and 'Idared' were insensitive to exogenous ethylene in CA storage.

It was confirmed that exogenous ethylene stimulated ripening of CA 'McIntosh' apples. However, response to ethylene was dependent upon the physiological age of the fruit at harvest and the concn of ethylene in storage. Lougheed et al. (6) found that "lowered ethylene levels were often but not always coincident with firmer fruit of early harvests after extended sotrage." Their low ethylene ranged from 5 to 16 ppm and high ethylene from 484 to 2459 ppm. Forsyth et al. (3) found that preclimacteric 'McIntosh' stored in 6 ppm ethylene were significantly firmer than those in 1,570 ppm ethylene. In the present experiment 'McIntosh' picked before the preclimacteric minimum and stored at ethylene concn below 1 ppm (Table 2) was less ripe than that stored at 10 or 500 ppm ethylene. 'McIntosh' at 10 and 500 ppm ethylene were not significantly different. When the fruits were harvested 1 week later, during the climacteric rise, they did not respond to 10 or 500 ppm ethylene probably because the fruits contained sufficient endogenous ethylene at or shortly after harvest time. Whether or not ethylene can be shown to stimulate ripening of apples in CA depends on cultivar, maturity at harvest, and the concn of ethylene in CA.

Literature Cited

1. Blanpied, G. D. 1973. Harvesting fresh market apples in New York. *Information Bul. 49.* Cornell Univ., Ithaca, New York.
2. _____, O. Cadun, and T. Tamura. 1972. Ethylene in apple and pear experimental CA chambers. *J. Amer. Soc. Hort. Sci.* 97:207-209.
3. Forsyth, F. R., C. A. Eaves, and H. J. Lightfood. 1969. Storage quality of McIntosh apples as affected by removal of ethylene from the storage atmosphere. *Can. J. PLant Sci.* 49:567-572.
4. Knee, M., J. T. Cockburn, and J. B. Watt. 1974. Effects of ethylene at storage temperatures. East Malling Res. Sta. Rpt. 1974. p. 79.
5. Kramer, A. and B. A. Twigg. 1970. Quality control for the food industry. AVI Publ. Co., Westport, CT. p. 499-550.
6. Lougheed, E. C., E. W. Franklin, S. R. Miller, and J. T. A. Proctor. 1973. Firmness of McIntosh apples as affected by Alar and ethylene removal from the storage atmosphere. *Can. J. Plant Sci.* 53:317-322.
7. Smock, R. M. and L. Yatsu. 1959. Apple volatile effects on the ripening of Cortland apples. *Proc. Amer. Soc. Hort. Sci.* 73:71-77.

J. Amer. Soc. Hort. Sci. 102(1):95–96. 1977.

Effect of Hydrogen Fluoride and Hydrogen Chloride on Pollen Tube Growth and Sodium Fluoride on Pollen Germination in 'Tilton' Apricot[1]

T. J. Facteau and R. E. Rowe[2]

Mid-Columbia Experiment Station, Oregon State University, Hood River, OR 97031

Additional index words. fruit set, air pollution damage, fluorescence microscopy, *Prunus armeniaca*

Abstract. **Fumigations with hydrogen fluoride (HF) decreased *in vivo* pollen tube growth of 'Tilton' apricot (*Prunus armeniaca* L.). Both tube lengths and percent of styles with pollen tubes that reached the base of the style were adversely affected more by high HF concentration for a short time than by low concentration for a longer time. Pollen germination was unaffected on agar containing sodium fluoride. Fumigations with hydrogen chloride had no effect on pollen tube growth at concentrations from 0.05 to 0.75 mg Cl/m^3 and durations of exposure from 8.5 to 72 hours.**

