Discussion

Our data indicate that firstly, the primary influence of K or Mg application on various peach tree tissues was to increase either K or Mg in the tissues when that element was applied. In addition, a decrease in levels of Ca in most tissues resulted from application of either K or Mg. Thirdly, application of K increased Mn in most tissues while Mg depressed Mn. Finally, neither K nor Mg application resulted in widespread changes in N, P, Zn, Fe, or Cu and no trends were clearly evident.

The antagonism between K and Mg appears to be limited to the foliage. Thus after deposition in the foliage the movement out of the leaves appears to be governed by the concn of each. Movement of either ion to other parts of the tree was not influenced by the concn of the other. In contrast, the depression in Ca levels, especially by Mg application, was rather widespread throughout the tree.

Chemical analyses carried out in all but 3 years between 1955 and 1970 showed that foliar concn of Ca, Mg, and K often varied widely from year to year. The effect, however, of K and Mg upon foliar levels of the 3 cations was consistent.

Levels of P, K, and Zn in the fruit approximated the levels of those elements in the foliage. With all other elements the level in the fruit was well below that in the foliage. Although treatments influenced the levels of some elements in the fruit, it appears that the fruit does not serve as a sink for the elements measured. In addition, treatments did not result in changes of great magnitude of any element in the fruit. In comparison to the metabolically active areas, the levels of all elements in the storage areas, trunk and branches, were low. Our data indicate that the capability of the woody portions of the tree to serve as a reservoir for the remainder of the tree is limited. However, bark and wood were not separated and the relative amounts of each in twigs, branches, and trunk varied widely. Before definitive statements can be made it will be necessary to separate bark from wood, analyze, and determine the relative contribution of each to the total elements in the tree.

Literature Cited

1. Ballinger, W. E., H. K. Bell, and N. F. Childers. 1966. Peach nutrition *in* N. F. Childers, Ed. Fruit Nutrition, p. 276-390. Horticultural Publications, New Brunswick, N. J.
2. Barber, S. A. 1962. A diffusion and mass-flow concept of soil nutrient availability. *Soil Sci.* 93:39-49.
3. Batjer, J. P., and M. N. Westwood. 1958. Seasonal trend of several nutrient elements in leaves and fruits of Elberta peach. *Proc. Amer. Soc. Hort. Sci.* 71:116-126.
4. Bollard, E. G. 1970. The physiology and nutrition of developing fruit. *in* A. C. Hulme, Ed. The biochemistry of fruits and vegetables, p. 387-425. Academic Press Inc., 111 Fifth Avenue, N. Y.
5. Cain, J. C. 1959. Plant tissue analysis. Part II. Observations on antagonistic effects in leaf analysis. *in* Mineral nutrition of trees -- a symposium. Duke University School of Forestry Bul. 15:63-70.
6. Cummings, G. A. 1965. Plant and soil effects of potassium and magnesium fertilization of Elberta peach trees. *Proc. Amer. Soc. Hort. Sci.* 86:141-147.
7. Frear, D. E. H., R. D. Anthony, A. L. Haskins, and F. N. Hewetson. 1948. Potassium content of various parts of the peach tree and their correlation with potassium fertilization. A sampling study. *Proc. Amer. Soc. Hort. Sci.* 52:61-74.
8. Kenworthy, A. L., and L. Martin. 1966. Mineral content of fruit plants. *in* N. F. Childers, Ed. Fruit Nutrition, p. 813-870. Horticultural Publications, New Brunswick, N. J.
9. Olan, K. 1963. Changes in the content of dry matter and major nutrient elements of apple foliage during senescence and abscision. *Physiologia Plantarum* 16:682-694.
10. Osborn, R. A. 1964. Chemical composition of fruit and fruit juices. *J. Assoc. Off. Agr. Chem.* 47:1068-1086.
11. Reeves, J., and G. Cummings. 1971. Factors influencing chemical characteristics of peaches. *J. Amer. Soc. Hort. Sci.* 96:320-322.
12. Rogers, B. L., L. P. Batjer, and H. D. Billingsley. 1955. Fertilizer applications as related to nitrogen, phosphorus, potassium, calcium, and magnesium ultilization of peach trees. *Proc. Amer. Soc. Hort. Sci.* 66:7-12.

