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SELECTION OF POTENTIALLY ELITE INDIVIDUAL COFFEE TREES IN FIVE COFFEE GROWING AREAS IN HAWAII

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SUMMARY

Thirty-seven potentially elite individual trees were selected from five coffee growing areas in Hawaii during the fall of 1997. Visual selection was conducted for tree vigor, good balance of fruit bearing and vegetative growth, bean size and timing of flowering. The individual trees showed large variation in their morphology and fruit characteristics. Open-pollinated seeds were collected from these trees, then they were cut back to initiate new vertical shoot growth for production of cuttings. Cuttings were obtained from these trees three months after cut back. Seedlings germinated from the open pollinated seed were planted at the HARC Kunia Substation to initiate a breeding orchard in April 1998. Up to 100 percent efficiency was obtained in initiation of roots from cuttings. The rooted cuttings will be planted in the Kunia breeding orchard. The seedlings will be evaluated for segregation, and will be compared to the vegetative clones from individual trees. The selections will be used for production of hybrids in the 1999-2001 flowering seasons.

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INTRODUCTION

Coffee production in Hawaii has increased substantially during the last ten years. Four new coffee growing areas have emerged outside of the Kona district on the Island of Hawaii where coffee has been grown since the early 1800s. With production of 9 million lbs in 1997-98, coffee has become a major agricultural commodity in Hawaii, ranking fifth in values statewide (Hawaii Agriculture Statistics Services). Coffee production methods have also become diversified from hand-picking a single variety, 'Guatemalan' (typica), to mechanical harvesting of other cultivars, such as 'Yellow and Red Catuai' and 'Mokka.'

The primary objective of the coffee breeding and selection program is to develop high-yielding, excellent bean and cupping quality cultivars with distinctive flavors adapted to specific growing conditions in Hawaii. Disease resistance and mechanical harvestability are also important criteria for breeding and selection of Hawaiian cultivars. As the area under coffee cultivation expands, we must anticipate the eventual arrival of serious diseases and pests. Currently grown varieties in Hawaii are not resistant to diseases such as coffee rust (*Hemileia vastatrix*).

Five major goals were set for the first year of the breeding and selection program: (1) develop strategies for breeding and selection of coffee cultivars in Hawaii with the assistance of a coffee breeding consultant, (2) develop the techniques required to implement the breeding program, (3) develop an efficient protocol for vegetative propagation (Sun et al., 1998), (4) visit existing coffee plantings and select potentially elite individual trees for vegetative propagation, and (5) begin test crosses of high yielding, disease resistant and flavorful cultivars in the existing breeding collection.

A consulting coffee breeder, Dr. Medina-Filho of the Genetics Department, Instituto Agronomico, Campinas, Brazil, came to Hawaii in April 1998, to assist in the development of coffee breeding strategies. We had intensive discussions on breeding of coffee, especially for the improvement of flavor and development of cupping quality of coffee. Dr. Medina also presented a workshop on coffee cross pollinating techniques at the HARC Maunawili Breeding Station.

HARC imported the rust-resistant cultivars PROMECAFE 1 and 2 from Guatemala in 1992, and the germplasm was established at the HARC Maunawili Breeding Station. During March and April 1998, crosses were made between the rust resistant lines of Promecafes and the cultivars Guatemalan typica and Catuai. The Promecafe lines were self pollinated to obtain selfed progenies of individual Promecafe trees. In the next flowering season (January to March 1999), we are planning to hybridize various lines of coffee using the methods demonstrated by Dr. Medina.

Here we report on the selection of individual, potentially elite trees from five coffee growing areas in Hawaii and their establishment as open-pollinated progenies and cuttings

(clones) in a common field at Kunia, Oahu, for a breeding orchard for variety improvement for the Hawaiian coffee industry.

