Table 2. Effect on CI severity of continuous ethylene (17 ppm) applied to various parts of avocados stored for 3 weeks at 5°C.

	CI index[z]			
	Air		Ethylene	
Fruit part treated	Pedicel[y]	Stylar	Pedicel	Stylar
Entire fruit	0.85 a[x]	1.00 ab	1.34 bc	2.20 e
Stylar end	0.74 a	0.93 ab	0.93 ab	2.02 e
Pedicel end	0.92 ab	1.09 ab	1.45 cd	1.88 de

[z]CI index determined by the method of Chaplin et al. (3). Each value is the mean of 5 fruit.
[y]Indicates part of the fruit assessed for CI.
[x]Mean separation by Duncan's multiple range test, 5% level.

a uni-directional transmission of the stimulus by an unknown 'factor', perhaps through the well-developed vascular system of the fruit.

This study indicates that comparatively low levels of exogenous ethylene induce earlier and/or more severe CI in avocados stored at low temperature than is the case in an ethylene-free atmosphere. Hence, ethylene-scrubbing practices should be employed in avocado cool stores to minimize the CI risk.

Kosiyachinda and Young (5) reported that avocados become increasingly sensitive to chilling temperatures as the respiratory climacteric progresses to the peak. The peak of the climacteric also corresponds with maximum endogenous ethylene production. Hence, the production of endogenous ethylene during storage also may be a factor associated with the development of CI of stored avocados. It could, therefore, be expected that the lower the storage temperature, the longer the time required to initiate endogenous ethylene production. This would explain the lower levels of CI found after storage at 1.5°C compared with those at 5° (Table 1). Further work on the possible interaction of ethylene and temperature on CI in stored avocados is, therefore, warranted.

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Effects of Low-pressure Storage on *Colletotrichum gloeosporioides* and Postharvest Infection of Papaya

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Additional index words. *Carica papaya*, hypobaric storage, anthracnose

Abstract. **Fruit of papaya (*Carica papaya* L.) stored at 15 mm Hg and 10°C for 21 days immediately after inoculation with *Colletotrichum gloeosporioides* developed less anthracnose during 5 days of ripening at room temperature than fruit stored for the same period at normal pressure. Fungistasis occurred in pure culture at low pressure and the infection process on inoculated papaya fruit was delayed. Infection did not appear to be altered otherwise and low pressure did not damage papaya fruit tissue.**

Low pressure (LP) retards growth of some pathogenic fungi and reduces susceptibility of fruit to diseases (6). Alvarez (1) and Jamieson (5) observed less anthracnose on papaya fruit refrigerated (10°C) at 12–20 mm Hg than on fruit refrigerated at normal atmospheric pressure (about 760 mm Hg). However, no histological studies were undertaken to examine how the infection process was altered or whether papaya tissues were damaged by LP storage. This paper reports the results of such studies using light and electron microscopy.

Cultures of *C. gloeosporioides* were grown on 10% vegetable juice agar (VJA) containing 10 ml of Campbell V-8 vegetable juice, 0.2 g $CaCO_3$, 1.6 g Difco agar, and 90 ml distilled water. Mycelial plugs (0.5 cm diameter) were transferred from the periphery of 7- to 10-day-old cultures to Petri dishes containing 15 ml of VJA and incubated in a low-pressure system (3) at 10°C and 15 mm Hg (LP). Controls were incubated at either 10° or 24° in air. The diameter of fungal colonies was measured after 18 days of incubation. Cultures were transferred to 24° air for 5 days and fungal characteristics were reexamined. Each treatment was replicated 4 times with 10 plates each. The presence or absence of sporulation also was examined in the last 2 replications when the cultures were removed from incubation and again 5 days later. Fungal materials for scanning electron microscopy (SEM) were fixed in 3% glutaraldehyde and processed as described (2).

The pathogenicity of *C. gloeosporioides* under LP storage was determined by inoculating mature-green papaya fruit held at 10°C with *C. gloeosporioides* (2). Inoculated fruit were stored either at LP or 10° air. Tissue sections were removed from inoculated fruit after 7 and 21 days of storage and processed for light microscopy and SEM (2). Disease

Table 1. The effects of low pressure on mycelial growth and sporulation of *Colletotrichum gloeosporioides* on 10% vegetable juice agar after 18 days of incubation.

