our *Phaedranthus buccinatorius* cuttings root, and feel that this is a good percentage.

These results are summarized in Table 1.

DAVID ADAMS: We have with us now, Dr. Robert Warner from the University of Hawaii. Dr. Warner lived in California for a number of years before he went to Hawaii, but he is now a resident in the Hawaiian Islands for I believe, eleven years. He's been working in quite a wide range of crops, macadamia, bananas, citrus rootstocks, and various nutritional problems. He is also in charge of the instructional arboretum which he tells me will be on the tour for the Western Region Meeting next year. He has some slides showing many of the things we can expect to see next year on the Hawaiian trip Today he will talk to us about propagation of certain tropical plants. Dr. Warner:

PROPAGATION OF TROPICAL CROP PLANTS[1]

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PLANTATION FIELD CROPS

SUGARCANE, *Saccharum officinarum* L., is a member of the grass family and, except when breeding for new varieties, is propagated vegetatively. Cane sections about 22'' long with 4 nodes are cut by hand or mechanically from mature plants, soaked in a fungicide and placed horizontally in furrows and covered lightly with soil Shoots and roots are produced at the nodes. In Hawaii the plant crop (the first after planting) matures in about 22 to 24 months. The cane is cured by withholding water and nitrogen during the last 3 to 6 months.

When ready for harvest, the field is burned to reduce the amount of dead leaves and trash. The stalks are bulldozed into windrows, loaded onto trucks and transported to the mill for grinding. The irrigation furrows are reestablished and the ratoon crops grow from

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the underground parts which remain after harvest. There are usually three ratoon crops harvested before the field is replanted, a total of 8 years Temperatures above 70° F are required for root development and 80° F. is considered optimum. High light energy and frequent irrigation are required (5).

PINEAPPLE, *Ananas comosus*, (L.) Merr. is propagated from various parts of the plant. The crown, attached to the top of the fruit, is removed in the field before the fruit goes to the cannery; the slips grow out of the peduncle below the fruit; hapas are shoots which grow out from the junction of the peduncle and the stem Suckers emerge from axillary buds on the main stem of the plant. These planting materials are broken off the plants and allowed to cure in the field for one or two weeks during which the base of the stem calluses They are then less susceptible to fungus diseases when planted

The time required for each plant part to produce its first fruit (the plant crop) is different enough so that only one kind of plant part is planted in a particular field. Crowns take 22 to 24 months, slips 18 to 20 months, hapas 19, and suckers about 17 months to mature the plant crop. Hapas are of minor importance.

Before planting, the fields are subsoiled, disced and black plastic is laid mechanically over the beds immediately after fertilizer and DD are injected into the soil After several days the plants are inserted through the plastic in double rows 2 feet apart and staggered 12-15 inches apart in the rows. This gives about 17,000 plants per acre Recently yields have been increased by higher densities experimentally up to 30,000 plants per acre The common density now in Hawaii is 19,000 to 21,000 plants per acre. Even higher densities are used for fresh pineapple production which requires smaller fruits

The smooth Cayenne type and its sub-varieties are used almost exclusively in Hawaii. Yields decrease and the fruit size is reduced in the ratoon crops The fields are usually replanted after harvest of one plant crop and one ratoon crop which makes about a four year cycle (7, 8)

PLANTATION ORCHARD CROPS

MACADAMIA For many years propagation was entirely by seed The seedling trees were quite variable in size, time of fruit maturity, nut size, shell thickness and yield of kernels (3) The need for selection of superior trees was realized but all attempts at grafting had failed until Moltzau in 1927 grafted potted seedlings successfully for the first time Then in 1937 Jones and Beaumont discovered the importance of carbohydrate accumulation in both the scion and stock (16). Ringing the scion increased the carbohydrate

storage in the wood significantly. This increased the number of takes among grafts of macadamia.

Fahmy (10) made macadamia grafts in Florida several times during the year and reported that the highest percent takes were during the early summer season He found no difference between the girdled and ungirdled twigs. He found accurate matching of the cambium layers of stock and scion was critical and difficult since macadamia wood is very hard During the other times of the year he advised the use of girdled twigs. Fahmy concurred with Hawaiian results (14) that the side wedge graft gave the best results

The development of grafting methods for macadamia opened the way for the development of an industry based on superior clone selections (17, 25)

There are only two species of macadamia considered to have edible nuts. They are the Smooth-shell, *Macadamia intergrifolia* Maiden and Betche and the Rough-shell, *Macadamia tetraphylla* L. Johnson In Hawaii, the Rough-shell species has now become the accepted and preferred rootstock for clonal selections of the Smooth-shell macadamia (12, 26) The seeds of the Rough-shell germinate and grow more rapidly, induce earlier bearing and heavier crops but do not reduce the size nor the quality of the Smooth-shell nuts (26).

