8. Kaufmann, M. R. and Y. Levy. 1976. Stomatal response of *Citrus jambhiri* Lush. to water stress and humidity. *Physiol. Plant.* 38:105-108.
9. Khairi, M. M. A. and A. E. Hall. 1976. Effects of air and soil temperatures on vegetative growth of citrus. *J. Amer. Soc. Hort. Sci.* 101: 337-341.
10. Livne, A. and Y. Vaadia. 1972. Water deficit and hormone relations. Vol. 3. p. 255-275. *In* T. T. Kozlowski (ed.) Water deficits and plant growth, Academic Press, New York.
11. Loveys, B. R. and P. E. Kriedmann. 1973. Rapid changes in abscisic acid-like inhibitors following alterations in vine leaf water potential. *Physiol. Plant.* 28:276-279.
12. Miller, E. V., A. Soboto, R. Hartman, W. Brykailo and M. Levy. 1965. A study of methods for the reduction of acids in certain plants. *Econ. Bot.* 19:218-222.
13. Newman, J. E., W. C. Cooper, W. Reuther and G. A. Cahoon. 1967. Orange fruit maturity and net heat accumulation. p. 127-147. *In* Ground level climatology, R. H. Shaw, ed. *Amer. Assoc. Adv. Sci. Publ.* 86.
14. North, C. P. and A. Wallace. 1955. Soil temperature and citrus. *Calif. Agr.* 9(11):13.
15. Rasmussen, G. K., A. Peynado, R. Hilgeman, G. Cahoon and J. R. Furr. 1966. The organic acids contents of Valencia oranges from four locations in the United States. *Proc. Amer. Soc. Hort. Sci.* 89:206-210.
16. Reuther, W. 1973. Climate and citrus behavior. Vol. 3, p. 280-337. *In* W. Reuther, ed. The citrus industry, Univ. of California, Berkeley.
17. _____, G. K. Rasmussen, R. H. Hilgeman, G. A. Cahoon and W. C. Cooper. 1969. A comparison of maturation and composition of 'Valencia' oranges in some major subtropical zones of the United States. *J. Amer. Soc. Hort. Sci.* 94:144-157.
18. _____ and D. Rios-Castano. 1969. Comparison of growth, maturation and composition of citrus fruit in subtropical California and tropical Colombia. Proc. First Int. Citrus Symp. 1 p. 277-299.
19. Rygg, G. L. and M. R. Getty. 1955. Seasonal changes in Arizona and California grapefruit. *U. S. Dept. Agr. Tech. Bul.* 1130.
20. Sinclair, W. B. 1972. The Grapefruit, its composition, physiology, and products. Univ. of California, Division of Agricultural Sciences.
21. Sites, J. W., Reitz, H. J. and E. J. Deszyck. 1952. Some results of irrigation research with Florida citrus. *Proc. Fla. State Hort. Soc.* 64:71-79.

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Ethylene in Fruits of Blackberry and Rabbiteye Blueberry[1]

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Abstract. **'Humble' blackberry (*Rubus arvenis* Bailey) extractable ethylene content reached more than 7.0 mg/liter shortly after full bloom and dropped to well under 1.0 mg/liter for the remainder of fruit development. The low ethylene levels during the latter stages of fruit development suggests that blackberries are nonclimacteric. 'Tifblue' rabbiteye blueberry (*Vaccinium ashei* Reade) extractable ethylene was more than 5.0 mg/liter approximately 2 weeks after bloom, declined to near 1.0 mg/liter during green fruit development and peaked at 3.7 mg/liter in reddish-green (ripening) berries. The increased level of ethylene in ripening fruits suggests that rabbiteye blueberries are climacteric.**

Ethylene has been associated with developmental stages of many fruits (8). The purpose of this research was to determine whether a relationship exists between endogenous ethylene and developmental stages of blackberry (*Rubus arvenis*) and rabbiteye blueberry (*Vaccinium ashei*) fruits.

