J. Amer. Soc. Hort. Sci. 103(5):576–578. 1978.

Ripening, Respiration, and Ethylene Production of 'Hass' Avocado Fruits at 20° to 40°C[1]

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Additional index words. Persea americana, propylene

Abstract. **The respiratory rate, ethylene production and ripening of mature 'Hass' avocado fruits (*Persea americana* Mill.) were determined at 20° to 40°C. Typical climacteric patterns occurred at 20°, 25°, 30° and 35° with the climacteric maximum increasing with temperature, but only a decreasing respiratory rate with time was observed at 40°. Maximum ethylene production decreased as the temperature increased, with a significant decrease between 25° and 30°, only trace amounts were produced at 35° and essentially no ethylene production was detected at 40°. The ripened fruit quality was excellent at 20°, 25° and 30°, fair at 35° and abnormal and unacceptable at 40°. Fruit held at 40° for up to 2 days resumed ripening when transferred to 20°. The exposure to exogenous ethylene or propylene hastened the ripening response up to 35°, however at 40° the respiratory rate was increased, but ethylene production and normal ripening did not occur.**

Avocado fruit, which do not ripen while attached to the tree, even when exposed to ethylene (9), may be exposed to high temp on the tree (fruit temp in the sun to 50°C) without apparent damage. However, postharvest, abnormal ripening at temp above 30° has been reported (7, 16). Similar results have been reported for other fruits (5, 10, 11, 15). The failure of fruit to ripen normally at temp above 30° to 35° has been attributed to the reduction of ethylene production at these temp. Ethylene production for several fruits when held at or above 30° has been reduced (1, 4, 10, 11, 15). However, data were not found for avocados. The ripening, respiratory rate and ethylene production of 'Haas' avocado fruits at 20°, 25°, 30°, 35° and 40° are reported.

Materials and Methods

Mature 'Haas' fruits were harvested from local groves, randomized, weighed and placed individually in respiration chambers at specified temp within 1 hr. A chamber thermo-regulated at specific temp placed in a 20°C constant temp room was used to control the temp of 5° intervals between 25° and 40°. Preliminary tests indicated that the air flow through the respiratory chambers influenced fruit temp. When the chamber was set at 30°, the exhaust air from the respiratory chamber was 27° and the fruit temp 28° and even greater differences were observed at higher temp. Therefore, many previously reported studies at elevated temp, where the fruit was assumed to be at the chamber temp, may be in error because of the cool air flow through the respiratory chambers. To correct this error, the air was passed through a 7 m × 6.35 mm copper tube wrapped with a heating tape connected to a variable autotransformer and the voltage adjusted so that the outlet air was the same as the chamber temp.

The air flow through the individual fruit respiratory chambers was freed of background ethylene by passing through a 50 cm × 50 mm glass tube containing Purafil, the CO_2 was removed by bubbling through 2N NaOH, and metered at about 16 liters hr by calibrated capillaries. CO_2 production of each fruit was automatically recorded each hr by an infra-red CO_2 analyzer equipped with an automatic switching system and a strip chart recorder. Ethylene production was determined 3 times daily (Twice on week-ends) on 1 ml samples taken from the outlet of each respiratory chamber by a Varian Aerograph hydrogen flame ionization gas chromatograph equipped with a 2 m × 3.2 mm column packed with 60-80 mesh activated alumina. The system was calibrated at each sampling with 1 ml samples from a cylinder of an ethylene-nitrogen standardized mixture. The CO_2 and ethylene data were summarized for an average daily reading except where peak values occurred between the 24 hr intervals.

Exogenous ethylene or propylene was applied by mixing the respective gas with air (12). The concn was checked periodically by gas chromatography. Ethylene concn was 10 ± 1 µl/ liter and the propylene concn were 1000 ± 50 µl/liter.

Results and Discussion

The respiratory rate and ethylene production at 5°C increments between 20° and 40° are given in Fig. 1 and 2. Typical climacteric respiratory response, similar to those previously reported for avocados (2, 3, 6, 14), were observed for fruit held at 20° to 35°. At 40° the respiratory rate 8 hr after harvest was higher than for other temp, but subsequently the rate declined with time, showing no climacteric (Fig. 2). Ethylene production at 20° and 25° (Fig. 1) showed the characteristic rise associated with the climacteric reported earlier (1, 3, 4, 14). Avocados held at 30° and 35° produced some ethylene during the climacteric, but the peak rates were much lower than for fruit held at 20° and 25°, especially for fruit at 35°. Fruit held at 40° did not produce significant quantities of ethylene (less than 0.1 µl/kg·hr).

