide. As with other growers in the state, we are observing increased incidence of Botryosphaeria. We sprayed again this year with Pristine. We have also observed some occurrence of anthracnose. There appears to be variation

among seedlings in susceptibility to both diseases and we have begun limited phenotyping and collecting observations on susceptibility of material in the breeding populations. Several years of husk fly sprays and careful attention to timing again significantly curtailed the serious infestation we were experiencing several years ago. We continue to see the same trend towards earlier emergence that other growers are experiencing and began trapping in early June. Mites continue to present a problem but we had better control this year following earlier and more wide-spread spray application in conjunction with husk fly sprays. Rodent control continues to be a serious problem as we farm in an increasingly urbanized area. Tree squirrels have become resident in Davis and populations in and adjacent to our walnut blocks are increasing noticeably in the last two years. This trend could seriously impede our work if it continues unabated.

Germplasm resources and maintenance

We continue to manage large collections of both field and *in vitro* germplasm for use by the Walnut Improvement Program, cooperating researchers, and commercial labs and nurseries. We supply microshoots and somatic embryos to commercial laboratories on request and to research cooperators for a variety of projects. Among these are licensed commercial rootstock releases, CLRV tolerant selections, *Phytophthora* survivors from growers' orchards, and PDS selections for crown gall, nematode, and *Phytophthora* resistance. We also maintain a long-term *in vitro* nematode population for use in nematode resistance research by the Dandekar, Ferris, and other labs. The field germplasm collection was used again this year by Bob Van Steenwyck for husk fly studies, Nick Mills for aphid work, and for rootstock breeding. We again supplied graftwood from these blocks to fill a variety of research and nursery requests.

Appendix 1. Description of Selections 2014. (*indicates most promising)

Gillet (95-022-26) (76-80 x Chico) (selected 2002): Gillet is a protogynous variety with excellent yield, large 7.8 g kernels, and a mid-season harvest date about two weeks earlier than Chandler. It is a large and vigorous tree that was selected in part for its low blight scores. The canopy is more open and allows better light penetration than Tulare. Nuts average 51% kernel and kernels are easily removed. Kernels color has been averages 87% light or extra light but has been inconsistent by location. Seals tend to be weak, especially in some years and locations.. This variety is suitable for cracking but not for in-shell use. Released 2004. (Trials: Whitney Warren, Scheuring, Crane, Modesto JC, Taylor, Headrick, Gilbert, Nickels, G. Anderson)

Forde (95-026-37) (Lara x Chico) (selected 2001): This selection produces kernels with good color and fill but it continues to harvest later than expected at release - close to or even later than Chandler in most grower's experience. It has large, plump 8.2 g kernels, a protogynous bearing habit, and nuts that average 53% kernel. Its shell and seal strength, kernel fill and plumpness all exceed Chandler and kernels seldom exhibit tip shrivel but nuts often loosen inside the hulls before the hulls split and hulls do not open widely, so nuts tend to stay in the canopy until shaken rather than fall readily on their own. This can impede drying of nuts in the field. This is a large vigorous tree with upright growth and little blight but yields in several orchards the last few years have not met expectations. New growth can push and feather following heavy pruning so only light pruning or no pruning is recommended. Released 2004. (Trials: Whitney Warren, Scheuring, Modesto JC, Crane, Stolp, Taylor, Headrick, Gilbert, Nickels, CSU-Chico)

Ivanhoe (95-011-14) (67-013 x Chico) (selected 2001): Ivanhoe is a protogynous (females bloom first) selection released in 2010 as very early-harvesting variety with excellent color. It harvests with, or before, Payne and Serr and continues to exhibit very good yields. It has smooth shells with excellent color and appearance and produces mostly Chandler-like extra light kernels averaging 7.4 g. Its shells are relatively thin and probably not suitable for in-shell use, the seals are adequate but should be watched, and nut size is not large. Nuts yield 57% kernel with very easy removal of halves. Kernel quality and harvest date are excellent. Trees leaf and bloom early, at Payne and Serr time, and this variety is susceptible to blight. Summer heat damage to the foliage, summer nut drop, a tendency to sunburn, and in one case a high frequency of blanks have been observed by some growers and these should be watched further. Ethylene applications are being used successfully to move harvest even earlier into late August. Trees should be planted on Paradox rootstock and/or closer spacing due to the relatively small stature of this variety and trees should be managed well to maintain nut size. Released 2010. (Trials: Scheuring, Whitney Warren, Moore, Spanfelner, Headrick, Carriere, Stolp, Noreen)

Solano (95-011-16) (67-013 x Chico) (selected 2003): This new release is a protandrous (males first) early in-shell sibling of Ivanhoe that harvests about a week after Payne and is similar in timing to Vina with good yield and color. It has large, light colored kernels that average 7.9 g. Nuts have very solid oval shells that have sufficient strength and seal for in-shell use, contain 54% kernel and have an attractive appearance. Leafing and flowering dates are about a week after Payne and similar to Vina. Trees appear to be upright and vigorous in growth habit. Several growers expressed concerns this year about color decline when not harvested promptly and this should be watched. Solano was released last year and is now available to growers through most nurseries. Released 2013. (Trials: Scheuring, Spanfelner, Stolp, Whitney Warren, Sierra Gold, Burchell, Moore)

****93-028-20** (Chandler x PI159568) (selected 2001): This selection is under strong consideration for release in the near future. It has Tulare or earlier timing with large, oval, very attractive nuts. It leafs a few days before Chandler but harvests about two weeks earlier with good yield and has had little blight to date in trials. The smooth, light-colored, very solid shells have good seals, 55% kernel and an attractive appearance. The large, very plump kernels average 8.4 g and kernel color is consistently excellent. Its shell qualities make it an excellent candidate for use as a mid-season in-shell alternative to Hartley. We have continued to evaluate the yield in particular. Yield was good again this year on mature trees but young trees appear, like Chandler, to be less precocious than Ivanhoe and Solano and not as likely to set more than two nuts at an inflorescence. (Trials: CSU-Chico, Whitney Warren, Scheuring, Stolp, Carriere, Sierra Gold, Burchell, Stuke, Dave Wilson, Crane, Moffitt, Crain).

00-006-227 (76-080 x O.P.) (selected 2009): This early-harvest date selection with very good yield harvests approximately with Vina, and is a potential release. The large, mostly extra light kernels average 7.7 g and appear to hold color well on the ground or after storage. The tree leafs a week after Payne and produces nuts with 60% kernel. Shells are thin but sufficiently strong, like Serr. The tree is protogynous with a bloom period that is the inverse of Chandler, so it could serve as a pollenizer for Chandler and vice versa. (Trials: Scheuring, Whitney Warren, Stolp, Sierra Gold, Suchan, Burchell, McDavid, Crane, Noreen)

03-001-977 (Chandler x Phase II) (selected 2009): This selection leafs with Chandler but harvests about two weeks earlier. The protogynous bearing habit, with flower timing inverse of Chandler, can provide good pollen coverage for Chandler. This selection has had no blight, even in years with late rain during bloom and has had less husk fly than other trees in the same block. The nuts have a strong shell with an excellent appearance, good seals and very easy kernel removal in halves. Kernel color is generally light but not consistent and rather veiny this year. Kernels average 8.1 g and nuts give 59% kernel. (Trials: Stolp, Whitney Warren, Scheuring, Sierra Gold, Suchan, Burchell, McDavid, Crane)

03-001-985 (Chandler x Phase II) (selected 2011): An early harvesting selection with solid shells very large nuts that could be suitable for in-shell use. Harvests a week after Payne but also leafs with Payne and has a protogynous bloom habit. Nuts average 54% kernel. Kernels have been mostly light color and average 9.0 g but color was poor this year at all locations. Shells may be harder and stronger than necessary and are well filled but kernel removal has been good. Although early leafing, blight scores have been low.

***03-001-1372** (Chandler x Phase II) (selected 2010): This mid-season protandrous selection leafs with Chandler but harvests with Tulare and is under consideration for release. This selection has good yield of 8.5 g kernels, excellent kernel color, and a history of almost no blight. The nuts average 55% kernel with excellent removal in halves. Kernel color is Chandler-like and almost entirely light to extra light. (Trials: Scheuring, Whitney Warren, Sierra Gold, Suchan, Burchell, McDavid, Crane)

***03-001-1457** (Chandler x Phase II) (selected 2010): This large vigorous tree exhibits excellent yield, harvests mid-season, and has a protandrous bloom habit. Leafing is a week later than Payne and little blight has been observed. The nuts have excellent shell appearance, yield 59% kernel, and shells are thin but have sufficient strength. The 8.0 g kernels have good color and are very easily removed in halves. (Trial: Whitney Warren, Scheuring, Stolp, Crane)

***03-001-1938** (Chandler x Phase II) (selected 2010): Selected for its huge yields and mid-season harvest timing similar to Tulare, this protandrous selection produces 7.9 g kernels with very good kernel color. The smooth and light colored shells have good strength. Seal strength should be watched appear sufficient. The attractive round and well-filled nuts yield 58% kernel with easy removal of halves. This selection is under consideration for release but needs to go to more grower trials. (Trial: Whitney Warren, Scheuring, Crane)

***03-001-2357** (Chandler x Phase II) (selected 2010): This selection has consistently exhibited strong yields and produced attractive kernels with excellent color and easy removal of halves. The tree is protandrous and leafs a week after Payne but with harvest a week or less before Chandler. Kernels average 8.6 g and have consistently been mostly extra light in color. Shells are well filled, have an attractive appearance, are thin but not weak, and give 60% kernel yield. Harvests fairly close to Chandler but color, fill and yield merit consideration for release, as was discussed at this year's crackout meeting. (Trial: Scheuring, Whitney Warren, Stolp, Crane, Noreen)

03-001-2434 (Chandler x Phase II) (selected 2010): This protandrous tree has excellent kernel color and strong mid-season yield about ten days before Chandler. The plump 8.8 g kernels have been entirely light or extra light and the well-filled nuts produce 57% kernel. The tree leafs approximately with Payne and has showed only moderate amounts of blight. This selection leafs and harvests a little earlier than 03-001-2357, color is light but not as light as that selection, and this selection more readily drops nuts on the ground after hull split while 03-001-2357 tends to hold them in the canopy. (Trial: Scheuring, Whitney Warren, Stolp)

03-001-2440 (Chandler x Phase II) (selected 2010): This selection is notable for its consistently outstanding extra light kernel color and is usually among the best selections evaluated for color. This tree leafs about a weak after Payne, nuts yield 57% kernel, kernels are very plump, easily removed, and kernel weight averages 8.2 g. The two concerns with this selection are blight incidence in several past years and yield has never quite been up to expectations. (Trial: Whitney Warren)

03-001-2556 (Chandler x Phase II) (selected 2010): This protandrous selection with very good kernel color harvests a week before Chandler and leafs a week later than Payne. Blight scores have been fairly low and yields very good. The nuts have smooth, light colored, attractive shells but are maybe too thin. The mostly extra light and very plump large kernels average 8.7 g and are very easily extracted from nuts averaging 60% kernel. (Scheuring)

***04-003-143** (Chandler x O.P) (selected 2011): This selection has very strong yields and good kernel color. The tree leafs mid-season and has a protogynous bloom habit that is inverse of, and overlaps, Chandler. The large round nuts have large plump kernels averaging 9.0 g with predominately Chandler-like light or extra light color. Nuts have smooth, light attractive shells that yield 54% kernel with easy removal of halves and a harvest date a week before Chandler. (Trial: Scheuring, Crane)

04-003-293 (Chandler x O.P) (selected 2011): A selection with huge yield within a week of Payne, excellent kernel color, and leafs a week after Payne but nuts continue to be small and kernels have averaged only 6.9 g. This selection has a protogynous bloom habit and its pollen shed covers Chandler well. The nuts tend to be a bit under-filled but have good shell traits with 50% kernel and kernels are entirely of light and extra light color. (Trial: Scheuring)

04-004-58 (91-096-3 x O.P.) (selected 2011): This is a late-leafing short-season protogynous offspring of a previous blight-resistant selection. It harvests mid-season, leafs two days after Chandler, and produces kernels with good color. Nuts average 7.2 g and 55% kernel, kernels are easily extracted in halves, and yield is good. Pollen would cover late Chandler bloom or Franquette. Shells are thin and seals may be too weak. Used as parent in crosses. (Scheuring, Suchan, Spanfelner)

05-001-94 (Ivanhoe x O.P.) (selected 2014): This selection has kernels with excellent color, consistently extra light, and 8.1 g average weight. The tree harvests a week after Payne. Nuts have good removal of halves and 58% kernel. It has a females-first bloom habit and leafs with Payne. Blight needs to be watched further but yield has been excellent. This selectin should be moved to grower trials.

