HAROLD TUKEY: Our next speaker is Dr. Andy Leiser and he is going to tell us about some interesting experiences with plant propagation for highway planting[1].

We have no time for questions and so we will move on to our next speaker, Dr. Hudson Hartmann. Dr. Hartmann has not been on our program before but he is probably well known to all of you. He is the co-author of one of the best books we have on plant propagation and is the International Editor for the Society. Dr. Hartmann is going to discuss some aspects of the present rootstock situation for fruit crops in California.

THE ROOTSTOCK SITUATION FOR TREE FRUITS AND GRAPES IN CALIFORNIA

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For most of the major fruit crops in California, the plants are propagated by budding or grafting on rootstocks. Very large acreages and high crop values are involved; the proper selection of scion-rootstock combinations is necessary or tremendous financial losses can occur.

The bulk of the deciduous fruit acreage in California is in the Central Valley — the Sacramento and San Joaquin valleys — where considerable emphasis is on the stone fruits — peaches and nectarines (110,000 acres); almonds (254,000 acres); apricots (35,000 acres); prunes (100,000 acres); and plums (27,000 acres). The English walnut is also grown in the Central Valley with smaller amounts in coastal valleys and Southern California, giving a total acreage of 198,000. The vinifera grape is a major and dramatically increasing crop in the San Joaquin valley with lesser amounts in the coastal valleys, making a total of almost 500,000 acres now planted. The San Joaquin valley and, to a lesser extent, Southern California, is the big producer of table oranges with 224,000 acres. The coastal region south of Santa Barbara and, to a lesser extent, Southern California, grows 56,000 acres of lemons. California is the sole producer of olives in the U.S. with 42,000 acres, grown mainly in the San Joaquin and Sacramento valleys. Pears, mainly Bartletts, are grown in the Sacramento valley as well as in the foothills of the Coast Range and Sierra Nevada, with a total acreage of about 46,000.

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[1]Dr. Leiser discussed his studies of plant materials used along new highway construction

The apple is considered a minor crop in California with 25,000 acres, although California ranks 4th in the U.S. in apple production. Other minor fruit crops are the avocado (24,000 acres), figs (17,000 acres), grapefruit (17,000 acres), cherries (14,000 acres), dates (4,000 acres), and pistachio (9,000 acres). The value of the 1969 production of the crops listed above was 787 million dollars. The rootstock situation and propagation methods for the various fruit crops have changed over the years. Rootstocks and propagation methods presently being used are as follows:

Peaches and Nectarines *(Prunus persica)*. Propagation is largely by T-budding in the fall or by June-budding. Since the root knot nematode *(Meloidogyne javanica* and *M. incognita)* is a considerable problem in the light soils of the peach areas, many trees are now being worked on the USDA's Nemaguard (peach — *P. davidiana* hybrid) stock, introduced in 1959, which is resistant to both types of nematodes. This stock may not be winter hardy in the colder areas of the U.S. Clonal mother trees of Nemaguard are used as the seed sources, the seedlings uniformly showing nematode resistance. Trees on Lovell seedlings are also available from nurseries for areas where nematodes are not a problem.

Almonds *(Prunus amygdalus)*. Propagation is by fall or June T-budding on year-old seedlings of peach (Nemaguard or Lovell) or almond. 'Marianna 2624', a vigorous clonal selection from the parent Marianna plum — *Prunus cerasifera x P. munsoniana* (supposedly), propagated by hardwood cuttings, is used for some almond cultivars that are to be grown in heavy, wet soils or where oak root fungus is present. The use of vigorous peach-almond hybrids, propagated by hardwood cuttings, show promise as a future almond rootstock Indolebutyric acid treatments given the hardwood cuttings of these clonal rootstocks before they are set out in the nursery have been of striking benefit.

Apricots *(Prunus armeniaca)*. This is propagated by T-budding, either in the fall, or by June budding. The principal rootstock is apricot or peach (Nemaguard) seedlings or 'Marianna 2624' plum. The California apricot cultivars ('Royal', 'Blenheim', 'Tilton') do well on peach roots but studies in Canada (6) and Michigan (1) show an incompatibility with certain other cultivars on peach roots.