The peak respiratory rate and ethylene production for each temp is summarized in Fig. 3. The climacteric maximum increased as the temp increased from 20° to 35°C. A climacteric was not observed for fruit held at 40° (Fig. 2). The respiratory rate shown in Fig. 3 for 40° is the 1-day value.

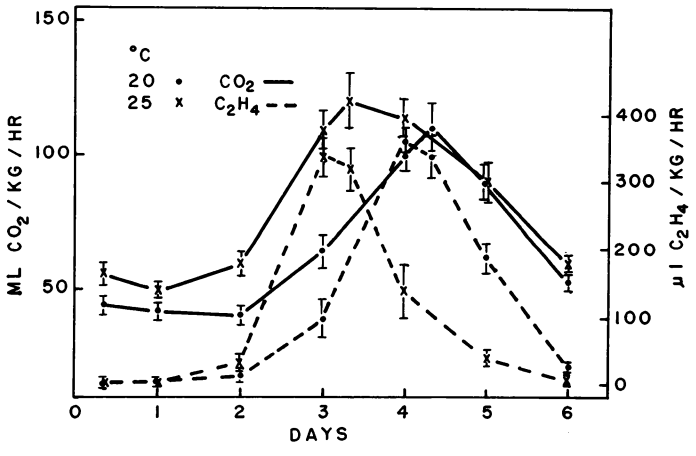

Fig. 1. Respiratory rate and ethylene production at 20° and 25°C.

[1]Received for publication March 24, 1978.
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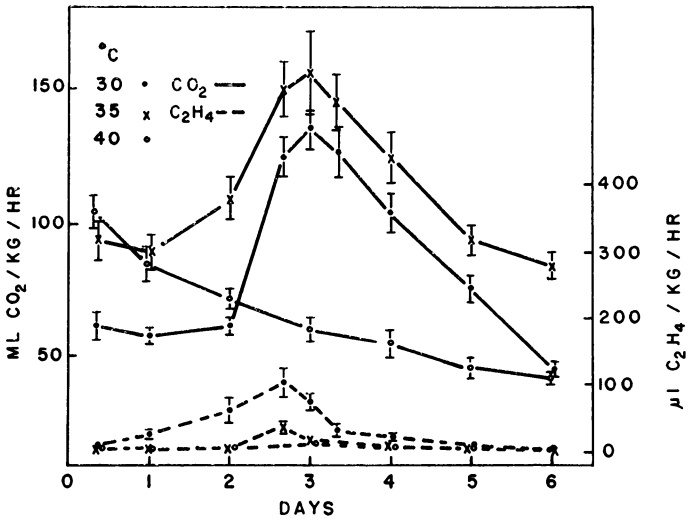

Fig. 2. Respiratory rate and ethylene production at 30°, 35° and 40°C.

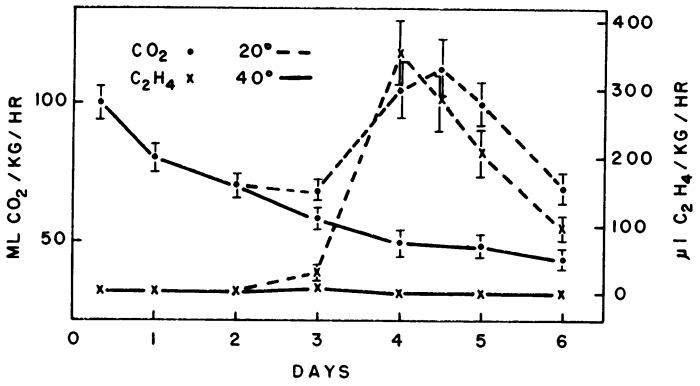

Fig. 4. Respiratory rate and ethylene production at 40°C and at 20° after 2 days at 40°.

High temp have inhibited the climacteric in other fruit. The climacteric was shown for Wickson plums at 25°C, but not at 30° or 35° (5). Pears displayed a climacteric at 20°, but not at 30°, 40° or 50° (11). In both these examples the climacteric was inhibited at 30°, while the avocado, a subtropical fruit, showed a climacteric at 30° and 35°.