Pressure (mm Hg)	Temp (°C)	Colony radius (cm)[y]	Cultures with spores (%)[y]
15	10	0.4 a	0 a
760	10	1.3 b	100 b
760	24	8.0 c	100 b

[x]Mean separation within columns by Duncan's multiple range test, 5% level.
[y]Mean separation within columns by χ^2 test, 5% level.

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Table 2. Effects of atmospheric pressure on disease development on papayas inoculated with *Colletotrichum gloeosporioides*, stored for 21 days at 10°C, and ripened for 5 days in air (20° to 24°).

Pressure (mm Hg)	Marketable (%)		Unmarketable (%)			
			Chocolate spots		Sunken anthracnose lesions	
	1 day	5 days	1 day	5 days	1 day	5 days
15	88 a[z]	26 a	9 a	2 a	3 a	72 a
760	64 b	6 b	27 b	8 b	9 b	86 b

[z]Mean separation within columns by χ^2 test, 5% level.

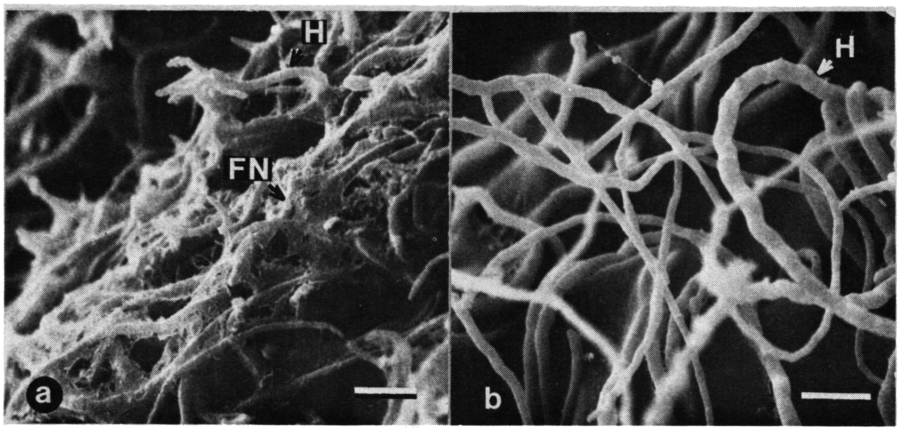

Fig. 1. Scanning electron micrograph of fungal hyphae (H) from the edge of *Colletotrichum gloeosporioides* cultures incubated at 10°C for 18 days in air (a) or low pressure (LP) at 15 mm Hg (b). A fibrillar network (FN) that covers hyphae (H) in air-grown cultures is absent in cultures grown at LP. (Bar represents 10 μm).

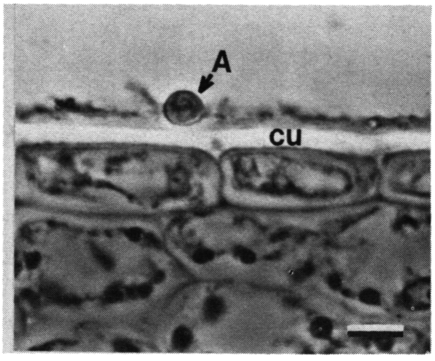

Fig. 2. Appressorium (A) of *C. gloeosporioides* on papaya fruit cuticle (CU) after 7 days of incubation under LP. (Bar represents 10 μm).

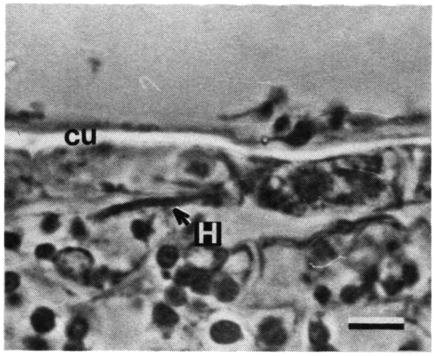

Fig. 3. Fungal hypha (H) in papaya tissue after 7 days of incubation at 10°C in air. (Bar represents 10 μm).

incidence on the inoculated fruit was determined on the first and 5th day after removal from 21 days of storage. Fruit were considered marketable if they were symptomless or showed only pin-point lesions with slight mycelial growth. The experiment was repeated 5 times and the data were analyzed with the χ^2 test.