MATERIALS AND METHODS

Potentially elite individual trees were selected at farms in five coffee growing areas in Hawaii (Kauai Coffee, Kauai; Dole Fresh Fruit, Oahu; Kaanapali Coffee, Maui; Coffees of Hawaii, Molokai; Greenwell Farms and Kona Mountain Coffee, Kona, Hawaii) during September and October 1997. A team of plant breeders and physiologists visited selected fields at each location following recommendations of coffee growers at each site. The team walked through fields to get acquainted with overall phenotypes of trees, and visually selected trees based on tree vigor, good balance of fruit bearing and vegetative growth, bean size and timing of flowering. The number of selected individual trees was limited to five per variety. Selected trees were numbered according to their locations of origin and marked by stakes with tags and surveying tape. Tree height and crown width were measured. Other tree characteristics recorded included vertical stem numbers, leaf and fruit (cherry) characteristics, and uniformity of ripening. Mature fruits were collected for determination of cherry and bean weight and size, and bean/pulp ratios. Average weight, length and width per cherry were determined from the total weight and cumulative length and width of ten cherries. Cherry volume (units cm^3) was estimated from the formula $4/3 \times \pi \times (W/2)^2 \times (L/2)/1000$, where W = average cherry width and L = average cherry length. Bean/pulp ratios were obtained from the dry weight of green beans without parchment, divided by the original fresh weight of the cherries. Trees were cut back to 1-3 ft from the ground to obtain vertical shoots for vegetative propagation by cuttings (Diversified Report No. XX).

New vertical shoots were cut from the selected trees three months after stumping. The cut shoots were wrapped in wet newspaper and transferred at ambient temperature to the HARC Maunawili Station for vegetative propagation. Additional cuttings for propagation were prepared from this material on the day of collection, or the next day according to Sun et al., 1998.

Four individual trees were also selected from the rust-resistant cultivars Promecafe 1 and 2 from Guatemala (Osorto 1992), which were imported to Hawaii in 1992 (Nagai and Osgood, 1993) at fields at the HARC Maunawili Station to add to the planned elite germplasm.

RESULTS

Selection of elite individual trees

A total of 37 individual trees were selected from five coffee growing regions (Table 1). Tree phenotypes were less variable in Red Catuai, Yellow Catuai, Red Cattura and Guatemalan (typica) than in Mokka and Blue Mountain in which a large range of morphological variation was

observed. We selected the most distinctive types of trees in Mokka (Maui) and Blue Mountain (Oahu) sites. Both varieties had been propagated from open pollinated seed of several generations of trees originating at the University of Hawaii, Kona Experiment Station. Morphological segregation of these trees could be attributable to natural hybridization at the Kona Station or before importation to Kona.

Table1. Selection of individual elite trees at five coffee growing areas in Hawaii

Dates	***Coffee growing area/Farm***	***Collaborators***	***Varieties***	***No. of trees selected***
09/16/97	Maui/Kaanapali Coffee	Richard Loero	Mokka, Red Catuai	5 5
09/18/97	Oahu (Waialua)/ Dole Fresh Fruit	Mike McLean	Blue Mountain	5
09/23/97	Kauai/Kauai Coffee	Derek Nishimura	Yellow Catuai Red Catuai	3 2
09/25/97	Molokai/Coffees of Hawaii	Dan Kuhn	Red Catuai Red Caturra	7 2
10/23/97	Kona/Greenwell Coffee and Kona Mountain Farms	Tom Greenwell Dick Emory	Guatemalan others [(1)]	3 1
10/02/97	Maunawili HARC Exp. Sta.	-	Promecafe [(2)]	4
Total				37

[(1)] Coffee cultivar imported to Kona before 1860s

[(2)] Rust disease resistant variety from Guatemalan

Morphological characteristics of selected trees

Table 2 shows general and morphological characteristics of the 37 selected trees. Leaf types were segregated in 10 Mokka and Blue Mountain selections, MA1, 2, 3, 4, 5 and OA11, 12, 13, 14, 15. MA9 showed Mokka type leaves, although it was selected in a Red Catuai field. The old Hawaiian variety at Kona, KO33, showed its characteristic 'ripple' leaves. We selected 1-3 vertical stem trees over 4+. Height and crown width of individual trees showed large variations that may have been associated with differences in age and pruning history.