Pope (1969) recommended that boxes of washed sand 12'' deep be used for macadamia seed germination. The seeds should be planted 2'' apart and 2'' deep in the direct sun to make strong plants of great stem diameter. They should be transplanted into well-drained soil in containers (20), or 6 to 8 inches apart in nursery rows (14). The taproot should be clipped back to 6 or 7 inches to prevent it from being bent in the container. Graft when stems are slightly woody and ⅜'' diameter or more, i.e. 6-8 weeks after transplanting (21)

The best procedure was to prepare scion wood by girdling 6 to 8 weeks before it is needed. Carbohydrate storage in scion and stock is vital to grafting success. Stored starch can be tested by an iodine starch test in the wood rays. The growth of stock should be retarded by withholding nitrogen and reducing the water during the last 4 to 6 weeks to permit accumulation of food reserves in the tree (3, 21).

Pope and Storey (1933) also recommended adding nitrate fertilizer to the seedling stocks 10 days before grafting and the tree of scion source about 3 weeks before cutting the scions (21).

Scion wood ½ inch or more in diameter is cut into pieces 4 to 5 inches long and having 2-3 nodes. The leaves are cut off. Flushing branches should not be used. The side wedge and the side-paste (veneer) graft were recommended (3) but the side wedge is most widely used now (14, 22, 23).

Another method of grafting is the approach graft or inarch. The

inarch is used to develop braces for better wind resistance (12). For grafting old trees, a chisel slit can be made in the bark and the scion is driven in. The scion is held in place with small wire nails.

For top working macadamia, the tree is cut back 4 to 5′ above ground and suckers, which grow out in 6 months to a year, can be grafted (3, 23) or scaffold limbs can be bark-grafted directly (14).

Tonks (29) in Southern Rhodesia, because of limited scion wood, grafted very young leafy scions down to 1½ mm in diameter in 90% shade in containers and covered them with plastic bags with split bamboo supports He made liberal use of Dithane M-45 on the scions, the bamboo, and inside the bags to control fungus growth. In 8 weeks he was able to cut off corners of the bags, opened bags in 10 days more and removed them 5 or 6 days later. Grafted plants were produced in as little as 14 weeks He now produces grafted trees at the rate of 10,000 per year

Budding macadamia, generally considered very difficult, was successfully accomplished at the Turrialba Center of the IICA, Camacho reported (6).

For rooting cuttings under intermittent mist, partially matured leafy cuttings 4 to 9" long are recommended They can be rooted in 6 to 10 weeks. Rooting is speeded up by a 5-second dip in 5,000 to 10,000 ppm solution of IBA and bottom heat at about 75° F (2) Rooted cuttings have produced shallower roots than macadamia seedlings and are not used commercially.

The BANANA, *Musa sp.*, is another crop which is generally vegetatively propagated Edible types almost never have seeds Most edible bananas are triploid and produce fruit parthenocarpically The primitive wild ancestors of these types and some ornamental bananas produce seeds

The seeds show best germination when planted soon after they mature. Seeds of *Musa velutna* Wendl and Drude, an ornamental from Assam, all grew when planted immediately. Seeds of *M. balbisiana* Colla, one of the seedy ancestors of our cooking banana cultivars is reported to germinate better when subject to alternate warm and cold temperatures of 32° and 10° C (90° and 50° F) (28) We had good germination from well-ripened seeds when the whole banana with its seeds inside were planted in furrows in the field Perhaps it prevented the seeds from drying out *Musa aroldiana* DeWild is a plant within Musaceae which does not produce suckers, so must be propagated by seeds

The banana plant grows from a corm. As the plant grows, suckers develop from the corm and new shoots are produced which replace the old ones The old plant dies after it produces flowers and fruit As the new shoots are formed, a mat of the corms all more or less connected results Commercially, the number of plants developing from a mat is controlled by pruning — cutting off the excess shoots

The suckers that develop on the sides of older plants are used for propagation The small ones just showing are called *peepers*. The intermediate sized shoots 1 to 3 feet tall are called *sword suckers* because they have narrow, lance-shaped leaves. These make the best propagative material because they have more food reserves and grow vigorously. Bullheads are old stumps from plants which have fruited. The stump is cut into sectors each with one more "eyes" (buds) which can develop into new plants.

Only clean healthy mats free of virus or fungus disease symptoms should be used for propagation. Bunchy top virus (not reported in Hawaii) and Panama wilt are the most serious; the later is a wilt disease that is caused by a pathogenic fungus, *Fusarium oxysporum* f *cubense*. Varieties resistent to Panama disease are used where this soil fungus is present. They include 'Dwarf Cavendish' ('Chinese'). 'Williams hybrid', 'Hamakua', 'Taiwan', 'Brazilian', 'Walha', Phillipine 'Lacatan' and 'Golden Beauty' (24).