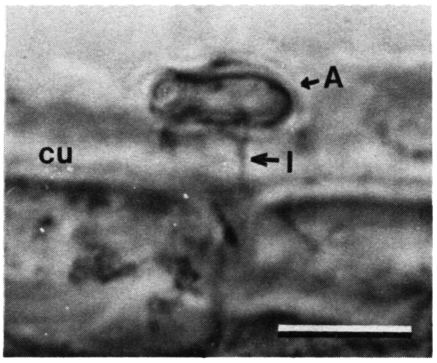

Fig. 5. Infection peg (I) in cuticle (CU) of papaya fruit after 21 days of incubation at LP. Most cells are collapsed and devoid of cytoplasmic contents indicating cell degeneration. (Bar represents 10 μm).

Radial extension and sporulation of *C. gloeosporioides* incubated at LP were retarded (Table 1), but the fungal cultures resumed normal growth after returning to 24°C air. A fibrillar network which covered the mycelium of the cultures grown at 10° and 24° air was absent on the cultures grown at LP (Fig. 1).

Fewer than 5% of the conidia germinated and formed appressoria (Fig. 2) within 7 days on papaya fruit stored at LP, whereas 30% to 50% of the conidia germinated and formed numerous appressoria on fruit stored at 10° and 24°C air. A mycelial mat covered the surface and hyphae were observed in the tissue of 10° air-stored fruit (Fig. 3). Infection of LP-stored fruit was observed 2 weeks later, at which time a mycelial mat and numerous appressoria formed on the fruit surface (Fig. 4), and infection pegs penetrated the fruit cuticle (Fig. 5). Fungal hyphae were observed in the parenchyma cells and vascular tissue, and the latex in infected lacticifers aggregated, forming numerous minute clots. This penetration mode resembles that pre-

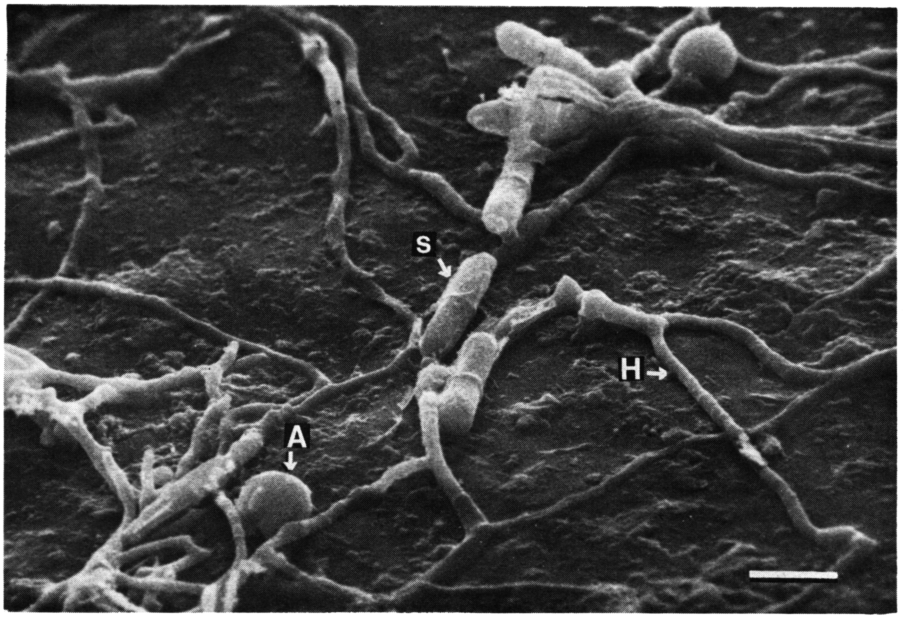

Fig. 4. Fungal hyphae (H), appressorium (A), and spores (S) of *C. gloeosporioides* on papaya fruit after 21 days of incubation at LP. (Bar represents 10 μm).

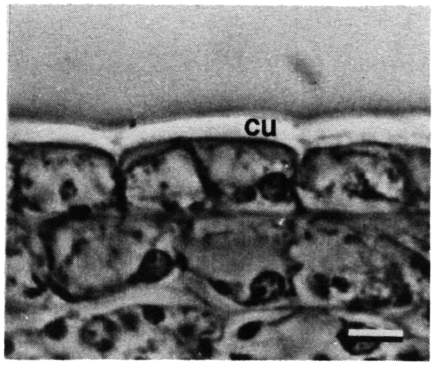

Fig. 6. Healthy fruit tissue from a papaya fruit after 21 days of incubation at 15 mm Hg and 10°C. (Bar represents 10 μm).

viously described for *C. gloeosporioides* on papaya fruit incubated in 24° air (2, 3, 7).