Peak ethylene production decreased as the temp increased, although the decrease between 20° and 25°C was not significant (Fig. 3). At 30° the maximum ethylene production was decreased to about one-third the rate produced at 20° or 25°. Only trace amounts were produced at 35° and at 40° ethylene production was essentially undetectable. The maximum ethylene production of pears was about 40 µl/kg·hr at 20°, but dropped to 0.01 to 0.07 µl/kg·hr at 30° and was essentially non-existent at 40° and 50° (11). The mechanism controlling the climacteric and ethylene production in avocados appears to be less sensitive to high temp than in pears.

Ripening as determined by the firmness of the fruit was hastened by high temp. Time to ripen at the various temp were: 6 days at 20°C; 5 days at 25°; 4 days at 30°; and 4 days at 35°. Fruit held at 40° did not ripen normally; the tissue was discolored and rubbery. The eating quality of the fruit ripened at 20°, 25°, and 30° was excellent, those ripened at 35° were fair and those ripened at 40° were completely unacceptable.

The climacteric and ethylene production are associated in most ripening fruit under normal ripening conditions (1). However, avocados held at 30°C and especially at 35° exhibited a characteristic climacteric pattern and ripened, but produced very little or only trace amounts of ethylene compared with fruit held at 20° or 25°. Therefore, it appears that the climacteric and ethylene production in avocados are independent at high temp (35°), but at 40° both mechanisms are inhibited. The mechanism of high temp inhibition is not known, however, protein synthesis may be involved since it has been shown that the inhibition of protein synthesis does not inhibit the climacteric, but does inhibit ethylene synthesis and softening (8).

The response of avocado fruits held continuously at 40°C compared with fruit held 2 days at 40° and then transferred to 20° is shown in Fig. 4. When transferred to 20° the fruit resumed normal ripening functions as evidenced by a climacteric rise in respiration, ethylene production and softening. Fruit held for 1 day at 40° and transferred to 20° had similar response patterns. This indicates that, at least after 2 days at 40°, the inhibition is reversible, i.e., enzyme denaturation did not occur or other mechanisms involved in the inactivation of the climacteric and ethylene production were not permanently damaged.

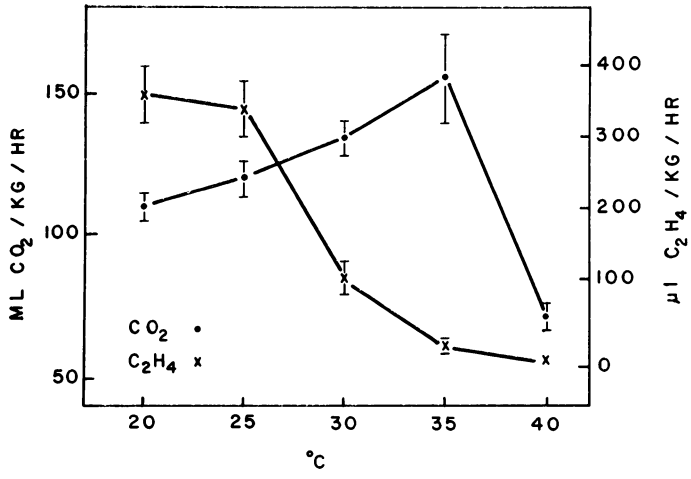

Fig. 3. Peak respiratory rate and ethylene production at 20°, 25°, 30°, 35° and 40°C. The respiratory rate at 40° is the 1 day value.

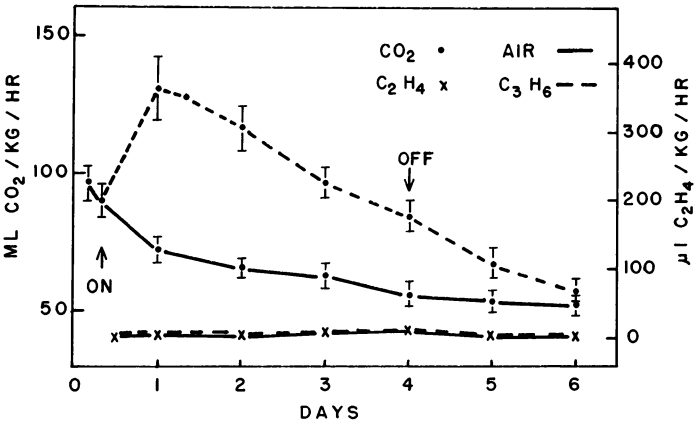

Fig. 5. Respiratory rate and ethylene production at 40°C in air and in 1000 ppm propylene (propylene on from 8 to 96 hr after initiation of experiment).