The burrowing nematode, *Radopholus similis*, is common throughout the tropics and causes root and corm lesions which reduce plant vigor and eventuallykills the plant. The corm treatment for cleaning up plant material involves trimming off all roots and discolored corm tissue and cut the pseudostem back to 6 or 8 inches and submerge for 15-20 minutes in hot water at 50-55° C (122-130° F). A fungicide such as Panogen may be added to the hot water to suppress decay organisms, or a cold 1:5 solution of Clorox for 5-10 minutes after the heat treatment may be used. Then plant in uninfested soil. New roots grow out at the base of the leaf sheaths. Bananas grow best in well drained soil with frequent watering and fertilized with a high potassium fertilizer mix.

COFFEE: There are three important species of coffee but probably 90% of the world's coffee production comes from *Coffea arabica* L. In the relatively cool mountains, 3500 to 6500 feet in the tropics, it produces the best quality coffee as compared to *Coffea canephora*, Pierre, ex Froehn. the Robusta coffee and *Coffea liberica*, Hiern. which are grown at low elevations. In Kona, a District of Hawaii, at an elevation of 700 to 2200 feet, the *C. arabica* coffee is rated among the best (7, 11, 19).

Most coffee propagation is from seeds sown in well prepared beds under shade which germinate in 6 or 7 weeks. When the plants are 6 to 8 inches high, they are ready for transplanting. Coffee is sensitive to root disturbance and must be transplanted with special care unless it is grown in containers.

Clonal varieties are propagated by cleft-grafting on seedlings in the nursery beds or on seedlings in containers. Rootstocks should be of pencil thickness before they are cut back for grafting. Scion wood must be from upright branches; if horizontal branches are used, the plants will be prostrate. Cuttings may be used as rootstocks.

When rooting hormones have been used, satisfactory results have been obtained with softwood leafy cuttings (19). For best results, high relative humidity (90%), temperature of 21-23° C (70-75° F), and about 50% shade is needed until the plants are well established.

PAPAYA, *Carica papaya* L.· The commercial papaya in Hawaii is completely of the Solo variety and the predominant type in home gardens. The papaya is propagated entirely from seed although it can be grafted or grown with difficulty from cuttings.

Seeds are taken from healthy ripe hermaphroditic fruits After the seeds are washed and dried, they can be stored in a cool dry place or in a sealed jar at low temperature. Under these conditions, they remain viable for 2 to 3 years. The seeds should be germinated in vermiculite or sterilized soil to prevent damping off. They germinate in about 2 weeks and are transplanted to small pots when they have 2 leaves. Papaya may be planted directly in the field by placing 10 or 15 seeds in prepared holes and later thinning them to 2 or 3 About 2/3 of the seedlings will be hermaphroditic and 1/3 will be female plants. The sex of the plants cannot be distinguished until they produce their first flowers, about 4-5 months after planting. Since the market preference is for the pear-shaped hermaphroditic fruits rather than the round female fruits, the female plants are removed. The female flowers have no anthers and the white petals are almost completely free and are attached below the ovary. The flowers of the hermaphroditic trees have pollen bearing anthers and the petals are fused together for one-half to three-fourths of their length, forming a corolla tube attached at the base of the ovary.

The male trees, not from the 'Solo', produce a long pendulous inflorescence with small staminate flowers and rarely set fruit.

Trees are planted in the field from 6 to 9 feet within the rows and from 9 to 11 feet between rows (7, 32).

PASSIONFRUIT. *Passiflora edulis* var. *flavicarpa* Deg., the yellow passionfruit is grown commercially in Hawaii for its juice. It grows and produces well at low elevations whereas the purple passionfruit *Passiflora edulis* Sims will produce best at 1500 to 2000 feet elevations The purple passionfruit is more suited for the fresh market

Passionfruit is propagated by seeds, cuttings and layers. Cuttings should be taken from actively growing vines between the winter and the summer crops in Hawaii. Cuttings should have at least one node It is necessary to have one leaf or a portion of it attached to the top node and the cutting set in the medium 2/3 of the way Cuttings with leaves root best, especially if treated with 1,000 ppm of NAA or IBA Cuttings usually start rooting in one month (7, 18)

Seeds may be planted immediately without cleaning and they germinate in 2 to 3 weeks. The ripe fruit for seed may be stored 1 to 2 months at 55° F If cleaned and dried, seeds may be stored 3 months or much longer if held at low temperatures and will give 85% germination (1)

Layers should be made on the partially hardened stems. They root in 4 to 8 weeks (1).

A high degree of self-incompatibility exists in passionfruit. For good production two or more clones growing near each other are needed for cross pollination. The flower structure is such that pollination is accomplished best by large insects. In Hawaii the carpenter bee is the principal pollinator, although the honeybee and hoverfly may also be effective (1).