05-002-233 (Gillet x O.P.) (selected 2012): This is a Gillet offspring that harvests a week after Payne, has good yield, nuts with solid shells and 56% kernel. Color has been consistently excellent with all light or extra light kernels that are plump and average 7.8 g. (Trial: Scheuring, Crane)

***06-005-18** (Ivanhoe x 59-124) (selected 2013): This Ivanhoe offspring harvests and leafs with Payne, has a protogynous bloom habit, and has excellent yield of mostly extra light kernels. The attractive nuts are well filled with plump kernels and yield 52% kernel with easy removal in halves. This selection has a harvest date before Payne, no blight has been observed to date, and we are using it as a parent. This selection continues to be an excellent candidate and needs to be moved to more grower trials. (Trial: Crane)

06-005-31 (Ivanhoe x 59-124) (selected 2013): This selection leafs a week later than Payne, harvest date averages four days after Payne, and we have not observed blight to date. The large, attractive, long-oval nuts yield 55% kernel. The very large, shiny, and plump10.1 g kernels have been entirely light or extra light in color and have good removal in halves. This should be moved to additional trials. (Trial: Scheuring, Crane)

06-027-16 (91-096-3 x 59-124) (selected 2013): This short-season selection leafs a week before Chandler and harvests a week after Payne. The 8.1 g kernels consistently exhibit excellent color. Nuts contain 55% kernels which are easily extracted. Yields are strong and no problems have been seen with strength or seal.

07-002-5 (91-077-6 x 93-028-20) (selected 2012): This is a short season selection that leafs out two days after Chandler and harvests with Tulare. It has 8.6 g pump kernels with excellent color and outstanding ease of removal, and nuts contain 59% kernel. This is still a fairly young selection that needs to be watched further for yield in particular but nut and kernel traits, absence of blight and phenology make this a very interesting selection. (Trial: Scheuring, Suchan, McDavid, Crane)

07-019-9 (Ivanhoe x 95-007-13) (selected 2014): This high yielding, early harvest selection leafs and harvests five days after Payne. Nuts are light colored, have solid shells and seals, yield very easy halves, and contain 53% kernel. Kernels average 7.6 g and have excellent color with almost all light and extra light color.

07-021-6 (95-007-13 x 93-028-20) (selected 2014): This is a very high yielding selection with a mid-season harvest date about 10 days before Chandler. The kernels have excellent color with all light or extra light scoring and average 8.0 g in weight. Trees leaf a week after Payne and no blight has been observed to date. Previous year's hulls tend to stay on the tree during the dormant season. Nuts yield 60% kernel and have thin shells but with good strength.

07-029-15 (94-019-29 x 91-077-6) (selected 2014): This short-season selection is a relatively small tree that has consistently shown outstanding yield. It leafs a week before Chandler, has a male-first bloom habit, and harvests four days after Payne. In spite of its heavy yields, this tree continues to also exhibit excellent nut and kernel size. Kernel weight averages 9.4 g and nuts yield 59% kernel with all light and extra light color and very easy extraction in halves.

08-002-4 (91-090-41 x 90-031-12) (selected 2014): This is a mid-season harvesting selection that leafs a few days before Chandler and is showing very good yield. Kernel color has been entirely light and extra light. Nuts average 61% kernel and kernels average 8.5 g with good removal in halves. Shells are fairly thin but strength and seals are good.

Appendix 2. List of Current Field Trials of Scion Selections

Field Trials of CLRV-Resistant Selections

San Benito – Coates

Bonturi

2003: 87-041-2, 87-262-4, 92-016-1, 93-045-1

2007: 94-022-24, 94-026-20, 95-027-19

2010: 95-027-23, 95-030-10, 03-019-9, 03-019-10

2011: 06-032-18

2013: 95-030-10, 06-003-1, 06-032-6, 06-032-13, 07-047-4, 07-047-39, 07-051-6, 07-052-2, 07-056-29, 07-058-7, 07-063-20

Corotto

2005: 93-045-1, 94-022-24, 95-027-11, 95-027-23, 95-029-4

2006: 92-016-11, 93-045-1, 95-027-19, 95-027-38, 95-029-4, 96-017-12, 96-027-8, 97-027-24, 97-027-55, 98-017-44

Contra Costa –Caprile

Tennant

92-016-1, 94-022-24, 97-027-55

San Joaquin - Grant

Barton

92-016-1, 93-045-1, 94-026-20, 95-027-19

Field Trials and Nursery Blocks of Standard Selections

Tehama - Buchner

Spanfelner-Anderson

2008: Solano

H. Crain

Blight resistant variety trial

Butte –

Chico State Farm

Chico State Selection Block

Chico State Farm Trial

2004: Sexton, 91-090-41, 95-026-22

Forde block

Stolp

2003: 94-020-5, 94-020-35, Forde

2007: Ivanhoe, 95-026-16

2008: Solano, 00-006-54, 00-006-179, 00-011-88, 01-004-2, 01-016-11, 02-005-870, 03-001-1098, 03-001-1747

2010: Solano, 98-002-129, 00-006-227, 01-007-1, 02-005-671, 02-005-999, 03-001-1457, 03-001-1649, 03-110-2357, 03-001-2434, 03-001-2824, 03-001-2825, 03-001-3382, 03-001-3395, 03-001-3441, 03-001-4097, 03-005-4, 04-001-390, 04-003-403, 04-007-48

2011: 93-028-20

Stuke Nursery

2012: Solano

2013: 93-028-20, 03-001-1457

Bertagna - red kernels

2006: 91-084-6, 90-024-3, 95-014-3

B. Crain

2013: 93-028-20

Moffitt

2014: 93-028-20

Lake – Elkins

Suchan

2007: 95-018-23, 96-014-12, 00-002-27, 00-006-48

2010: 00-006-48, 00-006-227, 03-001-977, 03-001-1098, 03-001-1372, 03-001-3441

2011: 00-006-54, 04-003-107, 04-004-58, 04-006-92

2013: 07-002-5

Glenn – Lightle

Carriere

2007: Ivanhoe

2013: 93-028-20, 95-007-13

Colusa - Hasey

Nickels Trial - pruning

2008: Gillet, Forde, Tulare, Chandler

Sutter-Yuba - Hasey

Whitney Warren Ranch

Selection trials

2001-2010: 91-077-40, 91-090-41, 92-070-12, 93-026-6, 93-028-20, 94-016-33, 94-019-85, 94-020-35, 94-028-20, 95-007-13, Ivanhoe, Solano, Gillet, Forde, 98-001-415, 98-001-520, 98-002-129, 00-004-44, 00-005-15, 00-005-30, 00-005-44, 00-005-144, 00-005-153, 00-006-227, 00-011-107, 01-007-2, 01-016-33, 02-005-870, 03-001-507, 03-001-665, 03-001-943, 03-001-977, 03-001-1372, 03-001-1457, 03-001-1938, 03-001-2357, 03-001-2434, 03-001-2440, 03-001-2822, 03-001-3383, 03-001-3395, 03-001-3446, 03-001-3701, 03-001-4097, 04-001-56

Selections for reduced tree stature – mostly removed

2009: Howard, Forde, Sexton, 91-077-40, Ivanhoe on RX1, VX211, Vlach rootstock

Gilbert

2008: Sexton, Gillet, Forde

Sierra Gold

2011: 93-028-20, 95-007-13, Solano, 95-026-16, 00-006-227, 00-011-107, 03-001-977, 03-001-1372, 03-001-2556

Noreen

2001: 91-096-3, 93-026-6, 94-017-69, 94-019-29, 95-017-47

2014: 93-028-20, 00-006-227, 03-001-2357, Solano

Moffitt

2014: 93-028-20

Yolo - Pope

Scheuring

2002, 2004, 2008: 90-027-21, Ivanhoe, Solano, Gillet, Forde, Sexton, 95-007-13, 91-096-3

2011: 00-006-54, 03-001-507, 03-001-977, 03-001-1457, 03-001-1938, 03-001-2556, 03-001-3382, 03-001-3446, 03-001-3682, 04-004-58

2012: 93-028-20, 03-001-475, 03-001-665, 03-001-958, 03-001-985, 03-001-3701, 04-001-390, 04-003-293, 04-008-28, 05-002-233, 07-002-5, 07-005-17, 07-019-16, 07-022-30

2013: 03-001-1457, 05-002-393, 05-005-295, 05-034-11, 06-004-2, 06-005-31, 06-012-21, 06-013-20, 06-025-21, 06-026-19, 06-027-16

Martinez

2013: Solano, 93-028-20

UCD Selection Blocks

San Benito – Coates

Bonturi

2002-2010: 91-077-6, 94-019-85, Ivanhoe

Corotto

2005: Sexton, Gillet, Forde

San Joaquin - Grant

Taylor

2005: Sexton. Gillet, Forde, 95-026-22

Calaveras - Grant

McDavid

2010: 00-006-227, 00-006-48, 03-001-977, 03-001-1098, 03-001-1372, 03-001-3441

2013: 07-002-5

Stanislaus – Anderson

MJC

2004: Sexton, Gillet, Forde, Tulare

Deardorff

2006: 91-077-6, 94-020-28, Ivanhoe, 97-003-208, 97-003-311, 97-003-319

2007: 91-090-41, 91-077-6, 93-028-20, 94-019-85, 94-020-5, 94-020-35, Ivanhoe, 95-026-16

Orestimba Nursery

2013: 93-028-20, 03-001-1457

Burchell Nursery

2010: 00-005-30, 03-001-977

2011: 95-007-13, 95-026-16, 00-006-227, 00-011-107, 03-001-1372, 03-001-2556

Dave Wilson Nursery

2013: 93-028-20, 03-001-1457

Merced – Doll

Crane Sr.

2002: Sexton, 90-023-11, 90-023-37, 91-094-18, 91-096-3, Tulare

2003: 92-070-12

Crane Jr.

2004: Sexton, Forde, 95-022-26

2010: 03-001-977

2012: Solano, 93-028-20, 03-001-1372, 00-006-227, 03-001-977, 04-003-143

2014: 03-001-1457, 03-001-1938, 03-001-2357, 05-002-233, 06-013-20, 06-005-18, 06-005-31, 06-005-36, 06-025, 21, 07-002-5, 08-011-26, 08-014-3

Fresno - Brar

KAC

2009: KAC Blight resistant variety block: Payne, Serr, PI159568, Gillet, Ivanhoe, Solano, 91-096-3, 95-026-11

Kings - Beede

Jeb Headrick

91-077-6, 94-020-28, 94-020-35, Ivanhoe, Forde, Gillet

Tulare –Fichtner

Moore

2004: Ivanhoe

2012: Solano

2013: 93-028-20, 03-001-1457

Appendix 3. Current Clonal Rootstock Field Trials.

County	Grower	Genotypes	Date Established	Comments
Tehama	H. Crain	RX1, VX211, Vlach, Paradox sdlg.	2009	Budded Sept 2009 New orchard Scion: Howard
Butte	Deseret	RX1, AZ2	2006	New orchard Scion: Chandler
Lake		VX211, Vlach, Paradox seedlings	2011	Nematode Scion: VX211 and Vlach are grafted to Chandler; seedlings will be grafted to Chandler in 2012
Lake		VX211, Vlach, Paradox seedlings	2011	Unfumigated new planting Nematode site Scion: black walnut scion for nursery trees, so will be Chandler inter-stems on the VX211 and Vlach
Lake		VX211, Vlach, Paradox sdlg.	2012	No fumigation, walnut to walnut; will be budded to Chandler in 2013
Lake		VX211, Vlach, Paradox sdlg.	2012	No fumigation, pear, fallowed, then to walnut; will be budded to Chandler in 2013
Glenn	Anderson	Vlach, Paradox sdlg	2006	Grafted to Howard
Sutter/Yuba	Whitney Warren	RX1,VX211, Serr, Vlach	2007	New orchard Spot fumigated old Hartley site
Sutter/Yuba	Noreen	VX211, RX1, Vlach, Paradox seedlings.	2013	New orchard To be grafted 2014
Sutter/Yuba	Conant	VX211, RX1, Vlach, Paradox seedlings. Black seedlings	2011	New orchard Scion: Gillet
Solano	Cilker	RX1, VX211, Burbank, Vlach, Paradox sdlg.	2009	New orchard Budded fall 2009 Scion: Tulare
Yolo	Turkovich	RX1, VX211	2011	New Orchard Grafted: 2011 Scion: Forde,
Contra Costa	Tennant	WIP2, WIP3, clonal Sunland and Vina,	2005	Blackline tolerant New orchard

County	Grower	Genotypes	Date Established	Comments
		Paradox sdlg.		Scion: Vina
Contra Costa	Maggiore	WIP3, clonal Chandler, Paradox sdlg., WIP1, WIP2	2011	Blackline tolerant New orchard Scion: Chandler
San Joaquin	Taylor	WIP3, WIP5, WIP6	2005	Blackline tolerant New orchard Scion: Chandler
San Joaquin	Lagorio (Concar)	RX1, VX211, WIP3, AZ025, Vlach June-bud, Vlach-grafted, Chandler own-rooted, Paradox sdlg.	2007	New orchard Scion: Chandler
Stanislaus	MJC	Clonal Vina and Chandler, Vlach, 84-121, Sunland sdlg., Px sdlg.	1999	Planted 1999 Grafted 2000 New orchard
Kings	Verboon	VX211, Px sdlg, with Vlach buffer	2008	Fumigation trial treatments New orchard Scion: Tulare

Appendix 4. Laboratories Licensed to Produce UC Clonal Rootstocks RX1 and VX211

Acemi Nursery

Agromillora California

Briggs Nursery

California Seed and Plant Labs – Micro Paradox

Duarte Nursery

Golden Roots Nursery

Jubilant Earth Nursery

North American Plants

ProTree Nursery

Rancho Tissue Technologies

Sierra Gold Nursery

Tissue Grown Corporation

V-Tree

Table 1. Number of individual crosses completed, seedlings planted, number of selections retained, and trees remaining under evaluation by year of cross.