Fruit characteristics of selected trees

Fruit characteristics of 37 selected trees including 10-cherry weight, average cherry volume and dimensions, and the ratio of green bean/cherry were determined (Table 3). The largest variation was found in 10-cherry weight (10.8-27.2 g) and average 10-cherry volume (9.0-35 cm^3). Variations in 10-cherry weight were small among genotypes in non-segregating varieties (CV = 10-12%), while large variation (CV = 30%) was observed among trees in Blue Mountain (OA11-15, Dole Fresh Fruit, Waialua) (Table 4). The distribution of 10-cherry weight and cherry dimensions are shown in Figures 1 and 2. All the trees showing the Mokka phenotype had round cherries with length/width ratio of 1.0-1.1, while trees of Catuai, Cattura and Guatemalan had more oblong cherries with a length/width ratio of 1.1-1.2 (Table 4).

Table 4. Fruit and bean characteristics of selected trees in coffee groups

Group	***No. of selected trees***	***10 Cherry wt (gram)***	***Cherry shape ratio length/width***	***% Green bean/cherry[(b)]***
Blue Mountain	5	19.0 ± 2.5[(c)] (cv = 30)	1.07 ± 0.02 (cv = 3.5)	17.4 ± 0.6 (cv = 7.7)
Guatemalan	3	17.8 ± 1.0 (cv = 10)	1.12 ± 0.02 (cv = 3.8)	18.7 ± 0.9 (cv = 8.2)
Red cattura	2	17.2 ± 1.3 (cv = 10.7)	1.22 ± 0	-
Red Catuai	14	15.2 ± 0.5 (cv = 12.5)	1.20 ± 0.01 (cv = 3.7)	18.3 ± 0.7 (cv = 6.3)
Yellow Catuai	3	15.6 ± 1.0 (cv = 10.8)	1.16 ± 0.01 (cv = 2.1)	17.0[(a)]
Mokka	5	12.1 ± 0.6 (cv = 10.5)	1.09 ± 0.03 (cv = 6.7)	21.0[(a)]
Promecafe	4	24.4 ± 1.3 (cv = 10.3)	1.28 ± 0.06 (cv = 9.0)	19.0 ± 0.6 (cv = 6.1)
Other	1	12.2	1.10	18

[(a)] = 1 sample only

[(b)] = Dry weight of green bean without parchment/fresh cherry weight

[(c)] = Standard error

Mokka has been recognized as a variety for a long time but no information is available concerning its origin as indicated by Krug and Calvalho (1951). In Brazil, where extensive genetic studies were carried out beginning in the 1930s, two genes *lr* (laurina), and *mo* (mokka), were found to control Mokka characteristics. Mokka is characterized by having the smallest fruits and seed size among *C. arabica* varieties, but the quality of coffee has been considered excellent. All of the Mokka plants grown in Hawaii are progenies of Mocha, at UH Kona Station, while the generations (F2,3,4, etc.) and segregations of genes *lr* and *mo* are not known.

Blue Mountain is a variety originating from typica coffee in Jamaica (van der Vossen, 1985), and is known for excellent cupping quality. Blue Mountain trees spread in Hawaii are originally from HAES6433 at the UH Kona Station. These trees showed large segregation in their phenotypes with Mokka characteristics. Selected trees, OA11 and OA15 for example, have strong Mokka phenotypes in their leaves and fruits. We suspect that the original Blue Mountain trees introduced to the UH Kona Station were not true Blue Mountain, or accidentally crossed with Mokka at the station. The segregating Blue Mountain trees in Hawaii are a unique population for breeding regardless of their original pedigrees.

Four individual trees selected from rust-resistant varieties, Promecafe 1 and Promecafe 2, showed large fruit size and weight (Table 3). We are planning to cross these trees with Hawaiian elite trees in the next several flowering seasons to create rust-resistant Hawaiian cultivars.

Establishment of the Kunia Breeding Orchard:

Over 95 percent of open pollinated seed collected from 37 selected trees were germinated at the HARC Maunawili greenhouse. Ten seedlings per selected trees were planted at the HARC Kunia Substation, with an additional 10 (total 20) seedlings planted from the selected trees from segregating group (MA1-5 and OA11-15) in April 1998. The field was prepared as 12 x 3 ft (4 x 1 m) spacing with bana grass as wind breaks. Cloned trees, which were derived from rooted cuttings (Sun et. al., 1998), will be planted in June 1998.

These trees in the Kunia field will be used for: (1) evaluation of morphological segregation among seed-derived trees, (2) evaluation of growth in vegetatively propagated trees, and (3) hybridization among various individual trees to produce F1 and F2 populations.

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