EFFECT OF ETHEPHON ON RIPENING, SEED DEVELOPMENT, BRANCH GROWTH AND LEAF ABSCISSION OF *COFFEA ARABICA* L.

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ABSTRACT

Ripening of coffee fruits in Hawaii was stimulated when increasing ethephon concentrations were applied to plants prior to the onset of ripening, but seed dry weight from ethephon ripened fruits was 18.7% lighter than seeds from nontreated fruits. When 250 mg liter^{-1} ethephon was applied to fruits at the onset ripening, dry weight of seeds from ethephon ripened fruit was 5.6% less than control seeds. The cupping quality of brewed coffee was also lowered with ethephon application. When fruits were treated with 250 mg liter^{-1} ethephon after 25% of the fruits had ripened, ethephon stimulated ripening of the remaining fruits within 6 days after treatment, and there was no significant difference in dry weight of seeds from ethephon ripened and control fruits. There was also no difference in cupping quality of brewed coffee from the ethephon and control treatments. Ethephon at 25, 50, 100, 250 and 500 mg liter^{-1} had no effect on the growth of vegetative, flowering, and fruit bearing branches, however, ethephon at 1000 mg liter^{-1} was phytotoxic to the branch tips. Leaf abscission on fruit bearing laterals increased with increasing ethephon concentrations.

Key words: (2-chloroethyl)phosphonic acid; coffee; fruits; parchment; beverage

INTRODUCTION

Although coffee was formerly grown throughout the State of Hawaii, since 1960 it has been commercially produced only in the Kona district of Hawaii. However, beginning in 1986 new plantings have been made in other areas of the state and large scale plantings are anticipated. Because the fruit ripening period in Hawaii occurs over 4 months, multiple hand-harvests of fully ripe fruits are required during the harvesting season to obtain high beverage quality (Goto and Fukunaga, 1956). Mechanized harvesting will be necessary for large scale expansion of the coffee industry since high labor costs preclude hand harvesting of the fruits. Trials with mechanical harvesters in Hawaii have shown that the amount of immature fruit harvested ranged from 15 to 40% (Monroe and Wang, 1968). This was due to the presence of ripe and immature fruits on the tree during the harvesting operation. In order to obtain higher percentages of ripe fruits during mechanical harvesting, more synchronous ripening will be necessary.

Ripening is hormonally controlled and can be manipulated by the application of plant growth regulators such as ethephon (Abeles, 1985, 1987; Burg and Burg, 1965; Cannell, 1985; Gopal, 1976). The objectives of this study were to investigate the effect of ethephon on ripening and seed dry weight when ethephon was applied at various times during the ripening season.

MATERIALS AND METHODS

All experiments were conducted on 2 year-old coffee, *Coffea arabica* L. 'Guatemalan' trees growing on the island of Kauai in Hawaii. The first experiment (located in Lawai) was arranged in a completely randomized design with 12 trees/treatment. Trees consisted of 2 to 3 orthotropic (vertical) shoots which produced the plagiotropic (lateral) branches (Cannell, 1985). Flower buds and fruits were borne on the plagiotropic branches. Lateral branches were classified into

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3 branch types as follows:

Vegetative branches - Plagiotropic branches at the distal end of the vertical shoots. Vegetative lateral branches were green, in their first year of growth and with no floral bud development in the leaf axils at the start of this study.

Flowering branches - Plagiotropic branches with visible flower buds and some small immature fruits in the leaf axils. These branches were situated below the vegetative branches and were in their second year of development.

Bearing branches - Woody plagiotropic branches upon which were borne a mixture of immature green and mature red fruits. These lateral branches were situated at the basal end of the orthotropic shoots and were near the end of their second year of development.

Ethephon at 0, 25, 50, 100, 250, 500, and 1,000 mg liter^{-1} + 0.1% X-77 (Chevron Chemical Company, San Francisco, CA) surfactant, was applied to entire trees to run-off with a hand sprayer on 29 July 1987, prior to first fruit ripening. Treatment plots were separated by 6 trees in the row and 1.5 m between rows.

Three vegetative, flowering and bearing lateral branches per tree were tagged and the branch length, number of nodes, leaves and fruits (ripe and green) were noted before and at 30 days after treatment. Fruits were scored as ripe when the exocarp was completely red. Dry weight of the seeds including the parchment (endocarp) was determined after harvesting.

In the second study (located in Wahiawa) ethephon at 0 and 250 mg liter^{-1} + 0.1% X-77 surfactant was applied at the onset of fruit ripening (7 August 1987), and after 25% of the fruits had ripened (30 September 1987). Treatments were arranged in a completely randomized design with 5 replicate trees/treatment at each treatment date. In the 7 August trial, ripe fruits were harvested at 22, 36, 49, and 61 days after treatment. In the 30 September trial, fruits were harvested at 6 days after treatment.