Year	Crosses (n)	Original seedlings (n)	Selections (n)	Under Evaluation (n)
1990	15	591	-	-
1991	18	493	1	1
1992	15	243	-	-
1993	14	116	1	1
1994	15	587	-	-
1995	15	758	-	1
1996	7	333	-	-
1997	13	611	1	3
1998	5	1759	1	3
1999	1	993	-	-
2000	12	2503	1	6
2001	16	210	-	1
2002	5	1200	1	1
2003	11	4608	9	18
2004	7	6000	8	24
2005	9	3332	12	56
2006	22	954	18	43
2007	27	1045	11	50
2008	33	929	11	50
2009	32	1187	6	374
2010	32	1081	-	512
2011	37	761	-	345
2012	60	758	-	758
2013	83	1550	-	1550
2014	58	2128*	-	-
Total	562	35447	81	3797

*Seed collected for germination and planting

Table 2. Seedlings produced from 2012 crosses showing pollen parent and female parents used. Seedlings were grown in the nursery in 2013 and planted at Davis in the spring of 2014.

	Male Parent																			
Female Parent	Ivanhoe	93-028-20	95-026-16	98-002-129	00-005-30	00-005-44	00-006-227	01-007-2	03-001-1372	03-001-1457	03-001-1938	03-001-2357	03-001-2434	03-001-2440	03-001-2556	03-001-3382	03-001-507	03-001-958	03-001-977	04-004-117
Ivanhoe									3							8	24			
Solano										8		18							2	
93-028-20										28										
95-026-16										21	23							27	7	
98-002-129																			1	
00-005-144										20										
00-005-30																	1			
00-005-44														30	16					
00-006-227		19																		
01-007-2													1							
03-001-1372					7		4													
03-001-1457							28													
03-001-1743		1																		22
03-001-1938		16		19																
03-001-2434							5													
03-001-2440					15			24												
03-001-3382	1							33												
03-001-507			6																	
03-001-665		43																		
03-001-825		2																		
03-001-958		2		14																
03-001-977							31													
03-001-985	2			9																
04-002-342	6																			
04-004-117					4	55		3												
04-004-58					2		1													
05-002-233	17	2																		

Table 3. Seedling trees from 2012 crosses, grown in nursery in 2013 and planted at Davis in 2014 with traits of interest indicated.

	93-028-20	Ivanhoe	98-002-129	00-006-227	03-001-507	03-001-665	03-001-825	03-001-958	03-001-977	03-001-985	03-001-1372	03-001-1457	03-001-1743	03-001-1938	03-001-2357	03-001-2434	03-001-2440	03-001-2556	03-001-3382	04-004-58	04-004-117	04-002-342	05-002-233
93-028-20 Color, shell, plump						43	2	2				28	1	16									2
Ivanhoe Very early, color, yield					24					2	3								9			6	17
Solano Early-mid, yield, color									2			8			18								
95-026-16 Early color					6			27	7			21		23									
98-002-129 Early, size, color								14	1	9				21									
00-005-30 Very early					1						7						15			2	4		
00-005-44 Early, yield																	30	16			55		
00-005-144 Size, color, plump												20											
00-006-227 Early, size, color	19								31		4	28				5				1			
01-007-2 Very early																1	24		33		3		
03-001-1743 Early color, yield, %																					22		

Table 4. Seedlings produced from 2013 crosses showing pollen parent and female parent used. Seedlings were grown in containers in the nursery in the spring of 2014 and planted at Davis in the fall of 2014.

	Male parent																
Female Parent	Ivanhoe	Solano	59-124	91-028-1	91-031-8	91-096-3	93-028-20	00-005-144	00-005-44	03-001-1457	03-001-1938	03-001-2434	05-001-434	05-001-94	06-005-18	06-005-5	07-002-5
Ivanhoe					109				136		108						
Solano			36							25							
59-124	24												13				
91-015-2		11									2	6	18				
91-028-1											3						
91-028-2										7							
91-031-8							8			5						6	
91-090-41	39					36	24						38				
91-096-3	25							16					49	84	27	32	
93-028-20													32	32			23
95-026-16					25						41						
96-013-13							49				38						
03-001-1457		14					17									1	
03-001-1938		16					4										
03-001-2434	2	6															
03-001-985													46			3	
03-019-9													6			19	
05-001-434			38														
05-001-94			19		8												
05-002-233																5	
05-002-396					7								30				
06-003-1										25							
06-004-2							8			11							
06-005-18					4		8										
06-005-27				2			21										
06-005-4					4		3										
06-005-5					19		10										
07-005-17			10														
07-047-39																2	
07-063-20		9					5						3	1			

Table 5. Seedlings planted in the fall of 2014 from 2013 color and early harvest date crosses.

	93-028-20	Ivanhoe	Solano	00-005-44	03-001-1938	05-001-94	05-001-434	06-004-2	06-005-4	06-005-5	06-005-18	06-005-27	07-002-5	07-005-17
93-028-20 Color, shell, plump						32	32	8	3	10	8	21	23	8
Ivanhoe Very early, color, yield				136	108									
Solano Early-mid, yield, color														
59-124 Early, thick shell, plump		24	36				38							10
91-090-41 HF resistance, Color	24	39					38							
95-026-16 Early color					41		0							
96-013-13 Early color	49				38									
03-001-985 Early color, yield, %	0						46			3				
03-001-1457 Mid, color, size, yield	6		39					11		1				
03-001-1938 Mid, color, shell	4		16											
03-001-2434 Color, size		2												
05-002-233 Early-mid, color yield										5				
05-002-396 Early color and yield							30							

Table 6. Seedlings planted in fall of 2014 from 2013 CLRV resistant crosses.

	93-028-20	Solano	03-001-1457	05-001-94	05-001-434	06-005-5
03-019-9					6	19
06-003-1			25			
07-047-4						
07-047-39						2
07-063-20	5	9		1	3	

Table 7. Seedlings planted in the fall of 2014 from 2013 crosses for blight resistance.

	91-015-2	91-028-1	91-028-2	91-031-8	91-056-9	91-096-3
Ivanhoe Very early, color, yield				109		25
Solano Early-mid, yield, color	11				0	
93-28-20 Color, shell, plump				8		
95-26-16 Early, color, yield				25		
00-005-144 Size, color, plump						16
00-006-227 Yield, color, %					0	
03-001-1457 Early-mid, color, size, yield			7	5		
03-001-1938 Early-mid, color, shell	2	3				
03-001-2434 Color, size	6					
05-001-94 Early-mid, size, color				8		84
05-001-434 Early pollen, color	18	1				91
05-002-396 Early, color, yield				7		
06-005-4 Early, color				4		
06-005-5 Shell, strength, color, early			0	19		32
06-005-18 Very early, color, yield				4		27
06-005-27 Very early, color, yield		2				

Table 8. Seed collected from 2014 crosses with male and female parents indicated.

	Male Parent															
Female Parent	Ivanhoe	Solano	PI 159568	Sheinovo sd.	59-124	91-041-12	00-006-227	02-005-870	03-001-1938	05-001-434	06-005-17	06-005-31	06-027-16	07-029-1	93-028-20	Unlabeled
Ivanhoe						38		274	120							
Sheinovo sd		52		58												
PI 159568																6
76-080		125														
91-028-1					26					22						
91-028-2		51														
91-031-8											121					
91-041-12		24														
91-041-13												12				
91-041-2		5														
91-056-9					27					2						
91-041-3																14
93-028-20												91	41			
00-006-227		158														
05-001-402																35
05-002-296								48								7
05-006-267													79			
05-014-118													35			
05-019-12												36				
05-019-5															101	
06-005-17		14														
06-005-2			66													
06-005-31													7			
06-005-36														32		
06-012-14												44				
06-015-7															74	
06-023-9																53
06-026-14															30	
06-026-19												18				
06-027-16												60				
06-032-20		58														
07-002-5							51									
07-029-15													12			
07-063-20		18														
08-014-3		36														

Table 9. Seed collected from 2014 short-season crosses collected planting in 2015.

	Short Season Parents																	
Quality Parents	91-041-13	91-041-2	00-006-227	05-006-267	05-014-118	05-019-12	05-019-5	06-005-2	06-005-31	06-005-36	06-012-14	06-015-7	06-026-14	06-026-19	06-027-16	07-002-5	07-029-15	08-014-3
Solano		5	158															36
93-028-20							101					74	30					
PI 159568								66										
00-006-227																51		
06-005-31	12					36					44			18	60			
06-027-16				79	35				7								12	
07-029-1										32								

Table 10. Seed collected from 2014 blight crosses for germination and planting in 2015.

	Quality Parents					
Blight Parents	Ivanhoe	Sheinovo sd.	Solano	05-001-434	06-005-17	59-124
Sheinovo sd.		58	52			
91-028-1				22		26
91-028-2			51			
91-031-8					121	
91-041-12	38		24			
91-056-9				2		27
76-080			125			

Table 11. Cultivar and Selection Evaluations at Davis – (Spring 2014)

	Seedling	Leafing		Pollen Shedding				Pistillate Bloom			%		Harvest	
	or Grafted	Date	DAP[a]	1st	Peak	Last	Abund.[b]	1st	Peak	Last	Lateral	Yield[b]	Date	DAP[c]
Cultivars														
Payne	G	3/17	0	3/19	3/26	4/7	7	4/1	4/5	4/10	100	7	9/9	0
Hartley	G	4/3	17	3/29	4/8	4/17	6	4/16	4/19	4/21	0	6	9/30	21
Vina	G	3/25	8	3/24	4/1	4/2	7	4/8	4/11	4/18	100	7	9/18	9
Serr	G	3/16	-1	3/17	3/22	3/31	7	3/30	4/4	4/7	0	8	9/12	3
Chandler	G	4/12	26	4/1	4/12	4/26	7	4/19	4/23	5/1	100	7	10/6	27
Howard	G	4/9	23	3/31	4/10	4/18	5	4/16	4/19	4/22	100	7	9/26	17
Tulare	G	4/1	15	3/30	4/12	4/19	7	4/13	4/17	4/20	100	7	9/30	21
Lara	G	4/2	16	3/28	4/5	4/12	7	4/15	4/19	4/23	100	6	9/22	13
Sexton	G	3/24	7	3/24	4/2	4/14	7	4/4	4/7	4/15	100	7	10/4	25
Gillet	G	3/21	4	4/2	4/8	4/14	8	3/28	3/31	4/3	100	7	9/30	21
Forde	G	3/27	10	4/7	4/14	4/20	7	3/29	4/4	4/9	100	7	9/30	21
Ivanhoe	G	3/14	-3	3/27	4/5	4/12	7	3/12	3/18	3/29	100	7	8/30	-10
Solano	G	3/23	6	3/22	3/29	4/20	8	4/4	4/9	4/22	100	7	9/20	11
Selections														
64-057	G	3/28	11	4/5	4/8	4/13	7	3/29	4/6	4/9	100	7	9/29	20
91-077-40	G	3/28	11	4/8	4/14	4/19	7	3/29	4/5	4/12	100	8	9/24	15
91-090-41	G	3/30	13	3/28	4/5	4/12	6	4/11	4/16	4/19	100	7	9/29	20
93-028-20	G	3/28	11	3/27	4/4	4/17	6	4/12	4/15	4/18	100	7	9/20	11
95-007-13	G	3/23	6	3/21	3/28	4/6	7	4/2	4/6	4/12	100	7	9/9	0
97-003-11	G	3/28	11	3/29	4/6	4/16	7	4/10	4/13	4/17	100	8	9/28	19
02-005-870	G	3/16	-1	3/16	3/22	4/5	7	3/28	4/5	4/8	100	8	9/20	11
03-001-475	S	3/17	0	3/17	3/24	4/6	7	4/1	4/6	4/9	100	8	9/10	1
03-001-665	S	3/24	7	3/27	4/4	4/14	7	4/8	4/11	4/14	100	8	9/23	14

[a]Days after Payne leafing date at Davis
[b]1=low, 9=high
[c] Days after Payne harvest date at Davis

Table 11. Cultivar and Selection Evaluations at Davis – (Spring 2014) – (cont.)