Apricots are sensitive to fluoride with 'Chinese' and 'Royal' leaf tissue more susceptible to injury than either 'Tilton' or 'Moorpark' (19). Reduction in cropping of 'Tilton' apricots has been noted near an aluminum reduction plant known to release fluoride. Crop reduction was probably a result of defoliation and bud injury (3). Citrus production has also been affected by HF, possibly because of reduced tree size (2), reduced photosynthetic acitvity (2, 12), or because of some adverse effect occurring during blossoming (11). HF affects potential fruit set of tomato (17), cucumber (17), and sweet cherry (6) by interfering with pollen tube growth. In tomatoes and cucumbers the responses occurred at higher HF concn than those normally found in the atmosphere. Fruiting of other plant species, however, has been shown to be potentially affected at F concn associated with F polluted areas (6, 15). No chronic effects of HCl have been reported, although foliar injury has been found on several plant species (7). This study was conducted to determine if HF and HCl fumigations affect *in vivo* pollen tube growth of 'Tilton' apricot and if NaF affects 'Tilton' pollen germination.

[1]Received for publication July 6, 1976. Technical Paper No. 4310, Oregon Agricultural Experiment Station. This research was supported in part by Contract No. CPA 70-130 from the Division of Ecological Effects Research of the Environmental Protection Agency and the Wasco County Fruit and Produce League.

[2]Associate Professor Horticulture, Mid-Columbia Experiment Station and Associate Professor Statistics, Oregon State University, respectively.

Materials and Methods

Branches of 'Tilton' apricots cut during February and March, 1972 and 1975, were forced to flower at 18°C and 20 to 30% relative humidity. At anthesis, flowers were pollinated and fumigated for 0 to 72 hr at fluoride concn from 0 to 59.1 μgF/m^3. Fumigations were conducted at the same temp and relative humidity at which flowers were forced. Seventy-two hr after pollination, 50 to 75 flowers were collected and infiltrated under vacuum in 3 formalin:1 acetic acid:1 alcohol. Preliminary observations showed that under these conditions, pollen tubes would reach the base of the pistil in 72 hr. Pollen tube lengths were determined on 10 flowers by observing callose fluorescence (13). In contrast to results with plum (9), addition of Calcofluor White M2R New did not improve callose observation. Within each flower, length of the longest pollen tube was expressed as percent of style length. The percent of styles in which pollen tubes reached the base of the style was also used as a measure of the response to fumigation. Fumigation techniques and determinations of air F levels were similar to those reported previously (6) except that HF was generated according to the method of Hill et al. (8). Hydrogen chloride was similarly generated from HCL (50% v/v) and monitored using methods described by Katz (10). Air HF and HCl concn were sampled whenever flowers were removed from the chambers. Pollutant concn were maintained at fairly constant levels for 72 hr during which time flowers were removed at intervals to give different exposure durations. Values were averaged together when neces-

sary to give concn over the entire time span.

Pollen was collected by suction, dried at room temp in a desiccator for 5 days, then stored at −29°C. Pollen was dusted on agar Petri plates (2 g agar, 15 g sucrose, 85 ml water or NaF soln, 12 ppm B) at 19° and germination counts made after 18 hr. Approximately 250 pollen grains were counted on each of 7 replications of 0, 5, 10 and 50 ppm NaF.

Results and Discussion

Fumigations of HF inhibited *in vivo* 'Tilton' apricot pollen tube growth and reduced the percent of styles with pollen tubes at the base after 72 hr. Response to fumigation was not simply a multiplicative combination (dose) over ranges of pollutant concn and time of exposure as found in the case of sweet cherry (6). The response surface presented in Fig. 1 shows that pollen tube lengths were reduced more by high concn for short periods than by lower concn for longer periods. The response surface for the percent of styles with pollen tubes at the base is not presented but the effect was similar. No important difference was found between 2 years data and so they were combined. Unfumigated samples were not used in developing the regression equation for the response surface. However, the close agreement between the mean of 95.7% for 57 unfumigated samples and the intercept (estimated pollen tube growth of 92.4% at zero time and zero concn) help to validate the model. We believe, as do others (1), that models of the effects of fumigation generally should include some representation of the effects of both pollutant concn and duration of exposure to the concn, since equal pollutant dosages do not necessarily produce equal plant responses (11). There are cases, however, where dose alone has been used to represent the effects of fumigation (6, 14).