Ripening Processes in Avocados Stored in Ethylene Atmosphere in Cold Storage[1,2]

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Abstract. Continuous ethylene treatment (100 ppm) of avocado fruit stored at 6°C, for 13 days, caused acceleration in respiration rate for the duration of the treatment. At the end of the low temperature treatment and, also, after transfer of the fruit to 20°C, polygalacturonase activity and softening of the fruit were enhanced by ethylene treatment in comparisons with non-treated fruit. Endogenous ethylene production of ethylene-treated fruit was suppressed markedly after transfer to 20°C. Fruit treated 24 hours with ethylene at 6°C at the beginning of the storage period, ripened similarly to untreated control fruits.

For avocado we suggest that in cold storage (6°C) the presence of ethylene should be avoided so that the shelf-life period of the fruit will not be reduced.

The question whether ethylene has an effect on avocado fruit in cold storage (6°) or not is not merely theoretical. This temperature is recommended for commercial storage and transportation of avocado in Israel; thus, the question and answers would have practical implications. It was reported (2) that the respiration of avocado fruit was not affected by ethylene treatment for 35 days at 5°C. On the other hand, it was recently reported that ethylene had an effect on the quality of 'Lula' avocado, stored in controlled atmosphere at 10°C (4). There are conflicting reports (2, 3) about the effect of ethylene on cold-storage apples. Data presented herein show that ethylene has an effect on ripening processes of 'Haas' avocado stored for 12 days in 100 ppm ethylene in air at 6°C. Respiration rate and softening of the fruits were accelerated, while inhibition of ethylene production during the respiratory climacteric was evident.

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Materials and Methods

Mature avocado fruits of 'Haas' (ca. 170 g each) were harvested and transferred to 6°C. Twenty fruits were placed in a 16-liter glass jars washed with continuous air flow of 200 ml/min for 24 hr at about 95% R.H. At the end of this period the fruit was brought to room temp and the respiration rate and ethylene production were determined. At this point, 3 different treatments were applied: 1) continuous air flow - as control; 2) continuous flow of 100 ppm ethylene in air for 24 hr and then a flow of air only, for the remainder of the experiment; and 3) continuous flow of 100 ppm ethylene in air for 12 days. On the 12th day, the flow of ethylene was replaced by pure air in the third treatment. One day later, all fruit was transferred to 20°C in continuous air flow for the remainder of the experiment. Three fruits from each treatment were used for studies of respiration rate and ethylene production throughout the experiment. The fruits were transferred to a 2-liter glass jar and sealed for 1 hr, afterwards the atmosphere in the jars was assayed for CO_2 and ethylene content by gas chromatography. The lowest quantity which could be detected was 0.04 ppm ethylene in a 1-ml sample. After 1 hr these fruits were returned to the large jars for further treatment. In order to study the effect of ethylene treatment on ethylene production and respiration rate during the treatment itself, 3 additional fruits from the continuous ethylene flow treatment were transferred to similar jars and identical determinations were made. These fruits were then kept for 24 hr in the open air and respiration rate and ethylene production were determined as described above. These fruits were discarded after the second determination. This procedure was followed during the first 13 days of the experiment.

As described previously (6) polygalacturonase activity was determined on the basis of substrate viscosity loss caused by action of the enzyme. Firmness was determined without removing the epidermis by a 'Chatillon' pressure tester. Determination of firmness and polygalacturonase activity was started on the 13th day after harvest.

Results

Ethylene production. No detectable level of ethylene production was observed from fruit treated with ethylene for only 24 hr, or from the control fruit at 6°C (Fig. 1). Fruit from the continuous ethylene treatment released ethylene immediately after transfer from the flowing ethylene environment; however, no ethylene production from this fruit could be detected after 24 hr in standard room atmosphere at