	Seedling	Leafing		Pollen Shedding				Pistillate Bloom			%		Harvest	
	or Grafted	Date	DAP[a]	1st	Peak	Last	Abund.[b]	1st	Peak	Last	Lateral	Yield[b]	Date	DAP[c]
03-001-825	S	3/27	10	3/26	4/2	4/14	7	4/12	4/15	4/18	100	7	10/2	23
03-001-977	S	3/30	13	4/7	4/16	4/25	7	4/1	4/6	4/9	100	5	9/25	16
03-001-985	S	3/14	-3	4/1	4/9	4/17	8	3/19	3/26	4/1	100	7	9/22	13
03-001-1098	S	3/28	11	3/30	4/7	4/17	7	4/10	4/13	4/18	100	7	9/27	18
03-001-1372	S	4/6	20	4/5	4/12	4/18	7	4/16	4/19	4/22	100	7	9/24	15
03-001-1457	S	3/21	4	3/21	3/25	3/31	7	4/4	4/8	4/13	100	8	9/21	12
03-001-1743	S	3/31	14	3/30	4/6	4/18	7	4/10	4/14	4/19	100	7	9/20	11
03-001-1938	S	3/16	-1	3/16	3/21	3/30	7	3/29	4/2	4/6	100	7	9/18	9
03-001-2357	S	3/26	9	3/26	4/5	4/13	7	4/12	4/14	4/17	100	8	9/29	20
03-001-2434	S	3/17	0	3/19	3/25	4/5	7	3/31	4/5	4/8	100	5	9/24	15
03-001-2440	S	3/30	13	3/31	4/7	4/15	7	4/12	4/14	4/17	100	6	9/26	17
03-001-2556	S	3/27	10	3/28	4/6	4/20	7	4/8	4/10	4/21	100	6	9/27	18
04-001-390	S	3/30	13	3/30	4/6	4/10	5	4/8	4/12	4/15	100	7	9/9	0
04-003-143	S	3/31	14	4/9	4/14	4/23	7	4/1	4/6	4/9	100	7	9/28	19
04-003-293	S	4/7	21	4/13	4/20	4/25	7	4/8	4/10	4/13	100	8	9/18	9
04-003-403	S	4/3	17	4/12	4/16	4/21	7	4/6	4/9	4/12	100	7	9/24	15
04-003-417	S	3/27	10	4/10	4/14	4/18	5	4/3	4/7	4/10	90	7	9/20	11
04-006-28	S	3/27	10	3/30	4/8	4/15	7	4/10	4/12	4/16	100	7	9/19	10
05-001-94	S	3/17	0	3/26	4/1	4/10	8	3/18	3/21	3/26	100	8	9/16	7
05-001-97	S	3/19	2	3/22	3/26	4/1	7	3/30	4/3	4/7	100	7	9/18	9
05-001-122	S	3/21	4	3/22	3/29	4/8	7	4/6	4/10	4/14	100	7	9/18	9
05-001-271	S	3/15	-2	3/26	4/4	4/11	7	3/17	3/21	3/27	100	6	9/14	5
05-001-295	S	3/21	4	3/23	3/29	4/6	6	4/6	4/8	4/10	100	6	9/14	5
05-001-362	S	3/15	-2	3/31	4/5	4/12	7	3/20	3/24	3/28	100	7	9/15	6
05-001-402	S	3/14	-3	3/19	3/24	3/29	7	3/26	3/29	4/1	100	7	9/12	3
05-001-412	S	3/25	8	3/24	3/30	4/8	7	4/3	4/6	4/9	100	7	9/21	12

[a] Days after Payne leafing date at Davis
[b] 1=low, 9=high
[c] Days after Payne harvest date at Davis

Table 11. Cultivar and Selection Evaluations at Davis – (Spring 2014) – (cont.)

	Seedling	Leafing		Pollen Shedding				Pistillate Bloom			%		Harvest	
	or Grafted	Date	DAP[a]	1st	Peak	Last	Abund.[b]	1st	Peak	Last	Lateral	Yield[b]	Date	DAP[c]
05-001-434	S	3/7	-10	3/14	3/16	3/23	4	3/18	3/21	3/24	100	7	9/6	-3
05-002-233	S	3/19	2	3/21	3/29	4/7	7	3/30	4/5	4/8	100	6	9/18	9
05-002-396	S	3/11	-6	3/28	4/6	4/11	7	3/18	3/22	3/27	100	7	9/8	-1
05-003-133	S	3/14	-3	3/29	4/5	4/11	7	3/18	3/22	3/26	100	7	9/17	8
05-003-256	S	3/20	3	3/22	3/27	3/31	7	3/31	4/5	4/8	100	7	9/22	13
05-014-59	S	3/24	7	3/24	3/31	4/8	7	4/6	4/8	4/10	100	7	9/21	12
05-014-118	S	3/23	6	3/24	3/31	4/10	7	4/9	4/11	4/13	100	7	9/10	1
05-014-197	S	4/1	15	3/31	4/6	4/15	7	4/13	4/15	4/17	100	7	9/23	14
05-019-12	S	3/28	11	3/28	4/3	4/9	7	4/11	4/14	4/17	100	7	9/16	7
06-004-4	S	3/25	8	4/10	4/17	4/24	5	3/28	4/1	4/8	100	7	9/12	3
06-005-2	S	3/21	4	3/22	3/31	4/19	7	4/4	4/7	4/11	100	7	9/20	11
06-005-5	S	3/16	-1	3/14	3/20	3/30	7	3/28	3/31	4/6	100	7	9/14	5
06-005-18	S	3/20	3	3/30	4/6	4/13	8	3/19	3/22	3/26	100	7	9/2	-7
06-005-31	S	3/28	11	3/27	4/2	4/9	7	4/8	4/10	4/13	100	6	9/15	6
06-012-21	S	3/20	3	4/2	4/8	4/16	8	3/25	3/29	4/3	100	7	9/14	5
06-013-19	S	3/25	8	3/28	4/3	4/9	4	4/8	4/10	4/12	100	7	9/15	6
06-013-20	S	3/19	2	3/21	3/28	4/8	5	4/6	4/8	4/11	100	7	9/16	7
06-015-7	S	3/29	12	3/26	3/30	4/3	4	4/9	4/12	4/15	100	7	9/15	6
06-015-15	S	3/24	7	3/22	3/28	4/4	7	4/6	4/9	4/12	100	6	9/22	13
06-017-34	S	3/21	4	4/6	4/13	4/18	5	3/28	4/1	4/5	100	6	9/14	5
06-017-51	S	3/17	0	3/17	3/27	4/14	7	4/7	4/10	4/15	100	7	9/15	6
06-023-9	S	3/16	-1	3/20	3/26	4/1	6	4/2	4/7	4/10	100	7	9/10	1
06-025-21	S	4/5	19	4/3	4/10	4/16	7	4/13	4/17	4/21	100	7	9/26	17
06-026-14	S	4/15	29	4/12	4/18	4/27	7	4/18	4/22	4/28	100	7	9/21	12
06-026-19	S	4/5	19	4/1	4/9	4/21	7	4/14	4/18	4/22	100	7	9/18	9
06-027-16	S	4/1	15	3/30	4/8	4/16	7	4/12	4/15	4/19	100	7	9/18	9

[a] Days after Payne leafing date at Davis
[b] 1=low, 9=high
[c] Days after Payne harvest date at Davis

Table 11. Cultivar and Selection Evaluations at Davis – (Spring 2014) – (cont.)

	Seedling	Leafing		Pollen Shedding				Pistillate Bloom			%		Harvest	
	or Grafted	Date	DAP[a]	1st	Peak	Last	Abund.[b]	1st	Peak	Last	Lateral	Yield[b]	Date	DAP[c]
07-002-5	S	4/10	24	4/8	4/16	4/21	5	4/19	4/22	4/25	100	6	9/23	14
07-004-15	S	4/5	19	4/12	4/18	4/28	8	4/6	4/9	4/12	100	7	9/16	7
07-021-6	S	3/24	7	3/27	4/5	4/12	7	4/6	4/9	4/12	100	8	9/23	14
07-029-1	S	3/22	5	3/25	4/2	4/8	5	4/6	4/9	4/11	100	8	9/15	6
07-029-15	S	3/26	9	3/26	4/3	4/10	7	4/7	4/10	4/13	100	8	9/15	6
07-031-4	S	3/26	9	3/26	4/4	4/16	7	4/10	4/13	4/16	100	7	9/18	9
08-001-28	S	3/29	12	4/7	4/12	4/16	4	4/1	4/5	4/8	100	7	9/22	13
08-001-34	S	3/30	13	4/11	4/14	4/21	3	4/5	4/8	4/11	100	7	9/24	15
08-002-4	S	3/28	11	4/1	4/5	4/9	3	4/7	4/9	4/11	100	8	9/22	13
08-006-11	S	4/6	20	4/10	4/15	4/21	7	4/7	4/10	4/13	100	7	9/18	9
08-011-26	S	3/15	-2	3/17	3/21	3/28	7	3/28	4/1	4/7	100	7	9/9	0
08-014-3	S	4/7	21	4/9	4/13	4/18	7	4/14	4/16	4/19	100	7	9/17	8

[a] Days after Payne leafing date at Davis
[b] 1=low, 9=high
[c] Days after Payne harvest date at Davis

Table 12. Cultivar and Selection Harvest Evaluations at Davis (Fall 2014)

		Harvest			Shell			Average Wt.					Color %			
	[a]Seedling or Graft	Date	[b]DAP	Seas Lgth	[c]Seal	[d]Strgth	Thick mm	Nut (g)	Kernel (g)	% Kernel	[e]Kernel Fill	[f]Ease of Removal	Extra Light	Light	Light Amber	Amber
Cultivars																
Payne	G	9/9	0	157	5	5	1.2	12.4	6.7	54.2	5	4	0	80	20	0
Hartley	G	9/30	21	164	5	6	1.5	14.4	6.8	47.4	5	6	10	90	0	0
Vina	G	9/18	9	160	5	6	1.3	13.5	7.0	52.0	7	6	0	30	40	30
Serr	G	9/12	3	161	5	5	1.1	12.8	8.4	65.1	6	5	0	80	20	0
Chandler	G	10/6	27	166	5	5	1.3	12.4	6.3	50.4	5	4	100	0	0	0
Howard	G	9/26	17	160	5	7	1.5	14.3	7.1	49.6	6	5	0	100	0	0
Tulare	G	9/30	21	166	5	5	1.2	14.5	8.1	55.8	5	4	0	100	0	0
Gillet	G	9/30	21	183	5	6	1.4	17.7	9.0	51.0	5	5	0	100	0	0
Forde	G	9/30	21	179	5	6	1.3	14.7	8.0	54.4	6	5	60	40	0	0
Ivanhoe	G	8/30	-10	165	5	5	1.2	13.6	7.7	56.4	6	4	100	0	0	0
Solano	G	9/20	11	164	5	5	1.3	15.3	8.2	53.4	5	4	10	90	0	0
Selections																
64-057	G	9/29	20	176	5	5	1.2	17.4	9.7	55.6	6	5	0	90	0	10
76-080	G	9/30	21	164	3	5	1.1	13.1	7.0	53.3	5	4	100	0	0	0
91-090-41	G	9/29	20	166	3	5	1.2	14.6	8.8	60.2	5	5	0	80	20	0
93-028-20	G	9/20	11	158	5	5	1.2	14.9	8.8	58.8	6	5	80	20	0	0
95-007-13	G	9/9	0	156	5	5	1.2	15.1	8.5	56.1	5	3	20	70	10	0
97-003-319	G	9/28	19	173	5	5	1.2	17.8	10.2	57.6	5	3	50	30	20	0
98-001-415	G	10/2	23	169	5	5	1.2	18.3	10.1	55.1	4	4	20	80	0	0
00-011-107	G	9/26	17	169	5	5	1.3	16.7	8.7	52.1	5	5	10	90	0	0
01-016-30	G	9/30	21	168	5	5	1.2	16.4	8.5	51.8	3	5	0	100	0	0
02-005-870	S	9/20	11	168	5	6	1.2	15.3	8.5	56.0	7	6	0	100	0	0
03-001-475	S	9/10	1	157	5	5	1.2	14.3	7.8	54.7	5	4	11	78	11	0
03-001-665	S	9/23	14	165	5	5	1.1	10.9	6.5	59.0	5	4	10	80	10	0

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[d]=Shell strength: 3 - poor, 5 - good, 7 - very strong
[e]=Kernel fill: 3 - poor, 7- well
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Table 12. Cultivar and Selection Harvest Evaluations at Davis (Fall 2014) – (cont.)

