Vitamin C — A Natural Smog Resistance Mechanism in Plants?

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VITAMIN C may be a factor responsible for smog resistance in plants. We have found that petunia varieties tolerant of smog have a higher concentration of this scurvy-preventing vitamin than do sensitive varieties.

Ascorbic acid, better known to the layman as vitamin C, has long been employed as a remedy for the common cold. Even before the existence of vitamin C pills grandma recommended it in the form of orange juice and lemonade. Although its function in the human body is poorly understood, the C-vitamin is believed to reduce man's susceptibility to infection. It is known that man's requirements for vitamin C are raised when he has a fever or is confronted by other physiological stresses including infection, pregnancy and breast feeding.

Biologists believe that vitamin C acts as an antioxidant and thus as a protector of delicate enzyme systems. Recently it has been found that people who smoke cigarettes have less vitamin C reserves in their bodies than do non-smokers which indicates that the vitamin may interact with the oxidants in tobacco smoke and become inert. Similarly we have found that petunias exposed to ozone, a major constituent of Los Angeles smog and a strong oxidizing agent, have lower concentrations of ascorbic acid than do unexposed plants. Both sensitive and tolerant varieties were treated with 0.4 parts per million (ppm) ozone for 2.5 hours (this dosage is normally exceeded many times each year in the Los Angeles area). The plants showed no visible symptoms upon removal from the ozone chamber and were tested immediately for their vitamin C content. The treated petunia leaves had 10% less ascorbic acid than did the control leaves indicating that the fumigation either prevented vitamin C synthesis or destroyed the existing vitamin or both.

AN EXCELLENT correlation exists between ascorbic acid concentration and the response of petunia leaves to ozone fumigation. As can be seen from Table I, the smaller and younger leaves contain much more vitamin per unit size than do the larger and older leaves. The 1.5-2.0 centimeter leaves contain twice as much vitamin C per square centimeter of leaf surface as do leaves in the 4.0-4.5 cm. class. Likewise the younger leaves are more tolerant of ozone than are the older leaves. The largest leaves on the plants were not tested. The 4.0-4.5 cm. class represents leaves that were approaching maturity rather than fully mature leaves. It will be noted that the tolerant varieties of each class have a higher score (are more tolerant) than do the sensitive varieties and that this same varietal relationship exists when comparisons are made of ascorbic acid concentrations. The 1.5-2.0 cm. leaves of variety 'Gypsy' have approximately the same concentration of ascorbic acid as do the 2.0-2.5 leaves of varieties 'Coral Satin' and 'Pink Satin.' However, leaves as large as 2.5-3.0 cm. in variety 'Sundance' have nearly this concentration. Within the range of experimental error all these leaves show similar amounts of damage when fumigated with ozone, indicating that higher ascorbic acid concentration may be responsible for ozone tolerance in petunias.

Studies are continuing to investigate this relationship. Crosses have been made in all possible combinations between the four F_1 hybrid varieties listed in Table I. The seeds obtained have been planted and the resulting seedlings will soon be ready to test. If the above correlation is maintained in the segregating petunia

progenies, the relationship will seem fairly well established for multiflora petunias.

OTHER PLANT SPECIES that have varietal differences in smog susceptibility or in vitamin C concentrations are being collected and analyzed to ascertain if a similar ozone-tolerance/ascorbic-acid-concentration relationship obtains. Although it is commonly believed that white petunias are more sensitive to smog, we have not found flower color important in this regard. The misconception is probably due to the relative sensitivity of the 'White Cascade' variety when compared to other varieties popular in the trade.

It is important to note that ascorbic acid has previously been proposed as an agent for the protection of plants.[2] When this substance is dusted or sprayed onto foliage the treated leaves are indeed made smog tolerant; however, leaves that develop after treatment are as sensitive as the untreated foliage and readily succumb to the air-borne poison. If naturally occurring ascorbic acid can be shown to determine smog resistance in other species, the plant breeder has a new tool. He can then select tolerant varieties of plants without having to depend upon natural smog or an expensive smog generating and testing device.

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[2] Freebairn, H. T. and O. C. Taylor. "Prevention of plant damage from air-borne oxidizing agents." Proc. Am. Soc. Hort. Sci. 76:693-699. 1960.

Table I. Comparison of ozone tolerance and ascorbic acid concentration for different sized leaves of ozone-sensitive and ozone-tolerant petunia varieties.

	Variety							
	Tolerant				Sensitive			
Leaf	Sundance		Pink Satin		Coral Satin		Gypsy	
Length (cm)	Ozone Score*	A. A. Conc.**	Ozone Score	A. A. Conc.	Ozone Score	A. A. Conc.	Ozone Score	A. A. Conc.
1.0 - 1.5	2.40	***	2.36		2.30		2.23	
1.5 - 2.0	2.25	2.29	2.12	1.77	1.91	1.75	1.78	1.63
2.0 - 2.5	1.95	2.00	1.72	1.58	1.49	1.63	1.35	1.43
2.5 - 3.0	1.73	1.51	1.46	1.43	1.36	1.19	1.15	1.31
3.0 - 3.5	1.25	1.27	1.28	1.21	1.24	1.13	0.97	1.16
3.5 - 4.0	1.07	1.04	1.11	1.01	1.18	0.94	0.89	0.94
4.0 - 4.5	1.00	1.01	1.12	0.89	1.06	0.88	0.87	0.92

*Average of more than 60 leaves in each size class where each leaf is given a rating of 2.4, 1.8, 1.2, or 0.6 depending on whether it was undamaged, stippled, spotted, or wilted respectively from an ozone treatment of 0.9 parts per million for 24 hours.

**Ascorbic acid concentration in milligrams per 100 square centimeters of upper leaf surface.

***About 1/4 pound of these leaves if eaten would satisfy the minimum adult daily requirement for this vitamin.

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