There was no effect from fumigations of HCl at concn ranging from 0.05 to 0.75 mg Cl/m^3 and durations of exposure ranging from 8.5 to 72 hr on pollen tube growth *in vivo* (data not presented). We could find no literature relating to HCl and pollen tube growth of any plant.

A slight but not significant inhibition of apricot pollen germination was found as the concn of NaF was increased from 5 to 10 to 50 ppm NaF (data not presented). Portjanko and Kudrja (16) reported that 5 to 10 ppm NaF agar stimulated apricot pollen germination and pollen tube lengths. The reason for the different response is unknown.

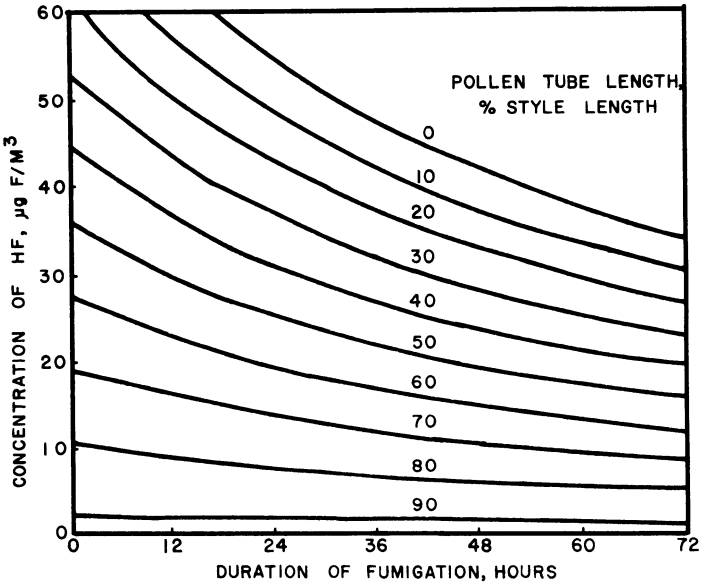

Fig. 1. Response plot of pollen tube lengths as percent of style length as a function of concn of HF in µgF/m^3 and dose of HF (concn F x duration of exposure in hr). Formula for plot construction: Pollen tube length as % of style length = 92.4 − 1.17 concn − 0.22 dose where concn is in µgF/m^3 and dose is concn F x duration of exposure (time) in hr. N = 171, R^2 = 0.6511.

Results suggest that pollen tube growth of 'Tilton' apricots is less sensitive than that of 'Napoleon' ('Royal Ann') cherries. We have reported that after 24 hr at 2.5 µgF/m^3 and 3.7 µgF/m^3 little or no pollen tube growth occurs in sweet cherry (6). At these times and concn apricot pollen tube growth would not be affected. Delaying pollination and/or fertilization of cherries (4, 5) and plums (18) tends to reduce fruit set. T. K. Toyama (personal communication) has indicated that 'Tilton' apricot fruit set starts to decrease 5 days after anthesis. There obviously is a certain period during which the ovules of these crops are receptive to fertilization. Delaying pollen tube growth could restrict fruit set and HF fumigations can reduce pollen tube growth of tomato (17), cucumber (17), sweet cherry (6), and apricot. Whether fruit set is restricted depends on many factors but the possibility exists that fruit set of apricots could be influenced by HF.

Even though 'Napoleon' cherries and 'Tilton' apricots are commonly grouped as intermediate in sensitivity to fluorides (19), they appear to be quite different with respect to HF susceptibility on pollen tube growth.