		Harvest			Shell			Average Wt.					Color %			
	[a]Seedling or Graft	Date	[b]DAP	Seas Lgth	[c]Seal	[d]Strgth	Thick mm	Nut (g)	Kernel (g)	% Kernel	[e]Kernel Fill	[f]Ease of Removal	Extra Light	Light	Light Amber	Amber
03-001-825	S	10/2	23	170	5	6	1.2	15.2	8.5	55.7	6	4	50	40	10	0
03-001-977	S	9/25	16	172	5	6	1.2	14.4	8.0	55.8	6	4	0	78	22	0
03-001-1098	S	9/27	18	167	5	6	1.2	14.4	7.6	52.9	7	5	22	78	0	0
03-001-1372	S	9/24	15	158	5	5	1.3	15.1	8.1	53.7	6	4	100	0	0	0
03-001-1457	S	9/21	12	166	5	5	1.2	12.6	7.4	58.8	5	4	20	70	10	0
03-001-1743	S	9/20	11	159	5	5	1.1	11.5	6.4	55.1	3	4	100	0	0	0
03-001-1938	S	9/18	9	169	5	5	1.2	12.1	7.0	58.0	6	5	0	100	0	0
03-001-2357	S	9/29	20	168	5	5	1.2	11.1	6.2	56.0	6	5	90	10	0	0
03-001-2434	S	9/24	15	172	5	7	1.3	13.9	7.5	54.0	7	6	0	100	0	0
03-001-2440	S	9/26	17	165	5	6	1.3	14.0	7.6	54.3	6	5	10	90	0	0
03-001-2556	S	9/27	18	170	5	5	1.2	14.2	7.9	55.1	5	5	0	89	11	0
03-001-3303	S	9/8	-1	153	5	4	1.1	12.1	7.3	60.2	4	4	44	56	0	0
03-001-3395	S	9/23	14	165	4	5	1.1	13.5	8.2	60.9	4	4	10	90	0	0
03-001-3443	S	9/12	3	155	5	5	1.2	16.1	8.5	52.5	5	4	100	0	0	0
03-001-3446	S	9/12	3	159	6	7	1.4	13.9	7.5	53.9	7	5	30	70	0	0
04-001-390	S	9/9	0	150	5	5	1.3	13.7	6.8	49.8	6	5	0	100	0	0
04-002-342	S	9/22	13	158	5	6	1.4	13.1	6.9	52.3	4	4	40	40	20	0
04-003-143	S	9/28	19	175	5	5	1.2	16.2	8.5	52.4	4	4	10	80	10	0
04-003-293	S	9/18	9	161	5	5	1.2	13.8	6.9	49.9	4	5	30	60	10	0
04-003-403	S	9/24	15	168	5	5	1.3	13.9	6.7	48.5	3	4	0	100	0	0
04-003-417	S	9/20	11	166	5	5	1.2	12.4	6.5	52.0	4	5	30	70	0	0
04-004-117	S	9/23	14	162	5	6	1.3	15.8	8.4	53.0	5	6	0	90	10	0
04-004-411	S	9/20	11	156	5	6	1.4	11.9	6.0	50.4	7	6	100	0	0	0
04-006-28	S	9/19	10	160	5	5	1.2	13.4	7.5	55.6	5	5	80	20	0	0
05-001-94	S	9/16	7	179	5	5	1.2	12.6	7.3	57.7	5	4	100	0	0	0

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[e]=Kernel fill: 3 - poor, 7- well
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Table 12. Cultivar and Selection Harvest Evaluations at Davis (Fall 2014) – (cont.)

		Harvest			Shell			Average Wt.					Color %			
	[a]Seedling or Graft	Date	[b]DAP	Seas Lgth	[c]Seal	[d]Strgth	Thick mm	Nut (g)	Kernel (g)	% Kernel	[e]Kernel Fill	[f]Ease of Removal	Extra Light	Light	Light Amber	Amber
05-001-97	S	9/18	9	168	5	5	1.1	11.3	6.5	57.2	6	5	0	100	0	0
05-001-122	S	9/18	9	161	5	5	1.2	13.0	7.0	54.0	6	5	30	70	0	0
05-001-271	S	9/14	5	177	5	5	1.1	9.5	5.8	61.3	6	5	0	60	30	10
05-001-295	S	9/14	5	159	5	5	1.1	11.1	6.8	61.1	6	4	40	50	10	0
05-001-362	S	9/15	6	175	5	5	1	11.0	7.0	63.7	7	5	0	90	10	0
05-001-402	S	9/12	3	167	5	6	1.3	11.4	6.3	55.1	6	5	63	25	13	0
05-001-412	S	9/21	12	168	5	6	1.4	15.7	8.4	53.7	6	5	30	70	0	0
05-001-434	S	9/6	-3	169	5	6	1.3	13.5	7.1	52.1	5	4	80	20	0	0
05-002-212	S	9/29	20	166	5	5	1.3	13.8	7.0	50.8	4	4	50	40	10	0
05-002-233	S	9/18	9	166	5	5	1.2	11.2	6.3	56.0	6	6	0	100	0	0
05-002-396	S	9/8	-1	170	5	5	1.2	11.0	6.0	54.7	5	5	0	100	0	0
05-003-133	S	9/17	8	179	5	5	1.2	13.8	7.1	51.4	5	4	100	0	0	0
05-003-256	S	9/22	13	170	5	5	1.3	13.9	7.2	52.1	5	4	0	90	10	0
05-014-59	S	9/21	12	166	5	5	1.2	12.4	7.4	59.6	6	4	40	60	0	0
05-014-118	S	9/10	1	152	5	5	1.2	9.8	5.3	53.8	6	5	30	70	0	0
05-014-197	S	9/23	14	161	5	5	1.1	10.9	6.2	56.8	5	4	0	90	10	0
05-019-5	S	9/10	1	162	5	5	1.1	11.3	6.3	56.1	5	5	20	80	0	0
05-019-12	S	9/16	7	155	5	5	1.3	12.5	6.8	54.1	5	4	40	60	0	0
06-004-5	S	9/23	14	167	5	6	1.4	13.6	7.0	51.4	5	4	0	100	0	0
06-005-5	S	9/14	5	167	5	7	1.4	14.6	8.0	55.1	7	6	0	100	0	0
06-005-18	S	9/2	-7	164	5	6	1.3	14.3	7.3	51.2	6	4	100	0	0	0
06-005-31	S	9/15	6	158	5	7	1.4	17.2	9.3	54.0	7	6	30	70	0	0
06-005-36	S	9/1	-8	162	5	5	1.2	12.8	7.3	57.0	5	5	20	80	0	0
06-011-1	S	9/14	5	159	5	5	1.2	13.5	7.9	58.0	6	4	0	100	0	0
06-012-21	S	9/14	5	169	5	6	1.3	13.9	7.7	55.2	6	4	80	10	10	0

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Table 12. Cultivar and Selection Harvest Evaluations at Davis (Fall 2014) – (cont.)

		Harvest			Shell			Average Wt.					Color %			
	[a]Seedling or Graft	Date	[b]DAP	Seas Lgth	[c]Seal	[d]Strgth	Thick mm	Nut (g)	Kernel (g)	% Kernel	[e]Kernel Fill	[f]Ease of Removal	Extra Light	Light	Light Amber	Amber
06-013-19	S	9/15	6	158	5	6	1.3	12.0	6.8	56.3	6	5	0	100	0	0
06-013-20	S	9/16	7	161	6	7	1.3	15.5	8.0	51.4	6	6	60	40	0	0
06-015-7	S	9/15	6	156	5	5	1.3	12.4	7.1	57.2	6	4	0	100	0	0
06-017-51	S	9/15	6	158	6	7	1.4	14.7	7.8	53.5	7	7	0	100	0	0
06-023-9	S	9/10	1	156	5	5	1.2	12.8	6.9	53.9	5	5	0	89	11	0
06-025-21	S	9/26	17	162	5	5	1.1	10.8	6.1	56.2	5	4	90	10	0	0
06-026-14	S	9/21	12	152	5	5	1.2	12.5	7.0	55.8	5	4	60	30	10	0
06-026-19	S	9/18	9	153	5	5	1.3	14.3	7.2	50.8	5	4	0	90	10	0
06-027-16	S	9/18	9	156	5	5	1.2	13.6	7.4	54.3	6	5	33	67	0	0
07-002-5	S	9/23	14	154	5	5	1.2	13.6	7.9	58.5	6	4	80	20	0	0
07-003-9	S	9/26	17	165	5	5	1.2	16.4	8.7	53.5	5	4	60	30	10	0
07-004-15	S	9/16	7	160	6	6	1.4	15.3	8.0	52.1	6	5	70	30	0	0
07-015-6	S	9/16	7	158	5	7	1.4	15.3	8.2	53.4	7	6	80	0	20	0
07-019-9	G	9/15	6	158	5	5	1.2	14.9	8.2	55.2	4	4	70	20	10	0
07-021-5	G	9/26	17	164	5	5	1.2	14.2	8.3	58.4	5	4	0	100	0	0
07-021-6	G	9/23	14	167	5	5	1.1	12.5	7.3	58.4	4	4	0	100	0	0
07-029-1	G	9/15	6	159	5	5	1.2	12.7	7.0	55.0	5	5	30	60	10	0
07-029-15	G	9/15	6	158	5	6	1.3	18.0	10.4	57.6	5	4	0	90	10	0
07-031-4	G	9/18	9	158	5	5	1.3	15.8	8.3	52.2	5	4	10	80	10	0
08-001-28	G	9/22	13	170	5	5	1.1	12.7	8.2	64.7	5	4	0	100	0	0
08-001-34	G	9/24	15	169	5	5	1.3	14.9	8.2	54.7	5	4	0	100	0	0
08-002-4	G	9/22	13	166	5	5	1.1	13.9	8.5	61.2	5	4	40	60	0	0
08-005-10	G	9/13	4	156	5	5	1.3	14.3	7.6	53.0	5	4	100	0	0	0
08-011-26	G	9/9	0	161	5	5	1.1	14.2	8.3	58.7	5	4	0	80	10	10
08-014-3	G	9/17	8	154	5	5	1.1	12.2	7.1	58.3	5	4	30	70	0	0