Plums *(Prunus* sp.), including prunes *(Prunus domestica)*. These are propagated by T-budding in the fall. The traditional rootstock, and still widely used, is Myrobalan plum seedlings (*Prunus cerasifera*). Certain exceptionally vigorous selections ('Myro B', 'Myro C') have been made and are propagated by hardwood cuttings. The clonal stock, 'Marianna 2624', is used to a considerable extent in California, but young trees on this and 'Myro C' stocks are shallow-rooted and will blow over in winds, more so than

those on Myrobalan seedlings. Peach seedlings are quite satisfactory as a plum rootstock, especially on light, well-drained soils, but in some areas of California trees of plum on peach roots tend to over-bear and develop a dieback condition.

English walnut (*Juglans regia*). This is propagated in California by patch budding or whip grafting on seedling rootstocks or top-grafting 3 or 4 year old trees in the orchard, planted in place. There is no ideal rootstock available The most commonly used stock over the years is *Juglans hindsii*, the northern California black walnut, but this is highly susceptible to *Phytophthora* crown rot, especially under wet soil conditions, and to root lesion nematode. It is highly resistant to oak fungus (*Armillaria mellea*). A major problem with this stock, however, is its susceptibility to "black-line", a condition occurring after about 20 years, where the tissues around the graft union deteriorate and the top dies, an example, perhaps, of delayed incompatibility. This occurs mostly in cooler coastal regions of the state and the cause is unknown. Seedlings of *Juglans regia* used as a rootstock do not show "black-line", but they are very susceptible to oak root fungus, which limits their usefulness in California. Paradox hybrid (*J. hindsii x J. regia*) makes a strong vigorous rootstock for *J. regia* cultivars and is much in demand. The nurseries charge $1 25 extra for trees on this stock; Paradox seedlings are found occurring naturally in the nursery row where the tree source of the *J. hindsii* seed is growing in close proximity to and is pollinated by *J. regia* trees. Such seedlings are easily located in the rows of *J. hindsii* seedlings by their larger leaf size

Although uniformly vigorous, there is considerable variability among Paradox seedlings in their resistance to nematodes and crown rot. Several superior clonal selections have been made but there is a great need for reliable methods of large scale propagation of these clones by cuttings. Either hardwood cuttings rooted over bottom heat, or leafy cuttings under mist can be rooted, provided IBA treatments are given, but such rooted cuttings will not tolerate any disturbance of the roots. Studies are underway presently to overcome this problem using techniques such as rooting in solid block media.

Grape (*Vitis vinifera*). The steadily increasing consumption of wine in the U.S. has resulted in a dramatic increase in wine grape plantings in California, the extent being limited only by the availability of nursery stock. Figures for 1971 showed a total of about 55,000 acres of non-bearing grapes in California, reflecting new plantings for 1969, 70, and 71 And in 1972 alone, 52,000 new acres were planted. This tremendous demand for nursery stock has quickly led to a modernization of the traditional propagation methods. Cultivars for planting in areas of the state — where

nematodes or phylloxera are not a problem — are being propagated in high numbers as one-node stem cuttings treated with IBA and set under mist. With high bottom heat — about 85° F — cuttings root in about 7 days. New growth taken from these rooted cuttings can again be rooted as stem cuttings so a geometrical increase in population can be obtained The original source of the propagating material being used is limited. It is supplied by the University of California's Foundation Plant Materials Service from stock plants that have been indexed and found to be free from known grape virus diseases.

Wine grape cultivars to be planted in the coastal valleys of California, where phylloxera and nematodes are a problem, must be worked onto resistant rootstocks, which complicates the propagation procedures. Again there has been considerable urgency in developing rapid propagation methods for such grafted vines The technique now in use was modified at the USDA Horticultural Field Station, Fresno, California (2). It consists, essentially in grafting in early spring an unrooted, disbudded, hardwood cutting of the resistant rootstock clone to a one-budded scion of the variety to be grown. The grafting is done by one of several devices, e.g. a French grafting machine which makes a saddlegraft, an inverted "V" in the scion and a "V" in the stock, or by a machine having several saw blades, which cuts out notches in the upper end of the stock and the lower end of the scion so that they will interlock upon being pushed together. The graft unions by the former machine are held together preferably by an ordinary desk staple, or in the latter by budding rubbers. The completed grafts are placed for callusing in moist wood shavings at 80° F for 2 to 3 weeks; after this the top of the graft to below the union is dipped in melted paraffin (usually double dipped) held at 140° F to coat the scion and union The grafts are then planted in soil in open 6" x 2" x 2" wax or plastic-coated paper tubes. After a 4-week period under protected greenhouse conditions, when scion shoot growth is 12 to 14 in. long, and when roots are well developed, the grafts — tube and all — are planted in their permanent location in the vineyard.