Cupping tests to assess beverage quality were performed on brewed coffee from ethephon treated and control trees after harvesting was complete. Cupping tests were conducted by the Division of Marketing and Consumer Services in Kona, Hawaii in accordance with the Administrative Rules of the Department of Agriculture, State of Hawaii (1986).

RESULTS AND DISCUSSION

There was a curvilinear increase in the percent ripe fruits with increasing concentration when ethephon was applied on 29 July 1987 (Figure 1). The mean dry weight of seeds from the ethephon treatments was 18.7% lower than the control (0.362 g and 0.445 g, respectively).

Fruit abscission from bearing lateral branches was stimulated with 1,000 mg liter^{-1} (Figure 1). Fruit counts after treatment showed that abscission was limited to the immature fruits. Browning and Cannell (1970) also reported that about 60-65% of the young, expanding fruits, undergoing cell division, abscised with 1400 mg liter^{-1} ethephon between 4-6 days after treatment.

No significant differences were observed between 0, 25, 50, 100, 250, and 500 mg liter^{-1} ethephon in the number of new nodes that were produced or the amount of growth that occurred on the vegetative, flowering or bearing branches at 30 days after treatment. A pices of all 3 types of branches became necrotic after treatment with 1000 mg liter^{-1}.

With 1000 mg liter^{-1}, 82.8 $\pm$ 18.7 (Sd)% and 70.5 $\pm$ 10.0 (Sd)% of the leaves abscised from the vegetative and flowering branches, respectively, but abscission was not stimulated with concentrations from 0 to 500 mg liter^{-1} ethephon. Leaf abscission from fruit bearing branches increased with increasing ethephon concentrations (Figure 1). Leaf abscission from the fruit bearing branches was also reported in India, however, no effect on yield of coffee plants occurred during 3 years of study (Gopal, 1976).

In the second study, application of 250 mg liter^{-1} ethephon at the onset of ripening (7 August) stimulated ripening of 80% of the fruits within 22 days after treatment compared to 26% for the control trees (Table 1). There was no difference in the total fruits harvested/tree between the ethephon and control trees. Dry weight of the ethephon treated seeds was about 5.6% less than in the control (Table 1). Similar results showing a reduction in seed dry weight with ethephon were reported for *arabica* (R.M. Bullock, unpublished data) and *robusta* (Gopal, 1976; Snoeck, 1977) coffee. In robusta coffee, ethephon accelerated ripening without accelerating seed development. This resulted in smaller, more immature beans at harvesting (Snoeck, 1977). Cupping tests from the 7 August trial indicated that beverage quality from the ethephon treatment was lower than the control.

When 250 mg liter^{-1} ethephon was applied after 25% of the fruits had ripened (30 September), the remaining fruits ripened within 6 days (data not shown). In contrast, only 30% of the control fruits ripened during the same 6 day period. There were no differences between mean dry weights of seeds from the ethephon and control treatments. Cupping tests of brewed coffee from the 30 September trial showed that beverage quality from the ethephon and control treatments were similar.

Results of this study indicate that ethephon can be useful for synchronizing coffee ripening in Hawaii. However, seed development and beverage quality are affected by the timing of applications and fruit maturity.

The differences in seed dry weight between the 30 September and 7 August ethephon treatment can be explained by the growth pattern of coffee fruits. The *arabica* coffee fruit has a double sigmoid growth pattern (Leon and Fournier, 1962), and seed development (filling of the endocarp) occurs during the 12 week period prior to ripening (Cannell, 1985; Leon and Fournier, 1962). When ethephon was applied near the end of the seed filling phase, dry weight of the seeds was greater compared to earlier applications when seed development was not complete. Ethephon application during earlier stages of fruit development accelerated ripening of the fruit, but did not stimulate seed development.

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TABLE 1. EFFECT OF 250 MG LITER^{-1} ETHEPHON APPLICATION AT THE ONSET OF RIPENING (7 AUG. 1987) ON YIELD

Days after treatment (Harvest date)	% of total harvest		Fruits harvested/tree		Seed dry wt[y] (g/seed)	
	Control	Ethephon	Control	Ethephon	Control	Ethephon.
22 (29 Aug. 1987)	26	80	142	422	.440	.392
36 (12 Sep. 1987)	30	20	168	104	.392	.312
49 (25 Sep. 1987)	21	-	116	-	.377	-
61 (7 Oct. 1987)	23	-	119	-	.367	-
Total harvest	100	100	545[a]	526[a]		
Mean					.395[a]	.373[b]

[y]DIFFERENT LETTERS FOR TOTAL FRUITS HARVESTED/TREE AND MEAN SEED DRY WEIGHT FOR THE CONTROL AND ETHEPHON TREATMENT ARE SIGNIFICANTLY DIFFERENT USING AT-TEST, 5% LEVEL.
[z]DRY WEIGHT OF SEEDS INCLUDES THE PARCHMENT (ENDOCARP).