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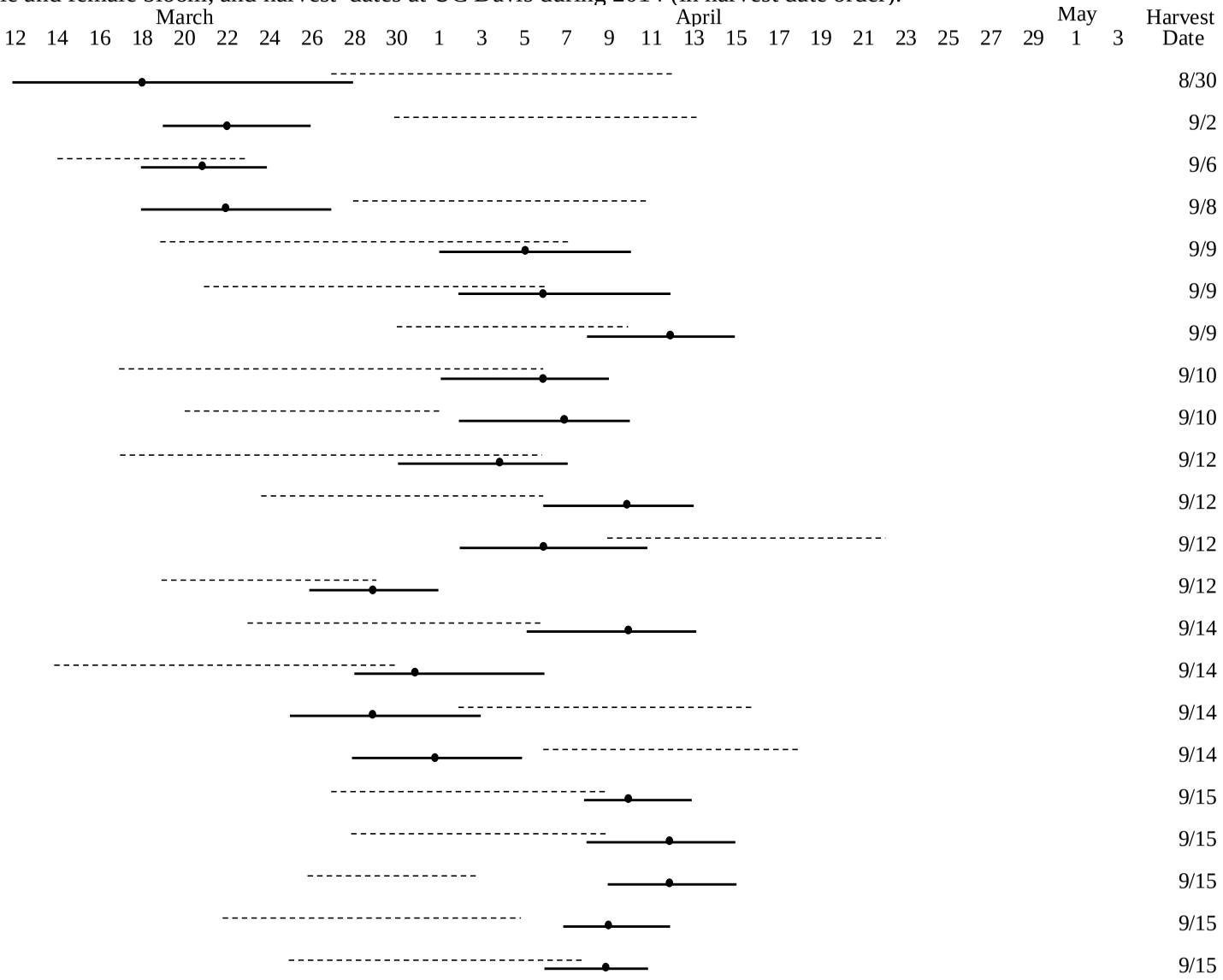
Table 13. Leafing, male and female bloom, and harvest dates at UC Davis during 2014 (in harvest date order).



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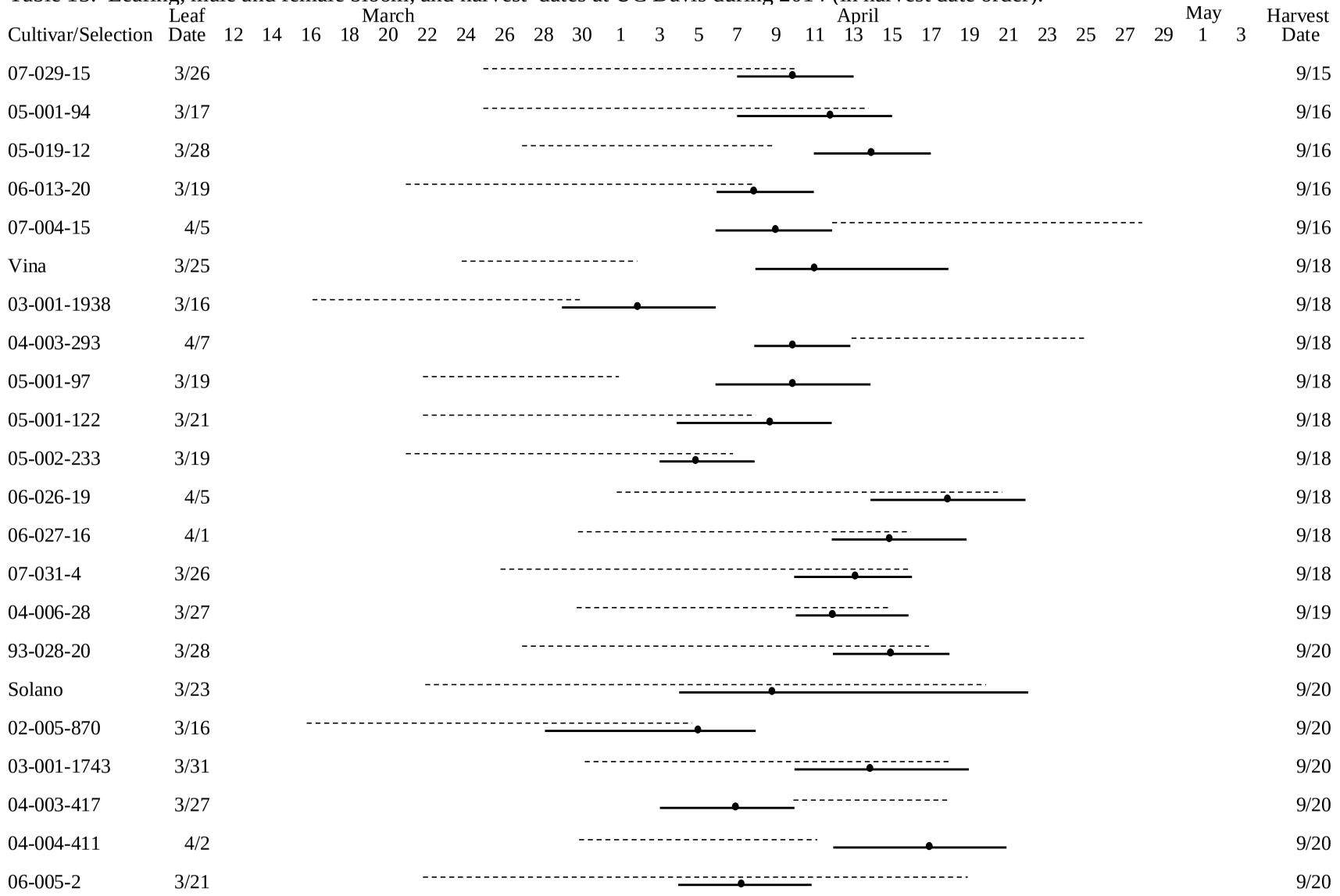
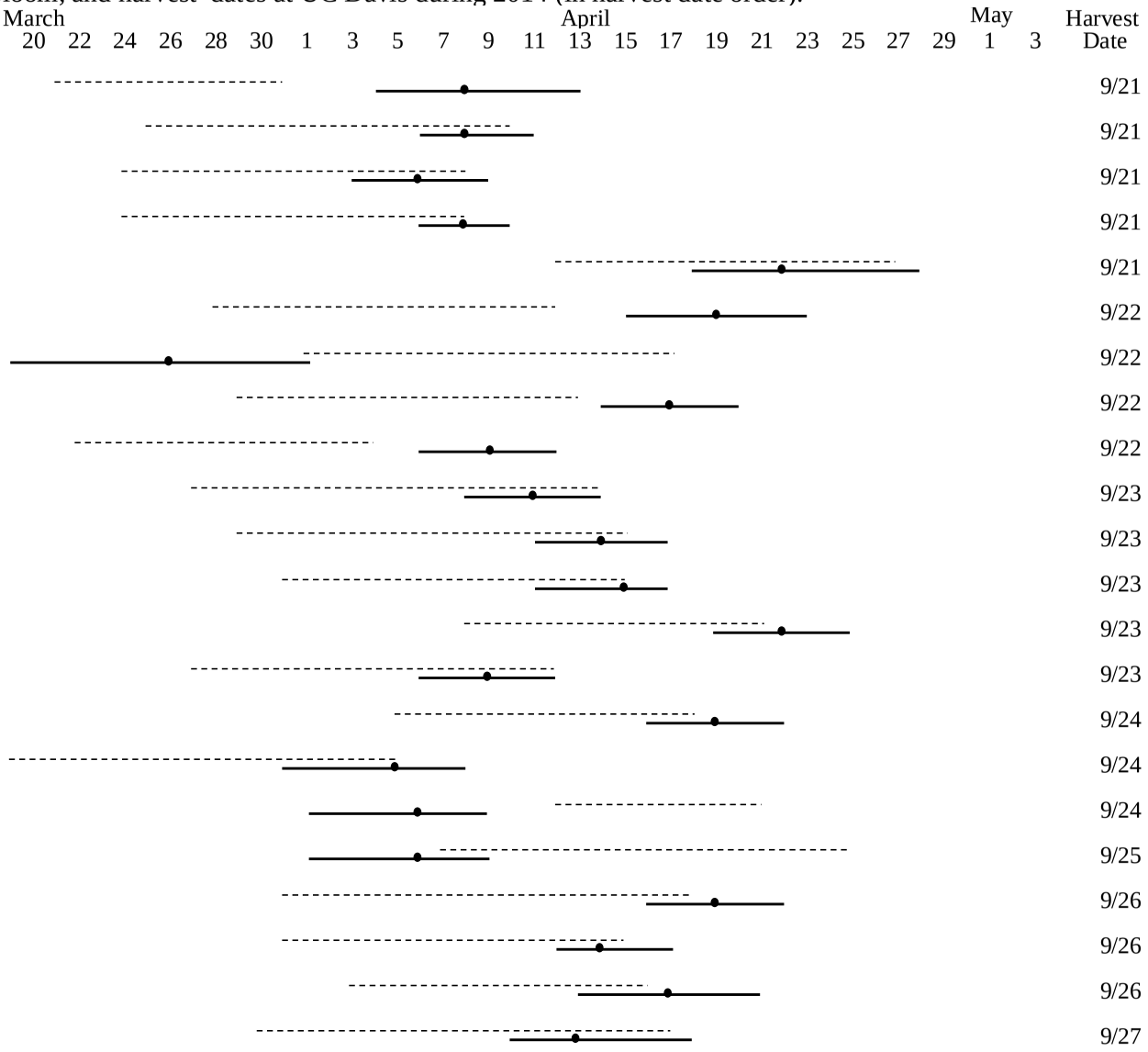


Table 13. Leafing, male and female bloom, and harvest dates at UC Davis during 2014 (in harvest date order).

Cultivar/Selection	Leaf Date	Harvest Date
03-001-1457	3/21	9/21
03-001-2105	3/24	9/21
05-001-412	3/25	9/21
05-014-59	3/24	9/21
06-026-14	4/15	9/21
Lara	4/2	9/22
03-001-985	3/14	9/22
04-002-342	3/30	9/22
06-015-15	3/24	9/22
03-001-665	3/24	9/23
04-004-117	3/27	9/23
05-014-197	4/1	9/23
07-002-5	4/10	9/23
07-021-6	3/24	9/23
03-001-1372	4/6	9/24
03-001-2434	3/17	9/24
04-003-403	4/3	9/24
03-001-977	3/30	9/25
Howard	4/9	9/26
03-001-2440	3/30	9/26
06-025-21	4/5	9/26
03-001-1098	3/28	9/27



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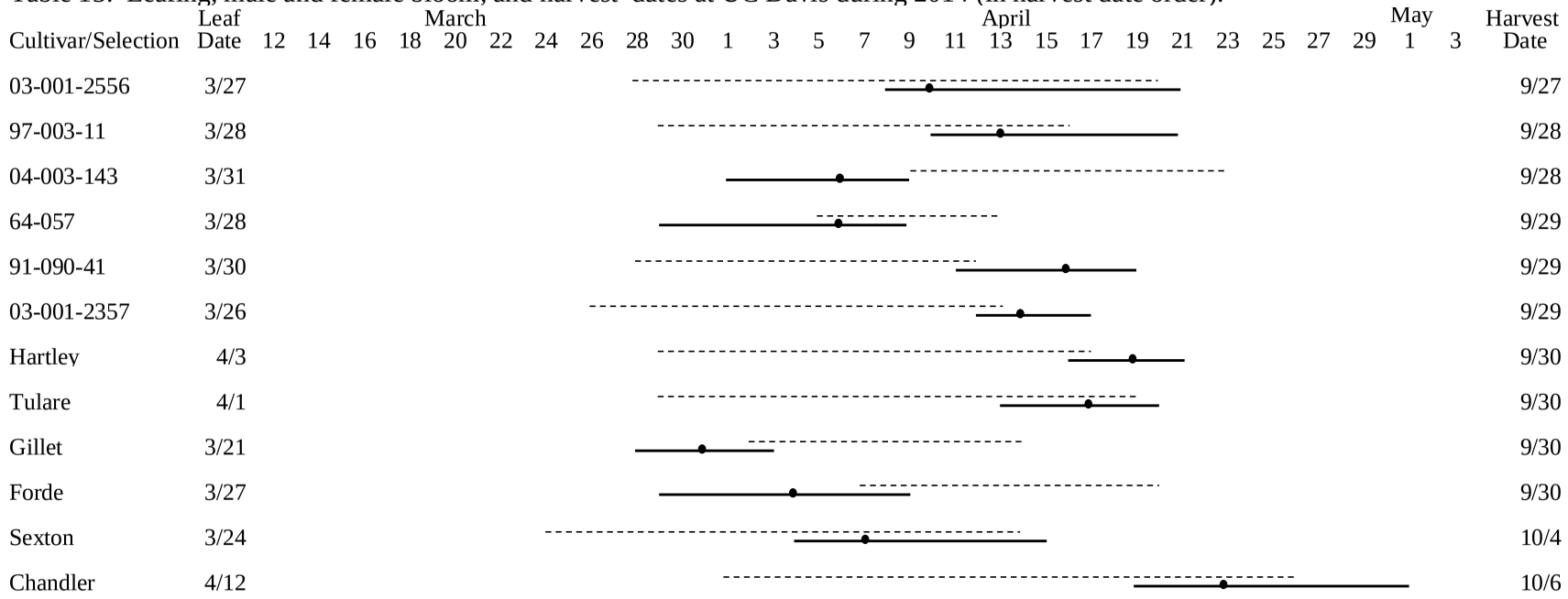