Less disease occurred on inoculated fruit stored at LP than on those stored in air (Table 2). On the first day after removal from storage, 88% of fruit stored at LP were marketable. After ripening for 5 days in air, 26% and 6% of the fruit stored at LP and 10° air, respectively, were marketable. No damage to papaya fruit tissue was observed after 21 days of storage at LP with gradual equilibration of pressure (Fig. 6), but softening occurred with rapid pressure changes (data not shown).

This study substantiates previous evidence (1, 6) that LP storage reduces losses due to anthracnose. However, since growth of the pathogen and disease development are merely retarded, LP storage only will be effective in reducing decay if disease control programs (1, 4) are used to reduce infection of fruit prior to LP storage.

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Genetic Variability in Pecan Fruit Development

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Additional index words. *Carya illinoensis*, breeding

Abstract. **Fresh and dry weights of fruit (nut and shuck) samples of 39 clones of pecan [*Carya illinoensis* (Wang) K. Koch] were determined weekly from July 23 until harvest. One early maturing clone had accumulated 24% of its final fruit dry weight by July 23, when the average for all clones was 11%. Total fruit dry matter decreased during October for some late-maturing clones. These decreases, which were the most obvious in 'Mahan' and its progeny clones, were not as common in early maturing clones.**

Pecan is a lower-yielding nut crop than Persian walnut (*Juglans regia* L.). One reason for this may be late nut development. Nut filling in pecan occurs mainly during September (1, 3, 6, 7, 8), when the days are shorter, leaves are often unhealthy, and when moisture and soil nutrients have often been depleted by 6 months of active growth. Trees also replenish root carbohydrate reserves for the winter during this period which may compete with other sinks for photosynthates.

Productivity of young walnut orchards has been increased by the development of new precocious cultivars (2, 4). This was accomplished by selecting clones which produced more pistillate flowers, especially on lateral branches. Pecan, in contrast, is incapable of filling more nuts, possibly due to its late nut-filling period (5). Clones which produce more nuts than they can fill are often useless because of poor nut quality and low percentage of kernel.

Clones which fill earlier and have a longer filling period may be needed to increase yields. This study was undertaken to determine genetic variability among clones for fruit developing periods.

Three- and 4-year-old, open-pollinated 'Riverside' seedling rootstocks were planted in deep, loamy Frio soil formed in calcareous alluvium with 0–1% slopes in a square design (7.5 × 7.5 m) in March 1967 at Brownwood, Texas. Thirty-nine clones representing a wide range in nut maturity periods (Table 1) were budded on these stocks in May 1971. Two tree plots of each clone were randomized within each of 3 replications. Rainfall and irrigation water received by the plots in 1980 totaled 94.1 cm. Trees were maintained by a normal spray and fertilizer program.

A 10-fruit (nut and shuck) sample was collected from each plot on July 23, 1980. Fruits were removed uniformly from the tree canopies. This sampling was repeated every 4–20 days, as weather permitted, through November 4. The earliest clones matured October 6, and the latest clones were harvested on November 4. All fruit samples were weighed, dried at 50°C to a constant weight, and reweighed. Fruit weights were expressed as percentages of mature fruit weights to correct for characteristic clonal fruit sizes.

There were pronounced differences in cross-sectional areas of fruits of selected clones on July 24 (Fig. 1). The earliest clone (48-15-3) was over twice as large as the latest one ('Mahan') on that date. 'Mahan' at maturity was 1.9 times as large (by volume) and weighed 1.7 times as much as 48-15-3.

Differences among clones for fruit dry-matter accumulations for all dates through October 14 were significant at the 0.1% level, but differences on October 21, 28, and November 4 were nonsignificant (Table 1). Percentages which decreased from the previous sampling dates are underlined. Twenty-four of the 39 clones decreased on at least one sampling date.

A typical clonal response for fruit dry-matter accumulation for each of the 5 maturity dates is shown in Fig. 2. The earliest maturing clones (e.g., 48-15-3) had the highest percentages of dry-matter accumulation when sampling began July 23. It maintained almost a linear accumulation rate until about September 1, then leveled off and matured during the first part of October. A typical clonal response for an October 14 maturity date is shown by 40-9-266. Accumulation initially was slow, then increased and sometimes exceeded 100% of final dry weight before receeding slightly at maturity. 'Cheyenne' had a more uniform accumulation and exceeded 100% on one date. 'Wichita' was variable for dry-matter percentage, increasing and decreasing for about a month before maturity. One late-maturing clone (i.e., 40-9-277) exceeded 100% of final dry weight on more

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