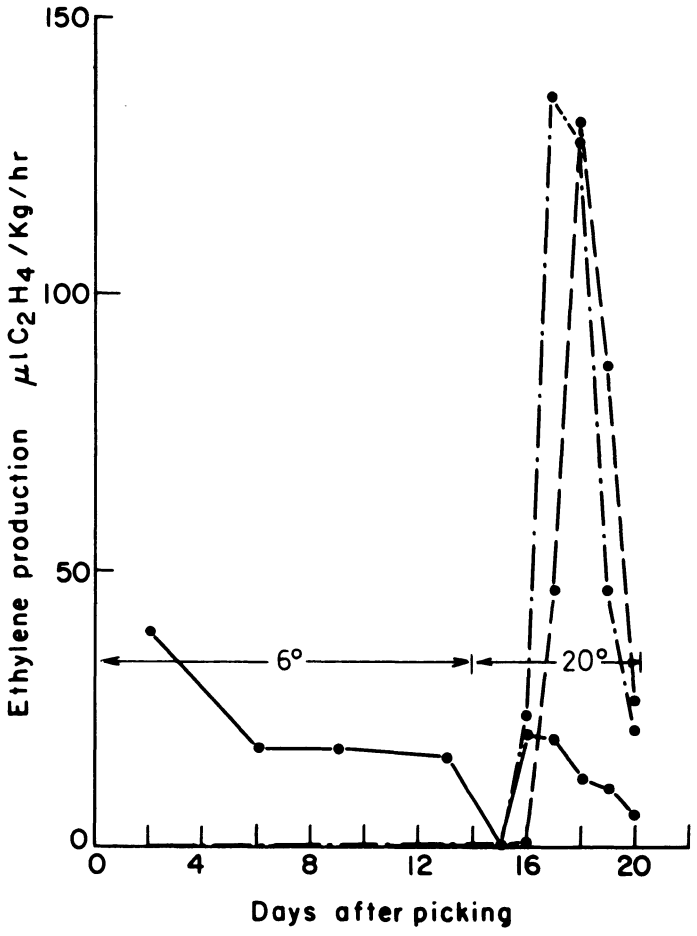

Fig. 1. Ethylene production of cold-stored (6°C), ethylene-treated avocado fruit. Each mean represents 3 determinations. Analysis of variance showed that continuous ethylene treatment (———) was very significantly (at 1%) lower than 24 hr ethylene (– – –) or continuous air treatments (– . – .).