Location	Variety or Selection	Sample Wt	Nuts per sample	Avg nut wt (g)	% Large	% Med	% Baby	% Large Sound	% Stain	% Broken	% Adh Hull	% External Damage
Davis	Payne	1003	87	11.53	98	1	1	95	0	0	0	0
Davis	Vina	1000	80	12.50	95	3	3	96	0	0	0	0
Davis	Serr	1000	82	12.20	100	0	0	96	2	0	0	2
Woodland	Serr	1001	76	13.17	100	0	0	99	0	0	0	0
Davis	Chandler	1003	84	11.94	94	5	1	92	0	0	0	0
Davis	Chandler	1002	77	13.01	100	0	0	99	0	0	0	0
Woodland	Chandler	1000	84	11.90	100	0	0	99	0	0	0	0
Durham	Chandler	1002	80	12.53	98	3	0	98	0	0	0	0
Davis	Howard	1001	80	12.51	99	1	0	98	0	0	0	0
Woodland	Howard	1001	75	13.35	100	0	0	100	0	0	0	0
Davis	Tulare	1002	76	13.18	100	0	0	97	0	0	0	0
Woodland	Tulare	1001	90	11.12	100	0	0	99	0	0	0	0
Chico	Tulare	1003	90	11.14	99	1	0	99	0	0	0	0
Davis	Forde	1002	91	11.01	87	12	1	88	0	0	0	0
Davis	Forde	1001	93	10.76	77	22	1	79	0	0	0	0
Woodland	Forde	1004	85	11.81	100	0	0	99	0	0	0	0
Davis	Ivanhoe	1000	76	13.16	100	0	0	96	0	0	0	0
Woodland	Ivanhoe	1001	87	11.51	100	0	0	98	1	0	0	1
Chico	Ivanhoe	1000	79	12.66	100	0	0	97	0	0	0	0
Wheatland	Ivanhoe	1003	91	11.02	90	8	2	85	1	0	1	2
Davis	Solano	1004	69	14.55	100	0	0	99	0	0	0	0
Woodland	Solano	1000	80	12.50	100	0	0	99	0	0	0	0
Woodland	Solano	1001	85	11.78	100	0	0	99	0	0	0	0
Durham	Solano	1002	83	12.07	99	1	0	98	0	0	0	0
Davis	76-080	1001	84	11.92	99	1	0	98	0	0	0	0
Davis	91-009-41	1001	102	9.81	84	12	4	80	1	0	0	1
Davis	93-028-20	1000	68	14.71	99	1	0	97	0	0	0	0
Davis	93-028-20	1002	64	15.66	100	0	0	100	0	0	0	0
Woodland	93-028-20	1000	64	15.63	100	0	0	100	0	0	0	0
Durham	93-028-20	1003	72	13.93	97	3	0	98	0	0	0	0
Chico	93-028-20	1000	73	13.70	99	1	0	99	0	0	0	0

Location	Variety or Selection	% Insect	% Mold	% Shrivel	% Offgrade	% Edible Yield	% Total Yield	Extra Light	Light	Light Amber	Amber	RLI	Relative Value
Davis	Payne	2	2	1	4	53	55	8	24	66	2	**49.6**	**0.949**
Davis	Vina	0	1	1	1	50	50	0	0	70	30	**50.2**	**0.898**
Davis	Serr	2	0	0	3	62	63	58	35	7	0	**53.7**	**1.189**
Woodland	Serr	0	0	1	0	61	61	30	42	26	3	**51.9**	**1.140**
Davis	Chandler	2	0	1	3	49	51	93	7	0	0	**58.8**	**1.043**
Davis	Chandler	1	0	0	1	50	51	91	8	1	0	**57.1**	**1.032**
Woodland	Chandler	0	0	2	1	50	50	88	11	1	0	**57.0**	**1.020**
Durham	Chandler	0	0	0	0	47	47	75	20	5	0	**54.7**	**0.918**
Davis	Howard	1	0	1	2	50	51	25	56	19	0	**52.2**	**0.942**
Woodland	Howard	0	0	0	0	50	50	36	46	18	0	**52.2**	**0.948**
Davis	Tulare	1	1	1	2	54	55	85	14	2	0	**56.1**	**1.082**
Woodland	Tulare	0	0	1	0	53	53	69	28	4	0	**53.2**	**1.018**
Chico	Tulare	0	0	0	0	53	53	11	81	8	2	**50.2**	**0.959**
Davis	Forde	0	0	0	0	56	56	91	5	4	0	**58.4**	**1.183**
Davis	Forde	1	0	2	2	54	55	90	7	3	0	**58.2**	**1.128**
Woodland	Forde	0	0	1	0	54	54	17	32	47	3	**48.9**	**0.945**
Davis	Ivanhoe	3	0	3	3	54	56	53	22	24	1	**56.3**	**1.101**
Woodland	Ivanhoe	0	0	2	0	58	58	66	18	16	0	**53.9**	**1.118**
Chico	Ivanhoe	0	3	1	2	55	56	84	13	3	0	**56.4**	**1.109**
Wheatland	Ivanhoe	0	5	1	4	52	54	13	46	41	0	**50.1**	**0.939**
Davis	Solano	0	0	1	0	55	55	67	25	8	0	**54.1**	**1.065**
Woodland	Solano	0	0	1	0	56	56	45	50	5	0	**54.2**	**1.085**
Woodland	Solano	0	1	0	1	52	53	12	46	35	7	**48.9**	**0.918**
Durham	Solano	0	1	0	1	56	57	35	51	14	0	**52.1**	**1.058**
Davis	76-080	0	0	2	0	52	52	86	12	2	0	**58.5**	**1.092**
Davis	91-009-41	3	1	16	8	50	54	31	32	36	0	**51.4**	**0.917**
Davis	93-028-20	1	0	0	2	58	59	83	14	3	0	**56.5**	**1.188**
Davis	93-028-20	0	0	0	0	55	55	69	18	12	1	**55.8**	**1.107**
Woodland	93-028-20	0	0	0	0	58	58	64	30	6	0	**54.3**	**1.134**
Durham	93-028-20	0	0	1	0	56	56	60	26	14	0	**53.3**	**1.069**
Chico	93-028-20	0	1	1	1	54	54	69	24	7	0	**51.5**	**0.992**

Location	Variety or Selection	Sample Wt	Nuts per sample	Avg nut wt (g)	% Large	% Med	% Baby	% Large Sound	% Stain	% Broken	% Adh Hull	% External Damage
Woodland	95-007-13	1000	72	13.89	100	0	0	97	0	0	0	0
Durham	95-026-16	1002	88	11.39	99	1	0	93	0	0	0	0
Davis	00-006-227	1000	79	12.66	100	0	0	94	0	0	1	1
Woodland	00-006-227	1003	86	11.66	100	0	0	98	0	0	0	0
Davis	02-005-870	1000	69	14.49	100	0	0	96	0	0	0	0
Davis	02-005-870	1004	59	17.02	98	0	2	96	0	0	0	0
Davis	03-001-1098	1000	75	13.33	100	0	0	99	0	0	0	0
Davis	03-001-1372	1004	59	17.02	100	0	0	100	0	0	0	0
Woodland	03-001-1372	1003	79	12.70	100	0	0	98	0	0	0	0
Davis	03-001-1457	1004	89	11.28	92	8	0	92	0	0	0	0
Davis	03-001-1457	1002	72	13.92	100	0	0	100	0	0	0	0
Davis	03-001-1938	1003	91	11.02	96	3	1	95	0	0	0	0
Davis	03-001-1938	1001	69	14.51	100	0	0	98	0	0	0	0
Wheatland	03-001-1938	1004	89	11.28	99	1	0	99	0	0	0	0
Davis	03-001-2105	1000	91	10.99	59	27	13	64	0	0	0	0
Davis	03-001-2266	1004	75	13.39	99	1	0	99	0	0	0	0
Davis	03-001-2357	1000	105	9.52	41	42	17	46	0	0	0	0
Davis	03-001-2357	1000	64	15.63	100	0	0	99	0	0	0	0
Woodland	03-001-2357	1002	78	12.85	99	1	0	99	0	0	0	0
Davis	03-001-2434	1001	61	16.41	100	0	0	99	0	0	0	0
Woodland	03-001-2434	1004	64	15.69	100	0	0	100	0	0	0	0
Davis	03-001-3443	1002	67	14.96	100	0	0	99	0	0	0	0
Davis	03-001-412	1000	69	14.49	100	0	0	97	0	0	0	0
Davis	03-001-475	1000	82	12.20	96	4	0	94	0	0	0	0
Davis	03-001-665	1000	92	10.87	100	0	0	98	0	0	0	0
Davis	03-001-665	1002	74	13.54	100	0	0	94	0	1	0	1
Davis	03-003-6	1004	93	10.80	77	17	5	65	0	0	0	0
Davis	03-003-6	1002	93	10.77	74	23	3	64	0	0	0	0
Davis	03-003-15	1003	79	12.70	99	1	0	97	0	0	0	0
Davis	03-017-4	1004	80	12.55	99	0	1	91	0	0	0	0
Davis	04-001-116	1000	86	11.63	100	0	0	95	0	0	0	0

Location	Variety or Selection	% Insect	% Mold	% Shrivel	% Offgrade	% Edible Yield	% Total Yield	Extra Light	Light	Light Amber	Amber	RLI	Relative Value
Woodland	95-007-13	1	1	0	3	55	56	60	23	15	3	**55.8**	**1.095**
Durham	95-026-16	0	6	1	6	50	52	0	79	18	3	**52.9**	**0.943**
Davis	00-006-227	0	0	14	3	57	58	71	16	9	4	**57.4**	**1.168**
Woodland	00-006-227	0	1	2	1	59	60	74	22	4	0	**57.5**	**1.230**
Davis	02-005-870	4	0	0	4	55	57	40	51	9	0	**53.1**	**1.048**
Davis	02-005-870	0	0	7	1	53	53	64	26	10	0	**55.4**	**1.053**
Davis	03-001-1098	0	0	1	0	52	53	77	19	4	0	**57.1**	**1.075**
Davis	03-001-1372	0	0	0	0	55	55	72	24	5	0	**55.4**	**1.100**
Woodland	03-001-1372	0	1	1	1	55	56	67	27	6	0	**54.1**	**1.074**
Davis	03-001-1457	1	0	0	1	58	58	74	20	7	0	**55.4**	**1.148**
Davis	03-001-1457	0	0	0	0	58	58	23	69	7	2	**51.4**	**1.078**
Davis	03-001-1938	0	0	2	0	59	59	67	29	4	0	**55.4**	**1.167**
Davis	03-001-1938	0	0	3	0	56	56	42	28	30	0	**52.4**	**1.061**
Wheatland	03-001-1938	0	0	0	0	61	61	63	32	5	0	**54.0**	**1.177**
Davis	03-001-2105	1	0	7	3	52	53	92	6	2	1	**57.6**	**1.074**
Davis	03-001-2266	0	0	0	0	54	54	82	11	7	0	**57.9**	**1.123**
Davis	03-001-2357	0	0	0	0	54	54	90	7	3	0	**61.5**	**1.200**
Davis	03-001-2357	0	0	2	0	57	58	72	13	16	0	**57.1**	**1.180**
Woodland	03-001-2357	0	0	0	0	62	62	93	5	2	0	**59.7**	**1.343**
Davis	03-001-2434	0	0	2	0	56	56	68	27	5	0	**54.1**	**1.093**
Woodland	03-001-2434	0	0	0	0	59	59	85	12	2	0	**56.5**	**1.207**
Davis	03-001-3443	0	0	3	0	52	52	70	20	11	0	**54.5**	**1.020**
Davis	03-001-412	0	1	3	2	52	54	38	45	17	0	**55.4**	**1.045**
Davis	03-001-475	0	0	6	1	55	56	72	20	9	0	**54.8**	**1.081**
Davis	03-001-665	1	0	1	1	59	60	92	5	3	0	**58.1**	**1.242**
Davis	03-001-665	4	0	3	4	57	60	78	17	5	0	**55.7**	**1.149**
Davis	03-003-6	19	0	0	19	48	59	28	68	4	0	**52.9**	**0.914**
Davis	03-003-6	16	0	3	16	49	59	33	49	18	0	**51.7**	**0.919**
Davis	03-003-15	1	0	1	1	52	53	24	46	29	1	**49.4**	**0.926**
Davis	03-017-4	8	1	1	9	37	40	20	48	32	0	**48.3**	**0.639**
Davis	04-001-116	2	0	6	4	50	51	0	75	19	6	**50.6**	**0.902**