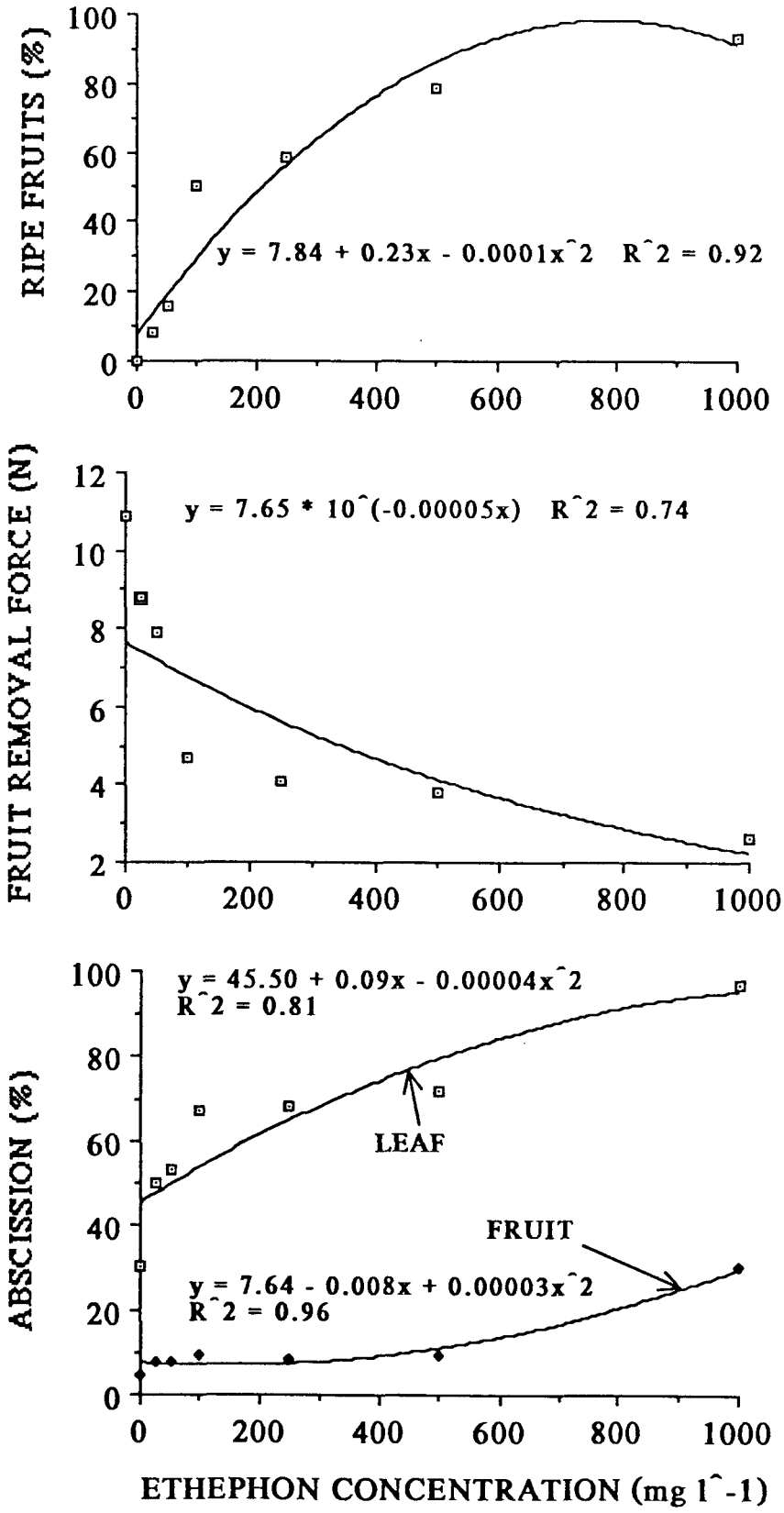

FIGURE 1. EFFECT OF ETHEPHON ON RIPENING, FRUIT ABSCISSION AND LEAF ABSCISSION FROM FRUIT BEARING BRANCHES. APPLICATION WAS MADE PRIOR TO FIRST FRUIT RIPENING (29 JULY 1987), AND THE DATA TAKEN AT 30 DAYS AFTER TREATMENT.