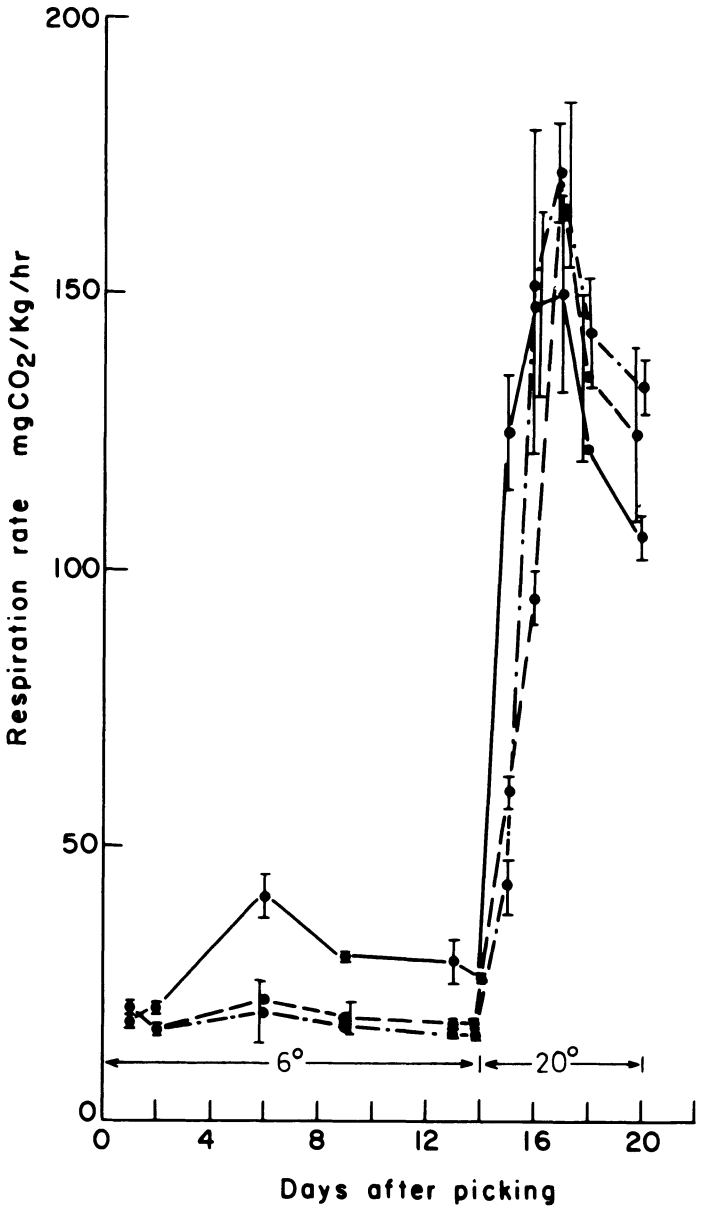

Fig. 2. Respiration rate of cold-stored (6°C), ethylene-treated avocado fruit. Each mean represents 3 determinations with the standard deviations indicated by vertical bars. Continuous ethylene flow (———), ethylene for 24 hr (– – –), and continuous air flow (–.–.).

6°C. The earliest actual ethylene production recorded in this experiment was observed 1 day after the fruit was transferred to 20°C. It is clear that fruit from the continuous ethylene treatment produced much less ethylene than the rest of the fruit after transfer to 20°C (Fig. 1).

Respiration rate. Respiration rate was doubled during continuous ethylene treatment for 12 days at 6°C (Fig. 2). Twenty-four hr of ethylene treatment, however, had no marked effect on the respiration rate. It is obvious that the presence of ethylene is essential in order to maintain the high respiration rates. Determination of respiration rate 24 hr after the fruit was removed from the ethylene treatment showed a reduction in the respiration rate level to that of the controls. Upon transfer to 20°C (on the 15th day), the respiration rate of the fruit under continuous ethylene treatment increased at least 2-fold over the fruit of the 2 other treatments (Fig. 2). All fruit reached the climacteric peak on the same day and climacteric maxima were essentially identical.

Polygalacturonase activity and firmness. Changes in the polygalacturonase activity (Fig. 3) and fruit firmness (Fig. 4) of avocados were evident on the 16th day in the continuous ethylene treatments, while only 2 days later such changes could be observed in fruit of the other treatments. These results show that fruit with continuous ethylene treatment has a shorter shelf-life than fruit of the other treatments.

Discussion

Storage of avocado fruit in ethylene atmosphere at 6°C had an effect on the respiration rate of the fruit both during and after ethylene treatment. Similarly, there were notable effects on ethylene production, polygalacturonase activity, and

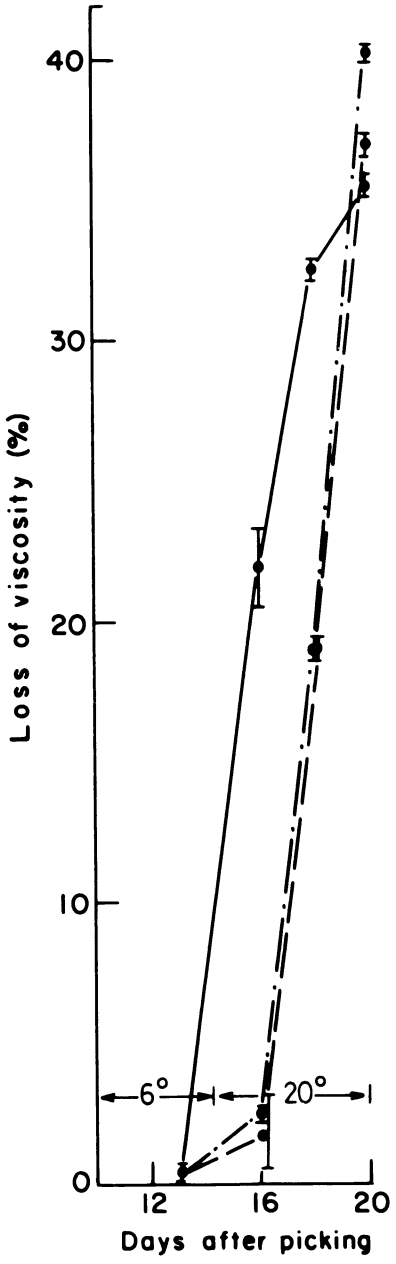

Fig. 3. Polygalacturonase activity of cold-stored (6°C), ethylene treated avocado fruit. Each mean represents 4 determinations with the standard deviation indicated by vertical bars. Continuous ethylene flow (———), ethylene for 24 hr (– – –), and continuous air flow (– . – .).