Location	Variety or Selection	Sample Wt	Nuts per sample	Avg nut wt (g)	% Large	% Med	% Baby	% Large Sound	% Stain	% Broken	% Adh Hull	% External Damage
Davis	04-001-191	1003	98	10.23	79	20	1	75	0	0	0	0
Davis	04-002-342	1000	81	12.35	98	1	1	96	0	0	0	0
Davis	04-003-143	1004	80	12.55	100	0	0	95	0	0	0	0
Woodland	04-003-143	1000	67	14.93	100	0	0	100	0	0	0	0
Davis	04-003-403	940	87	10.80	95	1	3	90	0	0	0	0
Davis	04-003-417	1002	102	9.82	91	8	1	84	0	0	0	0
Davis	05-001-362	1000	96	10.42	92	8	0	88	1	0	0	1
Davis	05-001-402	1002	92	10.89	87	9	4	83	0	0	1	1
Davis	05-002-212	1002	78	12.85	100	0	0	100	0	0	0	0
Davis	05-002-233	1004	110	9.13	54	32	15	52	0	0	0	0
Davis	05-002-396	1003	95	10.56	84	14	2	73	0	0	0	0
Davis	05-003-133	1001	86	11.64	97	2	1	55	0	0	0	0
Davis	05-003-256	1003	77	13.03	99	1	0	98	0	0	0	0
Davis	06-004-3	1003	71	14.13	100	0	0	94	0	0	0	0
Davis	06-005-2	1001	70	14.30	100	0	0	92	0	0	0	0
Davis	06-005-18	1003	79	12.70	94	5	1	88	1	0	0	1
Davis	06-005-27	1003	65	15.43	100	0	0	99	0	0	0	0
Davis	06-005-36	1001	79	12.67	95	5	0	91	0	0	0	0
Davis	06-005-5	1001	71	14.10	99	1	0	98	0	0	0	0
Davis	06-013-19	1001	95	10.54	69	21	9	65	0	0	0	0
Davis	06-013-20	1002	63	15.90	97	2	2	93	2	0	0	2
Davis	06-017-53	1003	99	10.13	84	12	4	85	0	0	0	0
Davis	06-023-9	1004	88	11.41	85	10	5	86	0	0	0	0
Davis	06-026-14	1001	86	11.64	100	0	0	98	0	0	0	0
Davis	06-027-16	1004	74	13.57	99	1	0	98	0	0	0	0
Davis	07-002-5	1003	84	11.94	92	7	1	94	0	0	0	0
Davis	07-019-9	1002	73	13.73	100	0	0	98	0	0	0	0
Davis	07-021-6	1003	90	11.14	100	0	0	96	0	0	0	0
Davis	07-029-1	1004	89	11.28	100	0	0	96	0	0	0	0

Location	Variety or Selection	% Insect	% Mold	% Shrivel	% Offgrade	% Edible Yield	% Total Yield	Extra Light	Light	Light Amber	Amber	RLI	Relative Value
Davis	04-001-191	5	1	1	6	52	56	17	33	51	0	**48.8**	**0.920**
Davis	04-002-342	1	1	2	3	52	53	38	17	45	0	**53.2**	**0.992**
Davis	04-003-143	0	0	9	3	49	51	43	39	18	0	**52.4**	**0.932**
Woodland	04-003-143	0	0	0	0	56	56	59	34	8	0	**55.9**	**1.133**
Davis	04-003-403	1	0	13	7	43	46	24	64	9	2	**56.3**	**0.869**
Davis	04-003-417	6	2	6	9	45	50	49	14	36	2	**51.9**	**0.837**
Davis	05-001-362	4	1	0	4	62	65	20	41	29	10	**51.2**	**1.145**
Davis	05-001-402	7	2	0	8	52	57	19	38	41	3	**51.6**	**0.971**
Davis	05-002-212	0	0	1	0	52	52	77	17	6	0	**57.2**	**1.073**
Davis	05-002-233	6	0	0	7	50	53	25	55	20	1	**52.3**	**0.936**
Davis	05-002-396	12	2	1	13	49	57	24	62	15	0	**51.9**	**0.924**
Davis	05-003-133	44	1	0	46	28	52	72	21	7	0	**52.8**	**0.537**
Davis	05-003-256	0	0	3	0	52	52	48	34	18	0	**54.0**	**1.014**
Davis	06-004-3	4	0	4	5	52	54	69	20	11	0	**54.8**	**1.017**
Davis	06-005-2	7	0	3	8	51	56	24	34	39	4	**50.4**	**0.923**
Davis	06-005-18	8	1	0	8	46	51	30	44	24	2	**50.7**	**0.846**
Davis	06-005-27	0	0	2	0	56	56	51	34	15	0	**54.9**	**1.100**
Davis	06-005-36	5	0	3	6	57	60	0	19	62	19	**46.2**	**0.940**
Davis	06-005-5	1	0	0	1	55	56	59	33	8	0	**53.7**	**1.066**
Davis	06-013-19	12	0	0	11	48	54	36	43	20	0	**51.6**	**0.896**
Davis	06-013-20	2	3	3	5	51	54	67	20	13	0	**56.0**	**1.030**
Davis	06-017-53	0	0	6	1	59	60	27	54	14	5	**53.5**	**1.144**
Davis	06-023-9	3	0	3	4	51	53	44	41	14	0	**54.0**	**0.999**
Davis	06-026-14	0	0	5	1	54	55	56	20	24	0	**54.5**	**1.064**
Davis	06-027-16	0	0	3	0	53	53	32	35	25	7	**52.1**	**0.990**
Davis	07-002-5	0	0	2	0	58	59	74	12	14	0	**56.6**	**1.190**
Davis	07-019-9	0	0	4	1	54	54	5	66	28	1	**51.3**	**0.990**
Davis	07-021-6	0	0	8	2	57	58	58	15	26	2	**54.1**	**1.117**
Davis	07-029-1	3	0	3	4	53	55	26	51	22	0	**51.9**	**0.984**

Table15. Results of *Juglans microcarpa* germination treatments using seed collected from three mother tree accessions, DJUG 29.11, 31.02, and 53.04, growing in the USDA-NCGR collection at Winters California.

Mother tree		**Stratification**	**Strat temp**	**Growth Temp**	**% Germination**
DJUG 29.11		5 mo	3 C	25 C	0
DJUG 29.11		6 mo	3 C	25 C	30
DJUG 29.11		7 mo	3 C	25 C	60
Hull condition	**Seed treatment**	**Stratification**	**Strat temp**	**Growth temp**	**% Germination**
hull intact	No soak before stratification	5 mo	3 C	25 C	poorest germ
hull intact	24 hr soak in still water before strat	5 mo	3 C	25 C	poorest germ
hull removed	KOH soak before strat to soften suture	5 mo	3 C	25 C	no germination
hull removed	Incubated at 25C before stratification to soften suture	5 mo	3 C	25 C	no germination
hull removed	no soak before stratification	5 mo	3 C	25 C	poor germination
hull removed	24 hr soak in still water before strat	5 mo	3 C	25 C	10-20%
hull removed	24 hr soak in running water before strat	5 mo	3 C	25 C	10-20%
hull removed	Water soak, cracked before strat	5 mo	3 C	25 C	40-50% for seed of 29.11 and 53.04
hull removed	Water soak, cracked after stratification	5 mo	3 C	25 C	40-50% for seed of 29.11 and 53.04
hull removed	Promalin 24 hr soak before strat, no crack	5 mo	3 C	25 C	70-90% for seed of 29.11 and 53.04
hull removed	Promalin 24 hr soak before strat, no crack	5 mo	3 C	25 C	same as water soak for seed of 31.02
hull removed	Water soak, crack before stratification	5 mo	3 C	25 C	slightly better than water soak for 31.02
hull removed	Water soak, crack after stratification	5 mo	3 C	25 C	slightly better than water soak for 31.02
hull removed	Promalin 24 hr soak, No crack	none	…….	25 C	no germination
hull removed	62.5 ppm Promalin	5 mo	3 C	25 C	Germination similar at all 3 concentrations
hull removed	125 ppm Promalin	5 mo	3 C	25 C	Germination similar at all 3 concentrations
hull removed	250 ppm Promalin	5 mo	3 C	25 C	Germination similar at all 3 concentrations

Table 16. Rooting percentages and survival to full establishment of several *Juglans* species propagated by air layering from potted plants in the greenhouse.

Species	No. Tried	No. rooted	% rooted	No. Plants Produced	% Survival	% Success
J. major	60	42	70	15	36	25
J. microcarpa	145	121	83	103	85	71
J. nigra	25	9	36	7	78	28
Total	230	172	74	125	73	54

Table 17. Rooting percentages and survival to full establishment of two genotypes propagated by air layering from potted plants in the greenhouse.

Genotype	No. Attempted	No. Rooted	% rooted	No. Plants Produced	% Survival	% Success
J. cathayensis '#21'	5	3	60	2	67	40
J. regia 'CR1'	25	12	48	7	58	28
Total	30	15	50	9	60	30

Table 18. Rooting percentages and survival to full establishment of Latin American species propagated by air layering from potted plants in the greenhouse.

NCGR DJUG No.	Species	No. Attempted	No. Rooted	% rooted	No. Plants Produced	% Survival	% Success
529.01	J. neotropica	2	1	50	0	0	0
530.01	J. neotropica	2	2	100	2	100	100
530.02	J. neotropica	2	2	100	2	100	100
627.03	J. australis	1	1	100	0	0	0
628.03	J. australis	1	0	0	-	-	0
629.01	J. mollis	-	-	-	-	-	
629.02	J. mollis	-	-	-	-	-	
634.02	J. mollis	-	-	-	-	-	
662.04	J. olanchana	2	1	50	1	100	50
664.12	J. olanchana	2	2	100	2	100	100
Total		14	9	64	7	78	50

Table 19. Air layering of *Juglans cathayensis* '#21' in the field.

No. Attempted	No. Rooted	% rooted	No. Plants Produced	% Survival	% Success
39	17	44	14	82	36

Table 20. Propagation of *Juglans cathayensis* '#21' by semi-hardwood cuttings.

Auxin Applied	mg/L	Single or Multi-leaf	Cut or Uncut	No. Tried	No. rooted	% rooted	No. Potted	% Survival	% Success
NAA/KI	8000	single	cut	10	0	-	-	-	-
NAA/KI	8000	single	uncut	10	0	-	-	-	-
KNAA	8000	single	uncut	10	0	-	-	-	-
KNAA	8000	single	cut	10	0	-	-	-	-
NAA/KI	4000	single	uncut	10	0	-	-	-	-
NAA/KI	4000	single	cut	10	2	20	1	50	10
KIBA	8000	single	cut	10	6	60	2	33	20
KIBA	8000	multi	cut	72	49	68	20	41	28
KIBA	8000	single	uncut	36	15	42	5	33	14
KIBA	8000	multi	uncut	52	28	54	10	36	19
IBA acid	8000	single	uncut	10	2	20	1	50	10
IBA acid	8000	single	cut	10	0	-	-	-	-
NAA	8000	single	cut	10	4	40	1	25	10
NAA	8000	single	uncut	10	2	20	0	-	-
Total				270	108	40	39	36	14

Table21. Clonal propagation of a population of potted wingnut seedlings from NCGR accession DPTE 1.09 by semi-hardwood cuttings in a greenhouse.

Year	No. of cuttings	No. Rooted	% Rooted	No. Plants Produced	% Survival	% Success
2012	371	212	57	184	86	50
2013	737	496	67	436	87	59
Total	1108	708	63	610	86	55