Several experiments were conducted applying exogenous ethylene (10 μl/liter) and propylene (1000 μl/liter) for 1 to 4 days at the various temp. At the concn used the physiological responses to the 2 gases were similar. The use of propylene facilitated the determination of ethylene production during the treatment period. Fruit held at 20°, 25°, 30° or 35°C gave the typical response to ethylene, i.e., an increased respiratory rate, ethylene production and softening (1, 6). Treated fruit produced less ethylene at the respective temp than untreated fruit and the maximum rate of ethylene production occurred after the maximum respiratory rate. Fruit treated with ethylene (data not shown) or propylene at 40° starting 8 hr after harvest increased in respiratory rate similar to fruit held at lower temp, but did not induce ethylene production (Fig. 5). Also, the exposure of ethylene or propylene did not enhance the rate of softening or the quality of the fruit held at 40° Similar results were obtained with pears (11). Although exposure to ethylene stimulated the respiratory rate, it did not overcome the inhibition of ethylene production and normal ripening processes. The suggested disassociation of the ethylene stimulation of respiration from other ripening processes previously reported (13) could explain the observed effects of high temp on avocados.

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J. Amer. Soc. Hort. Sci. 103(5):578–583. 1978.

Yield Component Analysis in the Cranberry[1]

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Additional index words. Vaccinium macrocarpon

Abstract. **Yield component analysis was used to study the components of yield diversity in cranberry (*Vaccinium macrocarpon* Ait.). The proportion of uprights flowering and fruit-set were identified as important contributors to yield diversity. Numbers of uprights, flowers per flowering upright, and fruit-size were less important. Isolated yield components were largely influenced by uncontrolled variation. However, component compensation effects were identified. Fruit-set compensated for uprights/dm^2 in several areas. Fruit-size compensated for uprights/dm^2 and fruit-set for flower number in only one area. Fruit-set and fruit-size were positively correlated in two cases. The numerical techniques employed have positively identified promising areas for further research.**

Yield variability may be studied by subdividing it into its major components. The contribution of each independent component may then be measured and its relationship to other yield components tested. Studies of yield components have been done on several crops including strawberry (9, 10), barley (7), bean (1, 3), rice (11), (13), oat (8), and cranberry (6). Adams (1967) observed component compensation in bean and concluded it was widespread in several crops, citing other negative correlations between yield components in corn, crested wheatgrass, ryegrass, wheat, cotton, rape, sorghum, soybean and barley.

In a study of the blooming and fruiting habits of cranberries in Wisconsin it was concluded that heavy yields were due more to an increase in numbers of flowering uprights than to an increase in the percentage of flowers setting fruit (2). Similarly in British Columbia, the number of flowering uprights per unit area made a major contribution to yield diversity while the number of flowers per upright and berry-set made less important contributions (6). That study accounted for differences among cultivars and among selected areas of high, medium and low yield. The present study reports the extent of yield diversity among commercial bogs, emphasizing the use of component analysis to account for yield variability over a wide sampling of commercial bogs during a 2-year period.

Materials and Methods

Yields of commercial bogs. Eleven years of yield data (1967-1977) provided by one commercial grower were analyzed by an analysis of variance involving 476 bog-years. Estimates of components of variance for bogs within years and years within bogs were obtained after adjusting for area and cultivar effects.

Yield component analysis. Just prior to harvest in the fall of 1976 and 1977, five samples were taken from each bog in 2 commercial enterprises in Richmond, B.C., namely Western Peat and Northern Peat. Northern Peat is divided into 3 areas – "West," "Old" and "Pacific" where 2 main cultivars are grown, 'McFarlin' and 'Ben Lear'. Western Peat grows mainly 'McFarlin' and 'Bergman'. 'McFarlin' represents 65%, 'Bergman' 27% and 'Ben Lear' 3% of the cranberry area in British Columbia (5). Each area consisted of several bogs. A typical bog occupies more than 1 ha of surface. The sampling in this study

[1]Received for publication February 8, 1978.
The cost of publishing this paper was defrayed in part by the payment of page charges. Under postal regulations, this paper must therefore be hereby marked *advertisement* solely to indicate this fact.

[2]S. I. Farkas, and L. H. Doliner gave valued technical assistance. Financial support was provided by the B. C. Cranberry Marketing Board and National Research Council of Canada operating grant A2023.