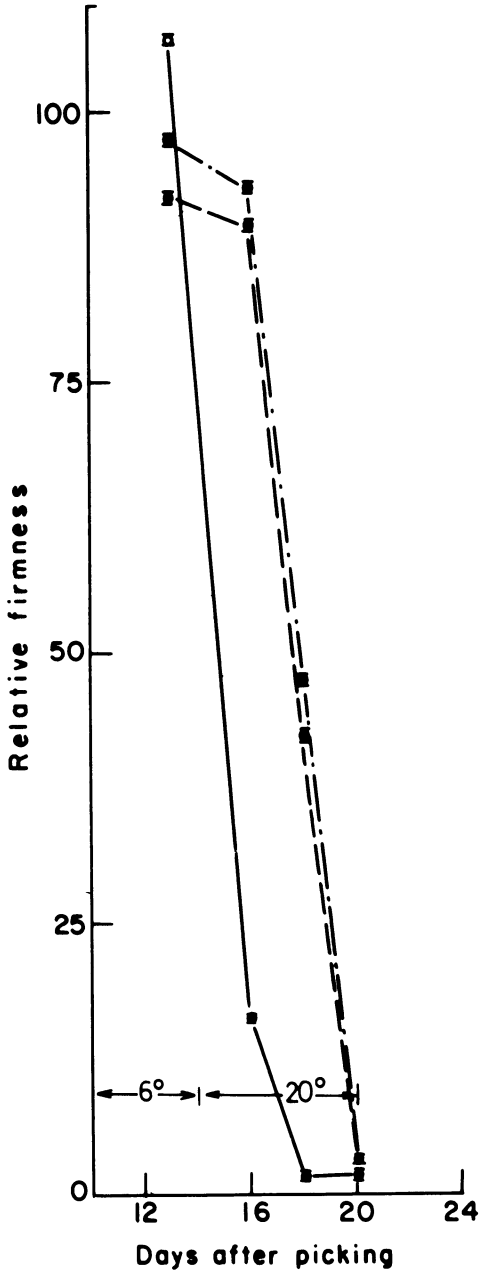

Fig. 4. Firmness of cold-stored (6°C), ethylene treated avocado fruit. Each mean represents 4 determinations with the standard deviation indicated by vertical bars. Continuous ethylene flow (———), ethylene for 24 hr (– – –), and continuous air flow (–.–.–.).

softening of the fruit. Similar results were obtained with fruit of 'Fuerte' (unpublished data).

The suppression of the endogenous ethylene production at 20°C by the previous exogenous ethylene treatment at 6°C (Fig. 1) is most striking. It seems that the enzymatic apparatus which is producing ethylene is affected irreversibly, since ethylene production remained low throughout the experiment. It should be noted, however, that the experimental procedures did not enable the measurement of endogenous ethylene production during the period of the ethylene treatment itself. It is suspected that in the first determination of fruit under continuous ethylene treatment, our measurements were primarily of that ethylene which was applied and absorbed by the fruit and then evolved by diffusion to the atmosphere, rather than of the ethylene produced by the fruit. Similar inhibitory effects of ethylene treatment at 20°C on the endogenous ethylene production of banana were reported recently by Vendrell and McGlasson (5).

Respiration rate was accelerated by continuous treatment with ethylene (Fig. 2). This is in contrast to what was reported previously (1), but it does agree with, and substantiate our other findings (Figs. 3 and 4) that polygalacturonase activity and softening rate were accelerated by ethylene treatment.

