fertilizer per 10 cm pot per week, is suggested. Commercial growers benefit by daily watering and fertilizer input to maximize plant size and plant quality per unit of greenhouse space. The fertilizer rate of 400 ppm N caused salt burn of the stem at the soil surface. However, caution is needed if one is to extend these results in areas where phytopathological factors are not under control, and for species not studied here. It is also suggested that watering be limited to once a week for a 2 week period prior to sale to increase the plant's disease resistance.

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Respiration and Ethylene Production in Mammee Apple (*Mammea americana* L.)[1]

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Additional index words. bioassay, climacteric

Abstract. **Gas chromatography and bioassays were used to identify ethylene (C_2H_4) in fruit emanations of mammee apple (*Mammea americana* L.). C_2H_4 production probably triggered the respiratory rise in preclimacteric fruit and its relationship to respiration was typical of that for a climacteric fruit. C_2H_4 production was however, independent of respiration in immature and postclimacteric fruits. C_2H_4 production increased to a peak and then declined with deterioration of fruit in spite of nearly constant rates of respiration in immature fruit and declining rates in postclimacteric fruit. Peak production of C_2H_4, 408 μl per kg per hr, from preclimacteric fruit is probably the highest reported among fruits.**

An unusually high production of what appeared to be C_2H_4 was discovered in the emanations of mammee apple in storage in the course of determining C_2H_4 production in various species of fruits. This paper reports the identification of the gas and its relationship to respiration.

Materials and Methods

Fruits of mammee apple (also known as mamey, apricot of Santo Domingo, etc.) were obtained from a single tree on the grounds of Poamoho Farm, Hawaii Agricultural Experiment Station.

Immature (about 85% developed), preclimacteric, mature and postclimacteric (just past ripe stage), fruit were individually sealed in gas-tight 3,250 ml glass containers for 1 hr at 27.5°C for C_2H_4 identification. One ml samples of the atmosphere surrounding the fruit were withdrawn with gas-tight syringe for gas chromatography analyses with a hydrogen flame ionization unit (Aerograph Hy-Fi 600-D) and alumina column. Emanations of the fruit were also bubbled into $Hg(C10_3)_2$ solution (0.25 M red mercuric oxide in a 2.0 M perchloric acid) for 1 to 2 hr. The trapped gas after being liberated with 4.0 N LiCl (11) was similarly analyzed for C_2H_4. The gas released was also scrubbed with brominated (23%) activated charcoal (4) and crystals of $KMnO_4$ (7, 9), materials known to be C_2H_4 inactivators, and again tested for C_2H_4. Bioassays were also utilized to verify the presence of C_2H_4 in the fruit emanations. Blossoms of vanda orchid (*Vanda* Miss Agnes Joaquim) and carnations (*Dianthus caryophyllus* L.); young seedlings of soybean [*Glycine max* (L.) Merr.] and papaya (*Carica papaya* L.); excised terminal shoots of weed species (*Amaranthus spinosus* L., *Portulaca oleracea* L., *Euphorbia hirta* L. and *Bidens pilosa* L.); and green fruit of tangerine (*Citrus reticulata* Blanco) were exposed to 50 ml per min streams of air passing through containers with mammee apples for 1 to 3 days.

Immature, preclimacteric, and postclimacteric fruits were tested within 2 hr after harvest. Four or more fruit of each stage of development were used for studies on the relationship between C_2H_4 production and respiration. Each fruit was weighed before sealing in a gas-tight 3,250 ml glass container for CO_2 respiration and C_2H_4 determinations at 27.5°C. Separate 1-ml samples of the atmosphere surrounding each fruit were withdrawn after 1 hr with a gas-tight syringe for gas chromatographic analyses of CO_2 and C_2H_4. A thermal conductivity detector unit (Varian Aerograph 90-F) with a silica gel column was used for CO_2 analysis and the hydrogen flame unit previously described was used for C_2H_4 determination. Sampling was performed at the time the experiments were begun and daily thereafter until the fruit deteriorated, i.e. showed physiological breakdown without decay. Fruit were aerated between samplings with a continuous flow of air bubbled

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through a column of water to humidify it before entering the fruit containers at a flow rate of 100 ml per min at 27.5°.