Literature Cited

1. Brandt, C. S. and W. W. Heck. 1968. Effects of air pollutants on vegetation, p. 401-443. *In* A. C. Stern (ed.) Air pollution. Volume I. Air pollution and its effects. Academic Press, N. Y.
2. Brewer, R. F., F. H. Sutherland, and F. B. Guillemet. 1969. Effects of various fluoride sources on citrus growth and fruit production. *Environ. Sci. & Tech.* 3:378-381.
3. DeOng, E. R. 1946. Injury to apricot leaves from fluorine deposit. *Phytopathology* 36:469-471.
4. Eaton, G. W. 1959. A study of the megagametophyte in *Prunus avium* and its relation to fruit setting. *Can. J. Plant Sci.* 39:466-476.
5. ———. 1962. Further studies on sweet cherry embryo sacs in relation to fruit setting. *Rpt. Hort. Expt. Sta. & Products Lab.*, Vineland, Ontario, Canada. p. 26-38.
6. Facteau, T. J., S. Y. Wang, and K. E. Rowe. 1973. The effect of hydrogen fluoride on pollen germination and pollen tube growth in *Prunus avium* L. cv. 'Royal Ann'. *J. Amer. Soc. Hort. Sci.* 98:234-236.
7. Heck, W. W., R. H. Daines, and I. J. Hindawi, 1970. Other phytotoxic pollutants, p. F1-F24. *In* J. S. Jacobson and A. C. Hill (ed.) Recognition of air pollution injury to vegetation. Informative Rpt. 1 TR. 7 Agriculture Committee, Air. Poll. Contr. Assoc., Pittsburgh, PA.
8. Hill, A. C. L. G. Transtrum, M. R. Pack, and A. Holloman, Jr. 1959. Facilities and techniques for maintaining a controlled fluoride environment in vegetation studies. *J. Air Poll. Contr. Assoc.* 9:22-27.
9. Jefferies, C. J. and A. R. Belcher. 1974. A fluorescent brightener used for pollen tube indentification *in vivo*. *Stain Tech.* 49:199-202.
10. Katz, M. 1968. Analysis of inorganic gaseous pollutants, p. 53-114. *In:* A. C. Stern (ed.) Air pollution. Volume II, Analysis, monitoring and surveying. Academic Press, N. Y.
11. Larsen, R. I. and W. W. Heck. 1976. An air quality data analysis system for interrelating effects, standards, and needed source reductions: Part 3. Vegetation injury. *J. Air Poll. Contr. Assoc.* 26:325-333.
12. Leonard, C. D. and H. B. Graves, Jr. 1966. Effect of air-borne fluorides on 'Valencia' orange yields. *Proc. Fla. State Hort. Soc.* 79:79-86.
13. Martin, F. W. 1959. Staining and observing pollen tubes in the style by means of fluorescence. *Stain Tech.* 34:125-127.
14. Oshima, R. J., M. P. Poe, P. K. Braegelmann, D. W. Baldwin, and V. Van Way. 1976. Ozone dosage-crop loss function for alfalfa: A standardized method for assessing crop losses from air pollutants. *J. Air. Poll. Contr. Assoc.* 26:861-865.
15. Pack, M. R. and C. W. Sulzbach. 1976. Response of plant fruiting to hydrogen fluoride fumigation. *Atmospheric Environ.* 10:73-81.
16. Portjanko, V. F. and L. M. Kudrja. 1966. Halogens as stimulators of pollen germination. *Fiziol. Rast.* 13:1086-1089. [Hort. Abst. 37: 4114.]
17. Sulzbach, C. W. and M. R. Pack. 1972. Effects of fluoride on pollen germination, pollen tube growth, and fruit development in tomato and cucumber. *Phytopathology* 62:1247-1253.
18. Thompson, M. M. and L. J. Liu. 1973. Temperature, fruit set, and embryo sac development in 'Italian' prune. *J. Amer. Soc. Hort. Sci.* 98:193-197.
19. Treshow, M. and M. R. Pack. 1970. Fluoride, p. D1-D17. *In* J. S. Jacobson and A. C. Hill (ed.) Recognition of air pollution injury to vegetation. Air Poll. Contr. Assoc., Pittsburgh, PA.