These findings are in accord with those of Hatton and Reeder (4), who showed that the removal of ethylene from controlled atmosphere storage chambers (10°C) increased the percentage of acceptable fruit at the end of the storage period. It has been reported that ethylene had an effect on apple fruits in controlled atmosphere cold storage (3). However, Blanpied et al. (2) claim that no effect of ethylene was evident in controlled atmosphere cold storage of apples. It should be noted that in this report the fruit was kept under regular storage atmosphere containing less than 0.5% CO_2 rather than under controlled atmosphere as described in the above mentioned papers (2, 3, 4).

From the data presented in Figs. 1 and 2 it is evident that the ethylene peak did not precede the respiration peak, while in normal ripening of avocado fruit at 20°C the respiratory peak always follows that of the ethylene.

From the practical point of view it is suggested that at 10°C (4) and also at 6°C, ethylene should be avoided whenever long shelf-life of avocado fruit is desired.

Literature Cited

1. Biale, J. B. 1959. Respiration of fruits. *Encyc. Pl. Physiol.* 12:536-592.
2. Blanpied, G. D., O. Cadun, and T. Tamura. 1972. Ethylene in apple and pear experimental CA chambers. *J. Amer. Soc. Hort. Sci.* 97:207-209.
3. Forsythe, F. R., C. A. Eaves, and H. J. Lightfoot. 1969. Storage quality of McIntosh apples as affected by removal of ethylene from the storage atmosphere. *Can. J. Pl. Sci.* 49:567-572.
4. Hatton, T. T., Jr., and W. F. Reeder. 1972. Quality of 'Lula' avocados stored in controlled atmospheres with or without ethylene. *J. Amer. Soc. Hort. Sci.* 97:339-341.
5. Vendrell, M., and W. B. McGlasson. 1971. Inhibition of ethylene production in banana fruit tissue by ethylene treatment. *Aust. J. Biol. Sci.* 24:885-895.
6. Zauberman, G., and Mina Schiffmann-Nadel. 1972. Pectin methylesterase and polygalacturonase in avocado fruit at various stages of development. *Plant Physiol.* 49:854-865.

Associated Effects of Mass Selection for Soil-Insect Resistances in Sweet Potato[1]

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Abstract. Character associations in a sweet potato [*Ipomoea batatas* (L.) Lam.] population after 4 cycles of selection for resistance to soil insects and in a control population with no selection were studied by use of contingency tables of pairs of traits. Possible common factors were indicated for resistances to the sweet potato flea beetle and the wireworm-*Diabrotica-Systena* (WDS) complex. Selection changed the means and distributions of 6 of 13 unselected root and vine traits. None of these changes were directly associated with insect resistances, but that in root cracking was caused by the grading techniques. Two traits appeared genetically associated (cortex thickness and leaf-whorl color), and 2 appeared to be expressions of the same character change (flesh-color changes were also expressed as skin-color changes). The selected population had shorter internodes than the unselected. These changes in unselected traits were probably due to drift caused by small population sizes in the selected generations. No barriers to development of insect-resistant cultivars were detected.

A randomly intercrossing sweet potato [*Ipomoea batatas* (L.) Lam.] population was initiated in 1963 for use in studies of mass-selection breeding procedures. In accordance with the proposed procedure (4), parent-offspring and selection studies were begun in the 4th generation, and results from 2 controlled-selection studies are now available. In the first study (6), rapid increases in proportions of plants with low oxidative root-discoloration scores were obtained with both of 2 mass-selection schemes: equivalent to 1-year and 2-year cycles when adapted to practical breeding programs. The second study (2) involved selection for resistances to a complex of root-damaging insects: the southern potato wireworm, *Conoderus falli* Lane; the banded cucumber beetle, *Diabrotica balteata* LeConte; the spotted cucumber beetle, *Diabrotica undecimpunctata howardi* Barber; the elongate flea beetle, *Systena elongata* (F.); *Systena frontalis* (F.); the grub, *Plectris aliena* Chapin; and the sweet potato flea beetle, *Chaetocnema confinis* Crotch. As in the previous study, very rapid progress was made with the selected traits. In both of these experiments, every effort was made to avoid selection for any trait not under study, thus providing an opportunity to detect associated changes in other characters and to evaluate better the suitability of the breeding procedure for applied breeding programs.

Observations of 16 traits in the population under selection for soil-insect resistances and implications of observed changes

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