Results and Discussion

Ethylene identification. Positive identification of C_2H_4 in fruit emanations at the 3 stages of development was made with gas chromatography. Samples of the atmosphere surrounding fruit in the sealed container and samples of gas liberated from the C_2H_4-$Hg(ClO_3)_2$ complex produced typical ethylene peaks in the chromatograms. The liberated gas did not produce C_2H_4 peaks when it was scrubbed with brominated activated charcoal and $KMnO_4$.

Bioassays also verified the presence of C_2H_4 in the emanations of the fruit. Exposure to emanations caused vanda orchid blossoms to fade, a typical C_2H_4 response (3, 4), and carnation flowers to close ("sleepiness"), another C_2H_4 response (10). Seedlings of soybean and papaya and excised terminal shoots of the weed species developed epinasty in the presence of the emanations which also degreened tangerines, all typical C_2H_4 effects.

Respiration-C_2H_4 relationship. Respiration of immature fruit declined during the first 3 to 4 days, then remained nearly constant throughout the rest of the storage period, and C_2H_4 production similarly declined slightly during this period, but then increased rapidly and peaked 8 days later, followed by a slight decline (Fig. 1). A respiratory pattern typical of a climacteric fruit was produced by preclimacteric fruit with an increase in C_2H_4 production preceeding the respiratory rise by perhaps 2 days (Fig. 2). C_2H_4 and CO_2 peaks were attained in 3 and 4 days, respectively, followed by a rapid decline in production of both gases. Respiration of the postclimacteric fruit gradually declined throughout the storage period, but C_2H_4 production decreased during the first 3 days then increased and peaked 9 days later and finally declined (Fig. 3).

The unusually high production of C_2H_4 just prior to the attainment of the climacteric peak (Fig. 2) in mammee apple is noteworthy in that this production of 408 μl per kg per hr

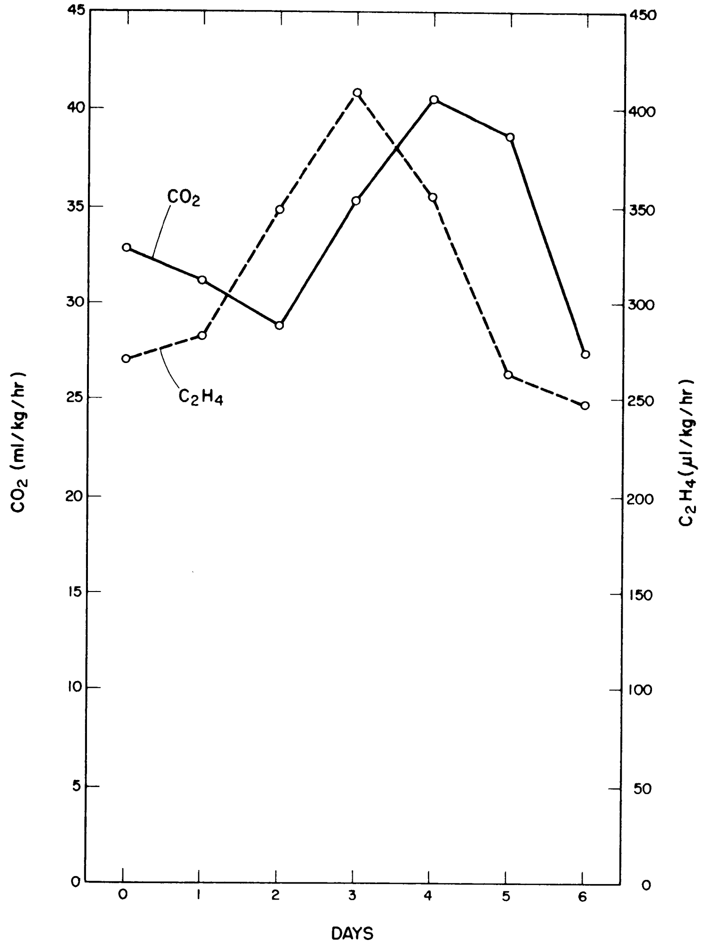

Fig. 2. Respiration and C_2H_4 production in preclimacteric fruit of mammee apple in storage at 27.5°C (avg of 4 fruit).