Materials and Methods

Samples of 25 fruits were collected periodically from field plots of 3 year old 'Humble' blackberry and 3 year old 'Tifblue' blueberry. 'Humble' is an upright self-fruitful blackberry cultivar. 'Tifblue' blueberry is not self-fruitful, but was in a planting with 9 potential pollinator cultivars. Fruit set in 'Humble' and 'Tifblue' was essentially 100% as young fruit abscission does not normally occur. Pollination was accomplished entirely by native insect populations.

About 20 blackberry flowers were tagged to visibly monitor fruit development and samples of comparable untagged fruits were collected at weekly intervals from bloom to maturity. Blueberries were collected biweekly beginning an estimated 2 weeks after the completion of bloom and at shorter intervals during the ripening stages. Samples were immediately transported to a laboratory for analysis. Ethylene analyses were completed within a maximum of 2 hr after sampling. The internal atmosphere of fruits was extracted by a technique similar to that of Beyer and Morgan (2). Fruits were submerged in a chamber filled with saturated sodium chloride solution and placed under a partial vacuum of 185 mm for 10 min.

A 2cc sample of the extracted atmosphere was injected into an F&M Model 5750 gas chromatograph equipped with a flame ionization detector and a 1.8m activated alumina column. The gas chromatograph had an ethylene sensitivity of 0.02 mg/liter. Ethylene levels are expressed as the concentrations (mg/liter) in the extracted tissue atmospheres.

Results and Discussion

The peak ethylene level in blackberries (untreated) was 7.1 mg/liter 1 week after full bloom (Fig. 1). Pollination and subsequent shedding of flower parts occurred during the period from full bloom to 1 week after full bloom. The high levels of ethylene were probably associated with these early developmental stages (1, 4, 7). The young fruit abscission associated with an increase in ethylene production following bloom in several fruits (1, 7) does not normally occur in blackberry.

Blackberry full bloom was April 15, 1976. Ethephon (2000 mg/liter) sprayed on blackberries 5 days after full bloom increased endogenous ethylene to more than 38 mg/liter 2 days after application (Fig. 1); no abscission of young fruits was induced. Ethephon was applied to young blackberry fruits at concentrations of 250 to 6000 mg/liter without causing fruit abscission. This suggests that a mechanism for ethylene induced young fruit abscission is not present in blackberries. Ten days

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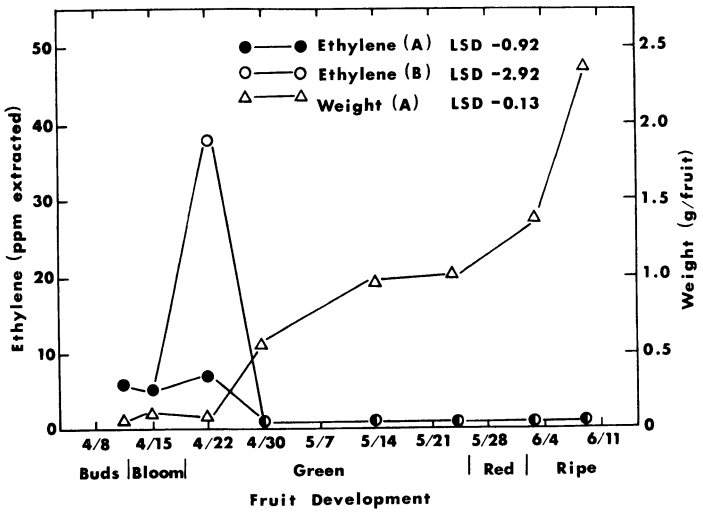

Fig. 1. Seasonal pattern (1976) of extractable ethylene and fruit wt of 'Humble' blackberries from untreated plants (A) and of extractable ethylene from berries sprayed with 2000 ppm ethephon on April 20, 1976 (B). Replicate variation is reported as LSD, 5% level.