Rootstocks for *Vinifera* varieties now being recommended in California — all of which are available from the U. C. Foundation Plant Materials Service from virus-tested sources — 'Rupestris St. George' (resistant to phylloxera but not nematodes); 'Aramon x Rupestris Ganzin No. 1' (mildly resistant to phlloxera but not nematodes); 'Solonis x Othello 1613' (resistant to nematodes but not phylloxera); 'Harmony' — a new USDA introduction (resistant primarily to nematodes and moderately to phylloxera); and 'Dogridge' and 'Salt Creek' (resistant to both nematodes and phylloxera, but so vigorous they should only be used in low fertility soils).

Oranges (*Citrus sinensis*), **lemons** (*C. limon*) and **grapefruit** (*C. paradisi*). The commercial propagation methods are the same for all species of citrus— T-budding on seedling rootstocks. Citrus is plagued by several serious virus diseases, as well as possible inferior mutations, so it is very important to use only transmissible disease-free and known true-to-type propagating material. The various members of this genus will intergraft readily and can be grafted to other closely related genera, such as *Poncirus* (trifoliate orange), as rootstocks.

The fact that citrus seeds produce apomictic (nucellar) embryos readily permits the propagation of clonal rootstocks by seeds. With the exception of the psorosis virus, transmissable diseases do not appear in citrus seedlings.

Rootstocks selected for plantings vary according to the type of citrus fruit to be grown and to the area in the state and the soil type to be planted. Those being used in California at the present time are seedlings of:

a) **Sweet orange** (*C. sinensis*). This is a very good stock for all citrus cultivars and does well except on heavy, poorly-drained soils where it often shows a gummosis problem due to *Phytophthora* infection.

b) **Sour orange** (*C. aurantium*) is an excellent rootstock also for all citrus species except that it is subject to the "tristeza" disease, a virus transmitted by an insect vector or by infected budwood. This stock is no longer used in California on this account, but is still widely used in Florida and Texas where "tristeza" has not been a severe problem.

c) **Rough lemon** (*C. limon*). In California this stock is only used on sandy soil in the desert regions, due to its high susceptibility to *Phytophthora*. Trees on this stock are very high yielding but the fruit is of inferior quality.

d) **Trifoliate orange** (*Poncirus trifoliata*). This is a dwarfing stock now widely used in California's central valley citrus region, doing best on a medium-textured soil. Trees on trifoliate orange yield heavily with high quality fruit and develop considerable cold resistance.

e) **'Cleopatra' mandarin** (*C. reticulata*). This stock is widely used in California, as well as in Florida and Texas, due to its resistance to gummosis, "tristeza" and to its salt tolerance. Yields are good and fruit quality is high, but fruit size is somewhat smaller than average. Its chief disadvantage is the slow seedling growth and slowness of trees worked on it to come into bearing.

Citranges (*Poncirus trifoliata x Citrus sinensis*). There are several named cultivars used as seed sources — 'Morton',

'Savage', 'Troyer.' These have been useful as dwarfing stocks for grapefruit and mandarins, and trees of sweet orange on this stock have been good yielders of high quality fruit.

Citrus macrophylla. Due to its boron tolerance this stock has found wide use in California as a rootstock for lemons grown in certain high boron soils. As a sweet orange rootstock, however, the trees would be susceptible to "tristeza".

Pears (*Pyrus communis*). 'Bartlett' pear production in California has had a stormy history of rootstock problems. *Pyrus communis* seedlings over the years have proven to be a satisfactory stock except for their susceptibility to fire blight (*Erwinia amylovora*). In the early part of this century oriental pears, such as *Pyrus pyrifolia* seedlings, were used due to their resistance to blight but pears from trees on this stock were found to develop abnormal conditions, turning black and hard rather than ripening normally (termed "black-end" or "hard-end" fruits). This defect disappeared if the trees were inarched with *P. communis* seedlings, then after the inarches were of sufficient size to hold up the tree, the original *P. pyrifolia* connection was cut. Apparently some material in the original root system was translocated to the fruit where it caused the abnormal condition.