Yellow passionfruit is planted at 10 foot intervals in rows 12 to 20 feet apart on trellises 10 or 12 feet high. More leaf surface is exposed to the light and increased yields result (7).

GUAVA: *Psidium guajava* L., the common yellow fruited guava, is the only one of this genus which is grown commercially in Hawaii 'Beaumont' is the only named cultivar at the moment, although several new processing types are expected to be released soon

'Beaumont' is propagated by patch budding, bark and side-wedge grafting and by rooting cuttings under mist (13, 18). Use of air layering and root cuttings has also been reported. Guava is easily grown from seeds. In fact, birds have distributed seeds over the moist mountain areas and pastures of Hawaii and have created a major weed problem. The acid, pink-fleshed fruits from these wild trees are harvested and processed along with the cultivated fruits in the production of frozen juice concentrate (7,9).

MINOR AND HOME GARDEN FRUITS

The MANGO, *Mangifera indica* L. is propagated vegetatively, except for the polyembryonic type which usually comes true from seed The Hawaiian or common mango, 'No. 9'' Chinese mango), 'Paris', and the 'Shibata' varieties are polyembryonic and widely distributed in Hawaii. Most of the selections in Hawaii and Florida such as the 'Haden', 'Joe Welsh', Momi K' and 'Gouveia' are monoembryonic and must be propagated vegetatively.

The side veneer graft is commonly used in Hawaii although the approach side wedge, side tongue, whip grafts and chip bud are also used. Budding is difficult, and special scion preparation is usually needed, such as removal of leaves and the terminal bud. Mango seeds grow readily but some of the seeds are destroyed by the mango weevil *(Sternochetus mangiferae)* which matures and exits after the mango is ripe and the seed has been discarded (30).

LYCHEE, *Litchi chinensis* Sonn., is usually propagated by air layering About 2 to 3 months are required to produce sufficient rooting before cutting and potting the layer. Layers should be grown in the pots for 6 to 8 months before planting out.

Budding and grafting have been demonstrated in Hawaii but are too difficult for general use The scion wood should be girdled 4 weeks before needed. Approach grafting is also used. Plants should be shaded and given wind protection when set in the field (7, 30). Seeds vary in size but appear to germinate readily when fresh

ANNONAS· These are easily propagated by seed Some varieties have been named and clones are propagated by graftage The trees have soft wood and are subject to dieback especially after a heavy crop. The soursop, *Annona muricata*, L. grows well from seeds and produces numerous large fruits. The custard apple, *A. reticulata* L. and the sweetsop, *A. squamosa* L., are propagated from seed. The cherimoya, *A.cherimola* Mill., is in high demand for its delicious fruit It is grafted on cherimoya seedlings. Cherimoya grows slowly, rarely fruits at low elevations in Hawaii but does well at Kona(1,500') and Kula(3,000'). There are several named varieties. The mountain soursop, *A. montana*, Macfadyan is seed-grown and produces many seedy fruits, which are edible but rarely grown. The Pond apple *A. glabra*, has been suggested as a rootstock for other annonas (7,19).

BREADFRUIT: The two species, *Artocarpus communis* Forst. and the jackfruit, *Artocarpus heterophyllus* Lam. are interesting members of the Mulberry family. The former produces no seeds and is propagted entirely from root cuttings. The latter, which seldom suckers, has edible seeds which grow readily. Both species produce large attractive trees. They have milky sap and large succulent leaves and twigs, not well adapted to production of rooted cuttings (7, 19).

CACAO: *Theobroma cacao* L. may be grown from seeds or leafy cuttings. Seeds can be stored for a short time at 60 to 70° F but at 45 to 50° F chilling injury may prevent germination. Seedlings can be budded in containers. Patch bud is best, but shield or Forkert buds have been successful. Cuttings seldom root without leaves attached. The cacao shoot does not store much carbohydrate. Rooting hormones, if used, must be applied before the cuttings are made. A mixture of IBA and NAA in equal amounts accelerates rooting. A well-aerated rooting medium is necessary with 100% relative humidity and light at 25 to 50% of full sunlight. Special care in hardening is necessary (7, 19).

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DAVID ADAMS· Well, that is just a taste of what you might see at the Western Region Meeting next year There are quite a few things to see and, of course, it's all new to us.

Our next speaker is Mr. Eichelser. He is from the Melrose Nursery near Olympia, Washington. He primarily grows rhododendrons and kalmia; he also has a few slides here showing some very beautiful kalmia. Mr. Eichelser:

PROPAGATION OF KALMIA LATIFOLIA

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The *Kalmia latifolia* I am talking about today is the Dexter strain and the red form of this strain, which is known as 'Ostbo Red'. Perhaps not all are familiar with this red clone or with the Dexter strain so I would like to show a few slides at this time to