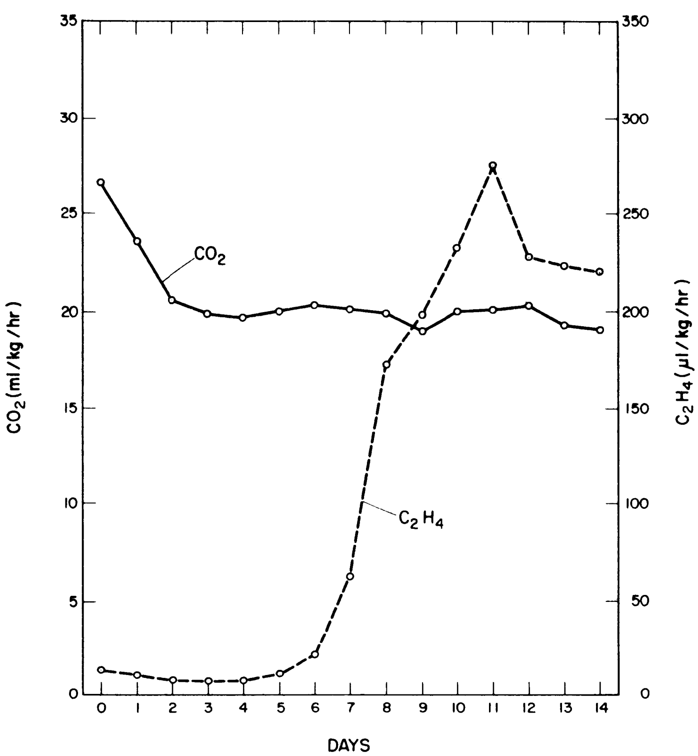

Fig. 1. Respiration and C_2H_4 production in immature fruit of mammee apple in storage at 27.5°C (avg of 4 fruit).

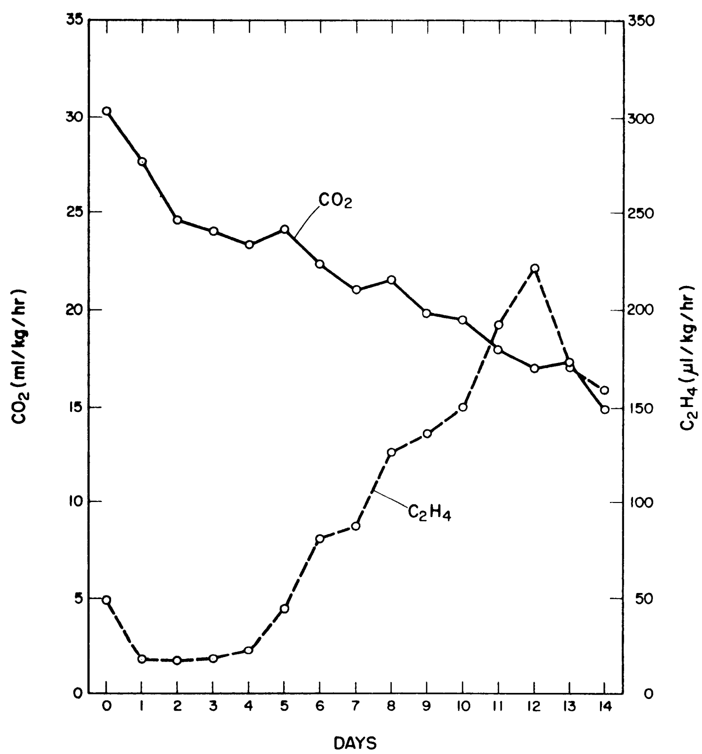

Fig. 3. Respiration and C_2H_4 production in postclimacteric fruit of mammee apple in storage at 27.5°C (avg of 4 fruit).

represents a production greater than that of purple passion fruit (*Passiflora edulis* Simms), which was the highest reported previously, 370 μl per kg per hr (5).