About 1960, the so-called "pear decline" condition swept the West Coast, killing hundreds of thousands of trees, again mostly on oriental roots, *P. pyrifolia* and *P. usseriensis*. An intensive research program over the next 10 years finally determined that the causal agent was a mycoplasma-like body spread by pear psylla (5), but only affecting trees on certain rootstocks, chiefly the oriental pears and quince (7). A phloem breakdown at the graft union caused the death of the tree. The 'Bartlett' clone itself is not susceptible and procedures were developed to propagate 'Bartlett' on its own roots by hardwood cuttings (3). Such trees in rootstock plantings have proven to be quite productive and somewhat dwarfed. At present in California, nurseries are mainly using as pear rootstocks, seedlings of the 'Winter Nelis' pear, where the fruits are collected in 'Bartlett' orchards having 'Winter Nelis' trees scattered through the orchard as pollinizers. This is to avoid indiscriminate collection of 'Bartlett' fruits from orchards where the pollinizing parent could have been an oriental pear, giving a hybrid seedling, which would be susceptible to "pear decline".

Apple (*Malus sylvestris*). Over the years, apple orchards in California have traditionally been on seedling rootstocks. Recently, however, more and more growers are using clonal rootstocks together with close plantings. Preferred stocks are 'Malling 7', 'MM 111', and some 'MM 104', 'Malling 9' has given too dwarf a tree for California growers. The trend toward these clonal apple stocks and away from seedling stocks is likely to continue.

Sweet Cherries (*Prunus avium*). These are propagated by fall T-budding on seedlings of Mazzard (*P. avium)*, or Mahaleb (*P. mahaleb)* cherry or on rooted cuttings of a dwarfing clone, 'Stockton Morello' *(P. cerasus)*. Registered seed taken from trees ındexed as being free of known stone fruit virus diseases is available from the U C Foundation Plant Materials Service. Source wood of virus-tested 'Stockton Morello' is also available.

In California, Mahaleb is widely used as a drought-resistant rootstock, giving trees slightly smaller than those on Mazzard but it is not completely compatible with all varieties. Mazzard roots give a strong, vigorous tree; more resistant to excess soil moisture than Mahaleb, and completely compatible with all sweet cherry varieties. 'Stockton Morello' is best propagated under mist as leafy cuttings. Since the viruses have been eliminated from this clone, the dwarfing influence has not been as pronounced as previously noted.

Olives (*Olea europaea*) In California, olive varieties traditionally have been propagated by cuttings, either hardwood or leafy cuttings under mist, with the exception of one cultivar, 'Sevillano', which is difficult to root. This was propagated by grafting or budding on seedlings of any small-fruited oil cultivar whose seeds germinate readily. With the advent of considerable cotton acreage in the San Joaquin valley, where all plants are infected with verticullium wilt *(Verticillium albo-atrum),* infectious material from the cotton has blown all through olive groves planted throughout the same area until now verticillium damage to the olive trees has become a major cultural problem. The University of California has developed at least two olive rootstocks resistant to verticillium infection so that in the future new plantings will be on these stocks (4).

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HAROLD TUKEY: Thank you, Dr. Hartmann, for a very interesting talk and for the chance of our members here in the Eastern Region to meet and become better acquainted with you and your work.

Now we come to another aspect of the systems approach and that is how to find out what the other fellow is doing. To handle this part of the program, we have Jim Wells.[1]

THURSDAY AFTERNOON SESSION

December 7, 1972

The afternoon session convened at 1·30 p.m. in the Terrace Room with Ralph Shugert presiding.

RALPH SHUGERT: This morning we explored some of the systems approach to plant propagation and this afternoon we will continue in this vein with some new ideas. It has been said that there is nothing new under the sun, but I believe the gentlemen who made that statement did not know plant propagators.

Our first speaker this afternoon is Mak Kawase from my home state of Ohio and he ıs going to tell us about the role of ethylene metabolism in root formation

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[1]Edıtor's note: Mr. Jim Wells and Doug Weguelin discussed the plant propagators' England tour scheduled for August and September, 1973.