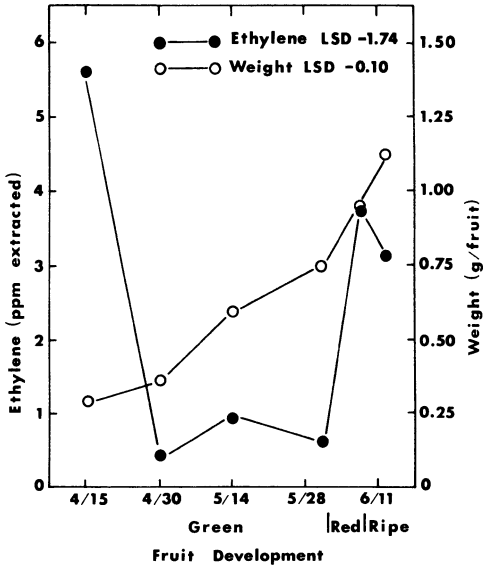

Fig. 2. Seasonal pattern (1976) of extractable ethylene and fruit wt of berries from 'Tifblue' blueberry. Replicate variation is reported as LSD, 5% level.

after application of ethephon, ethylene production from ethephon-treated berries had dropped to the same level as unsprayed berries (Fig. 1). The ripening period of these ethephon-treated berries did not differ from the control. Ethylene in blackberry fruits remained below 1.0 mg/liter from 2 weeks after full bloom throughout the remainder of the season (Fig. 1). Similar data were collected from blackberries during two previous seasons.

Ethylene involvement in stimulating a respiratory climacteric during ripening has been reported for many fruits (3, 8). The absence of increased ethylene production associated with ripening suggests that blackberries are nonclimacteric fruits; however, data documenting the respiratory pattern of blackberries are not available.

Measurement of ethylene production by young blueberry fruits began about 2 weeks after pollination (Fig. 2). The high level of ethylene extracted at that time (April 15, 1976) correspond with the period of normal young fruit abscission of most fruit crops; however, rabbiteye blueberries do not normally exhibit young fruit abscission during this period. Ethylene extracted from green blueberries dropped to a minimum of 0.45 mg/liter on April 30, 1976 and remained relatively low until June 9, 1976 when the ethylene content of ripening (reddish-green) berries increased to 3.7 mg/liter (Fig. 2). Ripe fruits subsequently declined slightly in ethylene content.

Based on the ethylene pattern, these data suggest that rabbiteye blueberries are climacteric. Hall and Forsyth (5) reported that lowbush blueberry was nonclimacteric; however, Ismail and Kender (6), measuring CO_2 evolution, classified both lowbush and highbush blueberry as climacteric. More recently, evidence by Windus et al. (9) confirms that highbush blueberries exhibit CO_2 evolution and ethylene production patterns characteristic of climacteric fruits. Data presented here for rabbiteye blueberry, while not conclusive, support this growing evidence that blueberries are climacteric fruits.

Literature Cited

1. Abeles, F. B. 1973. Ethylene in plant biology. Academic Press, New York.
2. Beyer, E. M., Jr. and P. W. Morgan. 1971. A method for determining the concentration of ethylene in the gas phase of vegetative plant tissue. *Plant Physiol.* 46:352-354.
3. Burg, S. P. and E. A. Burg. 1965. Ethylene action and ripening of fruits. *Science* 148:1190-1196.
4. Hall, I. V. and F. R. Forsyth. 1967. Production of ethylene by flowers following pollination and treatments with water and auxin. *Can. J. Bot.* 45:1163-1166.
5. _____and _____. 1967. Respiration rates of developing fruits of the lowbush blueberry. *Can. J. Plant Sci.* 47:157-159.
6. Ismail, A. A. and W. J. Kender. 1969. Evidence of a respiratory climacteric in highbush and lowbush blueberry fruit. *HortScience* 4:342-344.
7. Lipe, J. A. and P. W. Morgan. 1973. Ethylene, a regulator of young fruit abscission. *Plant Physiol.* 51:949-953.
8. Pratt, H. K. and J. D. Goeschel. 1969. Physiological roles of ethylene in plants. *Annu. Rev. Plant Physiol.* 20:541-584.
9. Windus, N. D., V. G. Shutak and R. E. Gough. 1976. CO_2 and C_2H_4 evolution by highbush blueberry fruit. *HortScience* 11:515-517.