Respiratory patterns in the 3 stages of fruit maturity were typical (Fig. 1, 2, and 3), and C_2H_4 production in the preclimacteric fruit was also typical (Fig. 2), but patterns of C_2H_4 production in the immature (Fig. 1) and postclimacteric (Fig. 3) fruits were atypical. C_2H_4 production in preclimacteric fruit was definitely related to respiration with C_2H_4 probably acting as the trigger mechansim to induce the respiratory rise. The decline in C_2H_4 after reaching peak production also paralleled the decrease in respiration a day later as the fruit entered the postclimacteric stage (Fig. 2). C_2H_4 production in immature and postclimacteric fruit was independent of respiration with C_2H_4 increasing in spite of nearly constant (Fig. 1) or decreasing CO_2 (Fig. 3) evolution as the fruits aged in storage. C_2H_4 production peaked even in these stages of fruit development, then declined as the fruit deteriorated, a pattern similar to that of the preclimacteric fruit. There was a similar rise in C_2H_4 production in cranberry fruit with decreasing respiration as the fruit ripened (2).

Methionine concn in the pineapple fruit increases with ripening and the onset of senescence (6), hence a similar buildup of this amino acid, a precursor of C_2H_4 in plants (1), may occur in both the ripening (preclimacteric) and senescing (immature and postclimacteric) mammee apple. Furthermore, new enzyme proteins which cause rapid onset of ethylene synthesis are synthesized in some aging climacteric fruits (8), hence similar phenomenon may occur in the aging mammee apple. These and other factors associated with C_2H_4 production need elucidation.

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Water Relations in Apple Seedlings: Changes in Water Potential Components, Abscisic Acid Levels and Stomatal Conductances under Irrigated and Non-irrigated Conditions[1]

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Additional index words. Malus domestica, abscisic acid, water relations, stomatal physiology

Abstract. **Stomatal conductance, abscisic acid levels, and water potential components (water, osmotic, and rurgor potentials) were measured in irrigated and non-irrigated open pollinated seedlings of 'Northern Spy' apples (*Malus domestica* Borkh.). Although non-irrigated seedlings typically displayed water potentials of 0.2 to 0.6 MPa lower than those of irrigated seedlings, turgor potentials remained comparable in both groups, Because diurnal osmotic adjustment was also greater for non-irrigated seedlings. Abscisic acid (ABA) levels in the leaf increased linearly in response to changes in leaf turgor, rather than water potential. Stomatal conductance was independent of bulk leaf ABA levels and was poorly correlated with leaf turgor potential above a critical value of 0.7 MPa.**

Higher plants possess a number of physiological adaptations which allow them to survive and continue growing even under very severe stress conditions (6). Plants such as mangrove are capable of surviving in salt water by developing osmotic potentials more negative than those of their environment. This osmotic regulating ability maintains leaf turgor at a sufficient level for growth. Some mesophytic plants also undergo diurnal or seasonal changes in osmotic potentials, a process known as osmotic adjustment, during periods of water stress. Goode and Higgs (4) have observed osmotic adjustment in apple trees of as much as 0.7 MPa during the day and 2.0 MPa over a growing season. Wenkert (24) has also measured seasonal osmotic adjustment in soybean of 0.4 MPa.

Whether osmotic adjustment occurs only as a passive process in which existing solutes such as sugars and organic acids become more concentrated, or as an active process in which the solute concn in increased through physiological changes, it

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[3]Abbreviations: ψ_w: water potential; ψ_p: turgor potential; ψ_s: osmotic potential; k_s: stomatal conductance; RWC: relative water content; MPa: megapascal = 10 bars: ABA: abscisic acid.